Business Model for Bio-hubs in Canada and Australia

IEA Bioenergy: Task 43

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Photo credit: Canadian Wood Fibre Centre, Natural Resources Canada

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Introduction

The International Energy Agency (IEA) Bioenergy Technology Collaboration Programme, under Task 43 (Sustainable Biomass Supply Integration for Bioenergy within the Broader Bioeconomy), aims to identify strategies to improve supply chain efficiencies of sustainably sourced biomass.

In the previous triennium, IEA Bioenergy Task 43 implemented two SWOT analyses on comparing biomass supply via bio-hubs against the alternative, through workshops held in Europe (October 2019, Sopron, Hungary) and North America (March 2020, Ottawa, Canada). These workshops collected insights from 55 participants across 17 countries. The workshop in Europe was co-hosted by the BioEast Initiative, a platform fostering bioeconomy collaboration among 11 Central and Eastern European countries (Kulisic et al., 2019). Natural Resources Canada (NRCan) implemented the workshop in Canada (Nasso et al., 2020). These workshops examined in-depth the strengths, weaknesses, opportunities, and threats associated with biomass supply via bio-hubs against the existing alternative. Both workshops outlined a list of possible actions to enable and/or strengthen bio-hub implementation in the real environment.

Subsequently, a follow-up initiative, supported by the Canadian national research fund continued to investigate bio-hubs further by engaging the focus groups in exploring the feasibility of bio-hubs in Canada. Early indications suggest a lack of clarity in the business rationale for bio-hubs in Canada, thereby limiting industry interest. The proposed research aims to present diverse business models to stakeholders to ascertain the prerequisites for their active involvement.

Centralized collection points, known as bio-hubs, play a crucial role in gathering, processing, and distributing diverse types of biomass to stabilize the biomass supply and maximize market value for renewable energy and bio-based products. This role is essential for fostering a sustainable, circular, and reliable bioeconomy (Pradhan et al., 2022; Nicholls et al., 2022). Despite their potential benefits in streamlining processes and reducing costs in the long term, challenges such as the lack of suitable locations, infrastructure, and feedstock availability can impede bio-hub development (Nicholls et al., 2022).

To optimize the impact of bio-hubs on sustainable biomass supply and utilization, a strategic approach is essential. This involves contextualizing the necessary bio-hub features within the existing biomass supply chain and integrating various components and processes. Bio-hubs should be designed with flexibility, considering factors such as location, size, level of processing, variability of feedstocks and position within the supply chain.

The features of a theoretical bio-hub are derived from past activities of the IEA Bioenergy Task 43 and available literature. This research presents the theoretical business model using a business model canvas template, based on the bio-hub SWOT analysis results—separately for Europe and Canada. During workshops conducted in the same settings (Canada, Australia), ideas and experiences from national focus groups will be collected through an action matrix via the Mentimeter online platform. Stakeholders from the EU (BioEast, EU15), Australia & Oceania, the US, and Canada will be invited to reflect and provide insights on the requirements for engaging in bio-hub businesses or enhancing the theoretical business model to make it more realistic, implementable, and attractive. The methodology serves both as an educational tool for stakeholders about bio-hubs and as a means to present bio-hubs as a novel stakeholder or business activity. A bio-hub is synonymous with integrated biomass

logistic centres (Balaman et al., 2018; Succelog, 2020), biomass logistics and trade centres (BioRES, 2020), and biomass logistics and distribution points (Lo et al., 2021). A bio-hub refers to gathering points for one or several biomass types serving various industries, including food and non-food products. In this context, the exploration extends beyond gathering biomass for the bioenergy market, to supplying renewable carbon contained in biomass for de-fossilizing the economy. Specifically for Canada, this would encompass sectors beyond just bioenergy.

On June 28, 2023, a workshop titled "Business Model for Bio-hubs in Canada" was conducted to develop a business model for bio-hubs within the broader bioeconomy, integrating the Canadian biomass supply setting (Fig. 1). The workshop convened 27 pre-selected individuals from diverse organizations, representing stakeholders in the Canadian bioeconomy sector—both on the supply and demand sides, as well as policy and academia representatives. A similar workshop was held in Australia on June 4, 2024, with 16 participants. Workshops are also being considered for other regions (e.g. United States, European Union).

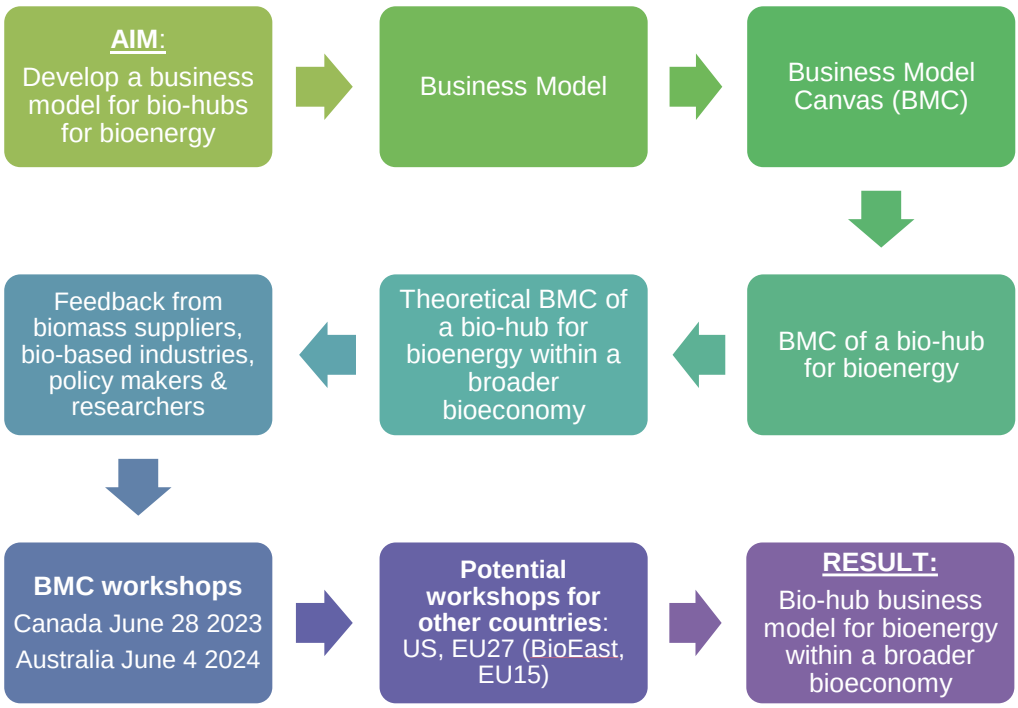

Fig. 1. A schematic diagram of workshop presentation aims and activities and how feedback from various stakeholders will result in a portfolio of business models for bio-hubs for

To gather insights for developing a business model for bio-hubs promoting sustainable biomass supply for bioenergy within the broader bioeconomy, a strategic management tool known as the business model canvas (BMC) was employed. The business model, depicting how a company creates value, is crucial for companies in the same line of business to compete based on their approach to creating added value with the available assets in the targeted market. The BMC outlines a template with nine interconnected and dependent building blocks: 1) key partners, 2) key activities, 3) key resources, 4) value propositions, 5) customer relationships, 6) market channels, 7) customer segments, 8) cost structures, and 9) revenue streams. These components and their interconnections define a business model created around the value proposition.

The specific objectives of the workshops were as follows:

- Presenting a "theoretical" bio-hub business model using the BMC template, centred around the existing collection points "selling wood for bioenergy" as a value proposition. The aim was to enhance and tailor this model for the Canadian and Australian contexts by incorporating input from participants, transforming it into "placing renewable carbon for the de-fossilization of the economy."

- Delving deeper into specific components of the business model to gather suggestions for improvement.

- Establishing a platform for sharing information related to the engagement requirements for bio-hubs to enhance the "theoretical" business model.

Bio-hubs: An Overview

A bio-hub links biomass supply chains and the markets they serve by acting as an "intermediate place" where biomass suppliers, including farmers and foresters, can deliver by-products such as straw or wood residues to be processed into commodities such as pellets with higher quality and value (Ghaffariyan et al., 2021).

Additionally, bio-hubs can serve various functions, including storage, loading, recycling, and processing facilities, allowing biomass to be transported for various end uses (Pradhan et al., 2022). A key feature of bio-hubs is the inclusion of a densification step to facilitate downstream transportation. Bio-hubs could be designed in such a way that these processes occur downstream. Hence, bio-hubs can facilitate biomass processing, storage, and transportation, reducing losses and administrative costs while promoting the production of a variety of biomass products at a single location (Kulisic et al., 2019; Nasso et al., 2020). Bio-hubs can also provide an opportunity for biomass product suppliers to continue producing in the off-season, as well as a location for companies to connect and conduct business (IEA Bioenergy, 2023). In summary, bio-hubs can improve biomass supply chains, enhance the value of biomass products, and facilitate the transition toward a more sustainable and circular bioeconomy (Ghaffariyan et al. 2021; Pradhan et al., 2022; Nicholls et al., 2022).

Despite the potential benefits of bio-hubs, several challenges could limit their development and implementation. These challenges include variability in biomass availability due to factors such as weather conditions, seasonality, and regional disparities, necessitating measures to ensure a consistent feedstock supply (Nasso et al., 2020; Nicholls et al., 2022). Maintaining biomass quality and meeting necessary standards is another concern, especially when managing diverse feedstock sources.

Additionally, efficient logistics and transportation of biomass from sources to bio-hub facilities can pose challenges because of the low density of these materials. Moreover, there is a potentially higher risk of accidents due to the higher volumes of biomass processed in a bio-hub (Ghaffariyan et al., 2021).

Biomass supply has been identified as one of the bottlenecks in the development of the bio-based industry on a larger scale (Leao et al., 2011; Balaman et al., 2018; Panteli et al., 2018; Zetterholm et al., 2020; Guo et al., 2020), primarily due to its transportation costs (Sosa et al., 2015) and a lack of expertise on how to avoid biomass degradation or loss during storage (Anerud et al., 2019; Yoo et al., 2020). Furthermore, the startup costs of a bio-hub are high, and integrating various technologies for biomass processing, conversion, and product

development can be technically complex, requiring substantial investments in research and development (Ghaffariyan et al., 2021; IEA Bioenergy, 2022).

Lastly, balancing economic viability with sustainability goals is also a challenge, as the bio-hub model must be financially sustainable to attract investment (Nasso et al., 2020).

These challenges highlight the importance of strategic planning and collaboration among various stakeholders to facilitate the development of bio-hubs in Canada, Australia and other countries. They also present multiple opportunities to explore approaches for how the development of bio-hubs can promote the sustainable supply of biomass for bioenergy in the broader bioeconomy. Moreover, as the bioeconomy continues to expand, bio-hubs are well-positioned to offer integrated solutions for biomass processing and supply (Nasso et al., 2020; Nicholls et al., 2022). Collaborative partnerships with biomass suppliers, technology providers, and research institutions, as well as favourable policies and incentives such as carbon pricing and the clean fuel standards, can create a supportive environment for bio-hub adoption (Nasso et. al, 2020).

Bio-hub Business Model

A business model is a framework that defines how a business creates, delivers, and captures value in generating sustainable revenue. It encompasses key elements such as products or services, target customers, revenue streams, cost structure, and distribution channels, providing a blueprint for the organization's operations and success strategy (Osterwalder and Pigneur, 2010; Onetti et al, 2012).

A bio-hub business model is essential for optimizing processes within bio-hubs, bioenergy, and the broader bioeconomy (Benjaminsson et al., 2019; Pradhan et al., 2022). For instance, the modelling tool CANBIO-HUB offers detailed techno-economic analysis and insights (Pradhan et al., 2022) that can inform bio-hub businesses. However, it is essential to consider various factors such as regional differences and the type of sector (e.g., agriculture, forest-based) in such analyses.

The theoretical bio-hub business model surfaced from two workshops: Europe, 2019 (Kulisic et al., 2019) and Canada, 2020 (Nasso et al., 2020), that acknowledged the "availability of sustainable biomass" as the biggest strength of having a biomass supply via a bio-hub. The "large investment needed", "infrastructure financing" and "limited access to capital in an uncertain environment" were the most intense weaknesses in the establishment of a bio-hub. The top threats are uncertainty (e.g., climate change), past failures of biomass (bioenergy) related projects that discourage investors, and their potential risk for all three dimensions of sustainability, linked with the volume of biomass managed.

While models are typically validated using secondary data and case studies, gathering feedback from stakeholders, including focus groups is crucial. Thus, by presenting a theoretical BMC to a pre-selected group of biomass suppliers and the bio-based industry, Canadian and Australian bioeconomy stakeholders provide valuable insights into the practical application of bio-hubs for bioenergy within the broader bioeconomy.

Business Model Canvas (BMC)

The BMC is a strategic management tool that visually frames the development, description, and analysis of a business model (França et al. 2017; Benjaminsson et al. 2019). BMC serves as a comprehensive guide for outlining essential components within the business model (Fig. 2). These components encompass key partners, activities, resources, value propositions, customer relationships and segments, channels for reaching target customers, cost structure, and revenue streams (França et al. 2017), which are important for the successful implementation of bio-hubs.

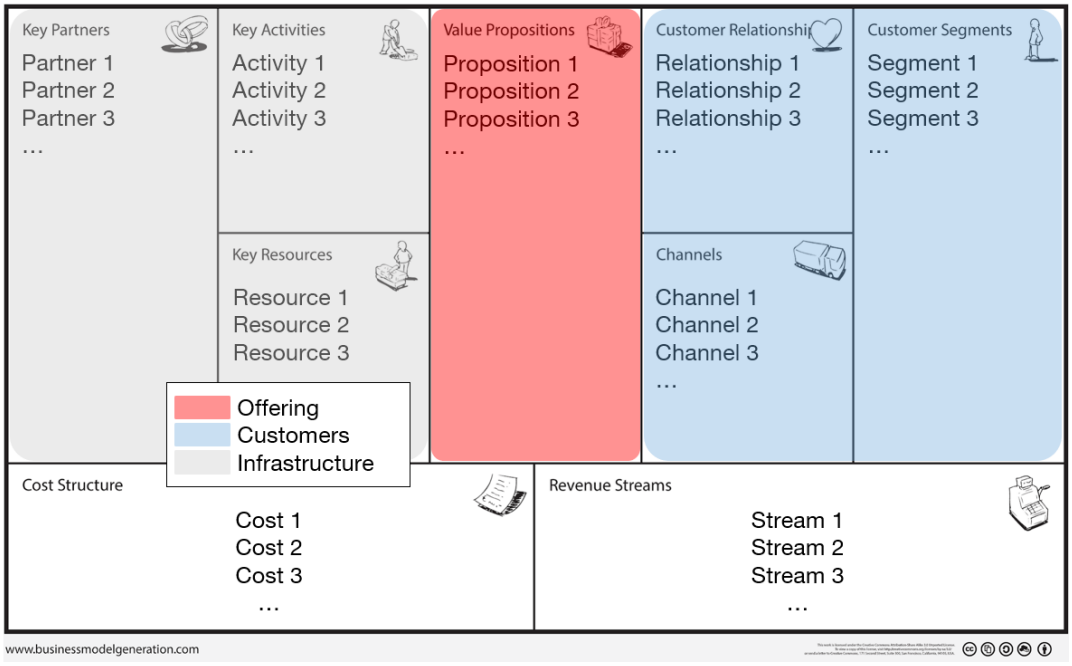

Fig. 2. Business canvas model template (source: Strategizer.com)

Those business components are built around the value proposition: goods or services that a company places in the market. A company can build a business around one or more goods or services or arrange different bundles of products and/or services. Placing a product or a service in the market will be related to the cost of engaging infrastructure (left side of the canvas) and will create one or more streams of income (right side of the canvas) that will come from customers. Each value proposition is interlinked and dependent on all remaining eight blocks of a BMC.

Components of a theoretical bio-hub emerged from the previous two workshops and literature review, with any missing elements being compensated for by dependable relations. For example, if the value proposition is “selling wood chips,” key partners might include “chip traders” or “forest owners,” which would then branch out to key resources such as a truck for a chip trader and a chipper for a forest owner, and so forth.

The business model of a bio-hub can be as diverse as the available biomass at the location (supply) and industry demand within reach (Fig. 3), coupled with the capacity of a bio-hub manager to recognize existing links or create new ones between these two sides of the market.

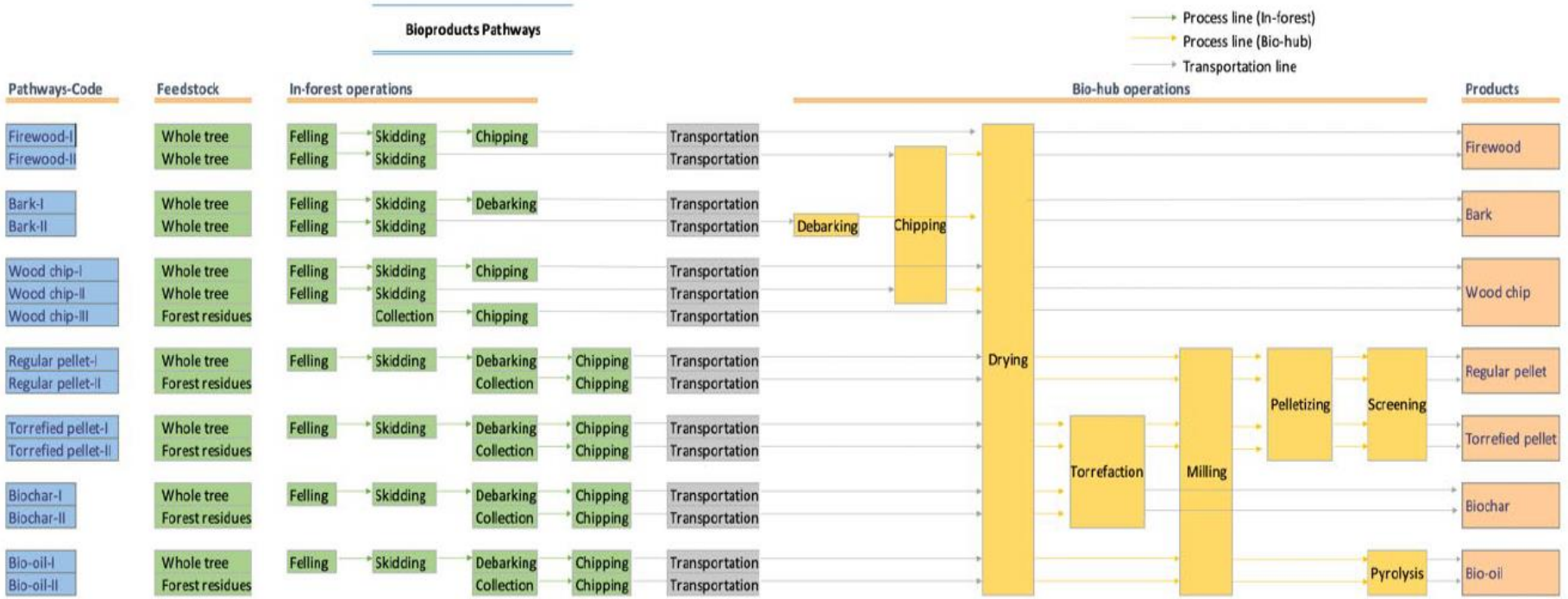

Fig. 3. Diversity of bio-hubs for supplying biomass for bioenergy (Pradhan et al., 2022).

The example (Fig. 2) illustrates the nine building blocks of the business model canvas, including the cost and revenue streams. Every business model begins with the value propositions, where a bio-hub distinguishes itself from competitors and enhances the operations of its customers. Key propositions of a bio-hub could include the sales of biomass, ensuring a consistent and reliable source of biomass for customers through, for instance, securing feedstock supply contracts. Additionally, it emphasizes efficiency and affordability in biomass conversion, making it an attractive option for customers. The bio-hub can also tailor offerings to meet specific customer needs, potentially including low-value biomass for energy, which can attract customers seeking affordable energy sources.

Key partners, key resources, and key activities constitute the infrastructure supporting the creation of value proposition(s).

- **Key partners** are stakeholders who provide access to resources, expertise, and networks, helping the bio-hub gain a competitive advantage in relation to the value propositions. Main partners include biomass suppliers (e.g., tenure holders, forest owners), equipment suppliers, leaders in the renewable industry, research institutions for technological advancements, certification organizations, and logistics companies.

- **Key activities** involve the core tasks undertaken to create and deliver biomass value propositions (Benjaminsson et al., 2019). These activities may include market exploration to source low-value biomass such as straw and forest residues, as well as efficient services for storing and processing biomass while minimizing losses. Additionally, key activities may involve securing biomass through various means, such as purchasing from harvesters, on-demand harvesting and collecting, machinery rental, and offering comprehensive services that cover harvesting, collecting, chipping, transportation, and sustainability certification (Kulisic, 2023). An activity is always related to key partner(s) and key resource(s) to deliver a value proposition. In other words, a bio-hub can provide the transportation (activity) of biomass to the customer. For that, a truck will be needed (key resource) and a driver (key resource), will be reflected in the cost structure, along with fuel and maintenance. Yet, it can outsource the transportation as a service, which will be recorded as a key partner with costs assigned to this service.

- **Key resources** are essential for providing value propositions of a bio-hub and could include biomass processing equipment, laboratory equipment for analysis, transportation infrastructure, as well as skilled personnel with expertise in biomass conversion, knowledge of biomass storage, innovative utilization of biomass, and sustainability certification mechanisms. Resource efficiency, diversification, know-how, and fixed capital intensity are some of the options to reduce unit cost per proposed value.

On the right side of the business model canvas from the value proposition(s) is the Customer side of the business: customer relationships, customer segments, and channels (Fig. 2).

Customer relationships represent a vital aspect of a bio-hub's operations, involving various elements aimed at fostering strong relationships and effective communication (Benjaminsson et al., 2019). Customer interactions with the industry, forest owners, and local communities are essential for meeting customer needs, addressing challenges, and establishing a solid reputation within the bioeconomy sector (Kulisic, 2023). For instance, engaging with the industry network is crucial as it enables collaboration with industry stakeholders and the

sharing of expertise and resources, thereby enhancing the bio-hub's capabilities. Furthermore, offering technical support related to biomass supply and processing ensures that customers receive the necessary assistance and guidance, contributing to the overall success of the bio-hub's operations (Kulisic, 2023).

Identifying **customer segments** is a crucial step in the bio-hub's strategic planning (Benjaminsson et al., 2019). These segments currently include the wood pellet industry, electricity producers, district heating systems, and industries seeking sustainable raw materials to reduce GHG emissions (Kulisic, 2023). These segments have distinct characteristics and needs, allowing the bio-hub to tailor its offerings effectively. Customer segments can be either recognized (existing) or created (emerging), either as a separate business (remaining in the Customer segment box) or becoming a Key Partner (infrastructure) where the bio-hub receives future revenues, builds know-how, or achieves some other infrastructure benefit in exchange for the key partnership.

Determining the right **channels** to reach and engage with customers involves selecting the most effective means to communicate the bio-hub's value propositions and offerings to its target audience (Benjaminsson et al., 2019). A bio-hub can utilize several channels, including maintaining an informative and user-friendly website, establishing strong business-to-business (B2B) relationships with relevant industry players, and actively participating in public procurement processes (Kulisic, 2023). These channels are vital pathways for the bio-hub to showcase its services, share information, and connect with its customer segments.

The cost structure of a bio-hub is an important aspect of its operational planning, detailing the financial considerations of running the facility (Benjaminsson et al., 2019; Nicholls et al., 2022). The cost structure covers both fixed and variable costs related to various aspects of bio-hub operations, encompassing expenses associated with biomass procurement, processing, transportation, and regulatory compliance. Effective evaluation and management of the cost structure enable the bio-hub to plan its budget, allocate resources, and make informed decisions to ensure sustainability and profitability (Kulisic, 2023). Yet, the cost structure is not related to the infrastructure side of the business model canvas. Costs can also occur from the other side of the Customer segment of the business, such as marketing costs, presentations, market analysis, travel, etc.

Bio-hubs can generate revenue through multiple avenues, including selling processed biomass and offering biomass processing services (Benjaminsson et al., 2019; Kulisic, 2023). While it is essential to ensure that the bio-hub's financial model is economically viable and sustainable over a certain period, the management of a bio-hub must recognize and reflect market dynamics from both sides of the market. By aligning revenue streams with the value propositions and customer segments of the bio-hub, it can optimize its income generation strategies, ensuring they remain competitive and profitable in the bioeconomy landscape.

Methodology

Pre-workshop Survey

Prior to the workshops, participants were invited to complete a short survey using AllCounted to provide information about their work location, the nature of their organization, the sector in which the organization operates, and the size of their organization based on the number of employees (Appendix 1). Respondents were also asked about their level of familiarity with bio-hubs. The survey responses were aggregated and prepared for presentation at the workshop.

Workshop Activities

During the Canadian workshop, Gregory Smith, a Director at NRCan's Canadian Forest Service (CFS), welcomed the participants with his opening remarks. Subsequently, the pre-workshop survey results were presented by Heather Macdonald, CFS, NRCan. The Overview of IEA Bioenergy Task 43 and previous activities on bio-hubs were presented by Bruno Gagnon, CFS, NRCan, as well as the national context and federal initiatives related to biomass supply. Finally, utilizing Miro (RealtimeBoard Inc.), Biljana Kulisic (European Commission Directorate-General for Energy) presented the BMC (Appendix 2) and a list of questions (Appendix 3) to obtain feedback from various stakeholders on the theoretical BMC to inform the development of a portfolio of business models for bioenergy within a broader bioeconomy. Participants were also invited to validate and provide feedback on the components of the BMC, including key partners, activities, and resources for bio-hubs (Appendix 2).

Considering the diversity of bio-hubs, this research links to the context with IEA Bioenergy Task 43 efforts to collect expert opinions utilizing a SWOT analysis of supplying biomass via bio-hubs, in comparison with the alternative in place (Kulisic et al., 2019; Nasso et al., 2020). To avoid threats and weaknesses of high investment costs and risk on location, existing bio-hubs for bioenergy were used as the starting point for a discussion on how to move towards the bioeconomy. For this exercise, a business model for a bio-hub supplying woody biomass for bioenergy was presented in a business model canvas template for the expansion to supplying certified sustainably sourced renewable carbon for the best market value. The details of the model are provided in Appendix 1.

A voting feature in Miro (RealtimeBoard Inc.) allowed participants to prioritize the component and sub-component of the BMC based on their knowledge and experience. Participant inputs were then integrated into the various categories of the business model, and the voting results as well as the total votes cast for each component were presented. The workshop materials and screenshots of the participants' inputs and voting activities, are available in the Appendices.

In a similar fashion, a 2.5 hours online workshop was planned and delivered to Australian industry, academic and governmental representatives. Mohammad R. Ghaffariyan (University of the Sunshine Coast) provided a short overview of the IEA Bioenergy Task 43 and its link with Australian forest and bioenergy research and development. Biljana Kulisic presented the BMC (Appendix 2) along with a set of questions (Appendix 3) to gather stakeholder feedback. This input aims to refine the theoretical BMC and guide the creation of business models for bioenergy within the broader bioeconomy. Participants were also asked to validate and provide input on key elements of the BMC, such as partners, activities, and resources for bio-hubs (Appendix 2).

Results and Discussion

The pre-workshop survey and workshop enabled a comprehensive exploration of bio-hub development and its implications within the Canadian context, gathering insights from a diverse range of participants representing various sectors, regions, and organizations.

Pre-workshop Survey

Approximately 25% of Canadian participants in the study were from Ontario, Quebec, and British Columbia, with 14% and 11% from Nova Scotia and New Brunswick, respectively. The organizations represented varied, with 25% from academia, 20% from provincial/territorial bodies and non-profits, 17% from the federal government, and 13% from the industry or research institutions. These organizations primarily operate in forestry, bioenergy, education, government, and professional sectors (Fig. 4). In terms of size, over 40% of participants work in organizations with 500+ employees, 23% in organizations with 10-29 employees, and around 13% in organizations with 1-4 employees. About one-third of the participants were somewhat familiar or not familiar with bio-hubs. Details of the survey outcome are provided in Appendix 1. This suggests the importance of increasing awareness of bio-hubs in Canada and the roles they can play in the broader bioeconomy.

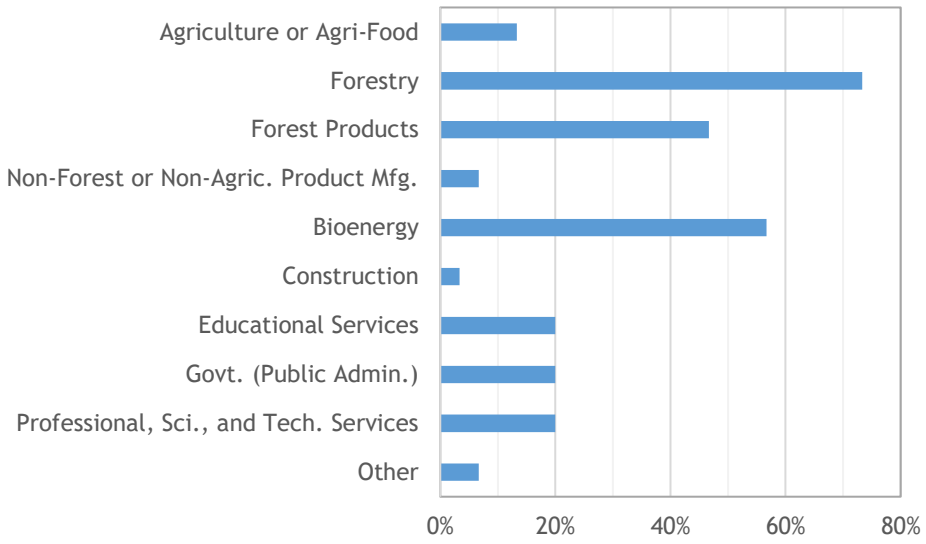

Fig. 4. Sectors in which participants' organizations in Canada operate

The Australian online survey gathered insights from a diverse group of participants across various States, Territories, and organizational backgrounds. Most respondents work in Queensland (38%) and New South Wales (23%), followed by Victoria (15%) and Tasmania (13%). Smaller representations came from Western Australia (9%) and Auckland (2%), with no responses from Australian Capital Territory (ACT), Northern Territory (NT), Nelson, New Plymouth, Canterbury, or Wellington.

More than half of the participants (52%) were from industry or business sectors, while government-affiliated respondents (federal, provincial, and municipal) collectively accounted

for 29%. Other notable contributions came from academia (8%), not-for-profit organizations (6%), and research institutes (2%). Bioenergy emerged as the dominant sector (35%), followed by government/public administration (19%) and forestry (10%). Other sectors include agriculture/agri-food, forest products (6% each), and professional/scientific services (8%). Smaller representations were noted in non-agricultural manufacturing and educational services (2% each).

Most organizations represented are large, with 40% employing over 500 people. Smaller organizations, ranging from 1 to 49 employees, collectively constituted 36%, while medium-sized organizations (51 to 499 employees) accounted for 25%. Participants demonstrated varying levels of experience in agriculture and forestry. A significant portion (32%) has 1 to 4 years of experience, while 19% were new entrants with less than one year. Others had substantial expertise, with 34% having over 10 years of experience in these sectors. Awareness of biomass processing centres, or "bio-hubs," was relatively low, with 23% of respondents being unfamiliar and 60% only somewhat familiar. A smaller group (17%) reported being very familiar with bio-hubs. This data highlights the diverse backgrounds and varying levels of expertise among respondents, providing a foundation for targeted strategies to enhance bio-hub awareness and engagement across sectors.

Workshop Activities: Business Model Canvas

The workshops enabled the presentation of BMC to diverse stakeholders and tailored their feedback to each component of the BMC, including the key activities, resources, and partners. Cost and revenue streams were not addressed during the workshops as they will follow the structure of the developed business model.

Value Proposition

In the value proposition category, feedstock supply contracts, leveraging economies of scale for cost-effective services, and consulting on biomass mix and properties received the most votes from Canadian participants (Fig. 5). These contracts ensure a steady supply of raw materials, reduce procurement and uncertainty as well as offer cost-effective services (Benjaminsson et al. 2019; Ouhimmou et al. 2021). Additional value propositions include value-added wood products, biomass conditioning for optimal value, and a fully integrated energy supply (stump to stack).

Bio-hubs need to provide cost-effective services like chipping, storage, and transport by leveraging economies of scale, benefiting businesses and industries (IEA Bioenergy, 2022). Bio-hubs should also be able to offer expertise in optimizing biomass use, helping industries make informed decisions and enhancing biomass value by producing higher-value products (Kulisic et al., 2019; Ghaffariyan et al., 2021).

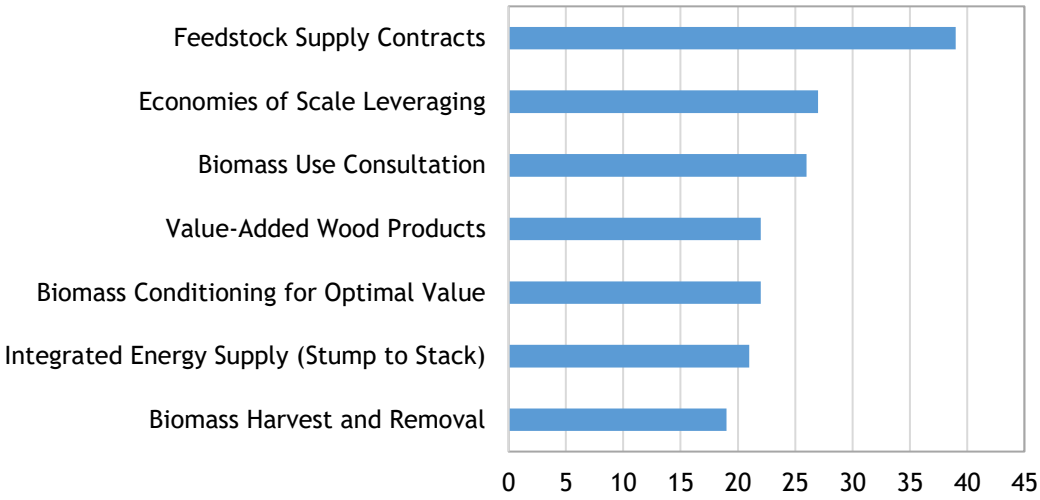

Fig. 5. Value proposition for successful bio-hub development and integration as indicated by Canadian workshop participants' votes (Total votes = 238).

In summary, Canadian bio-hubs should aim to offer diverse value propositions, including reliable feedstock supply, cost savings, expert guidance, value-added products, optimal biomass conditioning, and comprehensive energy supply solutions, fostering the growth, efficiency, and sustainability of the bioeconomy in Canada.

Australian participants indicated that in customer relationship, following items were highly ranked by the participants including service of the biomass harvest and logistic, providing feedstock supply and finding best use of the biomass resources (Appendix 5).

Key Activities

Among the key activities Canadian voters prioritized biomass supply, cascading biomass use, and providing related services while the top three items for Australian workshop attendees were cascading use of biomass, full fibre utilisation and providing services related to biomass. In the individual category, transport and long-term investment contracts for biomass supply received the most votes, followed by waste biomass management and chipping operations (Fig. 6). Transport and long-term investment contracts ensure efficient biomass movement and supply, waste biomass management optimizes resources, and chipping enhances the usability of residues as bioenergy feedstock (Umakanth et al. 2022).

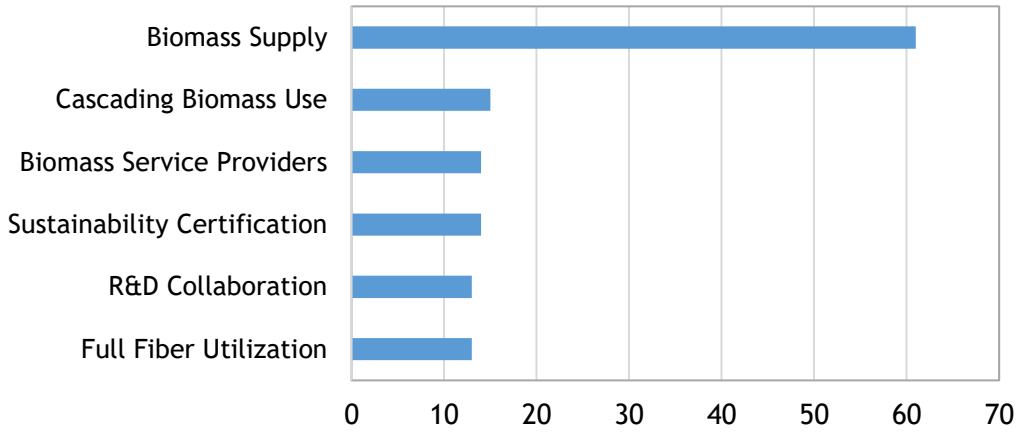

Fig. 6. Key activities for successful bio-hub development and integration as indicated by Canadian workshop participants' votes (Total votes = 147).

Key Resources

Knowledge of the innovative use of biomass received the highest votes from Canadian participants, followed by available biomass sources and biomass supply equipment (Fig. 7). Knowledge of the innovative use of biomass involves understanding and expertise in utilizing biomass for bioenergy production. Additionally, having access to available biomass sources that are technically feasible, socially accepted, and ecologically sustainable is crucial for ensuring a reliable supply of feedstock.

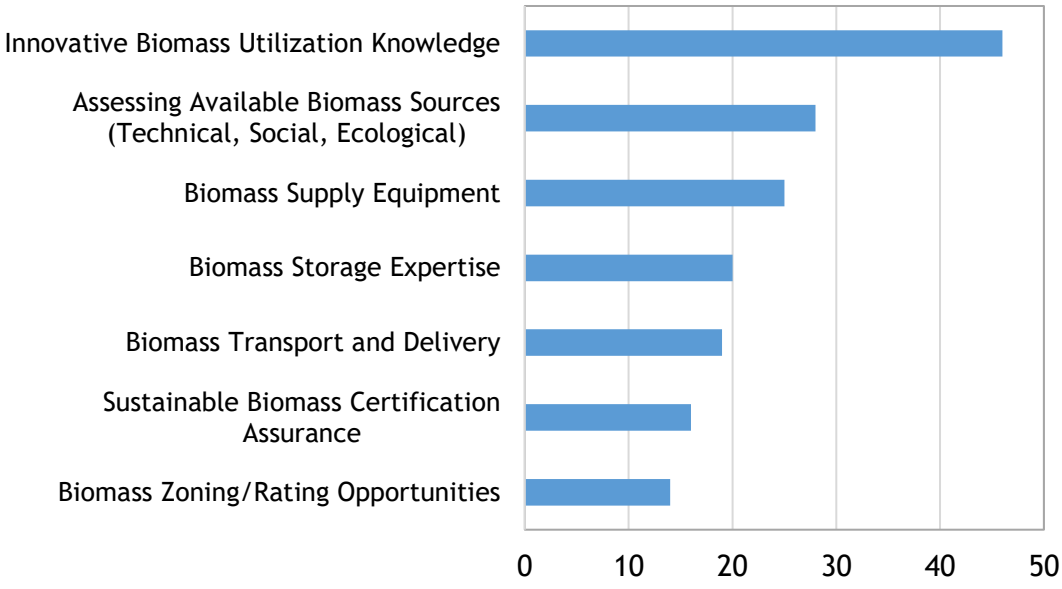

Fig. 7. Key resources for successful bio-hub development and integration as indicated by Canadian workshop participants' votes (Total votes = 217).

In the Australian case, laboratory equipment, knowledge on biomass storage and biomass supply equipment were identified as main resources for biomass and biohub planning (Appendix 5). Furthermore, biomass supply equipment is essential for the efficient collection, processing, and transportation of biomass, facilitating the smooth operation of bioenergy production processes. Together, key resources contribute to the sustainable and effective utilization of biomass for bioenergy generation (Benjaminsson et al. 2019; Nicholls et al., 2022).

Key Partners

Among the key partners identified by Canadian participants, biomass suppliers received the highest vote (61) from Canadian participants, followed by key industries seeking to replace fossil fuels with renewable energy (25), and innovation partners (22) (Fig. 8). Within this component, the wood-based industry, forest owners, First Nations, and tenure holders received the highest votes. Details are provided in Appendix 4.

The significance of these key partners lies in their pivotal roles in biomass supply and bioenergy production. The wood-based industry, comprising businesses involved in wood product processing, not only contributes to biomass feedstock but also possesses crucial expertise in the utilization of wood-based resources for several end uses, including renewable energy generation. Forest owners, including Indigenous Nations, are integral stakeholders in the biomass supply chain, as they manage vast forested areas, which serve as primary sources of biomass feedstock. Their involvement can ensure sustainable sourcing practices and foster community engagement in bioenergy initiatives.

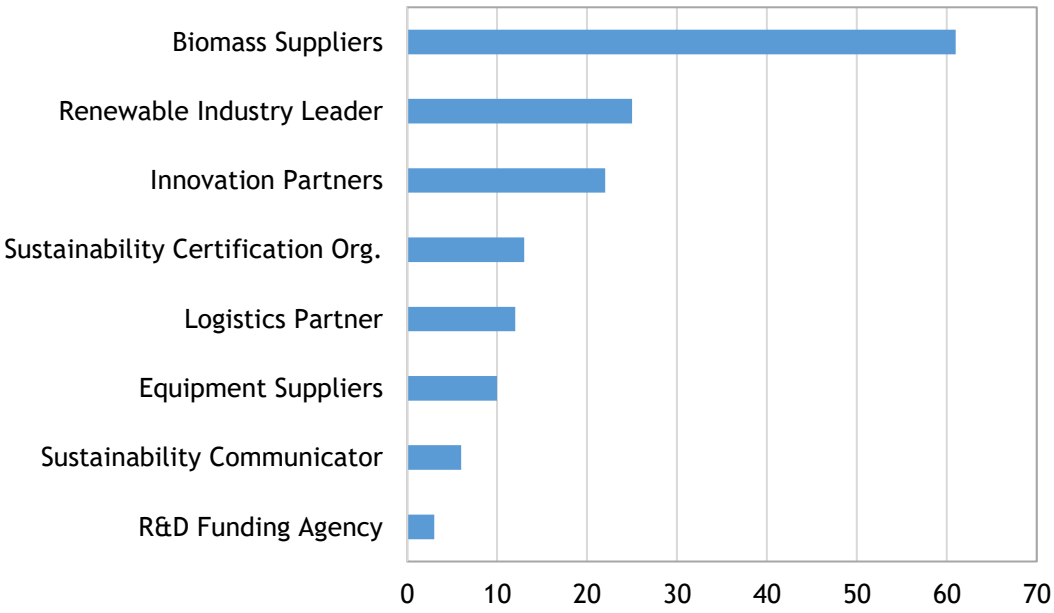

Fig. 8. Key partners for successful bio-hub development and integration as indicated by Canadian workshop participants' votes (Total votes = 152).

Indigenous Peoples around the world manage diverse bioeconomies, holding diverse cultural and environmental knowledge that can inform sustainable bio-hub development strategies, ensuring alignment with the values and priorities of Indigenous communities. As tenure holders, Indigenous Nations encompass various entities with land or resource rights,

contribute to the stability and continuity of biomass supply chains, and support the long-term viability of bioenergy projects

Out of 15 participants in Australian workshop, 6 people voted biomass supply and 4 people voted for key industry looking to replace fossil fuel with renewable energies. Other key partners such as logistic companies and innovation partners only got 1 vote each (Appendix 5).

Customer Relations

Collaboration with industry networks received the highest number of votes from Canadian participants, highlighting its pivotal role in providing expertise, resources, and support that shape various cost aspects, from material sourcing to product marketing (Fig. 9). Additionally, fostering cooperation with forest owners and operators is crucial for ensuring a stable and consistent biomass supply, which in turn stabilizes feedstock costs. Positive relations with the local community emerge as another key factor, helping to mitigate potential conflicts, regulatory challenges, and legal hurdles, thereby facilitating smoother project development and cost reduction.

Access to financing for infrastructure related to consumer fuel switching is important for bio-hub success, as these costs can be substantial, and financial support enhances the project's economic viability. The emphasis on circularity and sustainability principles within bio-hub operations leads to long-term cost benefits, including enhanced resource efficiency, waste reduction, and positive branding. Connections to capital markets are essential for securing funding, reducing financing costs, and attracting necessary investments.

Research networks, both national and international, play a crucial role in advancing bio-hub technology and knowledge, potentially reducing research and development costs, and improving overall efficiency based on the results of both workshops (Benjaminsson et al., 2019; Nasso et al., 2020).

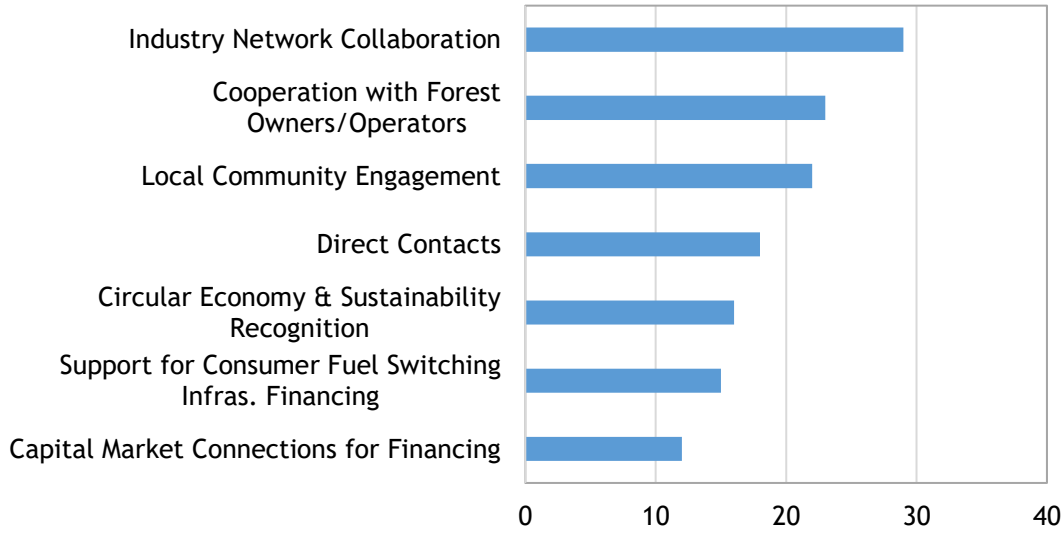

Fig. 9. Customer relationships for successful bio-hub development and integration as indicated by Canadian workshop participants' votes (Total votes = 159).

Australian participants suggested relationship with local communities and industry networking to be effective factors for consideration. Furthermore, the involvement of industry networks is essential, especially in sharing expertise and resources for bio-hub development.

Customer Channels

The top-rated channels identified in the Canadian workshop include engaging with the residue producing bio-based industry, participating in trade shows and business events focused on net-zero emissions, and catering to public procurement needs (Fig. 10). These channels reflect the importance of aligning bio-hubs with industries generating valuable biomass residues, connecting with sustainability-focused businesses (Benjaminsson et al. 2019; Kulisic 2023). Moreover, fostering business-to-business (B2B) relationships is a substantial customer channel for bio-hubs, allowing them to collaborate across the entire value chain, from biomass supply to product delivery. The votes emphasize the significance of these connections for streamlined operations and access to a broader market.

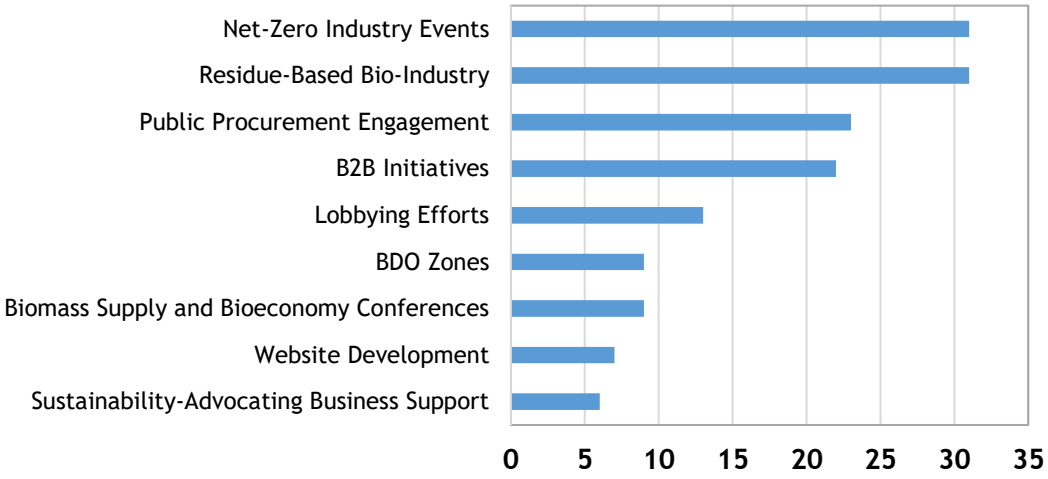

Fig. 10. Customer channels for successful bio-hub development and integration as indicated by Canadian workshop participants' votes (Total votes = 163).

Engaging in lobbying activities is another notable channel, highlighting the importance of shaping supportive regulatory frameworks and policies. Effective lobbying can create an enabling environment for bio-hub development by advocating for favourable policies and incentives. Also, establishing a presence in Bioeconomy Development Opportunity (BDO) zones and participating in conferences focused on sustainably supplied biomass and the bioeconomy offer opportunities for accessing resources, infrastructure, and potential customers while benefiting from an innovation-oriented environment (Kulisic 2023). A well-maintained website serves as a digital platform to showcase bio-hub offerings and connect with potential customers seeking bio-based solutions. (Benjaminsson et al. 2019; Kulisic 2023).

Building strong relationships with bio-based industries, sustainability-focused businesses, and public procurement entities is crucial for the success of bio-hubs. Simultaneously, engagement with policymakers, B2B partners, and regional stakeholders amplifies the potential impact of bio-hubs within the Canadian bioeconomy (IEA Bioenergy, 2022). Careful consideration and strategic utilization of these customer channels are necessary for the

growth and sustainability of bio-hubs in Canada. The Australian workshop participants listed the following items as key customer channels: bio-based industry with residues, business to business, BDO Zones, lobbying activities, website and influencers/social media (Appendix 5).

Customer Segments

Key customer segments crucial for the success of bio-hub initiatives in Canada include industries needing to reduce GHG emissions due to carbon pricing regulations (Fig. 11). Another vital segment includes industries striving to decarbonize and transition to clean fuels, where bio-hubs offer bio-based alternatives. Industries with biomass residues, energy companies, communities committed to reducing carbon footprints, and various other segments also play a role in the success of bio-hub initiatives. The voting results highlight the importance of building strong relationships with industries aiming to reduce emissions, transition away from fossil fuels, and embrace sustainable solutions. Furthermore, targeting energy companies, biomass-rich industries, and communities striving to reduce their carbon footprint enhances the potential for bio-hubs to achieve both environmental and economic objectives.

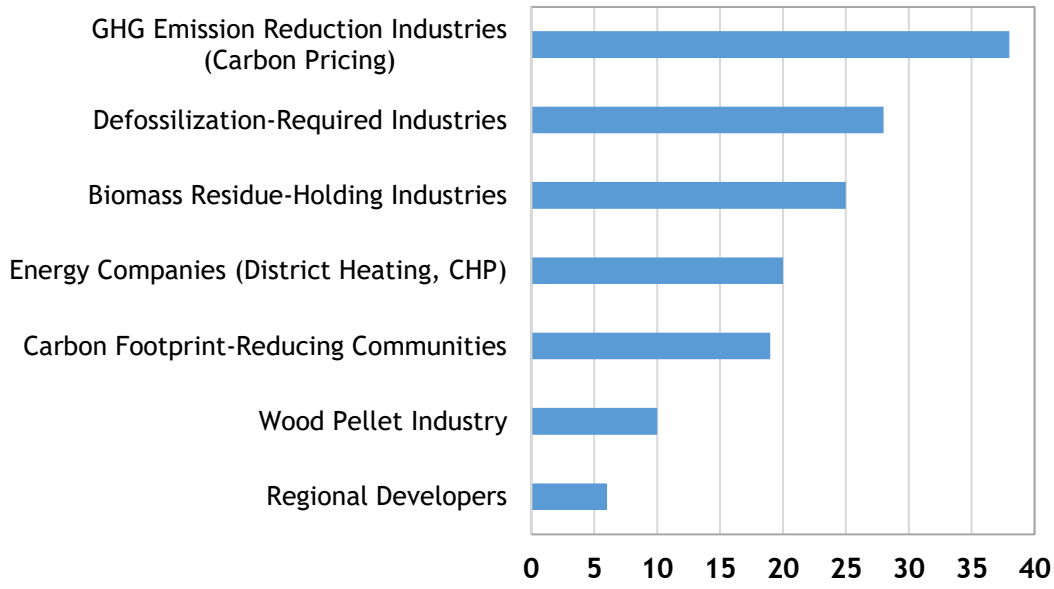

Fig. 11. Customer Segments for successful bio-hub development and integration as indicated by Canadian workshop participants' votes (Total votes = 154).

From an Australian perspective, energy companies, industries aiming to reduce carbon emissions, and those generating biomass residues emerged as the top customer segments, each receiving 3 votes out of a total of 15. The wood pellet industry and industries seeking to defossilize were identified as the second priority, with 2 votes each. Segments such as biomass exporters and regional developers received the lowest priority, garnering only 1 vote each (Appendix 5).

Key Partners	Key Activities	Key Resources	Value Proposition	Customer Relationships	Customer Channels	Customer Segments
• Biomass suppliers, 61 • Renewable Industry leader, 25 • Innovation Partners, 22 • Sustainability Certification Org., 13 • Logistics Partner, 12 • Equipment Suppliers, 10	• Biomass Supply, 61 • Cascading Biomass use, 15 • Sustainability certification, 14 • Biomass Service Providers, 14 • Full Fiber Utilization, 13 • R&D Collaboration, 13 • Biomass Storage Services, 8	• Innovative Biomass Utilization Knowledge, 46 • Assessing available biomass sources (technical, social, ecological), 28 • Biomass Supply Equipment, 25 • Biomass Transport & Delivery, 19 • Sustainable Biomass Certification Assurance, 16 • Insurance & Investment Support for Feedstock Supply, 14	• Feedstock supply contracts, 39 • Economies of Scale leveraging, 27 • Biomass use consultation, 26 • Biomass Conditioning for Optimal Value, 22 • Value-Added Wood Products, 22 • Integrated Energy Supply (Stump to Stack), 21 • Biomass Harvest & Removal, 19	• Industry network collaboration, 29 • Cooperation with Forest owners/operators, 23 • Local Community Engagement, 22 • Direct Contacts, 18 • Circular Economy & Sustainability Recognition, 16 • Support for Consumer Fuel Switching Infrastructure • Financing, 15	• Residue-based bio-industry, 31 • Net-zero Industry Events, 31 • Public Procurement Engagement, 23 • B2B Initiatives, 22 • Lobbying Efforts, 13 • Biomass Supply & Bioeconomy Conferences, 9 • BDO Zones, 9	• GHG Emission Reduction Industries (Carbon Pricing), 38 • Defossilization-required Industries, 28 • Biomass Residue-holding Industries, 25 • Energy Companies (District Heating, CHP), 20 • Carbon Footprint-Reducing Communities, 19 • Wood Pellet Industry, 10 • Regional Developers, 6

Fig. 12. Modified business model, highlighting the top seven key components prioritized by workshop participants in Canada. A more detailed input of the participants is provided in Appendix 4. B2B denotes business-to-business, while BDO signifies Bioeconomy Development Opportunity. The number after each item indicates the number of votes it received by workshop participants.

Key Partners	Key Activities	Key Resources	Value Proposition	Customer Relationships	Customer Channels	Customer Segments
• Biomass suppliers, 6 • Key industry looking to substitute fossil with renewable carbon, 4 • Certification org. for sustainability, 1 • Logistic company, 1 • Agency to apply for R/D funding, 1 • Innovation partner, 1 • Communicator to the customers on advances, 1	• Biomass supply, 5 • Provide service related to biomass, 3 • Full fibre utilization, 2 • Cascading use of bioenergy, 1, • Certifying biomass for sustainability, 1 • Communicating advances toward sustainability, 1	• Laboratory equipment • Knowledge on biomass storage • Assurance on biomass certification • Carbon policy education	• Selling certified sustainably sourced renewable carbon • Consulting on the best use of biomass, 2 • Storing biomass, 1 • Service of biomass harvest/removal, 1 • Providing sustainability certificate, 1 • Log/biomass grading sorting, 1	• Providing feedstock supply contract, 2 • Log/biomass grading sorting, 1 • Industry network, n/a	• Website • Lobbying activities • BDO Zones • Influencers/social media • BDO Zones	• Energy companies, 3 • Wood pellet industry, 2 • Biomass exporters, 1 • Industry that needs to lower emissions, 3 • Industry that needs to defossilize, 2 • Industry that has biomass residues, 3 • Regional developers, 2

Fig. 13. Modified business model, highlighting the top key components prioritized by workshop participants in Australia (more details in Appendix 5)

The integration of the key components in Canada as prioritized by the participants (Fig. 12), provides a comprehensive understanding of how the BMC can be tailored to host countries. It is crucial to be aware that this adaptation may vary depending on local and national needs for implementing bio-hubs. The identified key partners, activities, resources, value proposition, customer relationships, channels, and segments collectively contribute to a strategic approach in addressing the diverse requirements of biomass utilization and the bioeconomy. This alignment facilitates the optimal utilization of bio-hubs within the broader bioeconomy. Bio-hubs play a crucial role in de-risking supply chains, potentially facilitating business and investment in bioenergy and bioproduct production. Furthermore, bio-hubs can serve as a supply buffer to centralized facilities and prove effective during periods of lighter or more intermittent biomass supplies. As such, bio-hubs have the potential to become cornerstone elements or building blocks for future biorefineries, sustainable aviation fuels, and other structures related to the bioeconomy.

The integration of key components in Australia (Figure 13) also provides valuable insights into adapting the Business Model Canvas (BMC) framework for local contexts. The identified key partners, activities, resources, value propositions, customer relationships, channels, and segments highlight a strategic approach to advancing the bioeconomy within Australia. These components collectively reflect the nation's focus on fostering sustainable practices, particularly in substituting fossil carbon with renewable alternatives.

The emphasis on biomass suppliers, industry partnerships, and sustainability certification underscores the importance of collaboration across the supply chain. By aligning resources such as laboratory equipment, biomass storage knowledge, and carbon policy education, Australia is positioned to support innovation and address the technical and ecological challenges of biomass utilization. The value propositions of sustainably sourced renewable carbon and consulting services on biomass utilization cater to the needs of diverse customer segments, including energy companies, industries seeking defossilization, and biomass residue holders. These propositions align with Australia's goals of reducing greenhouse gas emissions and fostering a circular economy. Customer channels such as websites, social media influencers, and lobbying efforts demonstrate a commitment to engaging stakeholders and raising awareness about advancements in bioeconomy practices. Furthermore, the role of bio-hubs in de-risking supply chains and serving as a supply buffer for biomass resources positions them as essential elements in Australia's bioeconomic landscape.

With the potential to act as building blocks for future biorefineries and other bio-based industries, bio-hubs in Australia can play a pivotal role in achieving sustainability targets. This approach highlights the importance of tailoring the BMC framework to local and national needs while contributing to global efforts in the transition to renewable energy and sustainable industries.

Limitations

About one-third of survey respondents in Canadian workshop were only aware of the biomass processing centres, indicating a relatively high level of uncertainty associated with characterizing an “ideal” bio-hub business model for these respondents. Therefore, the results of this study should be viewed as an exploratory study, aiming to characterize the perception of sector representatives on how a bio-hub could operate and be developed, rather than presenting a fully validated business model.

Another limitation of the study is the absence of participation from Indigenous communities, despite invitations extended to several organizations for both the survey and workshop.

Future workshops should prioritize and actively seek the participation of Indigenous governments to achieve a more holistic and inclusive understanding.

Additionally, while representatives from the agriculture sector were invited, some respondents noted that the focus of the workshop appeared to be more on forestry than agriculture.

The Australia workshop results revealed that several respondents, including some key partners such as biomass suppliers and innovation collaborators, had limited familiarity with the operations of biomass processing centres. This highlights a degree of uncertainty in defining an "ideal" bio-hub business model tailored to the Australian context. Consequently, the findings of this study should be considered exploratory, aiming to capture sector representatives' perceptions of bio-hub potential rather than presenting a fully validated framework.

A notable limitation is the underrepresentation of certain customer segments, such as industries that need to lower emissions or defossilize, despite their critical role in the broader bioeconomy. Additionally, while the study involved stakeholders from sectors such as energy companies and biomass residue holders, input from agricultural stakeholders appears limited, as much of the discussion and focus leaned toward forestry-related applications. Future studies should strive to include both forestry and agriculture perspectives to better reflect the diversity of biomass utilization opportunities in Australia.

The absence of broader engagement through customer channels such as social media influencers or lobbying activities also constrained the study's ability to capture a wider array of perspectives, including those from regional developers and biomass exporters. Addressing these gaps in future research could enhance the comprehensiveness and applicability of bio-hub development models in the Australian context.

CONCLUSION

Bio-hubs can facilitate sustainable biomass supply or bioenergy within the bioeconomy by offering various services such as feedstock acquisition, conversion, and the production of high-quality bioproducts. However, the development of bio-hubs faces various challenges linked to biomass variability, logistics, quality control, regulatory adherence, and financial viability. A business model is essential to optimize processes within bio-hubs by promoting strategic partnerships, access to essential resources, optimized operations, robust customer relationships, and effective customer outreach channels.

In June 2023, a total of 27 representatives from various sectors including not-for-profit organizations, industry players, and government agencies within the Canadian forestry and agricultural sectors took part in an online survey and virtual workshop. A similar workshop was held in Australia on June 4, 2024, with 16 participants. The objective was to delineate an "ideal" business model for bio-hubs. Utilizing the BMC framework, participants outlined the value proposition for bio-hubs, emphasizing aspects such as secure feedstock supply contracts, the utilization of economies of scale to render services cost-effectively, and consultancy services regarding biomass composition and properties. Bio-hubs have the potential to enhance sustainable biomass supply and bioenergy by offering essential services such as feedstock acquisition and conversion. However, challenges related to biomass variability, logistics, and financial viability persist. Key customer segments identified include industries with emission reduction targets, energy firms, for example involved in district heating and combined heat and power systems, regional developers, as well as businesses operating in agriculture, forestry, and manufacturing. A tailored business model is crucial for optimizing bio-hub operations, strategic partnerships, and customer relationships.

The workshops showcase how bio-hub operations, which include biomass supply and utilization, along with related services, can be effectively coordinated within a network of stakeholders. This network typically involves biomass suppliers, tenure holders, and customers, especially industries that are focused on reducing GHG emissions.

Considering that a large proportion of participants in workshops were not familiar with bio-hubs, the absence of Indigenous government representation in the Canadian workshop, and a relatively low number of participants from the agricultural sector in both workshops, it is important to view these findings as preliminary. Nevertheless, the survey and workshop activities can be replicated in other countries to explore successful bio-hub business models. The approach can be tailored to the host country’s bioeconomy and biomass sector by incorporating insights from participants.

Future steps involve refining the model, namely by linking up the provided elements with value propositions and the customers’ side of the BMC. The next step will be to assign a cost to each of the elements included in the BMC as well as identify possible revenue streams. Cost and revenue data can be obtained through case studies to inform subsequent models. and expanding stakeholder engagement to validate bio-hub effectiveness within the Australian bioeconomy.

The outline of follow-up workshops will involve confirmatory work to refine the business model, along with applications of the business model canvas to bio-hubs in other countries. Furthermore, it is essential to engage more stakeholders (in Canada, Australia and other countries) in designing and operating bio-hubs to validate the model and demonstrate bio-hub implementation. Additionally, future studies should explore how investment and relevant policies can facilitate the development of bio-hubs.

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Appendices

Appendix 1 – Pre-workshop Survey

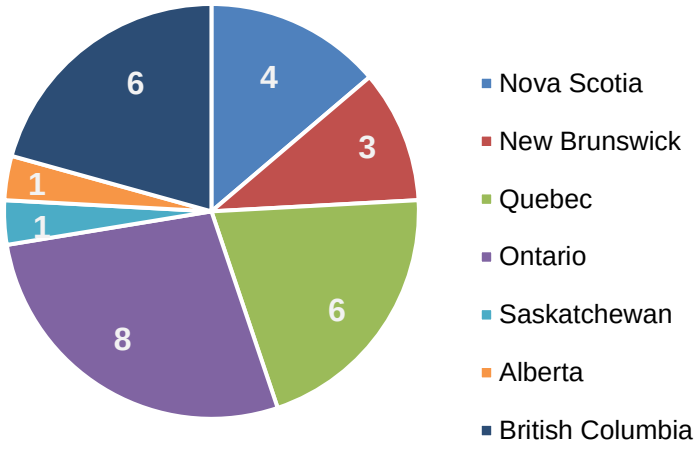


Fig. A1-1. Regional distribution of workshop participants

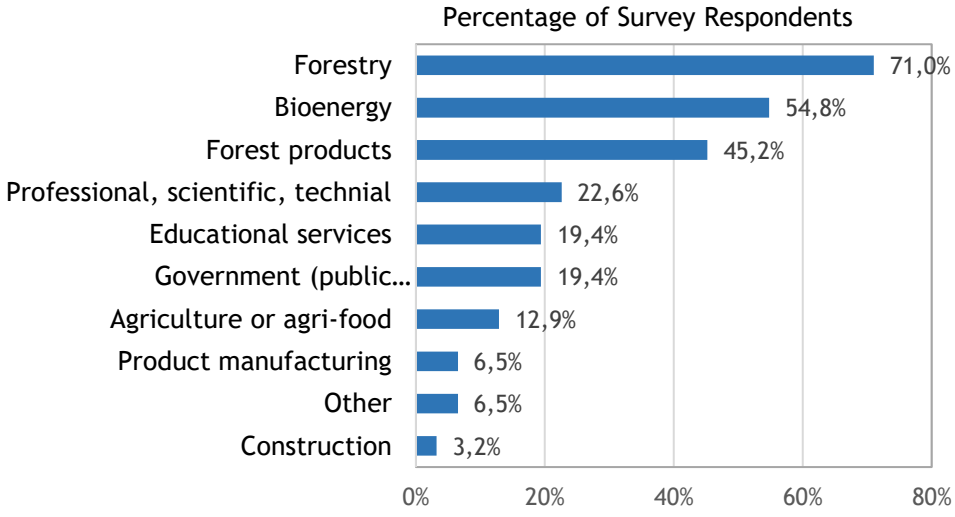


Fig. A1-2. Respondents by type of sector

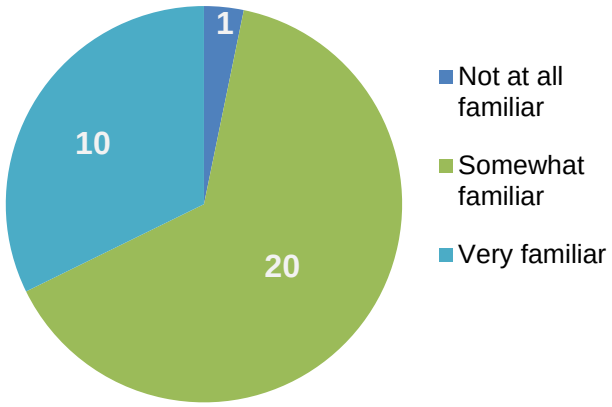


Fig. A1-4. Respondent familiarity with bio-hubs

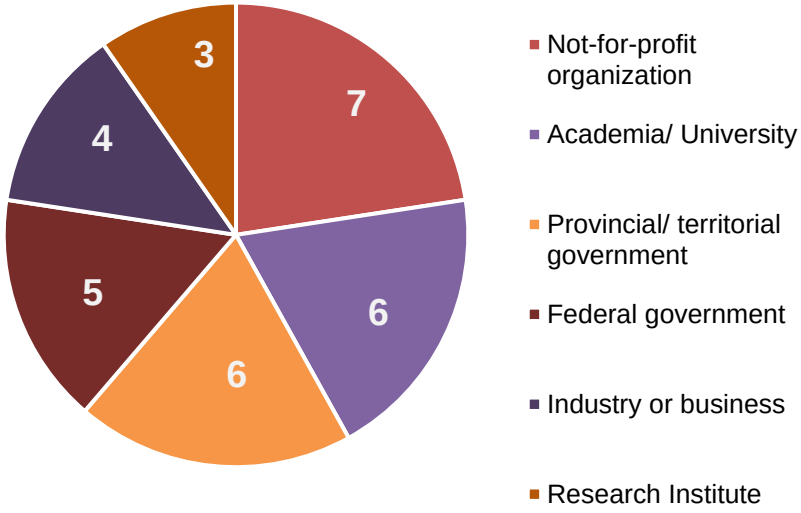


Fig. A1-3. Respondents by type of organization

Appendix 2 – Business Model and Business Model Canvas (BMC)

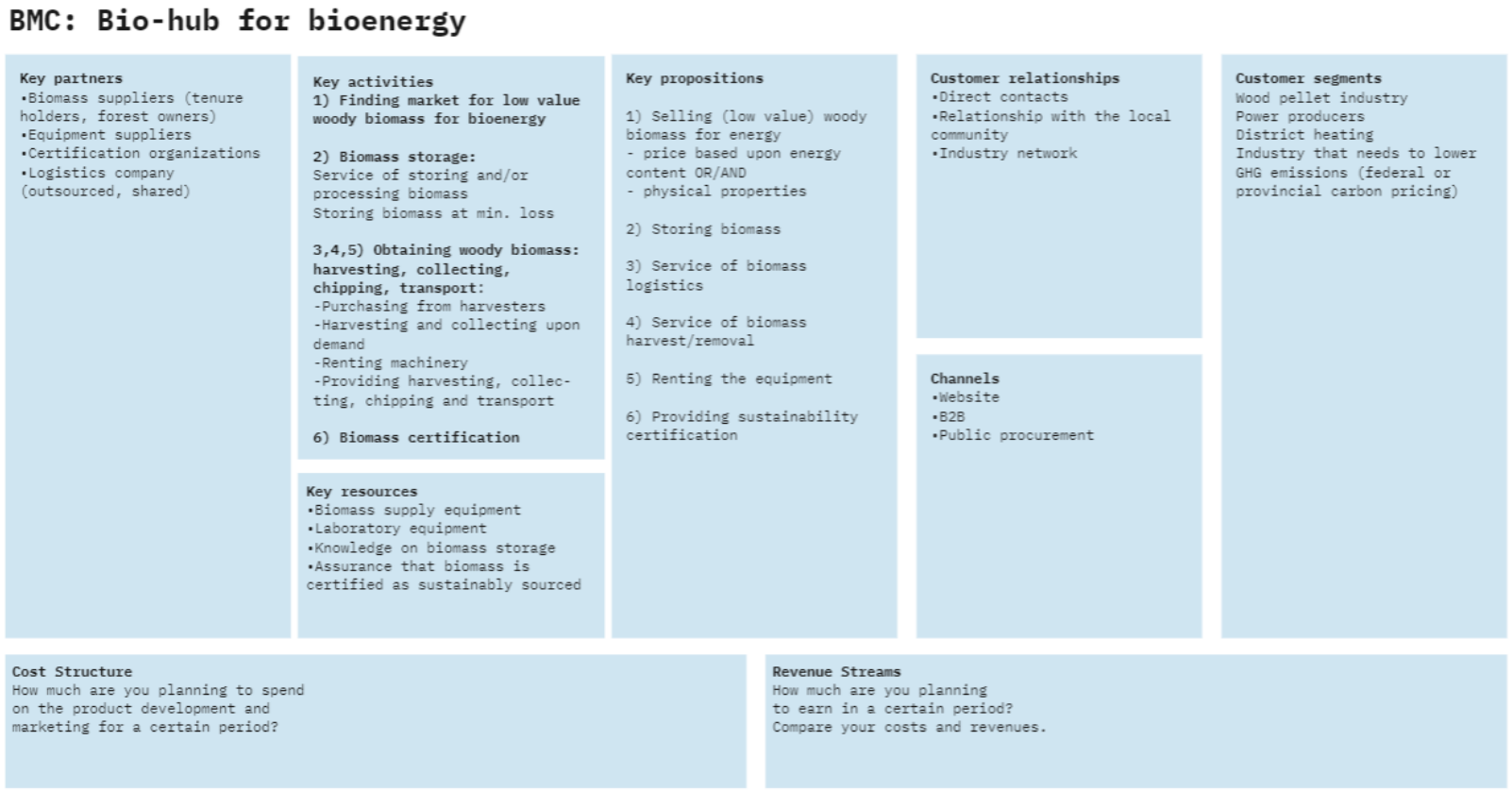


Fig. A2-1. Business Model Canvas: Bio-hub supplying woody biomass for bioenergy.

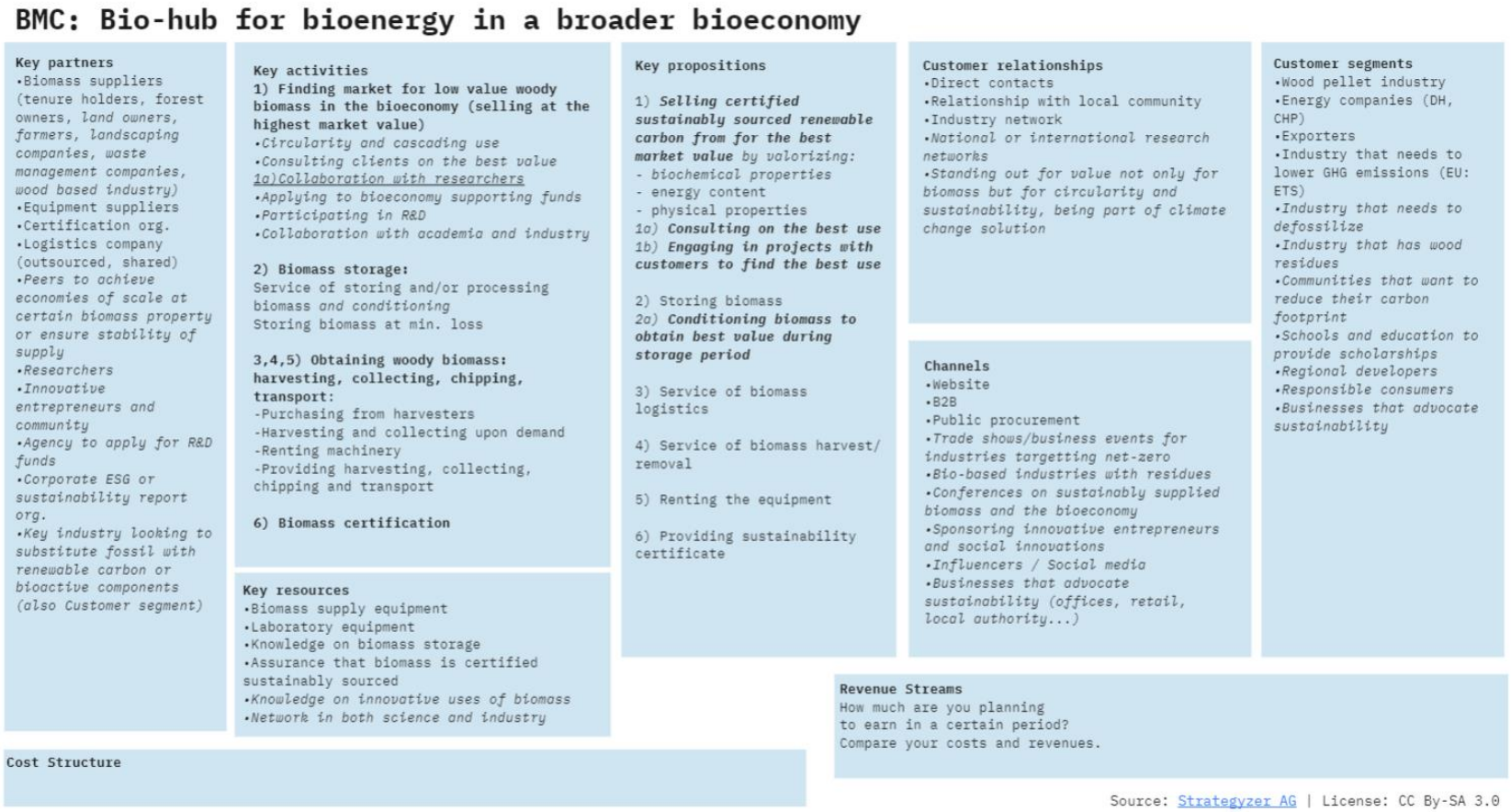


Fig. A2-2. Business Model Canvas: Expanding a bio-hub for bioenergy within a broader bioeconomy: supplying certified sustainably sourced renewable carbon for the bioeconomy.

Appendix 3 – A list of questions presented to the participants.

1. **How do I create a bio-hub?**
   - Key partners: With which key partners do you need to collaborate to gain a competitive advantage?
   - Key activities: What are the key steps needed to move ahead with your customers?
   - Key resources: What resources do you need to make your idea work?
2. **What do I do to make a profit?**
   - Key propositions: How will you make your customers' lives better?
   - Cost structure: How much are you planning to spend on product development and marketing for a certain period?
3. **What do I sell?**
   - Customer relationships: How often will you interact with your customers?
   - Customer segments: Who are your customers? Describe your target audience in a couple of words.
   - Channels: How are you going to reach your customers?
   - Revenue streams: How much are you planning to earn in a certain period? Compare your costs and revenues.

Appendix 4 – Voting Results

Value Proposition

Fig. A4-1. Voting activities on value proposition for successful bio-hub development and integration as indicated by workshop participants' votes (Total votes = 238). Supplementary information for Fig. 6.

Key Activities

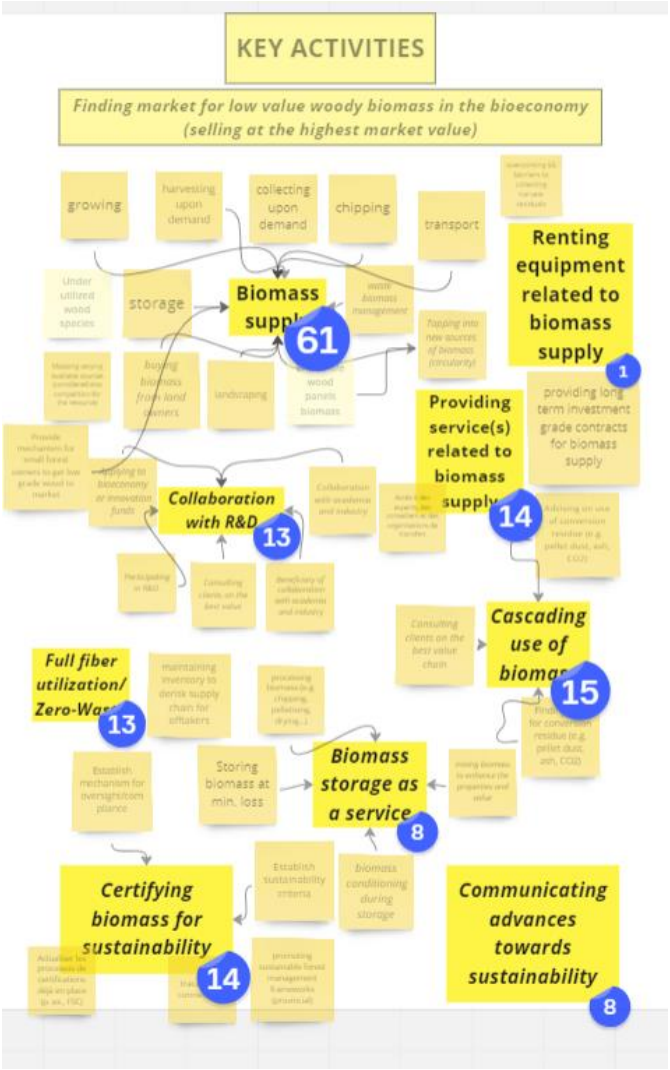


Fig. A4-2. Voting activities on key activities for successful bio-hub development and integration as indicated by workshop participants' votes (Total votes = 147). Supplementary information for Fig. 6.

Key Resources

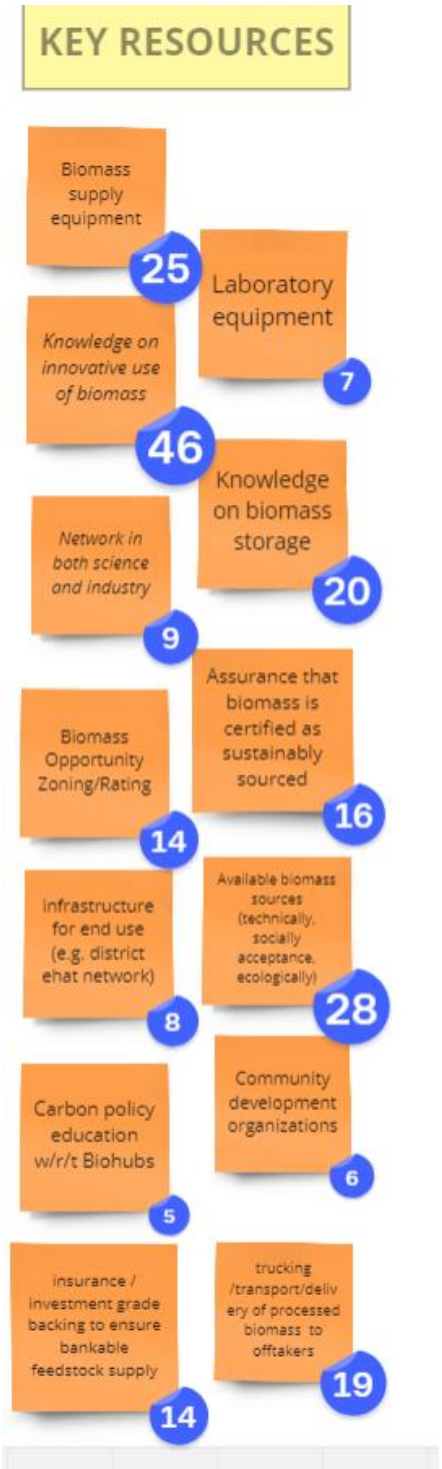


Fig. A4-3. Voting activities on key resources for successful bio-hub development and integration as indicated by workshop participants' votes (Total votes = 217). Supplementary information for Fig. 7.

Key Partners

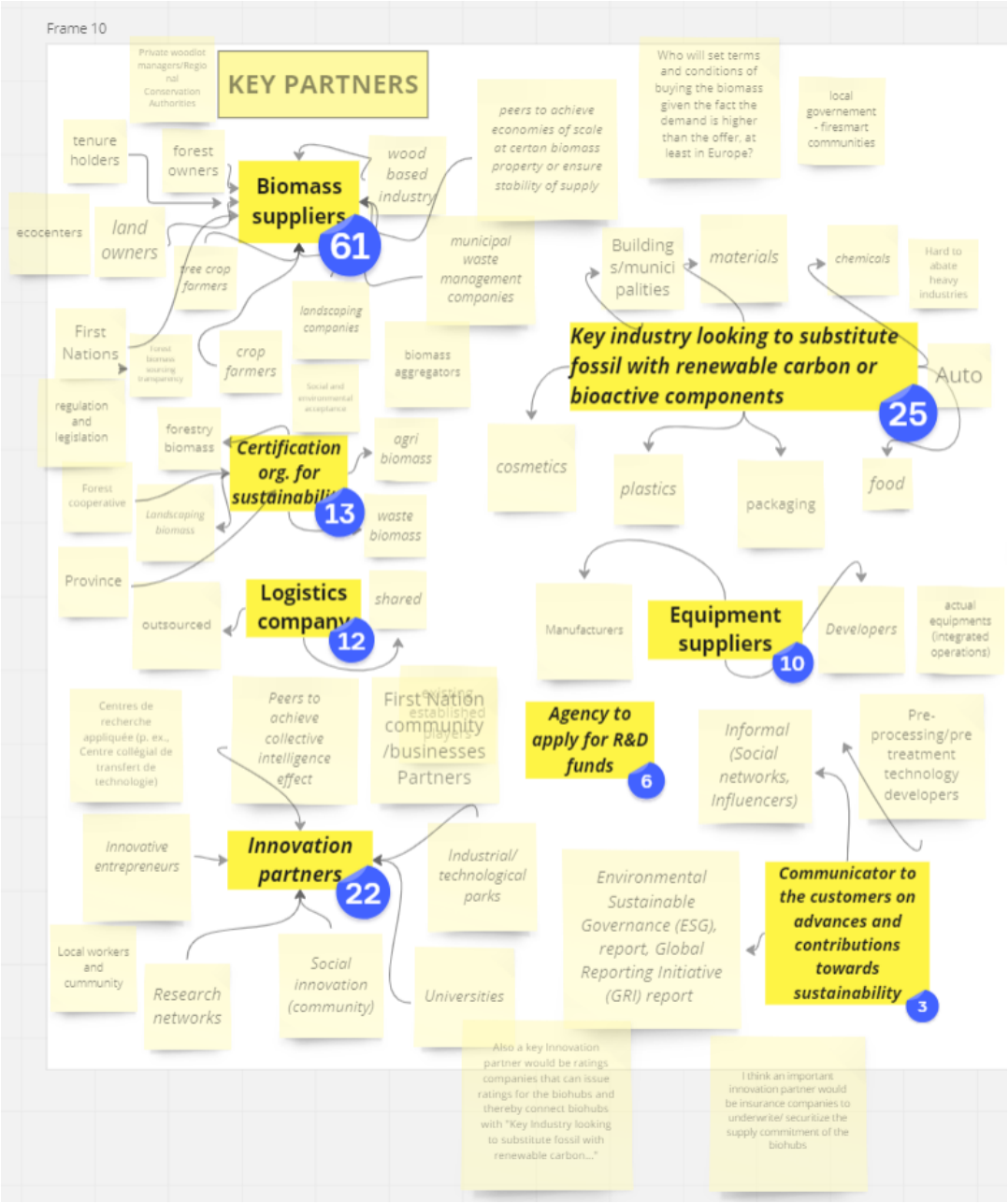


Fig. A4-4. Voting activities on key partners for successful bio-hub development and integration as indicated by workshop participants' votes (Total votes = 152). Supplementary information for Fig. 8.

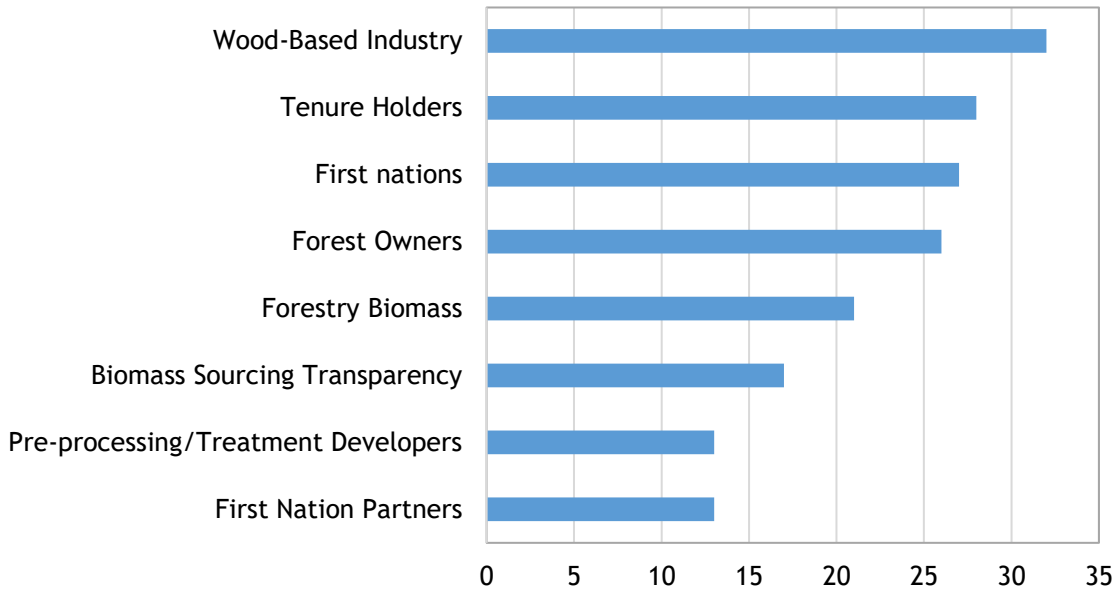


Fig. A4-5. Key individual partners for successful bio-hub development and integration as indicated by workshop participants' votes (Total votes = 221).

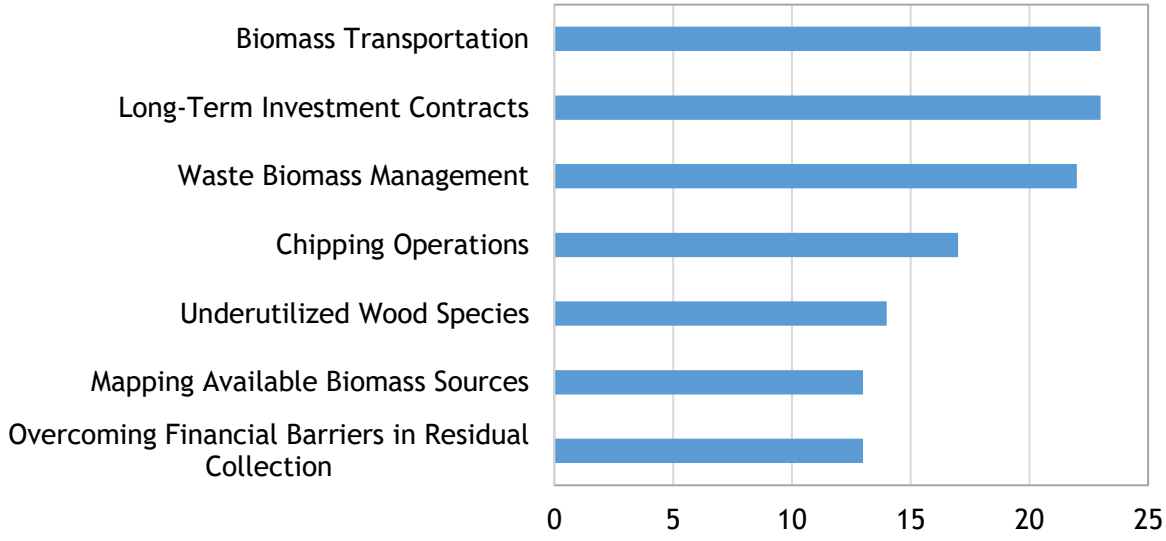


Fig. A4-6. Key individual activities for successful bio-hub development and integration as indicated by workshop participants' votes (Total votes = 181).

Customer Relationships and Customer Channels

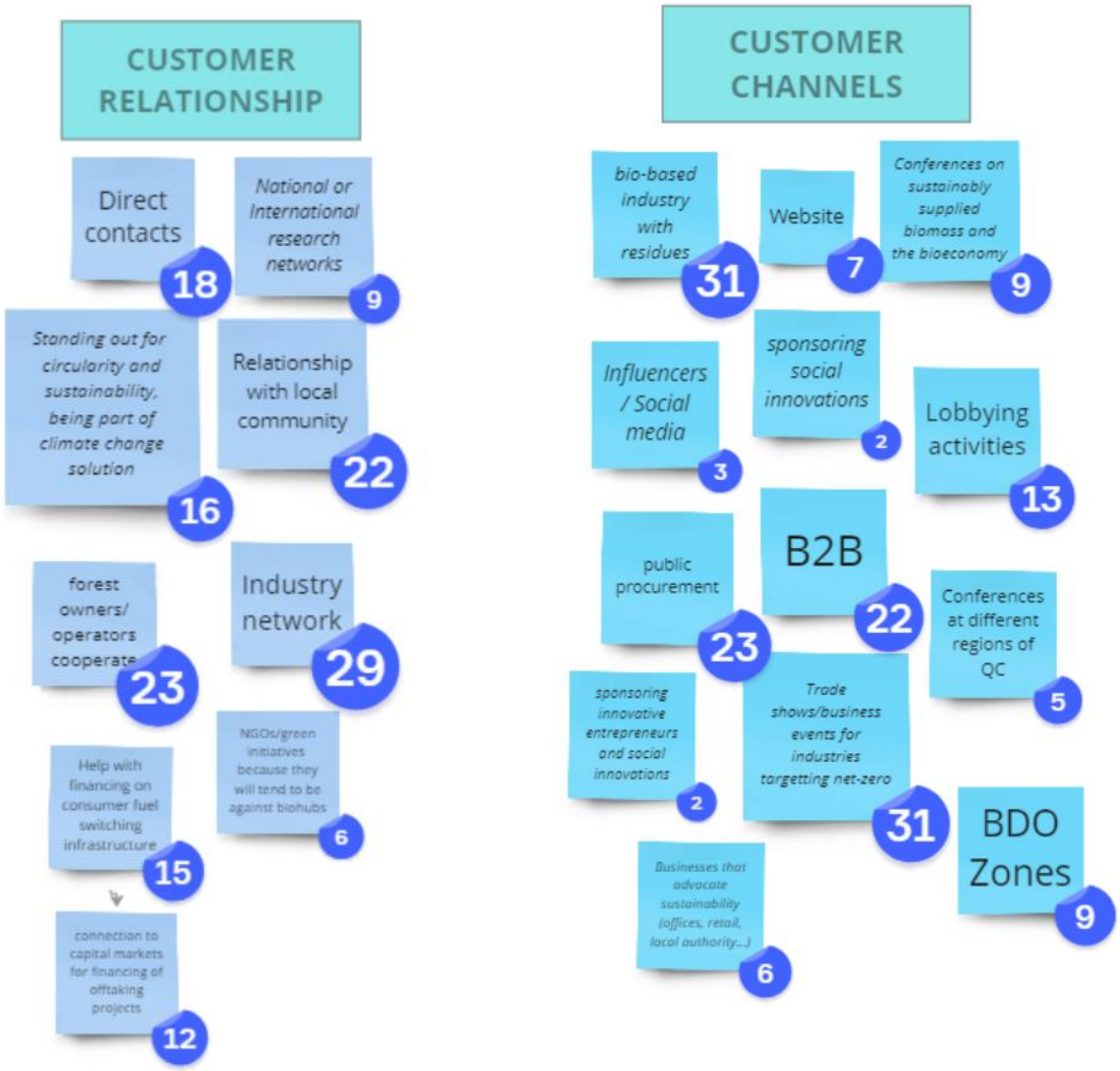


Fig. A4-7. Voting activities on customer relationships and customer channels for successful bio-hub development and integration as indicated by workshop participants' votes (Total votes = 159). Supplementary information for Fig. 9 and Fig 11.

Customer Segments

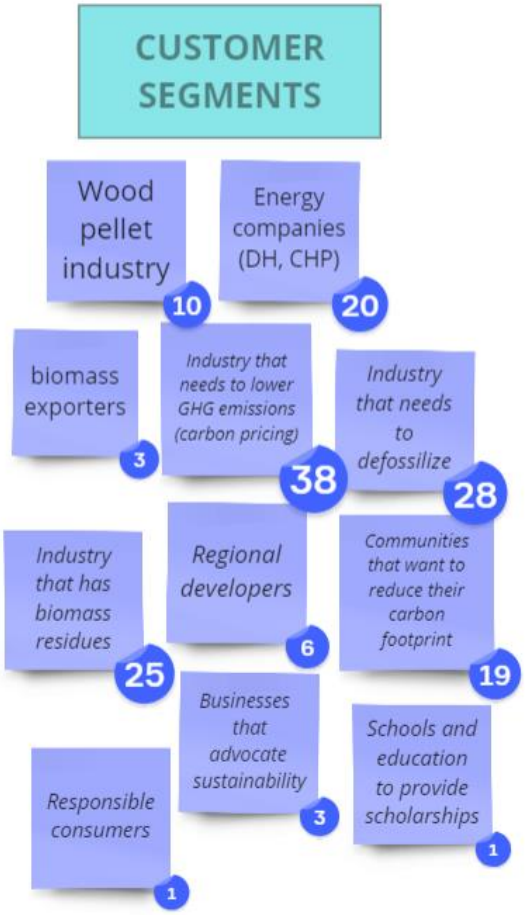


Fig. A4-8. Voting activities on customer segments for successful bio-hub development and integration as indicated by workshop participants' votes (Total votes = 154). Supplementary information for Fig. 10.

Appendix 5 – Webinar for the forest and bioenergy academy and industry users in Australia and New Zealand

Pre-workshop survey - Business Model for Bio-hubs: An international perspective

In what state or territory do you work?

ACT-0	QLD- 18 (38%)	WA-4 (9%)	Nelson-0
NSW-11 (23%)	TAS- 6 (13%)	Auckland-1 (2%)	New Plymouth-0
NT-0	VIC-7 (15%)	Canterbury-0	Wellington-0

What is the nature of your organization?

Industry or business-25 (52%)

Academia / University-4 (8%)

Research Institute-1 (2%)

Federal Government-5 (10%)

Provincial or Territorial Government-9 (19%)

Indigenous Government-0

Municipal Government-0

Not-for-Profit Organization-3(6%)

Other-1(2%)

In what sector does your organization operate?

Agriculture or agri-food-3 (6%)

Forestry-5 (10%)

Forest products-3 (6%)

Non-forest or non-agricultural product manufacturing-1 (2%)

Bioenergy-17 (35%)

Construction-0

Educational services-1 (2%)

Government (public administration)-9 (19%)

Professional, scientific and technical services-4 (8%)

Other-5 (10%)

What is the size of your organization in terms of the number of employees?

1 to 4 people- 8 (17%)

5 to 9 people-1 (2%)

10 to 49 people-8 (17%)

51 to 200 people-8 (17%)

200 to 499 people-4 (8%)

500+ people-19 (40%)

How many years of experience do you have in bio-based sectors (agriculture or forest)?

Less than 1 year-9 (19%)

1 to 4 years- 15 (32%)

5 to 9 years-5 (11%)

10 to 14 years-2 (4%)

15 to 19 years-3 (6%)

20 to 24 years- 6 (13%)

25 years or more-7(15%)

To what extent are you familiar with biomass processing centres, also known as "bio-hubs"?

Not at all familiar-11 (23%)

Somewhat unfamiliar-28 (60%)

Very familiar-8 (17%)

Do you have any questions or comments prior to the workshop? If so, please provide them in the space below.

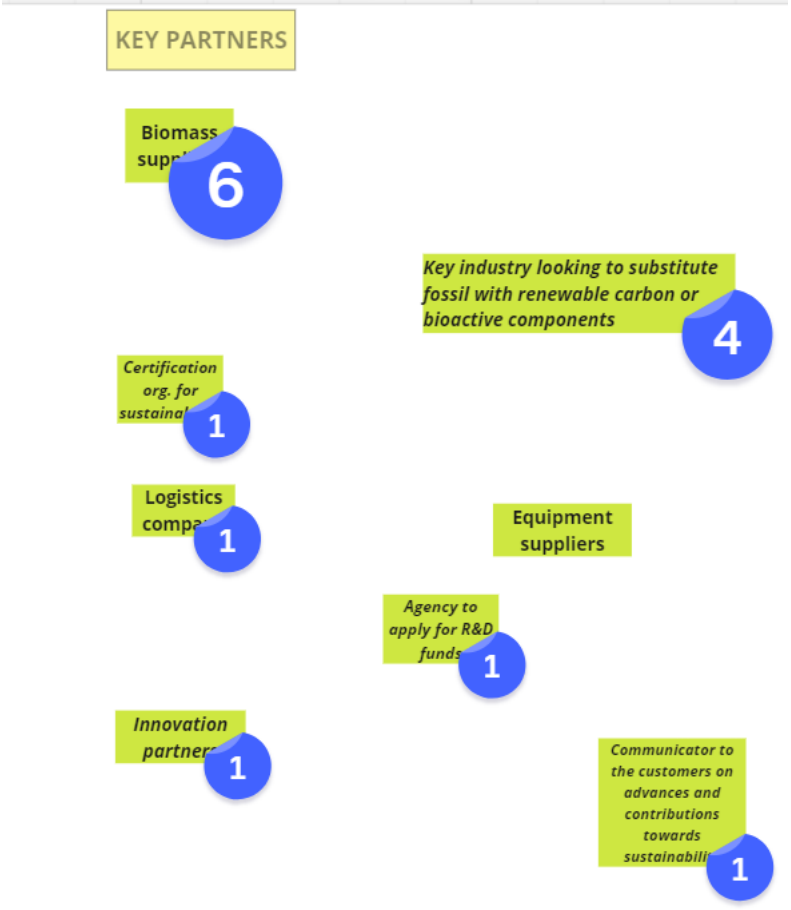
The Oil Mallee Association focuses on 'integrated agroforestry' and is confident that several hundred (now mature) plantations (2M tonnes) will eventually be harvested for biofuels on a cycle of about five years. How do we obtain confidence that this move to biofuels will continue so more farmers participate.

WORKSHOP RESULTS

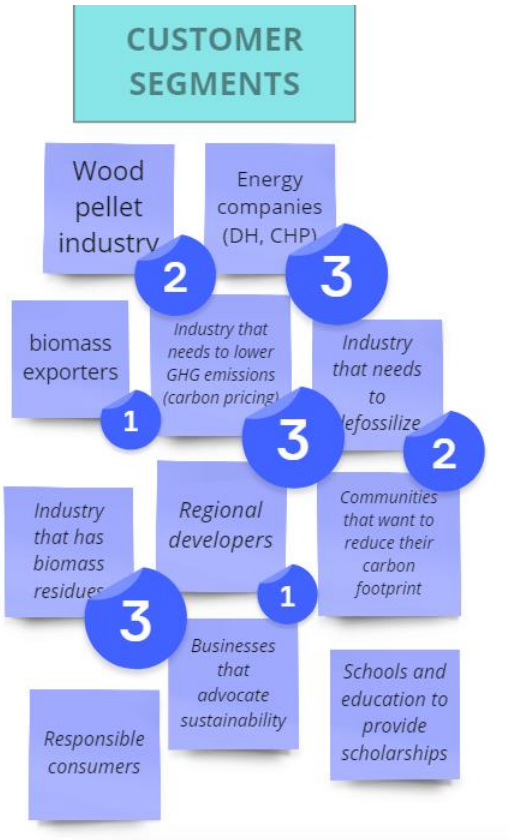
Customer relationship

Key activities

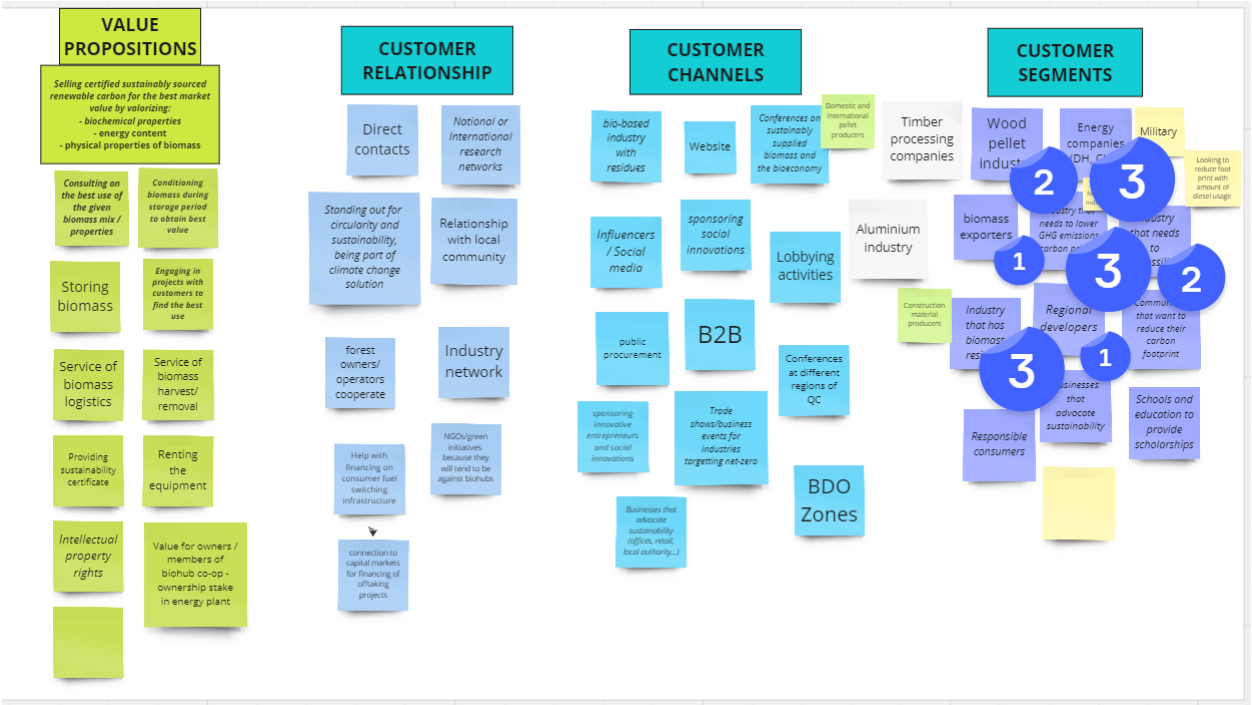
Key partners



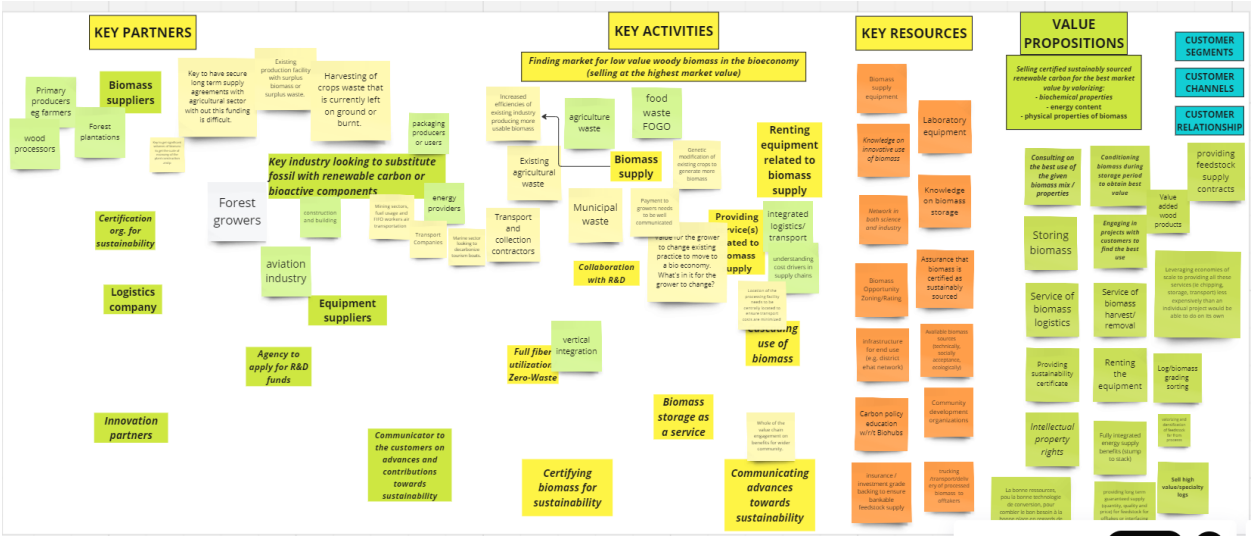
Customer segments



Overview of all results (1)



Overview of all results (2)




IEA Bioenergy
Technology Collaboration Programme