TREASoURcE

Exploring the Transferability of the Digital Marketplace Across Target Regions

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1. INTRODUCTION

The future circular economy is based on the efficient use of raw materials, which also supports the use of local resources. Working closely with farmers, other industries, local authorities and regions, the TREASoURcE project aims to create circular economy markets and business models, support the development of bio-based value chains, and explore opportunities for the use of waste and by-products in urbanand rural areas[1] .

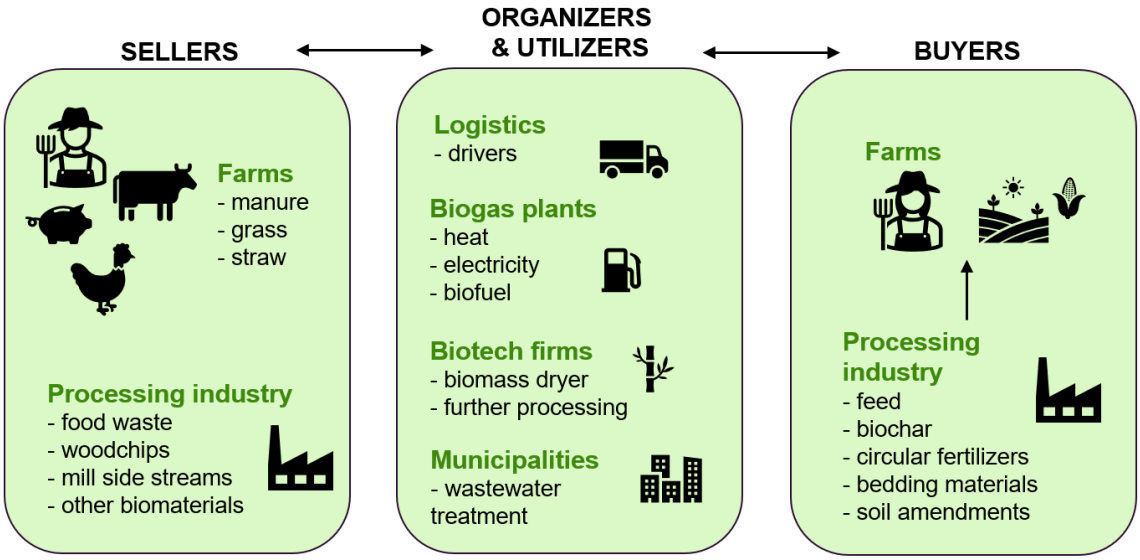

Figure 1. Stakeholders connected via the KiertoaSuomesta.fi platform

Today, the efficient use of agricultural by-products has been hampered by challenges related to profitability and logistics. On individual farms, the quantities of by-products may be small and/or seasonal, and it is not possible to find suitable buyers. To address these challenges and connect supply with demand, the digital marketplace *KiertoaSuomesta.fi* (*CircularFinland*) was established as a meeting place for sellers and buyers of these materials, with the aim of promoting their more efficient and sustainable use. The market's main target groups are companies in the agricultural, forestry and food industries that produce bio-based by-products and waste streams, as well as the industrial and public sectors that utilise these raw materials. The uniqueness of this platform lies in its ability to connect all parties in the value chain (Figure 1). The *KiertoaSuomesta.fi* platform has been established as a central platform for bio-based by-products, connecting geographically dispersed producers and potential buyers in Finland[2] .

[1] The TREASoURcE project website. Available at: https://treasource.eu/systemic-ce-solutions/bio-based-side-and-waste-streams/ May 2026.
[2] Platform KiertoaSuomesta.fi. Available at: https://www.kiertoasuomesta.fi/en/faq/ May 2026.

In the TREASoURcE project, we aim to understand whether and how the solutions we have created can be replicated and transferred to other countries. In this report, we present our conclusions regarding the potential transferability of the *KiertoaSuomesta.fi* platform to the local context of project target areas – Estonia, Latvia, Lithuania, Poland and Germany.

2. METHODOLOGY

The replication process of any practice or platform involves several phases, with dissemination and knowledge sharing playing critical roles in ensuring its success and sustainability. To disseminate information about the platform as well as to understand its transferability and replication potential in TREASoURcE target areas, we conducted several workshops and interviews (see ANNEX 1 for details).

The study is grounded in a **value proposition (VP)** analysis, a tool that helps to understand how the actual needs of customers overlap with the product or service offered through a business model[3]. For this purpose, a VP canvas (Figure 2) is employed to map both the company and customer profiles — in essence, the value creators of the product, as well as the characteristics of the product or service that can address the customer's problems, are identified. Conversely, the customer's benefits, problems, and needs are mapped. Following the analysis and mapping process, valuable insights are gained into how to enhance the value of the product or service[4] [5] . Although VP has long been used as a tool in product and service development, it is recognized that the needs of the target group are not always sufficiently taken into account[6]. In the context of platform transferability, the VP canvas is particularly useful, as it allows for a systematic comparison between the value offered by an existing solution and the needs of a new target market — thereby identifying both opportunities and barriers to replication.

Assessing the transferability of a digital bio-based by-products marketplace requires going beyond economic value alone. The platform operates at the intersection of environmental, social, and institutional dimensions — touching on waste recycling practices, regulatory frameworks, stakeholder readiness, and expectations for digital solutions. A standard VP analysis focused solely on market fit would therefore be insufficient. For this reason, a sustainable value proposition approach was adopted, which extends the traditional VP canvas to encompass these broader dimensions (Selvefors et al., 2024). This approach recognizes that sustainability considerations — including environmental impact, stakeholder engagement, and regulatory context — have become integral components of effective value propositions

[3] Osterwalder, A., Pigneur, Y., Berdarda, g., Smith, A. (2015). Value Poposition Design. Journal of Business Models, 3, 1, pp.81-92. https://s3.tenten.co/share/Value-Proposition-Design-Book.pdf May 2026.
[4] Osterwalder, A., Pigneur, Y., Berdarda, g., Smith, A. (2015). Value Poposition Design. Journal of Business Models, 3, 1, pp.81-92. https://s3.tenten.co/share/Value-Proposition-Design-Book.pdf May 2026.
[5] Shamsuzzoha, A., Suihkonen, A-M., Wahlberg, C., Jovanovski, B., Piya, S. (2023). Development of value proposition to promote green innovation for sustainable organizational development. Cleaner Engineering and Technology, 15. https://doi.org/10.1016/j.clet.2023.100668 May 2026.
[6] Selvefors, a., Renström, S., Whalen, K. A., Fallahi, S., Leivas, M., Nordenö, H., Fransson, A. (2024). User-centered circular value propositions - approaches in practice and research. Resources, Conservation & Recycling, 207. https://doi.org/10.1016/j.resconrec.2024.107628 May 2026.

in today's bio-based economy[7]. This approach informed the selection of eight analytical themes used in the stakeholder interviews: reuse of residues, regulations and legislation, new business models, expectations for the digital platform, cross-supply-chain collaboration, awareness, stakeholder pressure and readiness, and vision for the future. Together, these themes capture both the economic viability and the environmental and social conditions necessary for successful platform replication across target regions.

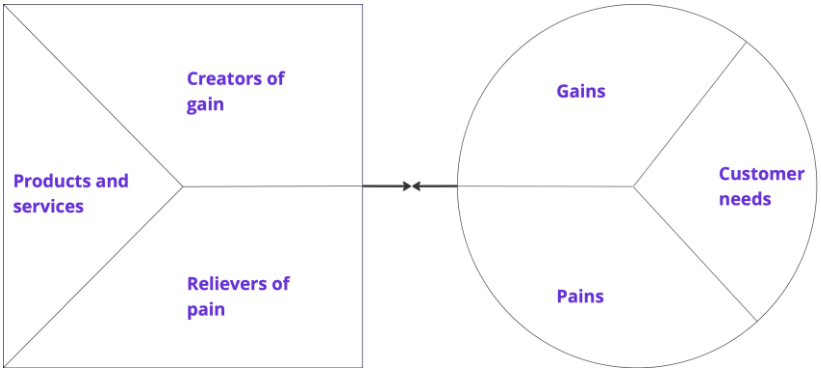

Figure 2. Value proposition canvas [8]

The analysis was conducted in seven stages:

- In the first stage, existing background material on the *KiertoaSuomesta.fi* platform was reviewed, the value proposition framework was adapted to the project context, and interview guides were prepared.
- In the second stage, an initial interview was conducted with the platform owner (MTK[9]), following the structure of a value proposition analysis (ANNEX 2). The platform owner presented the platform's advantages and the solutions it offers to problems identified during its development, and defined their vision of the target market, including the potential needs, problems, and motivations of prospective users.
- In the third stage, Estonian stakeholders were interviewed in depth using a semi-structured approach. The analysis placed greater depth on Estonia due to practical advantages, including direct access to stakeholders through project partners, allowing for more detailed qualitative insights. A total of 5 interviews with 12 participants were conducted between autumn 2024 and winter 2025 (3 individual and 2 focus group interviews), lasting 60–90 minutes, recorded and transcribed (ANNEX 1). The consulted stakeholders represented a diverse range of sectors, including service owners/developers, professional associations and trade unions, the public sector, agricultural enterprises, waste recycling companies, and agricultural waste brokers.

[7] Brunner, M., Backmann, N., Tripathi, S., Pöchtrager, S., Jodlbauer, H. (2024). Sustainability as a key value proposition - a literature review and potential pathways. 5th International Conference on Industry 4.0 and Smart Manufacturing, Procedia Computer Science, 232, 1-10. https://doi.org/10.1016/j.procs.2024.01.001 May 2026.
[8] Osterwalder, A., Pigneur, Y., Berdarda, g., Smith, A. (2015). Value Poposition Design. Journal of Business Models, 3, 1, pp.81-92. https://s3.tenten.co/share/Value-Proposition-Design-Book.pdf May 2026.
[9] MTK - the Central Union of Agricultural Producers and Forest Owners. More information available at: https://www.mtk.fi/web/en May 2026.

- In the fourth stage, the findings from the Estonian interviews informed the design of workshop content, which was subsequently delivered through in-depth workshops in Poland and Germany. Participants represented key professional organisations in the bioeconomy sector (including farmers' unions, the federation of food producers), industry bodies such as biogas associations and companies, research institutions, chambers of agriculture and commerce, circular-economy NGOs, national institutions such as environmental agencies, the chambers of waste management, the inspectorates for environmental protection, and local governments. At the end of each workshop, the findings were presented back to participants, the sessions were recorded and transcribed for subsequent analysis. During the workshops, the content of the platform was presented and the following questions were discussed:
    - What are the needs of the target group in relation to selling or disposing of agricultural bio-waste, and what are the main barriers to doing so?
    - What are the key challenges that need to be addressed before a platform of this kind could be successfully deployed?
    - What are the expectations of potential customers for a digital sales platform for agricultural bio-waste?
- In the fifth stage, desk research was conducted for Latvia and Lithuania, drawing on existing literature, policy documents, and relevant reports, supplementing the preliminary insights gathered through introductory stakeholder workshops conducted at the initial stage of the project.
- In the sixth and final stage, the findings across all target regions were synthesised, overlaps between the platform's value proposition and stakeholder needs were examined, and the final value proposition was formulated.
- In the seventh stage, the transferability criteria emerging from the value proposition analysis were systematically organised into six analytical dimensions — covering regulatory readiness, digital readiness, market and ecosystem context, trust and data quality, operational and economic feasibility, and strategic fit. Each dimension was developed into a set of concrete guiding questions to support context-specific assessment by potential platform initiators. The resulting self-assessment framework is presented in Section 5.2 and in full in ANNEX 3.

3. RESULTS

3.1 General insights

From the perspective of the **Estonian** public sector, there is a consistent focus on bio-waste, residues and by-products. At the level of various ministries, waste streams generated in agriculture are being addressed, bio-economies have been developed, and circular bio-economy roadmaps have been created. Efforts are also being made to find solutions for valorising biodegradable waste and reducing the generation of waste as residues, as well as waste reform (which is primarily aimed at municipal waste). In addition to biodegradable waste, there is also a strong focus on agricultural plastics and batteries.

The professional associations participating in the study are characterised by their representation of farmers and their engagement with current issues in the sector. For example, in addition to agricultural waste, they pay particular attention to agricultural plastics and the development of biogas plants, including ensuring a secure supply of materials. According to 2022 data, there are 8 biomethane plants and 4 industrial biogas plants in Estonia[10] . It is also known that 5 applications have been submitted for the construction of additional biogas plants under the relevant measures.

Producers are mostly farmers who largely utilise the waste generated based on established skills and knowledge. This also describes the sector more generally – agricultural waste is not such a major problem, as the vast majority of it ends up, so to speak, back on the fields. However, this study also takes into account the Circular Economy Centre, which operates all waste collection points in Tallinn, where, in addition to other specific types of waste (approx. 40 types), plastic and biodegradable garden waste is also handled.

In Poland, a government-approved circular economy action plan has been in force since 2019, the objectives of which are to create favourable conditions for the sector's development, build value chains and establish a raw material base. The action plan places significant emphasis on cooperation between various stakeholders (including industry, research institutions and the government) at different levels.[11] The main value chains for agricultural bio-waste include anaerobic digestion[12] [13] , composting[14] , pyrolysis and incineration, ethanol fermentation[15] and biogas production from vegetable waste[16] . The main challenge is the high proportion of unsorted bio-waste[17] , and the development of biogas plants and valorisation technologies is considered a key driver in the sector[18] [19] .

As regards agricultural bio-waste, no corresponding digital buying and selling platforms have been tested in Poland, but a crop protection DSS (decision support system) has been implemented within an IoT

[10] Biogas plants in Estonia https://www.eestibiogaas.ee/biogaasijaamad-eestis
[11] Marcinek, P., Marzena, S. (2020). Bioeconomy as one of the key areas of implementing a circular economy (CE) in Poland. *Environmental Research, Engineering and Management*, 76 (4)
[12] Igliński, B., Buczkowski, R., Inglińska, A., Cichosz, M., Piechota, G., Kujawski, W. (2012). Agricultural biogas plants in Poland: Investment process, economic and environmental aspects, biogas potential, *Renewable and Sustainable Energy Reviews*, 16 (7), pp 4890–4900
[13] Rolewicz-Kalińska, A., Lelicińska-Serafin, K., Manczarski, P. (2025). Selection Path for Energy-Efficient Food Waste Management in Urban Areas: Scenario Analysis and Insights from Poland. *Feature Papers in Energy, Environment and Well-Being*, 18 (2)
[14] Czekała, W. (2023). Selective Collection and Management of Biowaste from the Municipal Sector in Poland: A Review. *Advanced Technologies in Environmental Protection and Environmental Risk Assessment*, 13 (19)
[15] Rolewicz-Kalińska, A., Lelicińska-Serafin, K., Manczarski, P. (2025). Selection Path for Energy-Efficient Food Waste Management in Urban Areas: Scenario Analysis and Insights from Poland. *Feature Papers in Energy, Environment and Well-Being*, 18 (2)
[16] Janczak, D., Kozłowski, K., Zbytek, Z., Cieślik, M., Bugała, A., Czekała, W. (2016). Energy Efficiency of Vegetable Waste Used as Substrate for Biogas Production. *MATEC Web of Conferences*, 64
[17] Dronia, W., Połomka, J., Jędrczak, A. (2023). Morphological composition of bio-waste collected selectively in towns and villages during autumn and winter. *Journal of The Air & Waste Management Association*, 73 (4), pp 313–320
[18] Igliński, B., Buczkowski, R., Inglińska, A., Cichosz, M., Piechota, G., Kujawski, W. (2012). Agricultural biogas plants in Poland: Investment process, economic and environmental aspects, biogas potential, *Renewable and Sustainable Energy Reviews*, 16 (7), pp 4890–4900
[19] Marks, S., Dach, J., Morales, F. J. F., Mazurkiewicz, J., Pochwatka, P., Gierz, Ł. (2020), New Trends in Substrates and Biogas Systems in Poland. *Journal of Ecological Engineering*, 21 (4), pp. 19–25

(Internet of Things) network, offering various e-services to farmers and advisors[20] . More generally, the use of such digital solutions is limited, requiring more interdisciplinary projects[21] . Participants in the workshop organised in Poland as part of this project represented businesses from the biogas and agricultural sectors, as well as representatives from the public sector in the field. According to them, a similar platform to the one being developed within this project already exists in Poland, but it is aimed at the forestry sector. The agricultural sector's need for a platform has been briefly explored previously, but so far it has been found that waste streams have already been established and therefore the development of a new platform is not currently a priority. At the same time, there is interest and inspiration is being gathered on how the platform could be implemented.

Germany is one of Europe's leading countries in the use of bio-resources and the development of renewable energy[22] due to its current energy and environmental policies and its capacity (agricultural land accounts for just under 50% of the country's total area). Regional electricity and heat producers, as well as the transport sector, rely on biomass, which is regarded as a stable source of renewable energy. The biomass resources used are primarily agricultural waste, the most significant product of which is biogas following fermentation processes, as well as forestry by-products and other bio-sources. Energy production from biomass is regulated by the Renewable Energy Sources Act, which has encouraged the provision and use of support measures in the sector. In recent years, however, the principle has been adopted that the use of agricultural land for energy production should be reduced and that the food production sector should not be jeopardised[23] . Consequently, the focus is shifting towards the use of biomass from waste and by-products, with a preference for biowaste, manure, agricultural residues and industrial by-products, in order to reduce the environmental impact of waste management and landfill, and to increase resource efficiency. At the same time, there is interest in and inspiration being drawn from ways in which the platform could be implemented. In other words, there is a recognised opportunity to use biomass in the development of other bio-based products and value chains, for example in the chemical and materials industries[24] .[25] This is also supported by the objectives of the bioeconomy strategy to ensure the competitiveness of the German economy in the international market[26] .

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[20] Mueller, S., Plociennik, M., Zacharczuk, M., Fojud, A, Blaszczak, M., Jakubowska, M., Wojtowicz, A., (2022). Leveraging IoT solutions as a basis for the development of agricultural advisory services. *2022 IEEE International Conference on Omni-Layer Intelligent Systems, COINS 2022*

[21] Kosior, K. (2023). Research and development projects for digital agriculture in Poland. *Annals of the Polish Association of Agricultural and Agribusiness Economists*, 25 (2), pp 124–139

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[23] Beck-O'Brien, M., Bringezu, S., Banse, M., Barrelet, J., Bezama, A., Bösch, B., Brüning, S., Bührlen, B., Cabezas, A., Cyffka, K. F., Dzene, Gordillo Vera, F., I., Helander, H., Henke, J., Hennenberg, K., Hinz, R., Inofuentes, P. P., Iost, S., Jordan, M., Kilian, D., Köppen, S., Kynast, E., Lutz, C., Pereira, S., Pfeiffer, M., Phuntsho, Pozo Inofuentes, P., Reiss, T., Reuschel, S., Richter, S., Schaldach, R., Scheffler, M., Schomberg, A., Schüngel, J., Schweinle, J., Thrän, D., Wang, M., Weimar, H., Wiegmann, K., Wijesingha, J., Wilske, B., Wydra, S., Zeug, W., Zinke, C. (2024). *Monitoring the German Bioeconomy: Status, performance, trends and implications for sustainable development*. Published by the Centre for Environmental Systems Research (CESR), University of Kassel, Kassel

[24] Richter, S., Szarka, N., Bezama, A., Thrän, D. (2025). Enhancing the circular bioeconomy transition in Germany: A systematic scenario analysis. *Sustainable Production and Consumption*, 53, pp 125–146

[25] IEA Bioenergy. (2024). *Implementation of bioenergy in Germany – 2024 update: Country Reports*

[26] Lühmann, M., Vogelpohl, T. (2023). The bioeconomy in Germany: A failing political project? *Ecological Economics*, 207

3.2 Reuse of residues

In Estonia, the reuse and recycling of residues are key issues for all groups of interviewees. Although the sector's perspective is based on the waste hierarchy, where the aim is to prevent the generation of waste, it is understood that this is difficult in the agricultural sector and that waste generation is linked to various unavoidable external factors. From the public sector's perspective, the movement of waste streams is regulated by waste codes, and businesses are obliged to report data on these streams to the state. However, the state does not have a clear overview of by-products without waste codes (straw, manure, husks, press residues, bones, etc.). A national study has therefore been launched to identify a methodology for better managing by-products and the associated data. From a broader perspective, the public sector is committed to finding solutions, with the primary focus being on removing obstacles that have arisen through investment and legislation.

To better utilise agricultural waste, the public sector considers it important to invest more in research and development. As far as is currently known, the main options for utilising agricultural residues are biogas production, composting, and various chemical and material solutions. Therefore, fostering a better understanding of the value of residues among both farmers and valorisers is also considered a key consideration. From the valorisers' perspective, there is a clear understanding that we have significant room for improvement in terms of the circular economy and recycling to meet the agreed targets. However, it is acknowledged that when residues are put into circulation, the new products produced from them (e.g. compost) command a significantly higher price, which is influenced by external factors such as certifications, the associated bureaucracy and additional investments. Farmers who wish to channel their residues into value-added uses now have good, established contacts with whom they exchange materials. However, both the state and the private sector acknowledge that the distinction between residues and waste classified under waste codes is often so complex to understand that it hinders deeper commitment to materials sent for recovery. At the same time, financial gain is a motivating factor. For example, disposing of residues by sending them to landfill is significantly more expensive than selling them at a lower price, whilst the transport costs for removal are shared between the parties involved in the buying and selling process.

From an economic perspective, biogas plants are the most dependent on residues. On the one hand, depending on output, the investment required for a single biogas plant ranges from €5 million to €30 million. Consequently, the security of supply with waste streams is guaranteed even before the plant's project application is initiated. At the same time, biogas plants have very specific requirements that the quality of the waste must meet – availability, stability, seasonality, quality, energy content and dry matter content.

Among the participants in the **Polish** workshop, there was also a sense of uncertainty regarding residues and waste classified under waste codes, as well as the possibilities for their recovery, leading to a proposal to address this 'grey area' so that waste recovery would be more clearly understood and its implementation less bureaucratic. There was a general sense of uncertainty regarding new opportunities for the recovery of residues/waste, as existing waste streams are well-established.

Based on the **German** workshop, several practical market- and quality-related issues emerge regarding the reuse of residues and bio-waste. Firstly, material quality and purity are key issues for buyers, as contamination of biomass with metal, plastic or other unsuitable materials reduces its utility value and creates risks in subsequent processing stages, such as biogas production or composting. Therefore, quality control and reliable information on the composition of the material are essential for the functioning of the entire value chain.

Secondly, market participants raised issues regarding the seasonality of the supply of biowaste, which is linked to the risk of supply security. Although sources of biowaste are available year-round, their types and quantities vary significantly, making it difficult to ensure a stable input flow, particularly in biogas production, but also in composting. This, in turn, complicates production planning and may limit investment or the optimisation of production capacity.

A third key issue addressed was the need for quality control and the establishment of trust mechanisms, particularly in situations where the exchange of biowaste is conducted online. It is considered important that the platform be able to guarantee, or at least reliably verify, that the material streams offered meet the required quality standards. This may also involve the introduction of certification systems and cross-referencing with other data systems (independent third parties) to confirm that the bio-resource offered meets the requirements. At the same time, the platform remains responsible for its reputation and credibility, which is why quality assurance is a vital part of the functioning of the entire market and the development of trust between parties.

3.3 Regulations and legislation

From the perspective of the **Estonian** public sector, there are several issues relating to legislation and regulations. The main issue is that problems within the waste framework cannot be resolved arbitrarily at the national level, as they are dependent on EU-wide directives and requirements. A second major issue is the definition of terms – waste, residue and by-product – as many types of waste generated could be classified as by-products, yet there is no clear definition of by-products. Consequently, it is difficult for a recycling company to determine in which situations it is necessary to apply for a waste management permit and in which it is not. Based on practical examples, the state also wishes to find solutions where, for instance, a biogas plant adds food industry waste to manure during the fermentation process; in such cases, the digestate obtained as a by-product is also classified as waste. This is also dictated by the requirement that the waste accounting balance must be in equilibrium.

From the public sector's perspective, a problem may arise with a digital sales platform if materials subject to legal restrictions are traded. For example, manure can easily be exchanged, but the exchange of certain animal raw materials may raise legal issues, as may the exchange of biological materials. On the other hand, there is the question of whether the material being exchanged requires specific analyses. In most cases, a more philosophical question arises here: what kind of residues and waste does the farmer wish to return to the field? Above all, the aim is to prevent heavy metals from entering the field. From a practical perspective, for example, the high concentration of chemical elements in sewage sludge makes it neither preferable nor suitable for use as fertiliser on fields.

The views of recycling companies largely coincide with those of public sector representatives. They, too, recognise the complexity of understanding the terminology and the lack of clear definitions. For example, a biogas plant does not view digestate as waste, but as a by-product. Such ambiguities, however, lead to a great deal of bureaucracy, which farmers believe could be significantly simplified. On the other hand, a potential problem with the digital sales platform does not guarantee that the feedstock purchased via the platform will reach the biogas plant on time. This problem relates to a situation where material intended for gas production must reach the digester at at the earliest opportunity, so as not to allow it to compost or evaporate. However, if an irregular waste stream remains at the recycling facility for more than two days, the facility operator is required to deposit a financial guarantee to ensure that the waste is directed to the digester as soon as possible.

According to **Polish** representatives, they too often face difficulties related to legislation. Bureaucratic obstacles are frequently caused by procedures (such as applying for environmental permits), which many companies believe need to be simplified. There is also agreement with the findings from Estonia: regulations relating to environmental permits can significantly hinder the operation of digital buying and selling platforms.

In the **German** interviews, issues relating to regulations and permits were raised as one of the most significant barriers to the marketing and brokering of bio-waste. In particular, the situation was highlighted where smaller producers may not hold an official sales permit or be aware of the need for one. This also applies to the requirements set for means of transport. It was also pointed out that, in the case of cross-border flows, additional permits, certificates and local legal requirements must be taken into account. One possible solution suggested was that some of these issues could be incorporated into the platform's administrative functions, for example through the consolidation of key regulatory documents or individual consultations.

3.4 New business models

In Estonia, the adoption of new business models is important from a national perspective, but attention is being paid to several aspects. Firstly, taking the example of a biogas plant, the volumes of waste streams are large; therefore, it is considered more sensible to find solutions for smaller streams for which no widespread application has yet been found, or which are geographically too far from potential areas. At the same time, it is pointed out that competitiveness in the market for the use of raw materials of biological origin is rather weak, as the final price of the product is significantly higher than that of fossil-based products.

The state wishes to focus greater attention on industrial symbiosis, i.e. a situation where nearby industries exchange waste materials with one another. This would reduce transport costs and encourage the maximum utilisation of locally available materials to a greater extent. Recycling companies also agree with this view, particularly if there were a pyrolysis plant available that could gasify woody materials (e.g. tree stumps). A comprehensively developed concept would make it possible to supply nearby farmers with fertilisers and ensure a balanced carbon cycle in the forest.

Other business models for biogas plants included agricultural models and those based on urban areas and high-density settlements. Agricultural business models referred to the fermentation of manure and other animal biomass together with food industry residues from the surrounding area that have a high organic load. The urban biogas plant model could utilise both waste from nearby farmers and larger quantities of food industry waste. In the densely populated area model, biogas would be produced from the region's biowaste, including separately collected industrial food waste. A fourth option proposed was the fermentation of sewage sludge, but its value is low.

According to the **Polish** representatives, one possibility would be to create value chains and promote businesses and business models among the platform's users, given that the platform could bring together various sectors, centres and local associations. For example, it is suggested that the platform could additionally include a person or persons through whom a wider user base could be influenced and engaged. Such groups could function as a cooperative-style hub or a support centre for the collection and distribution of biomass.

At the same time, it is recognised that the platform's commercial or business sustainability may not be particularly strong or long-term. Several parties pointed out that, following the platform's establishment, there is a lack of financial resources for its management and development, which is why projects fizzle out. It is therefore considered that, in the early stages of the process, it should be determined who is responsible for covering the costs of management and development and ensuring a stable funding model. In this regard, it is recommended to consider funding the platform with public sector support, for example through public funding. Furthermore, the need for early validation of the platform was highlighted to ensure the system meets actual needs and the required quality standards.

Furthermore, the issue of price formation and transparency was raised, as the platform is expected to determine the correct market price for waste/biomass. As a business model, a solution should be found that prevents prices from being driven below market levels outside the platform. As the prices of waste/biomass tend to be seasonal in nature, participants believe the platform system should be capable of monitoring market prices in real time and adjusting them as needed.

In the **German** interviews, the need to expand the supply side of the platform was emphasised in relation to new business models, by involving more sectors where additional bio-waste is generated. This would help create a more diverse market and sufficient material volume, which in turn would improve investment confidence and support the platform's development. At the same time, it was considered important to ensure the platform's financial sustainability. If the platform operates on a non-profit basis, a lack of investment could lead to the cessation of operations and create a risk that suppliers would develop their own solutions, which could result in market fragmentation. Therefore, the importance of a clear financial plan and transparent transactions was emphasised.

The flexibility of the system and its ability to balance supply and demand were also considered important. In the agricultural sector, production is influenced by weather, seasonality and market conditions; therefore, the platform should offer alternative or contingency mechanisms for situations where the agreed quantities cannot be supplied. The need for effective matching logic between market participants

was also highlighted, which would help to connect supply and demand and support cooperation, for example through profit-sharing or other incentive mechanisms.

Furthermore, the importance of taking environmental impacts into account was emphasised, including carbon accounting as a potential additional revenue mechanism. Solutions that would help better interpret farmers' existing data and provide clear and practical decisions based on it were also considered important. In conclusion, it was emphasised that the business model to be created should be sufficiently flexible to adapt to changing policies, regulations and market conditions and to ensure the long-term sustainability of the system.

3.5 Expectations for the digital platform

In Estonia, a national database has been established for waste reporting, to which relevant sector representatives submit an annual report on waste generation and waste streams. Other statistics required by the state are also collected regularly. Therefore, the integration of the digital sales platform is envisaged as a cross-functional application, where the national waste permit database could automatically exclude materials unsuitable for sale upon detection, as well as identify unsuitable buyers, thereby automatically cancelling the transaction. As the purpose of the digital sales platform is not to collect data, the statistics on by-product flows there would not provide a sufficient overview. Consequently, the utility of such a platform is seen as greater for other waste streams, such as residues generated in the construction and demolition sector.

From the perspective of professional associations, there are two main concerns regarding the digital sales platform. Namely, it is estimated (a view shared by the public sector) that a situation is likely to arise where supply on the platform exceeds demand. This is primarily because the majority of waste stream movements have already been established, meaning that large quantities are unlikely to be reflected on the platform. This may leave the platform limited to the exchange of small quantities of residues. Taking a biogas plant as an example, this would mean purchasing a different type of residue (e.g. potatoes), for which the biogas plant may not hold a suitable environmental permit. However, the permit application process takes one year and costs €10,000. It can therefore be concluded that the adoption of digital solutions is hampered by unresolved legislative issues and bureaucracy. At the same time, it is suggested that the potential for greater use of the platform could be realised by sharing regional resources, i.e. by making the platform region-based.

The view of the implementing companies is that a great many different digital solutions have now been adopted, which require a significant time investment. Furthermore, based on experience with various developments, it is felt that the costs of creating and managing the platform are often the reason why digital solutions are not further developed, particularly if there is no guaranteed and stable usage behind them. Therefore, the data flow should be integrated into industrial process technologies that collect and transmit the relevant solutions without human intervention. Unfortunately, such technologies and AI solutions have not yet been implemented in biogas plants. Just like the public sector, waste management operators also recognise that there could be greater potential for realising such a platform in the case of other waste streams (e.g. plastic).

Representatives participating in the **Polish** workshop emphasised that a digital platform must be technologically efficient, user-friendly and reliable, whilst also being adaptable to the needs of different regions and users. The need to apply digital tools, including machine learning and artificial intelligence, was highlighted as a way to simplify and speed up buying and selling processes. It was felt that solutions should increase internal platform efficiency and make data processing and decision-making more automated. At the same time, it was noted that the platform should not become technologically complex; in other words, a simple user interface should be created so that users immediately understand what to do and how to do it. Cybersecurity, data protection and artificial intelligence were also highlighted as trust issues, as the region's population was assessed to have limited awareness of and trust in technology – there is a fear that artificial intelligence or automated systems could be misused, for example through misinformation or fraud. Consequently, the security of the platform, transparency and the visibility of relevant regulations were considered important, ensuring users that their data is protected and that logging in and sharing data is controlled and secure.

With regard to regional needs and context, it was considered important that, rather than a one-size-fits-all solution, a framework be created that can be adapted on a context-specific basis. It was also highlighted that end-user testing is expected prior to the platform's launch to avoid the service failing to meet requirements. To increase trust, it was further suggested that the platform should be officially certified or recognised, e.g. by the government or an educational institution. Finally, it was highlighted that, in addition to the technical and functional aspects, there must be clear motivation among users to adopt the platform, as well as a Q&A section and guidance materials. Representatives felt that it is not always economic benefit that is important, but also other values that the use of the platform enables – time savings, better visibility in the market, easier collaboration, higher-quality data, etc.

The **German** discussion emphasised that the digital platform must, above all, be efficient and as automated as possible, fitting in with farmers' daily work routines. As producers spend a large part of their time in the field, the system should be accessible via mobile devices and require minimal data entry. Potential is also seen in the use of artificial intelligence, which could support decision-making and provide, for example, forecasts of bio-waste volumes or market prices. It was also considered important that, in addition to providing a brokerage service, the platform should offer additional value-added services, such as marketing support, logistics management, etc. The need to integrate the new solution with existing systems and databases was also emphasised, in order to avoid duplication and increase the likelihood of waste recycling.

The key issues that emerged were the platform's reliability and economic viability. For example, it is important for buyers to find suitable, high-quality materials, which is why the platform should ensure clear categorisation, quality control and safety. Secure transactions, reliable payment solutions and mechanisms to verify the authenticity of parties operating on the platform were also considered important. Furthermore, it was highlighted that using the platform could, in theory, help reduce costs and offer users a clear and comprehensive service. This, in turn, requires a simple and intuitive user interface, transparent communication, and mechanisms that foster trust, such as certification and a clear division of responsibilities between parties.

3.6 Cross-supply-chain collaboration

From the perspective of **Estonian** practitioners, it was not generally perceived that the supply chain could influence the adoption of a digital platform. This may be due, on the one hand, to the fact that farmers, whose average age is 60, lack the necessary digital skills. At the same time, existing and necessary agreements regarding waste streams have mostly been in place for a long time. Nevertheless, it was acknowledged that farmers' awareness of potential waste recovery solutions could be significantly raised, which would promote better recovery of residues and likely also stimulate the exchange of residues between partners other than the usual ones.

From the perspective of **Polish** sector representatives, it was felt that the role of a digital platform in cross-supply-chain cooperation could be to establish stable and reliable links between biomass producers and users, particularly in rural areas. However, it was acknowledged that, with regard to the digital platform, it is necessary to ensure long-term contracts or guarantees that residues intended for sale would find a buyer. For example, it was felt that an annual contract would provide certainty and increase trust, and would motivate producers when planning the sale of biomass generated. At the same time, the need for cooperation would not be limited solely to the contractual certainty provided by . In addition to the compatibility of supply chain participants, the organisation of biomass transport and geographical dispersion are considered the most significant obstacles. Regarding the compatibility of parties, it is felt that a digital platform may not be an adequate service for everyone, as, for example, the sale of biomass to biogas plants depends on the demand for different types of materials and substrates, meaning that a digital platform does not meet the needs of all parties.

Regarding awareness, the need for targeted educational and awareness-raising activities was highlighted, which would help users understand why the platform is important and what problems it solves. Currently, there is a lack of awareness among both biomass producers and valorisers, as the various options for valorising residues are not fully understood. From the Polish perspective, not all biogas producers may always be aware of the resources available in their region, highlighting the need for information exchange. The need to communicate the existence and benefits of the platform was also emphasised, using channels appropriate to the region, including information days. The need to improve digital literacy was also highlighted, as businesses operating in agriculture were considered to be predominantly older, for whom guidance is important, including sharing information on system security.

From the perspective of the **German** representatives, several practical obstacles were considered significant, the main one being the potential digital literacy of platform participants, which could make it difficult to integrate secondary flows into the platform. This could complicate market entry and limit the number of potential platform users. Another issue highlighted was the organisation of logistics, as users are likely to be confused about transport arrangements, liability and the sharing of costs. Transparency in logistics was also considered important, so that it is clearly defined who is responsible for transport, who the contact person is, and how situations where intermediaries earn unfair commission fees are avoided.

In addition, the need to increase the platform's visibility and user base was emphasised, in order to bring together a sufficient number of sellers and buyers. To this end, a community-based approach was considered important, where knowledge sharing and the dissemination of best practices take place through existing networks and trusted intermediaries. Public recognition and raising awareness were also considered important, as farmers want their contribution to biomass utilisation to be recognised and valued in both economic and social terms.

3.7 Outlook for the future

With regard to digital solutions, the outlook for the future is primarily that solutions will be found to simplify work. Consequently, there is an expectation for AI and other machine-reading solutions that would prevent the movement of waste streams that are unsuitable for sharing under the law; reduce human working time, and be fully automated to assess inputs and outputs in terms of both volume and necessary parameters, so as to ensure a high-quality by-product stream and the stability of its production. One view was that digital market platforms could also be cross-sectoral. For example, a decline in the volume of peat products is currently anticipated at national level, which means that fertilisers could also be made more accessible to the horticultural sector via these platforms.

The **German** workshop highlighted, as a future prospect, a stronger link between digital solutions and carbon credit systems, which would enable biomass producers and by-product suppliers to create additional sources of income and strengthen the economic viability of the circular economy. The need for analytical and predictive capabilities based on artificial intelligence was also emphasised. For example, AI solutions could support decision-making by assessing potential partners for buying and selling, suitable times for transactions, and the optimal price. Furthermore, AI is seen as playing a role in planning the necessary inputs. The discussion indicated that the sector does not so much need new machines, but rather smart data-driven solutions that would help make processes more efficient and predictable, and support economic performance across the entire value chain.

3.8 Desk research findings

As noted earlier, primary data collection through introductory stakeholder workshops was conducted for Lithuania and Latvia at the initial stage of the project providing valuable preliminary insights into the local bioeconomy context. The analysis for Latvia and Lithuania was supplemented with desk research, drawing on existing literature, policy documents, and relevant reports.

Latvia's bioeconomy is a key sector for the country, encompassing economic activities in which renewable biological resources are used in production processes to produce food, feed, industrial products and energy. It is considered important that biological resources are used in the development of new products and technologies. Within the structure of the bioeconomy, agriculture, forestry and fisheries are distinguished as sectors of primary production of biological resources. Latvia's bioeconomy is influenced by policy and strategic development documents aimed at increasing the value of natural capital, promoting the efficient and sustainable use of resources, and supporting economic development

in a way that balances economic objectives with environmental protection, climate change mitigation and the conservation of biodiversity. [27]

In the context of strategic directions for the bioeconomy, the importance of cooperation between agriculture, forestry and industry is also emphasised, so that residues and by-products generated in production processes can be used to produce new bio-based products, including bioenergy. This approach helps to increase the efficiency of resource use and enables the inclusion of previously underutilised or marginal land areas in production. A practical example is also provided, where by-products from vegetable cultivation and processing are utilised to the maximum extent, and biogas is produced solely from production process residues. Such a practice illustrates the application of circular economy and cascade use principles in the bioeconomy and demonstrates how bio-resource residues can be used to create new value chains. [28]

The management of biowaste in Latvia is primarily viewed from the perspective of environmental and resource efficiency; in particular, the development of biomass and bioenergy has been a strategic focus, especially in relation to reducing greenhouse gas emissions and limiting landfill disposal. Studies show that landfill disposal is the least favourable method of bio-waste management, whilst recycling, incineration for energy production and the use of sorted food waste for biogas production are preferable solutions from an environmental impact perspective. The effectiveness of composting depends on the proper management of the process and the availability of markets for the compost.[29] At the same time, it is emphasised that Latvia's bio-waste management system is currently not sufficiently effective and requires reform. Studies indicate that, in the medium and long term, the preferred solution is the anaerobic digestion of biowaste, as this allows for the highest energy yield and environmental benefits. The same study confirms that, in the context of Latvia's , anaerobic digestion is the optimal solution in terms of both energy yield and the reduction of greenhouse gas emissions, with the reduction in emissions being statistically significantly dependent on energy consumption and the production of electricity and heat.[30] Furthermore, the need for reliable data[31] , high-quality feedstock[32] and systematic environmental impact assessment[33] is emphasised, which creates a methodological basis for the development of a digital market.

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[27] Latvian Bioeconomy Strategy 2030. https://www.zm.gov.lv/lv/media/1023/download?attachment

[28] Latvia's Bioeconomy Strategy Action Planhttps://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://keep.eu/api/project-attachment/22019/get_file/&ved=2ahUKEwiOktayzsqTAxXwPhAIHTKkPAIQFnoECBcQAQ&usg=AOvVaw1EWHyMCqhbDo8YEwBj8LA3

[29] Bendere, R., Teibe, I., Arina, D., Lapsa, J. (2014). Greenhouse gas emission reduction due to improvement of the biodegradable waste management system. *Latvian Journal of Physics and Technical Sciences,* 6

[30] Pubule, J., Blumberga, D. (2014). An assessment of the potential and optimal method for biowaste energy production in Latvia. *WIT Transactions on Ecology and the Environment*, 190

[31] Bendere, R., Teibe, I., Arina, D., Lapsa, J. (2014). Greenhouse gas emission reduction due to improvement of biodegradable waste management system. *Latvian Journal of Physics and Technical Sciences,* 6

[32] Pubule, J., Blumberga, D. (2014). An assessment of the potential and optimal method for biowaste energy production in Latvia. *WIT Transactions on Ecology and the Environment*, 190

[33] Pubule, J., Bergmane, I., Blumberga, D., Rosa, M. (2012) Development of an EIA screening phase for biogas projects in Latvia. *WIT Transactions on Ecology and the Environment*, 162

Although Latvia operates a web-based biomass trading platform[34] , its focus is primarily on wood-based biomass and raw materials intended for energy production. Agricultural residues have not yet been treated as a separate standardised commodity group. This means that although an auction-based and transparent digital trading model exists, it is not directly adapted for the exchange of agricultural bio-waste. At the same time, studies on bio-waste management indicate that the integration of the sector with the agricultural and energy sectors is of critical importance[35] , which also creates a potential basis for the digital marketing of agricultural bio-waste. It can therefore be concluded that, whilst a technical and institutional framework exists in Latvia, there is no specific system of market and quality standards for agricultural residues.

Lithuania lacks a unified bioeconomy strategy, and the sector is fragmented across various policy areas. However, the sector is governed by a number of policies and strategies relating to the use of bioresources, the circular economy and bioenergy. Consequently, the sector is linked to several different ministries, including the Ministry of Agriculture. From a broader perspective, biofuel production is encouraged by EU legislation. The most important industries related to the bioeconomy are agriculture, the food and drink industry, as well as manufacturers of tobacco, wood and bio-based furniture products. Lithuania sees great potential in biofuel production, but also acknowledges that this sector faces competitiveness issues, particularly when compared to fossil fuels. At the same time, Lithuania serves as a model for other countries, where rapid expansion of biogas production has led to energy independence. Although most of Lithuania's agricultural residues are used on-site by farms and businesses, the main source of biogas comes from agriculture in the form of manure and biodegradable waste, as well as food waste. According to 2023 data, biogas is produced from agricultural bio-waste at 14 plants. [36]

In the Lithuanian context, the biomass market is structured through the Baltpool biofuel exchange[37] , which operates as an auction-based and standardised mechanism. Similar to Latvia, it focuses primarily on wood-based biofuel. At the same time, studies of the Lithuanian industrial sector point to significant potential in the valorisation of biodegradable agricultural waste. A case study of the grain industry shows that processing biodegradable waste into solid renewable fuel can reduce waste volume by approximately 75% and natural gas consumption by over 60%, whilst simultaneously improving environmental well-being indicators[38] . The development of the region's bioeconomy requires strong cooperation between different sectors and stakeholders (e.g. the food and bioenergy sectors) as well as closer collaboration between businesses and research institutions. The need to raise awareness is considered important among consumers, businesses and policymakers alike. In this context, it is considered important to find new, higher value-added cascade solutions for the utilisation of residues. From an energy security perspective, the development of biofuels requires the creation of efficient

[34] BioEx Energy Resources Online Trading Platform. https://bioex.lv/en/home/
[35] Bendere, R., Teibe, I., Arina, D., Lapsa, J. (2014). Greenhouse gas emission reduction due to improvement of biodegradable waste management system. *Latvian Journal of Physics and Technical Sciences,* 6
[36] Vitunskienė, V., Aleksandravičienė, A., Čaplikas, J., Dapkuvienė, A. (2023). The Strategic concept for the Lithuanian bioeconomy: insights for niche bioenergy sectors. *Open Research Europe*
[37] Baltpool. https://www.baltpool.eu/ee/biokutuse-bors/biomassi-andmete-analuutika/turuandmete-aruanne/
[38] Kliopova, I., Staniškis, J. K., Petraškienė, V. (2013). Solid recovered fuel production from biodegradable waste in the grain processing industry. *Waste Management & Research*, 31 (4)

collection and logistics networks for biological waste, and it is considered necessary to direct additional financial support towards businesses, local authorities and clusters for the development of new technologies. Digital solutions would therefore support cooperation and data exchange. [39]

3.9 Digital readiness

Studies on the digital business ecosystem in the Baltic states show that Estonia, Latvia and Lithuania have undergone a significant digital transformation over the last two decades, but the development of their digital platform economy (DPE) has been uneven. A quadrant analysis of the DPE index indicates that all three countries have potential, but their ecosystems as a whole are inefficient, particularly in terms of the adoption of digital technology. This is also a key factor in the development of digital markets for agricultural residues, as such platforms require strong technological readiness, digital literacy and cross-sectoral cooperation. [40]

A comparative analysis of the circular economy in the Baltic states shows that Latvia leads in circular economy performance, followed by Lithuania, with Estonia lagging behind both, particularly in terms of resource efficiency and waste generation indicators[41] [42] . This suggests that although Estonia is stronger in the digital entrepreneurship ecosystem, the practical implementation of the circular economy is not as effective.[43] The results of the Digital Entrepreneurship Index also show that the biggest bottleneck in all the Baltic states is the adoption of digital technology[44] . Therefore, one of the key barriers to the development of digital markets for agricultural waste can be considered to be the limited readiness and capacity of businesses to adopt new digital solutions. E-commerce studies in Latvia and Lithuania also highlight a shortage of qualified specialists (who, moreover, are proficient in the language of the respective country), insufficient information about the product itself and its quality, and the need to improve digital communication between producers and consumers[45] . These factors are directly transferable to the context of the digital market for agricultural waste : the platform's success requires standardised information on the quality, quantities, price and logistics of raw materials. Without a clear quality framework and reliable data exchange, a functioning market mechanism cannot emerge.

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[39] Vitunskienė, V., Aleksandravičienė, A., Čaplikas, J., Dapkuvienė, A. (2023). The Strategic concept for the Lithuanian bioeconomy: insights for niche bioenergy sectors. *Open Research Europe*

[40] Taieb, S. H. (2025). Comparative analysis of the Digital Platform Economy index: The case of the Baltic states. *Society and Economy*, 47 (4)

[41] Zappala, G. (2023). Adaptation, beliefs, and impacts: Essays on the economics of climate [Doctoral dissertation, Université Panthéon-Sorbonne-Paris I

[42] Štreimikiene, D., Bathaei, A., Baležentis, T., Štreimikis, J. (2025). Multi-Criteria decision analysis of circular economy performance in the Baltic States: A comparative evaluation. *Journal of Business Economics & Management*, 26 (5), pp 1050–1070

[43] Štreimikiene, D., Bathaei, A., Baležentis, T., Štreimikis, J. (2025). Multi-Criteria decision analysis of circular economy performance in the Baltic States: A comparative evaluation. *Journal of Business Economics & Management*, 26 (5), pp 1050-1070

[44] Taieb, S. H. (2025). Comparative analysis of the Digital Platform Economy index: Case of the Baltic states. *Society and Economy*, 47 (4)

[45] Rivza, B., Kruzmetra, M., Rivža, P., Miceikiene, A., Balezentis, A., Jasaitis, J. (2020). E-commerce as a consequence of innovation and the cause of new innovations for SMEs: the perspectives of Latvia and Lithuania. *Comparative Economic Research, Central and Eastern Europe*, 23 (3)

In Latvia and Lithuania, key enablers include the existing auction-based biomass exchanges[46] [47] , the strategic priority given to bioenergy, and the scientifically substantiated potential for anaerobic digestion. In Lithuania, there is also strong investment activity in circular economy sectors and industrial experience in waste valorisation. Barriers include the fragmentation and heterogeneity of agricultural waste, the lack of quality standards, logistical constraints, and companies' limited capacity to adopt digital solutions. Furthermore, expanding the use of bio-waste for energy requires a transparent environmental impact assessment framework and clear regulatory incentives. Without these elements, there will be insufficient market certainty or investment confidence to develop the digital agricultural waste market.

In summary, it can be concluded that Latvia and Lithuania have auction-based digital platforms for biomass, but these focus on woody biomass and do not treat agricultural residues as a separate market category. Scientific studies confirm the significant energy potential and circular economy value of agricultural bio-waste, but the digital market infrastructure remains underdeveloped. In Estonia, digital capability is high, but the practical implementation of the circular economy and resource efficiency lags behind. Thus, the preconditions for developing digital markets for agricultural residues exist in all three countries, but their realisation requires standardisation, increasing readiness to adopt digital solutions, strengthening quality and data frameworks, and cross-sectoral policy coordination.

4. VALUE PROPOSITION ANALYSIS

4.1 Needs

The service offered by **the producer** is a digital platform that enables the sale of agricultural residues to value-added processors and creates a functioning market for matching supply and demand for residues. The platform facilitates cooperation between different target groups, bringing together producers and processors and thereby supporting the emergence of new cooperation models. At the same time, the solution helps to increase the proportion of waste that is recycled, channelling it towards uses with potentially higher added value. The platform also enables the interactive sharing of data related to waste, improving transparency and supporting more informed decision-making. From a broader perspective, the platform solution potentially supports national objectives by enabling better management of agricultural waste side streams, developing regional bioeconomy models, and supporting the targeted promotion of waste recycling.

From the **customers'** perspective, the analysis shows that the expectations of both the developer and users focus primarily on simplifying work processes and increasing efficiency. The platform is expected to provide solutions that enable waste to be disposed of more quickly and easily, whilst at the same time supporting better planning for its recovery. Customers have highlighted that process automation and user-friendliness are key priorities, with the platform needing to be mobile-friendly, require minimal data entry and reduce manual work. Value is also seen in the availability of decision-support and forecasting

[46] BioEx Energy Resources Online Trading Platform. https://bioex.lv/en/home/
[47] Baltpool. https://www.baltpool.eu/ee/biokutuse-bors/biomassi-andmete-analuutika/turuandmete-aruanne/

functions, such as predicting volumes and market prices, which would help increase both efficiency and economic viability across the entire value chain. In addition, the platform is expected to provide practical support services, such as visibility, logistics management and other service components that simplify the bringing of residues to market. Integration with existing systems and markets (e.g. carbon credits) is also considered important, as is the ability to identify the best possible uses for by-products.

In terms of enhancing cooperation, it is expected that the platform will help create more efficient value chains and support the development of business models between companies and various user groups. The establishment of long-term contractual relationships is considered particularly important, as this would give farmers the certainty that their biomass can be sold on a stable basis. There is also seen to be potential in expanding the offering to other sectors, which would contribute to broader resource circulation and the emergence of new market opportunities. Platform developers are also expected to raise awareness – which the platform currently does through information posts – as well as to build trust in the service. The latter is critical, as it directly influences the uptake of the service and the willingness to share data or participate in transactions.

From an environmental perspective, the platform is seen as an opportunity to better utilise resources by channelling by-products into higher-value uses. The adoption of local bio-based secondary raw materials is also considered important, as it strengthens the practice of the circular economy within the sector. At the same time, users also expect assistance with legislative processes; for example, they need the platform to provide rapid clarity on whether and which environmental permits are required for specific types of waste. In addition to the above, it is considered that the use of the platform should help to reduce costs, primarily through improved access to cheaper secondary raw materials.

Given that, in the strategic context of the bioeconomy, the aim is to increase the value of natural capital and direct bio-resources towards higher value-added uses. It is therefore important to apply the principles of cascading use wherever possible before directing materials towards energy use. For a digital market platform to function, standardised and reliable information on the quality, quantities, price and location of raw materials is required, enabling market participants to make comparable and transparent decisions.

From a needs-based perspective, the main barriers to the roll-out of the platform stem from the maturity of existing systems and market structures. Large-scale material flows, such as those for biogas production, are often already well-established, and restructuring them is not straightforward. At the same time, the platform primarily supports smaller and irregular flows, the economic viability of which may be limited. As the operation of biogas plants is entirely dependent on input flows, the digital market platform offers them more of a supplementary opportunity to increase production input volumes. It has therefore been suggested that, in some contexts, the implementation of the platform could be considered for the valorisation of biowaste collected from the public.

4.2 Challenges

From the **producer's** perspective, the proposed solution functions as an up-to-date and interactive database that reflects the current market situation in real time and enables users to make informed and timely decisions. This makes waste streams more visible and manageable, which in turn allows them to

be directed more systematically or repurposed for higher-value uses. At the heart of the solution are environmental friendliness and resource efficiency, with the platform helping to reduce both time and labour requirements whilst simplifying processes. As a result, waste management becomes not only more efficient but also more sustainable, supporting the principles of the circular economy.

From the perspective of potential **users** of the service, the analysis shows that there is a need for a better overview of both supply and demand in different regions, particularly in situations where local recycling options are limited. In terms of work efficiency and convenience, the study also highlights that communication channels for farmers should be very clearly differentiated, and one cannot overlook low digital literacy and uncertainty regarding volumes and demand, which are seasonal. This, in turn, raises quality issues, and there is a need for the platform to be able to offer certain guaranteed solutions regarding waste quality, e.g. through certification or cooperation with third parties. From the farmers' perspective, the issue of quality relates to the reputation of both the platform service provider and the seller, which directly affects the platform's reliability.

Security-related issues are also considered a key component of trust and may act as significant barriers to the adoption of the platform. Risks associated with payments and the need for reliable transaction channels were highlighted. Building trust across the entire supply chain and user authentication are also considered important to reduce risks and increase confidence when operating on the platform. From a funding perspective, a key issue is the costs associated with using the platform and who should finance the service. Potential users expressed concern that excessive dependence on market conditions and insufficient funding for platform development could hinder the sustainability of operations. Risks are also seen in the event that consumers become overly independent, finding opportunities to conduct direct transactions outside the platform.

The analysis suggests that a significant problem for clients is a lack of knowledge regarding value creation and product innovation, limiting the implementation of new solutions and reducing willingness to experiment with new value chains and business models. At the same time, the low level of cooperation is acknowledged, which means that the developer has a major role to play in addressing such shortcomings. It is also felt that, through a platform-based digital market, it would be necessary to raise awareness of legal issues, as there is confusion regarding the necessary environmental permits, import-export requirements, national regulations, certificates and local rules. Another significant issue raised regarding the platform is that it remains unclear how transport-related matters will be resolved – who will organise collection and how costs will be shared. At the same time, the uptake of digital solutions is uneven, which affects the wider implementation of the platform's solutions. Furthermore, the functioning of the market is constrained by the lack of standardised quality and data frameworks, which hinders reliable pricing and the formation of transactions.

From a public sector perspective, the platform could address the issue of valuing by-products where no national methodology has been implemented. Generally, the issue of agricultural waste streams is not considered a priority, compared to household bio-waste sorted by type, where improving the efficiency of sorting and collection rounds has received greater attention.

4.3 Requirements

The solution offered by **the producer** creates clear added value, supporting both environmental and operational objectives. Using the platform makes it possible to reduce environmental impact by channelling waste streams more effectively into the circular economy and enabling their better use in higher-value products/processes. At the same time, the solution is built on simple and user-friendly logic. The platform provides a clear overview of existing waste streams, being real-time based. This enables recyclers to monitor waste quantities and locations.

From the **users'** perspective, the analysis points to reliability as the most important requirement expected of the platform. Although it is felt that the solution does not need to be directly linked to national statistics, there is a clear expectation for an environment that is in the national language and institutionally trustworthy, recognised by state or educational institutions. Cybersecurity is also a key priority, including data protection and secure authentication. Trust is underpinned by transparent processes, realistic and honest communication, and a clear understanding of how the service operates. For users, it is important to be confident that the service functions as expected, that transactions are transparent, and that roles and responsibilities within the value chain are unambiguous.

Users also expect the platform to provide a comprehensive solution that is not limited to data exchange alone, but also offers practical support. This includes clear instructions both within the digital environment and, where necessary, through direct contact, to support implementation. Logistics arrangements must be understandable and transparent, including clear accountability for transport. The inclusion of carbon pricing components, the development of data-driven decision support, and the design of feedback systems that help improve service quality and the user experience are seen as added value.

Raising awareness is important both for the platform's launch and its long-term operation. Active communication about what happens on the platform and the opportunities it offers is necessary. Shared benefits or guaranteed waste volumes are seen as potential ways to motivate users. An environment-based approach is also important, where knowledge and practices are disseminated through both existing networks and new solutions. For farmers, public recognition and the valuing of their contribution are also important, as this supports their motivation to join the platform and remain engaged in the long term.

From the perspective of streamlining work processes, it is expected that the application should be intuitive and easy to learn; there is also a perceived need for alternative and flexible solutions that take into account the seasonality of the market and dependence on weather and market conditions. A key requirement highlighted was the need to support product development and innovation by creating the conditions for testing new solutions and facilitating knowledge transfer between research and practice. Furthermore, opportunities for cost reduction (both direct and indirect) are expected through recommendations on resource utilisation and process optimisation. It was also found that it is important for the platform to maintain flexibility and adaptability to a changing policy and regulatory environment in order to ensure the platform's long-term functionality and scalability.

The most significant barrier is seen as the fact that the platform currently covers only a limited proportion of by-products, which may reduce its perceived value.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Adaptation of the marketplace

To establish a digital market in Estonia, the study identified 'tasks to be performed' for a potential developer of the Estonian digital market based on a value proposition framework. In addition, national (i.e. Estonian) 'tasks'/recommendations were identified that would enable the implementation of such digital markets in Estonia. Alongside the recommendations for adapting the digital market, we reached several conclusions relating to the Estonian bioeconomy in general.

The following recommendations concern the development of the Estonian bioeconomy and are also important for adapting the digital market to Estonian conditions:

- In Estonia (and likely in other EU Member States as well), there is a need **to clarify the definitions of 'waste', 'residues' and 'by-products'** and to adapt the waste code system, particularly in relation to sector-specific issues. For example, the fermentation residue generated during biogas production is classified as a residue from a national perspective, but as a by-product from the perspective of the biogas producer, who naturally generates it during the production process. However, in order to channel digestate to farmers for use as a soil improver, they need to obtain an environmental permit allowing the use of digestate as waste. Similar scenarios involving different types of waste also occur in other sectors, which highlights the need to align definitions with the objectives of EU climate policy.

- Furthermore, the study has shown **that it is important to simplify the process of applying for waste permits in Estonia.** For example, if a biogas plant needs to use waste streams quickly in its production process, such as production waste from the food industry (e.g. yoghurt waste) or small-volume, unstable waste streams from agricultural producers (e.g. potatoes), an environmental permit must be applied for. However, the process of obtaining an environmental permit is usually lengthy (taking around a year) and involves significant financial costs. This hinders the use of such residues, as their energy value and quality deteriorate during storage.

- **In Estonia, it is recommended that industrial symbiosis parks be established nationwide in the vicinity of biogas plants.** These parks could include pyrolysis units that facilitate the processing of woody biomass (e.g. stumps). In addition, companies capable of sharing locally produced energy, materials and water should be involved.

Furthermore, our study highlighted two context-dependent findings that may apply only to the Estonian target market and which require the platform to be adapted for implementation in Estonia:

- The digital marketplace should be capable of **establishing interoperability with national systems** to ensure compliance with environmental permit requirements and the fulfilment of trading rights. As environmental permits applied for are registered in a separate database in Estonia, it is proposed that it should be possible and necessary to connect this database to the platform. The national data system would facilitate the automatic verification of permits for both sellers and buyers, enabling the platform to determine the validity of the waste offered for sale. In the absence of the relevant permits, the system would automatically block transactions and, conversely, allow transactions to proceed if the permits are deemed valid[48].

- In Estonia, the prevailing view is that large and major waste streams (manure, silage, etc.) are well-established and are handled by regional biogas plants. This is mainly due to the large investments required to build a biogas plant. Consequently, the creation of a digital market in Estonia is focusing on **smaller and less volatile waste streams**. Smaller flows are mainly associated with areas where there are no biogas plants within a geographically defined vicinity, or with waste types that are generated in smaller quantities and whose volumes are unstable. Consequently, digital market developers may face the challenge of managing smaller waste streams, which could also lead to a decline in the number of platform users. This raises the question of how to ensure the sustainable development of the platform, particularly from a financial perspective.

In addition, we present context-independent recommendations that may be worth implementing regardless of the target region. These recommendations draw primarily on data from Estonia, Poland and Germany, but are considered broadly applicable, including to Latvia and Lithuania, where findings from desk research and introductory workshops are supported by secondary sources on the broader bioeconomy context:

- The digital marketplace could **serve as an information hub**, providing both buyers and sellers with clear and accessible information on recycling options, legislation, regulations and support measures (similar *to KiertoaSuomesta.fi*, which features a dedicated content hub for sharing knowledge on the circular economy and side streams). Furthermore, ways need to be found to integrate the platform with research and development institutions to raise awareness and promote product innovation in the field of waste recycling.

- One of the most important components of the digital market is establishing **trust**, particularly in today's world where authentication and data sharing are sources of uncertainty. Therefore, significant attention must be paid to ensuring digital security and, where possible, cooperation with government or educational institutions should be considered when developing the platform.

- Furthermore, the digital market could **be expanded to cover several sectors**. For example, a biogas plant or agricultural producer does not rely solely on agricultural waste, but also on waste from the food and drink industry. Conversely, agricultural waste is not used exclusively by

[48] If the potential operator is a private entity, the issue of the GDPR and the possibilities for such a connection must still be investigated.

agricultural enterprises. For example, the horticultural sector has expressed an interest in fertilisers, given the climate policy shift towards a significant reduction in peat extraction, which consequently reduces the availability of peat substrate. Other sectors, such as the chemical industry and sectors utilising agricultural waste, have also expressed an interest in fertilisers. The value of the platform depends critically on the number of users and their motivation to use it; it is therefore necessary to ensure a sufficient number of participants on both the supply and demand sides to avoid a situation where the platform remains a niche solution with limited capacity. At the same time, it is important that the platform functions as a complementary mechanism, enabling less-used or unstable flows to be channelled into new value chains.

- **Simplifying and facilitating the use of the digital market** is particularly important **for waste sellers**. Practitioners have noted that multiple platforms are used, which requires a significant investment of time. Furthermore, uploading images and relevant information may not be feasible or a priority for all potential users, which highlights the importance of integrating automated solutions into workflows to ensure that relevant information is displayed on platforms as accurately as possible, particularly for the buyer. To keep the administrative burden low and ensure data accuracy, it may be necessary to add additional AI interfaces that offer various necessary solutions, such as forecasting functions.

- It is particularly important to ensure that the product being traded **has undergone the necessary analyses**, especially in the case of agricultural waste, where there is a higher risk of biological hazards being transmitted in the area where the waste is used. For example, it is important to carry out analyses on silage if it is used to feed dairy cows, to prevent an increase in the number of miscarriages. Furthermore, the content of chemical compounds limits the use of municipal waste in refining.

- It is extremely important to ensure that **comprehensive information is provided about the waste being sold**, as practitioners have observed that a general description may hinder transactions and lead to the purchase of non-compliant or unusable waste. It is therefore necessary to ensure direct contact between the waste buyer and seller. Another key requirement is the logistics approach, where, in addition to transport arrangements (including liability and payment obligations), the need for time-critical handling of certain types of bio-waste must be taken into account.

- Furthermore, it is important **to ensure the competitiveness of the market price of waste.** The sale of waste is a means of generating additional income, but as farmers do not prioritise the sale of waste, they may be unaware of its actual monetary value. Furthermore, a significant proportion of the waste is seasonal in nature, which causes considerable fluctuations in selling prices from year to year. Therefore, the digital marketplace must guarantee a minimum market price that is consistent with the quality and seasonality of the waste being sold. This is necessary to ensure that farmers benefit from the sale of residues, thereby promoting greater valorisation of agricultural waste.

In short, the developer of the digital marketplace should consider strategies to secure a significant user base and identify potential leaders and funders for the platform's development. To mitigate risks, it would be sensible to focus on specific and volatile agricultural waste streams, expand the platform's use across different industrial sectors, and ensure competitive pricing for waste streams. From the seller's perspective, it is important to ensure the digital marketplace is easy to use, and from the buyer's perspective, to provide a detailed overview of the residues for sale. It is also essential to ensure that the entire buying and selling process complies with legislation and regulations.

5.2 Criteria for transferability

Transferability criteria refer to the set of conditions that determine whether a digital marketplace model can be successfully replicated and implemented in a different national or regional context. In the context of bioeconomy-focused digital platforms, transferability depends not only on technical feasibility, but also on the alignment of regulatory frameworks, digital infrastructure, market structures, and user ecosystems. Factors such as legal clarity, data interoperability, availability of supply and demand, trust in digital systems, and economic incentives all influence whether the platform can function effectively outside its original setting. Therefore, assessing transferability requires a systemic perspective that considers both institutional readiness and market dynamics.

Table 1. Dimension overlap matrix (11 dimensions x 33 criteria)

Dimensions \ Criteria	RIC 1	RIC 2	RIC 3	TDI 1	TDI 2	TDI 3	MSWS 1	MSWS 2	MSWS 3	EIC 1	EIC 2	EIC 3	UBNE 1	UBNE 2	UBNE 3	TGS 1	TGS 2	TGS 3	UOE 1	UOE 2	UOE 3	IQS 1	IQS 2	IQS 3	LPI 1	LPI 2	LPI 3	EVP 1	EVP 2	EVP 3	SP 1	SP 2	SP 3
D1 · Regulatory & Institutional Compatibility (RIC)	●	●	◐														◐		◐			◐		◐									
D2 · Technical & Data Infrastructure (TDI)			◐	●	●	●										◐				●	◐			◐								
D3 · Market Structure & Waste Streams (MSWS)							●	●	●	◐	◐		◐		◐										◐		◐	◐			◐		
D4 · Ecosystem & Industrial Context (EIC)							◐		◐	●	●	●	◐	◐																	◐	◐	
D5 · User Base & Network Effects (UBNE)							◐		◐	◐			●	●	●						◐										◐	●	◐
D6 · Trust, Governance & Security (TGS)																●	●	●						◐									
D7 · Usability & Operational Efficiency (UOE)				◐	◐	●													●	●	●												
D8 · Information Quality & Standardization (IQS)	◐																	◐				●	●	●									
D9 · Logistics & Physical Infrastructure (LPI)									◐																●	●	●	◐		◐			
D10 · Economic Viability & Pricing (EVP)							◐				◐				◐										●	●	●	●	●	●			◐
D11 · Strategic Positioning (SP)							◐		◐	◐	◐		◐		●															◐	●	●	●

The criteria presented in this chapter were derived empirically from the interviews, workshops and value proposition analysis reported in Chapters 3 and 4, following the empirical-to-conceptual iteration recommended by Kundisch et al. (2022)[49]. This process yielded 33 criteria, initially grouped into 11 dimensions (ANNEX 3). As illustrated in Table 1, transferability is not solely a technical issue, but a systemic one — it depends on the alignment of several interrelated dimensions, including the regulatory environment, digital infrastructure, market structure, user ecosystem, and economic incentives. Each dimension is represented through specific criteria and indicators, which together provide a structured way to assess readiness for implementation. To identify overlaps between dimensions, an analytical matrix (Table 1) was constructed mapping each dimension against all 33 criteria. Dimensions that addressed the same underlying question were consolidated using the merge operation[50], in line with the requirements of conciseness and robustness in taxonomy design[51] [52]. This process resulted in six consolidated dimensions (Table 2).

Table 2. Transferability assessment dimension (following marge operation)

Dimension	Key Criteria	Indicators / Explanation
D1 Regulatory Readiness	Legal alignment; permitting systems; system integration	Clarity of definitions for waste, residues and by-products; speed and cost of permit procedures; connectivity to national databases and registries
D2 + D7 Digital Readiness	Interoperability; digital maturity; automation & AI; administrative burden; workflow automation; user accessibility	Availability of national data systems and digital identity solutions; API integration capacity; mobile accessibility; usability for non-technical users; potential for automated data input
D3 + D4 + D5 Market & Ecosystem Context	Scale and distribution of waste streams; sectoral diversity; industrial symbiosis; value chain integration; R&D collaboration; supply-demand balance; platform scope	Presence of fragmented or underutilised waste streams; geographic proximity to processing facilities; cross-sector demand; existence of industrial clusters and symbiosis networks; potential number of sellers and buyers
D6 + D8 Trust & Data Quality	Data security; institutional backing; transparency; product information; standardization; verification	Strength of data protection systems; willingness of public or academic institutions to cooperate; standardization of waste classifications; reliability of analyses and certificates; traceability of transactions
D9 + D10 Operational & Economic Feasibility	Transport systems; time sensitivity; geographic constraints; pricing mechanisms; market awareness; business model	Efficiency of transport infrastructure; clarity of liability and cost-sharing arrangements; manageability of distances and logistics; price transparency and competitiveness; sustainability of the platform funding model
D11 Strategic Fit	Complementary role; scalability; focus strategy	Whether the platform fills a gap not covered by existing systems; capacity to expand across sectors; feasibility of a phased or niche launch strateav

[49] Kundisch, D., Muntermann, J., Oberländer, A. M., Rau, D., Röglinger, M., Schoormann, T., Szopinski, D. (2022). An Update for Taxonomy Designers: Methodological Guidance from Information Systems Research. *Business & Information Systems Engineering*, 64 (4), pp:421-439. https://doi.org/10.1007/s12599-021-00723-x

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Regulatory Readiness addresses the legal and institutional conditions that determine whether a digital bio-waste marketplace can operate within the regulatory framework of the target region. The findings across all regions consistently point to regulatory ambiguity and administrative complexity as the most significant structural barriers to platform adoption — particularly the lack of clear definitions distinguishing waste, residues and by-products, and the burden associated with permit procedures. The extent to which the platform can integrate with existing national data systems and automate compliance verification is therefore a critical enabler, as it directly determines whether regulatory requirements become a facilitated part of the transaction process or remain an obstacle outside it. Countries with digitized, interoperable regulatory systems are therefore more suitable candidates for near-term platform implementation, while regions where legal definitions remain ambiguous or permit procedures are lengthy should prioritise resolving these preconditions before or alongside platform development.

Digital Readiness reflects the extent to which the target region's technical infrastructure and user capacity support platform adoption. The findings reveal a consistent tension between the technical ambition of the platform — which requires system interoperability, automated data flows and AI-driven functionality — and the digital reality of its primary users, who are predominantly older farmers with limited experience of digital tools and a preference for established personal contacts. Successful replication therefore depends not only on the availability of national data systems and integration capacity, but equally on whether the platform can be made sufficiently simple and accessible to overcome low digital literacy and limited institutional trust in automated systems. Higher digital infrastructure maturity in the target region increases the likelihood of successful implementation — however, technical readiness alone is insufficient if user-facing accessibility and simplicity are not prioritised in the platform design from the outset.

Market & Ecosystem Context assesses whether the structure of bio-waste streams and the surrounding industrial ecosystem create sufficient conditions for a marketplace to function. The findings suggest that the platform's transferability is strongest in contexts where existing value chains leave a visible gap — specifically where smaller, fragmented or volatile waste streams lack a reliable market mechanism, while large and stable flows are already absorbed by long-term bilateral agreements. The viability of the platform is further shaped by geographic and sectoral factors: proximity to processing facilities determines whether transactions are logistically feasible, while the breadth of cross-sector demand — spanning agriculture, food processing, chemicals and energy — determines whether sufficient market volume can be achieved to sustain the platform beyond a niche use case. Markets with fragmented or underutilised waste streams therefore benefit most from platform introduction — and the stronger the industrial ecosystem, including the presence of symbiosis networks, R&D linkages and multi-sector demand, the greater the platform's potential value and scalability.

Trust & Data Quality captures the conditions under which platform participants can reliably engage with one another and with the system. The findings across all regions indicate that trust operates at two distinct but interdependent levels: institutional trust in the platform itself — shaped by data security, authentication mechanisms and the backing of recognised public or academic bodies — and transactional trust in the information exchanged on it, which depends on the standardisation of waste classifications, the reliability of product descriptions and the availability of independent verification. Where either level is weak, market formation is inhibited — participants either do not join the platform or conduct

transactions outside it, undermining the platform's viability as a marketplace. Higher institutional trust environments therefore favour platform adoption — and regions where public or academic backing is available, waste classifications are standardised and verification mechanisms are in place offer significantly stronger conditions for a functioning market to emerge.

Operational & Economic Feasibility examines whether the physical and financial conditions in the target region allow the platform to sustain itself. The findings point to a dual sustainability challenge: on the operational side, logistical complexity — including unclear liability, cost-sharing arrangements and the time-critical handling requirements of certain bio-waste streams — can render individual transactions unviable regardless of market interest; on the financial side, the absence of a stable funding model beyond project cycles represents a structural risk that has caused comparable initiatives to cease operations. Price transparency and competitive pricing are a further prerequisite, as the platform must offer sellers a credible alternative to established disposal routes and buyers a reliable reflection of actual market conditions. Markets with clear economic incentives, transparent pricing mechanisms and a credible long-term funding model are therefore more replicable — and regions where logistical responsibilities and cost-sharing arrangements can be clearly defined from the outset offer significantly stronger conditions for operational sustainability.

Strategic Fit considers whether the platform addresses a genuine gap in the target region's existing market infrastructure. The findings suggest that transferability is most realistic where the platform is positioned as a complementary tool that fills spaces left by existing systems, rather than as a replacement for well-functioning market channels. This implies that the platform's entry strategy — whether broad or niche, immediate or phased — is itself a transferability condition: regions where underserved waste streams are identifiable and cross-sector expansion is feasible offer a more viable foundation for replication than those where established bilateral arrangements already cover the most significant material flows. Flexible and modular platform design therefore enhances adaptability across contexts — and regions where a clear market gap exists, combined with realistic potential for phased scaling across sectors, represent the strongest candidates for successful and sustainable replication.

The six dimensions form the analytical backbone of a practical self-assessment tool developed to support platform initiators in evaluating the transferability potential of a digital bio-waste marketplace to their specific regional context. The tool is presented in full in ANNEX 4, where each dimension is broken down into concrete guiding questions covering the key criteria and indicators identified through this study. It is intended for use by any organisation — whether a public body, industry association, research institution or private enterprise — considering the initiation or replication of a comparable platform and can be applied either as a preparatory scoping exercise before committing to implementation, or as a structured basis for stakeholder dialogue about regional readiness. The questions are not designed to yield a definitive verdict, but to surface the most critical gaps and preconditions that need to be addressed — allowing the initiator to determine not only whether replication is feasible, but in what sequence and at what pace it should be approached.

In practice, no target region will perform strongly across all dimensions simultaneously. The value of this framework lies precisely in identifying where the most critical gaps exist — be it regulatory ambiguity, low digital readiness, or fragmented market structures — so that these can be addressed as preconditions

or factored into the adaptation strategy. Regions that show strong performance across most dimensions can be considered high-priority candidates for near-term implementation, while those with systemic barriers may benefit more from a phased or pilot-based approach. Ultimately, the transferability of a digital marketplace is not a binary question, but a matter of degree and sequencing — and this framework provides the ideological foundation for that assessment, enabling decision-makers to move from an intuitive sense of 'will this work here?' to a more grounded, evidence-based evaluation.

The six dimensions outlined above are grounded in the value proposition analysis conducted across Estonia, Poland, Germany, Latvia and Lithuania, which systematically mapped the needs, challenges and requirements of both platform developers and potential users in each regional context. The transferability criteria presented here are therefore not derived from generic platform theory but reflect the specific conditions that emerged as decisive enablers or barriers to replication in practice — from regulatory ambiguity and logistical complexity to trust deficits and the structure of existing waste streams. Together, they translate the findings of the value proposition analysis into a structured basis for context-specific assessment.

6. SUMMARY AND KEY TAKEAWAYS

This analysis examines the possibilities for introducing a digital market for agricultural bio-waste in various European countries – Estonia, Latvia, Lithuania, Poland and Germany. The results show that, although there is clearly potential for digital solutions to improve the utilisation of bio-resources, their implementation depends heavily on the institutional framework, market structure and existing waste management practices in each country. Broadly speaking, it appears that digital market solutions may not function in isolation, but should fit into existing value chains and take into account regional opportunities and constraints.

In the Estonian context, the management of agricultural bio-waste is characterised by a situation where the majority of side streams are already integrated into existing production and utilisation systems, particularly in the agriculture and bioenergy sectors. Consequently, waste management is not perceived as a critical problem, but rather as an opportunity for optimisation. The greatest potential of the digital market lies in smaller and dispersed streams for which there is no significant demand. At the same time, stakeholders highlight the need for user-friendly, automated solutions that are integrated with existing systems. Key constraints include regulatory uncertainty, a lack of quality standards and logistical challenges.

The development of Latvia's bioeconomy is clearly guided by strategic objectives that focus on increasing the value of natural resources and implementing the principles of the circular economy. The country emphasises the importance of cross-sectoral cooperation to channel by-products from production processes into new value chains, including bioenergy production. At the same time, studies point to the fact that the bio-waste management system is not yet sufficiently effective and requires reform. Although digital biomass market solutions exist, they are primarily focused on wood-based biomass and do not treat agricultural residues as a separate market category. This suggests that the technical framework is in place, but sector-specific standardisation and market structures require further development.

Lithuania lacks a unified bioeconomy strategy, but the sector is regulated through a number of different policies that influence the use of bioresources and the development of the circular economy. Bioenergy, particularly biogas production, has developed rapidly in the country, and agricultural bio-waste plays a significant role in this. At the same time, a large proportion of by-products is still directed towards internal use within companies, which limits their wider marketing. A digital solution exists mainly in the biofuels market and is auction-based, but is not applicable to agricultural residues. Cooperation between sectors, raising awareness and the development of higher value-added cascade solutions are considered key areas for development.

In the Polish context, the approach to bio-waste is characterised by regional diversity and the coexistence of different practices, with both traditional waste management solutions and emerging circular economy models operating in parallel. The implementation of digital solutions depends largely on cooperation between various stakeholders. Although the potential for better utilisation of bio-resources exists, its realisation is limited by a fragmented market structure and logistical challenges.

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Germany stands out for its highly developed bioeconomy and bioenergy sector, where the utilisation of biowaste is strongly integrated into existing value chains. Biogas production and the use of bioresources have been systematically developed and supported by both political and economic measures. At the same time, a high level of maturity means that the added value of new digital market solutions is more limited, and their role lies rather in optimising existing systems. Environmental impact assessment systems and the regulatory framework, which ensure the sector's transparency and reliability, also play a significant role.

A comparative analysis shows that all the countries examined have the prerequisites for developing a digital market for agricultural bio-waste, but their realisation depends on several factors. On the one hand, the bioeconomy and circular economy are strategically important, and the potential for valorising bio-resources is significant. On the other hand, development is constrained by the fragmentation of market structures, the lack of quality frameworks, logistical challenges and uneven digital readiness. Digital marketplace solutions have the greatest potential in contexts where existing value chains do not cover all material flows, particularly in the case of smaller and scattered bio-waste streams. At the same time, the platform cannot be viewed as a universal solution, but rather as a complementary interface that supports existing systems and creates new opportunities where market gaps exist. The potential to operate independently depends largely, for example, on the extent to which the platform can be adopted across different sectors, enabling product innovation and the development of value-added opportunities.

Successful implementation, however, certainly requires a clear data and quality framework, effective logistical solutions, user-friendly digital tools, and strengthened cooperation between different sectors and stakeholders.

In brief, the following **key takeaways** can support the adoption of digital marketplace in new contexts:

1. Platform implementation depends primarily on systemic factors, especially:
   - institutional frameworks;
   - market structures;
   - existing biowaste management practices.
2. Digital platforms cannot function in isolation; they must be integrated into existing value chains and adapted to local conditions.
3. The level of bioeconomy maturity shapes the role of digital solutions:
   - in advanced systems (e.g. Germany) → optimization of existing processes;
   - in fragmented systems (e.g. Poland, Latvia) → improving coordination and utilisation.
4. The greatest opportunity lies in small, dispersed, and underutilized bio-waste streams, since large and stable streams are already efficiently used.
5. Common barriers across countries include:
   - fragmented market structures;
   - lack of quality standards and data frameworks;
   - logistical challenges;
   - uneven digital readiness;
   - regulatory uncertainty;
   - weak cross-sector cooperation.

6. Digital marketplaces should be seen as complementary tools, not standalone solutions.
7. Their main value is in filling market gaps, especially by:
    - enabling new value chains;
    - supporting cross-sector collaboration;
    - improving utilization of overlooked resources.

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ANNEX 1.

Table 3. Overview of workshops and interviews.

Activity	Date	Location & Participants
Workshop A	24.03.2023	Tallinn, Estonia. Participants representing city and state level authorities, recycling organisations, private companies, associations (18).
Workshop B	19.5.2023	Riga, Latvia. Participants representing municipality/policy makers, researchers, companies (16).
Interview A	8.11.2024	Online, Teams. MTK (2)
Focus Group 1	5.12.2024	Online, Teams. Estonian Ministry of Agriculture, the Biogas Association in Estonia (2)
Focus Group 2	9.12.2024	Online, Teams. Estonian Ministry of Climate, the Environmental Agency, Estonian Chamber of Commerce (6)
Interview B	4.2.2025	Online, Teams. Representative of the biogas plant (1)
Interview C	12.2.2025	Online, Teams. An intermediary between buyers and sellers of waste in Estonia (1)
Workshop C	24.4.2025	Warsaw, Poland Participants represented the following organisations: research institutions, professional associations such as National Bioeconomy Hub and Association Bioeconomy Cluster, local authorities, Polish Federation of Food Producers, Polish Chamber of Waste Management, Inspectorate for Environmental Protection, private companies both in retail of petrol as well as (food) waste management (29).
Workshop D	23.9.2025	Berlin, Germany Participants representing bioeconomy clusters, circular economy NGOs, research organization and industry representatives (22).

ANNEX 2.

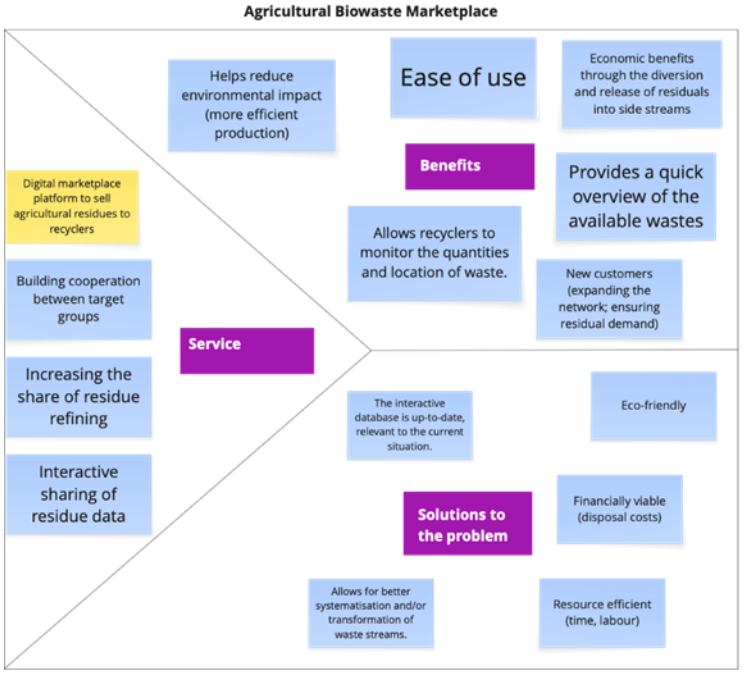

Figure 3. Value Proposition Analysis

The needs of the target group through the eyes of the service creator

TARGET GROUPS: farms and professional associations; public authorities and local authorities; valuers

Main Job-to-be-Done

Target market needs	Client problems	"Jobs-to-be-done"	Client wants
COMPANIES AND ASSOCIATIONS: - utilise resources sustainably more efficient waste disposal - cheaper access to secondary raw materials. VALORIZING COMPANIES: - more efficient recycling planning - possibility to use local bio-based secondary raw materials. PUBLIC SECTOR: - sale of waste by-products from owned land. - municipal waste management planning. - development of regional bio-economy models - development of targeted waste recycling activities.	COMPANIES AND ASSOCIATIONS: - getting rid of waste is difficult VALORIZING COMPANIES: - lack of overview of potential suppliers - lack of awareness in product innovation in waste recycling PUBLIC SECTOR: - Insufficient understanding of waste generation and side streams		COMPANIES AND ASSOCIATIONS: - easier and faster ways to get rid of waste. - Greater confidence by not being tied to national statistics. VALORIZING COMPANIES: - increase in recycling volumes - more opportunities for product innovation PUBLIC SECTOR: - Improved insight into waste generation and waste streams

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ANNEX 3.

Table 4. Criteria for Transferability

Dimension	Key Criteria	Indicators / Explanation
1. Regulatory and Institutional Compatibility	Legal alignment	Clear definitions of waste, residues, by-products; alignment with EU/regional policies
	Permitting systems	Speed, cost, and complexity of permits; flexibility for time-sensitive waste
	System integration	Connection to national databases; automated compliance and permit validation
2. Technical and Data Infrastructure	Interoperability	API connections with government databases and registries
	Digital maturity	Availability of national data systems and digital identity solutions
	Automation & AI	Forecasting, automated data input, workflow integration
3. Market Structure and Waste Streams	Scale of waste streams	Large/stable vs. small/fragmented/volatile streams
	Geographic distribution	Proximity to processing facilities (e.g., biogas plants)
	Sectoral diversity	Cross-sector demand (agriculture, food, chemicals, etc.)
4. Ecosystem and Industrial Context	Industrial symbiosis	Presence of clusters or parks enabling resource sharing
	Value chain integration	Creation of new uses for secondary materials
	R&D collaboration	Innovation support and knowledge transfer
5. User Base and Network Effects	Supply–demand balance	Sufficient participants on both sides of the market
	User engagement	Incentives for farmers, industries, intermediaries
	Platform scope	Multi-sector participation vs. niche focus
6. Trust, Governance, and Security	Data security	Reliable authentication and verification mechanisms
	Institutional backing	Cooperation with government or credible organizations
	Transparency	Clear transaction information and traceability
7. Usability and Operational Efficiency	Administrative burden	Minimal manual input required
	Automation	Integration with workflows and automated processes
	User accessibility	Ease of use for non-digital-native users

8. Information Quality and Standardization	Product information	Detailed data on composition, quality, risks, compliance
	Standardization	Comparable data formats across users
	Verification	Reliable analyses, especially for hazardous/bio-waste
9. Logistics and Physical Infrastructure	Transport systems	Infrastructure, liability, and payment arrangements
	Time sensitivity	Handling of perishable waste streams
	Geographic constraints	Distance and cost considerations
10. Economic Viability and Pricing	Pricing mechanisms	Competitive, transparent pricing reflecting quality and seasonality
	Market awareness	Seller understanding of waste value
	Business model	Sustainable platform funding
11. Strategic Positioning	Complementary role	Supports underutilized or unstable waste streams
	Scalability	Expansion across sectors
	Focus strategy	Niche entry vs. broad launch

ANNEX 4.

Table 5. Digital Marketplace Transferability Assessment Table

Dimension	Criteria	Key Indicators / Questions
1. Regulatory Readiness	Legal clarity & compliance	Are definitions of waste/residues/by-products clear and aligned with policy?
	Permitting efficiency	Are permits quick, affordable, and flexible?
	Digital compliance	Can permits be verified digitally/interoperably?
2. Digital & Data Infrastructure	Digital systems	Are national registries/databases available?
	Interoperability	Can systems exchange data (APIs, integration)?
	Digital maturity	Are authentication systems (e-ID, etc.) in place?
	Automation capacity	Can AI/data automation be implemented?
3. Market Conditions	Waste stream structure	Are there fragmented or underutilized waste streams?
	Geographic factors	Are there gaps in processing infrastructure?
	Demand diversity	Is there cross-sector demand for waste/by-products?
	Volume variability	Are waste streams variable enough to benefit from a market?
4. Ecosystem & Industry Structure	Industrial symbiosis	Are clusters or symbiosis networks present?
	Collaboration level	Do industries actively cooperate?
	Innovation links	Are R&D institutions engaged?
	Circular economy readiness	Is there openness to circular practices?
5. User Base Potential	Supply side	Are there enough potential sellers?
	Demand side	Are there enough buyers?
	Adoption willingness	Are users willing to adopt digital tools?
	Scalability	Can the platform grow beyond a niche?
6. Trust & Governance	Data security	Are strong data protection systems in place?

	Institutional trust	Do users trust digital platforms/government?
	Institutional support	Is there public or institutional backing?
	Transparency	Are compliance and transactions transparent?
7. Usability 3 Adoption Feasibility	Ease of use	Is the platform simple and intuitive?
	Workflow integration	Can it integrate into existing processes?
	Automation need	Can administrative burden be minimized?
	Accessibility	Is it usable for non-technical users?
8. Data Quality & Standards	Standardization	Are waste classifications standardized?
	Quality assurance	Are testing/analysis systems reliable?
	Information completeness	Is detailed product info available?
	Risk management	Are biological/chemical risks controlled?
9. Logistics Feasibility	Transport systems	Is transport infrastructure efficient?
	Time sensitivity	Can perishable waste be handled quickly?
	Responsibility clarity	Are liability and costs clearly defined?
	Geographic feasibility	Are distances/logistics manageable?
10. Economic Viability	Pricing mechanisms	Are prices transparent and competitive?
	Market awareness	Do sellers understand waste value?
	Seasonality handling	Are price fluctuations managed?
	Platform sustainability	Is there a viable business model?
11. Strategic Fit	Market gap	Does the platform address an unmet need?
	Complementarity	Does it complement existing systems?
	Sector expansion	Can it scale across industries?
	Phased approach	Can it start niche and expand?

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