energies

Article

Bioenergy for Community Energy Security in Canada: Challenges in the Business Ecosystem

Vikas Menghwani [1,*], Rory Wheat [2], Bobbie Balicki [3], Greg Poelzer [2], Bram Noble [1] and Nicolas Mansuy [4]

1 Department of Geography and Planning, Kirk Hall, 117 Science Place, University of Saskatchewan, Saskatoon, SK S7N 5C8, Canada
2 School of Environment and Sustainability, Kirk Hall, 117 Science Place, University of Saskatchewan, Saskatoon, SK S7N 5C8, Canada
3 Department of Agricultural and Resource Economics, College of Agriculture and Bioresources, 51 Campus Drive, University of Saskatchewan, Saskatoon, SK S7N 5A8, Canada
4 Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, 5320 122 Street, Edmonton, AB T6H 3S5, Canada
* Correspondence: vikas.m@alumni.ubc.ca

Abstract: Bioenergy represents a viable renewable alternative for the many off-grid remote communities in Northern Canada that rely on diesel-based energy infrastructure. Despite the abundance of forest-based biomass, bioenergy for heat and power in Canada is used primarily in industrial contexts. Community-scale bioenergy, although growing, has been limited. Supply chain challenges, institutional and policy arrangements, and community perspectives indicate a need to better understand the 'business ecosystem' for bioenergy in Canada. The ecosystem includes technologies, community contexts, suppliers, developers, and policy makers. In this study, we explore the bioenergy business ecosystem challenges and perspectives from supply-side stakeholders. Interviews were conducted with representatives from the government, industry, and community—all working in bioenergy. The results indicate the following challenges facing the bioenergy ecosystem, with respect to community energy security: lack of cross-jurisdictional consistency in legislation and policies across Canada, structural issues such as subsidized energy and utility ownership, and misdirected support for local capacity building in the bioenergy sector. We also find that the existing support systems are prone to misuse, pointing to efficiency gaps in investment flows. The insights that emerge from this work, especially from industry stakeholders, are meaningful for communities and policy makers alike.

Keywords: bioenergy ecosystem; indigenous energy; forest biomass; community energy

Citation: Menghwani, V.; Wheat, R.; Balicki, B.; Poelzer, G.; Noble, B.; Mansuy, N. Bioenergy for Community Energy Security in Canada: Challenges in the Business Ecosystem. *Energies* **2023**, *16*, 1560. https://doi.org/10.3390/en16041560

Academic Editor: Seung-Hoon Yoo

Received: 12 December 2022
Revised: 21 January 2023
Accepted: 25 January 2023
Published: 4 February 2023

1. Introduction

There are over 270 remote off-grid communities in Northern Canada, with nearly 75% reliant on diesel-based energy generation [1] and are energy insecure. Diesel is often transported through difficult and seasonal supply routes and needs storage under harsh winter conditions. Renewable energy options could be a viable and empowering alternative for remote communities, offering clean and locally produced sustainable energy. While wind and solar are the fastest growing energy sources in Canada [2], the country has substantial bioenergy potential and the highest amount of biomass per capita globally [3]. Forest biomass comprises approximately 6% of Canada's energy supply, second to hydropower in terms of renewable energy, but the majority of that is used in the pulp and paper industry [4]. In comparison, the European Union sources most of their renewable energy production from solid biomass [5]. With a mature and sustainable forestry sector, Canada is well positioned for a much higher contribution from bioenergy towards its total energy supply. Specifically, there is potential for community-scale bioenergy in remote communities, especially those located within or adjacent to the boreal forest [6]. For many remote communities, diesel displacement by bioenergy could not only increase energy security, but also lead to significant GHG reductions [7] and create new social benefits in terms of job creation [8]. There are examples of remote communities implementing biomass energy systems [9], specifically for meeting heating needs. This makes sense, given that the widespread use of wood stoves in households in remote northern communities. However, the use of community-scale bioenergy systems remains low in Canada, especially considering the availability of biomass resources. With nearly 3.5 million km^2, Canada's forested land accounts for 8% of global forests [10]. Nearly all (94%) forests in Canada are publicly owned and managed under sustainable forest practices and criteria [3,11]. Respecting sustainable harvest levels, over 40 million dry tons of biomass (for energy) per year could be harvested in Canada [3]. The country also produces more energy-efficient biomass feedstock such as wood pellets, but the majority of that is exported to Europe (3.9 million tons) [12]. The value of wood-based bioenergy is in its GHG reduction potential, which relies on sustainable and efficient biomass supply chains, which in turn requires sustainable forestry practices. The solid wood waste alone (urban, forests, and agriculture) could potentially provide up to 20% of Canada's energy supply [3]. This is promising for energy-insecure remote communities.

The International Energy Agency (IEA) defines energy security as the uninterrupted availability of energy sources at an affordable price, including many interrelated socioeconomic, human, and environmental dimensions, where a stable and sustainable supply of energy with controlled impacts on the environment is critical for the functioning of an economy [13]. Energy security is, therefore, a major concern in the North, especially for diesel-dependent communities, which are facing major impacts on their environment, health, and socio-economic development, as well energy sovereignty [14,15]. Recently, scholars have explored the challenges faced by bioenergy use. For example, there is Canada-centric literature that reports on community perspectives on bioenergy [14,16,17], supply chain analyses [18–20], and feasibility analyses [21,22]. Limited feedstock volume and operational concerns are identified as being among the highest reported risks that are specific to the security of biomass feedstock in northern regions [23]. Buss et al. [17], for example, delved into the nuances of five remote Indigenous communities that are pursuing bioenergy options in central and western Canada. Among the many risks they explore, they identify high investment costs, energy market competition, lack of capacity, technological difficulties, and difficult feedstock access due to remoteness as major risks facing wood-based bioenergy in communities. Logistic and operational risks are primarily driven by community remoteness, and relate to uncertainty in biomass supply and storage, infrastructure, feedstock quality, and transportation costs. The profitability of extracting bioenergy for fuel in Canada's boreal forest is heavily dependent on the cost of regional truck transport [18]. For Canada's remote, northern communities, imported biomass feedstock for heat and power can have transport distances reaching up to 3000 km [16]. Many of these challenges are directly related to development challenges that stem from economies of scale [24,25], suggesting that manufacturing biomass residues for power and heat generation may be more efficient in communities with an established industrial presence [26].

Community interest to pursue bioenergy varies across Canada, but there is a clear inclination for business leaders to build partnerships that promote new energy projects [14]. Coupled with the desire to seek self-sufficiency and community energy independence [14,24,27], bioenergy emerges as a viable option for many northern boreal communities. However, notwithstanding the recent growth in bioenergy scholarship in Canada, there are only limited analyses and understanding of the challenges and knowledge gaps in the development of the bioenergy business ecosystem necessary to support emerging community-scale use in Canada.

The business ecosystem conceptual lens is informative for analyzing socio-technological systems and interconnections as evolving biological/organic systems [28,29], and can enable a better understanding of the growth of bioenergy in northern community-energy contexts. The bioenergy business ecosystem encompasses elements of both industrial and entrepreneurial ecosystems. Korhonen et. al. [30], for example, notes that methods framed through the lens of industrial ecology and symbiosis have been used in the analysis of competitive biomass-based economies [26,30]. Generally, industry symbiosis or synergy in the forest bioenergy sector is achieved when industry stakeholders work together based on their perceived ability to co-benefit from a market transaction, while simultaneously reducing or eliminating wood waste. Assessing the quantity and quality of wastes from forest products is primary to understanding the feasibility of their use for energy production [26]. In a forest business ecosystem, a stakeholder is defined based on their role and (legal) responsibility [31]. Business ecosystems in the biomass sector encompass geographic boundaries, relevant stakeholders, and stakeholder value and stakeholder interactions [31] specific to power, money, and information dynamics [32].

Considering bioenergy is an emerging industry sector in Canada, tightly coupled with the industrial ecosystem is the entrepreneurial ecosystem [33]. Based on an analysis of high-tech start-ups, for example, Neck et al. [33] identified the following components as necessary for a thriving entrepreneurial system: informal social networks, formal networks (e.g., research services, governments, capital resources and talent pool), incubator organizations, physical infrastructure, and culture. Cohen [34] applied this framing and concepts from industrial ecology to imagine a “sustainable entrepreneurial ecosystem” (SEE), calling for deeper research into each component of such a system. In entrepreneurship research, sustainability has been a new addition [35]. Sustainable entrepreneurship means “the discovery, creation, and exploitation of opportunities to create future goods and services that sustain the natural and/or communal environment and provide development gain for others” [36]. Sustainable entrepreneurship goes beyond profitability and emphasizes social and environmental value. SEE is a novel concept that focuses on fostering entrepreneurial ecosystems for sustainability-focused ventures. The addition of sustainability as a motivator for investments is pertinent to a study such as this, since bioenergy (and other alternative energy sources) is a sought-out resource across governments and policy makers, due to its green credentials as an energy source. However, conceptualizations such as SEE focus more on private firms and the influence of private capital [37], which would be salient for the bioenergy business ecosystem in Canada, only under the assumption that private capital may trigger the market potential of bioenergy as an energy sector. In many regions of Canada, however, this assumption is challenged by the following two constraints: (i) energy supply infrastructure in most jurisdictions is monopolized and owned by Crown utilities, and (ii) the size of the market for remote communities may not be conducive for a thriving industry to emerge without additional support.

In this study, we expand the SEE to include various actors such as user communities, government bodies, policy makers and other non-business actors [37]. Energy development in remote communities in Canada is largely supported by policy-driven action, hence the importance of government level actors—at regional, as well as federal, levels. Industrial forest policy from multiple levels of the government often shapes a complex market [38] and emerging industries need a nurturing business ecosystem to deal with uncertainties around technology, application or regulation [39]. In addition, for bioenergy specifically, with its supply chain complexities [40,41], the supplier networks are extremely crucial. Decision making that benefits both the bioenergy and timber industries with salvaged wood can, thus, reduce costs and improve environmental outcomes for timber and bioenergy suppliers [42], whilst providing communities with a secure and sustainable energy supply. At the community level, support for biomass harvesting is positively correlated with an awareness of its direct economic benefits [38]. Although the cultural importance of forest ecosystems has been ranked higher than the feedstocks they supply [38,43], Solomon et. al. [38] assert that at the community scale, successful power generation from woody biomass can be achieved when projects are profitable and aligned with the socioeconomic values of local residents. This infers that the success of community-scale bioenergy in remote northern communities requires synergy between governments, utilities/developers, user communities, biomass producers, and technology suppliers—i.e., the biomass business ecosystem. In Figure 1, we visualize this ecosystem in terms of the different actors involved in the bioenergy space in Canada. The developer landscape includes actors from government agencies to user communities—because a significant amount of bioenergy development is supported by government funding programs and communities are also required to be involved in energy development. Indeed, governments (federal and regional) are also responsible for setting the entire policy landscape. The technology landscape includes the complex biomass supply chains, the industry responsible for woody biomass production, technical staff and manufacturers and technology suppliers for bioenergy systems. Together, these development- and technology-focused actors form the supplier networks.

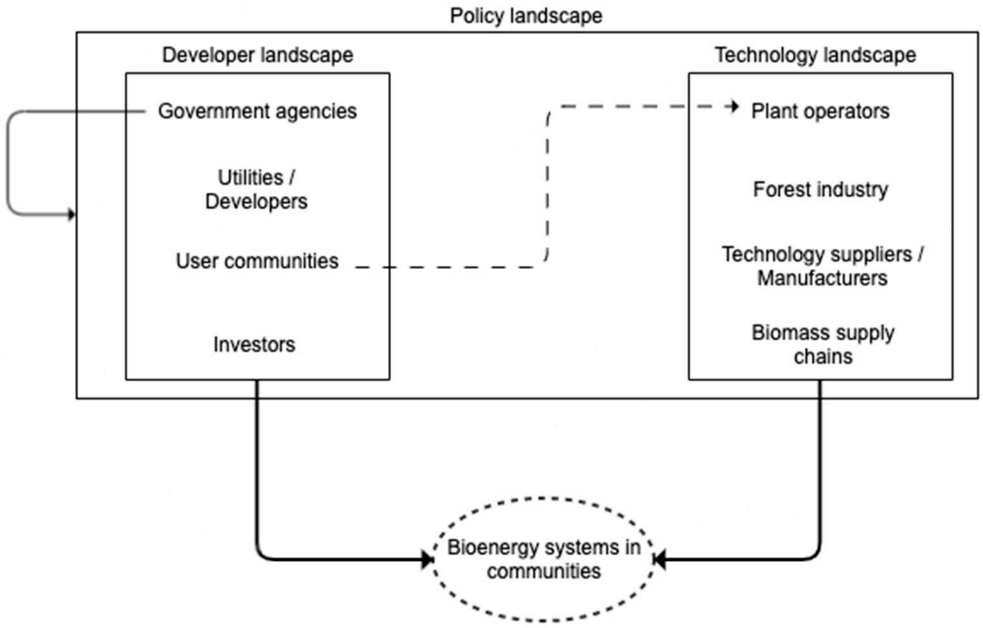

Figure 1. Bioenergy ecosystem for community-scale bioenergy use in Canada.

The objective of this study is to explore the challenges to community-scale bioenergy development in Canada by drawing on perspectives from the supplier networks, which are important stakeholders of the bioenergy ecosystem. Specifically, we ask the following question: what challenges does Canada's biomass business ecosystem face to support community-scale bioenergy projects? In answering this question, the study offers learning opportunities to improve bioenergy business ecosystems that support community level bioenergy systems.

2. Materials and Methods

We adopt the business ecosystem concept to explore the challenges and knowledge gaps in the development of the bioenergy business ecosystem for community-scale use in Canada. To explore the ecosystem, we interviewed participants who were identified based on their involvement (both past and present) in the development of woody biomass community projects. They represent bioenergy technology suppliers, government research departments, and First Nation communities (Figure 1). Participants from the communities also have experience working in the bioenergy sector, and thus have perspectives on local plant operations. Exploring community level perspectives is critical to assess and understand the industry ecosystem.

2.1. Data Collection

The study relies on primary data collected through open-ended interviews. The data collection strategy was guided by our focus on the bioenergy business ecosystem. Through our research network, we recruited a small number of initial participants and then through snowballing, we identified and recruited further individuals to achieve a total of nine participants. The sample size is small, as our intent was to ensure an opportunity for in-depth conversations with informed industry stakeholders and experts that work in bioenergy in Canada, and to ensure meaningful conversations with community members that have been involved in or have in-depth knowledge of community-based bioenergy projects and operations. Participants were asked broadly about the challenges (or opportunities) to advancing community bioenergy (Table 1). Interviews were in the form of conversations, allowing participants to speak about issues, opportunities, or challenges based on their broad experience. Interviews were conducted remotely via Zoom during March–September 2022. The audio from the interviews was recorded (with participants' consent) and later transcribed.

Table 1. Interview participants and topics covered.

Participant's Profile (N) and Organizations	Topics Covered		
	Overall Woody Biomass Industry	**Bioenergy Projects**	**Growth Potential of Community Bioenergy**
Government Natural Resources Canada Senior Researcher and Officer (2)	Challenges experienced by government in growing the bioenergy industry in Canada.	Success cases experienced by government with bioenergy projects in Canada.	General suggestions, goals and ambitions for promoting growth in Canada's bioenergy industry.
Industry Technology Supplier/Distributor (4) Manufacturer (1)	Challenges experienced in building a business case for bioenergy projects and following through on development.	Lessons from past and existing projects.	Identify what parts of the industry ecosystem are missing, where the knowledge gaps are and how funding can be injected to have the most impact.
Rural or Remote Communities Three different First Nations community members: British Columbia (2); Yukon Territories (1)	Challenges with bioenergy development from a community perspective.	Lessons for communities on success/failure of projects.	Identification of the changes that communities want from the government and industry.

2.2. Data Analysis

The interviews were transcribed into text documents. The interview data were assessed using thematic analysis [44], which helps to identify patterns and meaning. The transcripts included all the conversations between the interviewer and the participants. First, we extracted relevant data in terms of meaningful "remarks" from the participants. These remarks were then coded with 17 different labels/categories, all covering various elements of bioenergy. In total, 130 remarks were separated into 17 categories prevalent in the bioenergy ecosystem. These categories cover a range of topics from technical (like feedstock type and heat) to socio-political (community capacity and policy gaps). They are listed in Table 2 shown below in the results section.

3. Results

The interview data covered a range of challenges to bioenergy in the community energy context, from the perspective of stakeholders of the ecosystem. The following three broad ecosystem challenges emerged from the data: regulatory- and market-related, logistical- and technological-, and capacity-related challenges. Regulatory- and market-related challenges refer to those around policy structures and market conditions and incentives. Logistical- and technological-challenges refer to those related to supply chain management, fuel quality and maturity of conversion technologies. Capacity-related challenges include those related to communities' abilities in understanding, supporting, and working with bioenergy technologies. Table 2 shows the distribution of data as it relates to these themes. Overall, 22% of the interviewee's comments related to four categories specific to capacity issues, with the sociotechnical capacity of individuals and communities being the most significant topic of discussion. Four categories also emerged in the context of regulatory and market issues and challenges, with 21% of the respondents' comments relating to this theme. The majority (57%) of responses related to the logistical and technical aspects of the bioenergy ecosystem, with the largest proportion of comments relating to the feasibility of projects.

Table 2. Distribution of subject matter categories across interviews and the emergent themes.

Categories	Number of Times a Topic Was Raised	Number of Interviewees Who Raised Topic (Out of 9)	Themes
Diesel generation	7	3	Regulatory and market related
Jurisdictional issues	10	7	
Macroeconomics	9	3	
Local permits	1	1	
Industrial waste	3	2	Logistical and technological related
Direct heat	9	4	
Forest resources	11	6	
Biochar	3	2	
Wood pellets	4	4	
CHP and direct heat	7	6	
Woodchips	6	4	
Feasibility	29	7	
Biofuel	2	1	
Sociotechnical capacity	17	8	Capacity related
Education/training	9	6	
Community demand	2	1	
Wood stoves (household)	1	1	

All interviewees, in various ways, attested to the abundance of biomass resources in the country. One technology provider highlighted the following opportunity: "*there's so much material out there in Canada, whether it's in the forest, whether it's a byproduct or waste product at these mills. There's a lot of that isn't really being used to its full potential.*" Bioenergy systems can be a viable local energy alternative for many remote communities. A participant from a First Nation in Yukon emphasized that "*communities with their own microgrid that rely on diesel are perfect opportunities for thermal heating or combined heat and power systems to offset the fossil fuels*". Many participants also confirmed the opportunities that bioenergy offers in terms of benefits to the communities but emphasized the importance for communities to have autonomy over the projects and be able to manage their own energy systems. A participant with experience in bioenergy from another First Nation in Yukon also highlighted the following employment benefits that could arise from bioenergy: "*employment for [community] citizens, so we pay our citizens to provide the wood for the boiler system, and I think it's a reliable flexible income*".

Despite this potential and opportunity, it was clear from the interviews that although community bioenergy has had varying degrees of success in Canada, there are country-specific constraints to bioenergy emerging as a viable and thriving alternative for off-grid remote communities. One interviewee, a Scandanavian technology supplier, considers Canada to be "*the most difficult*" among their supply portfolio, which included 12 countries, including the UK, Scandinavia, Japan and Australia. From the remoteness of communities to misalignment in policies, the results show a wide range of challenges, which are presented below.

3.1. Regulatory and Market Context

3.1.1. Inconsistent Policy Regimes and Perceptions around Bioenergy

Domestically, Canada's energy markets are operated at the provincial and territorial level, which can lead to challenges, as suppliers and project developers must navigate jurisdictional differences. In the context of bioenergy, there are different levels of regulation, testing, and research required for projects in each jurisdiction. A boiler manufacturer characterizes the differences in requirements across jurisdictions in the following manner:

> "*testing is required in Quebec, there is some testing required in Ontario, they do the biggest test ever that costs you like hundred thousand bucks . . . . Then you go further*

> *to Saskatchewan and Alberta, they don't even look at that . . . ..certain areas in British Columbia. is very, very strict and in certain areas this is different. So it's a little bit of a difficulty to run into every jurisdiction and everyone asks something different*."

This inconsistency in the nationwide policy outlook on bioenergy was identified as a major challenge by three participants. Another manufacturer, who is mainly operational in foreign countries, finds Canada's regulations "*so complicated*" that the only way to enter the market is by "*teaming up with the local people, who are better aware of the tricks like how things need to be done*".

The interview results indicate that there not only has to be a favorable policy and regulatory environment for bioenergy to thrive, given the remoteness of the communities, policy also needs to be more certain and stable. In the far north, where there is no commercial forest management, it is necessary for a reliable supply infrastructure for wood pellets (or other biomass) to be shipped in from the south. In addition, building infrastructure, as one technology supplier noted, "*requires multi-year, predictable policy around energy, so they need to go back to declare what we're doing*".

Another challenge in the market is the perception around bioenergy. One participant lauded the Canadian forestry sector for its "sustainability", but bemoaned the lack of understanding around it, describing it as "*a very simple principle that people in the forestry sector understand [but] people in Toronto don't . . . that's what's keeping biomass out of the renewable space*". They went on to say that talking about "*waste burning*" is easy and palatable, but talking about "*forestry*" is not, and that the false perception even includes the sentiment that "*there's basically disagreement amongst experts whether forestry is sustainable*". This perception about the sustainability of the bioenergy sector may not necessarily be present in remote communities but plays an adversarial role in overall market growth and policy development. Even when bioenergy-focused policies may exist, they are not keeping up with technological or feedstock variability. For instance, as one interviewee noted in reference to wood-burning appliances, "*they're not rated for softwood*", suggesting that subsidies and incentives ought to focus on promoting new technologies that are economical and practical for suppliers to provide.

3.1.2. Status Quo of Existing Energy Systems

In Northern Canada, most remote communities also have their energy systems managed and operated by electric utility corporations, which interviewees found difficult to work with. Utility control can also heavily impact the likelihood of the success of a project. Communities that are grid-tied might be competing with cleaner energy sources such as hydropower. One supplier highlighted the following lack of incentives for the electric utility corporations to investigate biomass:

> "*the utility company that's taking care of the Caterpillar diesel genset. They get paid by the government to take care of the equipment. And they have secured pay to do the work . . . . And do they want to invest in renewable energy production? Probably not. No. Like any change would like threaten their secure business. They would step into, you know, more unknown field . . . . So they don't want to do it. It's a lot easier to keep flying the diesel fuel to the destination and keep the diesel [gensets] running*."

One related issue that was cited is pricing. A business representative with experience in bioenergy project development felt that biomass has not been given a "*level playing field*" to compete against the existing energy options. Another biomass equipment supplier highlighted that the presence of subsidized energy in remote communities may work against any incentive they could have towards bioenergy alternatives. If there is a "*real price of electricity in these locations, then it would be in the interest of the local people in these remote villages*" to take risks and try alternative options, such as bioenergy, to manage energy costs. The main driving force behind bioenergy expansion, as another industry participant notes, is going to be "*decarbonization and reducing greenhouse gas emissions*". In that context, the current energy market (with fossil fuel use) is not adequately paying for the environmental cost, although these interview participants were hopeful about carbon pricing. The participant went to on to call the "*low cost of conventional fuels, specifically natural gas, the biggest hurdle to development of the [bioenergy] project(s) . . . that's why we see biomass projects really be deployed in the north in areas that don't have access to natural gas because the economics make a little bit more sense*".

Another factor identified is the lack of pre-existing industry standards for long-term power purchase agreements (PPA), which can be critical to enabling the development of bioenergy projects. To develop a project that can attract investment or is eligible for debt financing, a long-term purchase agreement for the energy being produced is important. As one community project developer describes it, "*I think 10 to 20 years is the magic number to identify to. Amortizing enough of the asset over the agreement length to justify it from the developer and owner perspective.*" In addition, 10 to 20-year power purchase agreements are not standard practice for these types of projects. But long-term contracts can effectively de-risk any project from the developer's perspective and encourage outside investment interest, as well as improve eligibility for public funding.

3.2. Logistical and Technological Challenges

3.2.1. Fuel Availability and Supply Chain

One of the primary obstacles to the growth of bioenergy is supply-chain-related challenges, which are exacerbated due to the remoteness of communities. Bioenergy supply-chains are complex and require tremendous amounts of resources, as well as multi-party coordination. As a community member and an Indigenous project developer articulates, "*it was always supply chain and getting the supply chain developed in all of its required sophistication. You know, the logging side and having equipment, dedicated equipment, dedicated people, dedicated businesses to that, the transportation, the management of the logs, the processing of the storing, the delivery. That I think continues to be one of the biggest obstacles*". Further north in Canada, the regional terrain changes from the forested boreal shield to the barren tundra. The resulting trial and error process of finding the right fuel stock can be costly, time-consuming, and potentially threaten a project's success. Multiple interviewees mentioned distance to a sustainable biomass fuel stock as a challenge, particularly for remote communities. According to one participant, access to timber or a source of forest-based wood fuel that is both sustainable and available is crucial. Another stated that the fuel stock is the first and most important question to address when developing or proposing a biomass project. Geographic remoteness, as well as variation in resource availability, add to the challenge of fuel availability.

3.2.2. Technological Barriers

Other related technological challenges emerged from the results. Despite the abundance of forest biomass, the nature of the fuel itself raises challenges that need to be managed with more caution than other fuels. As one community representative stated, "*Mechanically harvesting wood is not cheap, either, you know, instead of running equipment, fuel operators, everything else that that comes at a pretty high price and that's on a good day. Once you start breaking things, then then the cost of generating power only goes up*". The same interviewee also highlighted the loss in environmental attributes that can result from complex feedstock logistics, saying that "*you're logging, you're burning diesel again. To do that, you're running it a little over two-kilometers to get it to there, so you have the cost of transportation*".

The type of fuel stock being used and how it is sourced are critical to the cost and overall environmental impact of a bioenergy project. Among the different feedstocks, the interview participants discussed wood pellets and wood chips, both of which are commonly used in bioenergy plants. Both have unique advantages and limitations. Pellets have high energy density and low variation in feedstock quality, but communities may find it difficult to source them. Wood chips, on the other hand, may be more locally available, but they vary in quality as an energy fuel. The shape, size, and moisture content of wood chips can vary considerably, and this can be challenging for operations, depending on the type of system being used. For example, as an interviewee from Natural Resources Canada (NRCan) notes, "*If you're if you're installing woodchip system, it may work, it may work fine. But. If you don't give it the right kind of chips, it might not work . . . . . . Just to give you an example of what I mean by that I'm aware of, we've tested in our lab a combined heat and power system, which runs on wood chips. The manufacturer specifies the wood chips. Should be about 15 percent moisture content. OK, then we found the system runs fine if you do that. Right. If you run the system at over 18 percent, it starts smoking a lot, not justifying properly. And basically, it can cause the system to shut down and that'll happen, say if you get over 20 percent. So that's a very narrow window to operate in*".

Given that many northern communities are also seeking alternatives to their electricity infrastructure, bioenergy—especially with combined heat and power (CHP) technology—could be a viable solution to meeting the electricity and heating needs. However, the interview participants were not optimistic. The concept of CHP for remote communities remains attractive, but CHP systems are more complex and require greater technical skills to operate. As one biomass equipment manufacturer noted about CHP, "*so far we don't have a great working example of a single one in a community in Canada that I'm aware of that's been functioning for a year or so and is a good example of it working*". Another technology supplier and project developer affirmed that "*combined heat and power is more technical, depends on a lot more factors, and I think the market has to mature a little bit to see more of that*".

3.3. Capacity-Related Challenges

3.3.1. Lack of Training and Education

One of the most frequently identified challenges was the importance of local capacity in bioenergy project setup and success, especially by technology suppliers. In all phases of a bioenergy project—project development, installation, and operations—there is a need for adequate local capacity. This includes adequate technical and market knowledge about setting-up a biomass supply chain, skilled human resources for plant operations, and in-house capacity for repair and maintenance. Many communities are located far distances away from the equipment that they need, and technical support is often days or even weeks away after installation, as recognized by several participants as an enduring challenge. The lack of understanding and maintenance experience with complex biomass systems is a major challenge for remote communities. This emphasizes the need for the availability of locally based technical training, particularly for remote communities.

Bioenergy systems operations require a variety of skillsets. One manufacturer articulated that "*a complex custom control system that has a lot of complexity to it in regards of wiring and programming and these things. And then you have a burning process that is totally different from anything else that is taught and then you have the mechanical augers and screws and all of that. . . . that is three things that you don't find a single person to do*". According to another manufacturer, "*no one offers a course that is in any way close for helping people to understand this [bioenergy systems as a whole] . . . we talked to universities, we talk to colleges. We have seen an interest in mechanical. We have seen an interest in control. But. For everything combined into one person that it's like, like, you know, that's not existing*". Even for the bioenergy plants in operation, it appears that operators are not well equipped for managing repair and maintenance. One boiler manufacturer recalls that "*we have people that work basically to or receive phone calls and do Canada wide support our systems. But no one calls us because they don't even know how, how to work, the question of what is going on*".

According to the interviewees, many communities do not even have an adequate understanding of the basics of bioenergy. The initial motivation within many communities may also be missing with regard to pursuing a particular energy development. One technology supplier argued that the lack of motivation is a strong determinant of a bioenergy project's failure, as shown by the following statement:

> "*So communities where there's a big success, there are communities that are motivated to see that their projects succeed. . . . the project [that] don't succeed really are largely, in my opinion, in places where parts of the community that just don't want to see the*

project right, like it's easier to just burn fossil fuel, so I'm just going to have a biomass boiler plug often fail".

One community participant mentioned that Canada simply needs "*tons of federal funding and support, it's more about getting participation and engagement from communities*". In the past, Natural Resources Canada attempted to allocate funding for programs that would focus specifically on education and training for bioenergy systems, but according to one government participant, the federal program has struggled to allocate funding in an effective way to promote bioenergy education and awareness, noting that "*a few years ago and we were looking at setting up courses that would train people on how to run these systems. And we did this at community colleges and universities, and I think Saskatchewan was one of the places . . . .So that was something we'd planned and we had like a dozen community colleges, universities across the country looking at setting up training programs for that. But in the end, we couldn't get funding*".

3.3.2. Scale-Related Capacity Challenges

The results also indicate that some communities do not have the capacity to access funding resources that are available, as demonstrated by the following statement: "*even getting that First Nation if even there's funding on the table, getting administration capacity within the First Nations to apply for the funding is hard*". The community member speaks of supportive organizations that could help with such bureaucratic work and offer some type of local "*centralization of administration, training, and research*", which can help communities "*enter into these projects with more certainty*". The interviewee went on to indicate that "*Yukon University . . . they have like a Northern Energy Innovation Center where they can do some of the legwork on energy projects and then redistributed back to the communities*". One interview participant from the federal government also acknowledged that "*most remote communities need assistance to develop the capacity to plan, install, manage the projects*".

One technology supplier imagined a thriving locally supported forestry sector so that communities can have "*forestry capacity within the community itself*". However, this sentiment stands in contrast to the following statement made by a community member about remote communities' capacity: "*for a small, remote community it can be very difficult to develop and maintain its own forestry industry that's scalable enough to support a bioenergy project which leads to a number of challenges*". It was also suggested that the government could encourage the development of biomass and other renewable energy projects by pushing for projects with government buildings to de-risk experiments with novel technologies and scale existing ones.

3.3.3. Misaligned Financial Support

A boiler manufacturer highlighted the problems with the existing financial support systems. Support may exist, but it does not always go into a meaningful direction. For instance, since investing in remote communities may not be lucrative, there may be large funding streams available, which are often prone to misuse, due to the lack of good-faith actors. The manufacturer made the following claims: "*You put a billion-dollar funding straight*", the manufacturer said, "*you attract all sorts of people . . . . They're making outlandish claims*". The participant went on to give the following example: "*I spoke with somebody who wanted to partner with us because they had some technology that allowed them to burn garbage and make our problem free. And they were trying to market this to promote it. And I was really like, I was like, like, I was polite. But then I got to the point where I was like, Listen, your technology doesn't exist. You're being dishonest by presenting opportunities that are suggesting that people can solve the problem through this*".

Even consultants may prioritize self-interest and access to government funding when approaching communities for projects. Another participant from the industry emphasized this by pointing out how the smallest tasks around energy projects have unnecessary price tags on them and the money does not go to the communities, arguing that "*The price tag for anything that's done for the projects are like gold plated, like crazy . . . .like with the price of* *feasibility study that's typically done for these. The whole project could be done in Europe. Like millions are used for doing something simple*". They went on to say that "*if [the communities] would get the benefit from successful projects that they would start guiding everything to the right direction. But as long as it's only bringing money for the consultants and the brokers around the project, it's never going to fly*".

One participant suggested that the most effective way to build and maintain project-level engagement with the communities is to provide ownership and direct involvement in the project's development from the beginning, stating the following: "*You need the community or the, you know, the demand side, you need them involved right from day one. Everybody needs to be involved in owning the project. They need to own it in some way. Right. It can't just be imposed on them*".

4. Discussion

By focusing on a diversity of actors from the bioenergy business ecosystem perspective, our findings highlight the real-world challenges that are often under-documented in the literature, which can be useful for different stakeholders, including the government, private companies, and communities alike.

Our findings show the several challenges to bioenergy uptake for community energy in Canada. Some of these challenges have already been identified in the literature. In their community-focused study of bioenergy risks in Canada, for example, Buss et al. [17] identify high investment costs and high energy market competition as "policy and economic" risks. By highlighting perspectives from international technology suppliers, we can understand such risks by also capturing the policy- and regulation-specific challenges. For example, jurisdictional inconsistencies in bioenergy policy and regulations from the macro- to the micro-level adds complexity to Canada's bioenergy business ecosystem, and generally lowers the feasibility of community-scale projects. This lack of homogenization of regulations and standards around bioenergy across the country makes it difficult for the few (international) technology suppliers to build and sustain relationships. Such insight is particularly meaningful for policy makers at federal and provincial/territorial levels who are looking to increase their biomass market competitiveness. Specifically for Arctic and Sub-Arctic communities, Poelzer et al. [45] talk of the need to have a more holistic approach in renewable energy development—wherein overall development and adjacent industrial sectors are all taken into account in promotional strategies. Industry perspectives also illustrate the fundamental differences between the European bioenergy landscape, driven largely by the GHG emission reduction goals, and Canada, which often focuses on balancing multiple imperatives [46], including reconciliation with Indigenous peoples and socio-economic development in North Canada [24,47].

On the technological front, while the CHP system holds much promise for remote communities that rely on diesel systems, the interview participants from industry and communities agreed that the market is not as mature as it needs to be for CHP to succeed. Our community-based respondents highlighted the simplicity of "heating only" options. As Madrali and Blair [9] note, many communities in Canada's north have installed biomass-based heating systems, while CHP experiences are very new, despite their great potential.

Another important insight in our finding is about the perceptions around forest biomass across different stakeholders. One industry participant noted the difference among experts regarding whether forest biomass is a renewable resource. This point about the very nature of forest biomass has emerged in larger debates around biomass in the last decade [48,49]. In addition, in more popular discourse, a recent review [50] showed that although in Canada, forest bioenergy is more likely to be perceived positively, there are growing discussions around its ecological impacts and carbon neutrality. This is important to note because most of the policy level support for forest bioenergy is premised on its renewable nature. Differing perceptions work against any synergy that many stakeholders seek across the sector.

Bioenergy's competition with fossil fuels has been identified as a challenge in the literature [17,46], but our study showed multiple market conditions that point to the role of incentives in the state of the sector. The monopolized/centralized control of energy development with utility corporations and subsidized energy regimes do not create adequate incentives for bioenergy exploration in remote communities. In Alaska, for example, Holdmann et al. [51] show that subsidies are a necessary condition for the development of community energy projects; however, large subsidies for the existing energy systems can stymie transition to new energy systems and technologies. For renewable alternatives to become viable, suppliers seek a level playing field with respect to energy prices.

Consistent with the recent literature [9,17,19], supply chain and technological challenges also emerged in our results as a critical concern. Many of these challenges are also true for the existing fossil-fuel-based energy systems, including transporting fuel to remote communities and storing it, while other challenges are specific to biomass resources, such as securing feedstock supply and feedstock quality variation [23]. We find that feedstock supply requires not only abundant forest resources, but also proximity to harvesting infrastructure such as forest management units or local forest planning arrangement to decrease the costs of biomass harvesting and transportation what [17].

As many respondents noted, addressing the complex policy environment, from the supply side, may require partnerships and collaborations with residents, or energy champions who are invested, both personally and professionally, in implementing and maintaining community-scale bioenergy systems in the long term. Echoing the assertion of Solomon et al. [38], one approach that technology suppliers could take to engage and build capacity is the provision of educational resources to bring awareness about the costs and benefits of community involvement in the bioenergy ecosystem. We found that a lack of capacity was one of the strongest barriers to the bioenergy ecosystem, revealing the tremendous scope for improvement in what government systems and the markets currently offer for capacity building—in terms of technical training and education for bioenergy. Capacity challenges have been documented elsewhere for bioenergy [15,19]. However, for energy transitions in general, limited capacity has been considered as a major constraint [52], especially in remote Indigenous communities [53,54]. A participant from the community also emphasized that building capacity is important in communities, but other locally active actors are crucial as well, a finding supported by the literature. Juntunen and Hyysalo [55] report that a network of actors and collaborations is necessary for the success of community energy systems. Even for the goal of community-owned bioenergy systems, collaborations with private sectors are important for technology provision, operations as well as maintenance [47].

We also find that the lack of local expertise may also mean that a significant amount of money is spent on outside consultants (with unnecessarily high price tags), a finding that parallels the observation of how climate funds have been spent globally in many developing countries [56]. Policies that are driven by climate goals have been termed as "spatially blind" [57], as they are often applied too uniformly within countries, leading to the sub-optimal use of public funds. Since much of the development of bioenergy in Canada relies on government funding, careful attention is required to ensure that public funds are spent to benefit communities and help increase their leadership and ownership in bioenergy projects [15]. Business opportunities around funding streams may lead to misaligned public funds. The existing policy-driven support programs could be too broad and may miss the local community contexts. This challenge is not specific to bioenergy. Leonhardt et al. [58] point out that funding programs around renewable energy in general often insufficiently incorporate local contexts. Solutions to this issue require considerable realignment of fiscal programs with local goals and priorities and capacities. While the government of Canada is aiming at investing further in clean energy for Indigenous, rural and remote communities [59], our finding of the misalignment of the available government funds towards bioenergy development is, thus, an important insight to guide clean energy programs, to orient funding towards building local expertise and capacity, as well as well as supporting education.

The insights from this study should be considered within the context of its limitations. The stakeholders that were approached were not specific to a geographical or regulatory jurisdiction in Canada, meaning that the data can only be understood in a broad context, reflecting collective experiences rather than jurisdiction-specific issues or challenges. Future research might target stakeholders (including utilities) who are actively pursuing bioenergy developments in remote communities to better understand the challenges and opportunities in specific jurisdictions in real time. A deep-dive into specific community bioenergy case-studies would also provide insights into specific off-grid remote communities poised for bioenergy innovation, and the lessons for other regions.

5. Conclusions

In this study, we adopted a "business ecosystem" perspective to explore the challenges faced by bioenergy for community energy use in Canada. This approach helped us to highlight the sectoral challenges from the supply-side perspective—including policy, markets, and other supporting infrastructure. We focused on supplier networks and interviewed participants from across various stakeholders, including technology suppliers, the government, and communities. Upon analyzing the interview data through thematic analysis, we found several challenges facing bioenergy uptake for community energy. The lack of legislative and policy consistency across Canada emerged as a strong barrier. While structural issues such as subsidized energy systems challenge bioenergy's competitiveness, utility ownership of the energy systems causes inertia and a lack of incentive. We find that communities lack capacity to pursue and support bioenergy projects, and meaningful collaborations between communities and sub-regional actors could fill these capacity gaps. We also found that the existing support systems are prone to misuse, pointing to efficiency gaps in investment flows. There is some indication that the perception of forest-based bioenergy—as a renewable source of energy—is not uniform among experts. The insights support and enhance the existing understanding of the bioenergy challenges faced by remote off-grid communities in Canada. Perspectives from industry stakeholders and communities could be meaningful for policy makers and supportive government institutions.

Author Contributions: Conceptualization, R.W., G.P., N.M. and V.M.; methodology, R.W., G.P. and V.M; formal analysis, R.W., B.B. and V.M; resources, R.W., B.B. and V.M; data curation, R.W. and B.B.; writing—original draft preparation, R.W. and V.M.; writing—review and editing, V.M., B.B., B.N. and N.M; supervision, V.M. and G.P.; funding acquisition, B.N. and G.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Social Sciences and Humanities Research Council of Canada (SSHRC) (grant no. 895-2019-1007).

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflict of interest. The funding entities had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. NRCan. Remote Communities Energy Database. Available online: https://atlas.gc.ca/rced-bdece/en/index.html (accessed on 20 June 2022).
2. NRCan. About Renewable Energy. Available online: https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/renewable-energy/about-renewable-energy/7295 (accessed on 5 September 2022).
3. Stephen, J.; Wood-Bohm, S. *Biomass Innovation: Canada's Leading Cleantech Opportunity for Greenhouse Gas Reduction and Economic Prosperity*; Emissions Reduction Alberta: Edmonton, AB, Canada, 2016.
4. NRCan. Forest Bioenergy. Available online: http://www.nrcan.gc.ca/forests/industry/bioproducts/13325 (accessed on 17 June 2022).
5. Solid Fuels Sub-Working Group. *Solid Biomass Fuels in Canada's Low Carbon Energy Future*; Clean Fuel Steering Committee: Tokyo, Japan, 2019.
6. Serran, J.N.; Creed, I.F.; Ouellet Dallaire, C. Reimagining Energy in the Canadian Boreal Zone: Policy Needs to Facilitate a Successful Transition to a Low-Carbon Energy Future. *Environ. Rev.* **2019**, *27*, 393–406. [CrossRef]

7. Cambero, C.; Hans Alexandre, M.; Sowlati, T. Life Cycle Greenhouse Gas Analysis of Bioenergy Generation Alternatives Using Forest and Wood Residues in Remote Locations: A Case Study in British Columbia, Canada. *Resour. Conserv. Recycl.* **2015**, *105*, 59–72. [CrossRef]
8. Cambero, C.; Sowlati, T. Incorporating Social Benefits in Multi-Objective Optimization of Forest-Based Bioenergy and Biofuel Supply Chains. *Appl. Energy* **2016**, *178*, 721–735. [CrossRef]
9. Madrali, S.; Blair, J. Remotely Powerful: Nine Rural Communities' Experience with Bioenergy. *Canadian Biomass*, 28 July 2020.
10. IEA Bioenergy. *Implementation of Bioenergy in Canada—2021 Update*; IEA Bioenergy: Paris, France, 2021.
11. National Forestry Database-Canadian Council of Forest Ministers (CCFM) Wood Supply—Background. Available online: http://nfdp.ccfm.org/en/data/woodsupply.php (accessed on 8 November 2022).
12. Voegele, E. Canadian Wood Pellet Production to Reach 3.8M Metric Tons in 2021. Available online: https://biomassmagazine.com/articles/18147/canadian-wood-pellet-production-to-reach-3-8m-metric-tons-in-2021 (accessed on 8 December 2022).
13. IEA Energy Security. Available online: https://www.iea.org/topics/energy-security (accessed on 5 December 2022).
14. Bullock, R.C.L.; Zurba, M.; Parkins, J.R.; Skudra, M. Open for Bioenergy Business? Perspectives from Indigenous Business Leaders on Biomass Development Potential in Canada. *Energy Res. Soc. Sci.* **2020**, *64*, 101446. [CrossRef]
15. Zurba, M.; Bullock, R. Framing Indigenous Bioenergy Partnerships. *Int. Indig. Policy J.* **2018**, 9. [CrossRef]
16. Buss, J.; Mansuy, N.; Laganière, J.; Persson, D. Greenhouse Gas Mitigation Potential of Replacing Diesel Fuel with Wood-Based Bioenergy in an Artic Indigenous Community: A Pilot Study in Fort McPherson, Canada. *Biomass Bioenergy* **2022**, *159*, 106367. [CrossRef]
17. Buss, J.; Mansuy, N.; Madrali, S. De-Risking Wood-Based Bioenergy Development in Remote and Indigenous Communities in Canada. *Energies* **2021**, *14*, 2603. [CrossRef]
18. Mansuy, N.; Barrette, J.; Laganière, J.; Mabee, W.; Paré, D.; Gautam, S.; Thiffault, E.; Ghafghazi, S. Salvage Harvesting for Bioenergy in Canada: From Sustainable and Integrated Supply Chain to Climate Change Mitigation. *Wiley Interdiscip. Rev. Energy Environ.* **2018**, *7*, e298. [CrossRef]
19. Mansuy, N.; Staley, D.; Taheriazad, L. Woody Biomass Mobilization for Bioenergy in a Constrained Landscape: A Case Study from Cold Lake First Nations in Alberta, Canada. *Energies* **2020**, *13*, 6289. [CrossRef]
20. McFarlan, A. Techno-Economic Assessment of Pathways for Liquefied Natural Gas (LNG) to Replace Diesel in Canadian Remote Northern Communities. *Sustain. Energy Technol. Assess.* **2020**, *42*, 100821. [CrossRef]
21. Stephen, J.D.; Mabee, W.E.; Pribowo, A.; Pledger, S.; Hart, R.; Tallio, S.; Bull, G.Q. Biomass for Residential and Commercial Heating in a Remote Canadian Aboriginal Community. *Renew. Energy* **2016**, *86*, 563–575. [CrossRef]
22. Coady, J.; Duquette, J. Quantifying the Impacts of Biomass Driven Combined Heat and Power Grids in Northern Rural and Remote Communities. *Renew. Sustain. Energy Rev.* **2021**, *148*, 111296. [CrossRef]
23. Auer, V.; Rauch, P. Wood Supply Chain Risks and Risk Mitigation Strategies: A Systematic Review Focusing on the Northern Hemisphere. *Biomass Bioenergy* **2021**, *148*, 106001. [CrossRef]
24. Rezaei, M.; Dowlatabadi, H. Off-Grid: Community Energy and the Pursuit of Self-Sufficiency in British Columbia's Remote and First Nations Communities. *Local Environ.* **2016**, *21*, 789–807. [CrossRef]
25. Vazifeh, Z.; Mafakheri, F.; An, C. Biomass Supply Chain Coordination for Remote Communities: A Game-Theoretic Modeling and Analysis Approach. *Sustain. Cities Soc.* **2021**, *69*, 102819. [CrossRef]
26. Kikuchi, Y.; Kanematsu, Y.; Ugo, M.; Hamada, Y.; Okubo, T. Industrial Symbiosis Centered on a Regional Cogeneration Power Plant Utilizing Available Local Resources: A Case Study of Tanegashima. *J. Ind. Ecol.* **2016**, *20*, 276–288. [CrossRef]
27. Brewer, J.P.; Vandever, S.; Johnson, J.T. Towards Energy Sovereignty: Biomass as Sustainability in Interior Alaska. *Sustain. Sci.* **2018**, *13*, 417–429. [CrossRef]
28. Nielsen, S.N. What Has Modern Ecosystem Theory to Offer to Cleaner Production, Industrial Ecology and Society? The Views of an Ecologist. *J. Clean. Prod.* **2007**, *15*, 1639–1653. [CrossRef]
29. Despeisse, M.; Ball, P.D.; Evans, S.; Levers, A. Industrial Ecology at Factory Level—A Conceptual Model. *J. Clean. Prod.* **2012**, *31*, 30–39. [CrossRef]
30. Korhonen, J.; Wihersaari, M.; Savolainen, I. Industrial Ecosystem in the Finnish Forest Industry: Using the Material and Energy Flow Model of a Forest Ecosystem in a Forest Industry System. *Ecol. Econ.* **2001**, *39*, 145–161. [CrossRef]
31. Hack, T.; Ma, Z.; Jørgensen, B.N. Digitalisation Potentials in the Electricity Ecosystem: Lesson Learnt from the Comparison between Germany and Denmark. *Energy Inform.* **2021**, *4*, 1–18. [CrossRef]
32. Ma, Z.; Broe, M.; Fischer, A.; Sϕrensen, T.B.; Frederiksen, M.V.; Jϕergensen, B.N. Ecosystem Thinking: Creating Microgrid Solutions for Reliable Power Supply in India's Power System. In Proceedings of the 2019 1st Global Power, Energy and Communication Conference (GPECOM), Nevsehir, Turkey, 12–15 June 2019; pp. 392–397.
33. Neck, H.M.; Meyer, G.D.; Cohen, B.; Corbett, A.C. An Entrepreneurial System View of New Venture Creation. *J. Small Bus. Manag.* **2004**, *42*, 190–208. [CrossRef]
34. Cohen, B. Sustainable Valley Entrepreneurial Ecosystems. *Bus. Strat. Environ.* **2006**, *15*, 1–14. [CrossRef]
35. Volkmann, C.; Fichter, K.; Klofsten, M.; Audretsch, D.B. Sustainable Entrepreneurial Ecosystems: An Emerging Field of Research. *Small Bus. Econ.* **2021**, *56*, 1047–1055. [CrossRef]
36. Patzelt, H.; Shepherd, D.A. Recognizing Opportunities for Sustainable Development. *Entrep. Theory Pract.* **2011**, *35*, 631–652. [CrossRef]

37. Tsujimoto, M.; Kajikawa, Y.; Tomita, J.; Matsumoto, Y. A Review of the Ecosystem Concept—Towards Coherent Ecosystem Design. *Technol. Forecast. Soc. Chang.* **2018**, *136*, 49–58. [CrossRef]
38. Solomon, B.D.; Barnett, J.B.; Wellstead, A.M.; Rouleau, M.D. Deciphering Support for Woody Biomass Production for Electric Power Using an Ecosystem Service Framework. *For. Policy Econ.* **2020**, *117*, 102207. [CrossRef]
39. Rong, K.; Shi, Y.; Yu, J. Nurturing Business Ecosystems to Deal with Industry Uncertainties. *Ind. Manag. Data Syst.* **2013**, *113*, 385–402. [CrossRef]
40. Yue, D.; You, F.; Snyder, S.W. Biomass-to-Bioenergy and Biofuel Supply Chain Optimization: Overview, Key Issues and Challenges. *Comput. Chem. Eng.* **2014**, *66*, 36–56. [CrossRef]
41. McCormick, K.; Kåberger, T. Key Barriers for Bioenergy in Europe: Economic Conditions, Know-How and Institutional Capacity, and Supply Chain Co-Ordination. *Biomass Bioenergy* **2007**, *31*, 443–452. [CrossRef]
42. She, J.; Chung, W.; Han, H. Economic and Environmental Optimization of the Forest Supply Chain for Timber and Bioenergy Production from Beetle-Killed Forests in Northern Colorado. *For. Trees Livelihoods* **2019**, *10*, 689. [CrossRef]
43. Darvill, R.; Lindo, Z. Quantifying and Mapping Ecosystem Service Use across Stakeholder Groups: Implications for Conservation with Priorities for Cultural Values. *Ecosyst. Serv.* **2015**, *13*, 153–161. [CrossRef]
44. Braun, V.; Clarke, V. Thematic Analysis. In *APA Handbook of Research Methods in Psychology, Vol. 2. Research Designs: Quantitative, Qualitative, Neuropsychological, and Biological*; APA: Washington, DC, USA, 2012.
45. Poelzer, G.; Gjørv, G.H.; Holdmann, G.; Johnson, N. *Developing Renewable Energy in Arctic and Sub-Arctic Regions and Communities: Working Recommendations of the Fulbright Arctic Initiative Energy Group*; Fulbright: Washington, DC, USA, 2016.
46. Coote, D.C.; Thiffault, E.; Brown, M. Chapter 9—Constraints and Success Factors for Woody Biomass Energy Systems in Two Countries with Minimal Bioenergy Sectors. In *Mobilisation of Forest Bioenergy in the Boreal and Temperate Biomes*; Thiffault, E., Berndes, G., Junginger, M., Saddler, J.N., Smith, C.T., Eds.; Academic Press: Cambridge, MA, USA, 2016; pp. 165–189, ISBN 9780128045145.
47. Hoicka, C.E.; Savic, K.; Campney, A. Reconciliation through Renewable Energy? A Survey of Indigenous Communities, Involvement, and Peoples in Canada. *Energy Res. Soc. Sci.* **2021**, *74*, 101897. [CrossRef]
48. IEA Bioenergy. *Is Energy from Woody Biomass Positive for the Climate?* IEA Bioenergy: Paris, France, 2018.
49. Berndes, G.; Abt, B.; Asikainen, A.; Cowie, A.; Dale, V.; Egnell, G.; Lindner, M.; Marelli, L.; Paré, D.; Pingoud, K.; et al. *Forest Biomass, Carbon Neutrality and Climate Change Mitigation*; European Forest Institute: Joensuu, Finland, 2016.
50. MacDonald, H.; Hope, E.; de Boer, K.; McKenney, D.W. Sentiments Toward Use of Forest Biomass for Heat and Power in Canadian Headlines. *Heliyon* **2022**, preprint.
51. Holdmann, G.; Pride, D.; Poelzer, G.; Noble, B.; Walker, C. Critical Pathways to Renewable Energy Transitions in Remote Alaska Communities: A Comparative Analysis. *Energy Res. Soc. Sci.* **2022**, *91*, 102712. [CrossRef]
52. Gui, E.M.; MacGill, I. Typology of Future Clean Energy Communities: An Exploratory Structure, Opportunities, and Challenges. *Energy Res. Soc. Sci.* **2018**, *35*, 94–107. [CrossRef]
53. Krupa, J. Identifying Barriers to Aboriginal Renewable Energy Deployment in Canada. *Energy Policy* **2012**, *42*, 710–714. [CrossRef]
54. Karanasios, K.; Parker, P. Tracking the Transition to Renewable Electricity in Remote Indigenous Communities in Canada. *Energy Policy* **2018**, *118*, 169–181. [CrossRef]
55. Juntunen, J.K.; Hyysalo, S. Renewable Micro-Generation of Heat and Electricity—Review on Common and Missing Socio-Technical Configurations. *Renew. Sustain. Energy Rev.* **2015**, *49*, 857–870. [CrossRef]
56. Phakathi, M. Poor Countries Spending Climate Cash on Rich World Consultants. Available online: https://www.climatechangenews.com/2017/11/02/poor-countries-wasting-climate-cash-consultants-says-african-official/ (accessed on 5 December 2022).
57. OECD. *OECD's Rural Agenda for Climate Action*; OECD: Paris, France, 2021.
58. Leonhardt, R.; Noble, B.; Poelzer, G.; Fitzpatrick, P.; Belcher, K.; Holdmann, G. Advancing Local Energy Transitions: A Global Review of Government Instruments Supporting Community Energy. *Energy Res. Soc. Sci.* **2022**, *83*, 102350. [CrossRef]
59. Natural Resources Canada. Clean Energy for Rural and Remote Communities Program. Available online: https://www.nrcan.gc.ca/reducingdiesel#a2 (accessed on 5 December 2022).