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DigiBiogasHubs

Digitaaliset alustat joustavan ja skaalautuvan biokaasutoiminnan mahdollistajina

WP1 Development of the platform ecosystem's cooperation model and description of platform services

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1 Introduction

1.1 Contextual Background

Industries are experiencing rapid changes driven by technological advancements such as digitalization (e.g., connectivity and artificial intelligence), globalization (or deglobalization and semi-globalization), and changing consumer demands due to the techno-economic and socio-economic trends and the coexistence of different generations (e.g., Gen X, millennials, and Gen Z). In this dynamic environment, the need for digital platforms arises to streamline transactions, foster collaboration, and drive innovation. The expanding business shift towards digital platforms, following complex network structures, demands a futuristic approach to industrial transformation (De Reuver et al., 2018). The widespread access to digitalization has accelerated the development of digital platforms built upon existing digital architecture (Constantinides et al., 2018). Still, significant obstacles are present in these transformations, such as disrupting established industries and businesses, altering work context, and demanding innovative forms of regulation and governance. The transformative impact of platforms like eBay, Alibaba, and Facebook has changed how users connect and transact, underscoring the influence of digital platforms (Rochet & Tirole, 2006).

1.2 Rationale for a Digital Platform

Digital platforms foster ecosystem innovation and enable diverse stakeholders to collaborate, creating a synergistic environment that leads to novel services and solutions and increased efficiency. Digital platforms like Alibaba and Amazon have obtained substantial competitive advantages by capturing a global chain of suppliers and consumers.

1.3 Significance of Digital Platforms

Emphasize the transformative power of platforms, unlocking collaborative potential and creating new economic value through network effects. Most successful platforms generate significant value

by decreasing the cost, including time, to benefit all participants (e.g., producer/supplier and customers), which further helps them secure a sustainable position in their respective industries (Hagiu, 2014). Digital platforms are of particular significance for their contributory nature. These platforms foster openness, encourage dynamism, and enable multi-sided interactions. Our understanding of the significance of digital platforms is influenced by several drivers and dimensions, as well as several outcomes that affect the functioning of these platforms (Broekhuizen et al., 2021). Digital platforms are essential because they can transform several sectors, changing how producers and customers communicate and exchange products and services, generating value through network effects, and creating new business opportunities (Rietveld & Schilling et al., 2021). Indeed, these platforms have become indispensable, offering various services and products that meet multiple needs (Constantinides et al., 2018). For instance, eBay, Alibaba, and Facebook are just a few digital platforms that have revolutionized user connections and transactions and are the leading global online destinations for connecting buyers and sellers (Rochet & Tirole, 2006). Complementors and consumers in two-sided network markets are locked into self-reinforcing loops by digital platforms, which generate indirect network effects (Inoue & Tsujimoto, 2018).

2 Platform Literature Review

2.1 Emerging Trends in Platform Design

Recent advancements in the viability of information technology have transformed businesses by simplifying platform construction and scalability. This improvement facilitates seamless participation and data sharing by reducing the dependence on physical infrastructure. Platforms are changing the competitive environment by emerging from traditional linear value-chain models and moving toward ecosystem structures. Alstyne (2016) identifies three fundamental shifts: 1) "Orchestrating business resources," 2) "external interaction over internal optimization," and 3) "ecosystem value over customer focus." Thus, the platform differs from the pipeline business regarding value creation and interaction among other external members. Alstyne (2016) also segregates platform ecosystem players into four types: "providers, owners, producers, and Consumers." In this context, digital platforms like Amazon, Facebook, Alibaba, and YouTube control the global economy by utilizing network effects to create enormous value.

Despite their achievements, platform managers have to anticipate the directions that will define the success or failure of platforms in the upcoming years and the technological advancements that will give rise to innovative platforms. According to Cusumano (2020), platform businesses face several significant challenges. A key issue concerns selecting stakeholders in the platform, such as sellers/producers, buyers/consumers, and complementors/stakeholders. Managers must also overcome the chicken-and-egg dilemma[1] to initiate the network effects and define a revenue-generating model, guideline rules, and governance regulations for managing the platform efficiently. Cusumano (2020) also categorized platforms based on their functionality and similarities into innovation and transaction platforms. Innovation platforms like Microsoft Windows or Apple's iOS allow third-party developers to build complementary applications and services while using their platforms. In contrast, transactional platforms like Uber and Airbnb facilitate transactions between users by providing them with a digital platform. However, some companies use both types to constitute a hybrid strategy, like

[1] A new platform doesn't initially create enough value to attract new users. It's not economical for consumers to join the platform when there are no producers, and vice versa. This is called the chicken-and-egg problem

Amazon and Google, which combines an innovative-driven ecosystem with transactional efficiencies to enhance user engagement.

Additionally, Gawer and Cusumano (2014) Characterized platforms into two predominant classes: 1) platforms (company-specified) and 2) external platforms (transverse industries). They also explicate the best practices for platform leadership. Some of the main points are:

- Envision Integration: Formulate a vision that describes how your product and service can seamlessly integrate into the broader business ecosystem, focusing on creating elements with platform potential and identifying other companies that will enhance your service.
- Architectural Flexibility: Creating a flexible technical architecture with solid connections and interfaces and sharing the resources of these connectors to encourage complementary innovation.
- Network Building: Engage with potential partners and stakeholders to co-create a strong platform ecosystem. Establish industry credibility by sharing risk with stakeholders and sharing identity by creating beneficial business models and promoting the benefits of the technological architecture.
- Continuous Improvement: Maintain the platform's central position by consistently innovating on the core functionality and investing in long-term initiatives to increase the ecosystem's value and sustainability.

The success of digital platforms often remains a puzzle, with a focus on traditional success stories. Understanding why some platforms thrive and others do not is crucial. This involves identifying key factors contributing to a platform's growth or decline. Determining if successful platforms developed intentionally or by accident from goods and services is the scope of this investigation into platform design and their formation. In determining the platform's performance and future course of expansion, platform design in this capacity may help clarify how digital dynamics differ from traditional ones (De Reuver et al., 2018). Jacobides (2018) declares that platform-based ecosystems are becoming the new standard for business structures. He pointed out that an adaptable platform's architecture, which can accommodate a range of players and stakeholders, is essential to its success.

Furthermore, Jacobides (2018) examined the characteristics, motivations, and leverage among these actors to influence the platform ecosystem's structure and operation. This exploration demonstrates how value is generated and extracted in diverse ecosystems. In order to foster innovation and advancement, he also emphasizes the significance of ecosystem governance tactics and how platforms may control and support interactions between actors and stakeholders. Factors including market reach, financial performance, and service provider control are essential for a digital platform to be successful and sustainable since they may boost sales despite the platform's challenges (Hänninen & Smedlund, 2021). Platforms with high service homogeneity may need to differentiate complementary services from their competitors' offers, which will help enhance the value proposition (Au et al., 2020). Adner (2017) also defined the ecosystem as a complex network of multiple entities and partners (stakeholders, customers, suppliers), all playing a specified role, intended to convene communication and facilitate the emergence of key value propositions. He highlights four essential elements that make up the ecosystem structure-linkages, activities, actors, and positions. However, Alstyne (2016) stated that digital platforms are changing the operational system of businesses in three main ways. Firstly, it improves efficiency by separating the value produced by physical assets, such as machinery or land, from their use. Secondly, it presents innovative intermediaries that use intelligent technologies and user feedback to improve the connection between producers and consumers. Lastly, it combines diverse marketplaces, simplifying the process for individuals to locate what they want with less effort. Businesses and individuals are experiencing changes due to these shifts, which present new opportunities and difficulties.

2.2 Platform Design Principles

Designing a platform requires a complex technical infrastructure to encourage participation and deliver substantial benefits to all the actors and stakeholders you want to attract. The platforms that succeed in the business world are the ones that link producers with consumers, partners, affiliates, and users through several services and tools that mutually cement their match. Most critically, the platform's architecture must focus on the scale with sound network effects that can connect and prop up the business across multiple regions, markets, and user needs. The main goal of platform design is to determine its fundamentals, such as its services, governance, monetization techniques, and key-value function. Alstyne (2016) states that the platform's main design centers around crafting

its core interaction, a primary value exchange between producers and consumers. This interaction is built upon three core elements: the participants (producers and consumers who may interchange roles across different interactions), the value unit (the information or service exchanged, like a LinkedIn Profile), and the filter (an algorithm that ensures value units reach the appropriate consumer). Producers' creation and management of value units is critical as it clarifies the operational dynamics of platforms, highlighting its critical role in facilitating communication between sellers and buyers in exchange for values. He distinguished the platforms into two types: one that allows direct connection between their user (e.g., social networks) and the other that does not have a direct connection and uses different methods to exchange value between its users (e.g., TikTok, YouTube).

To ensure a platform's success, designing it in a way that naturally encourages valuable interactions among its users is crucial. This involves three main strategies: attracting users to the platform (Pull), making their interactions as seamless as possible (Facilitate), and connecting the right users (Match). Attracting users requires solving the initial hurdle of providing value to encourage participation. Once users are on the platform, keeping them engaged and ensuring they find it useful involves creating feedback loops that personalize their experience. Facilitating interactions consists of providing tools and a user-friendly environment and setting up guidelines that promote positive exchanges and discourage negative ones. Effectively matching users means using data to understand their needs and preferences, ensuring that they find the interactions and transactions on the platform relevant and rewarding. This approach is not static; it requires ongoing refinement to respond to user behaviors and preferences, technological advancements, and the competitive landscape. He also states that transactions in the platform ecosystem are similar to conventional business and social interaction, which involve the mutual exchange of value (e.g., information sharing, revenue sharing, goods, and services).

According to Gawer (2009)Evaluating the platform's context, objectives, design rules, participants, scalability, and support services(platform typology) is essential to identify the suitable platform design for project needs. Comparing these key elements guarantees a data-driven decision-making process that leads to the selection of the platform, which can accommodate future growth and changes. A table similar to the one constructed by Gawer for a typology of platforms is illustrated below in Table 1.

Table 1 Typology of Platform (Gawer, 2009)

Platform Type	Internal Platform	Innovation Platform	Data Platform	Multi-sided markets or Platforms
Context	Single Firm	New Innovation and network system	Data management and analytics	Different Industries and groups
Objective	To increase productive efficiency within a single firm by leveraging shared infrastructure, components, or services.	To facilitate innovative products and services by leveraging the platform's capabilities and ecosystem.	To collect, store, process, and analyze large data sets from various sources, making them accessible and usable for decision-making and product/service enhancement.	To facilitate interactions and transactions between different groups of users, benefiting from network effects.
Design Rules	To increase productive efficiency within a single firm by leveraging shared infrastructure, components, or services.	Open standards for innovation, modular components for easy integration, and stability of system architecture.	Data governance and quality standards, privacy and security protocols, scalable and flexible architecture.	Rules and standards for transactions, quality control mechanisms, pricing, and incentive structures.
Participants	Standardization of components and processes, modular architecture for flexibility and reuse.	Platform providers, third-party developers, and end users.	Data providers, platform operators, data consumer analysts, and data scientists.	Buyers, sellers, platform operators, and possibly other intermediary service providers.
End-Use	Internal applications, processes, and services that support the organization's operations and strategy	It varies; it depends on the innovative solutions the platform participants develop.	Insights, analytics, AI, and machine learning models, reporting.	Transactions, services, or content exchange between participant groups.
Key Considerations	Alignment with organizational goals and strategies, change management, internal adoption, and usage.	How to incentivize innovation, protect intellectual property, and ensure quality and security of third-party contributions.	Data privacy and security, scalability, data quality and integrity, and compliance with regulations.	Balancing the interests and needs of different participant groups, managing network effects, trust, and safety.
Examples	Amazon's AWS was initially developed as an internal infrastructure platform,	Apple's iOS platform enables developers to create apps that leverage iPhone capabilities.[2]	BigQuery, offering data warehousing and analytics services[3]	Airbnb connects travelers with property owners for short-term rentals.[4]

[2] How Apple Is Organized for Innovation (hbr.org)

[3] What Is A Data Platform? And How To Build An Awesome One (montecarlodata.com)

[4] Multi-Sided Platforms — Uber, Airbnb, and ZoomThru. | by Richard Malone | Medium

These platforms are distinguished by network effects critical to their functionality and expansion. Two-sided markets or multi-sided markets feature indirect and direct network effects, where the direct network effect means the value for users increases as the number of users within the same group increases, expanding the platform's value for each user (e.g., Facebook, Snapchat). On the other hand, indirect network effects manifest themselves when growth on one side of the market increases value for users on the other side (e.g., eBay, Airbnb). The combination of direct and indirect network effects makes two-sided markets extremely successful at creating and expanding value for all players, which is why they are preferred in industry economic approaches (Evans & Schmalenseeet al., 2008). The multi-sided platforms (MSPs) design principle enables direct interactions between suppliers and consumers, allowing suppliers to control their service offerings fully. In essence, it deviates from the vertically integrated tradition firms have as it enables suppliers' various degrees of independence when interfacing with consumers. Stakeholders can either pay a fee to be allowed access to the site or bear a fee, which, once varied, can enable one to become a shareholder based on a calculation of the number of customers or the sales they make on the platform. This approach allows room for leverage to the suppliers of service offerings by adjusting the efforts and the service offerings in line with the fees (Hagiu & Wright et al., 2015). Furthermore, scalable tactics, efficient operating models, and transparent ownership arrangements ensure long-term viability in platform design (Gawer & Cusumano, 2014).

2.3 Platform Ownership, Operating Model, and Scalability Strategies

A platform's performance and sustainability depend on a few factors to consider when developing ownership and operating structures. The operational model describes how the platform works and provides value to its users, whereas platform ownership refers to the organization or entity controlling the platform. Hagiu & Wright (2015), on multi-sided platforms, emphasized the importance of understanding platform ownership dynamics and the function of platform operators in promoting communication across various user bases. They highlighted the need for platform owners to maintain the interests of multiple stakeholders, e.g., users, developers, and advertisers, to ensure the platform's long-term success.

Alstyne (2016) also argued that a significant shift from conventional business techniques is the transition from traditional "push" methods, such as targeted direct advertising, to "pull" strategies,

which emphasize more user involvement and organic growth. This approach underscores the need to create platforms that attract users through attractive incentives and integrated marketing inside the platform itself, such as YouTube's content creator-focused growth strategy. He also exemplified that the launch strategies of YouTube, Megaupload, and Vimeo show that understanding your platform's market position and emphasizing the right group (producers or consumers) solving the Chicken-or-Egg dilemma first can make all the difference.

Each platform launch approach is valuable, depending on the situation and goals. Follow-the-Rabbit methods involve using an existing product to draw users to the platform naturally from day one. Staging Value Creation employs valuable core content or services to attract one user group and, swiftly, the other, creating a self-reinforcing cycle. Targeting a Specific User Group utilizes features or services that are inherently more appealing to either producers or consumers, naturally attracting a critical mass of the opposite group. Simultaneous On-boarding is designed to offer immediate benefits to both user groups, leading to widespread use from the start. Piggyback strategies rely on a more compelling value proposition than competitors to quickly attract an initial user base. Seeding involves high-quality content or services to attract an initial group, which then quickly draws more from the other group. Marquees use the influence of key early adopters to draw in more users. Single-side strategies focus on gaining traction on one side before addressing the other due to its leverage or to conserve resources. Producer Evangelism is preferred in markets with few suppliers or where the producer's value proposition is weaker than the consumer's. Big-Bang Adoption is for situations requiring fast and large sign-up numbers, possibly through significant marketing efforts or high-visibility events. The Micro Market Strategy targets a small, focused market to quickly achieve critical mass, after which growth should become self-sustaining. Optimizing a platform launch is all about execution. If the unique value proposition and its interaction with platform dynamics are misunderstood, the platform's success can be significantly affected. (Alstyne et al., 2016). Platform ownership and scalability plans must consider the possibility of incumbents driving changes to the platform and integrating new technologies within current capabilities. (Wells et al., 2020).

Furthermore, Cusumano's (2020) Work on platform leadership provides insights into platform owners' strategies for maintaining their competitive advantage. It discusses the importance of platform governance, ecosystem orchestration, and architecture in shaping a platform's success and highlights platform owners' challenges in managing relationships with external developers and partners.

2.4 Revenue Model and Monetization

Effective revenue models and monetization methods are essential to digital platforms' financial sustainability. These methods are defined by factors that impact how platforms earn income and maintain their operations, including market segmentation, waiting periods, and negotiating power. (Adachi & Tremblay, 2020; Gal-Or, 2020; Tavalaei, 2020). Alstyne (2016) Illustrates an important aspect of platform businesses: the complexity of monetization strategies. He revealed the challenges of generating revenue without suppressing platform growth or deterring user engagement. In platform ecosystems, most of the value resides in the network effects that drive their growth in self-reinforcing loops in which more users attract even more users, thereby increasing the platform's overall value. However, directly monetizing these network effects can be counterproductive. Charging users for access or participation can create a disincentive to join or actively contribute to the platform. It can effectively restrain the network effects that provide the platform's value.

Alstyne (2016) also proposes that charging ad agencies to join, charging firms a fee for services, or charging for project listings may appear logical. However, it would likely have introduced friction in the platform, reducing its growth. He recommends exploring alternative revenue models that do not charge users upfront but instead find value from the transactions or interactions facilitated by the platform. Examples of successful platforms like eBay, Alibaba, and Facebook demonstrate the power of digital connectivity and revenue generation through transactions and advertising. (Au et al., 2020). This view also aligns with the successful platform monetization strategies that Airbnb, Uber, and eBay have adopted, where the platform still does not charge for access but instead takes a cut from the transactions facilitated by the platform.

Furthermore, subsidizing participation to reduce barriers to entry and enhance user engagement is a particularly notable idea. By finding ways to make it as easy as possible for users to join and participate, the platform can grow its user base; hence, its network effects can grow much more rapidly. Platform performance and durability depend on understanding revenue generation and profitability, which includes evaluating the impact of multi-sided marketplaces and new players (Seamans & Zhu, 2014). This approach can potentiate a platform in its early stages when its capacity to build a critical mass of users is essential to its long-term viability. At the same time, Wells (2020) discussed various shared-use options requiring membership and per-use payments. Reisinger (2014) presented a two-

tariff payment revenue model. The pricing strategy of that model implied that when two actors of a two-sided market interact within a platform, the platform often charges them two tariffs: fixed subscription fees and a pay-per-use variable transaction fee. This approach is usually adopted for users who engage more actively in transactions or provide more product options. The platform's inability to forecast the interaction intensities of all users results in the adoption of a uniform pricing strategy. This strategy leads to user sensitivity to pricing adjustments as users with a high volume of transactions do not encourage high per-use transaction fees.

In contrast, users of low-volume scale will only be affected. It is built to balance growing your user base while maximizing your revenue, considering there would be multiple ways the different platform users respond to the pricing changes. He proposed that the platform pricing should be considerably higher for the users achieving more benefits from the platform compared to low prices for the users contributing more to enhance value within a platform. He believed these platforms could attract more users, facilitating initial participation and trading opportunities. This platform has two user journeys: the first decision is based on the overall pricing structure to join the platform, and the second is about the volume of transactions to perform with the platform. A delicate price strategy is needed to maintain the balance for what is present between the platform and its users to make it more attractive and diverse in usability.

Typically, monetization strategies in platform businesses often require creative thinking and deep insight into the value created within the ecosystem. Charging for enhanced services, premium features, or successful transactions can generate revenue streams without burdening participation. In addition, indirect monetization strategies, like data monetization or circumstantial services that complement the main activities of the platform, might prove effective. (Alstyne et al., 2016). Essentially, developing a dynamic and expanding user base and creating creative methods to extract revenue from the exchanges and transactions the platform facilitates are the keys to effective platform company monetization. These tasks require establishing a balance between promoting mass involvement and capturing value without harming the quality of users' experience or the platform's potential to grow. (Alstyne et al., 2016).

3 Successful Examples and Their Design Features: A Benchmarking

The rise in online digital platforms (marketplaces), including cases like Amazon, Uber, Airbnb, and eBay, has greatly facilitated and transformed traditional business models. These platforms heavily rely on establishing trust and communication between seller and buyer to promote transactions effectively. In order to achieve this, they provide comprehensive details not only about the product or service but also about the individuals/companies involved in this value exchange. Creating different profile portfolios and linking them to online platform sources helps businesses build reputation and credibility. Successful transaction platforms possess key design features that contribute to their success. These aspects are critical for improving user experience, facilitating transactions, and building trust among platform actors.

Subsequently, Chen and Sheldon (2015) Highlight the success of Uber as a transaction platform and discuss the dynamic pricing model and real-time matching algorithms adopted by the company. Such features help the company allocate resources efficiently and facilitate smooth communication between drivers and passengers, ensuring the best price quotation for both parties. They look at how the real-time matching algorithm effectively connects the users with service providers, contributing to the platform's efficient performance and success in providing on-demand transportation services. Another example is Airbnb, a leading worldwide home-sharing digital platform. According to Edelman and Luca (2014)Airbnb has created a platform that promotes trust, allowing different hosts and guests to engage seamlessly. Airbnb operates through matchmaking algorithms that match hosts with their guests based on specified factors such as location, price range, availability, and guest preference; user feedback mechanisms enable the optimization of the search processes to ensure accountability and prioritize inclusivity and safety to create a communicative environment within their platform. Airbnb has adopted preventive risk management strategies to ensure successful operations, considering the complexities of online platforms (marketplaces). Different Examples of Vertical B2B platforms and marketplaces are listed below in Table 2.

Platform	Description	Ownership and operating model	Value proposition	Revenue model, monetization, and scalability
CheMondis	**A** vertical B2B platform for the chemical industry, connecting buyers and suppliers	-Product marketplace.	A vertical platform.	Boost your sales.

	worldwide. Trusted by a wide range of brands, it facilitates transactions and promotes growth and solutions in the chemical sector. Moreover, it offers various tools and consulting services to improve the user's overall trading experience.[5]	-Single Owner (LANXESS). -Improve the customer journey. -Prevent fraud.		
ChemDirect	Specializes in serving businesses within the chemical industry, providing them with a dedicated marketplace that connects buyers directly to various chemical products from verified suppliers. It also offers a wide range of chemical products, facilitates pricing, and provides customers real-time inventory stock updates, catering to chemical businesses.[6]	-Product marketplace. -Listings platform. -Consortium Privately Held (Backing). -Improve the customer journey	A vertical platform.	Revenue sharing. Dynamic pricing
Wind-turbine.com	A B2B marketplace with 12000 customers and sellers spread around 150 countries, Wind-turbine has over 12 years of experience in the wind industry. It mainly focuses on buying, selling, and operating commercial wind projects, catering to businesses in the wind energy industry.[7]	-Listing platforms. -Product/Service marketplaces. -Asset-light marketplace. -Single Owner -Prevent fraud.	A vertical platform.	Pay for visibility. Pay per use. Freemium Munchausen bootstrap. Let your users bring them in.
Wucato	This is a vertical B2B marketplace aiming to help companies optimize their procurement procedures by providing a central platform that makes purchasing easier and supplier management more efficient. It allows businesses to easily manage complicated procedures while saving valuable time and resources by centralizing vendors and cataloging orders.[8]	-Product marketplace. -Single Owner (WÜRTH GROUP) -Asset-light marketplace. -Protect data	Aggregate Demand and Supply.	Revenue sharing. Leverage existing assets. Let your users bring them in. Piggyback

[5] CheMondis | Leading B2B marketplace for trusted chemical suppliers

[6] Fine Chemical Supply | Buy & Sell 400,000+ Chemicals | ChemDirect

[7] Über uns - die Macher von wind-turbine.com

[8] Wucato – your digital procurement platform | Wucato

Traktorpool	A vertical B2B platform operating globally. It serves as an online marketplace specifically for the buying, selling, and renting of agricultural machinery, catering to businesses within the agricultural industry.[9]	-Product marketplace. -Single Owner (LV Digital GmbH) -Listing platforms. -Maintain network effects	A vertical platform. Aggregate Demand and supply.	Advertisement. Freemium. Subsidize the sensitive. Follow-the-rabbit
MoBase	Specializes in catering to the needs of businesses within the mobility sector, making it a vertical B2B platform.[10] It offers a wide range of products related to the mobility industry, including automation equipment, digital transformation solutions, electrification products, etc.	-Product marketplaces. -Single Owner (Siemens Mobility GmbH) -Listing platform	Aggregate demand and supply.	Advertisement. Focus on both sides. Platform exploitation.
XOM-Materials	A vertical B2B platform based in Berlin. Founded in 2017, XOM eProcurement provides practical solutions to materials-related businesses. It connects explicitly the buyers and suppliers within the steel and metal industry. It allows the user to communicate, send a proposal, accept offers, and place an order within a platform. It also promotes data transparency and legitimate information sharing.[11]	-Service Marketplace -Single Owner (Klöckner & Co.) -Listings platform	A vertical platform.	Revenue sharing. Follow the rabbit. Improve the customer journey.
Tapio	A vertical B2B platform connecting stakeholders, including carpenters, furniture makers, panel processors, machine makers, and suppliers, collectively functioning as an ecosystem specially created for the wood sector. This platform facilitates digital transactions, collaboration, and data-driven decision-making and is built solely to meet the specific requirements of the wood industry.[12]	-Industrial innovation -Single Owner (HOMAG) -Closed core platform. -Integration platform. -Managed platform. -Protect data.	Create a complementor ecosystem.	Revenue sharing.

[9] Käytettyjen traktoreiden ja maatalouskoneiden johtava markkinapaikka - traktorpool.fi

[10] MoBase | Homepage (mymobase.com)

[11] XOM Materials (xom-materials.com)

[12] Home | tapio - ecosystem of the wood industry

Flexport	Flexport is a vertical B2B platform for the logistics and freight forwarding industry, connecting shippers with carriers globally. Widely trusted by businesses of all sizes, it streamlines international trade through innovative technology, offering comprehensive solutions for transportation, customs brokerage, and cargo insurance.[13]	-Service Marketplaces -Open for co-innovation. -Single Owner (Privately Owned) -Light marketplace	A vertical platform.	Pay-per-use Dynamic pricing
TREASoURcE	A vertical initiative marketplace dedicated to creating systematic circular economy solutions for cities and regions. Its main objective is to address problems with bio-based waste, side streams, end-of-life electric car batteries, and unused plastic waste. This platform focuses on sustainable practices and economic growth within the Nordic and Baltic Sea Region.[14]	-Vertical initiative marketplace. -Protect data. -Knowledge sharing.	A platform vertical.	Circular economy practices.

Table 2 Examples of Vertical B2B Platforms and Marketplaces.

[13] The Supply Chain Logistics Platform | Flexport
[14] TREASoURcE - Home

4 DigiBiogas Platform: Stakeholder Analysis

4.1 Overview of Stakeholders in the three biogas hubs

Stakeholders can be identified and classified (considering layers, one figure per hub). Subsequently, a detailed analysis of their needs and expectations can be conducted.

As shown in Figure 1, the stakeholders include manufacturers, suppliers, service providers, and consumers. Exchanges encompass the exchange of finished products (biogas) and transactions related to raw materials, components, and a spectrum of supporting services across the ecosystem.

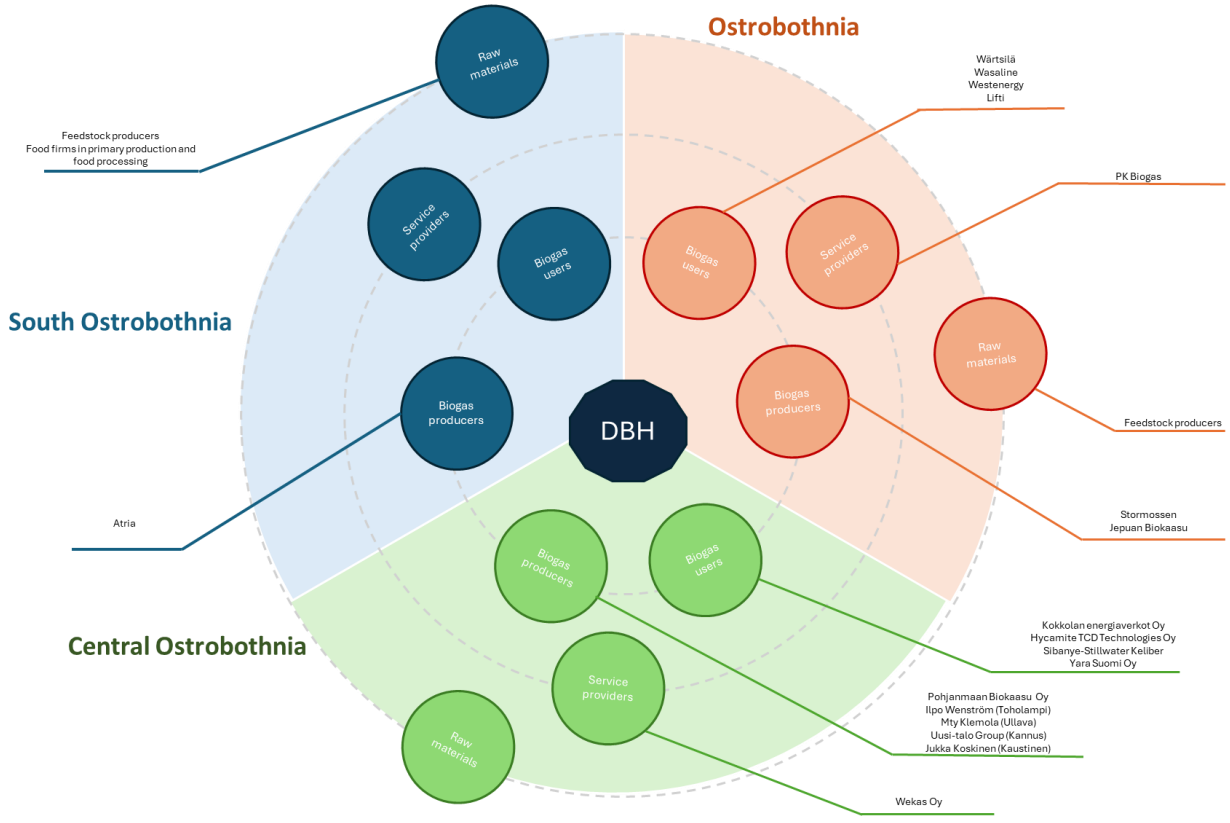

Figure 1. Identification of Stakeholders in Three Regions of Ostorbothnia

4.2 Understanding stakeholders' business models and balancing their interests

To understand the platform's design, it is first necessary to map and understand how it creates value for each participant. In doing so, it is necessary to understand what is valuable for each stakeholder and how each one co-creates and shares value with other actors in the ecosystem and captures part

of the value generated. In other words, understanding the logic of value creation, delivery, and capture (the so-called business model) at the ecosystem level will define opportunities for the platform to create value. Thus, it is critical to find an equilibrium among competing stakeholder interests. In doing so, there is a need to understand individuals' value, recognize suitable business models, and map the fluxes (physical and monetary) between stakeholders to find fair strategies for value co-creation and sharing. For example, how can biogas producers compensate feedstock or industrial biowaste producers? In the case of feedstock, compensation could be either money or fertilizer, which results from the biogas production.

5 Methodological Insights

5.1 Methodology

The main focus of this project is to develop a state-of-the-art digital platform ecosystem mainly related to the biogas industry. The research was conducted across three regions: Ostrobothnia, South Ostrobothnia, and Central Ostrobothnia. Each region has its own discrete industrial focus. The methodology of this report incorporates the systematic flow of the research process. This report relies on a qualitative methodology that involves many methods, including literature review, platform benchmarking for identifying their key services and functionalities, semi-structured interviews of multiple actors, and workshops in each region (Central Ostrobothnia, South Ostrobothnia, and Ostrobothnia) to gather an understanding of participants' perspectives and needs, as shown below in Figure 2. This strategy allows us to analyze the platform ecosystem comprehensively in a real-world context. This technique also combined data from multiple sources to provide an enriched vision of digital platforms and their key functionalities.

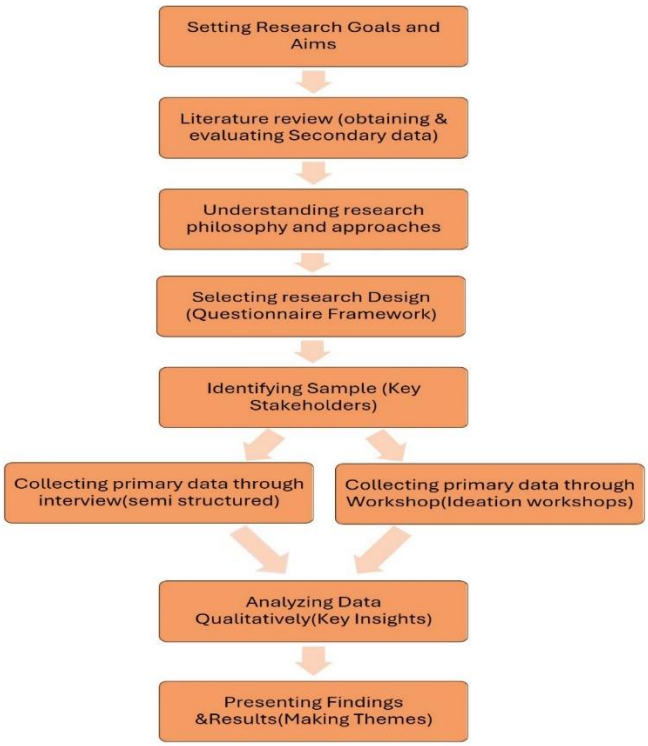

Figure 2 Research Methodology

5.2 Data, data collection, and data analysis

Data collection involves gathering information through various methods, such as literature reviews, interviews, and workshops, which will then be analyzed through different processes to interpret the data. Some of the methods are discussed below:

5.2.1 Literature review

A literature review was initially conducted to lay the foundation of the theoretical grounds for this research. The literature review includes relevant academic articles on the platform ecosystem, digital platforms, value co-creation, and network effect. Scopus and Web of Science databases were used to identify relevant academic papers. The Research string used to extract the search was TITLE ("platform ecosystem*" OR "digital platform*" OR "digital platform ecosystem" OR "Platform-based market" OR "Marketplace platform" OR "platform marketplace*" OR "Multi-sided Marketplace" OR "Multi-sided Platforms" OR "Multi-Sided Platform") AND TITLE-ABS-KEY("Value Co-creation" OR "Value creation" OR "Value proposition" OR "Value capture" OR "Creating Value" OR "Value capturing" OR " Network Effect") AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")). The search was confined to only academic articles, case studies, and review papers; conference papers and book chapters were excluded.

Along with the literature review, a benchmark analysis was also conducted to identify similar platforms that could further help develop Digi Biogas Hub's digital platform. This benchmarking involves analyzing the types of platforms, their core services, ownership and operating models, value propositions, and monetization models. Ten vertical platform examples were benchmarked to highlight the best practices applicable to the DBH (Digi biogas Hubs) platform.

5.2.2 Stakeholder Interviews

A total of 20 semi-structured interviews were conducted to learn more about the needs and challenges faced by each stakeholder in the biogas ecosystem. The purpose of the interviews was to get both quantitative and qualitative information. The questionnaire framework was developed, as shown in Table 3, considering the major themes found in the literature research, which further

guided the development of the interview questions. Questionnaires were customized for each stakeholder's domain.

	Biogas Producers	Biogas User	Biogas Distributor	Service Providers	Raw Material Supplier
Participation conditions	Scalability -Stakeholder Engagement	Scalability -Stakeholder Engagement	Scalability -Stakeholder Engagement	Scalability -Stakeholder Engagement	Scalability
Service In DBH	Value proposition-Business Opportunities-Core Interaction	Value proposition-Business Opportunities-Core Interaction	Value proposition-Services	Value proposition-Services	Value proposition- Core Interaction
Ownership	Ownership Choices	Ownership Choices	-	Ownership Choices	-
Operational Model	Revenue Model - Monetization- Model Preferences	Revenue Model - Monetization- Model Preferences	Revenue Model-Monetization-Operational Complexity	Revenue Model-Monetization-Operational Complexity	Monetization
Challenges	Compliance Strategies - Regulatory Challenges	Compliance Strategies - Regulatory Challenges	Compliance Strategies - Regulatory Challenges	Technical Aspect-Platform Challenges	-
Solutions	Needs	Needs	Needs	Solutions	Expectations

Table 3 Questionnaire framework

- **Participants**: Key stakeholders across Ostrobothnia, South Ostrobothnia, and Central Ostrobothnia, including biogas producers, users, distributors, raw material providers, city council representatives, and service providers, were interviewed.
- **Objective**: To gather detailed insights into stakeholder needs, challenges, expectations, and opportunities in the biogas industry and digital platform services.
- **Interview Focus**: The interviews focused on participation conditions, value proposition, value-added services, business opportunities, Monetization streams, ownership models, and regulatory challenges.

Process and Consent:

All interviews were conducted online, and written consent was obtained from each participant in compliance with the EU GDPR Regulation before the start of the interview. Participants were informed in detail about the Privacy Notice, which includes explaining the entire data collection process, starting from how the data would be collected and stored, who can use it, and who has access to it. Participants were also notified about their right to review and verify their contribution and how their data would be interpreted and reported in the results.

The participants were guaranteed that their identity would be protected until they gave their expressive agreement to be identified and that the interviews would be recorded and transcribed for analytical research reasons only. Depending upon the participant's choice, interviews were conducted in Finnish and English, which helped the interview sessions go smoothly and did not create any barriers to communication due to language.

Interview Structure:

The interviews were conducted in a way that usually involved asking the respondents 8 to 10 specific questions. They were encouraged to share their experiences and views openly. These core questions were followed by additional follow-up questions to make this conservation constructive and more engaging, allowing the participants to elaborate more expressively.

Duration time:

Most of the interviews lasted approximately 40 to 50 minutes. However, some extended beyond that as the conservation flow allowed the participants to delve deeper into specific topics of interest and provide more comprehensive information.

Interview Analysis:

The Stakeholder interview was analyzed using a content analysis approach based on the key topics from which we developed the questionnaire framework. This analysis carefully reviewed the interview transcripts to identify key themes and topics. This method allows us to categorize the stakeholders' perspectives on key challenges, needs, expectations, risks, opportunities, and key enablers regarding the biogas industry, thereby providing a flexible framework for designing our cooperation model for the DBH platform.

5.2.3 Interactive Workshop

A total of 3 collaborative workshops were organized across three regions of Ostrobthnia. Different stakeholders from different domains participated in engaging in problem-solving and decision-making processes. The workshop was designed to promote active participation, allowing open discussions where all stakeholders could collectively voice their opinions and agree on potential solutions. The Carousel brainstorming (Me-We-Us) technique was implemented, allowing participants to think

individually, discuss in small groups, and finally reach a consensus as a consolidated group for the solutions. This approach helps increase the dialogue between the participants and adds creativity, teamwork, and a shared understanding for finding practical solutions.

Workshop Analysis:

The analysis of the workshops conducted across three regions of Ostrobothnia was carried out through an interactive session where participants from various domains were brought together to perform engaging tasks. During these sessions, structured exercises such as Carousel brainstorming were implemented to engage participants in discussion, scenario building, and brainstorming to identify key digital services for the DBh platform. This collaborative process allows the participant group to collectively prioritize the top five functionalities, considering the interests and expectations of all stakeholders within the ecosystem. The resulting insights ensure the platform design aligns with the biogas industry's strategic objectives and real-world challenges.

6 Findings: Insights from the interviews and workshops

The analysis performed for the interviews and workshops helped to identify important insights highlighting the considerable challenges, needs, risks, and opportunities. It also explains the correlations related to stakeholders' interests and expectations about the digital services and functionalities that would be a part of the DBH platform. These insights support the DBH objectives of developing a structured and data-driven decision-making mechanism for the DBH platform.

6.1 Interview Analysis Framework (Key Insights)

The analysis is divided into different sections based on participant domains. A framework was developed for each group of stakeholders, considering their specific domains. These individual frameworks were then combined to form a consolidated framework. The descriptions of each framework were extracted from the interviews and categorized depending on the stakeholder type as follows:

6.1.1 Biogas Users

We have interviewed multiple biogas users from different industries to identify their main challenges and key needs. The insights from these interviews were then analyzed and categorized to develop a comprehensive framework that highlights the challenges, needs, expectations, risks, opportunities, and enablers. This framework helped us understand the practical areas within the biogas sector and key points where support and development are required. The consolidated framework we developed from the interviews with biogas users of all three regions of Osotrobothnia is shown below in Table 4.

Before we examine the combined perspectives of biogas users across all three regions more deeply, let us first examine region-specific insights from the interviews. Biogas users from the Ostrobothnia region highlighted significant economic and logistical challenges related to utilizing biogas as their primary energy source. The primary obstacle is the high cost of biogas, which is four times higher than that of fossil fuels, making large-scale adoption of biogas economically unfeasible in the current scenario. Interviewees mentioned that several companies have considered conversion to biogas but have postponed projects due to high capital costs and market uncertainties. Another critical challenge is the region's lack of adequate transportation and logistics infrastructure. They believe that

without an extensive pipeline network or infrastructure, difficulties related to cost and supply will persist, as biogas is currently transported by trucks, which adds to operational costs. Additionally, they mentioned that regulations related to the storage and permitting of biogas create further barriers for companies considering a switch to biogas.

Despite these challenges, there is a strong demand for sustainability and carbon reduction. Regional companies agree that regulatory changes and modifications (e.g., joining the EU Emissions Trading System (ETS)) may improve projections for future biogas use and demand growth. Some companies are looking into producing synthetic methane using carbon capture and hydrogen technologies, and there is growing interest in combining hydrogen and biogas as a potential solution for future energy demands. To guarantee that biogas is a competitive option in Ostrobothnia, the interviewees emphasized the need for long-term contracts, price protection measures, and upgraded infrastructure before it can be widely adopted in the industrial sector.

Biogas users in Central Ostrobothnia are experiencing a transition, as this region is developing progressively, along with industries aggressively replacing fossil fuels with renewable gas and attempting to integrate biogas shortly. The primary problem biogas users of this region identify is obtaining economies of scale since most industrial customers need significant regular volumes of biogas to justify their investments. Current domestic biogas production is insufficient to fully replace natural gas, allowing only partial substitutes in the short term. Interviewees also highlighted the logistical and storage difficulties regarding the biogas since the application of LBG is more demanding and liquefied biogas (LBG) can readily be transported across long distances compared to compressed biogas (CBG). Domestic producers, on the other hand, primarily concentrate on compressed biogas (CBG) since LBG units require additional infrastructural investments.

Quality control remains a significant concern for biogas users in these regions, mainly for applications where gas purity significantly affects production specifications and safety compliance. Comprehensive quality testing and certification before injecting biogas into industrial gas grids is a significant ask for the users. Biogas users also desire enhanced sourcing coordination, advocating for centralized hubs or marketplaces to integrate small-scale biogas production into more substantial and reliable supply chains. The goal is to combine biogas with other renewable energy sources, such as hydrogen, to strengthen long-term energy security.

Despite these challenges, companies in Central Ostrobothnia recognize the increasing regulatory pressure for decarbonization and expect that elevated carbon taxes will make biogas more economically attractive in the near future. Interviewee stresses the importance of a digital platform that connects producers, distributors, and industrial end-users to ease the transition, offering transparent pricing, quality assurances, and logistics management.

Component	Title	Description	Interview Extract
Challenges	**-Logistical Barriers** **-Lack of Infrastructure for transportation**	It discusses the difficulties in transporting biogas from production sites to consumers, highlighting the need for adequate infrastructure, such as pipelines or trucks.	"For a growing population, maybe the biggest obstacle is transportation. It is possible to have local production or biogas in many different places. However, how do you get it forward, and how do you have the infrastructure? Do you need pipelines, trucks, or whatever you transport to the consumers?"
	-High Conversion Costs	High costs associated with switching from heavy fuel oil to biogas are a significant barrier.	"The costs were quite high, so the project was put on hold." "We are not buying in biogas at the moment because it is four times more expensive, and we are also looking after costs available on biogas from the only supplier we have in Finland."
	-Quality Control and Assurance	Emphasizes the importance of maintaining high-quality standards for biogas, especially for industrial applications.	"Feasibility of refining biogas to biomethane and pressurizing it."We need to follow what we are getting in the gas pipes, and the quality is one difficult question because we need to have laboratory equipment to ensure that the quality is good enough for our customers."
	-Reliable Biogas Supply	The primary challenge is ensuring a consistent and reliable biogas supply to maintain operations.	"The primary requirement is securing a reliable supply of biogas because this is an essential commodity for us."
	-Investment Uncertainty **-High Capex**	It discusses the difficulty of making investment decisions when long-term contracts for feedstock and buyers are not in place, leading to hesitation in project development.	"No plan is going to be built if we do not have that kind of feedstock and the off-take locked."
	-Limited Market Awareness	Addresses the difficulty in developing biogas projects due to the current low market prices and the lack of demand for compressed biogas, making it less viable as a business proposition.	"Basically, the biggest challenge at the moment is the market. The market price is so low that it is hard to develop the project. There really are no users switching to traffic for compressed gas."
	-Reliable biogas Supply **-Access to local biogas sources**	The need for reliable biogas supply to meet the operational requirements of industrial customers	"We would like to utilize as much biogas as possible, especially since it can result in a negative CO2 footprint."

Needs	**-Marketplace for Biogas** **-Strategic Partnerships** **-Long-Term Contracts**	Emphasizes the need for a centralized marketplace where biogas producers and users can find each other, with transparency in volumes and prices, to support business planning and operations.	"It would be helpful to have a marketplace... with volumes and perhaps prices, to make it easier for a biogas user like us to plan our business."
	-Flexibility in Logistics	Given the logistical challenges in biogas transportation, flexibility in the transportation and storage of gasses is key.	"Liquefied gas would be preferable for long-range transports, but we do not own or operate the logistics side."
Risks	**-Market Uncertainty**	Uncertainty in market conditions and regulatory changes could impact the decision to switch to biogas.	"The key issues are availability and the opportunity costs of investing."
	-Price Competitiveness **-High price**	Discusses the risk that local biogas might not be price-competitive with other biogas sources across Europe due to high demand.	"There is going to be a huge demand all over Europe. So, it is a price issue. We are not going to get biogas from our locally produced biogas." "Liquefied biogas is more expensive."
	-Economic Viability **-Dependency on Fossil Fuels**	Highlights the economic risk associated with the high cost of biogas compared to fossil fuels.	"There are interested parties in the market, but they are unwilling to pay the price because fossil fuels are so cheap."
	-Regulatory Uncertainty **-Permit Storage**	Highlights the risk of evolving regulations in the EU, especially concerning carbon emissions, which may affect the company's strategic direction and market focus.	"We are actively lobbying in the EU. However, places like the US are now focusing more on the absolute CO2 footprint." "Permitting for gas storage is one question, and arranging safe storage is another."
Expectations	**-Cost-Effective Solutions** **-Commitment to Sustainability**	Expectation for biogas solutions to be both cost-effective and environmentally sustainable.	"We want to keep energy production both cost-effective and climate-effective."
	-Digital Platform Efficiency **-Platform Services**	Expect a digital platform to streamline stakeholder communication, allowing for better business efficiency and access to reliable producer information.	"Maybe this platform could provide services like access to different suppliers, geo-mapping, and compliance."
	-Growth in Biogas Infrastructure **-Scaling Production**	Anticipates growth in infrastructure development, including distribution networks for liquefied biogas, which will improve the market's capacity to handle larger volumes of biogas.	"Every new filling station is a plus. It helps transport companies feel safer when committing to biogas."

	-Regulatory Changes to Support Biogas **-Future Adoption**	Expects that future regulatory changes, particularly from the EU, will impose stricter carbon emissions limits, driving demand for renewable energy sources like biogas.	"We think that the market will rise. There will be changes in the legislation and regulations the EU imposes for the carbon footprints and emissions."
Opportunities	**-Industrial Symbiosis -Hydrogen-Biogas Integration**	Describes the potential for creating synergies between biogas and hydrogen production, particularly by using hydrogen for synthetic methane production from CO2, which can help reduce emissions and create additional value.	”We aim to produce synthetic methane from CO2, which comes from the biogas plant, and then use locally produced hydrogen.”
	-Negative CO2 Footprint **-Cost & climate effective solutions**	Highlights the opportunity to achieve a negative CO2 footprint by using biogas as a feedstock and capturing the carbon, which can be used in industries like cement or steel.	”We would like to utilize biogas, and when we get the fixed carbon, we can use it in industries like cement and steel. This gives us a negative CO2 footprint.”
	-Platform Services	Expecting digital platforms to offer tools for identifying suppliers, managing compliance, and validating sustainability.	”Maybe this platform could provide…services like access to different suppliers, geo-mapping, and compliance.”
Enablers	**-Digital Platform for Connections**	It stresses the importance of having a digital platform where buyers and sellers of biogas can connect, facilitating transactions, communication, and business planning.	"A marketplace that would bring together gas producers and buyers would be of interest to us, where we could advertise our needs and get offers."
	-Third-party management of the Platform	It highlights the need for a neutral third party to manage the platform, ensure smooth operations, and avoid conflicts of interest between stakeholders.	"It would be beneficial to have a third party running the platform. Like in the green card system in Finland."
	-Local Distribution Support	The platform can play a key role in bridging the gap between producers, distributors, and users, providing a complete value chain solution for the local biogas ecosystem.	"The platform aims to include the distribution side and provide ease because there is a gap between the producer and the users."

Table 4 Interview Analysis Framework (Biogas Producers)

6.1.2 Biogas Producers

We have also communicated with multiple biogas producers from different regions, whether small producers or big enterprises, to identify their main challenges and key needs within the biogas industry. The insights from these interviews were then analyzed and categorized to develop a comprehensive framework that highlights the challenges, needs, expectations, risks, opportunities, and enablers. This framework helped us to understand the practical areas within the biogas sector and key

points where support and development are required. The consolidated framework we developed from the interviews with biogas producers is shown below in Table 5.

However, before that, we will analyze region-specific observations from the interviews, Starting with Ostrobothnian biogas producers interviews, where they mentioned facing significant scaling and infrastructure challenges, particularly regarding scaling production and connecting with liquefied biogas (LBG) infrastructure. As stated by them, the current production of biogas is largely compressed biomethane (CBG), although there is increasing demand and interest in liquefying biomethane, which can be further supplied to the heavy transport and maritime sectors. The significant investment cost of liquefaction facilities and uncertainty about market demand have shadowed the decisions for large-scale investment and caused a significant delay in development. Production capacity constraints are also a primary concern according to the producers, as their digesters are already operating near full capacity, and they believe raw material availability and supply chain resilience will play a key role in deciding the future of biogas expansion.

Biogas producers expressed that regulatory uncertainty is creating hurdles for them as EU and national policies evolve and affect market incentives, taxation, and compliance obligations. While considering that Ostrobothnia has a very advanced biogas ecosystem, producers emphasize the need for long-term buyer contracts and policy stability to justify expansion. The biogas producers of Ostrobothnia that were interviewed also showed an interest in coupling hydrogen with biogas production, mainly through CO2 capture and methanation. However, this remains at the initial exploration stage. According to the interviewees, an online platform for biogas trading, securing supply agreements, and receiving real-time policy information could enhance business predictability and regional coordination.

The region of South Ostrobothnia has a close connection to agriculture and food production, with a strong emphasis on manure-based biogas and side streams from the food industry. However, the biogas ecosystem in south Ostrobothnia is also well established. Nevertheless, economic feasibility remains a significant concern for biogas producers of this region, particularly in ensuring that manure producers receive financial benefits from supplying raw materials. Further, many farms are reluctant to participate unless it is economically viable and does not add extra workload. Therefore,

transitioning from waste-based biogas business models, which previously relied on gate fees, to energy-focused biogas production presents a significant financial challenge.

Also, the interviewees identified the market as a critical issue, with market uncertainty disrupting business planning. Further, removing Sweden's distribution obligation caused a collapse in biogas prices, leading to hesitation around large-scale investments. However, there is growing interest in liquefied biogas (LBG) for heavy transport, and logistics companies are already testing biogas-fueled vehicles in the region. Nevertheless, stakeholders emphasized the need for long-term contracts, infrastructure development, and stable regulatory frameworks to expand biogas production and improve market confidence.

Comparatively, biogas producers in Central Ostrobothnia elaborated on facing significant regulatory and market-related uncertainties, making long-term planning difficult. Further, it explained that a key challenge is policy instability, as unexpected tax changes and shifting government support discourage large-scale investments in biogas production. However, many producers express concern over financial risks, especially regarding the viability of expanding operations without guaranteed buyers and stable pricing mechanisms. Despite these constraints, there is a significant desire to boost production for transportation fuel uses, notably compressed biogas (CBG) and liquefied biogas (LBG).

Also, the high capital investment required for liquefaction infrastructure is still a high obstacle. However, producers emphasize the need for a cooperative framework in which multiple stakeholders collaborate to balance supply and demand, improving market access and resource allocation. Further, nutrient recycling and digestate management are becoming crucial, with increasing demand for practical solutions for biogas byproducts. Therefore, to enable these advancements, producers underline the significance of long-term contracts, improved logistics infrastructure, and a centralized marketplace to connect buyers and sellers efficiently.

Component	Title	Description	Interview Extract
Challenges	**-Regulatory Uncertainty and Policy Complexity**	Frequent changes in laws and regulations create a challenging environment for planning and investments.	"It is a very regulated sector, and the operating environment of the time such a change-sensitive; it is the regulatory change, which takes place in so many different fields, starting from the transport sector and the agricultural sector and environmental legislation and sustainability legislation."
	-High Capital Expenditure and Economic Feasibility	Significant costs and financial risks associated with building new plants and expanding operations.	"It takes some years for you to use your production facility fully. The business goes some years in the red numbers."
	-Scaling Production and Capacity Constraints	Small-scale production and the limited capacity of digesters are obstacles to meeting market demand.	"The gas supply would be small-scale since it is currently farm production. "The digesters are too small. We cannot feed them much more."
	-Infrastructure Development and Logistics	Inadequate infrastructure for transporting liquefied biogas and connecting production to consumers.	"Developing the infrastructure to liquefy biogas for heavy-duty vehicles and the maritime sector." "There is an interest in receiving AIV fodder or, for example, fat waste suitable for biogas production if needed. In that case, the raw material should be reliably available."
Needs	**-Stable Buyers and Long-Term Strategy**	Emphasizes the need for a stable market with reliable buyers to ensure the viability of biogas production and encourage expansion.	"There is a need for reliable buyers for the gas. Additionally, a long-term strategy should be planned for production so the producer can dare to expand operations if necessary."
	-Reliable coordination and partnership	Calls for consistent and supportive coordination that fosters growth in the biogas sector and stabilizes long-term investments.	"The main benefit for us if you see with other companies in the value chain is to look for newer technical solutions and find new business opportunities."
Risks	**-Economic Viability of Expansion**	Discusses the financial risks of expanding biogas production without guaranteed demand or regulatory support, making investments uncertain.	"Unexpected taxes may be imposed on biogas operations, which do not encourage maintaining the operations. There is little trust that the government, which changes every four years, will support growing or maintaining operations." "At one point when the distribution obligation was finally reached - that it was going to be a good thing, and that the plants would start up now, and in Europe, we were going in the same direction, and prices were good and high, but then these aforementioned challenges also caused prices to collapse."

	-Market Fluctuations **-Financial Risk**	Describes the risk of market oversupply and price collapses due to external factors such as changes in international regulations and market growth, which can significantly affect business.	"The changes to Sweden's distribution obligation, which has had a significant impact on the energy market here in Europe and in Finland, because it has largely been Neste's biodiesel and HBO that has set the price for the ticket, and when Sweden dropped its obligation, then we suddenly had an oversupply in the market quite significantly, which then collapsed prices."
Expectations	**-Improved Logistics for Biogas Transport**	Anticipates that improvements in logistics infrastructure for liquefied biogas transport will help overcome challenges, especially for long-distance transportation and large-scale use.	"Different operators would do more because it kind of helps each other, that the transport companies then get a safer feeling, that if they commit to something in our direction, then they know that, well here now the world does not end, that then there is another station here or there."
	-Information and Compliance Tools	Expectation for platforms to provide information, especially on changing regulations and compliance needs.	"Information is always to follow up on the legislation's change in that it takes one person's time if you try to keep yourself updated on everything."
	-Effective and Reliable Governance of Platforms	Expect a digital platform to be effectively governed and maintained, offering consistent benefits and ensuring operational reliability.	"The ownership structure of the platform itself does not matter as long as it can be ensured that the operation is reliable and functional."
Opportunities	**-Market Expansion**	Potential to scale production and enter new markets, mainly through biomethane liquefaction.	"The long-term goal is definitely to liquefy biomethane. If we consider this platform, it could be used for handling centralized liquefying units, either connected by gas pipes or by transporting gas in containers and trucks, and then selling it to filling stations or the maritime sector."
	-Collaborative Networks for Biogas Production	Describes the potential for cooperative models and collaborative networks to facilitate biogas production and distribution, improving market access and resource allocation.	"The most profitable model for biogas production is seen as a cooperative model, where trading is organized among many parties."
	-Circular Economy and Nutrient Recycling	Highlights the opportunity to create synergies between energy production and nutrient recycling, offering agricultural waste management solutions while generating renewable energy.	"Our biggest interest is the greenhouse gas emission reductions from manure - I mean, reducing emissions from manure storage is the one major, then these nutrients -To be the actor that balances the possible phosphorus surpluses in the deficit area, to be the one that also partly manages the logistics." "Biogas plants could play a role in the hydrogen economy by cost-effectively utilizing CO2 compared to other methods of CO2 collection." "The raw materials are primarily produced in the farm, i.e., slurry and solid manure + surplus fodder. There is an interest in receiving AIV fodder or, for example, fat waste suitable for biogas production."

Enablers	**-Supportive Legislation**	Stable and supportive legislation would enable long-term planning and investment in the biogas industry.	"If you look at politics and the four years, It does not always come with new laws, and the next group of politicians changes them, so there should be more long-term regulations and programs."
	-Collaboration Across the Ecosystem	Emphasizes the importance of collaboration with various stakeholders, including farmers, logistics companies, and biogas producers, to create a more integrated and efficient ecosystem.	"We have a lot of transport companies in both companies already; we have contracted partners in a certain way, and we have a way this ecosystem is largely in our own hands."
	-Digital Platforms	Platforms could enable efficient sharing of regulatory updates, logistics coordination, local interactions, marketplace listing raw material procurement, and compliance requirements.	"It could help us in a new and unfamiliar area. A platform might help." "Platform could serve some purpose, but I see it more as a mass balancing system."

Table 5 Interview Analysis Framework (Biogas Producers)

6.1.3 Biogas Distributors

We have also communicated with quite a few biogas distributors from different regions. However, we only succeeded in interviewing one of them, which somehow identified their domain's main challenges and key needs within the biogas ecosystem. The insights from these interviews were then analyzed and categorized to develop a comprehensive framework that highlights the challenges, needs, expectations, risks, opportunities, and enablers. This framework helped us to understand the practical areas within the biogas sector and key points where support and development are required. The consolidated framework we developed from the interviews with biogas distributors is shown below in Table 6.

Biogas distribution is an important link between producers and end-users, but interviews with distributors identified that they face unique challenges that influence biogas businesses' scalability and financial viability. While investment costs, regulatory constraints, and supply chain sustainability are typically recognized issues, municipally owned distributors explained that they must overcome one additional hurdle: bureaucratic delays in decision-making. Unlike private enterprises, municipal distributors need political approval processes, which can slow infrastructure development, investment planning, and day-to-day decision-making. This added complexity affects the ability to respond to market demands efficiently and discourages the cultivation of biogas as a viable energy alternative. Further elaboration on the key insights from the interviews with biogas distributors are discussed in detail in Table 6

Component	Title	Description	Interview Extract
Challenges	**-High Investment Costs**	Highlights the challenge of high costs associated with building biogas plants, pipelines, and other infrastructure, particularly given recent increases in construction costs and interest rates.	"We have planned to build our biogas plant shortly. However, when the Ukraine crisis arrived, all the construction prices went up, as did the interest rates, so we had to postpone it."
	-Seasonal Demand Variability	Describes the difficulty of balancing biogas production with seasonal fluctuations in demand, particularly with higher use in winter than in summer.	"The problem is, of course, the use of biogas is much higher during winter than during summer."
	-Dependence on External Suppliers	Discusses reliance on external suppliers like Jeppo Biogas, which creates challenges in ensuring consistent gas availability during high-demand periods.	"A couple of days, we used large quantities of gas, so it was a little bit difficult to deliver it, and their production was close to maximum."
Needs	**-Efficient Logistics and Infrastructure**	Emphasizes the need for better logistics and infrastructure solutions, such as pipelines or alternative transport methods, to distribute biogas more effectively.	"For the moment, I think we have three different enterprising or four enterprises using the biogas we built 11 kilometers of this pipeline to serve our customers."
	-Farmer Engagement for Raw Material Supply	Highlights the importance of involving local farmers in the supply chain to provide raw materials for biogas production, mainly grass and manure.	"If we should build our biogas plant, then we need to have a lot of farmers involved because the biogas plant we are planning for would mainly use grass as raw material for this production in a mix with also manure from milk production since in our region we have a lot of milk producers."
Risks	**-Regulatory Constraints**	Discusses the challenges posed by municipal decision-making and regulatory constraints, which can delay or complicate investments in biogas infrastructure.	"It is a little bit difficult when you work in an enterprise under the municipality because you need decisions from politicians."
	-Sustainability of Local Supply Chains	Highlights the risk of long-distance transport undermining the sustainability and efficiency of biogas production.	"I do not like the big plants because then the transportation will use a lot of the benefits you otherwise would have."
Expectations	**-Promoting Local Circular Economy**	A strong focus on establishing a local circular economy, with biogas production integrated into the agricultural ecosystem.	"They provide the raw material for gas production, and instead, they get fertilizer from the reject from the biogas plant."
	-Collaborative Efforts for Scaling Production	Highlights the potential to strengthen local energy security by focusing on small-scale, regionally distributed biogas plants that minimize transportation needs.	"We have been discussing a subject close to this and also to build gas pipelines together with other stakeholders, but since the investment costs are a little bit too high."
Opportunities	**-Local Energy Solutions**	Offering fertilizer as a byproduct of biogas production creates a win-win scenario for farmers, encouraging their participation.	"I see the local circular economy; people also think bigger circles. However, for me, local, sustainable, and energy production is the main thing."
	-Development of Biogas usage for Transport	Describes the potential for increasing biogas use in transportation, particularly for cars, to stabilize demand and strengthen the economic viability of biogas operations.	"What is most important is perhaps increasing the use of biogas for cars since that would strengthen our economy considerably and allow us to make this investment."

Enablers	**-Supportive Legislation**	Stable and supportive legislation would enable long-term planning and investment in the biogas industry.	"If you look at politics and the four years, It does not always come with new laws, and the next group of politicians changes them, so there should be more long-term regulations and programs."
	-Digital Platforms for Collaboration and Resource Sharing	Stresses the need for platforms that bring together stakeholders in the biogas value chain, facilitating cooperation, resource allocation, and efficient supply chain management.	"Since there are also other stakeholders who would build biogas plants around, then it could be useful to have up some form of platform to use the most efficient way to find the raw material."
	-Involvement of Municipalities and Public Sector	Highlights the role of municipalities in supporting biogas projects through infrastructure investments and decision-making processes.	"If we see a solution for a decision to be made, but we cannot do it because we need to have it in line with what our municipality says before we can make the decision."

Table 6 Interview Analysis Framework (Biogas Distributors)

6.1.4 Raw Material Providers

We have communicated with plenty of key raw material providers(farmers) from all three regions of Ostrobothnia. Our primary target was to identify and incorporate their demands and key needs, as they are an essential part of this biogas ecosystem. A few interviews (with food processors, farmers, and food producers), especially from the South Ostrobothnia region, were conducted because this hub mainly aims towards food systems. These interviews were then analyzed and categorized to develop a comprehensive framework highlighting the challenges, needs, expectations, risks, opportunities, and enablers. This framework helped us to understand the practical areas within the biogas sector and key points where support and development are required. The consolidated framework we developed from the interviews for biogas raw material (feedstock) providers is shown below in Table 7.

While the detailed analysis is in Table 7, highlighting all the key aspects, the South Ostorbthnia region has a particular obstacle: the economic trade-off between manure sales and biogas production. Certain raw material suppliers, particularly poultry farmers, have found direct raw manure sales to be economically more beneficial than processing through a biogas plant under subsidy policies and market demand for untreated manure. This introduces a challenge towards enhancing the biogas feedstock supply in that economic incentives favor the direct selling of manure compared to utilizing it to produce biogas. This highlights the need for enhanced economic incentives, policy reform, and organized markets to encourage farmers to prioritize biogas over traditional manure sales.

Component	Title	Description	Interview Extract
Challenges	**-Hygienization of Digestate**	Highlights the challenge of managing large volumes of manure and digestate, especially when selling the byproducts, which requires additional processing and hygienization for compliance.	"One of which it is perhaps so from a practical point of view is this hygienization, that as long as we, of course, spread on our fields, so it is not really any problem, but then if we want to sell the digestate from us forward, so then it comes to the hygienization and it is again for us a pretty tough on farm-scale reactors."
	-Logistics Costs	Describes the availability of suitable feed materials as contingent on reasonable logistics costs. If the fees are too high, it could limit the types of feed they can utilize in their biogas plant.	"Logistics of it, so that it would be easy to see where and how and in what form it comes, and what kind of pre-treatment it requires."
	-Balancing Energy Production and Use	Highlights the difficulty in matching biogas production with the fluctuating energy demand for heating, especially during peak times when more energy is required.	"The production is steady all the time, but the momentary spike in consumption is such a challenge in this biogas."
Needs	**-Marketplace for Manure and Digestate**	Describes the need for a digital platform or marketplace where farmers can advertise and sell manure and digestate, enabling more efficient resource allocation and sales.	"We need to develop a kind of marketplace, a kind of manure market. So, in a way, it would be like a portal to which you could announce that "I have 1000 tons of chicken manure every year. Who will buy it?" and there would be a bit of an auction type."
	-Biogas synergy with organic farms	This highlights the need to access livestock manure in organic crop farms, which otherwise negatively impacts their yield. There should be synergy between the area where it is highly available and the one which does not have any.	"One of the biggest problems of organic farms is that they do not have access to the livestock manure; if you have a cow farm that produces its manure, then it benefits from that creation because it has that phosphorus available to it from another way. But then again, if you have only an organic crop farm, you have the problem that you cannot easily get phosphorus into the field, which reduces harvest levels and the organic's profitability."
Risks	**-Regulatory Hurdles for Hygienization**	Discusses the regulatory barriers associated with selling biogas digestate, which requires significant investment in hygienization systems to meet legal standards.	"Now that we are talking about avian flu and salmonella and what other animal diseases are still on the livestock side, they are, however, such moderately serious things, and that is why it has probably been one obstacle. It is probably one of the problem areas or kind of challenges in this manure market, this hygiene."
	-Economic Viability	Discuss the risks related to market fluctuations for manure and digestate sales, especially when there are limited buyers or transportation logistics that pose additional hurdles.	"At the moment, I can sell turkey manure untreated directly, and there is a reasonably good price for it. This has led to the fact that I put quite a little of the turkey manure into the biogas plant, and I sell it directly."
	-Improved Logistics	Expects that improved logistics infrastructure will make it easier to transport biogas and its byproducts, enabling the	"Logistics is a pretty important part when we talk about feed or then digestate, so they are such that it must be looked at the surrounding

Expectations		business to expand operations and sell more gas and digestate	area, where it could be sensibly put the digestate and nutrients, and of course then also the feed, so that it would be a reasonable distance to reach, that it is such a pretty local activity."
	-Expansion of Biogas Operations	Anticipates expanding the biogas plant operations once the infrastructure, such as a gas pipeline, is in place, allowing for steady gas production and distribution.	"We do have and, in fact, have had plans for a second reactor, but that will have to wait. Let's say there would probably be a reasonably good amount of feed from our back and surrounding areas, but we are now waiting for the gas pipeline to get here."
Opportunities	**-Circular Economy Solution**	Highlights the opportunity to use digestate to support circular economy principles, particularly by creating synergies between different farms and industries, such as organic farming and nutrient recycling.	"You have only a crop farm that's organic, you have the problem that you cannot easily get phosphorus into the field, But then this kind of crop market activity, because there is a little bit too much manure in a certain area, it could allow this profitability to develop in other areas where it is not available."
	-Potential for Expansion and Diversification	Describes the potential for expanding biogas production to process additional waste streams, including shelter-zone grasses and other biomass that can be turned into bioenergy.	"If you count the whole of Finland's protection zones and these kinds of natural grasslands and others where there are some collection obligations, they should be made into bioenergy."
Enablers	**-Collaboration with External Contractors**	Stresses the need for collaboration with contractors who can manage the logistics and hygiene requirements for transporting manure and digestate, ensuring a safe and efficient value chain.	"The logistics team must be committed to the fact that it knows the risks that it takes and it cleans and does, that it cannot be just anyone who does it, but it must be committed to the fact that it keeps hygiene levels in order when it rotates to farms and all."
	- Digital Platform Support	Stresses the need for a digital platform that connects biogas producers with feedstock suppliers and buyers and offers support with logistics and compliance, making biogas production more efficient and scalable.	"Yes, it would be quite an interesting platform, of course, that it would be able to see what is on offer and could then pick it up."

Table 7 Interview Analysis Framework (Raw Material Providers)

6.1.5 City Councils and Regional Representatives

For more clarification on the impact of the biogas industry on the region, it is important to have input from the local city councils and regional representation. We have communicated with multiple representatives from city councils, local bodies, and authorities from different regions, whether a small city council or a large municipality, to identify their main challenges and key needs within the biogas industry. The insights from these interviews were then analyzed and categorized to develop a comprehensive framework that highlights the challenges, needs, expectations, risks, opportunities, and enablers. This framework helped us to understand the practical areas within the biogas sector and key points where support and development are required. The consolidated framework we

developed from the interviews with City Councils and Regional representatives is shown below in Table 8.

However, before that, we will analyze region-specific observations from the interviews. The primary biogas issue in South Ostrobothnia is the lack of a conclusive national biogas policy and logistics problems that delay mass-scale utilization. Regional representatives indicate that regulatory uncertainty and slow government decision-making are delaying the development process, primarily regarding funding projects for biogas. Although various regional farms and projects already produce and use biogas, the sector requires expansion with enhanced infrastructure, such as distribution lines and refilling stations, for easy transportation and industrial applications. Energy security also takes priority, with calls from the authorities to use biogas in self-sufficient energy generation to reduce dependence on foreign fuel. The region also sees potential in integrating biogas production with an energy grid to allow supply and demand management flexibility. Economic feasibility remains a concern, with city councils urging stronger municipal and national policies to support local energy investment and encourage business participation in the biogas sector.

In Central Ostrobothnia, the regional development organizations and municipal councils place the strategic position of biogas as a key component of their energy transition strategies. The region has been developing biogas actively for the past four years, focusing on constructing an enabling environment through municipal and EU-supported funding. The key aim is to integrate agriculture, primary production, and regional industries into the biogas value chain to retain energy production within the region and stimulate economic benefits. However, challenges remain, particularly concerning regulatory matters, e.g., EU Renewable Energy Directives, which create uncertainty concerning using specific biomass sources such as fertilizer crops. Further, the high initial investment costs make large-scale biogas businesses dependent on external funding. The region aims to create a collaborative ecosystem involving local farms, businesses, and municipalities and leveraging digital solutions to optimize biogas logistics, resource coordination, and market transactions. Municipalities are also exploring incentives, such as zoning laws and procurement practices, for integrating biogas into district heating and transportation systems. Further elaboration on the interviews with the city council and regional representative is discussed in detail in the consolidated framework shown in Table 8 below.

Component	Title	Description	Interview Extract
Challenges	**-Lack of Clear National Biogas Policy**	Mentioned the absence of a national biogas policy, making it difficult to develop infrastructure and secure investment.	"We lack a biogas policy if I can be brief; at the national level, it is not there. In my view, at least in this region at the moment, there is not enough interest, let's say, on the part of national decision-makers to get involved in this development." "These national challenges, which we have with the progress of this biogas economy, that now, for example, even in transport use is focused on the electrification, and emissions are calculated from the end of the pipe, that is not seen as so important to promote this biogas economy at the national level."
	-Regulatory Uncertainty & EU Policies	Regulations on digestate use, EU Renewable Energy Directives, and manure management policies create unpredictability for biogas projects.	"(the regulation) does not harm the biogas operator as such, but it harms the waste facilities when it would be so convenient that they could be there at the same time because it is most uneconomical to make a small plant for a few tons, which cannot now be mixed then elsewhere. "Consider the regulatory and policy-related challenges we have right now in your Europe Union, whether on the farm or the raw material. The raw material producer is responsible for disposing of their manure. So, how are you going to be forcing this? Because right now, the producers are not willing to pay." "What has caused some concern is this EU Renewable Energy Directive two and three, and specifically whether, in a certain sense, for example, harvested from peat fields, so under what conditions it can be used."
	-Infrastructure and Logistics Limitations	Highlights the difficulty in matching biogas production with the fluctuating energy demand for heating, especially during peak times when more energy is required.	"We lack distribution stations, and if we could get a biogas receiving terminal in the area, and through that we would then be able to receive larger quantities of biogas, for example, and it could be used both in road transport and then in that large industrial area."
Needs	**-Cross-Municipal Collaboration**	Describes the need for collaboration between municipalities and sub-regions to support biogas infrastructure and logistics, ensuring a reliable supply chain for biogas production.	"It would give the message to those actors that things are worth taking forward. And that it would be such a structural part of the urban strategy that it would start from there. Of course, it could be that it would be a regional, municipal / city own, whether it is a resource wise, road map or what it would be, which would develop the circular economy and thus also the biogas sector in the region."
	-Political Will and Support for Local	Describes the need for stronger political support at the national level to promote	"It is the task of politicians at the national level to take all aspects into account in their policies, and I believe that these are

	Energy Solutions	local energy solutions such as biogas and ensure energy security.	important aspects of ensuring the security of supply by also managing the emergence of local innovations and local energy solutions." "We have also tried to follow what is happening in the sector and find new and different solutions that would enable even smaller farms to develop biogas, at least for their own needs."
Risks	**-Economic Viability and Initial Investments**	Highlights the economic risks of requiring significant financial capital to start biogas projects, while profitability may be uncertain without strong demand and supportive policy frameworks.	"This initial phase required financial capital, capitalization, and sacrifices on that side, but when the broader entity is brought to work, it is also able to take care of the economic viability of the matter." "Some have already received support for large plants so that then similar other plants so they should get (the money also), that they are in a similar position then there on the market when it comes to selling the final product forward."
	-Fluctuating Demand and Policy Dependency and Market Conditions	Discusses the risk of fluctuating demand for biogas, which depends heavily on national policies such as investment support, energy pricing, and promoting biogas as a transport fuel.	"Demand will arise from political decisions at the national level if we do not give a kick-start to the idea of starting and increasing biogas in some way more than just at the level of words, but only, it is quite difficult for us to start scaling up if demand does not arise, and if we have a problem with pricing policy or something similar." "The development of the distribution obligation and such government decisions, so, of course, they can at some point be quite a big deal, but right now, the market is still so small, even though we know that there is a lot of demand and there is a lot of production potential, these are not yet in the right level and the right quality of balance."
Expectations	**-Economic Boost for the Region**	Expect biogas to bring significant economic benefits to the region by reducing energy costs and retaining energy spending locally.	"If by the end of this decade, even half of that amount could be produced by local, regional renewable energy systems, which includes all kinds of things, but that biogas has a very important role in it, that it then means that the regional economy will have new money." "At least in regional economic terms, it has a broader significance in that it can replace the fuels we import, but it also brings more profitable operators into the regional economy."
	-Municipal Support for Biogas Use	Anticipates municipalities supporting biogas use by integrating it into public services like waste management and school transport, which can help create demand and support local biogas plants.	"The municipality can direct its procurement in such a way that gives even better points to the operator who uses biogas as a transport fuel for school transport or something like this where it would be very well suited."
	-Promoting Network Ecosystem	Highlights the opportunity to use digestate to support circular economy principles, particularly by creating synergies	"The ecosystem that is created would be open in some way so that it would also enable international partners to join in so that we

Opportunities		between different farms and industries, such as organic farming and nutrient recycling.	would form an interesting area, that this would not be done through individual things." "The cooperation between municipalities also comes because then we are already talking about pretty big things if we talk about energy networks or things like that, so yes, it may be worth thinking a little more broadly."
Enablers	**-Digital Platform for Public-Private Cooperation**	Stresses the need for a digital platform that facilitates cooperation between public and private stakeholders in the biogas sector, streamlining operations and ensuring efficient management of resources.	"Developing a digital platform of this kind, for example, because it could really bring about this cooperation and networking, which would then enable closer cooperation, exchange of information, innovation and the spread of best practice."

Table 8 Interview Analysis Framework (City Councils and Regional Representatives)

6.2 Findings from interviews: A synthesis

The findings from the interviews identified key concepts regarding the functioning and development of the biogas industry. While each stakeholder interprets the ecosystem differently based on their domain, this analysis provides a solid foundation for understanding the industry's growth hurdles. It is important to address the specific challenges and opportunities highlighted by each stakeholder to scale up and enhance this sector. We identified several critical issues that need to be resolved for the ecosystem to thrive as part of the research agenda. While some obstacles are essential and need urgent action, others can naturally go away as the ecosystem around the biogas platform develops. Growth and sustainability in the sector will be promoted by carefully addressing these factors. Focusing on each domain actor's perspectives, turn by turn, helps us to understand their future vision towards this industry in depth.

Concerning the biogas user, the most significant challenge relates to the high conversion cost of switching to biogas fuels compared to other heavy fuel options. Due to its limited access and production of biogas, despite its vast use potential, it is 4x times more expensive than other fossil fuels. A significant obstacle for biogas users is the lack of infrastructure for transporting biogas (compressed or liquefied). While local biogas producers may exist in different areas, delivering it to consumers remains a significant challenge. Primarily, this is because the industry is still developing, and no concrete transportation infrastructure (such as pipelines, specialized trucks, or gas stations) exists. Another hurdle is maintaining high-quality standards for industrial applications, as most small biogas producers cannot meet this quality requirement due to infrastructural and technological limitations.

However, industries must ensure the use of fuels that comply with EU ETS Requirements, EU ESG regulations, and EU sustainability goals targeted for 2030. However, challenges like reliable supply, sourcing biogas, limited market awareness, investment uncertainty, and regulatory requirements exist, but they could be quickly resolved once this industry scales up.

DBH can cash in on the opportunities identified by the stakeholders to fulfill their needs. For example, Stakeholder engagement will solve the requirement for raw material supply. As more suppliers will be a part of the DBH platform, provide more user options. Collaboration across the value chain, including logistics, transport companies, and biogas producers, will minimize the demand-supply variations, ensuring a stable supply. It will eradicate logistics inflexibility as these transport companies uptake sustainable fuel usage, such as liquified biogas, storage, and transportation. Vertically integrating other byproducts related to biogas, such as hydrogen and CO2 utilization, will help develop new markets and provide opportunities to expand biogas' usage, increasing the market demand for biobased products. Leveraging technological innovation to improve biogas production and efficiency will determine the necessity for a consistent, high-quality supply that meets biogas user operational and regulatory standards.

Although certain risks related to economic viability, market competition, regulatory uncertainty, and high investment costs shadow the decision power of the biogas user, they expect that future development and adaptability will change the fate of this industry if circumstances change quickly. Biogas users also anticipate the evolution of the biogas industry if key focus areas like efficient logistics, practical solutions, sustainable practices, digital platform services, regulatory support, and infrastructural growth are executed and implemented successfully.

DBH platform could bring together the gas producers and buyers by offering them important features like real-time producer information, logistics coordinates, and geo maps, which would enable their potential to advertise their needs and get offers. A few more enablers could boost this industry development, such as collaborations among small and medium-sized producers with large industries, a supportive regulatory framework, strategic alliances, local distribution support, etc.

Biogas Producers play a centric role in visualizing the biogas industry dynamics. Addressing their challenges would highly support the evolution of this industry. The biggest challenge faced by the biogas producers in Finland is the significant gap between current production and potential due to

its small scale. The root cause of this challenge has multiple sub-dimensions, such as capacity constraints, infrastructure underdevelopment, technical feasibility, and financial and economic barriers like high investment costs. While these are not just the challenges, they are dealing with now. At the macro level, regulatory uncertainty and policy complexity have also created hurdles adhering to risk associated with large-scale investments in biogas projects. Ensuring a steady and reliable supply of raw materials for biogas production while maintaining sufficient demand for the produced gas requires aligning the sourcing and demand variation. These variations entail the limitations of transportation infrastructures and dependence on small-scale farm-based biogas production, which struggles to meet significant demands or expand without external support.

The opportunistic evaluation of the interviews with the biogas producer explains how capitalizing on their need will solve the problems of this domain within the biogas industry. Collaboration within the industry with other stakeholders for scaling production and sharing resources will facilitate biogas production's reliable supply and viability. It also encourages the expansion into transporting (compressed and liquified) biogas while stabilizing the market with trustworthy buyers. This long-term strategy will foster the circular economy principles, providing solutions like manure management, nutrient recycling, low-emission products, and sustainable energy production while ensuring economic and environmental benefits for the agricultural sector. Expanding stakeholder engagement throughout the value chain, including a local network of feedstock suppliers, customers, and distributors, will support business growth and provide cooperative opportunities for long-term planning and investments. As the market matures, issues related to standardization and certifications will be mitigated relatively.

Although risks like economic instability, market uncertainty, high capital expenditure, financial risk, technology uncertainty, profitability fluctuations, and limited market development and access exist in the stakeholder’s expression, certain expectations enlighten their interest to think brighter for the future. One of the significant expectations is the strategic use of a digital platform for collaboration and innovation, which means the platform would offer services like a marketplace for trading products and access to information regarding regulations, compliance, subsidiaries, technical solutions, and investment opportunities. Expansion of production facilities and market growth anticipate an increase in biogas production shortly. Integrating biogas into the transport sector implies that

liquified biogas will play a key role in the heavy transport and marine fuel market as it can quickly meet distribution obligations and environmental targets.

Adherence to government regulations and standards will enable the success of this industry while stable long-term partnerships, including joint ventures and collaborations among stakeholders, will drive biogas growth. The DBH platform could unite these stakeholders by supporting local interactions, leveraging key services like marketplace listings, and facilitating the movement of raw materials (feedstock) and byproducts through logistics coordination. DBH platform can be a trustworthy partner providing necessary updates relevant to its users.

In concluding the biogas distributor's interview, the challenges experienced by these parties are similar to what we mentioned above, except that the two major hurdles for them are engaging the local farmers, which is necessary for a reliable supply chain, and seasonal demand fluctuation, which disrupts the smooth flow of distribution operations. Expanding biogas operations may need much investment that calls for financial stability. Using biogas for transportation may solve the question of a reliable supply chain. Still, it must be considered that local parties that provide raw materials should be compensated accordingly (offering fertilizer as an alternative), enhancing the possibility of introducing circular economy practices in the regions. Due to uncertain forecasts, enterprises working under local or regional authorities are reluctant to invest heavily in infrastructure. They merely see the region's future prosperity as increasing infrastructure (pipelines, gas stations, transportation) that will only benefit the large corporations, jeopardizing the rights of small and medium local players. Besides, they believe increasing collaboration among regional stakeholders will benefit the local agricultural ecosystem and establish a circular economy. According to them, localized biogas operations and supply chain initiatives are more sustainable and efficient options as they minimize transportation costs.

Raw material providers serve as the backbone of the biogas industry. Advancement in the application usage of biogas cannot be done unless the obstacles these raw material providers experience are solved. Several challenges were identified while interviewing them. One of their biggest challenges was managing manure and organic waste economically and logistically for biogas production. Farmers mentioned that selling untreated manure or putting it in the digestate directly and using it as fertilizer afterward is more profitable than running it through a different process for purification

and hygienization. This is because subsidies or permits to sell treated materials are usually difficult to secure.

Despite these challenges, different potential opportunities can help fulfill these actors' needs. For example, using the manure and residue of crops to produce biogas not only facilitates the energy consumption of those farms but also helps the remaining byproduct after the gas is produced be used as a fertilizer. A digital marketplace could resolve their need by offering key services like trading feedstock, digestate, and biogas. One of the interviewees mentioned that a “manure marketplace” could reshape the fate of feedstock providers as animal farms with access supply of manure can connect with different buyers (biogas producers or crop farm owners lacking livestock) to trade their products efficiently to produce biogas and ensure sustainably to boost the soil fertility with the manure used after the digestate.

Regulatory and financial uncertainties make it difficult for the raw material provider to have complete information about subsidy policies and rules for handling and treating materials. In addition, they are concerned about contamination risks that may spread diseases like avian flu, swine flu, salmonella, etc. Due to the high standard of hygiene, it is difficult for them to handle and transport their raw material effectively. The lack of regional infrastructure makes scaling difficult, and many providers are reluctant to invest until the right support system is introduced.

On the other hand, farmers believe that if the investment is made in the infrastructure (local gas pipelines, centralized biogas networks) and the right support system (policies, subsidies) is introduced, then their problems can be resolved. They also expressed that a digital platform like DBH will make a difference by connecting them with buyers or facilitators who could fix the raw material handling problems. Localized initiatives to resolve the issues of these raw material providers are more sustainable, driving the growth of the circular economy in the sector.

Lastly, the development of the biogas industry is not fully scaled until the input of the city councils and local bodies' municipal authorities is considered. According to them, the most significant obstacles are weak national policies and uncertainty, which stop investors from investing in biogas projects. Different regulations, like the EU renewable energy directive (RED II and III), digestate use restrictions, making it difficult to start new projects. Another obstacle to adequate finances and funding options is that small farmers and businesses struggle with high start-up costs. Stakeholders also

identified the lack of biogas distribution networks, refueling stations, and efficient supply chains, especially in rural areas, as a cause of the slow scaling of this industry. Challenges related to the technological gap also make it difficult to produce better small-scale biogas, develop better nutrient recovery systems, and improve integration with municipal energy grids.

Despite these challenges, they mentioned many opportunities to expand biogas usage in the regions. One of these is that city councils and municipalities can increase biogas utilization in district heating, public transport, waste management, etc., helping to minimize carbon emissions and dependency on fossil fuels. Policies like public procurement can incentivize biogas adoption by prioritizing biogas-powered vehicles and services, which will, in return, allow farmers and small businesses to benefit economically and have additional revenue streams while reducing their operational costs. Furthermore, it will ensure the utilization of organic waste for energy production and convert the digestate into value fertilizers with higher yields, contributing to sustainable circular economy practices. Stakeholders also believe that liquified biogas (LBG) will be a game changer to revolutionize the industry and heavy transport applications.

However, they expressed several risks along with the biogas potential that need to be addressed to expand the biogas industry successfully. Economic issues that might significantly impact the financial feasibility of investing in the execution of biogas projects include shifting energy costs and market demand. Uncertainties in regulations and changing legislative objectives might also cause delays in investment choices. Technological and logistical risks, such as ineffective storage and transportation, can affect the supply chain's stability. Policies, investment incentives, and enhanced regional collaboration are required to mitigate these risks.

The stakeholders have also stated their future expectations clearly. They demand national policy interventions to ensure biogas projects have long-term stability and funding. They demand interregional collaboration for efficient supply chains and coordinating regulatory processes, better refueling stations, incentives for infrastructure and equipment, and stable pricing systems, which the producers and consumers require. Consequently, they want more open incentives for shifting to fuel and heat products from biogas.

Lastly, they illustrated how unlocking the full potential of biogas requires specific enablers to be put in place. A clear national biogas strategy, streamlined national permitting procedures, and the

coupling of national energy transition programs in short policy and regulatory support are required. They are urging for a mechanism of investment, such as municipal funds, European grants, and public-private partnerships, which will help to bridge most of the financial gaps. Moreover, infrastructure development, including new biogas fuelling stations and other transport networks, and integration into existing energy grids are necessary. Advances in production technology for biogas, nutrient recovery, and digital monitoring systems bring about even more efficiency. Finally, they ask for community engagement and knowledge-sharing initiatives to drive local uptake so businesses, farmers, and municipalities all speak the same language about the benefits of biogas.

6.3 Workshop Results

Below are some results gathered during the iterative and collaborative workshop held in the three regions of Ostrobothnia. Each region has its unique findings and proposed solutions based on the participants involved in the workshop. The region-specific results and findings are detailed below.

6.3.1 Ostrobothnia Workshop

The first workshop, which took place in Ostrobothnia, laid the foundation for a collaborative concept in which different stakeholders contributed by discussing possible scenarios and brainstorming key functionalities that could be part of the DBH platform. Multiple activities were carried out to reach a consensus, considering that each stakeholder had specific needs and challenges. After several discussions and interactive sessions, the respondents and participants of the workshop finally agreed on the top five highest-priority digital services to be included in the DBH platform. However, it was not just about listing names; it was also about discussing the implications of how these services would serve the cause and benefit specific stakeholders. This is illustrated in Table 9, which describes the highest-priority digital services and functionalities identified in the Ostrobothnia workshop.

Name of service/ functionality	Description of service/ functionality (2-3 bullets)	To whom creates value	What kind(s) of value?
1. E-Commerce	• Bidding (Buying & Selling) Marketplace • Seller provides info on the amount, location, price (short term), Reliable supply network, and availability of knowledge. • Buyers can indicate the price they are willing to pay Optimized Price • Forecast & Data visibility (long term)	• Buyers • Sellers • Platform Owners	• Time-Saving • Ease of Selling/buying • Reduce Uncertainty • Price Optimization
2. Community	• Attracting a broad base of stakeholders/users of the platform Scaling • Small Memberships Fee Business Model • Peer-to-peer interaction through info and "social media Channel" functions Chatbot. • Possibility to create own API's 3rd party developers	• To all users • Network Effects	• Increases business opportunities for users • Increase the value of the platform for the platform owner
3. Quality of Products Sold	• Guarantee of Origin (GO) or Digital Product Passport (DPP) sustainability and regulations • Blockchain? How to Improve the Operation and Process Efficiency • Verifying product standards through the value chain • Verification and validation Audit certifications • International standards quality filter settings	• Buyers • Sellers	• Security of Product Quality • Reduces risk of conflict
4. Security	• Cyber security of digital platforms strongly identifies verification. • (cyber) Security of physical plants/infrastructure premium or registered members could have access to data • Alarms report/functions information and treat backup plans	• Buyers • Sellers • Society	• Trust • Reduces risks • Transparency
5. User Experience & Interface (UI/UX)	• Map Function geo-mapping of key stakeholders and total info about their facility, capacity, and demand. • Open API new developers access to add features • User Friendliness (AI use) Games, etc., so that users can spend time on a platform	• All Users	• Flexibility • Tailor-made to different needs • Learning

Table 9 Description of Ostrobothnia Workshop Highest Priority Digital services/functionalities

Central Ostorbothnia stakeholders also identified the priority-wise digital services /functionalities, as shown in Figure 3. Within the Ostrobothnia region, must-have features listed by the stakeholders were mainly emphasized on real-time biogas monitoring, price transparency, and quality control. Stakeholders demanded a system for tracking biogas production and carbon footprint statistics to provide enterprises with up-to-date environmental impact reports. Price transparency and product quality guarantees also featured highly among the stakeholders calling for a bidding platform and certification program to guarantee biogas origin and quality standards. Regulatory and security expertise were essential, allowing companies to operate safely and within national and EU policy. The workshop mindset here was innovation-driven, prioritizing technological advancement, predictive analytics, and digital integration for greater biogas industry efficiency.

The functionalities considered important in the DBH platform by the participants include logistics and supply chain coordination, enabling companies to streamline transportation and optimize feedstock utilization. Artificial intelligence-powered data analytics and long-term forecasting were also proposed to enhance operational effectiveness and investment planning. A digital networking platform was also seen to bring together distributors, producers, and consumers, facilitating collaboration and information exchange. Additionally, a digital networking platform was seen as a way of uniting producers, distributors, and consumers, leading to cooperation and information sharing.

For add-on functionalities, stakeholders proposed educational materials and consultative services to enlighten businesses regarding biogas laws and best practices. The participants also proposed investment analysis facilities to help businesses analyze costs, risks, and potential earnings before making heavy investments.

Figure 3 Ostrobothnia Priority wise Digital services/functionalities

6.3.2 South Ostrobothnia Workshop

The second workshop built on the efforts of the first workshop, with a greater emphasis on defining the collaborative strategy for the DBH platform services and functionalities. In this workshop, a diverse group of stakeholders communicated and engaged in discussions, scenario construction, and exercises to clarify the essential digital services required. These workshop activities were designed to ensure all inputs were considered and address different participants' varied priorities and

challenges. Through several rounds of discussion and deliberation, participants prioritized the top five significant digital services that must be included in the DBH platform. The goal was not just to list these services but to highlight their implications in the real world, specifically, how they would benefit stakeholders and affect the overall functionality of the platform. The output of this workshop, namely the prioritized digital services and their descriptions, is presented in Table 10.

Name of service/ functionality	Description of service/ functionality (2-3 bullets)	To whom creates value	What kind(s) of value?
1. Verse/ Fraction Marketplace	• Tender service for random and homogeneous fractions (Quotations) • A simple portal for the customer (input provider) from logistics to bio gasification (Provider platform)	• The entire value chain	• Economic
2. Legal	• Ready-made contractual guidelines to facilitate trade (Templates) • A legal/current information package available (Information) • Contracts " written open" (Open Templates)	• The parties to the contract	• Ease and the problematic aspects of the contract
3. Station Location (Geo-Information)	• Up-to-date situation, e.g., about disturbances (Real Time Status) • Information on whether it can accommodate the type of transport equipment (HCT) (Heavy Container)	• Selling biogas plants • Station keepers (Operators) • Potential refuelers	• Predictability
4. Informa-tion and alert service	• A real-time system for procurement subsidies, etc., would facilitate the application process (updated information) • Also, for plant investments to make it easier to apply for subsidies (facilitation applying for grants)	• Those planning investments • Entrepreneurs	• Project management becomes easier
5. Inputs sustainability reporting	• The requirements of the bureaucracy are easily met, and the actors do not need to familiarize themselves more deeply (easy reporting, no briefer introduction)	• Smaller companies	• There is no need to familiarize yourself; the operation becomes more manageable, and time is saved.

Table 10 Description of South Ostrobothnia Workshop Priority Digital services/functionalities

South Ostorbothnia stakeholders also identified the priority-wise digital services /functionalities, as shown in Figure 4. In South Ostrobothnia, the key priorities were security, transparency, and infrastructure reliability. The stakeholders emphasized the need for an electronic marketplace where companies could trade feedstocks, biogas, and byproducts. Legal support through pre-formatted contract templates and a regulatory information system was also vital for facilitating trade. Security of physical plant and digital platform was also a priority, with the need for measures of cybersecurity, alarm systems, and emergency response plans. Sustainability reporting was also deemed a minimum imperative to meet environmental regulation compliance and gain credibility in the biogas market. Regional cultural orientation was business-oriented to a great extent, with priorities in market development, legal policy, and economic sustainability.

The stakeholders' important-to-have feature consent was mapping stations to provide real-time data on fuel availability, transportation logistics, and plant capacity. They also suggested an information and alert service to provide information on subsidies, investment prospects, and procurement guidelines, easing enterprises' access to finance. The other mandatory suggestions were standardizing contract tools to break legal barriers and improving coordination between stakeholders for efficiency in supply chain management.

For the nice-to-have functionalities, stakeholders suggested tools to minimize bureaucracy, such as easy-to-use templates for regulatory compliance. They also suggested a regional collaboration platform where different cities and businesses could share best practices and coordinate investments. Financial modeling tools were also considered helpful but non-essential tools to allow businesses to assess risks and plan investments.

Figure 4 South Ostrobothnia Priority Wise Digital services/functionalities

6.3.3 Central Ostrobothnia Workshop

The last workshop was conducted in Central Ostrobothnia, with more participants to gather insights and inputs. This session included representatives from all relevant domains, such as biogas users, producers, raw material providers, city council members, and regional representatives. The carefully planned and successfully executed workshop activities followed the same objective as the previous sessions: to identify the highest-priority services and functionalities that stakeholders from this

region wanted to be part of the DBH platform. Table 11 below provides a detailed description of the selected prioritized services and functionalities.

Name of service/ functionality	Description of service/ functionality (2-3 bullets)	To whom creates value	What kind(s) of value?
1. Map feature	• Operators can be identified on the map with different views • Executable information on a map of what is being searched for (e.g., distribution stations, biogas plants, pending projects, etc.)	• For all users of the service	• Information for buyers about, for example, where feeds can be found. • Visibility for sellers (additional sales) • Understanding the overall picture of ecosystems (regional councils and municipalities)
2. Raw material "feed" inputs • **Taxation** • **Optimization**	• All entities providing feeds have been compiled into the service. • Feed providers add their raw materials to the service	• Feed providers and processors	• Feed logistics improves • We can optimize the feeds. • Improve the homogeneity of the feed (proportions of dry and wet feed) • Improves the supply of feeds.
3. Gas Producers • **Basic info** • **Capacity** • **Gas quality**	• All gas producers brought together in the service (in production + projects that have passed the pre-clearance phase) • Information on what kind of biogas is available in the service (capacity and gas quality, location)	• For consumers and further processors • Primary producers (feed providers)	• Supply reliability (for biogas users) • Supports further processing investments • Information about potential partners for producers (feed providers).
4. Real-time production monitoring	• Through this feature, service users can follow biogas production in the area in real-time information on facility utilization. • Enables real-time carbon footprint monitoring (providing up-to-date information on which feedstocks the biogas is produced from)	• For all users of the service.	• Improve ecosystem optimization • The producer can verify, for example, how the manure is recycled. • Buyers of biogas can verify how much the carbon footprint has been reduced (Municipalities and regions)

5. Pricing/ Pricing Comparison	• The service provides information on the cost distribution of different gas qualities with a price comparison option	• For biogas buyers • Financiers • Investors • Biogas producers	• Promotes investment planning (refines cost calculations)

Table 11 Description of Central Ostrobothnia workshop Highest Priority Digital services/functionalities

Central Ostorbothnia stakeholders also identified the priority-wise digital services /functionalities, as shown in Figure 5. Central Ostrobothnia stakeholders consented to several must-have digital features for the DBH platform, which were considered necessary for the success of the biogas sector. Most important among them was real-time production monitoring, enabling users to monitor biogas production efficiency and carbon footprint information. The stakeholders also emphasized quality control and price transparency, which explains that introducing a pricing system that offers cost breakdowns and comparisons of varying biogas qualities in the digital platform will significantly benefit. Security systems, such as cybersecurity protection, alarm systems, and emergency response planning, were essential to safeguard physical facilities and the DBH digital platform. Besides this, sustainability reporting and regulatory guidelines were considered essential tools to assist businesses and producers with regulations. The workshop culture for the central Ostrobothnia was very data-driven, focusing on optimization, efficiency, and transparency in biogas production and market operations.

Besides the core services and functionalities, several important digital features were mentioned, which include logistics optimization to optimize feedstock transport and storage. AI-driven forecasting was suggested to allow firms to predict demand and optimize investments. A mapping system was also suggested to graphically display the locations of biogas plants, fuel stations, and feedstocks in supply, which enables producers and consumers to contact each other very quickly. Furthermore, a social network for community engagement was considered a means of encouraging cooperation among companies, governments, and investors.

Participants recommended educational resources, such as a biogas learning database and consulting services, as desirable extras. Software for investment analysis, including cost simulators and financial planners, was also recommended so that firms could assess the viability of biogas ventures. Although the stakeholders do not consider these traits a priority for immediate adoption, they believe they may have long-term benefits in improving decision-making and expanding understanding of biogas.

Figure 5 Central Ostrobothnia Priority Wise Digital services/functionalities

6.4 Findings from Workshops: A synthesis

Three interactive and collaborative workshops were organized in the three regions of Ostrobothnia. While the focus of each region differs, Central Ostrobothnia stakeholders expressed more focus on data-driven initiatives. The South Ostrobothnia stakeholders have a business oriental demand, while Ostrobothnia stakeholders demand innovative-driven measures.

Across Central, South, and Ostrobothnia, there were many shared priorities for the biogas industry among stakeholders. Foremost were security, transparency, and stability in pricing. Each region highlighted the need for strong cybersecurity measures, alarm systems, and emergency response plans for protecting digital platforms and physical facilities. Real-time production monitoring was also a paramount issue, allowing for tracking biogas production, quality, and environmental impact. Moreover, stakeholders concurred that price transparency and competitive bidding mechanisms must be established to ensure a stable and equitable biogas market.

Every region highlighted better logistics, forecasting, and data analysis as the most important features. All stakeholders considered AI-driven predictive models an effective investment planning and supply chain management tool. Station location mapping and feedstock optimization were also important, as they would help businesses and municipalities better plan storage, transportation, and fuel distribution.

Lastly, some features were a pleasure but did not have high-priority requirements. These included educational materials, planning for finance, and ease of regulatory compliance procedures. While these were not urgent needs, they would still support and contribute towards long-term business growth by helping companies make informed decisions and become better updated about biogas regulations.

6.5 Main conclusions: The platform, its design, and business model

The results from the workshops and interviews reveal how a digital platform such as DBH would play a central role in transforming the biogas industry through increased efficiency, transparency, and coordination among actors. For the platform to succeed, its design must integrate updated tools like production monitoring, price transparency mechanisms, security protocols, and regulatory

compliance mechanisms, as seen in the priorities across regions. AI-driven predictive analytics and logistics optimization tools would enhance operational efficiency, enabling stable supply chains and well-informed investment choices. The business model should have a marketplace-centric approach, enabling the trading of biogas, feedstocks, and byproducts with ease while incorporating financial modeling tools to help in investment planning. Additionally, enabling cooperation among producers, distributors, and consumers through networking features would create synergies for industry development. However, the platform must address regulatory complexities and geographical policy variations to gain broad stakeholder adoption. While must-have features must be marked for development on a priority basis, secondary tools like education and financial planning tools may be the long-term drivers of market expansion. Eventually, DBH may emerge as a fundamental enabler of the biogas ecosystem, driving sustainability, economic viability, and strategic growth through digitalization.

7 DigiBiogasHubs Platform: Design Principles

The previous chapters provide an overview of the three regional hubs and their interrelation with various stakeholders. They also describe the principles for platform design alongside a summary of the literature review, benchmarking exercise, interviews, and workshop analysis. Several design-related options for the DigiBiogashubs platform are presented, discussed, and assessed in this context. This chapter and the next chapter aim to present the proposed configuration principles of the DBH Platform. Figure 6 below is a schematic representation of each DBH Platform business model block, which will be discussed next in the following chapters of this report (based on Wortmann et al., 2024).

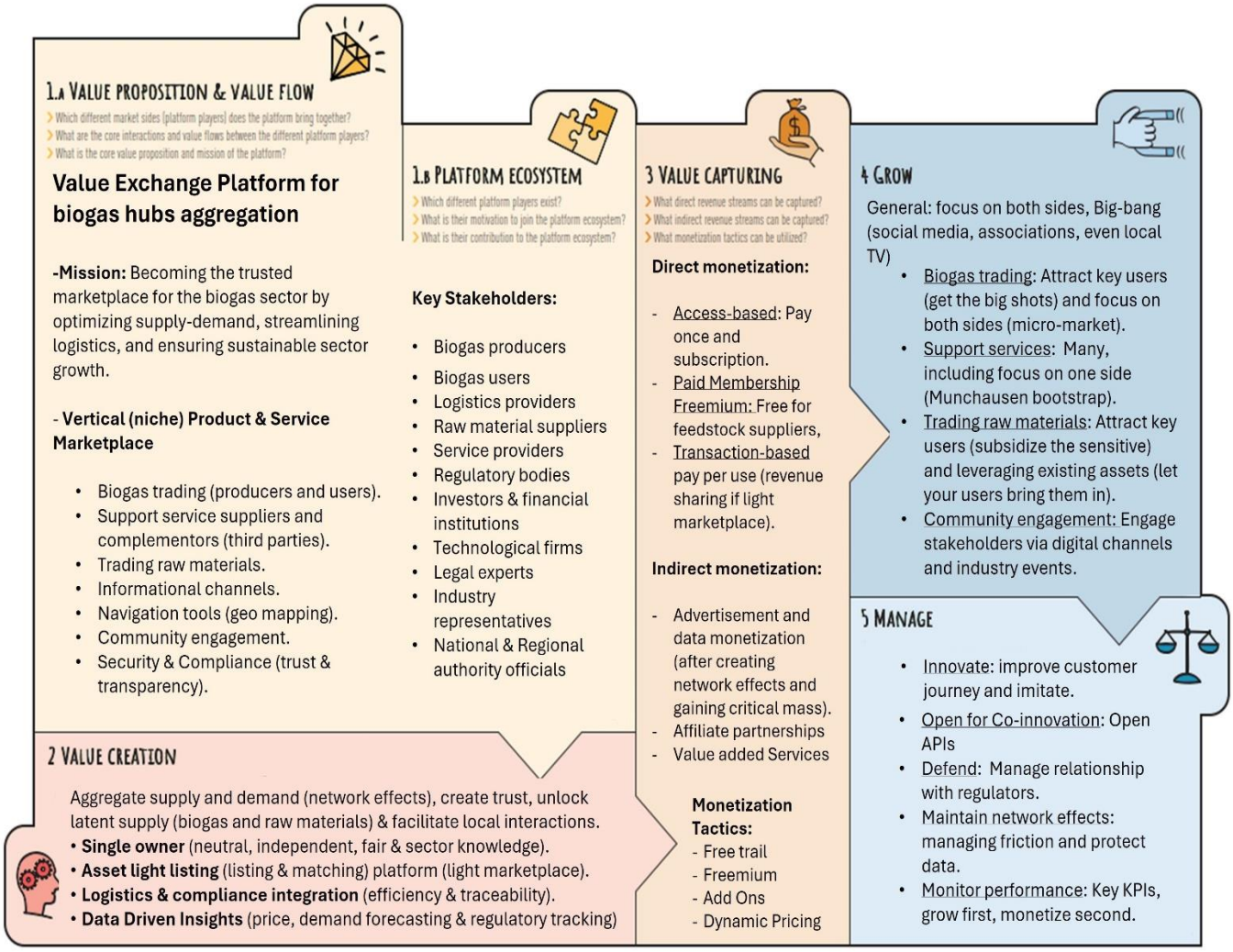

Figure 6 Brief Description of DBH Platform Business Model (Wortmann et al., 2024)

The DigiBiogashubs (DBH) platform is conceived as a multi-sided transaction platform or marketplace. (Cusumano et al., 2019). It means a digital infrastructure designed to facilitate matchmaking and transactions (a vertical or niche platform aiming to connect buyers and sellers in the biogas sector), orchestrating external resources and enabling exchanges between suppliers and buyers (Wortmann et al., 2024). A proper design must acknowledge a set of principles that cover different dimensions, such as an appropriate business model, including a compelling value proposition for each side of the platform (including guidelines concerning the revenue model and monetization strategies), and an operating model (including the ownership model) that outlines the platform's core value-creation activities (including the essential rules to facilitate interactions). Details for each of the above dimensions are presented below.

7.1 DBH Business Model

From an ideation viewpoint, and following the types proposed by Wortmann et al. (2024), the DBH platform may have two core and two secondary business opportunities: 1) Product marketplace, 2) Service marketplace, 3) Data harvesting platform, and, eventually, 4) P2P support platform(potential future expansion). While the core activities will be developed around 1 and 2, opportunities for 3 and 4 can also be considered and explored in later developmental stages (after the piloting Phase). Accordingly, following Parker et al. (2016), and based on the stakeholder analysis, the first step for identifying the requirements of an optimal platform's value proposition is understanding the core interactions and the value unit (and who creates this unit and how to attract them), one at a time, and then layering core interactions after individually identifying the features for making the engagement in each interaction attractive, thereby achieving a high volume of relevant core interactions.

7.1.1 Core Interaction and Value Unit

Based on the stakeholder analysis and the objectives of the DBH platform, we have identified three core interactions, which can be layered in the following order: 1) Biogas Trading, 2) Trading of support services (eco-system/value chain), and 3) Trading of raw materials. These interactions are summarized below in Table 12, detailing key participants, features, and value drivers.

Core I interactions	Description	Potential participants (Names or types)		Key features/requirements and value drivers	
		Suppliers	Buyers	For suppliers	For Buyers
Biogas trading	Trading Of Biogas between biogas producers, suppliers, and buyers	Stormossen Jepuan Biokaasu Pohjanmaan Biokaasu Oy Ilpo Wenström (Toholampi) Mty Klemola (Ullava) Uusi-talo Group (Kannus) Jukka Koskinen (Kaustinen) Atria	Wärtsilä Wasaline Westenergy Lifti Kokkolan energiaverkot Oy Hycamite TCD Technologies Oy Sibanye-Stillwater Keliber Yara Suomi Oy	Market access. Consistent demand. Network of potential Buyers. Logistics collaboration. Extended infrastructure (Pipeline, gas stations)	Quality Biogas, Different forms of Biogas (compressed, Liquefied biogas). Reliable supply. Sustainable resources to achieve target emission goals
Support services	Additional services that support and enhance biogas trading within the ecosystem	PK Biogas Wekas OY Rannikon Biokaasu Logistic companies	Wega Oy Biogas Traders Technological firm legal firms End users	value-added services (geo mapping) awareness of new technologies, legal requirements investment opportunities	Streamlined supply chain reduced operational cost compliance and legal information investment opportunities
Trading of raw materials	Biomass(feedstock) trading is used for biogas production.	Atria Finland Lakeuden Etappi Alamarttila Oy Viinamäen Farmi Oy Alangon tila Feedstock producers Food firms in primary production and food	Stormossen Jepuan Biokaasu Pohjanmaan Biokaasu Oy Mty Klemola (Ullava) Uusi-talo Group (Kannus) Suomen Lantakaasu Oy	Steady Revenue Stream long term contracts Reducing waste (circular economy principles)	Reliable supply of feedstock information about biomass availability Easy access cost-efficient production Sustainable resources utilization

		processing	Biogas Producer and Biomass trader		

Table 12 DBH platform: Key Interactions and Participants

7.1.2 Value Proposition Concept

Based on these core interactions, the platform's value proposition must align with the needs of multiple stakeholders to ensure successful adoption. As in most transaction platforms, the different sides in the platform will facilitate the trading or exchange of three things (Parker et al., 2016), which will be at the core of the value proposition for each stakeholder and ultimately impact each party's business model and the ecosystem's dynamics in terms of value co-creation, value capture, and value sharing.

1. Goods and/or services.
2. Information, and
3. Some form of currency (money or other intangible value).

Generally speaking, a value proposition is typically defined in traditional (analog) markets as a combination of products and services that a seller offers to a buyer to satisfy its needs. It refers to the unique benefits or how a product or service solves a customer's problem or satisfies a need uniquely in comparison to other value propositions in the market (Osterwalder & Pigneur, 2010). Therefore, an essential task for platform managers is ensuring alignment between the demands of all sides and the platform's unique value proposition. In other words, the platform's value proposition must be defined in a way that aligns with the needs of multiple stakeholders since the participation of all of them is a must to break the chicken-and-egg dilemma (how to attract all the needed sides simultaneously) and create the necessary network effects, or network economies, for the platform to succeed (Cusumano et al., 2019). Therefore, making participation and even role-changing easy through a well-designed digital infrastructure is critical (Wortmann et al., 2024).

From the platform design viewpoint, the value proposition may include the following characteristics to facilitate disruptive interactions. First, the DBH may establish a vertical platform (carefully

managed and curated to cater to niche-specific interactions in the biogas sector)[15] and facilitate local interactions (bringing people together to enable physical real-time interactions)[16]. This principle calls for achieving viable network effects and the challenge of gaining a critical mass in a local area as a fundamental success condition. Ease of use and seamless user journey are critical attributes for achieving this (Wortmann et al., 2024). Moreover, the DBH must unlock latent supply for some core transactions, such as trading raw materials, since they can stimulate the market of underutilized stock by providing the right incentives and conditions.

7.1.3 DBH Current(Pilot) Value Proposition

The primary purpose of building this platform is to make life easier for every stakeholder in the biogas ecosystem by simplifying biogas operations, by addressing key industrial issues, and by unlocking new opportunities for regional players.

So, in the pilot phase, the DBH platform includes Easy matchmaking to facilitate users such as biogas producers, biomass (feedstock) suppliers, and buyers, reducing transaction costs, time, and resources. It also provides Clear market insights with up-to-date information on feedstock availability, supply and demand, and pricing trends to enable smart decision-making.

A critical component of this phase is logistics, which has been identified as a significant challenge. The DBH platform aims to overcome transportation barriers by offering Logistics information and tools and connecting third-party logistics providers to ensure supply chain efficiency. However, it is necessary to define how it is implemented, as it can be done in different ways (quotation listed on the platform, supplier-organized logistics, user/buyer-managed logistics, or platform-facilitated delivery). The DBH platform will also offer easy access to regulation information, including laws, rules, subsidies, and technological advancements, which will benefit users.

7.1.4 Enhanced Value Proposition

In the longer term, the platform must follow a long-tail approach (one-stop-shop that involves many third parties) by adding more layers of core interaction to reduce transaction costs and aggregate

[15] For example, CheMondis (LANXESS) is a B2B marketplace for buying and selling chemicals. XOM Materials is a marketplace for industrial materials.
[16] A critical decision here is whether DBH will become a 'Wolt for X' or, instead, will allow logistics companies to be on the other side, engaged in the platform and listing their services there.

supply and demand for different products and services related to the biogas sector across regions (e.g., being open to adding more hubs in Finland) to enable network effects. Thus, DBH can focus on creating a complementor ecosystem in later developmental stages to extend the platform core and its basic capabilities, allowing some stakeholders to implement complementary models[17] (although this is a strategic decision and call for technological integration).

Adding new services as the platform grows will further enhance its value proposition. It will deliver added value through Data monetization, unlocking new revenue streams, such as advertising. AI-enabled technologies, including blockchain to ensure quality and tools like SCI and ERP, will help improve supply chain efficiency across the ecosystem.

These advancements will drive innovative features such as real-time market alerts, predictive analysis, and advanced forecasting, fostering smart decision-making. Comprehensive services, including legal support, expert advice, training programs, and certification services, will help users grow and meet compliance standards. Adding accreditation bodies to the platform will ensure quality and consistency across industries, fostering trust and promoting sustainable practices. By integrating these features, DBH will strengthen its core offerings and drive industry-wide adoption and sustainability in the biogas sector.

7.2 Understanding Value Creation/sharing/capture processes

In addition to understanding the value proposition, it is crucial to comprehend the processes of value creation/sharing/capture. Understanding how the platform creates, delivers, and captures value is vital to implementing the right incentives to encourage participation. Even if the platform could be conceptualized as a non-profit, it must cover its operations and costs. Moreover, engaging participants simultaneously on both sides of the different core exchanges described above is critical to breaking the chicken-and-egg dilemma and creating the necessary network effects. In doing so, it is necessary to consider that the demands on both sides of each transaction are interdependent (Evans & Schmalensee, 2016) and set aside some economic precepts that work in traditional business and subsidize one side to achieve network effects (Evans & Schmalensee, 2016; Parker et al., 2016). The

[17] For example, Amazon allows third parties to sell through the platform.

platform manager must explore innovative monetization strategies and insights into the decision-making process between alternative models.

7.3 DBH Monetization Model

As anticipated, Table 13 shows different ways to determine a digital platform's revenue model, such as pay-per-user, freemium, subscription-based, transaction-based, etc. However, there is no one-size-fits-all solution. The choice must be specific and analyzed for each type of exchange and each stakeholder. It is important to consider that some segments must be subsidized to guarantee participation/loyalty (and avoid the organization of future transactions outside the platform) and, therefore, will be granted free access to maintain engagement.

Core Interactions	Direct monetization		Opportunities for indirect monetization		Monetization Tactics	
	Suppliers	Buyers	Suppliers	Buyers	Suppliers	Buyers
Biogas trading	-Subscription fees (SME's) -Premium Listing/Transaction fees (Growth phase)	-Pay once -Yearly or monthly Paid Membership (Large Companies) -Subscription fees (SME's)	-Advertisement	-Targeted Ads (premium users)	-Premium subscription plans -Advertisement	-Membership -Subscription
Support services	-Free Listing & Promotions (Early Stage) -Marketing and branding fees (Growth Phase)	-Pay per use Licensed Premium features (exclusive tools inGrowth Phase)	-Affiliate partnership -Data monetization	-Pay for Visibility (AI induced data insights)	-Discounted Listing plans, -Paid Marketing & branding Packages	-Add Ons (Paid Advanced analytics Data insights)
Trading of raw materials	-Freemium (Early Stage) -Subsidized fees(Growth Phase)	-Reduced fee access (Fixed Period early adopters) -Revenue Sharing/ Transaction fees(Growth Phase)	-Subsidization (Growth phase)	-Upsell (Third Party Logistics Services)	-Freemium to Premium	-Free Trial (early adopters) -Dynamic Pricing

Table 13 DBH platform: Monetization Strategies and Opportunities

7.3.1 Direct Monetization

As illustrated in Table 13, regarding direct monetization, access-based models such as pay once, subscription, or membership[18] (Wortmann et al., 2024) seems suitable for the DBH platform at an early stage. In the piloting phase, DBH will employ a decentralized method for revenue generation, allowing users more power, such as direct bargaining between seller and buyer. Various monetization strategies will be introduced in this phase. Some of them are discussed below.

As a starting point, the DBH platform will test a freemium model on a trial basis, allowing users to sign up and explore various available services for free for a limited time. Particular participants, such as raw material suppliers (e.g., feedstock and biowaste providers), may be subsidized afterward, while alternative revenue models will be explored with other participants. This strategy will allow the DBH platform to test its prototype services and help build an initial user base, including suppliers, buyers, service providers, and raw material providers.

As users become familiar with the DBH platform's offerings, subscribed suppliers can list their products and services for free. This will build a strong supplier base and increase user engagement on the platform. To encourage more users to sign up and remain active on the platform, DBH will implement various subsidization strategies in the early stages:

- Reduced or waived fees for early adopters
- Free access to specific informative channels.

As the supplier base reaches critical mass and the platform enters its growth phase, suppliers can pay for premium listing features such as enhanced visibility and highlighted placements that will help them attract more buyers, increase their sales, or improve their offered services branding on the platform for a small marketing fee. Large companies can have a lifetime paid membership (pay once) or choose a yearly or monthly membership fee, while SMEs will have subscription fee options. As the platform matures, it can provide a transaction-based interface if users demand digital trust and proficiency. Although it is too early to determine if payments will be included, the platform can

[18] Membership is a special subscription type that grants exclusive features in enhanced or premium access (for instance, having faster service or access to posts).

function as an intermediary channel where agreements are made and transactions are carried out through it. Transaction-based model options, such as pay-per-use (e.g., a price per post or transaction done) or revenue sharing (a percentage for one or both sides), could be good options for DBH in the long run for stable revenue generation. However, the latter requires that payments be included in the platform's operational model (adding legal and tax-related complexities). Of course, the final model could be a combination, for instance, a low membership or one-time payment and some charge per post.

7.3.2 Indirect Monetization

Data monetization (with data privacy and regulations as main barriers) and advertisement (e.g., cost per view) can be explored at different developmental stages of the platform as an indirect monetization strategy. However, they require a large-scale user base, access to detailed user data, and considerable network economies (usually more suitable for B2C platforms but also possible in B2B). Once the platform enters the growth phase, the DBH platform will provide targeted advertising options for its premium users, such as service providers, equipment manufacturers, and traders, to promote their products and services. This will increase their chances of driving user engagement and generating revenue from the platform.

The DBH platform will also provide users with specific investment opportunities to feel connected to the platform and engage with it more deeply. In return for their investment, they will also receive additional revenue streams from the platform, along with potential upsell opportunities for exclusive features and benefits. Affiliate partnerships will also serve as an indirect monetization strategy to extend the platform’s reach and offerings. Shared increased revenue usually benefits both the platform and the affiliate partners, enhancing value for both parties.

The platform can also monetize buyers in the growth phase, particularly those seeking more advanced or premium features. Several indirect monetization options can be implemented, some of which are discussed below:

- The platform can charge buyers(Pay for visibility) in exchange for usage and access to exclusive tools or data insights to improve their decision-making.

- Discounts, deals, or priority support can offer extra platform benefits.

- Yearly subscription fees help buyers be tension-free and enjoy all the platform's services without any payment delays.

7.3.3 Monetization Tactics

Regarding monetization tactics, freemium (base version for free and full version for a fee)[19] Free trials (for a limited time) are the most relevant ones for the DBH (Pilot and emerging Phase) to lower entry barriers, build a large user base, and/or demonstrate added value rather than more complex alternatives, such as add-ons or dynamic pricing(that could be explored later in Growth Phase).

However, once the platform reaches maturity (Growth phase) and a centralized data analytics mechanism can be initiated, prices can be adjusted dynamically depending on user behavior, market trends, and market conditions. This mechanism will help maintain fair and competitive pricing while leveraging revenue opportunities. Along with the Dynamic Pricing, the DBH platform will also offer certain add-ons (value-added services) to continue progressing and differentiating from competitors by providing additional value to our users.

- Detailed Market Insights & Analytics:

The platform will provide different tools to generate detailed reports and data insights for its users (third-party suppliers and external stakeholders such as market researchers or regulators). However, a nominal fee will be charged for these insights. AI-integrated data analytics generated within the ecosystem will play an essential role in providing valuable intelligence to users, helping them to analyze and make actionable decisions after understanding the market.

- Marketing And Branding services:

  DBH's platform marketing and branding services will significantly assist suppliers in improving

  their branding, increasing their visibility to a broader user base, and creating opportunities for business growth. Users can choose from various paid marketing and branding packages.

[19] The main challenge is to balance between the free and the premium versions functionalities, to make the platform attractive and stimulate users to become premium.

7.4 Roadmap for Long-Term Revenue Generation

By establishing a user-centric approach, the DBH platform's first focus is to create value for its users and succeed in reaching a critical mass of participants before its transition to introduce different revenue strategies. The DBH platform aims to gradually introduce monetization, considering its users' risks and challenges. A centralized fixed price mechanism can be implemented in the growth phase to gain control and support fair pricing requirements. One side of the market is strategically subsidized (e.g., suppliers) to increase the platform's cross-side network effect, which helps increase the user base. In contrast, the other side (e.g., buyers' service providers) can be monetized simultaneously through premium features, transaction fees, and advertisement. Originating secure, fair, and transparent pricing and compliance with fair pricing law and data privacy standards. DBH will create trust among its users, enable repeat usage, and deliver long-term sustainability.

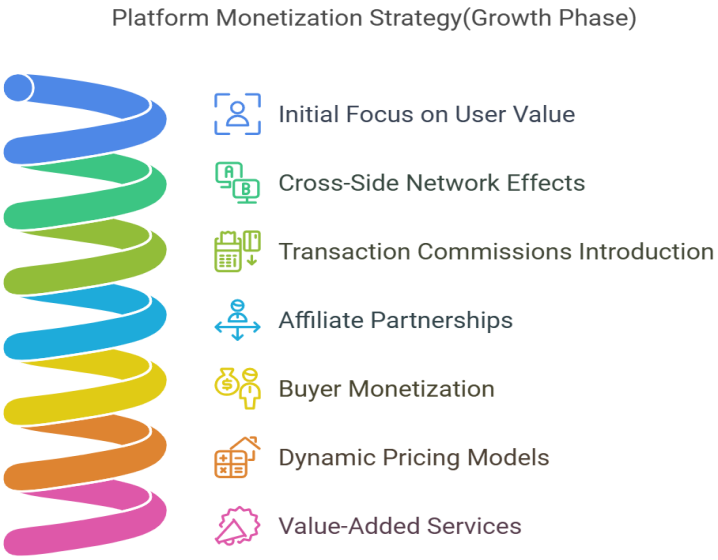

Figure 7 Roadmap For DBH Monetization (Growth Journey)

The spiral framework above in Figure 7 shows the interlinked roadmap for the DBH monetization growth journey. Some of its components are described below:

7.5 Scalability Strategies

Monetization is linked to scalability, another critical topic in the existing literature on platform design and management, which is closely related to breaking the chicken-and-egg dilemma to kickstart network effects (Cusumano et al., 2019; Parker et al., 2016). The success of the DBH platform depends on how well its scalability improves over time. Scalability strategies help the platform progress by simplifying processes and making it more accessible and efficient for its users. To scale up the platform in later stages, complementary business lines, including e-commerce and direct-to-consumer models, could be explored. The first analysis point should be which sides are accessible and which are difficult to attract, and the next should be defining the specific escalation strategies.

7.5.1 Initial Escalation Strategies

Some specific initial escalation strategies can be found in the academic literature. As Wortmann et al. (2024) categorize escalation strategies into traditional (e.g., focus on one side, attract key users, leverage existing assets, and focus on both sides) and opportunistic strategies (e.g., injection, exploration, and pacing). While not all may suit DBH, many may be simultaneously applied, depending on the core transaction.

More general types of strategies, such as 'Big Bang' marketing (Wortmann et al., 2024) which is based on web advertisements and social media or even direct contacts and contacts through linked associations (and why not some news on local TV), may help build the initial traction. However, it seems natural to focus on attracting key users or 'get the gig shots' (leading players on the supply and demand sides) and on both sides following the 'micro-market' strategy (Wortmann et al., 2024), which means starting in a small local market and dedicated product category, creating strong network effects, and scaling it up (e.g., adding hubs and regions later on).

7.5.2 Strategies for Biogas Trading

First, concerning biogas trading, the assumption is that supply and demand will come to the platform with minimal effort since some large producers and users are part of the consortium. In some hubs, such as Ostrobothnia, excess demand will call for new supply capacity (either new producers or an increment of the existing capacity). Nevertheless, attracting additional producers and users is still a

necessary condition. Partnering with key influencers, such as large biogas producers and municipalities, can help expand the platform's reach and credibility. Addressing barriers like digital literacy, affordability, and internet access ensures inclusivity and accessibility for a broader audience. Employing tipping strategies, such as feature bundling, special deals, incentives, pricing integration, or forming coalitions, can further attract and retain users. Dynamic user engagement can be achieved through gamification and community channels that encourage user feedback while promoting third-party innovation and integration, enhancing the platform's capabilities and ecosystem.

7.5.3 Supporting Services and Raw Material Trading

Attracting the supporting services suppliers may be more complicated since it will require the creation of network effects in the biogas trading market first. Still, the primary services must be explored and detailed, but distribution and logistics for biogas and raw materials must be the most natural and straightforward. Finally, concerning the trading of raw materials, the bottleneck is on the supply side. Still, everything will depend on the conditions given to the suppliers, which must be defined in the value capture and sharing rules. In this context, scalability may need a 'Munchausen bootstrap' logic (e.g., focusing on one side first), which implies that the DBH organizes deliveries or helps the parties organize them by engaging logistics companies (and charging for it). Finally, concerning the biowaste suppliers, strategies such as 'let your users bring them in' (based on referral benefits or exclusive conditions) or 'subsidize the sensitive' (giving good conditions to those highly price-sensitive players) may be suitable (Wortmann et al., 2024).

8 DBH Operational Model

8.1 DBH Operational Model Structure

DBH's operational model structure contains the three key building blocks identifying its core elements, as shown in Figure 8. It primarily explains how these building block units work. The Core vision of this platform is to enable a seamless interaction between different stakeholders in the biogas industry in the three analyzed regions, including biogas producers, biogas users, feedstock suppliers, Service providers, etc., by creating a digital marketplace that reduces transaction costs and ensures every stakeholder benefits from simplified processes and precise information. The platform also aims to build trust and transparency while addressing variations in the supply and demand of biogas throughout the system.

DBH Operation Structural Model(Boston Consulting Group BCG, 2023) consists of three key blocks:

1. Top Block (Business Units)
2. Middle Block (Business Platform)
3. Bottom Block (Foundational Platform)

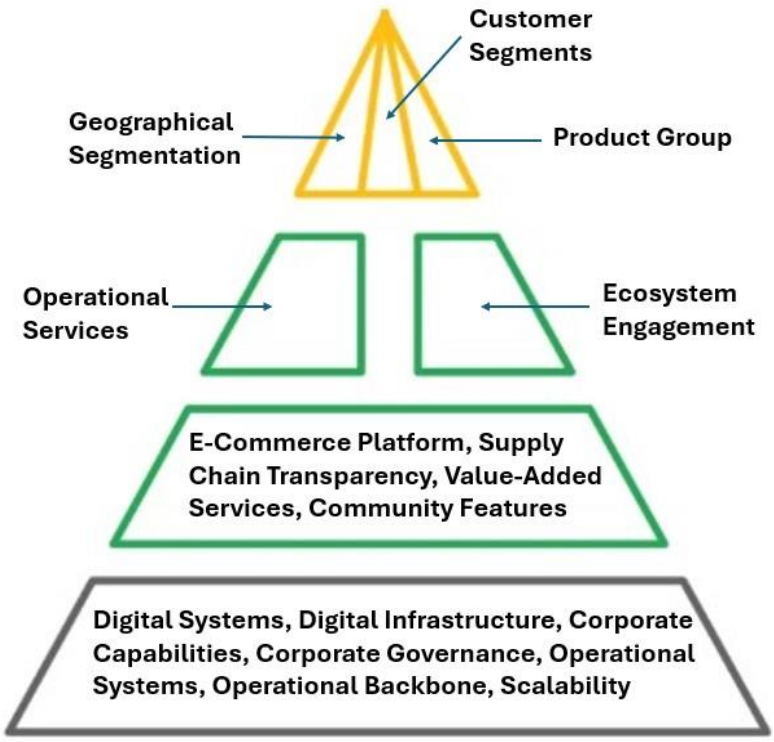

Figure 8 DBH Operational Model Platform Structure (Boston Consulting Group BCG, 2023)

- **The first block is Business Units.** As illustrated in Figure 8, we have segmented our primary business units into three parts:

1. **Geographical Segmentation:** For the piloting phase, this platform service operability is restricted to the three regions of Ostrobothnia (Ostrobothnia, South Ostrobothnia, and Central Ostrobothnia). This unit primarily represents the regional markets and the distinct needs of key players in the biogas ecosystem present in these regions. It also incorporates compliance with the EU legal framework and other regulations alongside localization.

2. **Customer Segmentation:** The platform categorizes its customers mainly into biogas producers (biogas plant operators), biogas users (industrial players), Raw Material providers (feedstock suppliers), municipalities, agricultural businesses, and service providers such as logistics companies, maintenance firms, and technological companies.

3. **Product Segmentation:** The platform offers diverse product groups to meet stakeholders' needs. These include raw materials like feedstock input, trading of different biogas types for industrial and municipal use, and essential services like maintenance, consultancy, and regulatory compliance support.

- **The second block is the Business Platform.**

The business platform's upper block is the backbone of platform operations. It primarily ensures a customer-centric approach by delivering shared and customizable services that support tailored needs and ensure smooth platform functionality.

The two main sub-blocks of the business platform are:

1. **Operational Services:**

This sub-block focuses on core operational systems that streamline processes and enhance efficiency. It includes tools for supply-demand matching, which connects producers and buyers, and logistics management systems that integrate with third-party transportation services. Additionally, it incorporates value-added services that enhance overall functionality.

2. **Ecosystem Engagement:**

The Ecosystem engagement and marketing sub-block of the Business platform focuses on increasing collaboration, building trust, and driving stakeholder participation through various strategic initiatives. Marketing efforts include targeted campaigns to onboard producers and buyers, coupled with branding strategies to position the platform as the leading marketplace for the biogas industry. Community engagement is enhanced through tools like social media channels, such as chat forums and knowledge-sharing information modules, while gamification features and reward programs can also motivate active participation. Trust and traceability mechanisms, powered by blockchain technology, ensure transparency in source origins and transaction security. Additionally, AI-driven insights provide personalized recommendations to improve user retention and engagement. The platform will offer comprehensive customer service tools, such as a helpdesk, to efficiently resolve queries and manage disputes to further support stakeholders.

- **The bottom block is the Foundation Platform.** It usually focuses on the core digital and operational infrastructure. It is all about creating a strong digital and operational system to make the platform efficient, scalable, and ready to grow. On the digital side, it includes secure and flexible APIs that connect easily with third-party services like logistics and AI tools and reliable data storage to analyze and share important information. Operationally, it automates key processes like matching supply with demand, setting prices, and generating reports while ensuring safety through fraud detection and data protection systems. It is designed to expand quickly with a modular structure (Open API) and cloud-based systems that allow it to handle more users and services across different regions to support the adaptability and growth of this platform. On the governance side, it has financial tools to stay compliant with local regulations and manage reporting, along with systems to align with policies and certifications specific to the biogas industry. This backbone keeps the platform running smoothly and ready to adapt as it grows.

8.2 Conceptualizing the DBH platform operating model

A few options are available for conceptualizing the DBH operating model. However, the complexity (operational complexity, taxation, and legal aspects) increases when more features are added. Following Wortmann et al. (2024), the four basic options are as follows: 1) Listing platforms, simply focusing on listing and matching and facilitating the contact between sides (including some

mechanisms for trust building) and requiring direct contact between parties for organizing payments and delivery; 2) Light marketplaces that add functions such as handling payments and transactions to take a revenue share, 3) Full-stack marketplaces, which also add order/transaction fulfillment, with no direct contact between parties, which may require some physical infrastructure, and 4) Market makers that also put assets on their balance sheet and temporarily hold inventory to speed up complex and costly asset transactions (Wortmann et al., 2024). The latter two models add more value-creation activities and revenue opportunities but also have too many complexities and require the platform to own expensive physical assets, becoming asset-heavy platforms.

Therefore, in principle, the best options for DBH in an initial developmental stage are asset-light designs, such as a listings platform or light marketplace (Wortmann et al., 2024), the former being a good start or primary option, as it requires fewer resources and avoids legal and tax challenges (although it may be considered in the future to increase the revenue per user and user loyalty, especially if the revenue-sharing direct transaction-based monetization model is adopted to capture value when scaling the business, as discussed next). Still, additional free features or services can be incorporated beyond simply listing or matching supply and demand, such as curation or whatever characteristic that smoothens the navigation or improves matchmaking (e.g., offering categorization, information, or description). Also, asset-light adjacent services offered by the platform or third parties can be added to increase user experience without adding capital requirements.

After launching the platform, a stage outside the DigiBiogasHubs project's scope, managing the platform will be critical. Two key activities are particularly relevant (Wortmann et al., 2024): 1) innovating and defending the platform and 2) managing and monitoring network effects. Concerning the latter, managing network effects involves reducing friction and transaction costs by preventing exchange problems, protecting data, increasing curation, and continuously simplifying sign-up, navigation, and transactions (Wortmann et al., 2024). Instead, monitoring performance (e.g., establishing the right metrics) requires efforts, such as tracking network effects based on relevant leading and lagging KPIs (antecedents of success/North Star metric[20] vs. performance) that are aligned with the platform's strategic goals and drive the organization (e.g., active users, percentage of active users, number and value of successful interactions, liquidity to ensure supply-demand balance) and

[20] Wortmann et al. (2024) define North Star metric as the one capturing "best how users behave if they love the platform".

introducing measures to achieve targets. Additionally, monitoring network effects may involve a 'from inside to outside' approach (external resource and value co-creation orchestration to increase user productivity) and strategies for growing first and monetizing second (Wortmann et al., 2024).

Concerning the first activity type (innovating and defending the platform), platform managers should watch for competitors entering the market to defend their position by finding strategies to 'weaken rivals' (e.g., creating entry barriers) or 'acquire early' threatening projects. Of course, cooperation or mergers are also potential avenues, especially when the objective is to boost the biogas sector in Finland. Therefore, while rivalry does not seem to be a probable issue, the key seems to be to 'manage regulators' in the early stages (e.g., concerning GDPR and DMA or whatever general or industry-related regulation may be affected by the platform operations). Also, developing and scaling may require innovating the platform (Wortmann et al., 2024), which calls for efforts to 'improve the customer journey' of sellers and buyers by identifying and addressing unmet or adjacent customer needs (Wortmann et al., 2024), which means addressing stakeholders' pains and gains (Osterwalder, 2014). With a renewed value proposition to improve their experience (e.g., creating interdependencies and synergies between the components of the value proposition or adding new services to increase loyalty and monetization opportunities and reduce disintermediation risks), particularly key for vertical marketplaces that cannot grow by horizontally expanding product portfolio (Wortmann et al., 2024). This activity also involves exploring the 'imitate to innovate' (Wortmann et al., 2024) by continuously benchmarking and learning from industry platforms.

8.3 Current (Baseline) Operational Model Blueprint

Strategic Foundations:

Before establishing the baseline for the current(pilot) operating model, the first step is to define the platform's strategic vision and objective goals. To do this, we create a strategic framework that clearly explains the purpose and vision and how it will help achieve the target objectives in the future through its differentiation offerings and tailored solutions.

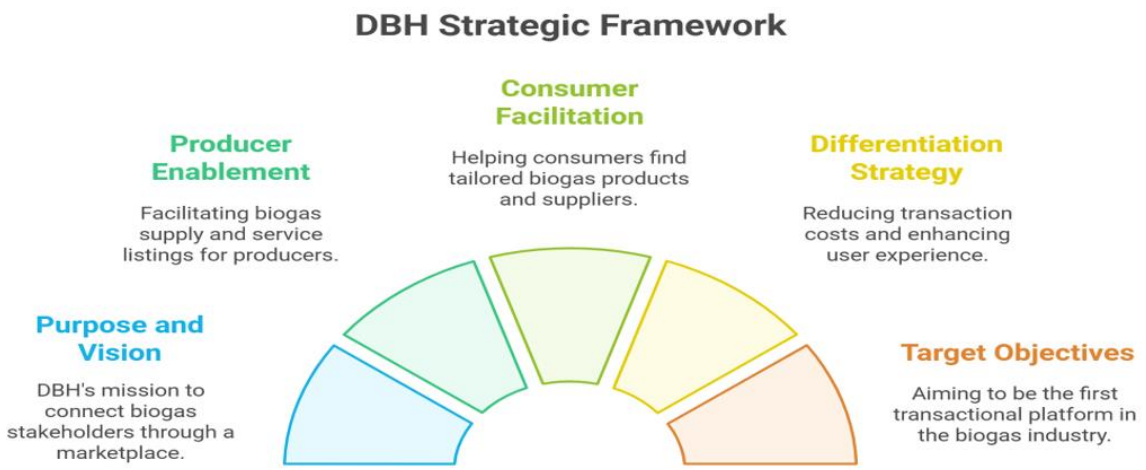

Figure 9 DBH Strategic Framework

Figure 9, DBH Strategic framework, explains the foundation strategies for developing and operating a successful platform. DBH's primary baseline current operational model (pilot phase) objective is to act like a listing and matchmaking marketplace and serve as an information channel (e.g., information about maps, logistics routes, facilities locations, biogas plants, company profiles, information about legislation, laws technological upgradation, subsidies, investment opportunities) which facilitate the biogas trading, raw material trading and create a network between different stakeholders of the ecosystem through interaction.

For Producers: Enable listing of available biogas supply, feedstock, and services (e.g., maintenance).

For Consumers: Facilitate the discovery of biogas products and suppliers tailored to their needs.

It aims to differentiate in the long run through reduced transaction costs and enhanced user experience based on its unique functionalities (e.g., chat rooms, gamification, clubs, cooperation channels, and collaborative opportunities).

Its target objective is to be a transactional platform for the biogas industry encompassing additional services like logistics, expert knowledge, AI-induced Technologies, decision-making, interfaces, compliance tools, etc. However, it will take time to achieve this, as various challenges, such as the lack of dynamic data, no virtual network between actors, and information gaps, already exist in the biogas sector.

For the startup of the piloting phase, as discussed above, A blueprint of the current (baseline) operational model was developed, as shown in Figure 10, that will be further modified during the growth phase as the platform evolves to achieve the targeted operational objectives. This current model shows how the operational structure of the platform will deliver value that is in line with the project's business strategy and will further support value generation. As the platform develops, it must be ensured that the operational model will adapt to include new services and integrate more technologies to achieve growth and create more user value.

Andrew Campbell's Canvas is used to design the operational flow of this platform during the piloting phase, which can be further updated and expanded into a more advanced model as the platform progresses through the later stages of its life cycle (Lancelott et al., 2017). As illustrated in the canvas below, we have defined the current value streams and what is done in the pilot phase, depending on our strengths and boundaries. Thereafter, we have also suggested a future value stream for the services identified by the stakeholders in the workshops and interview sessions that can further bring more value to this platform and help solve the specific challenges faced by the actors of this biogas ecosystem with customized solutions in the future. This baseline (pilot) operational model aims to explain how functions and processes connect, how services are delivered, and how the platform's mission is carried out. It outlines the business's alignment with its region, services, and target client groups. It also explains the details of governance, structure, processes, and resources and how it plans to meet market demand.

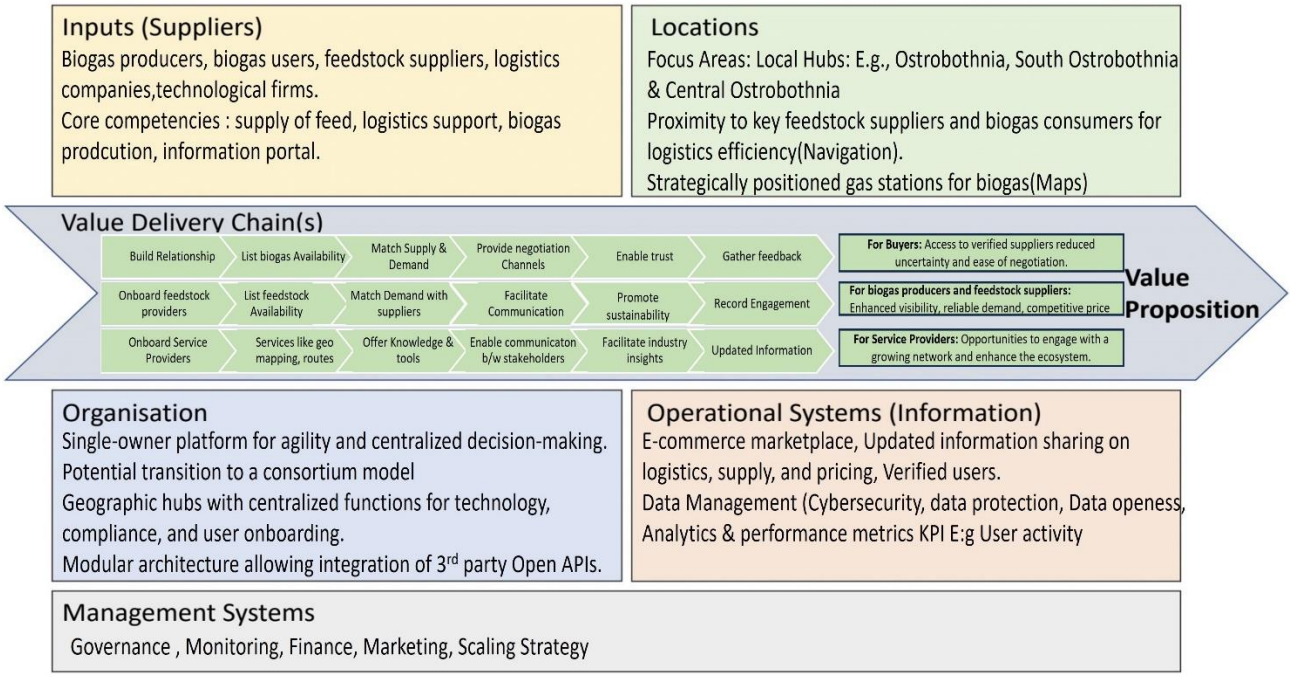

Figure 10 Current Baseline(Pilot) Operational Model (Lancelott et al., 2017)

8.3.1 Value Delivery chains

The platform's Value Delivery Chains are designed to create a seamless and reliable ecosystem for all users. In Biogas Trading, the platform connects biogas producers with buyers through easy-to-use listings and negotiation tools, ensuring smooth communication directly on the platform. Quality assurance is maintained through certifications and blockchain technology, though users themselves handle this process during the piloting phase. Feedback loops allow users to share their experiences and insights to build trust and strengthen platform credibility.

For Raw Material Trading, the platform connects feedstock suppliers with biogas producers. Once enough users are onboarded, it plans to introduce recommendation algorithms during the growth stage. The platform also emphasizes sustainability by promoting circular economy practices, offering sustainability reporting, and tracking carbon emissions. Users can access aggregated market trends and data-driven insights to make informed, strategic decisions.

Regarding Support Services, the platform integrates essential logistics and technological providers. Tools like geospatial mapping, ready-to-use legal templates, and compliance support, such as open contracts, will streamline processes in the future. Peer-to-peer communication keeps everyone

connected, while updated information posts, articles, and alerts ensure users are notified of any disruptions, helping them respond quickly and effectively.

8.3.2 Stakeholder Identification (Input; Suppliers)

Another aspect of the DBH operational model is identifying the key stakeholders that will be part of this platform. We have divided the stakeholders into two categories, as shown below:

- Primary Stakeholders: This includes biogas producers, biogas users, feedstock suppliers, and service providers, who serve as the platform's primary users.
- Secondary Stakeholders: This includes government officials, regional and local officials, industry representatives, technological firms, accreditation firms, legal firms, and other actors related to the biogas ecosystem.

The main question arises: Which side should we add first? Asynchronous setting. This decision is challenging as it defines the platform's future success and operational excellence, including user scalability.

Since this platform operates as a multi-sided marketplace, we can assume the presence of indirect network effects, which suggests that the provider side (suppliers) should be added first. Adding suppliers can help attract more user groups as the platform grows in a zigzag configuration. There are many examples where adding users too early or too slow has negatively impacted platform growth, so it is essential to know.

- Prioritize the side that provides initial value and attracts other stakeholders, which will decide the platform's success factors.
- Understand that early prioritization is essential for creating value.
- How many sides should be included, and in what order? Adding too many sides early or failing to balance their needs can lead to platform failure.

8.3.3 Focus Area (Locations)

When discussing the geographical segmentation of the DBH platform, the focus is on three key regions with existing biogas facilities and utilization: Ostrobothnia, South Ostrobothnia, and Central Ostrobothnia. The platform prioritizes identifying areas with high feedstock availability and biogas production and locating dense demand zones. Regarding location considerations, there is a strong emphasis on mapping important infrastructure, including biogas plants, refueling stations, and transportation routes within these regions. As part of its expansion plans, the platform aims to focus on other local hubs with significant growth potential initially. Over time, it will gradually scale operations across Finland, with long-term ambitions to expand into Europe.

8.3.4 Operational Systems (Key Operation Functions)

This operational systems framework highlights the key functions of a biogas customer-centric platform as it evolves from its initial stages into a mature operation. In the Emerging Phase (Pilot), the focus is on building a solid foundation. This includes creating a comprehensive listing system for (trading and other services) including biogas, feedstock, logistics, and maintenance to connect the right players. The mechanism to evaluate that the listing post is created by a registered user (having a registered company or authentic user profile) includes certain aspects like quality, quantity, and asking price. Here, it is important to know that anybody can be a user to surf the platform but to use features like listing materials, only registered users can list their offerings, which will then proceed to be approved and scrutinized by the platform administrator, after which the users access it. Premium members would have premium listing visibility, providing a competitive advantage. It also involves matching opportunities through a decentralized technique. We have not used centralized right now because it uses an algorithm that chooses on the user's behalf and provides specific results that fit the user's search. As the platform is emerging, decentralized matching practices are more recommended as they offer users multiple options based on their preferences, and they can select by themselves. The platform also aims to provide valuable information about user and company profiles (created on the platform), a knowledge bank (Wikipedia Style) comprising articles and papers related to subsidies, contracts, legislations, investment opportunities, and technology advancements to support industry growth. The platform added a community engagement tool to increase collaboration, which includes social media channels and group portals. Location visibility of farms,

biogas plants, and gas stations with geo-mapping are services available for premium members only. The platform also ensures security with features like verified users (registration required) and data privacy protocols (GDPR). It facilitates seamless communication (contact among stakeholders through messaging services available in the platform). This feature is important to adopt as it will discourage platform bypass activities. The platform also aims to provide its premium members access to comprehensive data banks to empower decision-making.

As the platform moves into the Growth Phase (Target), it shifts its focus to more advanced and scalable offerings. This includes providing stakeholders with legal aid and expert knowledge, integrating AI technologies (Blockchain, chat box, SEO, SCI, ERP, etc.) for smarter solutions, and providing updates to enhance user experience. It can partner with third-party logistics providers to provide logistics services (quotations). Gamification features will be added to the platform, as well as real-time alert services (open contract, disturbance, actual supply, and demand), to improve efficiency. The platform also plans to enable smooth transactions, work with accreditation bodies (generating certificates, GO's, DPP's, quality checks) to ensure quality, and collaborate with third-party developers (addition of applications) to expand functionality. By exploring data monetization(advertisement) and offering training and certification programs (learning), the platform aims to become a comprehensive ecosystem supporting the biogas industry at every level.

8.3.5 Organization Structure (Roles and Functions)

Once a platform matures, it will serve as a central hub for managing operations effectively. It will require a centralized team of IT experts and system administrators responsible for platform development, user onboarding, and compliance monitoring. Regional hubs will play a significant role in facilitating local engagement, building relationships, and supporting scaling efforts by strengthening connections at the regional level. Once the platform moves beyond the initiation phase, a service team will be established, comprising business experts, designers, analysts, and engineers who will evaluate and implement go-to-market strategies while ensuring the platform remains efficient, user-friendly, and reliable. As in the maturity phase, a dedicated finance team will oversee budgeting, cost administration, and marketing efforts to ensure smooth operations and effective resource allocation.

8.4 Comparison between DBH business and technical operating model:

The Business Operational Model of the DBH platform focuses on delivering value to its stakeholders through a connected ecosystem. This centralized platform helps the different ecosystem actors communicate and collaborate. Minimizing transaction costs and delivery times entails a comprehensive service portfolio, including supplier connection, analytics tools, compliance tools, and logistics support. Another aspect of the business operational model is regional hub integration, showing how the platform and these hubs can tackle challenges and address regional needs, e.g., biomass availability, infrastructure limitations, production estimation, and supply-and-demand variations. Integrating legal support is also a part of the DBH business model to simplify user regulatory processes.

The technical model of the DBH platform is built on a flexible, secure, and customer-centric architectural approach. Its modular design, e.g., Open API, ensures it can evolve according to user needs. Its flexible structure allows third-party developers to add upgrades and new applications, increasing the platform's user base. By incorporating data-driven insights, the platform can easily collect data, e.g., biomass production, biogas consumption, and supply-and-demand variations. This not only helps users optimize their operations but also facilitates smart decision-making. To enhance user experience, intuitive dashboards, and interfaces are included in the platform, ensuring accessibility for all users. Emphasis on data security and privacy guidelines further protects data and builds trust among users, enabling safe and reliable interactions through the platform.

8.5 Conceptualizing the platform ownership model

Ownership is a key aspect of designing the platform, which is conceptually introduced here and discussed in more detail below. From the three typically available options for platform ownership (Wortmann et al., 2024), the two natural options for DBH are single owner or consortium rather than a P2P community. While the single ownership model seems to be the primary option for most of the digital platforms due to maximum freedom and speed/agility for designing and managing it, this system also calls for mechanisms to maximize onboarding/adoption and independence and neutrality to be guaranteed to benefit the whole Industry rather than some players. Of course, the pros and cons of the cooperative model can also be explored based on collecting opinions from the industry stakeholders, especially if B2B competitors are involved in the platform or if there is a risk of

emerging competing platforms. This suggestion means that single ownership can be the initial model and changed to consortium after scaling takes place, and it requires so. The single owner must be selected based on sector knowledge and expertise, autonomy, and neutrality (concrete suggestions emerged from the fieldwork in Task 1.2).

8.5.1 DBH Ownership Model

Based on stakeholder analysis and knowledge from academic literature, a single-owner platform ownership model is recommended for the DBH platform in the piloting phase to ensure agility and streamlined management. This approach allows for a better understanding of value chain dynamics, helps to address the target audience effectively, and facilitates the implementation of the most suitable communication channels for different stakeholders. It also supports adaptability and growth in response to changing needs. As for the pilot phase, the Centria University Development Team is mainly responsible for managing the pilot version of the platform, utilizing their digital server database until the DBH project ends.

Once the DBH project ends, it will be available for any user or company (Technology preferable) to take over and run the platform efficiently, and the work(data) files could be easily transferred to their servers(or can use a cloud service). It is good to know that except for the development cost required for the upgrade and addition of new features and services, the operating cost of the pilot version is very low(only labor cost). From a technical development perspective, it is better in the emerging phase that a technological company (neutral entity), depending upon their technical and operational capacity, build more features and services to increase the user base, enhance user experience, and make the platform start generating revenue on its own.

As the platform progresses to the growth phase, there could be a transition to a consortium ownership model, allowing more stakeholders (public and private companies) to participate and support the platform’s development, or it could have an affiliate partnership model where different stakeholders can invest in the platform and advertise their offerings and services through the platform.

8.6 Management Systems

8.6.1 Governance

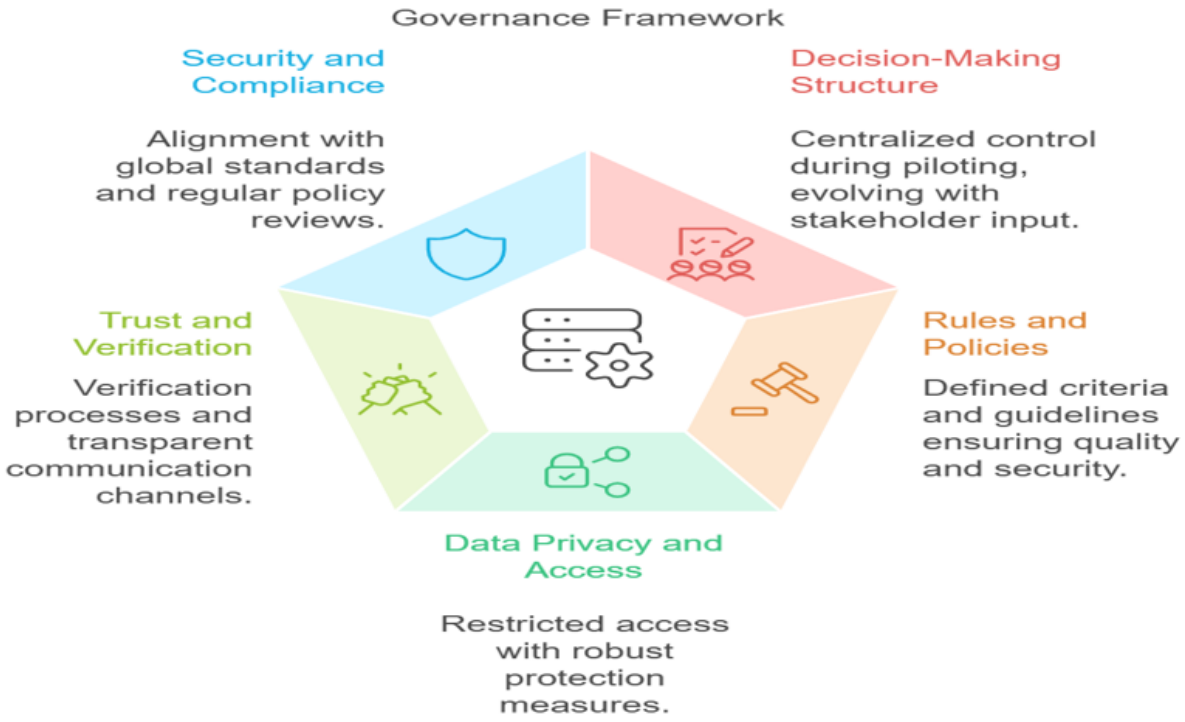

Figure 11 DBH Governance Framework

Governance acts as the backbone of the DBH platform's operational model. It ensures integrity, scalability, and trust in all interactions among platform users. It establishes the principles, rules, and mechanisms that guide not only the platform's operations but also manage the participants and promote opportunities for collaboration.

Governance Framework:

The governance framework shown in Figure 11 has been developed for the DBH platform. Some of its main elements are as follows:

Decision-Making Structure:

During the emerging phase of the platform's development, a centralized decision-making structure is recommended to keep operations focused and well-managed. A dedicated team, including the platform administrator, will handle essential responsibilities like onboarding new users, updating applications and policies, and resolving conflicts the user will face while using the platform. This

governance mechanism will ensure stability and accountability as the platform takes its first steps. As the platform grows, a restructured plan should be implemented to evolve our decision-making process, like inducing AI-enabled technologies, which opens up the input from users' experience to improve and provide opportunities to third-party service providers with a more collaborative approach.

Rules and Policies:

Specific rules and policies will be implemented during the piloting phase to make this platform user-friendly and safe, which will be upgraded as the platform grows. The platform ensures that the user's registration goes through a scrutiny process to ease the users' access to potential trustworthy partners, which guarantees the registered user has met predefined criteria regarding their authenticity and originality. This will not only certify the quality but also the security of the platform. Clear behavioral guidelines concerning the users' conduct will help maintain a fair and respectful environment throughout the platform. Violating these rules may lead to penalties or permanent removal from the platform. As the platform progresses, third-party developers can contribute through Open APIs. To confirm the accountability of these developers, signed collaborative agreements, including abidance with the platform governance rules and regulations, will be required.

Platform users will be regularly notified about the updates and receive accessible guides on governance policies, data privacy measures, and security protocols. Policy changes will be transparently communicated to all stakeholders to build users' trust. All legislation affecting sales, including regulations handling and hygiene requirements for manure products, should be circulated among key stakeholders.

Data Privacy and Access:

DBH platform necessitates safeguarding user data privacy and access. To ensure controlled openness of the platform, only platform administrators have the right to access restricted data during the pilot phase. Moreover, Open APIs will be made available to third-party developers under controlled conditions to enhance the usability of the services without compromising data security. User data will be protected using robust tools like encryptions. The platform will comply with GDPR standards to

fulfill digital legal obligations. All users will be asked to consent to data policies during registration or sign up clearly.

Trust and Verification:

Trust plays an important role in the platform's success, and it will be the priority of the DBH platform. It will be assured that all users of the DBH platform, including buyers, sellers, and developers, will undergo an intense verification process before joining the platform to maintain its integrity. Clear and transparent communication channels will be integrated within the platform to establish trust among the users, address user feedback, resolve problems, and ensure smooth interaction.

Security and Compliance:

DBH platform ensures compliance with global and national legal and regulatory standards. Data protection measures, such as encryption, access control, risk assessment, backup, and destruction, will be regulated to ensure operational security. Governance policies will be reviewed systematically to remain updated with regulatory changes and industry revolutions.

8.6.2 Platform Governance Evolution

As the platform grows, governance mechanisms will adapt to accommodate increased data openness and seamless third-party integrations. The platform aims to act like a centralized hub and spoke network, enabling service providers, users, and developers to co-create more value for the platform under the governed framework. Open APIs will provide opportunistic value to third-party developers to introduce innovative applications that enhance platform functionality while maintaining the rules and regulations. Another factor that reshapes the platform governance mechanism in the growth phase is the induction of digital monitoring and reporting tools within the platform functionalities to track User activity, API usage, Network traffic, Network log, Predictive monitoring, etc. AI-induced technologies will also be a part of this transformation, which further provides more accessibility and control to the users. Regular audits and performance reports will be shared with Platform owners, ensuring its operations remain secure, efficient, and aligned with its principles.

8.6.3 Finance and Budgeting

Finance and budgeting are essential aspects that must be defined well while starting a platform business, as they will decide the long-term financial utilization map for the platform's operability. As the platform will begin from its emergent phase, I recommend reserving the funds, considering the initial expenses. Tight financing should be prioritized as there will be expenses related to the IT team hiring, their salaries, and other operational costs related to the platform. Specific fixed amounts should be calculated and preserved unless the platform grows and generates revenue from its services and offerings. Administration costs, including the monthly maintenance and management of the platform, should also be reserved before the platform matures. Additionally, funds should be allocated in advance to incorporate additional services into the platform and synchronize with other service providers, such as Biomass Atlas (biomass mapping) and logistics service providers over time. Marketing and technological investments should also be considered when deciding the financial strategies for the platform's life cycle, e.g., the pilot, growth, and mature phases.

To attract users and improve the appearance of the platform’s interfaces, strategic investments in marketing, graphic design, and communication channels are necessary. Setting aside a budget for platform advertisements, technology upgrades, and new features is important to stay competitive and meet changing user needs. By managing finances wisely, the platform can build a strong foundation and stay prepared for unexpected expenses or future growth opportunities.

8.6.4 Marketing

Throughout the lifecycle of the DBH platform, different marketing strategies should be implemented at different stages. In the pilot phase, social media channels like DBH's LinkedIn page, DBH Facebook Page, and DBH Official website should be circulated and regularly updated to increase and attract awareness among the biogas industry stakeholders, which in return enhance direct marketing opportunities for them through DBH digital platform. Platform Administrators should organize different webinars and seminars to evaluate and educate potential users in the biogas industry. Taking part in different tech exhibitions to showcase the functionality usage and accessibility of the DBH platform to increase user engagement.

Once the DBH platform emerges, digital media influencers can be contacted to advertise the platform to their subscribers and gain more visibility. With the help of SEO experts, we can improve the search optimization of this platform. Integrating more government and local officials should be a part of this platform to direct more regional users to increase marketplace usage. The marketing team will communicate through different channels how this platform will implement the principles of circular economy and help resolve issues related to sustainable development.

9 Technical Architecture and Infrastructure

9.1 Technical scalability and interoperability

The Digi biogas Hubs (DBH) platform will be designed using a modular architecture.[21] To ensure scalability, Open APIs[22] will help integrate third-party services in the future. Once the platform scales up, different AI-enabled technologies will be included to improve efficiency and operability. For example, Blockchain technology[23] will be incorporated to verify product quality. AI chatbot will be a part of the operational services to answer users' queries and concerns. Different accreditation and certification bodies will also be part of the platform's services, ensuring authenticity and promoting secure and transparent data exchange between stakeholders. The pilot phase of the platform primarily features a web-based interface, which can later be developed into a mobile application (Android or iOS) during the maturity phase to expand user access and onboarding.

9.2 Seamless User Experience

In the maturity phase, to increase the user experience, the DBH operational model will provide real-time and updated data-sharing tools to users for accessing information about logistics, feedstock availability, policy changes, subsidized support, pricing, gas availability, and other byproduct availability. The information channel on the platform will serve as a data bank where real-time alerts and updates ensure stakeholders are well informed, possibly reducing uncertainties and promoting smooth communication. Verified user profiles, easy navigation, and centralized communication tools will facilitate smooth, trustworthy, and transparent user interaction.

[21] Modular architecture is a special design approach that structures systems into independent, interchangeable modules, enabling flexibility, scalability, and easier maintenance

[22] Open APIs are a special type of interface that allows developers to access and integrate services or data from external platforms, enabling seamless connectivity and innovation

[23] Blockchain is a special technology that enables secure, transparent, and tamper-proof transactions, providing enhanced trust and efficiency across industries

9.3 Interface Design Strategies

The DBH platform interface promotes user engagement, encouraging stakeholder interaction through social media channels, community portals, and gamification[24]. The interface also includes interactive tools for matching supply and demand to fulfill user needs, sharing market trends, and facilitating legal and technical support. In the future, smart data visualization tools will make it easier for consumers to comprehend complicated measures like seasonal supply and demand patterns and market predictions.

9.4 Aesthetics and User Satisfaction

The DBH platform is designed on the principles of easy-to-use, accessibility, and user-first approach, which makes it familiar for everyday use. It will focus on reducing digital barriers like digital proficiency[25], improving the user's overall experience, and helping users develop new skills. Additionally, ensuring affordability to a wide range of users will be a key priority of this platform. Gamification and community channel strategies will create a sense of belonging among users. At the same time, clear rules, verified data, and transparency in communication will boost user trust and satisfaction on the platform.

[24] Gamification is adding game mechanics into nongame environments, like a website, online community, learning management system, or business intranet, to increase participation

[25] Digital proficiency is the ability to use digital devices, networks, apps, software and services

10 Regulatory and Legal Considerations

10.1 Platform Regulation Frameworks

The exploration of multisided platforms provides a foundation for understanding regulatory frameworks and ensuring compliance and fair competition. As the DBH platform will be operating in the EU, it must comply with the Digital Service Act (DSA)[26] and Digital Markets Act (DMA)[27] of EU platform regulations. The DSA focuses on the transparent algorithm, content moderation, and user safety, which calls for the platform to disclose the algorithms and enforce safeguards against illegal content. At the same time, the DMA demands fair access, avoiding anti-competitive practices and interoperability. DBH must comply with these regulations once it scales up and becomes a pioneer in its niche market. The DBH platform's General Data Protection Regulation (GDPR)[28] is designed to ensure its users' data protection and privacy rights. A user-friendly interface and multilingual support are also part of DBH to support inclusivity across the region. It will be ensured that DBH's social media community channels and gamification features respect diversity and are designed to avoid discriminatory practices. Transparency, safety, and accessibility will always be a priority for the DBH platform.

Following the guidelines of the EU's Code of Practice on disinformation[29]Clear policies will be communicated to manage misinformation, hate speech, and illegal content while balancing freedom of speech.

10.2 Compliance Challenges

DBH will comply with the EU's competition law[30], which mandates fair treatment for users, accessibility of essential services to all users, and prevention of monopolistic behaviors, which will help discourage unfair and preferential treatments. According to the EU Intellectual Property Office

[26] The Digital Services Act (DSA) is an EU regulation adopted in 2022 that addresses illegal content, transparent advertising and disinformation

[27] The Digital Markets Act establishes a set of clearly defined objective criteria to qualify a large online platform as a "gatekeeper" and ensures that they behave in a fair way online and leave room for contestability

[28] The EU general data protection regulation (GDPR) governs how the personal data of individuals in the EU may be processed and transferred

[29] The Code of Practice on Disinformation is a pioneering framework to address the spread of disinformation, agreed upon by a number of relevant stakeholders

[30] In the European Union, competition law promotes the maintenance of competition within the European Single Market by regulating anti-competitive conduct by companies to ensure that they do not create cartels and monopolies that would damage the interests of society

(EUIPO)[31], implementation tools will be integrated into the platform to detect copyrights and facilitate information exchange with strong IP protection mechanisms. DBH will maintain compliance with global and national regulations, ensuring that security measures are continuously updated with emerging EU policies or any regulatory changes to sustain long-term operational security.

The final report of Work Package 5 of this project will provide more detailed information about the specific laws and regulatory acts.

10.3 Ethical Considerations:

Martin & Freeman (2003). Stakeholder theory guides ethical considerations, ensuring responsible and sustainable platform practices. Gamification features included in the platform will be designed in a way that avoids manipulation and discourages addictive behavior and unfair practices. DBH platform will ensure its hosting services are energy efficient and sustainable, reducing carbon footprints and supporting sustainable business practices aligned with the EU Green Digital Strategy[32].

[31] The European Union Intellectual Property Office (EUIPO) is the European Union (EU) agency responsible for managing the EU trade marks (EUTMs), the registered Community design (RCDs), the Geographical Indications (GIs) for craft and industrial products

[32] The Digital Compass aims towards a secure human-centred digital ecosystem, where citizens are empowered, and businesses prosper from the digital potential.

11 Risk Management and Security

11.1 Cybersecurity Threats

DBH incorporates strict governance mechanisms to resolve issues related to cybersecurity. During the pilot phase, a centralized decision-making structure will ensure controlled security protocols, including user authentication and data protection measures. The platform administrator will be responsible for scrutinizing user registration and enforcing rules and regulations regarding secure onboarding, profile updates, and conflict resolutions, which will reduce the possibility of cyber threats. This governance framework will guarantee that only verified users will gain access after verification, lowering the risk of fraud activities and cyberattacks. Transparent feedback channels enhance security, allowing users to report suspicious activity and resolve issues effectively.

As the platform scales up, it will introduce a comprehensive security framework that includes multi-factor authentication (MFA)and end-to-end encryption mechanisms to minimize the risk of cyber threats such as phishing, malware, and ransomware. Additionally, compliance with the EU's cybersecurity regulation, e.g., the Network and Information Security (NIS2) Directive[33], will enhance the platform's strength to avoid cyberattacks. Basic cyber training provided to the user will minimize the risk and protect user trust. The platform administrator will empower security protocols such as encryption, access control, risk assessment, data backup, and destruction to secure and protect the platform.

11.2 Data Breach Prevention

The DBH platform follows strict data privacy and access control mechanisms to safeguard sensitive user information. During the pilot phase, access to restricted data will only be limited to the platform administrator, ensuring that unauthorized users do not access sensitive information. The registered users must consent to the General Data Protection Regulations (GDPR) to eliminate ambiguity or data breaches. Failing to oblige will result in a user penalty in the form of removal or a permanent ban from the platform.

[33] The NIS 2 Directive (Directive (EU) 2022/2555) is the EU's baseline framework for cybersecurity risk management and incident reporting for essential and important entities

The platform aims to implement Privacy by Design (PbD)[34] Principles that allow security to be embedded at every stage of platform development. Specific measures will be integrated into the platform, like enhanced access control and data encryptions, to ensure transparency in data collection and processing of the data in the maturity phase of the platform, which will comply with GDPR and ensure that users can have greater control over their information. This will strengthen the users' trust. Employee training on cybersecurity will enhance the platform's ability to prevent and mitigate data breaches. Additionally, third-party access to the platform through Open APIs is regulated under security agreements to avoid security breaches caused by external integrations.

[34] Privacy by Design is a methodology for proactively embedding privacy into information technology, business practices, and networked infrastructures.

12 Implementation Roadmap

12.1 Phased Implementation Plan

The planned implementation of the Digi biogas Hubs DBH Platform is divided into several phases, which are described in detail below:

Exploration Phase: The first phase involved in the DBH project implementation plan is the exploration phase, where we analyze the academic literature and benchmark digital platforms. It lays the foundation for defining the DBH platform's Project scope, goals, and objectives: to become a trusted marketplace for the biogas sector by optimizing supply and demand, streamlining logistics, and ensuring sustainable sector growth. Then, we defined this platform's targeted initial market reach, which will be three regions of Ostrobothnia. The exploration phase also includes exploring the project's technical, financial, and operational feasibility.

Planning Phase: The second phase of the DBH project encompasses planning and design processes. This phase will develop the project plan, the timelines for defining roles and responsibilities, and draft a roadmap for initiating development activities and attaining future milestones. The design will demonstrate a clear project governance structure, as discussed in the above chapter.

Development Phase: Once these initial aspects have been satisfactorily implemented, the next step will be developing the pilot version of the DBH platform, mainly adding the minimum essential services and features highlighted as the most important by the stakeholders.

Testing Phase: The internal testing plan will be executed after the pilot version is ready, after which a limited user trial will be organized to gather their feedback. Substantial changes to the platform will be made based on this feedback, which will serve as an important reference for further platform tuning. This iterative approach will include quality assurance, user testing, and performance testing as the main components of this phase. After further refinements to the pilot, beta testing will commence, and the platform will be made available in a real-world setting with real users. In this regard, there will be various options to access the program among registered users according to their choice preferences. A feedback loop channel will also be integrated into the platform to address user issues,

resolve conflicts, and help streamline operations smoothly. In this phase, customer validation is carried out to considerably minimize the risk of platform failure and guarantee the desired quality.

Implementation Phase: Full-scale implementation is the stage in which the project is rolled out across the target location or focus area. This implementation is divided into two phases: an Emergent phase focused on scaling up and retaining users through ease of use and continuous assessment for tracking platform effectiveness, exploring opportunities for further refinements, and scaling up operational services. Marketing strategies will be key to creating awareness and attracting users. The growth phase is the most critical in a platform's lifecycle, where the platform's future success ratio is defined. Multiple constructive measures should be taken to retain customers and their interest and to provide appealing opportunities for new users to join. This ensures the fulfillment of users' initial expectations and needs and helps maintain user trust to sustain long-term viability and effectiveness. At this point, when the platform is saturated with a critical mass of users, it should adapt to changes in the evolving needs and feedback from the registered users. The measures of success in implementing this process are then compared against how much it is aligned with the goals and objectives. The results of performance and feedback assessments would also initiate optimization strategies. Expansion value-added strategies such as third-party integration should be introduced to enhance the service portfolio, offer more features and functions, keep the platform afloat, and earn money.

12.2 Pilot Testing and Feedback Loops

Pilot testing and Feedback loops of the DBH platform are valuable to ensure the project application and practical authenticity in consideration of the improvements needed and the involvement of the actual industry users. It is designed so that the trail user base highlights challenges and issues unforeseen during the planning phase. In fact, during the pilot test, a systematic mechanism will be set up for collection, analysis, and responses to user feedback. The feedback gathered through surveys, interviews, and focus group workshop discussions has helped identify detailed information on the users' needs. Valuable direct feedback from the trial users will further polish the platform's functionality and operability as it will help us understand the real-world implications of this platform and provide the basis for further adjustment.

This Feedback will then be looped back into the platform refinement process. This involves slightly modifying iterative cycles through reshaping changes, retesting, and obtaining additional feedback based on user experience. These feedback loops will help the DBH administrators refine the platform functionality to meet user needs better and address problems arising during the pilot stage. The phase not only improves the design and functions of a platform but also significantly helps resolve potential risks that could occur during the final implementation phases.

12.3 Continuous Improvement Strategies

Strategies for Continuous enhancement include handling essential modifications and guaranteeing a long-term enhancement of the implementation procedures. Efficient performance assessment and feedback methods will be integrated into the DBH platform for iterative improvements in the platform operations. This includes setting up mechanisms for stakeholders' input so that ongoing enhancements may be made accordingly to satisfy the evolving demands of the users. In addition, DBH will implement an internal feedback system for real-time user input and have monthly feedback follow-ups to provide an in-depth understanding of users' experiences and recommendations. As a result, the development process will ensure agility and adaptability as the platform administrators use real-time data and stakeholder feedback.

The DBH Platform's continuous improvement strategies also comprise doable tasks that promote steady progress in user happiness and performance. Regular feature upgrades and optimizations will be made accessible to users, taking into account their comments and responses to these technological enhancements. The DBH administration team will employ powerful analytics to track and monitor KPIs. User engagement in suggestions will create an environment that guarantees a data-driven approach to define enhancements and improvements required. The platform will be audited annually to ensure it is secure and compliant with evolving laws and regulations.

System scalability tests will be carried out on operational needs to determine if the infrastructure can sustain a growing population and make the required adjustments to manage any expansion effectively. All these strategies aim to make the DBH platform state-of-the-art in terms of innovation, security, dependability, and user-centered service.

13 Conclusion

Key Findings and Recommendations:

The report highlights the importance of balancing stakeholders' needs with the platform design in response to industry changes. The DBH platform focuses on continuously improving cycles that integrate user feedback, ensuring the platform remains responsive to current needs.

Key findings include:

- Stakeholder feedback is crucial for shaping the platform's functionality.
- Continuous strategy enhancement, enabled by user input mechanisms like surveys and feedback loops.
- Platform scalability to adapt to evolving user needs and industry best practices.
- Data-driven decision-making that utilizes analytics to automate processes, track key performance indicators (KPIs), and improve platform performance.

Lastly, the report proposes that an iterative and agile development approach is crucial for maintaining the platform's operation and functionality.

Impact on Industry:

The DBH platform has the potential to transform the industry by connecting biogas producers, consumers, and other stakeholders within a digitally networked marketplace. Based on platform strategy literature, the report argues that network effects will be key drivers of adoption and value creation.

Potential industry impacts are:

- Market Efficiency: By providing a centralized market, the platform enables transparent trading, enhances price discovery, and nurtures trust among industry participants.
- Regulatory Compliance: The platform helps adapt to evolving regulatory landscapes to ensure compliance with industry regulations.

- Sustainability and Circular Economy: The platform promotes sustainable operations by optimizing resource efficiency and supporting environmentally friendly production and consumption.
- Scalability and Growth: The platform's flexible design guarantees that it can expand its operations across multiple regions, embrace new technologies, and offer additional services.

The DBH platform uses a platform-based approach that may catalyze industry-wide transformation, fostering innovation and stakeholder cooperation.

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