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Forest Biomass Policy in Minnesota: Supply Chain Perspectives on Barriers to Bioenergy Development

Laura Eaton Carleton ^{1,*} and Dennis Becker ² ¹ Department of Forest Resources, University of Minnesota, St. Paul, MN 55108, USA² Policy Analysis Group, University of Idaho, Moscow, ID 83844, USA; drbecker@uidaho.edu

* Correspondence: eato0126@umn.edu; Tel.: +1-218-209-1495

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Abstract: Forest biomass used for heating, electricity, and biofuel production is a source of energy that could reduce the dependence on energy imports while reinvesting domestically. Using the appropriate scale and technology, the US state of Minnesota is poised for increased forest bioenergy production due to the large existing forest products industry. Forest bioenergy investments have been slow to materialize despite state and federal incentives, and this research aims to determine what barriers there are to bioenergy development from the perspective of supply-chain actors by applying theories of natural resource governance. Findings from interviews include the need to create an equitable playing field in terms of energy subsidies and integrate forest bioenergy production with bio-based markets, including traditional forest product markets. Additionally, interviews indicate poor coordination and shared responsibility among state agencies, industry associations, and nonprofit organizations, resulting in a fragmented policy system. Principles to guide enabling forest bioenergy development are identified and discussed in the context of the study findings.

Keywords: forest biomass; forest bioenergy; biomass energy; energy policy; supply chain analysis

1. Introduction

The US state of Minnesota, like many forested regions, has the potential to utilize forest biomass for bioenergy production. Forest biomass—which includes the treetops and limbs left over from forest management activities and wood manufacturing—offers an opportunity for expanding state energy portfolios. The US Energy Information Administration (EIA) estimated that more than 156 trillion Btu of biomass energy was consumed across Minnesota in 2015, or 8.7% of total consumption, which includes forest biomass [1]. That was more than all other renewables combined, more than nuclear power, and more than half that of coal [1]. A recent study by Kukrety et al. (2015) suggests that significantly more energy from forest biomass could be sustainably harvested on an annual basis, but growth has been cyclical, like in the rest of the US [2].

Forest biomass first became an important source of domestic energy after the 1973 Arab oil embargo, but failed to gain widespread adoption because of subsequent low fossil fuel prices [3]. More recently, the need to reduce the risk of catastrophic wildfires through forest biomass removal and the desire to reinvest in local economies has led to a resurgence in the interest in biomass for energy that has resulted in a proliferation of state and federal policies [3]. In Minnesota, the Next Generation Energy Act was signed into law in 2007, requiring that 25% of the total energy used in the state be derived from renewable-energy resources by the year 2025 [4]. The act provided a framework for locally produced renewable energy to reduce carbon emissions, and established forest biomass as a qualifying feedstock. Today, investment in biomass energy continues to be an important objective but the pace and scale of development has slowed.

1.1. Analysis Framework

Institutional forces and related governance comprise the system of rules, norms, and sociocultural processes that shape human actions. Governance involves the enforcement of those rules and norms; it determines authority, who makes decisions, and accountability for outcomes [5]. Investment in forest biomass for energy production is but one example, but when considered, may inform policy design and implementation to more effectively coordinate legislative and management actions. Was the policy structured such that institutional forces created the appropriate incentive? This study aims to identify those institutional forces and subsequent policies that comprised the forest bioenergy supply chain in Minnesota, and to identify how they affected outcomes.

Theoretical applications of institutions and governance to forest policy analysis have been limited historically [6]. Existing analyses are often geared toward policy recommendations as opposed to theoretical understanding of underlying aspects. Arts (2011) organizes these aspects into five areas: rational policy analysis [7], institutional policy analysis [8], policy network analysis [9], advocacy coalition framework analysis [10], and critical policy analysis [6]. An institutional perspective is used in this analysis to understand how an individual's choices are affected by those rules, norms, and sociocultural processes.

A second strand of theory relates to those laws and regulations that collectively comprise the forest governance system. Institutional forces dictate how forest biomass is used, where it is sourced, and the mechanisms used to encourage certain types of consumption. Governance in this sense refers to a process of interaction among entities that comprise those institutions shaping how forests are managed. The result is a 'system' comprised of an interacting and mutually reinforcing community, state, and market forces operating via policy (Figure 1). Historically, forest governance has been heavily shaped by non-state entities like nonprofit organizations and private businesses [11,12]. There has been a shift from forest government to forest governance, recognizing not only federal and state authority and action within the forest sector, but also the importance of non-government organizations, businesses, and local community involvement that impacts how forests are governed in terms of policy formation, implementation, and enforcement [8]. Biermann's (2007) Earth System Governance provides a convenient framework to operationalize variables germane to institutional theory and forest governance, and is used in our analysis of forest bioenergy policy in Minnesota [13]. Five dimensions of governance that may affect policy formation and implementation include: architecture, agency, adaptiveness, accountability, and allocation (Table 1).

Table 1. Summary of Earth System Governance and Definitions, adapted from Biermann et al., (2007) [13].

Dimension	Forest Bioenergy Variables	Supporting Literature
Architecture	Overall structure of institutions, governance structures, and existing policies and programs within forest bioenergy system.	Biermann et al., 2007 [13], Biermann et al., 2009 [14]
Agency	The power and authority given to an individual or group entity, as well as how this is exercised and distributed within the forest bioenergy system	Biermann et al., 2009 [14], Fu, 2008 [15], Yousefpour et al., 2012 [16], Mohammed and Inoue 2011 [17]
Adaptiveness	The ability of a system to 'adapt' in a dynamic environment, in order to change and evolve to address changing institutional forces and governance processes.	Lemos and Agrawal, 2006 [18], Lidskog and Löfmarck, 2016 [19], Biermann et al., 2009 [14], Yousefpour et al., 2012 [16]
Accountability	The level of responsibility and authority that each involved actor in the forest bioenergy system possesses, and is perceived to possess.	Jedd and Bixler, 2015 [20], Mohammed and Inoue, 2011 [17], Biermann et al., 2007 [13]
Allocation	The equitable access to forest resources as well as information that is granted to all actors involved in the forest bioenergy system.	Anderson et al., 2015 [21], Ameha et al., 2014 [22], Biermann et al., 2007 [13]

The Governance Triangle

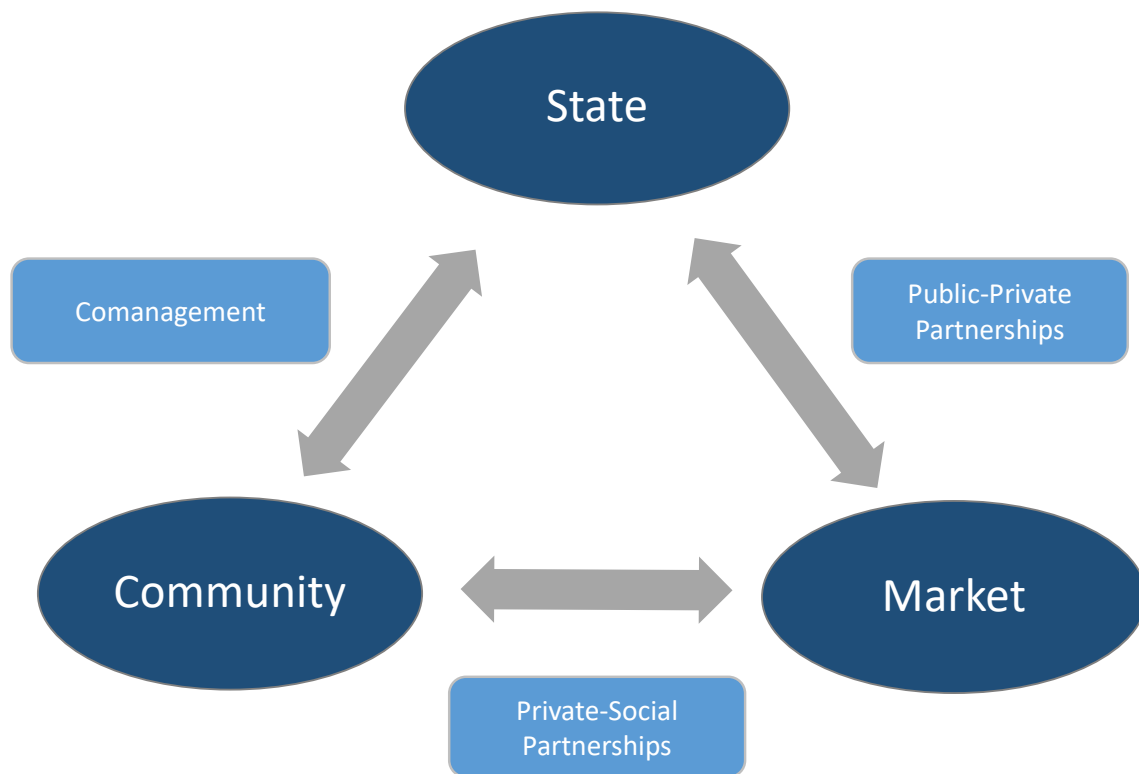


Figure 1. The governance triangle, adapted from Lemos and Agrawal (2006) [18] and (Arts, 2014) [6].

The goal of this study was to identify the barriers to biomass energy production and use from the perspective of supply chain actors, and to understand how those perceived barriers influenced policy development. Business owners, land management agencies, academics, and other experts from multiple sectors were interviewed to understand the role that institutions play in shaping policy and subsequent investment decisions. An institutional framework is provided that could be applied in other states and regions.

1.1.1. Architecture

Architecture refers to the overall design and structure of the policy system comprising state and non-state institutions and governance, as well as those specific policies and programs that shape human actions. The architecture of the forest bioenergy system in Minnesota, or the governance structure as referred to by Biermann, is comprised of the institutions, policies, and programs that exist and interact to shape forest bioenergy development. A fragmented or disjointed governance structure can reduce efficiency and create supply chain conflicts; whereas coordination can result in synergistic, cooperative architectures [14]. In this study, we are interested in the organization and coordination of institutions, governance structures, and existing policies and programs within the forest bioenergy supply chain.

1.1.2. Agency

Understanding the power and authority given to an individual or entities and how this authority is exercised and distributed among actors is integral to understanding personal capacity. The issue of agency includes the consent and involvement of both government and non-government actors, and powers expressly granted or fairly or unfairly assumed by actors. Examples include non-profit organizations, intergovernmental bureaucracies, private business owners, or non-governmental actors acting as an intermediary between a government entity and private business [14]. Central to the issue of agency is the rationale behind the decision-making process employed by those making decisions [15,16]. An important aspect of this study is identifying the range of actors involved, their perceived influence on forest bioenergy development, and responsibility for particular outcomes ranging from business development to environmental sustainability.

1.1.3. Adaptiveness

The ability of a policy, program, or system of governance to change and evolve to address changing conditions may enhance institutional performance. This includes organizations and businesses having the ability to prepare for and adapt to the consequences of changing forces. An adaptive system increases the need for administrative, organizational, technological and financial resources, and capacity [13]. In the context of forest bioenergy production, this might include the ability to adapt to changing feedstocks caused by market or environmental perturbations [16,19]. It could also include changing legislative influences over the types of subsidies available, or regulations surrounding biomass removal and use. Identifying how these institutional forces influence forest bioenergy production at each step in the supply chain can illuminate policy gaps and opportunities.

1.1.4. Accountability

Accountability refers to the level of responsibility and authority of those actors involved. The involvement of federal, state, and local private landowners as suppliers of biomass, private businesses, associations, and even advocacy groups who collectively exercise authority over forest resources results in a complex network of accountability [17,20]. Networked governance accountability, as described by Jedd and Bixler (2015), includes the authentic engagement of these actors relative to their position relative to one another. This hierarchy leads to positions of advantage and brokering of outcomes or bridging opportunities. The legitimacy of these arrangements and of outcomes is fundamental to institutional stability [13].

1.1.5. Allocation

Access to resources, distribution of information and benefits, and equity define the degree of transparency in the system and contribute to its perceived legitimacy. This includes access to raw material feedstocks for forest bioenergy production, as well as the distribution of grant funding or tax incentives for related production. Attention to the allocation of resources and benefits may facilitate supply chain coordination through increased consistency of biomass available for processing, or targeting supply chain gaps that might increase market pull. An equitable distribution of resources can increase perceived legitimacy, but is not required to achieve results [13,21]. Rather, having equitable access to similar opportunities, such as tax incentives, capital, or even the downstream effects of sustainable forest management [22], is the focus of this dimension.

2. Materials and Methods

A total of 40 forest bioenergy experts from various sectors of the forest biomass supply chain in Minnesota were interviewed in the spring of 2011 to solicit their perspectives on the five dimensions of governance. Participants were asked about their perceptions on current policies and practices that prevent or encourage the use of forest biomass as an energy source, as well as questions on the structure

of the policy system, issues of power and responsibility in decision-making, access and allocation of resources, and the adaptability of policies and programs to accommodate industry growth.

Open-ended, semi-structured interviews were conducted face-to-face and by phone with the following individuals: forest industry and manufacturing (eight people); public-utility officials (four people); economic development experts (four people); state-agency representatives (six people); technical-assistance organizations, conservation organizations, and other conveners (11 people); and university and private-sector researchers (seven people). Study participants were purposively sampled from a list of experts identified by peers as being highly knowledgeable about these topics [23]. Participants were asked the same set of pre-tested questions and were asked to expound as necessary or desired to assure that data quality, saturation, and depth were attained.

All interviews were digitally recorded to provide a systematic collection of data and subsequent analysis, in adherence to accepted qualitative data acquisition methods [24]. The data were analyzed using open coding to identify initial categories of responses organized by the five dimensions of governance, followed by axial coding to find common themes within and across response categories. Combining open coding and axial coding allowed the identification of common themes discussed within the dimensions unique to specific supply-chain actors.

3. Results & Discussion

The following themes emerged from our interviews and reflect those most consistently identified in response to questioning organized by the five dimensions of governance (Table 1). Some themes reflect internal barriers, while others are external forces outside the control of those actors interviewed. Each area includes potential solutions articulated by participants that may guide discussions regarding future policy design and implementation.

3.1. Architecture

3.1.1. Lack of Policy Coordination

A key theme that emerged was a lack of policy coordination across supply chain actors, leading to disjointed policies and activities. Many experts, especially within the forest-products sector, highlighted what they viewed as incompatible objectives relating to the management of state and federal forests. On one hand, individuals interviewed felt that the USDA Forest Service has expressed a desire to manage federal forests in Minnesota for greater timber and biomass production, but the forest-planning rules and procedures at the time of interviews were perceived to result in paralysis and too few projects being implemented. Forest management experts, in particular, were dismayed at the lack of progress given the enormous potential for forest restoration, carbon mitigation, and economic development that existed at the federal level, which posed a significant risk to the emerging forest bioenergy sector: “It doesn’t make any sense to have one [forest] stand being managed for old growth by the U.S. Forest Service, and the one next to it managed for timber sales by the state [of Minnesota]. This is just bad forestry practice”.

Such policy misalignment was also cited as a problem within public agencies. Agency intentions, as manifested through rules and procedures, were perceived by the participants to be in opposition to mutual goals to expand forest bioenergy production. For instance, the synchronization of definitions of what types of biomass qualified for tax credits could facilitate new production and provide more secure and stable growth. The same was true where rules existed pertaining to utility-mandated purchases of distributed energy, which could benefit small-scale thermal production, but where qualifying thresholds were too low for small-industrial or community-scale applications to qualify.

3.1.2. Issues of Scale

Given the inherent challenges of coordinating policy and institutional actions across jurisdictions and supply chain sectors, many of those interviewed stated that smaller scale efforts based on

established best practices might yield greater near-term success. Nearly five million acres of public and private forestlands in Minnesota are third-party certified sustainable under the Forest Stewardship Council or Sustainable Forest Initiative [25]. Minnesota was also the first state to implement sustainable biomass-harvesting guidelines [25].

One response has been to pursue state legislation providing financial assistance to community-scale district-heating or small-scale combined heat and power systems. This would empower communities to invest in their energy futures while supporting development of the forest bioenergy sector across the state. The positive net financial return these systems are capable of producing, particularly in communities served primarily by high cost propane and heating oil, could significantly reduce future fossil fuel dependence and significantly increase the amount of household dollars retained in the local economy.

3.2. Agency

3.2.1. Lack of Agency

A number of organizations and efforts existed throughout the state and region broadly aimed at capitalizing on the benefits of forest bioenergy production. They ranged from organizational efforts to establish an industry presence, such as Heating the Midwest and the Statewide Wood Energy Team that emerged after this research was conducted, to agency administrative procedures to speed up environmental permitting and business siting. The challenge identified by those interviewed was that confusion existed over who had the responsibility, or agency, to coordinate efforts and provide oversight. Participants all along the supply chain cited a general lack of leadership and coordination necessary to accomplish their mutual goals and that the underlying objectives themselves were vaguely defined. Without clear leadership, many posited at that time that there could be neither a coherent strategy for forest bioenergy development nor accountability for the lack of progress. Interestingly, there was little agreement on how to coordinate efforts or what entity or organization should assume responsibility for “steering” efforts. It is unknown how leaders would view this today given more recent organizational efforts through the newly established Statewide Wood Energy Team discussed below.

Several state agency representatives also pointed out the lack of communication and coordination among the various public agencies and with nongovernmental organizations, and how a lack of clear responsibility impeded progress. No less than one dozen nongovernmental organizations and associations worked on issues of forest bioenergy around the state at the time of the interviews, making improved coordination and leadership both a challenge and a necessity. The coordinated actions of these actors present an opportunity for increased accountability and responsibility. In fact, legislation passed in the spring of 2015 provides a production incentive for biomass thermal energy made possible by the efforts of the Bioeconomy Coalition, comprised of many of these organizations working together for the first time for the purpose of bioenergy development [26].

Some of those interviewed wanted to see the Minnesota Department of Natural Resources take a greater role given its high profile and the amount of forest biomass originating from state lands. The department routinely works with private forest land-owners and is involved in state environmental permitting. Because they were already heavily involved in forest bioenergy governance through the allocation of these resources, the department is in a unique position to provide leadership on several fronts. Experts envisioned maintaining the role of individual programs and agencies while articulating distinct roles and responsibilities within an overarching framework. The Statewide Wood Energy Team (SWET) emerged after the interviews as a way accomplishing this coordination, which was supported by a three-year grant through the U.S. Department of Agriculture. The main objective of the SWET was to enable new forest resource markets in partnership with private, state, and federal organizations through the installation of wood energy systems in facilities that currently only had access to high priced heating oil and propane [27]. This effort was an example of how the agency

and partner organizations and businesses were actively seeking ways to coordinate authorities and responsibility across the supply chain.

3.2.2. Lack of Public Support

Another theme identified by most participants was a lack of public awareness of the environmental and economic benefits of forest bioenergy and, as a result, a lack of public agency and knowledge for enabling efforts. One individual stated that the lack of public awareness and understanding of the potential benefits of biomass as an energy source stymies development: “We lack a coherent plan of attack as a...social consensus when it comes to biomass. If society can get behind biomass, it stands to have a much better chance at being successful, and now that is just not the case”.

In addition to the lack of public awareness of environmental and economic benefits of forest bioenergy use, many interviewees also noted that investors were hesitant to invest in forest bioenergy, either for fear that the public may not understand the benefits or because investors were uninformed of the ecological or financial risks involved. For instance, participants shared the frequent misconception that new wood boilers are similar to residential fireplaces with high emissions levels. In reality, the technology has advanced dramatically and is highly regulated by the U.S. Environmental Protection Service [28]. Miscommunication about the technology, or a lack of understanding of the financial opportunities, created trepidation and uncertainty about their application.

One solution suggested by participants was for state agencies and nongovernmental organizations to help citizens, investors, and legislators to become aware of the environmental and economic benefits. This could be done through assisting regional economic developers in areas with high biomass availability to facilitate discussions with area businesses.

The lack of technical experience with forest bioenergy systems, the amount of capital investment required, and inexpensive natural gas prices inhibit new forest bioenergy investments in some areas of the state. Several experts stressed the need to mobilize support for public-private partnerships that could reduce investment exposure and share technical experience. In fact, since these interviews, two organizations have emerged as important venues for education. The Minnesota SWET provides targeted education and energy system planning to help open new markets, promote economic vitality, and use renewable energy, while reducing overall energy costs [27]. The second organization, Heating the Midwest, was established with the mission of advancing biomass thermal heating in the Midwest to secure a more sustainable energy future while improving the economic, environmental, and social well-being [29]. The establishment of these organizations highlights the relevance of such goals, as well as the progress that has been made in recent years.

3.3. Adaptiveness

3.3.1. Wood Harvesting Practices

Adaptive policy systems can be an asset with volatile energy pricing and political uncertainty. During the course of this study, the price of oil has fluctuated from about \$40 to over \$100 per barrel [30]. The impact on alternative energy sources, including biomass thermal and electricity demand, is significant and will continue to influence future energy profiles [31]. In the context of adaptiveness, a key theme identified from interviews was the slow nature by which the forest products industry has traditionally responded to external forces, whether market or policy driven. Interviewees characterized the industry as being slow to adapt to new harvesting practices, contract mechanisms, and policy incentives. The majority of the utility and industry experts suggested the need for a fundamental change in how timber is harvested—by integrating biomass harvesting with traditional forest-products product merchandizing. Participants explained that in the typical timber-harvesting process, loggers remove the higher valued saw logs and pulpwood to be used in lumber or paper production, leaving the residual tops and limbs at the harvest site. Where biomass is removed, it is generally done immediately or soon after logging crews have left, as typically stipulated in the contract.

This results in the transport of “green” or “wet” biomass to processing facilities, where it is purchased on a green-ton or total-weight basis. Purchasing green biomass in effect creates a perverse incentive for loggers to transport water to maximize weight, instead of partially drying the material in the woods. Transportation of wet biomass ultimately increases the cost of production, both because of increased transportation costs and because higher moisture content reduces the efficiency of energy conversion. It also increases air emissions through less efficient combustion.

One solution offered by several agency and industry representatives suggested revising the state best management practices for biomass and timber harvesting to allow larger landing sites in the woods in order to accommodate onsite drying of biomass for later retrieval. Some utility and industry experts suggested adapting logging and procurement systems to emulate the Scandinavian model, considered the gold standard. In countries like Sweden and Finland, biomass remains onsite to air-dry for several months before being purchased on an energy content (Btu) or dry-ton equivalent basis and chipped and delivered for heat or electricity production. In this model, forest bioenergy products are more fully integrated into the broader production supply chain that financially rewards high-quality biomass, maximizes energy output per unit of production, and ultimately minimizes air-quality impacts through more efficient energy conversion. This assumes that there is a market for the biomass, but where one does it exist, it creates efficiencies across the supply chain that in turn can provide positive economic and ecological benefits.

Other solutions focused on subsidizing the cost to chip or grind biomass in the woods. Cost-share programs or investment tax incentives could be used to entice loggers to purchase new equipment in order to improve the integration of biomass with timber harvesting. They also discussed direct subsidies, in the form of production payments per ton of biomass shipped to qualifying heating or electricity facilities, as a way to offset the disparity in production costs and what utilities were willing to pay. The Advanced Biofuel Production Incentive was passed during the 2015 legislative session to provide initial subsidies of \$2.11 per MMBtu for advanced biofuel production from cellulosic biomass [32]. Such programs can enable forest bioenergy efforts to co-exist with traditional forest-products industries and potentially provide increased efficiencies for both.

3.3.2. Issues of Scale

Another key theme related to adaptation was the issue of scale. Individuals felt strongly that existing policies too often gave preference to a particular scale or size of project, often larger projects, rather than providing incentives that could be applied to and used by both large and small businesses. Such consideration would provide flexibility in terms of matching the size of production to the amount of biomass available, level of community support, and local demand for the type of production (e.g., heat or electricity). One expert said: “Most of the policy initiatives and subsidies have gone to large-scale development, and I would like to see a greater proportion of policy opportunities go to small-scale operations, because for Minnesota I think that is where our best opportunities are”.

Encouraging small-scale forest bioenergy could address environmental sustainability concerns over rapid up-scaling and building of plants built too large for the surrounding area’s biomass resource capacity. Coincidentally, what some participants might call large projects have also failed to gain traction. But having the flexibility with respect to the size of projects that qualify for certain financial benefits addresses concerns about counter-productive competition of large projects and the displacement of existing jobs, and is generally easier for municipalities and small businesses to finance. One example cited by participants was the Minnesota Net Metering law that mandated public utilities to purchase distributed-electricity generation of up to 40 kW of electricity. At the time of the interviews, there were no state policies, fiscal or otherwise, to facilitate community-scale independent electricity or district heat production. Legislation was updated in 2015 to accommodate community energy systems of 40–1000 kilowatts [32]. Additional recent developments include passage of the Bioeconomy Production Incentive Program in 2015 that provides \$5.00/MMBtu of biomass thermal production for ten years, at an amount that does not exceed \$150,000 annually [26]. While budget appropriations

would only support a small number of projects initially, they provide pathways for the increased allocation of resources, as well as a starting point for future changes according to market fluctuations. These developments are examples of effective policy design that aims to address problems of scale and financial feasibility to accomplish broader objectives.

3.4. Accountability

3.4.1. Lack of Authority

Issues related to accountability resonated less with interviewed experts. This might include the role of a third-party watchdog organization overseeing activities or a state agency facilitating related development. The Minnesota Logger Education Program (MLEP) is one example whose responsibility it was to educate loggers on safe, productive, and sustainable forest operations [33]. MLEP facilitated opportunities for landowners to hire qualified loggers who would follow best management practices for biomass removal.

3.4.2. Role of Subsidies

Less directly related to accountability, but equally important, was the role of subsidies provided to traditional fossil fuel industries. The lack of authority or responsibility to correct market imbalances was a significant concern among interviewees. There was broad agreement that energy policy favored coal and natural gas, which was rooted in direct government expenditures and tax breaks historically made available to fossil fuel industries for production, distribution (e.g., pipelines, transmission, railroads), and related research and development. Interviewees believed these subsidies created artificially low energy prices, especially when considering the environmental and human health impacts of fossil fuels. This presents a significant barrier for forest bioenergy competition. As one individual representing the forest-products industry stated: “Right now oil and gas are just too cheap to have biomass make any sense. Federal subsidization of fossil fuels is a major culprit. This is distorting the market. Who would buy biomass right now when fossil fuels are so cheap?”

Statements like these are supported by energy consumption trends in Minnesota, where fossil fuels account for 68% of consumption, while biomass was up less than 1% [34]. Another individual who works for a small bioenergy start-up voiced the concerns of many by stating that if there was a comprehensive national energy policy, equal treatment was needed for bioenergy, particularly if the energy security, economic, and environmental benefits are so pronounced: “Just look at the incentives for ethanol versus biomass fuels, wind power versus biomass, oil company incentives versus renewable-energy industry in general. Either ignore the special-interest groups and eliminate them for all industries and let the marketplace decide, or make certain that the economic incentives are equally applied”.

Overwhelmingly, interviewees preferred that such subsidies did not exist, and that if the market was a level playing field and resources were more evenly distributed, biomass would be able to prove itself as a dependable, efficient, and environmentally responsible source of energy, especially when considering the environmental and human health impacts of fossil-based energy sources [35,36]. It was perceived by the participants that the gradual elimination of fossil fuel production incentives would enhance bioenergy competitiveness and reduce the risk of investment in renewable energy ventures. At the federal level, the Renewable Fuels Standard in the 2007 Energy Independence and Security Act disqualified the use of forest residues obtained from most public forest lands. The law was purposefully designed to prevent the use of biomass from public lands out of fear it might promote unsustainable harvesting practices. Alternatively, the federal Clean Power Plan established under section 111(d) of the Clean Air Act authorized the use of some biomass for power generation [37]. This legislation is aimed at reducing carbon pollution from stationary source power plants in order to reduce the carbon contributions to climate change.

3.5. Allocation

3.5.1. Market Distortion

Although many of the experts interviewed argued for parity in government support for energy production, a majority did not want bioenergy policies to distort market prices out of fear that they could “cannibalize” existing wood-products markets through artificial competition for the biomass resource. Participants were wary of government intervention that increased biomass demand, thus driving up the price and in effect reducing the competitiveness of complementary industries such as pulp and paper manufacturing that would have to pay higher feedstock prices to compete. These experts feared that this could result in a redistribution of jobs that are, on average, lower paying than those in the pulp and paper industry.

3.5.2. BCAP

One example of unintended consequences that interviewees identified was the Biomass Crop Assistance Program (BCAP). BCAP had two main goals, as defined in the 2008 U.S. Farm Bill: to support the establishment and production of eligible crops for conversion to bioenergy; and to assist forest and agricultural landowners in the collection, harvest, storage, and transport of eligible crops for conversion [38]. Despite intentions, existing forest-products businesses, and in particular pulp and paper companies, captured a majority of the funding. As a result, very little new production was created, and new sources of biomass feedstock were not developed [39]. A study in Michigan found no major changes in land use practices under the BCAP program and the impact on biomass supply development in the region was marginal at best [39]. A conservation organization representative summarized the issue this way: “BCAP was good, because it incentivized foresters to get biomass out of the woods, but was designed so poorly that it just became a monster and didn’t add any infrastructure to the system”.

Poor policy design resulted in the unequal allocation of financial support resources. Instead of supporting developing entities, BCAP resources largely went to entities that might not have needed the resources or made no new investments. BCAP was suspended in 2010, subsequently revised, and resumed in 2015, only to provide payments for the establishment of new biomass feedstock production; gone are the payments for the harvest, storage, and transport of biomass. Interestingly, most participants stated that if BCAP had been more carefully designed to favor the development of new biomass crops, as it recently was, it could have been a successful approach.

Many forest-products experts interviewed reinforced the idea that forest bioenergy policy must be designed to benefit multiple industries. They pointed out how the pulp and paper and energy sectors are increasingly mutually dependent and that higher valued pulp-wood and saw log markets are necessary to subsidize the physical removal of forest residues used for lower valued forest bioenergy markets. Likewise, the use of residual biomass from the timber harvesting not suitable for higher valued products was an important revenue stream for beleaguered forest-products industries and landowners. Integrated harvesting practices with an emphasis on feedstock quality and energy optimization are critical. For example, loggers could form a long-term partnership with a biorefinery that produces high value wood products that might help offset the costs of biomass removal. Emulating such practices that make sense in Minnesota would enhance the financial feasibility of forest bioenergy as a viable fossil fuel alternative. Instead of viewing pulp and paper and wood energy sectors as competitive, interviewees articulated the need to allocate resources and shape policy in such a way that optimized the growth of each industry symbiotically.

4. Conclusions

Overall, the findings of this study build on the existing frameworks of institutional policy analysis and forest governance [12] and the organizing concept of earth systems governance [13]. These frameworks were applied to empirically measure the effectiveness of existing policies and institutions

that exist within the forest bioenergy supply chain within Minnesota in terms of the role of architecture, agency, adaptiveness, accountability, and allocation. Interviews with forest bioenergy experts elicited the perceptions of the five dimensions based on their experiences. The perceptions were analyzed to identify overarching themes in terms of major barriers, as well as opportunities for forest bioenergy development. The findings are specific to Minnesota, but the application to other states and regions is relevant and useful in thinking about how to organize institutional structures in order to guide future bioenergy development.

The overall structure of existing institutions, policies, and programs were cited as being barriers in terms of a lack of coordination resulting in complex and sometimes counterproductive rules and procedures, as well as a lack of a unified strategy and responsibility for progress amongst state authorities and actors. Major policy barriers that were identified gave preference to traditional energy sources that have largely failed to integrate forest bioenergy with traditional forest-product industries. Opportunities were also identified and included increasing public awareness of the benefits of forest bioenergy, and the creation of incentives supporting both traditional and new uses of forest biomass.

We also found that since the collection of this data, there has been significant progress in terms of policies, incentives, and programs aimed at enabling forest bioenergy production. These include the Statewide Wood Energy Teams [27], the Advanced Biofuel Production Incentive [40], Bioeconomy Production Incentive Program [41], and at the federal level the US EPA Clean Power Plan [37], which as of this writing was still law but not yet implemented and targeted for removal. Most of these examples place value on forest bioenergy potential and provide opportunities to remove institutional barriers perceived to exist. But the lack of a stable policy environment can also be observed in the uncertainty of the Clean Power Plan, as well as state legislation passed in 2017 that discontinues the requirement that Xcel Energy purchase electricity produced from biomass [42].

Though Minnesota is not representative of the myriad of challenges faced in other states, these findings may increase our understanding of how governance affects forest bioenergy policy implementation. Dimensions of forest and bioenergy policy can be examined in other contexts using the same methodology and questions. The array of local institutions and perceived barriers will vary, but this framework provides a way to view opportunities and strategies in a different light. The findings of this study may help inform future policy and practices in Minnesota's forest bioenergy sector, in particular, as well as provide a framework for similar studies in other states and regions looking to do the same.

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