The Power of a Forest: Informing Forest Bioenergy Policy Development through Facility Case Studies

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Authorization to Submit Thesis

This thesis of Michelle E. Benedum, submitted for the degree of Master of Science with a Major in Natural Resources and titled, “The Power of a Forest: Informing Forest Bioenergy Policy Development through Facility Case Studies” has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

Forest biomass is source of sustainable heat and electricity supplied through forest management activities. Sustainably utilizing forest biomass for energy provides a host of benefits including: supporting and diversifying the domestic energy industry, reducing the cost of hazardous fuel treatments, rural economic development, greenhouse gas (GHG) emissions reduction, and habitat improvements. Despite the aforementioned benefits the pace and scale of development has been slow and the role of policy intervention continues to be challenged. Numerous barriers to utilizing forest biomass are documented in the literature including unfavorable economics, supply chain deficiencies, and public opposition. Despite decades of industry innovations and prolific research, the bioenergy industry continues to lack policy intervention that effectively minimizes the barriers to biomass use. However, it is not just effective policy that is challenged, but also the role of government in shaping how forest resources are governed. This thesis focuses on two gaps of research pertaining to the use of forest biomass for energy purposes. First, despite being well documented in the literature, barriers are not understood in the context of necessary policy responses and there is little empirical data on biomass barriers from a forest bioenergy facility perspective. Specifically, unanswered questions include: How do the aforementioned barriers affect facility operations? And how do existing or proposed facility companies respond to changes in particular policies? Second, there are few empirical studies that explore the following questions: How do forest bioenergy networks influence policy intervention?

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Dedication

To Professor Nick Sanyal: For the abundance of opportunities, encouraging me to pursue graduate school, and endless support for all other endeavors. But most of all, for believing in me.

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CHAPTER 1: INTRODUCTION

Abstract

This chapter provides an introduction to the topic and acts as a roadmap for the remainder of the thesis. The following section synthesizes peer-reviewed articles, technical reports, and agency databases to explore current bioenergy challenges and opportunities and expose research gaps in the existing literature that this thesis aims to explore. This chapter concludes with a thesis overview and specific research questions that the remaining chapters attempt to address.

1.0 Literature Review

1.1 What is forest biomass?

Forest biomass is a source of sustainable heat and electricity supplied through forest management activities. Forest biomass includes limbs, tops, needles, and other residuals of forest management activities (USDA, 2007). Forest biomass usually refers to low-value material that cannot be sold as pulpwood or saw timber (Evans & Finkral, 2009). In 2017, an estimated 103 million dry tons of forest biomass was available in the contiguous United States (Langholtz, Stokes, & Eaton, 2016). Data indicates that as of 2016, the United States produces 8,184.4153 megawatts (MW) of energy using over 81 million green tons of forest biomass on an annual basis (Appendix A).

1.2 Benefits of biomass energy

Forests are increasingly recognized for their role in managing for climate change adaptation mitigation (Carina et al., 2016), and to provide a source of sustainable and renewable energy (Lindahl, Sandström, & Sténs, 2018). The use of forest biomass in an environmentally and economically sustainable manner results in a host of ancillary benefits including: reducing national security threats associated with reliance on foreign energy sources (Aguilar & Garrett, 2009), providing economic means for road improvement (USDA, 2007), reducing greenhouse gas (GHG) emissions (Malmsheimer et al., 2008), offset the cost of fuels reduction, while simultaneously promote healthier habitat (Carleton & Becker, 2018; USDA, 2007), and supporting rural economic development (Gan & Smith, 2007; Guo, Sun, & Grebner, 2007; Hjerpe & Kim, 2008).

Bioenergy production is driven by energy security concerns, particularly after the 1973 oil crisis (Carleton & Becker, 2018; Gan & Cashore, 2013). However, it failed to gain widespread adoption due to the low costs of fossil fuels, particularly natural gas. In 2017, the United States imported approximately 10.14 million barrels of petroleum per day from approximately 84 different countries (U.S. Energy Information Administration, 2018). The reluctance to depend on foreign energy and the unstable nature of oil prices fuels public concern and the demand for changes within the energy industry. Utilizing forest biomass presents an opportunity for the United States to diversify the energy sector by using locally sourced material rather than rely on imported fuels. In California, 22 biomass facilities use approximately 7.3 million tons of the state's wastes each year and produces an estimated 532 MW of electricity (California Biomass Energy Alliance, 2019).

Biomass utilization along riparian areas also benefit the watershed by removing thick understory in favor of larger trees. These larger trees act as a cooling mechanism for the stream and simultaneously improve habitat within the watershed. Biomass harvest from fire suppressed areas could improve the habitat for wildlife species by removing encroaching tree species and preventing an overabundance of material from accumulating and decaying or being burned on site (USDA, 2007). Integrating biomass harvesting into forest management may make restoration initiatives and fuel reduction treatments more cost effective (USDA, 2007).

Much of the landscape, particularly in the west, is susceptible to catastrophic wildfires due to years of fire suppression (Bracmort, 2013; Hjerpe & Kim, 2008). While some wildfires occur naturally, abnormally high biomass levels lead to increased risk of catastrophic wildfires across the landscape (Bracmort, 2013). In 2017, 2.78 million acres of forests burned in the western United States (National Interagency Fire Center, 2018). Recently, the recognition of biomass utilization as a tool for wildfire risk reduction and an economic opportunity for rural communities, bioenergy re-gained interest across the United States (Carleton & Becker, 2018).

Compared to alternative energies, bioenergy has high income and employment multipliers, creating a ripple effect on income and job creation (Domac, Richards, & Risovic, 2005; Gan & Cashore, 2013). One study showed that fuel reduction treatments within one fiscal year across five national forests helped generate 500 jobs and over $40 million of output (Hjerpe & Kim, 2008).

Reducing the risk of catastrophic wildfires, diversifying domestic energy sources, and improving forest health and resiliency are among the many motives for increasing the utilization of forest biomass. But despite nearly two decades of technological and planning enhancements, forest biomass utilization continues to be challenged in much of the United States.

1.3 Barriers to biomass

Despite the aforementioned benefits the pace and scale of development has been slow and the role of policy intervention continues to be challenged. Numerous barriers to utilizing forest biomass are documented in the literature including unfavorable economics (Aguilar & Garrett, 2009), supply chain deficiencies (Becker, Abbas, et al., 2009), and public opposition (Stidham & Simon-Brown, 2011).

The cost of transportation is well documented as one of the primary hindrances to using forest biomass (Becker, Larson, & Lowell, 2009; Becker, et al., 2009; Fei, Han-Sup, Johnson, & Elliot, 2008; Guo et al., 2007; Han, Lee, & Johnson, 2004). Chips vans can only carry a fixed amount of biomass at one time (less than 23 metric tons in California and Arizona) and the cost of each trip increases with distance and travel time (Nicholls et al., 2018). In the U.S., biomass is considered a low-value, waste product and without appropriate markets, there is no incentive to absorb the cost to haul the material to a processing facility. Recent studies suggest the barriers to forest biomass include more than just the cost of transportation to include inconsistent supply, lack of markets, diminished forest product industries, and inefficient technology. Accessing supply with a chip van can be problematic due to its large turning radius. Forest roads are typically designed for log trucks that can make a horizontal curve radius down to 15M, whereas a chip van may be unable to pass through sections of the road with less than 18M curve radius (Bowers, 2012; Sessions, Wimer, Costales, & Wing, 2010). In some areas, inconsistent supply hinders greater biomass use (Aguilar & Garrett, 2009; Becker et al., 2009; Guo et al., 2007). The size of the facility also effects the amount of consistent supply necessary. Larger facilities require a greater supply and could quickly become economically inefficient and unsustainable if local supply is not plentiful and harvested sustainably (Becker et al., 2009; Mafakheri & Nasiri, 2014).

Utilizing biomass for energy is difficult in areas where there is no existing forest products industry or the industry is significantly diminished because there is often a limited supply chain (Becker et al., 2009). The supply chain logistics include harvesting, handling, processing, and storage of all material (Keefe, Anderson, Hogland, & Muhlenfeld, 2014; Mafakheri & Nasiri, 2014). In areas with a little forest industry, remaining infrastructure is often geared towards larger, more profitable trees. These areas often struggle soliciting capacity with the appropriate equipment and technology to use small-diameter trees. Research acknowledges that many failed of attempts of bioenergy development are attributed to supply issues (Nicholls et al., 2018). When utilizing small-diameter trees from restoration initiatives, information regarding the size, quality, and quantity of material removed must be transparent (Nicholls et al., 2018).

Social acceptability also plays a role in forest bioenergy success. Understanding how individuals interpret and respond to changes in the landscape and towards policy decisions is an important part of implementing an effective policy (Shindler, Brunson, & Stankey, 2002). The level of social acceptability is largely associated with the cultural, economic, and natural organizations of the surrounding forestlands (Nielsen-pincus & Moseley, 2009). For example, social resistance may occur in areas where traditional forest uses, such as timber harvesting, are facing competition from emerging bioenergy markets (Nielsen-pincus & Moseley, 2009). Concerns also circulate around air quality from emissions, and noise and traffic pollution from increased transportation (Madlener & Vö Gtli, 2008; Miranda & Hale, 2001).

Adding to the complexity of forest biomass utilization, forests encompass a variety of uses including the ability to harness renewable energy (Lindahl, & Westholm, 2010; Gan & Cashore, 2013; Lindahl et al., 2018), maintain forest biodiversity (Westholm, Lindahl, & Kraxner, 2015), and allow recreational use on forests (Sandström, Lindahl, & Sténs, 2017). As a consequence, existing mechanisms for balancing interests are challenged (Sandström et al., 2017). Furthermore, it is not just effective policy intervention that is being challenged, but also the role of government in the forest governance process (Agrawal, Chhatre, & Hardin, 2008; Arts, 2014; Sandström et al., 2017). Forest government is a centralized approach to forest management dominated primarily by federal and state actors. Historically, forest government has been criticized for overexploiting forest resources and for managing forests in a manner that conflicts with local community needs (Arts, 2014). The shift from forest government to forest governance recognizes the importance of non-government agencies, businesses, and local communities involved in the decision-making process (Agrawal et al., 2008; Arts, 2014). Forest governance can be defined as the interaction between informal and formal institutions consisting of rules, norms, and decision-making that shape how forests are managed (Giessen & Buttoud, 2014; Nguyen, Ancev, & Randall, 2018).

2.0 Thesis Overview

This thesis focuses on two gaps of research pertaining to the use of forest biomass for energy purposes. First, despite being well documented in the literature, barriers are not understood in the context of necessary policy responses and there is little empirical data on biomass barriers from a forest bioenergy facility perspective. Specifically, unanswered questions include: How do the aforementioned barriers affect facility operations? And how do existing or proposed facility companies respond to changes in particular policies? Second, there are few empirical studies that explore the following question: How do forest bioenergy networks influence policy intervention?

The following chapter explores power facility operations and the policy and market interventions that may serve as either barriers or opportunities to bioenergy from four bioenergy facility perspectives. The third chapter proposes four dimensions of network governance to examine bioenergy networks and their influence on forest bioenergy policy intervention.

2.1 Chapter 2

Chapter 2, titled "*Evaluating Policy and Market Barriers for Forest Biomass Energy Development"* explores regional difference in the use of forest biomass, identifies policy and market barriers, and opportunities for policy intervention from a facility perspective. I use data from 21 key informant interviews with regional biomass experts to collect in-depth information on regional differences in the operation of biomass power facilities and areas for potential policy intervention. I then develop a comparative case study of four bioenergy facilities from different geographic regions and representing a variety of project configurations and outcomes. Through a series of semi-structured interviews with facility owners, managers, utilities, and other relevant stakeholders representing the four selected facilities, I assess the particular factors influencing biomass power facility operation and the policy and market interventions that may serve as either barriers or opportunities to bioenergy in the future. I conclude with a discussion of the similarities and differences documented across the four cases, and provide policy recommendations to address identified barriers.

2.2 Chapter 3

Chapter 3, titled "*Using dimensions of network governance to examine forest bioenergy policy development*" explores dimensions of network governance as a lens to examine bioenergy networks and their influence policy intervention. I propose a framework consisting of four network governance dimensions: heterogeneity, integration, strength of ties, and structure to apply to a single, critical case study. I use this framework to explore the underlying aspects of forest bioenergy networks and identify additional forest bioenergy barriers and network vulnerabilities that warrant additional study.

3.0 References

Aboii, S. (2012). The Secrets Behind San Antonio's Water Conservation Success | StateImpact Texas. Retrieved November 6, 2017, from https://stateimpact.npr.org/texas/2012/05/22/the-secrets-behind-san-antonios-water-conservation-success/

Agrawal, A., Chhatre, A., & Hardin, R. (2008). Changing governance of the world's forests. *Science (New York, N.Y.)*, *320*(5882), 1460–1462. https://doi.org/10.1126/science.1155369

Aguilar, F., & Garrett, H. E. (2009). Perspectives of Woody Biomass for Energy: Survey of State Foresters, State Energy Biomass Contacts, and National Council of Forestry Association Executives. *Journal of Forestry*, *107*(6), 297–306.

ARP. (2018). American Renewable Power acquires 20MW Biomass Plant in Loyalton, California. Retrieved March 7, 2019, from http://www.amerpower.com/news-details/9

ARP. (2019a). About American Renewable Power. Retrieved March 31, 2019, from https://www.amerpower.com/

ARP. (2019b). Loyalton Biomass Plant. Retrieved March 31, 2019, from http://www.amerpower.com/facilities-detail/6

Arts, B. (2014). Assessing forest governance from a 'Triple G' perspective: Government, governance, governmentality. *Forest Policy and Economics*, *49*, 17–22. https://doi.org/10.1016/j.forpol.2014.05.008

Becker, D. R., Abbas, D., Halvorsen, K. E., Jakes, P. J., McCaffrey, S. M., & Moseley, C. (2009). *Conventional Wisdoms of Woody Biomass Utilization*. *Journal of Forestry*. Retrieved from https://cesu.umn.edu/sites/cesu.umn.edu/files/mtu-usfs-02report.pdf

Becker, D. R., Larson, D., & Lowell, E. C. (2009). Financial considerations of policy options to enhance biomass utilization for reducing wildfire hazards. *Forest Policy and Economics*, *11*(8), 628–635. https://doi.org/10.1016/j.forpol.2009.08.007

Becker, D. R., Moseley, C., & Lee, C. (2011). A supply chain analysis framework for assessing state-level forest biomass utilization policies in the United States. *Biomass and Bioenergy*, *35*(4), 1429–1439. https://doi.org/10.1016/j.biombioe.2010.07.030

Beland Lindahl, K., Westholm, E., Beland Lindahl, K., & Westholm, E. (2010). Food, Paper, Wood, or Energy? Global Trends and Future Swedish Forest Use. *Forests*, *2*(1), 51–65. https://doi.org/10.3390/f2010051

Black, & Veatch. (2004). *Gainesville Regional Utilities - Supplementary study of generating alternatives for Deerhaven Generating station*. Jacksonville. Retrieved from https://www.gru.com/Portals/0/Legacy/Pdf/futurePower/SUPPLEMENTARY_STUDY_OF_GENERATING_ALTERNATIVES.pdf

Bodin, Ö. (2006). *A NETWORK PERSPECTIVE ON ECOSYSTEMS, SOCIETIES AND NATURAL RESOURCE MANAGEMENT*. Retrieved from https://pdfs.semanticscholar.org/dbed/60b3de676d13780aa5c77ef6c569ced4f7d0.pdf

Börzel, T. A. (1998). Organizing Babylon - on the different conceptions of policy networks. *Public Administration*, *76*(2), 253–273. https://doi.org/10.1111/1467-9299.00100

Bowers, S. (2012). *Designing Woodland Roads*. Retrieved from https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/ec1137.pdf

Bracmort, K. (2013). *Wildfire Fuels and Fuel Reduction Kelsi Bracmort Specialist in Agricultural Conservation and Natural Resources Policy*. Retrieved from www.crs.gov

California Biomass Energy Alliance. (2019). Biomass: Essential for California. Retrieved February 21, 2019, from http://www.calbiomass.org/general-statement/

California Legislative Information. SB-901 Wildfires. (2018). Retrieved from https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB901

California Legislature. SB-859 Public resources: greenhouse gas emissions and biomass. (2016). Retrieved from https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB859

Caplan, A. (2017a). Biomass buyout takes some big steps this week. Retrieved March 3, 2019, from https://www.gainesville.com/news/20170821/biomass-buyout-takes-some-big-steps-this-week

Caplan, A. (2017b). City gives final OK for biomass plant buy. Retrieved March 3, 2019, from https://www.gainesville.com/news/20170907/city-gives-final-ok-for-biomass-plant-buy

Carina, E., Keskitalo, H., Bergh, J., Felton, A., Björkman, C., Berlin, M., … Jokela, E. J. (2016). Adaptation to Climate Change in Swedish Forestry. https://doi.org/10.3390/f7020028

Carleton, L. E., & Becker, D. (2018). Forest biomass policy in Minnesota: Supply chain perspectives on barriers to bioenergy development. *Forests*, *9*(5), 254. https://doi.org/10.3390/f9050254

Carlsson, L. G., & Sandström, A. C. (2007). Network Governance of the Commons. *International Journal of the Commons*, *2*(1), 33. https://doi.org/10.18352/ijc.20

Carter, D., Langholtz, M., & Schroeder, R. (2007). *Economic Availability of Alternative Biomass Sources for Gainesville, Florida*. Gainsville, FL. Retrieved from https://www.academia.edu/2729665/Economic_Availability_of_Alternative_Biomass_Sources_for_Gainesville_Florida

Clean Energy Resources. (n.d.). *Laurentian Energy Authority Renewable Biomass Combined Heat and Power Energy Production from the Hibbing and Virginia Public Utilities.* Retrieved from https://www.cleanenergyresourceteams.org/files/CERTs_presntations_CHP_Hibbing_Virginia.pdf

Conway, K. (2018). *UTILIZATION-BIOENERGY GROUP TASK FORCE MEMBERS*. Retrieved from http://www.fire.ca.gov/treetaskforce/downloads/204_UTILIZATION_BIOENERGY.pdf

Courtney, R. A. (2018). Network governance in the heritage ecology. *Journal of Management and Governance*, *22*(3), 689–705. https://doi.org/10.1007/s10997-017-9399-z

CPUC. (2016). Public Utilities Commission of the State of California. Energy Division Resolution E-4137. Retrieved March 8, 2019, from https://www.gov.ca.gov/docs/10.30.15_Tree_Mortality_State_of_Emergency.pdf

Davies, J. S. (2012). Network governance theory: a Gramscian critique. *Environment and Planning A*, *44*, 2687–2704. https://doi.org/10.1068/a4585

Domac, J., Richards, K., & Risovic, S. (2005a). Socio-economic drivers in implementing bioenergy projects. In *Biomass and Bioenergy* (Vol. 28, pp. 97–106). Pergamon. https://doi.org/10.1016/j.biombioe.2004.08.002

Domac, J., Richards, K., & Risovic, S. (2005b). Socio-economic drivers in implementing bioenergy projects. *Biomass and Bioenergy*, *28*(2), 97–106. https://doi.org/10.1016/J.BIOMBIOE.2004.08.002

Evans, A. M., & Finkral, A. J. (2009). From renewable energy to fire risk reduction: A synthesis of biomass harvesting and utilization case studies in US forests. *GCB Bioenergy*, *1*(3), 211–219. https://doi.org/10.1111/j.1757-1707.2009.01013.x

Fei, P., Han-Sup, H., Johnson, L. R., & Elliot, W. J. (2008). Production and cost of harvesting, processing, and transporting small-diameter (~ 5 inches) trees for energy. *Forest Products Journal*, *58*(5), 47–53. https://doi.org/Article

Fleeger, W. E. (2008). Collaborating for Success: Community Wildfire Protection Planning in the Arizona White Mountains. *Journal of Forestry* , *106*(2), 78–82. Retrieved from https://search.proquest.com/docview/220813373/fulltextPDF/51D761D221A545FCPQ/1?accountid=14551

Gan, J., & Cashore, B. (2013). Opportunities and Challenges for Integrating Bioenergy into Sustainable Forest Management Certification Programs. *Journal of Forestry*, *111*(1), 11–16. https://doi.org/10.5849/jof.11-092

Gan, J., & Smith, C. T. (2007). Co-benefits of utilizing logging residues for bioenergy production: The case for East Texas, USA. *Biomass and Bioenergy*, *31*(9), 623–630. https://doi.org/10.1016/j.biombioe.2007.06.027

Giessen, L., & Buttoud, G. (2014). Defining and assessing forest governance. *Forest Policy and Economics*, *49*, 1–3. https://doi.org/10.1016/j.forpol.2014.11.009

Granovetter, M. (1986). The Strength of Weak Ties: A Network Theory Revisited. *Sociological Theory*, *1*, 201. https://doi.org/10.2307/202051

Guo, Z., Sun, C., & Grebner, D. L. (2007). Utilization of forest derived biomass for energy production in the U.S.A.: status, challenges, and public policies. *International Forestry Review*, *9*(3), 748–758. https://doi.org/10.1505/ifor.9.3.748

Hafdahl, B., & Berguson, B. (2013). *Commercial Application of Biomass Energy Laurentian Energy Authority*. Retrieved from https://www.energy.gov/sites/prod/files/2016/05/f31/feedstocks_berguson_7154_0.pdf

Han, H. S., Lee, H. W., & Johnson, L. R. (2004). Economic feasibility of an integrated harvesting system for small-diameter trees in southwest Idaho. *Forest Products Journal*, *54*(2), 21–27. https://doi.org/10.1007/978-3-7908-2375-2

Head, B. W. (2008). Assessing network-based collaborations. *Public Management Review*, *10*(6), 733–749. https://doi.org/10.1080/14719030802423087

Hjerpe, E. E., & Kim, Y.-S. (2008). Economic Impacts of Southwestern National Forest Fuels Reductions. *Journal of Forestry*, *106*(6), 311–316. https://doi.org/10.1093/jof/106.6.311

Holt, L. (2016). The importance of the regulatory framework for U.S. electric utility creditworthiness. *The Electricity Journal*, *29*(3), 13–18. https://doi.org/10.1016/J.TEJ.2016.03.002

ICF. (2006). *City of Gainesville Electricity Supply Needs*. Fairfax, VA. Retrieved from https://www.icf.com/news/2017/06/energy-efficiency-alberta-selects-icf-to-implement-energy-savings-program

Jossi, F. (2017). *Plant closures could be turning point for Minnesota biomass industry*. Retrieved from https://energynews.us/2017/09/29/midwest/plant-closures-could-be-turning-point-for-minnesota-biomass-industry/

Keefe, R., Anderson, N., Hogland, J., & Muhlenfeld, K. (2014). Woody Biomass Logistics. In *Cellulosic Energy Cropping Systems* (Vol. 9781119991, pp. 251–279). https://doi.org/10.1002/9781118676332.ch14

Keeler, D., & Bertrain, J. (2015). *SB 859: Funding for Cap-and-Trade Program and Forest Projects to Reduce GHG Emissions*. Retrieved from http://leginfo.legislature.ca.gov/.

Klijn, E. H. (2009). Networks and Inter-Organizational Management: Challenging, Steering, Evaluation, and the Role of Public Actors in Public Management. In *The Oxford Handbook of Public Management*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199226443.003.0012

Koliba, C., Meek, J. W., & Zia, A. (2011). *Governance networks in public administration and public policy*. CRC Press.

Langholtz, M. H., Stokes, B. J., & Eaton, L. M. (2016). *2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy*. https://doi.org/10.2172/1271651

Lester, T. K., Peterson, J., & Stathos, D. (2015). *Independent Investigative Review of the Gainesville Regional Utilities (GRU)*.

Lindahl, K. B., Sandström, C., & Sténs, A. (2018). Alternative pathways to sustainability? Comparing forest governance models. *Forest Policy and Economics*. https://doi.org/10.1016/j.forpol.2016.10.008

Lu, H., de Jong, M., & ten Heuvelhof, E. (2018). Explaining the variety in smart eco city development in China-What policy network theory can teach us about overcoming barriers in implementation? *Journal of Cleaner Production*, *196*, 135–149. https://doi.org/10.1016/j.jclepro.2018.05.266

Lynn, K. (2013). A triple 'S' for sustainability: Credit ratings agencies and their influence on the ecological modernization of an electricity utility. *Utilities Policy*, *27*, 9–14. https://doi.org/10.1016/J.JUP.2013.08.003

Madlener, R., & Vö Gtli, S. (2008). Diffusion of bioenergy in urban areas: A socio-economic analysis of the Swiss wood-fired cogeneration plant in Basel. https://doi.org/10.1016/j.biombioe.2008.01.006

Mafakheri, F., & Nasiri, F. (2014). Modeling of biomass-to-energy supply chain operations: Applications, challenges and research directions. *Energy Policy*, *67*, 116–126. https://doi.org/10.1016/j.enpol.2013.11.071

Malmsheimer, R., Heffernan, P., Brink, S., Crandall, D., Deneke, F., Galik, C., … Mortimer, M. (2008). Forest management solutions for mitigating climate change in the United States. *Journal of ForestryJournal of Forestry*, *106*. Retrieved from https://www.fs.usda.gov/ccrc/library/biblio/14334

Mattor, K. M., & Cheng, A. S. (2015). Contextual Factors Influencing Collaboration Levels and Outcomes in National Forest Stewardship Contracting. *Review of Policy Research*, *32*(6), 723–744. https://doi.org/10.1111/ropr.12151

Meersman, T. (2017a). Loggers and truckers sue Xcel Energy over proposed shutdowns of plants. Retrieved February 24, 2019, from http://www.startribune.com/loggers-and-truckers-sue-xcel-energy-over-proposed-shutdowns-of-plants/458920883/

Meersman, T. (2017b). New law allows much of Minnesota’s biomass industry to be shut down. Retrieved December 3, 2018, from http://www.startribune.com/new-law-allows-much-of-minnesota-s-biomass-industry-to-be-shut-down/426537051/

Minnesota Public Utilities Commission (MN PUC). Petition of Approval to Terminate the Power Purchase Agreement (PPA) with Benson Power, LLC (Docket E002/M-17-530); Petition for Approval to Terminate the PPA with Laurentian Energy Authority I, LLC (LEA) (Docket E002/M-17-551) (2018).

Miranda, M. L., & Hale, B. (2001). *Protecting the forest from the trees: the social costs of energy production in Sweden*. *Energy* (Vol. 26). Retrieved from www.elsevier.com/locate/energy

National Interagency Fire Center. (2018). National Interagency Fire Center. Retrieved June 11, 2018, from https://www.nifc.gov/fireInfo/nfn.htm

Neary, D. G., & Zieroth, E. J. (2007). Forest bioenergy system to reduce the hazard of wildfires: White Mountains, Arizona. *Biomass and Bioenergy*, *31*, 638–645. https://doi.org/10.1016/j.biombioe.2007.06.028

Nguyen, M. D., Ancev, T., & Randall, A. (2018). Forest governance and economic values of forest ecosystem services in Vietnam. *Land Use Policy*. https://doi.org/10.1016/j.landusepol.2018.03.028

Nicholls, D. L., Halbrook, J. M., Benedum, M. E., Han, H.-S., Lowell, E. C., Becker, D. R., & Barbour, R. J. (2018). Socioeconomic Constraints to Biomass Removal from Forest Lands for Fire Risk Reduction in the Western U.s. *Forests*, *9*(5), 264. https://doi.org/10.3390/f9050264

Nielsen-pincus, M., & Moseley, C. (2009). Social Issues of Woody Biomass Utilization :, (20), 1–4.

PG&E. (2019). Bioenergy Renewable Auction Mechanism. Retrieved February 25, 2019, from https://www.pge.com/en_US/for-our-business-partners/energy-supply/electric-rfo/wholesale-electric-power-procurement/bioenergy-renewable-auction-mechanism-request-for-offers.page

Poocharoen, O., & Sovacool, B. K. (2012). Exploring the challenges of energy and resources network governance. *Energy Policy*, *42*, 409–418. https://doi.org/10.1016/J.ENPOL.2011.12.005

Provan, K. G., & Kenis, P. (2007). Modes of Network Governance: Structure, Management, and Effectiveness. *Journal of Public Administration Research and Theory*, *18*(2), 229–252. https://doi.org/10.1093/jopart/mum015

R.A.W. Rhodes. (2008). *The Oxford Handbook of Public Policy*. Oxford; New York: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199548453.001.0001

Reagans, R., & Zuckerman, E. W. (2001). Networks, Diversity, and Productivity: The Social Capital of Corporate R&D Teams. *Organizational Science*, *12*(4), 502–517. Retrieved from https://www.jstor.org/stable/pdf/3085985.pdf

Rhodes, R. A. W. (1996). The New Governance: Governing without Government. *Political Studies*, *44*(4), 652–667. https://doi.org/10.1111/j.1467-9248.1996.tb01747.x

Ropeik, A. (2018). Legislators Narrowly Override Sununu's Biomass Veto, But Fall Short On Net Metering. Retrieved March 29, 2019, from https://www.nhpr.org/post/legislators-narrowly-override-sununus-biomass-veto-fall-short-net-metering#stream/0

Sandstrom, A. (2008). *Policy Networks: The relation between structure and performance*. Luleå University of Technology Department of Business Administration and Social Sciences Division of Political science. Retrieved from http://www.diva-portal.org/smash/get/diva2:989924/FULLTEXT01.pdf

Sandström, C., Lindahl, K. B., & Sténs, A. (2017, April). Comparing forest governance models. *Forest Policy and Economics*, *77*, 1–5. https://doi.org/10.1016/j.forpol.2016.10.007

Sessions, J., Wimer, J., Costales, F., & Wing, M. G. (2010). *Engineering Considerations in Road Assessment for Biomass Operations in Steep Terrain*. Retrieved from https://academic.oup.com/wjaf/article-abstract/25/3/144/4683577

Shindler, B. A., Brunson, M., & Stankey, G. H. (2002). *Social Acceptability of Forest Conditions and Management Practices: A Problem Analysis*. Retrieved from https://www.fs.fed.us/pnw/pubs/pnw_gtr537.pdf

State of California. (2013). Tree Mortality Task Force. Retrieved April 2, 2019, from http://www.fire.ca.gov/treetaskforce/index

Steelman, T. A. (2010). *Implementing innovation : fostering enduring change in environmental and natural resource governance*. Georgetown University Press. Retrieved from https://www.jstor.org/stable/j.ctt2tt61t

Stidham, M., & Simon-Brown, V. (2011). Stakeholder perspectives on converting forest biomass to energy in Oregon, USA. *Biomass and Bioenergy*, *35*(1), 203–213. https://doi.org/10.1016/j.biombioe.2010.08.014

Sundstrom, S., Nielsen-Pincus, M., Moseley, C., & Mccaffery, S. (2012). Woody Biomass Use Trends, Barriers, and Strategies: Perspectives of US Forest Service Managers. *Journal Of Forestry*, *110*(1), 16–24. Retrieved from http://pdxscholar.library.pdx.edu/esm_fac

Swirko, C. (2017). Biomass plant ordered to pay $4.6 million in damages. Retrieved March 8, 2019, from https://www.gainesville.com/news/20160623/biomass-plant-ordered-to-pay-46-million-in-damages

Tait, D. (2017). Understanding Public Utility Regulatory Policies Act of 1978 (PURPA). Retrieved November 6, 2018, from https://alcse.org/understanding-public-utility-regulatory-policies-act-1978-purpa/

U.S. Endowment. (2019). Wood2energy. Retrieved March 27, 2019, from https://www.wood2energy.org/

U.S. Energy Information Administration. (2018). *Short-term energy outlook*. Retrieved from https://www.eia.gov/outlooks/steo/report/renew_co2.php

U.S. Forest Service. (n.d.). What We Believe - US Forest Service. Retrieved April 3, 2019, from https://www.fs.fed.us/about-agency/what-we-believe

Union of Concerned Scientists. (2017). Public Utility Regulatory Policy Act (PURPA). Retrieved December 18, 2018, from https://www.ucsusa.org/clean_energy/smart-energy-solutions/strengthen-policy/public-utility-regulatory.html#.XBlCnWhKjIU

USDA. (2007). Woody Biomass Use Desk Guide. Retrieved from https://www.forestsandrangelands.gov/documents/woody-biomass/biomass_deskguide.pdf

USDA Forest Service, & UC Berkley. (2017). BioRAM Facility Woodbaskets Suitable National Forest System (NSF) Lands. Retrieved February 25, 2019, from http://www.fire.ca.gov/treetaskforce/downloads/TMTFMaterials/2017-04-27_BioRAM_ContractPlants_WoodBaskets_MWood_ v03.pdf

Westholm, E., Lindahl, K. B., & Kraxner, F. (2015). *The future use of nordic forests : a global perspective*.

Woody Biomass Utilization Group. (n.d.). Overview: Woody Biomass Utilization and the WBUG. Retrieved June 11, 2018, from https://www.forestsandrangelands.gov/Woody_Biomass/overview.shtml

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, *35*(5), 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001

Yin, R. K. (2012). *Case Study Research: design and methods*.

CHAPTER 2: EVALUATING POLICY AND MARKET BARRIERS FOR FOREST BIOMASS ENERGY DEVELOPMENT

Abstract

Reducing the risk of catastrophic wildfires, diversifying domestic energy sources, and improving forest health and resiliency are among the many motives for increasing the utilization of forest biomass for energy purposes. Despite over 220 bioenergy facilities operating across the United States, widespread adoption of forest biomass utilization remains an elusive goal in much of the United States. Where financially viable, utilizing forest biomass for energy can fulfill many of these goals. However, the value proposition that spurred the creation of the nation's bioenergy fleet has been severely undercut by the availability of inexpensive natural gas and low-cost wind and solar energy. Even with public assistance, financial viability has been difficult to sustain without durable policies, community support, and facilitative market structures.

This study investigates the role of policies and social systems in different states and regions with a goal of isolating and describing policy and market barriers conducive to targeted policy reform. We conducted 20 key informant interviews with regional biomass experts to collect in-depth data on regional differences in the operation of biomass power facilities and areas for potential policy intervention. We then developed a comparative case study of four bioenergy facilities from different geographic regions and representing a variety of project configurations and outcomes. Through an additional 20 semi-structured interviews with facility owners, managers, utilities, and other relevant stakeholders representing the four selected facilities, we assessed the factors influencing biomass power facility operation and the policy and market interventions that may serve as either barriers or opportunities to bioenergy in the future. We conclude with a discussion of the similarities and differences documented across the four cases and provide policy recommendations to address identified barriers.

1.0 Introduction

Forest biomass includes limbs, tops, needles, small diameter trees and other residuals of forest management activities (USDA, 2007). Forest biomass can be sourced directly from forests or from urban wood waste. Biomass becomes available through timber harvest operations, pre-commercial thinnings, restoration initiatives, wildfire protection plans, and community development projects (Fleeger, 2008; Neary & Zieroth, 2007; Nielsen-pincus & Moseley, 2009; Woody Biomass Utilization Group). Despite over 220 bioenergy facilities operating across the United States and the variety of ancillary benefits supported by forest bioenergy and a desire to diversify energy sources, the industry has been challenged to adapt to low cost natural gas, solar and wind energy (U.S. Endowment, 2019). Numerous social and economic barriers to utilizing forest biomass have been documented in the literature, such as unfavorable economics (Aguilar & Garrett, 2009; Sundstrom, Nielsen-Pincus, Moseley, & Mccaffery, 2012), supply chain deficiencies (Becker, Moseley, & Lee, 2011) , and lack of social and political acceptability (Stidham & Simon-Brown, 2011; Wüstenhagen, Wolsink, & Bürer, 2007). However, these barriers are rarely understood in the context of necessary policy responses and there is little empirical data on biomass barriers from a facility perspective. Specifically, unanswered questions remain with regard to how the aforementioned barriers affect facility operations and how existing or proposed facility owners respond to changes in state or federal policies. This study seeks to address these questions by interviewing regional biomass experts and bioenergy supply chain actors representing four separate facilities across the U.S.

2.0 Methods

We first categorized the social and economic literature into three broad domains to frame interview questions: social and political acceptability, supply chain logistics, and markets and economic development. Next, we identified and interviewed regional biomass experts who have conducted extensive research in these topic areas, or who are active in shaping regional policy opinion. A series of interview questions were generated for each of the three domains (Appendix A). We conducted 20 key informant semi-structured phone interviews with these biomass experts to identify regional differences in facility operations, market conditions, socio-political conditions, and policy incentives. The experts represented a variety of sectors including academia, public agencies, and non-profit conservation and industry associations to ensure a well-rounded perspective. Each interviewee answered one set of questions based on the domain of their expertise.

We then undertook a comparative case study using four facilities encompassing a range of configurations and outcomes. Using a maximum variation sampling strategy, we selected facilities in four areas of the country currently operating. Facilities were purposively selected to provide insight into a variety of factors that have and may continue to affect the viability of the bioenergy industry. While the findings are not generalizable to all bioenergy facilities, the cases reveal how the present array of social, economic, and supply chain barriers and how existing and potential policies may address, or compound, those barriers.

For each facility, we conducted a series of semi-structured telephone interviews with facility managers, owners, biomass suppliers, and other relevant stakeholders (Appendix B). The interviews were generally similar, but also included facility-specific questions and probes to ensure investigation of the unique attributes of each facility. The open-ended structure of the questions allowed respondents to discuss a range of factors affecting biomass use and facility operations including relevant policy information; supply chain logistics; public perceptions; political support; and key market and economic factors. Interviewees were purposively sampled to ensure a range of knowledge and perspectives to obtain a comprehensive understanding of the issues. In addition, we asked interviewees to identify other federal, state, and local government individuals; loggers; utilities; managers; and other relevant stakeholders who may provide related information regarding each of our cases. Due to time and resource constraints, and the sensitive nature of facility operations in some locations affecting response rates, our sample size included 20 individuals representing four facilities, across four states.

Interviews lasted approximately one hour and were recorded and transcribed for analysis. Our final sample size included 40 interviews; 20 key informants, and 20 representing the four case studies. We employed an iterative, open and descriptive coding technique to identify barriers and opportunities within and across each facility. This approach allowed us to identify themes across cases and explore how barriers influence facility operations and the subsequent policy responses. To ensure consistency across transcripts, a subset of transcripts was distributed to the research team. The transcripts were independently coded and then compared. Discrepancies were discussed and revised. The codebook (Appendix C) was revised to ensure consistency across the cases and coding process.

Notably, we did not attempt to prove or disprove the challenges and opportunities identified by key informants, but rather sought to provide a richer, in-depth understanding of their relevance, prominence, and implications from a facility perspective that may inform future policy recommendations.

3.0 Facility Case Findings

The facility case studies below illustrate how each facility is bounded by its unique characteristics. In each case, we seek to establish an understanding of how social, economic, and pollical context influence bioenergy facility operation decisions. This further contributes to our understanding of the role of policy in these unique situations, establishing the basis for our cross-case findings and recommendations that follow. Expert interviews are where relevant, supplemented by information gathered from the literature, media reports, and project documentation.

3.1 American Renewable Power, Loyalton Cogen

Figure 2.1. ARP Loyalton co-gen, Lovalton. California

American Renewable Power (ARP) Loyalton Cogen is a 20 MW biomass electricity generation facility that shut down in late 2010 and later re-started in 2018 with financial support from a BioRAM 2 power purchase agreement made possible by 2016 legislation passed in California. The state legislature passed SB 859 (BioRAM 2), which added 125 megawatts to the renewable auction mechanism, raising the total to 175 megawatts (California Legislature, 2016). BioRAM2 contracts require at least 80% of the feedstock to be a byproduct of sustainable forest management, of which 60% must originate from Tier 1 or Tier 2 high hazard zones. Two bioenergy facilities completed BioRAM2 power purchase agreements as of this writing: Wheelabrator Shasta and ARP Loyalton. BioRAM2 facilities combined to remove an estimated 363,360 bone dry tons from 80% high hazard zones in 2018, with more than 1.5 million bone dry tons removed on average over the next five years. It is estimated that combined BioRAM activities will result in more than 400,000 acres treated of high hazard zones by 2021 (USDA Forest Service & UC Berkley, 2017).

This case illustrates two key themes. First, it illustrates the recognition of the value of a facility beyond energy generation. The original bioenergy plant at Loyalton was built to provide renewable energy at a competitive price. Changes to fossil fuel and renewable energy pricing meant the plant could no longer operate economically. The new owner of the plant, American Renewable Power, was able to bring it back on line because state policy recognized how bioenergy facilities could be used to help address an urgent public safety challenge by providing a market outlet for hazardous fuels reduction efforts. In other words, the BioRAM policy monetized the environmental value of hazardous fuel removal by using energy markets as a vehicle to accomplish broader environmental goals. Secondly, the case illustrates the challenges of relying on short-term policy incentive to address systemic ecological challenges. The original BioRAM policy was enacted with a five-year window; an expectation reflecting the time required to address significant tree mortality in

California. Unprecedented mortality in 2015 resulted in more than 120 million dead trees across the Sierra Mountains. Plagued by a long-running drought, insects and disease killed vast swaths of forests, creating an immediate public safety and wildfire hazard. On October 30, 2015, Governor Brown issued Emergency Proclamation E-4770 directing the California Public Utility Commission (CPUC) to require the state's largest investor-owned utilities to purchase power from bioenergy facilities using a high percentage of feedstock from high hazard zones as defined by the California Department of Forestry and Fire (Calfire). Tier 1 high hazard zones included areas posing a risk to public safety including roadways, infrastructure, and parks; and Tier 2 included watersheds with significant tree mortality, areas with high risks for wildfire, severe drought, and bark beetle infestation (Keeler & Bertrain, 2015; PG&E, 2019). This program became known as BioRAM. The initial resolution required Pacific Gas and Electric, Southern California Edison and San Diego Gas and Electric to purchase a combined 50 megawatts of biomass power sourced using material from high hazard zones, starting at 40% in 2016 and escalating to 80% in 2019 through 2021 (CPUC, 2016). Bioenergy and sustainable forestry advocates later pressed legislation to extend the policy for an additional five years (BioRAM 2), raising the total to 175 megawatts of bioenergy (California Legislature, 2016).

Overall, the resurrection of the ARP Loyalton facility was seen by interview participants to be socially and politically acceptable. The facility provides benefits to the Loyalton community through job creation and better forest management.

> *If you're near Loyalton, if you're one of those areas where work is going on protecting your roads and your houses and your other infrastructure because trees are coming down, because there's an outlet for all the waste for it.... but those communities need those facilities, they benefit from those facilities in more ways than one. (California 6)*

Further evidence of the community support expressed for the facility is witnessed in the more than 20 letters of support submitted as part of their bid package, many from locals and elected officials. Interview participants also highlighted the role of education as a major determinant, particularly that there are opportunities for education for the community and policy makers alike.

> *When it comes down into policy and you hear about a lot of these bioplants closing, and they don't know if it's state policy or where it comes in to where some people are kinda against puttin' their name on a bill that's gonna cut down trees to produce energy. I think it's more of an education side of it from the public and from the agency and from Cal Fire and all these folks to say, "Hey, here's what we're doin', why we're doin' it, and here's one of the benefits from it." And having more of an education piece on it too to say, "Puttin' these trees into a chipper and makin' energy out of 'em is a good thing." It supports local community, it supports power, it's a renewable, yeah. (California 3)*

This case demonstrates that policy receives traction when there is a pressing need. For example, a participant representing a federal land management agency discussed the uncertain longevity of the ARP Loyalton facility considering the BioRAM policy was set to expire after five years. Considering this uncertainty, advocates worked with the legislature to secure an extension for program.

Also presenting challenges are a lack of coordination between state, federal, and local actors, particularly around contract requirements.

> *Yeah, it's my understanding that it is a challenge for them. Number one, it was getting land owners and fuel providers to kind of understand all the rules around that, first, because everything that shows up at a facility needs paperwork, and needs to be crystal clear where it came from and it needs to be certified as high-hazard zone fuel for the BioRAM 2 plan, that the sustainable forest management rule needed to be understood by people who are delivering the material. I would say that there's still folks out there right now who probably don't want to deliver material because they don't want the liability of whatever the rules are around whatever sustainable forest management means. (California 6)*

Similar concerns about the coordination between state and federal agencies was expressed by a respondent describing the challenges the additional demand for biomass created by the BioRAM policy.

> *So all of a sudden, plunked on our lap, was the equivalent of seventy new sawmills. Just in terms of having to produce that type of volume. Just an enormous amount of carbonate could mean an enormous opportunity, but it would take much more work for us… Just because the state initiatives passed, we're not getting extended extra money from our central office. (California 2).*

According to respondents, opportunities to improve upon the BioRAM policy might include the removal of geographic boundaries, and expansion of acceptable supply to include post-fire material, and forest residual wastes. Policy makers sought to address these issues by passing Senate Bill 90, which included an expansion of the definition of a high hazard zone to include biomass fuels removed from fuel reduction operations, a requirement that contracts be extended an additional five years, and contracts cannot be terminated for failure to meet the fuel requirements (California Legislative Information, 2018).

BioRAM participants and observers relayed that despite supportive policy increasing demand for biomass material, many businesses in the supply chain were vulnerable to regulatory challenges that increased operating costs. In particular, respondents noted that forestry contractors were challenged to meet more stringent air quality regulations on trucks and chipping equipment. The responses highlight the vulnerability of biomass industry to withstand external shocks, despite the presence of supportive policy.

The restart of the ARP facility established a market for low-value biomass where one did not previously exist. However, some respondents mentioned the design of the BioRAM, particularly the unique sliding scale supply requirement, was uneconomical and thus, led to unintended market changes. Additionally, respondents noted the abundance of displaced agricultural residues due to the focus on forest material.t Despite large swaths of dead forests providing abundant biomass supply, the high cost of transportation hinders the ability to use the material. For example, one participant representing a federal land management agency discussed the challenges of transportation biomass, including the lack of revenue for road maintenance or improvements, and the special road requirements to transport biomass.

> *A chip van requires a different road system. With the alignment of a lot of different turns that a standard configuration, you know like a log truck can most definitely make those turns, where a chip vans definitely longer. Native surface roads that are OK for a log truck...and they're probably OK for a chip van that is loaded, but with a chip van comes back to the landing, via that road system, and it's not loaded, it really jars that chip van and has a lot of wear and tear on those chip vans. We kind of modified, really looking at our road systems and making those improvements to the road systems to make it work. (California 4)*

Economic use of biomass has also been inhibited by the significant diminishment of forest product supply chains. BioRAM participants and observers conveyed that despite supportive policy, many businesses in the supply chain are vulnerable to regulatory challenges that may increase their operating costs. One interviewee discussed the challenges resulting from strict regulations placed on trucks and chippers.

> *So, a lot of the smaller loggers, number one, they had to either get out of the business or purchase new trucks. And that was a financial burden. As well as chippers, they had to be in compliance with California Resources Board and they had to purchase new chippers and a new chipper is about $750,000, so a lot of the smaller folks went out of the system and went on to bigger and better things. They sold your equipment to Oregon, to Washington and other states. They got out of the business. At the same time, they also sold their chip vans. So, bottom line in results, it's been a lot smaller level of infrastructure for both removal of saw logs as well as biomass. (California 4)*

In California, the Renewable Portfolio Standard (RPS) mandates utilities procure 50% of their energy from renewable sources. However, the construction of the RPS stated that utilities just need to procure energy under a least-cost, best-fit scenario. Utilizing forest bioenergy may be best-fit throughout many regions in California, however, it is not meet the least-cost criteria.

> *The way that our RPS is written is that utilities just need to procure under a least-cost, best-fit scenario. And while bioenergy may be best-fit in many regions of this state, it's never going to be least-cost…the wind blows for free, and the sun shines for free, and of course all the cheap Chinese solar panels that are entering the solar market is creating this huge cost differential between wind, and solar, and biomass. That when a bioenergy facility bids into a utility RFO at… eight to ten cents, it's competing against three to five and a half cent wind and solar. (California 6)*

3.2 Deerhaven Renewable Energy

The Gainesville Renewable Energy Center (GREC), also known as Deerhaven Renewable (DHR), is a 102.5MW capacity biomass power facility. The DHR facility was originally developed as a standalone facility and is now operated by the city of Gainesville's municipal utility, Gainesville Regional Utilities (GRU). Since its inception, the facility has generated a great deal of controversy, stemming in part from increased electricity prices

Figure 2.2. Deerhaven Renewable Energy; Gainesville, Florida

and what was perceived to be a series of missteps in project design and implementation. This case represents the operation of a facility in the face of significant policy and market challenges. It also captures the role of municipal entities in biomass power implementation and operation decision-making. It provides a sense of the challenges facing biomass power facilities in the face of state and federal policy uncertainty, as well as the ways in which stakeholders perceive and address such challenges.

In 2003, the Integrated Resource Plan for the Gainesville Regional Utility identified a need for additional capacity to be brought online between 2008 and 2012 (Lester et al., 2015). Subsequent analyses evaluated a variety of conventional fossil and renewable generation options for the city (e.g., Black & Veatch, 2004; ICF, 2006). Plans to build a larger (220MW) coal facility were abandoned owing to local opposition (Power Technology). In April 2006, the City Commission began a process to evaluate pricing and design of only small (<100MW) biomass and ~260MW or greater IGCC, with an emphasis on carbon neutrality. As reported by Lester et al. (2015), the mayor of Gainesville's climate commitment in 2005 was a driving force in generation technology selection.

The decision to seek proposals for a 100MW facility was made in October 2007, and a winning bid was selected by the City Commission in May 2008 (Lester et al., 2015). A 30-year PPA was executed by GRU and GREC in April 2009 and approved by city commission in May 2009. Construction of the facility began in 2011, and the facility went into operation in 2013. Though the facility was larger than GRU required for its specific needs, it was believed that a buyer could be found for the excess power.

In hindsight, interview participants noted both positive and negative aspects of the characteristics of the chosen plant. The decision to increase the size of the unit triggered additional regulatory review under the state's Public Service Commission. Potentially more significant challenges were presented by declining population growth in the utility's service area, declining per-capita energy consumption, significant outlays for capital improvements and DSM deployment, increasing fuel costs, and increasing debt obligations (Lester et al., 2015). These problems were exacerbated by the difficulty GRU had in reselling excess power, largely due to the availability of cheaper natural gas-fired electricity (e.g., Lynn, 2013).

The decision to adopt a larger biomass facility itself stemmed from both political priorities and assumptions about future market and policy conditions. Specifically, the analyses justifying the choice of generation technology were conducted using incorrect assumptions about state renewable energy policy to support biomass power, the likelihood of future federal carbon regulation, and the declining price of natural gas (Caplan, 2017a). These miscalculations resulted in increased biopower rates and loss of political support (Lester et al., 2015). As stated by one interview participant,

> *[T]he period leading up to the biomass contract, there was a lot of pressure to be renewable and green. So it was green green green green green. And then the rate impact of all these measures kind of came into play, and the rates when up and the economy went down, and it was bad timing kind of coming together. And then there was a swing in the city commission, where you had all new city commissioners, and then it was all rates rates rates. (Florida 7)*

In recent years, price differentials widened between the costs of operating the GREC facility and the availability of cheaper power elsewhere on the grid, forcing the facility to be idled at times (Caplan, 2017b). While the focus on biomass and the contractual arrangement between the developer and the utility was viewed favorably by credit raters at the time the arrangement was being pursued (Lynn 2013), GRU eventually experienced a credit rating downgrade due to the high-costs of biomass generation relative to declining natural gas prices (Holt, 2016). This resulted in additional finance fees, further contributing to the high prices paid by consumers and the political blowback on the project (Holt, 2016). As a result, the project became a public point of contention.

To reduce costs, the city of Gainesville moved to purchase the facility and PPA in a series of votes in August and September 2017 (Caplan, 2017a; Caplan, 2017b). Interview participants generally reported that opposition has somewhat subsided since the purchase was finalized. But the facility remains politically contentious leading to a referendum being placed on the ballot in November of 2018 to install an independent authority to run GRU instead of the City Commission. Though the referendum was defeated at the polls, the outcome of that decision had the potential to dramatically influence the operation of the DHR facility.

Somewhat fortuitously, lower fuel costs have driven down the dispatchable cost of the unit over the last year. Participants also noted that the original management agreement and PPA, through which a third-party would construct and operate the facility, resulted in a particularly well-constructed unit. Since the purchase of the PPA by the city, GRU has been able to adjust operation of the unit to suit their needs, allowing operation between 30 MW and 100MW depending on load. This has allowed for better integration into the utility's generation fleet, while allowing the utility to take advantage of low-price feedstock when available.

Regarding feedstock availability, analyses conducted prior to construction suggested that a moderately sized facility (e.g., 40 MW) could be supplied predominantly with logging residues and urban wood waste, with the balance of feedstock coming from longleaf pine restoration, the thinning of overstocked forests, and excess pulpwood (Carter et al., 2007). At its present size, the facility requires approximately one million tons of feedstock annually. To ensure sustainable use of forest resources, in 2014, the facility received chain-of-custody certification from the Forest Stewardship Council, the first bio-power facility in the U.S. to do so (GRU). Even so, some aspects of fuel sourcing were subject to controversy, and litigation eventually ensued over the ability of certain types of wood waste to be utilized as feedstock (Swirko, 2016).

Cited as important in feedstock acquisition were both a consistency of demand and the availability of supply from both hurricane storm clean-up and landscape restoration operations. Specifically cited by one participant was the critical role that DHR played in longleaf restoration efforts by providing an outlet for non-merchantable wood. The same participant also noted the importance of a traditional forest products industry in supporting the infrastructure that allowed for efficient feedstock acquisition, stating that:

> *If there wasn't so much demand for your traditional round wood products around here we wouldn't have the infrastructure to, you know, the infrastructure just wouldn't be here to catch all the stuff out of the woods that we get. (Florida 8)*

In that respect, consolidations and transitions in the forest products industry, as well as the challenges associated with feedstock transportation, particularly a shortage in truck drivers, remain as potential challenges to securing a stable supply of feedstock. Interview participants also noted some measure of controversy surrounding individual harvest activities but noted that this largely stemmed from misconceptions about feedstock acquisition. Other respondents linked localized concern with harvest practices back to the larger controversies surrounding the facility.

Despite these challenges, interview participants were generally optimistic about the role that DHR would continue to have in the region. Part of this is attributable to the older, less efficient units that the utility has in its fleet, units that DHR inherently must compete against in the dispatch of electricity. One participant also mentioned a recent push towards the electrification of vehicles, and the advantages that could have for a large biomass facility.

> *You know, especially for a utility like GRU that doesn't, that has more electricity than it knows what to do with, electricity vehicles are the most fantastic thing they could hope for. I mean, it's a new customer and a customer that can control when they charge. (Florida 9)*

At the same time, however, the changing nature of the grid and the technologies being deployed could create very real and existential issues for large solid-fuel based facilities, biomass included.

> *[I]f solar and batteries, or whatever and batteries, becomes cost effective, they [the utilities] would just love that, all day long…You know, it's so much easier. I mean, a biomass plant is like a coal plant, you have a lot of moving parts, and conveyor belts, and all that stuff. So, yeah, they could disappear. They could go the way of the coal plant. (Florida 9)*

Interview participants were unanimous in their perspective that another large, utility-scale biomass facility was not likely to materialize in the region. Part of this was related to the energy needs of the utility and the city it served. Others cited financial challenges with the citing of a new facility, particularly given the low price of natural gas and a continuing emphasis on deployment of other renewable energy sources. As one participant succinctly stated,

> *Is there an opportunity for another hundred megawatt, you know, bioenergy facility like this? Not in a million, well I wouldn't say not in a million years, but not until natural gas stops being free. (Florida 8)*

3.3 Xcel Energy and Laurentian Energy Authority

Laurentian Energy Authority (LEA) manages the 20 MW repowered coal plant in Hibbing, MN and the 15MW repowered coal plant in neighboring Virginia, MN. The two municipal facilities utilize 250,000 green tons per year to provide power to 3,600 customers (Clean Energy Resource Teams, nd). This case represents a situation in which facilities ceased using wood for energy in the face of significant policy and market challenges. It also captures the effect that a lack of policy durability and the incentives facing a large utility have on biomass power implementation and operation decision-making. It provides a sense of the challenges facing biomass power facilities in the face of changing state and federal policy, and the challenges that biomass power advocates have in both securing opportunities for new facilities as well as maintaining existing operations. Finally, it speaks to some of the implications of biomass power facility closure on affected markets and stakeholders.

Figure 2.3. Laurentian Energy Authority; Hibbing and Virginia,

LEA secured a PPA to sell 35 MW of biomass power to Xcel Energy. This PPA extended from a 1994 state mandate requiring Xcel Energy to purchase 110 MW of biomass-based energy to offset their nuclear cask storage at their Prairie Island facility (Jossi, 2017). Xcel Energy also has a separate requirement of 31.5% renewable by 2020; 25% of which must come from wind or solar based on the 2007 Minnesota Renewable Energy Standard (RES) requiring 25% of utility energy utilization to be renewable by 2025.

In 2017, a provision under the omnibus jobs and energy bill allowed Xcel Energy to purchase and decommission the Benson energy plant and withdraw from the PPA with LEA, if agreed upon by the plant owners and Public Utilities Commission (Meersman, 2017b).

Xcel stated that the cost of electricity produced through biomass was the most expensive energy in their portfolio and argued that ratepayers should not be forced to bear that cost when there are cheaper alternatives (Meersman, 2017a, b). On November 30, 2017, the Minnesota Public Utility Commission authorized termination of the PPA, and a reconsideration of that termination was denied on March 22, 2018 (MN PUC 2018). While Xcel must provide compensation for the cities affected by the transition away from biomass, there are remaining concerns about job losses, particularly in the timber industry (Meersman, 2017a, b).

The conversation with interview participants generally took a broader view of bioenergy. Particularly salient were aspects of competition between bioenergy and other renewable energy sources and the role of bioenergy in a larger forest management context, with the former dominating the conversation among most participants. For example, they often spoke to the cost differential between biomass and other renewable and non-renewable energy sources. The availability of cheaper energy sources was seen to present both a current and potential future challenge to bioenergy in the state.

> *The cost to the utility purchasing the energy is the, the largest challenge. There's other "green energy" sources that are more readily available, a lot more established, have received a lot more state incentives over the last decade, and thus have developed a lot further than wood energy... And then of course the, the low price of fossil fuels has been working against us for the last few years as well. (Minnesota 11)*

An element of this response was the role of state and federal policy support in encouraging the decline of other energy sources, a sentiment expressed by other participants.

> *[B]ioenergy doesn't have near the subsidy structure that, that wind...Solar is growing pretty dramatically in the state of Minnesota right now. I think there was a mandate of about a percent and a half or something like that dropped in by the state legislature 4 years ago approximately and that has, you know, really created a solar demand, you know, in the in the state. But that low cost, you know, fossil fuels has, has been a big deal…[P]robably about 70% of my heat comes from wood off my own property, but I can tell you that propane prices for the last three years have been cheaper than if I had to buy wood or pellets on the market. (Minnesota 10)*

Interview participants generally cited both a lack of a natural advocate for bioenergy and a related wariness of bioenergy by the forest products industry as contributing factors to the uneven policy support. Though specific concerns over the potential increase in stumpage pricing related to new bioenergy capacity were cited by a few respondents, also mentioned was a lack of active support by the forest products industry.

> *I think the forest products industry and the energy sector have done themselves a disservice because wind and solar were, were kind of new technologies, RC&D, up and coming, lobbyists, ready to move forward, whereas wood energy, the, the forest products sector, you know, said we're already using it, it's already benefiting us, we don't really want these large wood energy consumers coming in and, and utilizing more of our resource, so were not going to push for it. And, on that same token, the energy facilities said, well, if, you know, wind and solar is working that hard and that technology's coming along so quick, and, you know, there's all these incentives and pushes for it and the public wants it, why would we go after wood and try promote that? They had, they had no incentive to do it. And the industry didn't have an incentive to do it. So it never had a real strong lobby or support group or anyone really looking to lead it in the state, is, is, is my perspective on it. (Minnesota 11)*

Interview participants expanded upon this perspective, noting that there was not so much an opposition to bioenergy, but rather uneven and wavering support for the technology.

> *There hasn't been a lot of strict opposition, except for maybe solar and wind lobbies. But I mean, people are just, they're just kind of very neutral about it. They don't really, they're not excited about it. I wouldn't say, they're, they're not going to be out there picketing, there's just not a lot of interest in general around it. There's not much media around it, there's not, there's not much anything around it. (Minnesota 11)*

Participants connected this lack of strong support to a lack of education on the potential benefits of the technology. Specifically mentioned were synergies between bioenergy operations and the overall health of the forest product supply chain, forest resource management benefits that stem from forest markets, and the increased number of continuous jobs associated with bioenergy relative to other green energy technologies.

Though one participant did note that the recent cancellation of the PPAs resulted in an uptick in support for bioenergy, the support was said to be, “in my mind, a little too late”.

The recent decision to cease using wood for energy in multiple facilities in Minnesota comes against the backdrop of multiple forest management obligations and feedstock supply opportunities. For example, one participant noted the ongoing fight against the emerald ash borer, and the volume of material that is expected to be generated from the removal of infected trees, describing the fortuitous availability of bioenergy capacity in the Twin Cities region.

> *[T]hey have you know north of a million ash trees, urban ash trees that are, that are, that are being killed by emerald ash borer and without that kind of access to market, you know, you've got, you know, a million plus trees that are going to be piled burned that are going to be, you know, just, just under, non-utilized underutilized, left to die, you know, these are urban trees, these are city streets, these are boulevards, these are city parks … the amount of ash that's coming their way in the next 10 years is probably 2 to 3 times more than they can actually burn in that time period. (Minnesota 10)*

The same participant noted the opposite situation in other regions of the state, where bioenergy capacity did not exist to make use of excess forest material.

Alternatively, interview participants noted the existence of potential chicken-and-egg type situations, particularly involving a lack of demand to encourage the development of pellet production infrastructure. Others noted the persistent high costs of transporting feedstock, the specialized equipment needed to supply feedstock to bioenergy facilities, and the strong role of personal relationships in encouraging or discouraging feedstock acquisition contracts.

The loss of bioenergy capacity is nonetheless expected to have wider market implications. The extent and duration of those impacts varied by interview participant. Without passing judgment on the validity of its conclusions, one participant recalled an analysis undertaken by the Minnesota Department of Employment and Economic Development, finding that there may be near-term impacts of the closures but perhaps lesser long-term effects (CG2-5). Other participants discussed more localized impacts. One participant noted the difficulty for sawmill residue suppliers to transition back to markets they had participated in prior to the bioenergy facilities coming online, saying,

> *It's going to be pretty tough to get back into even those lower end markets unless they ship farther or I mean really it'll be either giving them away for free or paying them to be landfilled most likely. (Minnesota 11)*

Turning to the subject of future challenges or opportunities, interview participants expressed both pessimism and guarded optimism, specifically with respect to niche or targeted applications for bioenergy. Participants were generally in agreement in their view that district heat and energy applications could make sense in some instances, with the district heating facility in the Twin Cities being cited as a success story, as an example of a project that had managed to be cost-competitive. In describing the opportunities for district heat and energy systems, interview participants discussed several factors that could influence the viability of future applications. Careful consideration of project attributes, including design and location, constituted one set of factors, as succinctly summarized by one participant:

> *I think it needs to be the right fit, the right sized facilities in the right place that use the correct material…I think it really needs to be more carefully thought out and planned and sized correctly than it has been in the past (Minnesota 11).*

Another participant discussed the importance of securing a sufficient customer base for district heat offtake, a process that itself takes time and energy. This participant further reflected on the political capital required to successfully implement such a project, and the risks that come with changes in leadership over time.

> *And there's always ongoing uncertainties with leadership within some of those communities, whereby a lot of work goes into it and you get decision-makers familiar with a lot of the different factors that need to be considered in these types of developments and then election cycles happen and you get new people in and then you start from, you know, kind of, you know step one again. (Minnesota 12)*

Participants also reflected on longer-term and more general opportunities for bioenergy in Minnesota. One prominent theme was the electrification of the economy, specifically vehicles, and the opportunities that bioenergy could play in such efforts, particularly in municipal and cooperative utilities. Other participants took a broader view of bioenergy, specifically biofuels and anaerobic digestion, as well as the expansion of bio-based chemicals, and spoke to the opportunities for further expansion of those applications in the state.

The same was not said of large, utility-scale electricity-only facilities. One participant noted,

> *I don't see it growing, I see it shrinking, even more than the, the two facilities that were lost here in, in 2018, or actually three facilities. (Minnesota 11)*

This was echoed closely by another participant, who reflected that,

> *I don't see new biomass power plants being constructed right now. I, I just don't see the economics. I mean, they're closing them, not, not opening them, so I don't, I don't see, think that that's going to change in the next 5 years. (Minnesota 10)*

A third participant noted bluntly, "*I think that right now, biomass is just out of the money*" (Minnesota 12).

3.4 Bridgewater Power Company

Bridgewater Power Company is a 15 MW biomass electricity generation facility located in Bridgewater, New Hampshire that began operations in 1987. The facility uses approximately 235,000 green tons of wood chips annually. This case represents a situation in which policy was specifically targeted to preserve the operation of a specific bioenergy facilities. It also provides insight into the social, political, and financial context into which such policy decisions can be made.

Figure 2.4. Bridgewater Power Company; Bridgewater, New Hampshire

The bioenergy fleet operating in New Hampshire originated with federal Public Utility Regulatory Policies Act (PURPA) contracts in the 1980s. In the midst of an oil crisis, PURPA sought to reduce dependence on foreign oil, promote alternative energy sources, and diversify the electric power industry (Tait, 2017; Union of Concerned Scientists, 2017). The law created a market for non-utility power producers by requiring utilities to purchase power from independent companies that could produce power costing less than the utilities could produce it themselves (Union of Concerned Scientists, 2017). The combination of guaranteed rate orders, capacity payments and, eventually, Renewable Energy Credit (REC) payments provided a predictable revenue stream for early bioenergy facilities.

The economic landscape for bioenergy has changed dramatically since the 1980s. When the first PPAs expired in the early 2000s, plant owners faced dramatically lower energy prices and competition from other renewable energy sources. After several years of subsequent operating losses due to lower energy prices of alternative sources, many bioenergy facility owners considered shutting down.

As one interviewee states, *“back in 2014, this whole biomass heating was poised to take off, and then we just got the wind taken out of our sails when the oil price crashed”* (New Hampshire 14). That said, interviewees felt that the Bridgewater Power facility could compete with natural gas during the winter months when there is a large demand for heat.

> *Natural gas, their obligation is for heat first, not for power production, so there a lot of people in the Northeast rely on natural gas and there's not enough of it. During the months of December, January and February, wood becomes very competitive with natural gas, but only for three months a year. (New Hampshire 15)*

In response to the looming plant closures a broad coalition of the forest products and renewable energy industry campaigned for a solution, out of which Senate Bill 365 was created requiring utilities to buy more electricity from wood power plants at a discounted rate for three years. Senate Bill 365 passed both houses of the New Hampshire state legislature with broad majorities but faced opposition from New Hampshire Governor Chris Sununu who vetoed the bill on the grounds it would raise energy prices for consumers (Ropeik, 2018). On September 18, 2018, the New Hampshire House of Representatives voted 226-113—the minimum needed to overturn Governor Sununu’s veto (Ropeik, 2018).

Interviews suggest Bridgewater Power is generally seen as socially acceptable in New Hampshire. Several respondents noted that local residents and businesses have a strong appreciation for the forest economy.

> *Well I think what it says is that the considerable effort over the years to educate people of the state of New Hampshire and their elected officials about the value and*

importance of a healthy forest products industry and strong markets has been successful. (New Hampshire 14)

However, the Bridgewater facility faced opposition from community residents during the initial siting process. Residents feared that once the plant was built, all the wood around Squam Lake and Newfound Lake would be used to operate the facility.

And I remember going into this group of meetings and explaining to people that's not the way this was gonna unfold. Nobody believed that, but there was this fear back then that this was gonna have a terrible effect. And I think today it's just the opposite, I think the plants have operated successfully. A lot of landowners sell wood to the plants, and they're kind of part of the community now. (New Hampshire 17)

The political acceptability of bioenergy also suffers from “subsidy stigma”. Several respondents in New Hampshire noted that legislators were weary of providing public policy support for bioenergy after more than twenty years of price supports. Those in favor of finding a solution to keep Bridgewater Power and five other facilities solvent addressed these concerns by framing their approach in terms of overall economic benefit to the state. Their arguments emphasized that SB 365 would cost the state $18 million a year for three years but would create an economic return of $250 million in direct, indirect and induced economic impacts. The campaign also highlighted that the loss of six operating bioenergy facilities would cost the state $17 million. In addition to framing SB 365 as a benefit to the broader forest products industry, advocates for the measure also aligned themselves with wind and solar industry representatives seeking to address net metering requirements. As one respondent said,

The biomass people really needed the legitimacy of the broader renewable energy community so that their efforts were not seen as too self-serving, and the renewable energy community that was primarily advocating for the net metering bill needed the political cover that an engaged forest industry to the campaign, because they're such a Republican constituency. (New Hampshire 14)

The experts interviewed for this case study agreed that bioenergy provides an important market for low-grade wood resulting from forest management. They noted that low-grade wood accounts for 40 percent of all wood sold in the state suggesting the market impacts were pervasive. Interviewees noted that when markets for low-grade wood are strong and stable they engender a variety of benefits to forest landowners. Robust markets for low-grade wood help make sustainable forestry profitable by providing an outlet to remove diseased, infested and low-quality wood to improve forests.

One forest landowner noted that low-grade wood accounts for 60 to 70 percent of the material resulting from forest management treatments on their land. They noted that with accessible low-grade markets they can afford treatments that improve habitat and cultural resources. A forest manager succinctly summarized the environmental benefits of bioenergy markets,

> *Strong markets are the most effective hedge against loss of forestlands and non-forest uses. Because land owners who are inclined to keep their woodlands have the economic justification for doing so. Similarly, public land owners who practice forestry on public lands also have an economic justification for doing so. (New Hampshire 14)*

Conversely, without the markets for low-grade wood provided by bioenergy facilities the economic justification for sustainable forestry weakens. Respondents noted that without this demand, forested land loses value creating both short and long-term impacts. In the short term, the supply of saw logs decreases as sales of more marginal timber sales are no longer viable. In the long-term, the lack of markets amplifies uncertainty and volatility, which negatively affects landowner attitudes toward maintaining forests as forests. Respondents noted that lack of markets for low-grade wood made forestlands more vulnerable to fragmentation.

Biomass energy costs more than other sources of energy but it is important tool for maintaining forest health and a viable forest products supply chain. With the passage of SB 365, advocates of biomass energy were granted a three-year reprieve but larger questions remain regarding the long-term fate of the industry. The effort to pass Senate Bill 365, despite the veto of Governor Sununu, suggests that the operating space for bioenergy can be widened when the benefits are demonstrated to outweigh the costs. Advocates for SB 365 made the case that strong markets provide a robust justification for keeping working forest working. However, the bill is for only three years, and when asked about next steps respondents observed that efforts to craft a new bill had not garner much stakeholder support.

4.0 Cross-Case Findings and Policy Recommendations

The four case studies originate from four regions of the country representing different resource conditions and motivations, and differences in facility size and level of social and economic support. Taken together with our expert interviews, the case findings illustrate that the influence of changing policy and market conditions on facility viability, or lack thereof, of bioenergy enterprises in the respective states. On a general level, findings from the expert interviews and individual case studies reinforce findings from the literature, namely that the challenging nature of bioenergy feedstock supply chains (Becker et al., 2011), challenges to the cost competitiveness of facility operation (Aguilar & Garrett, 2009; Sundstrom, Nielsen-Pincus, Moseley, & Mccaffery, 2012), and challenges to political and social acceptability (Stidham & Simon-Brown, 2011; Wüstenhagen et al., 2007).

Findings from the expert interviews and individual case studies are also suggestive of more nuanced trends and commonalities that are important to consider for the development of national bioenergy policy. These findings are distilled into common themes that emerge from or have salience to the individual case studies (Table 1). Below, these common themes are developed further and accompanied by targeted policy recommendations that emerge from both the interviews themselves as well as from the extant literature.

Table 2.1. Summary of key cross-case themes derived from the individual case studies and relevant supporting evidence.

Theme	California ARP Loyalton	Minnesota Laurentian Energy Authority	New Hampshire Bridgewater	Florida Deerhaven Renewable
Bioenergy is in flux	- Recent (<5 years) change in policy that dramatically affected facility viability [BioRAM 1 & 2]	- Recent (<5 years) change in policy that dramatically affected facility viability [withdrawal of PPA]	- Recent (<5 years) change in policy that dramatically affected facility operation or viability [SB 365]	- Recent (<5 years) change in policy that dramatically affected facility operation [city purchase of facility; failure of RPS to materialize]
Bioenergy remains vulnerable to policy change	- Despite supportive policy to increase demand for biomass, many businesses in the supply chain were vulnerable to regulatory challenges that increased operating costs	- 2017 legislation allowed for utility to withdraw from an existing PPA. - Withdrawal of the Clean Power Plan reduced opportunities for additional coal plant repowering.	- Legislation was passed, and a gubernatorial veto overridden to require utilities to buy electricity from biomass power plants at a discounted rate.	- Built in anticipation of an RPS that did not materialize. Subsequent drop in natural gas price has created pressure to reduce rates for consumers.
There are limited opportunities for utility-scale stand-alone electricity facilities.		- Challenges specifically referenced with respect to economics of bioenergy relative to other energy sources.		- Challenges specifically referenced with respect to economics of bioenergy relative to other energy sources
Bioenergy remains vulnerable to energy and forest market changes	- Facility initially shut down because it was no longer cost-competitive with alternative energies - Vulnerable to changes in natural gas prices and advancements in renewable energy technology	- Vulnerable to changes in natural gas prices and advancements in renewable energy technology	- Vulnerable to changes in natural gas prices and advancements in renewable energy technology	- Vulnerable to changes in natural gas prices and advancements in renewable energy technology

Theme	California ARP Loyalton	Minnesota Laurentian Energy Authority	New Hampshire Bridgewater	Florida Deerhaven Renewable
Bioenergy faces challenges due to a lack of a natural advocate	- Offers conflicting evidence. Communities supported facilities in the BioRAM program; ARP Loyalton facility received more than 20 letters of support from local entities and elected officials.	- Presence of lower-cost renewables provided opportunity for state to allow utility withdrawal of PPA.	- Noted presence of "subsidy stigma", of reluctance to continued price supports. Bioenergy advocates aligned with wind and solar industry seeking to address net-metering.	- Localized opposition to specific harvest activity (even if not associated with the facility), but most opposition stems from high electricity rates.
Ancillary benefits are not translated to the market	- Conflicting evidence. The state legislature recognizes public safety, ecological and economic benefits of bioenergy facilities, those benefits have yet to be recognized in bioenergy cost.	- Lack of public awareness on the benefits of biomass over alternatives (i.e., emerald ash borer creating a surplus of supply that could not be used in traditional forest products markets).	- Conflicting evidence. Markets for low-grade wood help make sustainable forestry profitable by providing an outlet to remove diseased, infested and low-quality wood to improve forests.	- Demand from facility facilitates hazardous fuels reduction and longleaf restoration efforts by providing an outlet for non-merchantable wood.
The industry depends on more than just an operational facility, but also the presence of a working supply chain.	- BioRAM policy supported the re-start of ARP Loyalton but did not provide support along the supply chain thus creating challenges	- Bioenergy industry plays a role in supporting the supply chain and providing markets for low-value biomass material that provide an overall healthier forest products industry	- Supply is available but there is a lack of logging capacity	- Supply is available but there is a lack of logging capacity

Bioenergy is in flux. The cases reveal an industry grappling, with some success, with broad-scale forces mostly beyond its control. These forces include low fossil fuel energy prices, competition from other renewable technologies, rate payer fatigue and a fractured policy environment. In general terms, the California and New Hampshire cases illustrate how forest bioenergy gained policy support by monetizing value to external stakeholders. For instance, in California proponents used bioenergy to address the state's tree mortality crisis enabling it to secure a short-term financial lifeline. Similarly, the bioenergy businesses in New Hampshire obtained three years of financial support by demonstrating its economic value to the broader forest products sector. Though each of the policy recommendations offered here could in some way address an industry in flux, a primary mechanism to provide stability and predictability is to appropriately value the contributions of the technology.

- ***Seek opportunities to monetize values beyond renewable energy generation.*** Across these cases and more generally across the US, market forces have severely undercut the viability of renewable energy generation from forest biomass. However, the experience of California and New Hampshire show how policy changes can monetize the value of bioenergy to address environmental objectives and support its role in state energy policy.

Bioenergy remains vulnerable to policy change. Each of the cases revealed the impact of policy change by either encouraging or discouraging bioenergy. In California and New Hampshire, and initially in Minnesota, policy change was instrumental in the creation of opportunities for bioenergy use or deployment. But it was also instrumental in subsequent closure of facilities in Minnesota. In Florida, the facility has endured despite anticipated policies not materializing and significant ensuing controversy.

An important conclusion from these cases is that the forest bioenergy industry remains vulnerable to policy change. Interviewees mentioned that supportive bioenergy policies, specifically regulatory agreements, fluctuate with election cycles. The presence of a natural hazard or disaster event also impacts the presence of supportive policy. As one regional expert noted,

> *We don't really have a long-term policy about forest biomass. It's just been reactive for the last 10 years. You know, when there's a drought and a tree mortality event and we get some traction and some investments. But there's no long-term strategy or policy. (Regional expert 8)*.

Policy recommendations to address instability include efforts to better document past incremental gains, the implementation of policies with longer time horizons, and a better recognition of the uncertainty that will always be present in the policy process.

- ***Show demonstrable results to seek broader policy change.*** Due to the contentious policy environment around forest bioenergy it can be difficult to develop comprehensive solutions. Participants in both California and New Hampshire used incremental successes to obtain more favorable policy outcomes.
- ***Reduce uncertainty by implementing long-term policies.*** Implementing long term, durable policies would not only help sustain but open new market opportunities and avenues for biomass. A participant representing a federal land management agency discussed the uncertain longevity of the ARP Loyalton facility considering the BioRAM policy was set to expire after five years. Considering this uncertainty, advocates worked with the legislature to secure an extension for program.
- ***Recognize and manage for the nature of the policy process.*** The contentious and uncertain nature of current policy debates around renewable energy, generally, and bioenergy specifically, suggest that actors wait until some degree of resolution has occurred rather than trying to anticipate outcomes. The DHR facility was initially built on the anticipation of an RPS that did not materialize.

There are limited opportunities for utility-scale electricity-only bioenergy facilities. Despite some optimism about the opportunities for existing facilities to continue operation and opportunities for new district or municipal applications, participants were generally pessimistic about the opportunities for new, large-scale bio-power facilities. Part of this stems from the economic challenges presented by changing forest and energy markets, described further below. In light of these conclusions, policy recommendations are centered on both the maintenance or better targeting of existing incentives, and the exploration of new markets or non-traditional opportunities for bioenergy generation.

- ***Maintain, develop new, or better target existing production incentives.*** Several participants discussed the role of incentives in helping to encourage bioenergy deployment and operation. Potential solutions included the creation or reinstatement of state incentives where previous tools had lapsed or better targeting or marketing of existing tools. Others cautioned that there was decreasing appetite for such incentives, particularly in areas where funding has been available for a long period of time. Several respondents in New Hampshire noted that legislators were weary of providing continued policy support after more than twenty years of bioenergy price supports. However, the legislation only supported bio-power markets for three additional years, after which the same questions will come up again.
- ***Develop new or better target existing transportation incentives.*** Despite the high cost of transporting biomass, there are presently few haul subsidies available to biomass facilities in most states (Becker et al., 2011). As noted by a regional expert, specifically targeting transportation costs, for example in the form of a sliding or tiered incentive per mile driven, could help reduce the cost of the forest bioenergy supply chain, particularly where federal land dominates leading to longer haul distances (Regional expert 18).
- ***Explicitly consider the role of bioenergy in policies to either encourage greenhouse gas reduction or renewable energy generation.*** Multiple participants reflected on the potential role of bioenergy to contribute to greenhouse gas reduction or renewable energy goals. Other participants emphasized that the debate around the carbon-neutrality of biomass energy was important to address. Explicit consideration of both the costs and benefits of bioenergy relative to other generation technologies could provide opportunities for bioenergy to make expanded contributions, particularly at the local and municipal levels.
- ***Consider new markets for bioenergy.*** Several participants mentioned the continued electrification of the economy, particularly vehicles, as one opportunity for bioenergy. Bioenergy has an advantage over other forms of renewable energy in

> that it provides stable, dispatchable power, creating opportunities for both baseload as a supplement to intermittent renewables and overnight charging capacity for an increasing electric vehicle fleet.

Bioenergy remains vulnerable to energy and forest market changes. The complex nature of the bioenergy industry exposes it to risks from both energy and forest markets. Bioenergy faces direct competition with other forms of energy, be it fossil or renewable. Participants reflected that other energy sources are increasingly cheaper than bioenergy, putting pressure on municipal and larger, investor-owned utilities to justify the choice of biomass over some other form of energy production. And because the forest products industry provides much of the infrastructure on which bioenergy feedstock production depends, changes in that industry also threaten to further complicate the economics of standalone bioenergy production.

In both expert and case study interviews, participants noted that without markets for low grade biomass removed in conjunction with wildfire fuels reduction projects or pre-commercial thinnings, the number of contractors and the ability to purchase and maintain equipment would steadily decline. For example, over the last decade California experienced a significant loss of infrastructure and a subsequently diminished forest energy supply chain. The reduced labor force was signaled out as a long-term and pervasive challenge to raw material acquisition even in the presence of adequate feedstock supply.

> *That's driving the cost of those treatments up, because labor is so scarce. It's definitely a challenge. It's not quite clear to me how you build that workforce. It's definitely a need. You know, having vocational schools that promote that type of work, but also obviously being able to make money at it. Right? (Regional expert 18)*

Elsewhere, interviews in Florida suggested the challenge is finding the right people to process and haul the material. In Minnesota, the contracts between LEA and Xcel Energy gave suppliers the confidence to make investments in equipment. In the face of LEA closures, however, there are concerns over whether suppliers can remain in business (Jossi, 2017).

High procurement costs, high transportation costs, and the specialized equipment add to the cost of forest bioenergy. As a result, several interviewees reinforced the importance of developing synergistic relationships with other producers and users of potential feedstock. For example, an interviewee mentioned that one strategy is to partner with the agriculture industry whose needs compliment those of the forest bioenergy industry. Several individuals representing both ARP Loyalton and DHR, mentioned the opportunity for synergistic relationships to form with sawmills. Participants from California, however, highlighted challenges to forming synergistic partnerships under the BioRAM policy, specifically a lack of coordination between state, federal, and local actors, particularly around contract requirements.

From an energy market perspective, the value proposition for biomass energy centered on the development of sustainable energy sources to increase energy independence and decrease reliance on imported fossil fuels. But the availability of cheaper, domestically-produced natural gas, as well as declining prices for wind and solar, have undercut this value proposition. Facility interviews highlighted that all four facilities faced significant obstacles to be competitive in the renewable marketplace. Multiple participants also reflected on the role of subsidies supporting the availability of cheaper alternative forms energy.

The relationships between forest and energy market are complex, complicating simple and direct policy recommendations to address the challenges currently faced by bioenergy. In that sense, the following recommendations speak to a more holistic assessment of the role of the technology. Part of that is better analysis to better assess risks and opportunities of single site investments. Alternatively, thinking about bioenergy as but a single component in larger forest and energy market systems can help to integrate the technology into forest and energy markets.

- ***Conduct more preliminary research.*** For states or facilities considering bioenergy, talk to experts, bring engineers on to the project early on, and look at fossil fuel energy prices over the long term. The key is that the facility needs to be sized appropriately with adequate sources of supply. For example, some facilities were not set up to handle mill residues and failed to capitalize on what would be an inexpensive, easier feedstock for the facility to take rather than relying solely on collecting tops and limbs.

- ***Consider bioenergy as an integrated component of a larger system.*** It would be naïve to suggest that the decision to design, build, and operate a large bioenergy facility does not consider how it integrates into larger forest and energy markets. Financing due diligence and utility planning processes require exactly that. Reversing this perspective somewhat, viewing individual installations in terms of the contributions they make to forest and energy systems, could help to increase the perceived value of those installations as well as insulate an operation from external market risks. Though such system visioning operations could take place at the federal level, these are perhaps more appropriate to think of in terms of state-level policy and planning.

Bioenergy faces challenges due to a lack of a natural advocate. Case study interviews suggest a varying degree of social acceptability of bioenergy. Interviews and related documents suggest that acceptability is influenced by many factors including facility size, employment opportunities, source of supply, and overall public perceptions of bioenergy. There is strong sentiment that a lack of education on the operation and potential contributions of bioenergy is a major determinant to the social and political viability of the technology. The topic of education opportunities varies from the advancement of bioenergy technology and the benefits of forest bioenergy, to identifying where the material is sourced for a facility. Specifically mentioned were synergies between bioenergy operations and the overall health of the forest product supply chain, on the forest resource management benefits that stem from forest markets, and on the greenhouse gas implications and other air emission concerns. Similarly, several respondents noted that bioenergy facilities are not always recognized for their ability to contribute to forest management objectives.

Related to this, participants reflected that bioenergy lacks a natural advocate, that other types of renewable energy at times received greater public support, and that potential allies in the forest industry were reluctant to aggressively promote the technology. Others reflected on how bioenergy was a second or third tier priority for many government agencies but not a top priority for nearly any agency. This varying level of explicit, strong, and sustained support is contributing to recent policy decisions either favoring or disfavoring the technology. For example, the ARP Loyalton facility re-opened due to policy intervention on the state level. Bridgewater faced localized opposition from certain individuals and groups but overcame that opposition in the form of SB 365. LEA in Minnesota did not so much experience political opposition at the local level, but rather what could be characterized as lesser support than alternative generation technologies at the state level. Considering these observations, policy recommendations to address variations in political support largely pertain to issues of planning, education, and coalition development.

- ***Mobilize support for coalition development.*** There are numerous actors involved in bioenergy industry. In the case of New Hampshire, the broad advocacy campaign that included renewable energy and forest industry representatives suggests that the operating space for biomass energy can be increased through coalition development and effective communication of the benefits of bioenergy to allied industries.
- ***Continue public education and outreach on the role of bioenergy in larger energy and forestry contexts.*** Majority of respondents noted the opportunity to continue educating the public on the benefits of forest bioenergy. In general, public concerns include the source of material used to supply a facility, the costs of using bioenergy compared to other sources of power, and related air quality impacts.

- ***Engage with the public as early as possible.*** Respondents indicated that, in general, public perceptions of forestry are becoming a barrier to garnering sufficient support for legislative efforts, whether they be price support or biomass procurement policies. Several experts noted that the public maintains varying levels of support and understanding for forestry and the forest economy, and that public perceptions do not always agree with the use of biomass for energy. The lack of public understanding and support can make it difficult to advance policy solutions due to stakeholder resistance.

Ancillary benefits are not translated to the market. Participants often spoke about the various climate, forest market, or hazard reduction benefits associated with bioenergy. They also spoke about the lack of market valuation or other formal recognition of these benefits. For example, interviewees noted that robust markets for low-grade wood help make sustainable forestry profitable by providing an outlet to remove diseased, infested and low-quality wood to improve forests. But as these values were not captured in the price paid for bioenergy, and the technology was viewed as less competitive on a pure-cost basis relative to other generation technologies. Participants also reflected about the contributions that bioenergy could make to base load power generation, GHG mitigation efforts, and the avoided cost of wildfire. However, contributions are currently seen as undervalued. As a result, bioenergy suffered when compared to other energy technologies on the basis of price alone. Policy recommendations thus pertain to better accounting for and capturing value stream associated with the unique contributions that bioenergy can make to broader environmental objectives.

- ***Provide guidance on how to value the various costs and benefits of biomass.*** Experts nation-wide agreed that monetizing the diverse benefits of biomass utilization would reduce the overall cost of removing biomass. Identified benefits include carbon-neutrality, reduced wildfire risk, baseload capacity and/or waste disposal. A first step in this process is to determine how to value these disparate streams and a mechanism to market them.

- ***Capitalize on bioenergy as a tool to achieve land management goals.*** The case studies show that bioenergy facilities can act as a tool to achieve other land management benefits. In the case of California, the BioRAM policy was implemented to address a tree mortality issue. In Florida, the DHR facility acted as a waste disposal for material following Hurricane Irma.

The industry depends on more than just an operational facility, but also the presence of a working supply chain. Respondents noted challenges along the supply chain, specifically high costs and a lack of workforce capacity that continue to act as barriers to the bioenergy industry. For example, in the California case, the BioRAM policy allowed the ARP Loyalton facility to restart operations by mandating utilities into contracts with the facility. Challenges occurred because the policy created additional demand on federal lands to secure high hazard zone material and did not provide support to lessen the barriers along the supply chain. Respondents specifically mentioned the high cost of hauling the biomass to the facility and the lack of workforce capacity to keep up with the additional demand. In the Florida and New Hampshire case studies, respondents discussed that there is sufficient supply of material available but the challenge is to the lack of logging capacity. In Minnesota, interviewees mentioned the role of the bioenergy industry in supporting the supply chain and providing markets for low-value biomass material that provide an overall healthier forest products industry.

- ***Provide support throughout the supply chain.*** The case studies show that challenges along the supply chain, specifically transportation costs and lack of logging capacity, continue to hinder the industry. Providing incentives along the supply chain to increase the workforce capacity and reduce the overall cost of hauling and processing biomass, combined with support for the facility itself, could reduce existing barriers to facility operations.

5.0 References

Aguilar, F., & Garrett, H. E. (2009). Perspectives of Woody Biomass for Energy: Survey of State Foresters, State Energy Biomass Contacts, and National Council of Forestry Association Executives. *Journal of Forestry*, *107*(6), 297–306.

Becker, D. R., Moseley, C., & Lee, C. (2011). A supply chain analysis framework for assessing state-level forest biomass utilization policies in the United States. *Biomass and Bioenergy*, *35*(4), 1429–1439. https://doi.org/10.1016/j.biombioe.2010.07.030

Black, & Veatch. (2004). *Gainesville Regional Utilities - Supplementary study of generating alternatives for Deerhaven Generating station*. Jacksonville. Retrieved from https://www.gru.com/Portals/0/Legacy/Pdf/futurePower/SUPPLEMENTARY_STUDY_OF_GENERATING_ALTERNATIVES.pdf

California Legislative Information. SB-901 Wildfires. (2018). Retrieved from https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB901

California Legislature. SB-859 Public resources: greenhouse gas emissions and biomass. (2016). Retrieved from https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB859

Caplan, A. (2017a). Biomass buyout takes some big steps this week. Retrieved March 3, 2019, from https://www.gainesville.com/news/20170821/biomass-buyout-takes-some-big-steps-this-week

Caplan, A. (2017b). City gives final OK for biomass plant buy. Retrieved March 3, 2019, from https://www.gainesville.com/news/20170907/city-gives-final-ok-for-biomass-plant-buy

CPUC. (2016). Public Utilities Commission of the State of California. Energy Division Resolution E-4137. Retrieved March 8, 2019, from https://www.gov.ca.gov/docs/10.30.15_Tree_Mortality_State_of_Emergency.pdf

Fleeger, W. E. (2008). Collaborating for Success: Community Wildfire Protection Planning in the Arizona White Mountains. *Journal of Forestry* , *106*(2), 78–82.

GRU. (n.d.). Meeting Gainesville's long-term energy needs. Retrieved April 23, 2019, from https://www.energy.gov/sites/prod/files/2016/05/f31/feedstocks_berguson_7154_0.pdf

Holt, L. (2016). The importance of the regulatory framework for U.S. electric utility creditworthiness. *The Electricity Journal*, *29*(3), 13–18.

ICF. (2006). *City of Gainesville Electricity Supply Needs*. Fairfax, VA. Retrieved from https://www.gru.com/Portals/0/Legacy/Pdf/futurePower/ICF_FINAL_REPORT.pdf.

Jossi, F. (2017). *Plant closures could be turning point for Minnesota biomass industry*. Retrieved from https://energynews.us/2017/09/29/midwest/plant-closures-could-be-turning-point-for-minnesota-biomass-industry/

Keeler, D., & Bertrain, J. (2015). *SB 859: Funding for Cap-and-Trade Program and Forest Projects to Reduce GHG Emissions*. Retrieved from http://leginfo.legislature.ca.gov/.

Lester, T. K., Peterson, J., & Stathos, D. (2015). *Independent Investigative Review of the Gainesville Regional Utilities (GRU)*.

Lynn, K. (2013). A triple 'S' for sustainability: Credit ratings agencies and their influence on the ecological modernization of an electricity utility. *Utilities Policy*, *27*, 9–14. https://doi.org/10.1016/J.JUP.2013.08.003

Meersman, T. (2017a). Loggers and truckers sue Xcel Energy over proposed shutdowns of plants. Retrieved February 24, 2019, from http://www.startribune.com/loggers-and-truckers-sue-xcel-energy-over-proposed-shutdowns-of-plants/458920883/

Meersman, T. (2017b). New law allows much of Minnesota's biomass industry to be shut down. Retrieved December 3, 2018, from http://www.startribune.com/new-law-allows-much-of-minnesota-s-biomass-industry-to-be-shut-down/426537051/

Minnesota Public Utilities Commission (MN PUC). Petition of Approval to Terminate the Power Purchase Agreement (PPA) with Benson Power, LLC (Docket E002/M-17-530); Petition for Approval to Terminate the PPA with Laurentian Energy Authority I, LLC (LEA) (Docket E002/M-17-551) (2018).

Neary, D. G., & Zieroth, E. J. (2007). Forest bioenergy system to reduce the hazard of wildfires: White Mountains, Arizona. *Biomass and Bioenergy*, *31*, 638–645. https://doi.org/10.1016/j.biombioe.2007.06.028

Nielsen-pincus, M., & Moseley, C. (2009). Social Issues of Woody Biomass Utilization :, (20), 1–4.

PG&E. (2019). Bioenergy Renewable Auction Mechanism. Retrieved February 25, 2019, from https://www.pge.com/en_US/for-our-business-partners/energy-supply/electric-rfo/wholesale-electric-power-procurement/bioenergy-renewable-auction-mechanism-request-for-offers.page

Power Technology. (n.d.). Gainesville Renewable Energy Center. Retrieved April 23, 2019, from https://www.power-technology.com/projects/gainesville-center/

Ropeik, A. (2018). Legislators Narrowly Override Sununu's Biomass Veto, But Fall Short On Net Metering. Retrieved March 29, 2019, from https://www.nhpr.org/post/legislators-narrowly-override-sununus-biomass-veto-fall-short-net-metering#stream/0

Stidham, M., & Simon-Brown, V. (2011). Stakeholder perspectives on converting forest biomass to energy in Oregon, USA. *Biomass and Bioenergy*, *35*(1), 203–213. https://doi.org/10.1016/j.biombioe.2010.08.014

Sundstrom, S., Nielsen-Pincus, M., Moseley, C., & Mccaffery, S. (2012). Woody Biomass Use Trends, Barriers, and Strategies: Perspectives of US Forest Service Managers. *Journal Of Forestry*, *110*(1), 16–24. Retrieved from http://pdxscholar.library.pdx.edu/esm_fac

Swirko, C. (2017). Biomass plant ordered to pay $4.6 million in damages. Retrieved March 8, 2019, from https://www.gainesville.com/news/20160623/biomass-plant-ordered-to-pay-46-million-in-damages

Tait, D. (2017). Understanding Public Utility Regulatory Policies Act of 1978 (PURPA). Retrieved November 6, 2018, from https://alcse.org/understanding-public-utility-regulatory-policies-act-1978-purpa/

U.S. Endowment. (2019). Wood2energy. Retrieved March 27, 2019, from https://www.wood2energy.org/

Union of Concerned Scientists. (2017). Public Utility Regulatory Policy Act (PURPA). Retrieved December 18, 2018, from https://www.ucsusa.org/clean_energy/smart-energy-solutions/strengthen-policy/public-utility-regulatory.html#.XBlCnWhKjIU

USDA. (2007). Woody Biomass Use Desk Guide. Retrieved from https://www.forestsandrangelands.gov/documents/woody-biomass/biomass_deskguide.pdf

USDA Forest Service, & UC Berkley. (2017). BioRAM Facility Woodbaskets Suitable National Forest System (NSF) Lands. Retrieved February 25, 2019, from http://www.fire.ca.gov/treetaskforce/downloads/TMTFMaterials/2017-04-27_BioRAM_ContractPlants_WoodBaskets_MWood_ v03.pdf

Woody Biomass Utilization Group. (n.d.). Overview: Woody Biomass Utilization and the WBUG. Retrieved June 11, 2018, from https://www.forestsandrangelands.gov/Woody_Biomass/overview.shtml

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, *35*(5), 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001

CHAPTER 3: USING DIMENSIONS OF NETWORK GOVERNANCE TO EXAMINE FOREST BIOENERGY POLICY DEVELOPMENT

Abstract

Reducing the risk of catastrophic wildfires, harnessing domestic renewable energy sources, and improving forest health and resiliency are among the many motives for increasing the utilization of forest biomass. Despite decades of industry innovations and prolific research, the bioenergy industry continues to lack policy intervention that effectively minimizes the barriers to biomass use. However, it is not just effective policy that is challenged, but also the role of government in shaping how forest resources are governed. Forest governance recognizes that not only federal and state actors, but also non-government agencies, private businesses, and local communities impact how forest resources are governed in terms of policy design and implementation. Policy and market barriers are well documented in bioenergy literature, but there are few empirical studies that examine dimensions of forest bioenergy networks. Networks are comprised of multiple actors that span across jurisdictional and administrative sectors and coordinate to influence policy intervention. Furthermore, the impacts of these networks and their subsequent governance configurations are largely unexplored in the context of forest bioenergy policy intervention. In this paper, we propose a framework to examine bioenergy network arrangements using four dimensions of network governance: heterogeneity, integration, strength of ties, and structure. We apply this framework to a single case study to provide an in-depth exploration of these network dimensions, examine its influence on forest governance, and identify network vulnerabilities.

1.0 Introduction

Forest government is a centralized approach to forest management dominated primarily by federal and state actors. Historically, forest government has been criticized for overexploiting forest resources and for managing forests in a manner that conflicts with local community needs (Arts, 2014). The shift from forest government to forest governance recognizes the importance of non-government agencies, businesses, and local communities involved in shaping how forest resources are governed (Agrawal et al., 2008; Arts, 2014). Forest governance is defined as the interaction between informal and formal institutions consisting of rules, norms, and decision-making that shape how forests are managed (Giessen & Buttoud, 2014; Nguyen et al., 2018). Forests have many purposes including: the ability to harness a renewable energy source (Lindahl, & Westholm, 2010; Gan & Cashore, 2013; Lindahl et al., 2018), maintain habitat biodiversity (Westholm et al., 2015), and recreational use (Sandström et al., 2017). While there are numerous uses for forest resources, this article focuses on the use of forest biomass for energy purposes in the United States.

Forest bioenergy production is driven by energy security concerns, particularly after the 1973 oil crisis (Carleton & Becker, 2018; Gan & Cashore, 2013). However, it failed to gain widespread adoption due to the low costs of fossil fuels, particularly natural gas. Recently with the recognition of biomass utilization as a tool to offset the cost of wildfire risk reduction and an economic opportunity for rural communities, bioenergy has re-gained interest in the United States (Carleton & Becker, 2018). Compared to alternative energies, bioenergy has high income and employment multipliers, creating a ripple effect on income and job creation (Domac, Richards, & Risovic, 2005a; Gan & Cashore, 2013). Despite this resurgence in interest, wide scale adoption is lacking primarily and effective policy intervention and the role of government continues to be challenged.

Numerous social and economic barriers to utilizing forest biomass have been documented in the literature, such as unfavorable economics (Aguilar & Garrett, 2009; Sundstrom et al., 2012), supply chain deficiencies (Becker et al., 2011) , and lack of social and political acceptability (Stidham & Simon-Brown, 2011; Wüstenhagen et al., 2007). However, there are few empirical studies that examine the dimensions of forest bioenergy governance networks. Furthermore, the impacts of these attributes and their subsequent governance configurations are largely unexplored in the context of forest bioenergy policy intervention.

2.0 Network governance literature

Governance refers to the process in which policy, such as market incentives, is produced within multi-actor structures, involves the enforcement of rules and norms, and determines authority and direction of decision-making power (Carleton & Becker, 2018; Carlsson & Sandström, 2007; Lu, de Jong, & ten Heuvelhof, 2018; R.A.W. Rhodes, 2008; Steelman, 2010). These multi-actor structures typically encompass diverse actors that span across social sectors, and bring a variety of resources, perspectives, and interests to the network. To effectively govern natural resources, it's becoming increasingly common for actors, particularly government actors (e.g. US Forest Service) to be dependent on the cooperation and resource mobilization of several other actors. From this dependence, networks emerged as a form of governance , further encouraging the mix between public and private resources, and the use of various policy instruments (Klijn, 2009; Poocharoen & Sovacool, 2012). Governance networks are relatively stable patterns of coordinated action and resource exchange, comprised of multiple actors that span across jurisdictional and administrative sectors and scales, who interact through a variety of structures to influence the design, implementation, or monitoring of policies (Koliba, Meek, & Zia, 2011). There are many components to network governance that may impact the ability to effectively govern natural resources. For example, if a network consists of primarily one social sector, that network is likely to lack the ability to exchange resources. Additionally, a network that lacks the ability to coordinate and communicate within the network is likely to result in disjointed and ineffective policies. We propose four dimensions of network governance that may affect policy formation and implementation: heterogeneity, integration, strength of ties, and structure (Table 2).

Table 3.1. Four dimensions of network governance and definitions

DIMENSION	BIOENERGY VARIABLES	SUPPORTING LITERATURE
Heterogeneity	The diversity of actors that span jurisdiction and geographic boundaries involved in the network	(Carlsson & Sandström, 2007; Head, 2008; Koliba et al., 2011; Reagans & Zuckerman, 2001; Sandstrom, 2008)
Integration	The coordination of actors to facilitate business transactions; general agreement on goals and priorities; often inclusive decision-making	(Carlsson & Sandström, 2007; Head, 2008; Koliba et al., 2011; Mattor & Cheng, 2015)
Strength of ties	Based on the frequency of contact, potential to exchange resources, and levels of trust	(Börzel, 1998; Davies, 2012; Klijn, 2009; Koliba et al., 2011; Mattor & Cheng, 2015)
Structure	Overall organization and nature of relationships among actors, the dissemination information, and exchange of resources.	(Courtney, 2018; Provan & Kenis, 2007; Rhodes, 1996; Sandstrom, 2008)

2.1 Heterogeneity

Networks encompassing a range of actors are typically diverse in terms of perspectives, interests, goals, and resources (Head, 2008). To cope with complex natural resource systems, networks often incorporate actors that span across social sectors (Carlsson & Sandström, 2007; Koliba et al., 2011). Public social sector organizations are formal institutions of the state, span across legislative, executive, and judicial branches of government, and are guided by public interest and public policy goals. For example, the U.S. Forest Service is guided by mission to sustain the health, diversity, and productivity of the U.S. forests and grasslands for both present and future generations (U.S. Forest Service). The private sector is driven by market forces and often the pursuit of profit. The non-profit sector is comprised of voluntary entities, prohibited from earning profits and are driven largely by their mission designed to represent social interests, inform the public, or deliver social services (Koliba et al., 2011). Imperative to the network are the resources that actors mobilize and are willing to exchange. Particular resources include: financial, intellectual, natural, human, social, physical, cultural, and political (Table 2). For example, bioenergy facilities bring financial resources in the form of job creation and economic development, natural capital in the form of renewable energy, and physical capital in the form of infrastructure to exchange within network. The local community may exchange human capital in the form of labor for financial capital; utilities may exchange financial capital for renewable energy; land management agencies may exchange natural capital in exchange for use of the facilities physical capital.

Table 3.2. Capital resources possessed and exchanged throughout the network

RESOURCE	EXAMPLES
Financial	Cash; loans; grants; securities; other forms of wealth
Intellectual	Information; knowledge
Natural	Forestland; watersheds; recreation areas
Human	Skills; labor
Social	Trust; community influence; common norms
Physical	Equipment; infrastructure; property
Cultural	Customs; rituals; traditions
Political	Favors; political power

Some scholars believe that homogenous groups are expected to perform at a higher level largely because of their ability to coordinate action more easy than diverse actors; however, some argue the performance of these groups is limited by the relatively redundant perspective and resources (Reagans & Zuckerman, 2001). Actors within the network exercise power and exert influence on the decision-making process with the presence of and willingness to exchange resources. Identifying actors and their associated boundaries allows us to understand the capacity in which actors work together.

2.2 Integration

Integration refers to the coordination between actors to facilitate business transactions, establish a general sense of agreement on the priorities and goals, and to foster an inclusive decision-making process (Carlsson & Sandström, 2007; Mattor & Cheng, 2015). Integrated networks are presumed to result in coordinated and more effective policies while simultaneously achieving forest management and community needs (Mattor & Cheng, 2015). A myriad of federal and state level policies, regulations, laws, and common arrangements among members of the network that influence the ability to integrate and make decisions (Mattor & Cheng, 2015). The level of integration often depicts whether there is a concerted effort to understand the problem and form relationships with other stakeholders (Mattor & Cheng, 2015). In this study, we are interested in examining to what extent forest bioenergy networks are integrated and whether there are particular circumstances that hinder the ability to coordinate and exchange resources.

2.3 Strength of ties

Strength of ties pivots on the frequency of contact, the measurement of resource exchange, trust, and the actors subjective perceptions of the relationship (Courtney, 2018; Davies, 2012; Koliba et al., 2011; Provan & Kenis, 2007). The ability and willingness to exchange resources and communicate frequently, are indicators that trust is prevalent and the relationship is strong (Courtney, 2018; Davies, 2012). Contrarily, weak ties are characterized by infrequent contact and resistance to exchanging resources (Granovetter, 1986; Koliba et al., 2011). The strength of ties have significant bearing on how the network is governed and influences the ability to formulate and implement effective policy (Koliba et al., 2011). For example, a commonly cited bioenergy barrier is the overall cost compared to alternative energy sources. The resistance to enter into bioenergy contracts and exchange financial resources results in a weak tie between the facility and their respective utility companies. This resulting scenario indicates the network may need to operate in hierarchical structure rather than a collaborative, horizontal structure to achieve effective policy.

2.4 Structure

Structure refers to the overall design and organization of the network. Structure includes the nature of relationships between actors, the dissemination of information, and the flow of resource exchange. Governance structures are comprised of institutions, policies, and programs that interact to shape forest bioenergy development (Carleton & Becker, 2018). The direction of power refers to whether the relationship between actors is hierarchical, or whether actors negotiate and compromise, coordinate with, or compete with one another (Table 3). For example, when actors within a network negotiate and reach a compromise, authority is ideally, exchanged equally between the actors. In contrast, when actors work together to implement a policy or program that forces certain actors to do something, the structure of the network is considered hierarchical and power is exerted in the traditional top-down fashion.

Table 3.3. Network governance structures

STRUCTURE	DIRECTION OF POWER	NATURE OF RELATIONSHIP
Hierarchical	↓	Power is exerted in a top-down fashion; one entity has authority over others
Negotiation and compromise	⤢⤡	Authority is negotiated between actors
Collaborative	↔	Actors work together; structured through social norms and trust
Competitive	→ ←	Actors are pitted against one another; results in winners and losers

In this study, we are interested in the organization of actors, the nature of their relationships, and the impact these structures have on policy formulation and implementation.

3.0 Research methods and case selection

We selected a singular forest bioenergy facility to serve as a critical case study to examine four dimensions of network governance. The American Renewable Power (ARP) co-gen facility serves as a critical case study, to explore dimensions of network governance (Yin, 2012).

We conducted eight semi-structured, telephone interviews with facility managers, state and federal land management agencies, utilities, and other relevant stakeholders. The open-ended structure of the questions allowed respondents to discuss a range of factors affecting biomass use and policy development including (a) relevant policy information and policy actors, (b) supply chain logistics, (c) public perceptions, (d) political support, and (e) key market and economic factors. These broad, open-ended questions allowed us to explore features of network governance using an inductive approach.

All interviewees were purposively sampled to present a range of knowledge and perspectives and to obtain a comprehensive understanding of the current forest bioenergy industry surrounding ARP Loyalton. We asked our interviewees to identify other federal, state, and local government individuals; loggers; utilities; managers; or other relevant stakeholders who may provide additional information regarding each of our case studies. All interviews lasted approximately one hour and were recorded and transcribed for consistent analysis. To supplement the interviews, we collected news articles, technical reports, and policy briefs relating to the facility for document analysis. The structure of the interviews and the use of secondary data allowed us to examine dimensions of network governance and draw general conclusions regarding the network.

4.0 Case Study - American Renewable Power, Loyalton Co-gen

4.1 Facility background

The original bioenergy facility began operations in 1987 as a combined heat and power plant (CHP) to serve a sawmill and the NV Energy system(ARP, 2019b). The facility operated as a co-generation plant until an onsite sawmill shut down in 2001. The plant continued in commercial operations with 21 full-time employees until 2010 when it was shut down due to dramatic changes in fossil fuel and renewable energy pricing that undermined the facilities ability to operate economically (ARP, 2019b). Several years later, the facility was purchased by American Renewable Power (ARP). ARP is a California-based company that owns and operates renewable power facilities in the United States (ARP, 2019a). Restarting the facility includes a host of benefits to the region including job creation, expansion of small, local businesses, development opportunities, increased local commerce, and creating a regional market for biomass materials (ARP, 2018). Sierra County and several community members provided ARP with letters of support for purchasing and re-opening the facility. The ARP Loyalton co-gen facility commenced operations in April 2018 under a BioRam 2 contract.

In 2015, California was facing an unprecedented die-off of over 120 million dead trees in the Sierra Mountains due to drought, insects, and disease (ARP, 2018). On October 30, 2015, Governor Brown responded by issuing Emergency Proclamation E-4770 directing the California Public Utility Commission (CPUC) to require the state's largest investor-owned utilities to purchase renewable energy from bioenergy facilities using a high percentage of feedstock from high hazard zones as defined by the California Department of Forestry and Fire (Calfire). Tier 1 high hazard zones include areas that pose a risk to public safety including roadways, infrastructure, and parks; and Tier 2 includes watersheds with significant tree mortality, areas with high risks for wildfire, severe drought, and bark beetle infestation (Keeler & Bertrain, 2015; PG&E, 2019). The initial resolution required Pacific Gas and Electric, Southern California Edison and San Diego Gas and Electric to purchase a combined 50 megawatts of biomass power using material from high hazard zones. The resolution required that 40% of the fuel in 2016 to originate from high hazard zones, increasing to 50% by 2017, 60% by 2018 and 80% in 2019 through 2021 (CPUC, 2016). In 2016, the state legislature passed SB 859 (BioRAM 2) which added 125 megawatts to the renewable auction mechanism, raising the total to 175 megawatts (California Legislature, 2016). BioRAM2 contracts require at least 80% of the feedstock to be a byproduct of sustainable forest management, of which 60% must originate from Tier 1 or Tier 2 high hazard zones.

This case illustrates the development and implementation of a state-wide policy due to a pressing environmental need. This case also showcases the need for several different entities to work together to support the forest bioenergy industry. ARP was able to bring the facility back on line because state policy recognized how bioenergy facilities could address an urgent public safety challenge. In other words, the BioRAM policy monetizes the environmental value of hazardous fuel removal and uses the mechanism of bioenergy as the vehicle to accomplish broader environmental goals. This paper sheds light on the underlying theoretical aspects that encourage actors to come together and exchange resources in order to accomplish a common goal.

4.2 Heterogeneity

The ARP Loyalton co-gen facility network is diverse in terms of the actors, social sectors, interests, and resources represented. The network includes a combination of public, private, and non-profit actors, and a variety of interests and resources (Table 4). Specific actors mentioned throughout interviews included: facility management, state and federal agencies, non-profits, end-users, utilities, state and local politics, private landowners, general public, and local community.

Table 3.4. ARP Loyalton co-gen network

SOCIAL SECTOR	ACTOR	INTERESTS	RESOURCES
Private	Facility management	Forestry, profit	Natural; human; financial; physical
	Landowners	Forestry, profit	Natural; human
	Utilities	Providing affordable power to ratepayers	Financial
	Sawmills	Profit	Physical; natural
Public	Federal land management agencies	sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations	Human; natural; physical; information; political
	Political entities	Respective constituents	Social; political
	State land management agencies	Management and protection of California's natural resources	Human; information, physical; political
	Utilities	Providing affordable power to ratepayers	Financial
	Community	Community needs, locals	Social; political; cultural
Non-profit	Forest non-profit groups	Respective missions	Social; political

ARP intends to further diversify its network, internally. Recently, ARP rebranded the on-site, Sierra Valley EcoTech Campus (ARP, 2018). The campus is ready for development with entitlements secured and zoning potential to attract a range of businesses (ARP, 2018). The industrial park is designed to attract energy intensive businesses due to the on-site biomass facility. This unique opportunity, allows the facility to diversify and expand its network on-site, rather than rely on external actors who may have alternative priorities.

However, an abundance of diverse actors, does not always equal a positive outcome. One respondent mentioned too many players involved in the network,

> *The reason that biomass energy has made it as far and as long as it has made it, is because there are so many people in a corner saying that it's partially useful for them. But for almost no one is it a primary thing that they should be working on. Even for Cal Fire, our mission is to protect the property and serve the people, property and resources and people of California. And biomass energy is just a way to help pay for land treatment, right? It's not something that we support for the sake of itself. It's the same with the California Public Utilities Commission, whose main charge is to keep power costs low. Or the California Energy Commission, who is interested in pursuing renewable energy but has several other renewable energy sources that serve their needs better. (California 5*)

A diverse network may result in conflicting interests between actors. For example, utilities operate on behalf of ratepayers to provide affordable sources of power. Alternatively, state land management agencies may prioritize the removal of low-value forest biomass to reduce the risk of wildfire. Diverging interests may create a resistance to exchange resources between actors. For example, utilities are less likely to exchange more financial resources without receiving benefits in return or being mandated.

4.3 Integration

This case study appears to have mixed levels of coordination between actors. The creation of the BioRAM policy was largely due to actors working together to put forest management on the public policy agenda. Actors advocated there is an abundance of material that needs to be removed from the forest and framed the bioenergy industry as a mechanism for disposing of the material. Additionally, when initially formulating the BioRAM policy, a working group of multiple entities worked together to inform policymakers that a single 30-50 megawatt facility would not address a tree mortality problem spread across seven counties, but rather five smaller, de-centralized facilities were more appropriate. Beyond implementing the BioRAM policy, a coalition of state and federal agencies, local governments, utilities, and other stakeholders created what is known as the Tree Mortality Task Force. The purpose of the task force is to coordinate emergency protective actions, and monitor ongoing conditions to address the tree mortality issue (State of California, 2013). This working group works directly with California bioenergy facilities, including ARP Loyalton co-gen. The group ensures forest bioenergy facilities receive high hazard material and work with facilities to identify potential funds to offset higher feedstock costs (Conway, 2018).

While numerous actors were involved with the formulation and implementation of the BioRAM policy, certain aspects lacked effective coordination. Respondents mentioned disagreement on the definition of high hazard material and the designation between Tier 1 and Tier 2 high hazard zones.

Interviewees noted examples of a disconnect between the state formulating a policy and on the ground conditions. Several state agencies had to work together to decide how to document high hazard zones and create a paper trail of how to keep track of the material leaving the forest. There was also a lack of coordination with how the fuel requirement would work. One interviewee discussed that requiring a fuel requirement to run for a calendar year, however, despite efforts to illustrate why that was not feasible, the fuel requirement runs for a calendar year beginning at the start of the program.

Respondents also mentioned a disconnect between the state policy initiative and federal land management agencies.

> *The speed that this BioRAM policy came into place, that created this additional demand, it didn't come with additional dollars for the forest service. (California 2)*

The BioRAM policy is a state initiative that mandated utilities to purchase a pre-determined amount of power from facilities. The policy required the facilities to use material from designated high hazard Tier 1 or Tier 2 areas, which are located on federal land. Facilities entering into BioRAM contracts received subsidies from the state in exchange for providing power to the utilities. However, despite the additional demand placed on federal forest land, federal land management agencies did not receive additional resources.

4.4 Strength of ties

There are both strong and weak ties present in this network arrangement. In general, support from state and federal land management agencies and the local community indicates a strong tie with the bioenergy facility. The facility provides a variety of resources including financial (e.g. economic development), natural (e.g. renewable energy), and infrastructure to these actors in exchange for other resources including social and political capital, information, and financial support. The ease of resource exchange and general attitude towards the facility from these actors suggests trust is present between these actors.

Contrarily, weak ties are also present in the network. A frequently cited barrier to biomass energy development is the cost of the bioenergy, especially in comparison to other renewable energies (Aguilar & Garrett, 2009; Becker, Larson, et al., 2009; Nicholls et al., 2018). The high cost of bioenergy results in a weak tie between the facility and utilities, who are reluctant to enter into contract agreements without policy intervention.

4.5 Structure

There are three structures present in this network: hierarchy, collaborative, and competitive. In this particular case study, the state government exerts the majority of the power. The state mandates utilities to enter into contract agreements with facilities who are required to use specifically designated materials; thus depicting a hierarchy structure.

However, there is evidence of collaboration and coordination among several actors to explore avenues for managing tree mortality due to years of drought, insects, and disease. The formation of partnerships across diverse state agencies created an emphasis on wood products, and specifically the ability for forest bioenergy to be a solution to many land management issues/state agency priorities. These partnerships closely resemble a horizontal network structure.

Competitive structures are also present in the network. Forest bioenergy competes with alternative sources of energy, primarily natural gas, wind, and solar. Plummeting natural gas prices and highly subsidized renewable energies undermines the ability for forest bioenergy to be competitive in the marketplace on a purely cost basis; thus creating an opportunity for policy intervention.

> *we have like 4 or 5 years of some really intense drought in the state of California and a lot of these bio-mass facilities kind of simultaneous to that drought, were either not operational because the subsidies had gone away, but at the same, a lot of the bio-mass facilities were just barely hanging on. And they could not compete on the open market with power purchase agreements because they were not getting the subsidies that were similar to wind, as well as solar (California 4)*

5.0 Discussion

Though limited to a single case study, the proposed framework allows us to explore certain dimensions of forest bioenergy networks that inform policy formulation and implementation. The framework also allows us to uncover network vulnerabilities and additional barriers to forest bioenergy utilization. In this section, we discuss each dimension of network governance, identify vulnerabilities and challenges, and areas for future policy development.

Although there are numerous benefits to having a heterogeneous network, it is apparent that more diversity, does not always equal a better outcome. A growing number of actors within the network proliferates interests represented. For this specific case study, bioenergy garnered support because of the large number of actors that framed bioenergy as a way to help pay for land treatment. The network is currently supporting the benefits associated with bioenergy, rather than the industry itself. Many respondents discussed the role of the BioRAM policy for accomplishing land management goals, rather than its ability to support the bioenergy industry. For example, one interviewee criticized the BioRAM,

> *It was designed to deal with the high hazard material, the 120 million dead trees from the drought, but it doesn't have any way of dealing with the ongoing large fire threat (California 4)*

The study shows a resistance to exchange resources when there was not a perceived mutual exchange benefit. For example, utilities resisted exchanging financial capital with bioenergy facilities when cheaper options were available. This is largely because utilities are held accountable for providing affordable power to ratepayers and are less concerned with forest management or supporting domestic, renewable energy sources. Despite the utilities resistance, the BioRAM policy forced the utilities to enter into contracts with biomass facilities that would take material from designated high hazard zones. Reliance on one particular actor to be successful causes the network to be vulnerable to exogenous circumstances that cause actors to fluctuate in and out of the network. This suggests this networks in this situation may not be resilient to a change in heterogeneity. ARP Loyalton co-gen, however, is in a unique position to diversify and grow its network internally, potentially lessening the need to rely on external actors for support.

This case study also suggests that without monetizing the environmental benefits of bioenergy, resources are valued based on the actors' perceptions. For example, some actors value the additional benefits of using bioenergy and are willing to pay the higher cost of energy; thus suggesting those benefits are equivalent to the cost. However, it is apparent that not all actors value those benefits equally. This finding suggests that rather than the presence of the resource itself, the ability to use and exchange resources depends on how actors value that particular resource.

Agreement on a common goal is central to effective network governance. The need to manage forest conditions due to years of drought, insects, and disease, brought actors with fundamentally different priorities together to form the network specific to this case study. Coordination and communication across the network encouraged government actors to intervene and implement a state-level policy aimed at achieving a common goal. This brings to question the durability of these relationships. Once actors believe they achieve their goal, will the network dissolve?

Currently, the network follows a predominantly hierarchical structure. The state exerted power in a traditional top-down fashion by implementing a policy that mandates other actors to take specific actions. Regardless of the state's role in formulating and implementing the BioRAM policy, the state relies on additional public and private actors to cooperate and mobilize resources to carry out the policy. However, the ARP Loyalton co-gen facility has hopes of diversifying and coordinating internally, thus potentially reducing the reliance on state policy support. As the facility shifts to a more independent entity, there may be a transition to a more de-centralized structure. Additional research in the form of a longitudinal study could capture these shifts in network structures.

To further explore these network governance dimensions, additional data collection is warranted. The inductive discovery of elements of network governance resulted in specific attributes that were not thoroughly discussed. For example, it is unclear whether this is a comprehensive list of actors and resources present within the network. It is also difficult to thoroughly and credibly measure levels of integration and the strength of ties with the current data. Additional interviews, with specific network governance questions are necessary to adequately address these questions. It is also important to note there are areas of research that this framework does not address including: resilience of networks, perceptions of resources and their associated value, or whether the network is effectively governing forest resources.

6.0 Conclusion

We proposed a framework of four network governance dimensions including heterogeneity, integration, strength of ties, and structure to explore the role of networks in shaping how forest resources are governed. The proposed framework was applied to a single, critical case study, the ARP Loyalton co-gen facility. Using semi-structured interviews with various stakeholders, we inductively explored these dimensions of network governance.

There are many diverse actors encompassing a range of resources present in this network. One respondent mentioned that there are too many actors involved, suggesting that a highly heterogeneous network may not always be desired. Actors bring unique perceptions, perspectives, and interests to the network. The more actors that are present, the higher chance for competing interests within the network and the longer it may take to coordinate between actors. This study identifies varying levels of integration within the network. The state agencies and non-profit organizations represented in the network showed characteristics of integration by working together to place forest management on the public policy agenda. However, some interviewees discussed the lack of integration when the policy created additional demand but without providing additional resources to the U.S. Forest Service. The ease of resource exchange between the local community, facility, and state and federal land management agencies indicates that trust is present in the network, thus illustrating a strong tie. However, the utilities resistance to enter into contract agreements with the facility indicates a weak tie is also present within the network. Currently, the network exists in three structures: hierarchical, collaborative, and competitive. One respondent foreshadowed changes the ARP Loyalton co-gen facility that may transition the network from a hierarchical structure to a negotiating or collaborative structure. This framework also uncovered network vulnerabilities including questionable resilience to changes in heterogeneity and network durability. Overall, the findings of this study suggest this proposed framework is useful for further exploring the bioenergy industry, identifying additional bioenergy barriers, and highlighting vulnerabilities within the network.

7.0 References

Aboii, S. (2012). The Secrets Behind San Antonio's Water Conservation Success | StateImpact Texas. Retrieved November 6, 2017, from https://stateimpact.npr.org/texas/2012/05/22/the-secrets-behind-san-antonios-water-conservation-success/

Agrawal, A., Chhatre, A., & Hardin, R. (2008). Changing governance of the world's forests. *Science (New York, N.Y.)*, *320*(5882), 1460–1462. https://doi.org/10.1126/science.1155369

Aguilar, F., & Garrett, H. E. (2009). Perspectives of Woody Biomass for Energy: Survey of State Foresters, State Energy Biomass Contacts, and National Council of Forestry Association Executives. *Journal of Forestry*, *107*(6), 297–306.

ARP. (2018). American Renewable Power acquires 20MW Biomass Plant in Loyalton, California. Retrieved March 7, 2019, from http://www.amerpower.com/news-details/9

ARP. (2019a). About American Renewable Power. Retrieved March 31, 2019, from https://www.amerpower.com/

ARP. (2019b). Loyalton Biomass Plant. Retrieved March 31, 2019, from http://www.amerpower.com/facilities-detail/6

Arts, B. (2014). Assessing forest governance from a 'Triple G' perspective: Government, governance, governmentality. *Forest Policy and Economics*, *49*, 17–22. https://doi.org/10.1016/j.forpol.2014.05.008

Becker, D. R., Abbas, D., Halvorsen, K. E., Jakes, P. J., McCaffrey, S. M., & Moseley, C. (2009). *Conventional Wisdoms of Woody Biomass Utilization*. *Journal of Forestry*. Retrieved from https://cesu.umn.edu/sites/cesu.umn.edu/files/mtu-usfs-02report.pdf

Becker, D. R., Larson, D., & Lowell, E. C. (2009). Financial considerations of policy options to enhance biomass utilization for reducing wildfire hazards. *Forest Policy and Economics*, *11*(8), 628–635. https://doi.org/10.1016/j.forpol.2009.08.007

Becker, D. R., Moseley, C., & Lee, C. (2011). A supply chain analysis framework for assessing state-level forest biomass utilization policies in the United States. *Biomass and Bioenergy*, *35*(4), 1429–1439. https://doi.org/10.1016/j.biombioe.2010.07.030

Beland Lindahl, K., Westholm, E., Beland Lindahl, K., & Westholm, E. (2010). Food, Paper, Wood, or Energy? Global Trends and Future Swedish Forest Use. *Forests*, *2*(1), 51–65. https://doi.org/10.3390/f2010051

Black, & Veatch. (2004). *Gainesville Regional Utilities - Supplementary study of generating alternatives for Deerhaven Generating station*. Jacksonville. Retrieved from https://www.gru.com/Portals/0/Legacy/Pdf/futurePower/SUPPLEMENTARY_STUDY_OF_GENERATING_ALTERNATIVES.pdf

Bodin, Ö. (2006). *A NETWORK PERSPECTIVE ON ECOSYSTEMS, SOCIETIES AND NATURAL RESOURCE MANAGEMENT*. Retrieved from https://pdfs.semanticscholar.org/dbed/60b3de676d13780aa5c77ef6c569ced4f7d0.pdf

Börzel, T. A. (1998). Organizing Babylon - on the different conceptions of policy networks. *Public Administration*, *76*(2), 253–273. https://doi.org/10.1111/1467-9299.00100

Bowers, S. (2012). *Designing Woodland Roads*. Retrieved from https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/ec1137.pdf

Bracmort, K. (2013). *Wildfire Fuels and Fuel Reduction Kelsi Bracmort Specialist in Agricultural Conservation and Natural Resources Policy*. Retrieved from www.crs.gov

California Biomass Energy Alliance. (2019). Biomass: Essential for California. Retrieved February 21, 2019, from http://www.calbiomass.org/general-statement/

California Legislative Information. SB-901 Wildfires. (2018). Retrieved from https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB901

California Legislature. SB-859 Public resources: greenhouse gas emissions and biomass. (2016). Retrieved from https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB859

Caplan, A. (2017a). Biomass buyout takes some big steps this week. Retrieved March 3, 2019, from https://www.gainesville.com/news/20170821/biomass-buyout-takes-some-big-steps-this-week

Caplan, A. (2017b). City gives final OK for biomass plant buy. Retrieved March 3, 2019, from https://www.gainesville.com/news/20170907/city-gives-final-ok-for-biomass-plant-buy

Carina, E., Keskitalo, H., Bergh, J., Felton, A., Björkman, C., Berlin, M., … Jokela, E. J. (2016). Adaptation to Climate Change in Swedish Forestry. https://doi.org/10.3390/f7020028

Carleton, L. E., & Becker, D. (2018). Forest biomass policy in Minnesota: Supply chain perspectives on barriers to bioenergy development. *Forests*, *9*(5), 254. https://doi.org/10.3390/f9050254

Carlsson, L. G., & Sandström, A. C. (2007). Network Governance of the Commons. *International Journal of the Commons*, *2*(1), 33. https://doi.org/10.18352/ijc.20

Carter, D., Langholtz, M., & Schroeder, R. (2007). *Economic Availability of Alternative Biomass Sources for Gainesville, Florida*. Gainsville, FL. Retrieved from https://www.academia.edu/2729665/Economic_Availability_of_Alternative_Biomass_Sources_for_Gainesville_Florida

Clean Energy Resources. (n.d.). *Laurentian Energy Authority Renewable Biomass Combined Heat and Power Energy Production from the Hibbing and Virginia Public Utilities.* Retrieved from https://www.cleanenergyresourceteams.org/files/CERTs_presntations_CHP_Hibbing_Virginia.pdf

Conway, K. (2018). *UTILIZATION-BIOENERGY GROUP TASK FORCE MEMBERS*. Retrieved from http://www.fire.ca.gov/treetaskforce/downloads/204_UTILIZATION_BIOENERGY.pdf

Courtney, R. A. (2018). Network governance in the heritage ecology. *Journal of Management and Governance*, *22*(3), 689–705. https://doi.org/10.1007/s10997-017-9399-z

CPUC. (2016). Public Utilities Commission of the State of California. Energy Division Resolution E-4137. Retrieved March 8, 2019, from https://www.gov.ca.gov/docs/10.30.15_Tree_Mortality_State_of_Emergency.pdf

Davies, J. S. (2012). Network governance theory: a Gramscian critique. *Environment and Planning A*, *44*, 2687–2704. https://doi.org/10.1068/a4585

Domac, J., Richards, K., & Risovic, S. (2005a). Socio-economic drivers in implementing bioenergy projects. In *Biomass and Bioenergy* (Vol. 28, pp. 97–106). Pergamon. https://doi.org/10.1016/j.biombioe.2004.08.002

Domac, J., Richards, K., & Risovic, S. (2005b). Socio-economic drivers in implementing bioenergy projects. *Biomass and Bioenergy*, *28*(2), 97–106. https://doi.org/10.1016/J.BIOMBIOE.2004.08.002

Evans, A. M., & Finkral, A. J. (2009). From renewable energy to fire risk reduction: A synthesis of biomass harvesting and utilization case studies in US forests. *GCB Bioenergy*, *1*(3), 211–219. https://doi.org/10.1111/j.1757-1707.2009.01013.x

Fei, P., Han-Sup, H., Johnson, L. R., & Elliot, W. J. (2008). Production and cost of harvesting, processing, and transporting small-diameter (~ 5 inches) trees for energy. *Forest Products Journal*, *58*(5), 47–53. https://doi.org/Article

Fleeger, W. E. (2008). Collaborating for Success: Community Wildfire Protection Planning in the Arizona White Mountains. *Journal of Forestry* , *106*(2), 78–82. Retrieved from https://search.proquest.com/docview/220813373/fulltextPDF/51D761D221A545FCPQ/1?accountid=14551

Gan, J., & Cashore, B. (2013). Opportunities and Challenges for Integrating Bioenergy into Sustainable Forest Management Certification Programs. *Journal of Forestry*, *111*(1), 11–16. https://doi.org/10.5849/jof.11-092

Gan, J., & Smith, C. T. (2007). Co-benefits of utilizing logging residues for bioenergy production: The case for East Texas, USA. *Biomass and Bioenergy*, *31*(9), 623–630. https://doi.org/10.1016/j.biombioe.2007.06.027

Giessen, L., & Buttoud, G. (2014). Defining and assessing forest governance. *Forest Policy and Economics*, *49*, 1–3. https://doi.org/10.1016/j.forpol.2014.11.009

Granovetter, M. (1986). The Strength of Weak Ties: A Network Theory Revisited. *Sociological Theory*, *1*, 201. https://doi.org/10.2307/202051

Guo, Z., Sun, C., & Grebner, D. L. (2007). Utilization of forest derived biomass for energy production in the U.S.A.: status, challenges, and public policies. *International Forestry Review*, *9*(3), 748–758. https://doi.org/10.1505/ifor.9.3.748

Hafdahl, B., & Berguson, B. (2013). *Commercial Application of Biomass Energy Laurentian Energy Authority*. Retrieved from https://www.energy.gov/sites/prod/files/2016/05/f31/feedstocks_berguson_7154_0.pdf

Han, H. S., Lee, H. W., & Johnson, L. R. (2004). Economic feasibility of an integrated harvesting system for small-diameter trees in southwest Idaho. *Forest Products Journal*, *54*(2), 21–27. https://doi.org/10.1007/978-3-7908-2375-2

Head, B. W. (2008). Assessing network-based collaborations. *Public Management Review*, *10*(6), 733–749. https://doi.org/10.1080/14719030802423087

Hjerpe, E. E., & Kim, Y.-S. (2008). Economic Impacts of Southwestern National Forest Fuels Reductions. *Journal of Forestry*, *106*(6), 311–316. https://doi.org/10.1093/jof/106.6.311

Holt, L. (2016). The importance of the regulatory framework for U.S. electric utility creditworthiness. *The Electricity Journal*, *29*(3), 13–18. https://doi.org/10.1016/J.TEJ.2016.03.002

ICF. (2006). *City of Gainesville Electricity Supply Needs*. Fairfax, VA. Retrieved from https://www.icf.com/news/2017/06/energy-efficiency-alberta-selects-icf-to-implement-energy-savings-program

Jossi, F. (2017). *Plant closures could be turning point for Minnesota biomass industry*. Retrieved from https://energynews.us/2017/09/29/midwest/plant-closures-could-be-turning-point-for-minnesota-biomass-industry/

Keefe, R., Anderson, N., Hogland, J., & Muhlenfeld, K. (2014). Woody Biomass Logistics. In *Cellulosic Energy Cropping Systems* (Vol. 9781119991, pp. 251–279). https://doi.org/10.1002/9781118676332.ch14

Keeler, D., & Bertrain, J. (2015). *SB 859: Funding for Cap-and-Trade Program and Forest Projects to Reduce GHG Emissions*. Retrieved from http://leginfo.legislature.ca.gov/.

Klijn, E. H. (2009). Networks and Inter-Organizational Management: Challenging, Steering, Evaluation, and the Role of Public Actors in Public Management. In *The Oxford Handbook of Public Management*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199226443.003.0012

Koliba, C., Meek, J. W., & Zia, A. (2011). *Governance networks in public administration and public policy*. CRC Press.

Langholtz, M. H., Stokes, B. J., & Eaton, L. M. (2016). *2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy*. https://doi.org/10.2172/1271651

Lester, T. K., Peterson, J., & Stathos, D. (2015). *Independent Investigative Review of the Gainesville Regional Utilities (GRU)*.

Lindahl, K. B., Sandström, C., & Sténs, A. (2018). Alternative pathways to sustainability? Comparing forest governance models. *Forest Policy and Economics*. https://doi.org/10.1016/j.forpol.2016.10.008

Lu, H., de Jong, M., & ten Heuvelhof, E. (2018). Explaining the variety in smart eco city development in China-What policy network theory can teach us about overcoming barriers in implementation? *Journal of Cleaner Production*, *196*, 135–149. https://doi.org/10.1016/j.jclepro.2018.05.266

Lynn, K. (2013). A triple 'S' for sustainability: Credit ratings agencies and their influence on the ecological modernization of an electricity utility. *Utilities Policy*, *27*, 9–14. https://doi.org/10.1016/J.JUP.2013.08.003

Madlener, R., & Vö Gtli, S. (2008). Diffusion of bioenergy in urban areas: A socio-economic analysis of the Swiss wood-fired cogeneration plant in Basel. https://doi.org/10.1016/j.biombioe.2008.01.006

Mafakheri, F., & Nasiri, F. (2014). Modeling of biomass-to-energy supply chain operations: Applications, challenges and research directions. *Energy Policy*, *67*, 116–126. https://doi.org/10.1016/j.enpol.2013.11.071

Malmsheimer, R., Heffernan, P., Brink, S., Crandall, D., Deneke, F., Galik, C., … Mortimer, M. (2008). Forest management solutions for mitigating climate change in the United States. *Journal of ForestryJournal of Forestry*, *106*. Retrieved from https://www.fs.usda.gov/ccrc/library/biblio/14334

Mattor, K. M., & Cheng, A. S. (2015). Contextual Factors Influencing Collaboration Levels and Outcomes in National Forest Stewardship Contracting. *Review of Policy Research*, *32*(6), 723–744. https://doi.org/10.1111/ropr.12151

Meersman, T. (2017a). Loggers and truckers sue Xcel Energy over proposed shutdowns of plants. Retrieved February 24, 2019, from http://www.startribune.com/loggers-and-truckers-sue-xcel-energy-over-proposed-shutdowns-of-plants/458920883/

Meersman, T. (2017b). New law allows much of Minnesota's biomass industry to be shut down. Retrieved December 3, 2018, from http://www.startribune.com/new-law-allows-much-of-minnesota-s-biomass-industry-to-be-shut-down/426537051/

Minnesota Public Utilities Commission (MN PUC). Petition of Approval to Terminate the Power Purchase Agreement (PPA) with Benson Power, LLC (Docket E002/M-17-530); Petition for Approval to Terminate the PPA with Laurentian Energy Authority I, LLC (LEA) (Docket E002/M-17-551) (2018).

Miranda, M. L., & Hale, B. (2001). *Protecting the forest from the trees: the social costs of energy production in Sweden*. *Energy* (Vol. 26). Retrieved from www.elsevier.com/locate/energy

National Interagency Fire Center. (2018). National Interagency Fire Center. Retrieved June 11, 2018, from https://www.nifc.gov/fireInfo/nfn.htm

Neary, D. G., & Zieroth, E. J. (2007). Forest bioenergy system to reduce the hazard of wildfires: White Mountains, Arizona. *Biomass and Bioenergy*, *31*, 638–645. https://doi.org/10.1016/j.biombioe.2007.06.028

Nguyen, M. D., Ancev, T., & Randall, A. (2018). Forest governance and economic values of forest ecosystem services in Vietnam. *Land Use Policy*. https://doi.org/10.1016/j.landusepol.2018.03.028

Nicholls, D. L., Halbrook, J. M., Benedum, M. E., Han, H.-S., Lowell, E. C., Becker, D. R., & Barbour, R. J. (2018). Socioeconomic Constraints to Biomass Removal from Forest Lands for Fire Risk Reduction in the Western U.s. *Forests*, *9*(5), 264. https://doi.org/10.3390/f9050264

Nielsen-pincus, M., & Moseley, C. (2009). Social Issues of Woody Biomass Utilization :, (20), 1–4.

PG&E. (2019). Bioenergy Renewable Auction Mechanism. Retrieved February 25, 2019, from https://www.pge.com/en_US/for-our-business-partners/energy-supply/electric-rfo/wholesale-electric-power-procurement/bioenergy-renewable-auction-mechanism-request-for-offers.page

Poocharoen, O., & Sovacool, B. K. (2012). Exploring the challenges of energy and resources network governance. *Energy Policy*, *42*, 409–418. https://doi.org/10.1016/J.ENPOL.2011.12.005

Provan, K. G., & Kenis, P. (2007). Modes of Network Governance: Structure, Management, and Effectiveness. *Journal of Public Administration Research and Theory*, *18*(2), 229–252. https://doi.org/10.1093/jopart/mum015

R.A.W. Rhodes. (2008). *The Oxford Handbook of Public Policy*. Oxford; New York: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199548453.001.0001

Reagans, R., & Zuckerman, E. W. (2001). Networks, Diversity, and Productivity: The Social Capital of Corporate R&D Teams. *Organizational Science*, *12*(4), 502–517. Retrieved from https://www.jstor.org/stable/pdf/3085985.pdf

Rhodes, R. A. W. (1996). The New Governance: Governing without Government. *Political Studies*, *44*(4), 652–667. https://doi.org/10.1111/j.1467-9248.1996.tb01747.x

Ropeik, A. (2018). Legislators Narrowly Override Sununu’s Biomass Veto, But Fall Short On Net Metering. Retrieved March 29, 2019, from https://www.nhpr.org/post/legislators-narrowly-override-sununus-biomass-veto-fall-short-net-metering#stream/0

Sandstrom, A. (2008). *Policy Networks: The relation between structure and performance*. Luleå University of Technology Department of Business Administration and Social Sciences Division of Political science. Retrieved from http://www.diva-portal.org/smash/get/diva2:989924/FULLTEXT01.pdf

Sandström, C., Lindahl, K. B., & Sténs, A. (2017, April). Comparing forest governance models. *Forest Policy and Economics*, *77*, 1–5. https://doi.org/10.1016/j.forpol.2016.10.007

Sessions, J., Wimer, J., Costales, F., & Wing, M. G. (2010). *Engineering Considerations in Road Assessment for Biomass Operations in Steep Terrain*. Retrieved from https://academic.oup.com/wjaf/article-abstract/25/3/144/4683577

Shindler, B. A., Brunson, M., & Stankey, G. H. (2002). *Social Acceptability of Forest Conditions and Management Practices: A Problem Analysis*. Retrieved from https://www.fs.fed.us/pnw/pubs/pnw_gtr537.pdf

State of California. (2013). Tree Mortality Task Force. Retrieved April 2, 2019, from http://www.fire.ca.gov/treetaskforce/index

Steelman, T. A. (2010). *Implementing innovation : fostering enduring change in environmental and natural resource governance*. Georgetown University Press. Retrieved from https://www.jstor.org/stable/j.ctt2tt61t

Stidham, M., & Simon-Brown, V. (2011). Stakeholder perspectives on converting forest biomass to energy in Oregon, USA. *Biomass and Bioenergy*, *35*(1), 203–213. https://doi.org/10.1016/j.biombioe.2010.08.014

Sundstrom, S., Nielsen-Pincus, M., Moseley, C., & Mccaffery, S. (2012). Woody Biomass Use Trends, Barriers, and Strategies: Perspectives of US Forest Service Managers. *Journal Of Forestry*, *110*(1), 16–24. Retrieved from http://pdxscholar.library.pdx.edu/esm_fac

Swirko, C. (2017). Biomass plant ordered to pay $4.6 million in damages. Retrieved March 8, 2019, from https://www.gainesville.com/news/20160623/biomass-plant-ordered-to-pay-46-million-in-damages

Tait, D. (2017). Understanding Public Utility Regulatory Policies Act of 1978 (PURPA). Retrieved November 6, 2018, from https://alcse.org/understanding-public-utility-regulatory-policies-act-1978-purpa/

U.S. Endowment. (2019). Wood2energy. Retrieved March 27, 2019, from https://www.wood2energy.org/

U.S. Energy Information Administration. (2018). *Short-term energy outlook*. Retrieved from https://www.eia.gov/outlooks/steo/report/renew_co2.php

U.S. Forest Service. (n.d.). What We Believe - US Forest Service. Retrieved April 3, 2019, from https://www.fs.fed.us/about-agency/what-we-believe

Union of Concerned Scientists. (2017). Public Utility Regulatory Policy Act (PURPA). Retrieved December 18, 2018, from https://www.ucsusa.org/clean_energy/smart-energy-solutions/strengthen-policy/public-utility-regulatory.html#.XBlCnWhKjIU

USDA. (2007). Woody Biomass Use Desk Guide. Retrieved from https://www.forestsandrangelands.gov/documents/woody-biomass/biomass_deskguide.pdf

USDA Forest Service, & UC Berkley. (2017). BioRAM Facility Woodbaskets Suitable National Forest System (NSF) Lands. Retrieved February 25, 2019, from http://www.fire.ca.gov/treetaskforce/downloads/TMTFMaterials/2017-04-27_BioRAM_ContractPlants_WoodBaskets_MWood_ v03.pdf

Westholm, E., Lindahl, K. B., & Kraxner, F. (2015). *The future use of nordic forests : a global perspective*.

Woody Biomass Utilization Group. (n.d.). Overview: Woody Biomass Utilization and the WBUG. Retrieved June 11, 2018, from https://www.forestsandrangelands.gov/Woody_Biomass/overview.shtml

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, *35*(5), 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001

Yin, R. K. (2012). *Case Study Research: design and methods*.

CHAPTER 4: CONCLUSION

The bioenergy industry is unique for several reasons. Beyond providing renewable energy, the industry encompasses various other benefits including the ability to stimulate rural economic development, reduce greenhouse gas emissions, and reduce the dependence on foreign energy sources. Despite these benefits, the pace and scale of bioenergy development is slow to progress. The challenges to the industry are not well understood in the context of policy responses and specifically unanswered questions including: How do challenges influence facility operations and how is policy developed in response to these challenges?

This research focused on these two vexing questions using key informant interviews and four case studies. Twenty key informant interviews provided insight on regional differences in facility operations, market conditions, policy intervention, and social conditions. Next, four case studies explored how barriers are manifested across a variety of characteristics and how policy is designed and implemented in response to these challenges. I conducted 20 additional semi-structure interviews with facility owners, managers, utilities, and other supply chain actors representing the four cases in four different states. This research included 40 interviews in total.

Key findings from this research included the existence of opportunities for forest bioenergy to become more economical including the need to monetize ecological benefits the and the avoided cost from catastrophic wildfire. Beyond monetizing ecological benefits, there is a need to recognize facilities as a vehicle to accomplish land management goals. The industry is vulnerable to fluctuations in politics and short-term, fluctuating policy support. Subsequently, wavering social and political support makes it difficult to advance durable policy solutions. Policy incentives are paramount for supporting stable markets through supply chain coordination, however, policy currently tends to favor alternative energy sources, particularly natural gas, solar, and wind.

Additionally, through an inductive coding process, elements of network governance surfaced. Based on the network governance literature, there are few empirical studies that explore the following question: How do forest bioenergy networks influence policy intervention? I proposed a framework to examine four dimensions of network governance: heterogeneity, integration, strength of ties, and structure. Heterogeneity identifies the variety of actors involved across social, jurisdictional, and administrative boundaries and the resources these actors bring to the network. Integration examines the coordination of actors to accomplish business transactions, including those involved in the decision-making process. Strength of ties pivots on the frequency of contact, levels of trust, and the ability to exchange resources. Structure refers to the overall organization and nature of relationships within the network. This framework is useful for examining the bioenergy industry and identifying additional barriers using a lens that provides insight into the theoretical underpinnings of bioenergy policy development. In addition, this framework identified vulnerabilities throughout the network. I applied this framework to one case study: the ARP Loyalton co-gen facility. Though limited to one case study, aspects of each dimension prevailed. However, dimensions such as integration and strength of ties were difficult to assess based on the data collected. Additionally, it is unclear whether the actors discussed throughout the interviews are the only actors participating in the network. Data collection in the form of additional interviews with network specific questions will take place this summer, followed by a more thorough exploration of how these networks impact the policy process.

Taken together, this research explored social-political, market, and logistical challenges to the bioenergy industry and how policy is developed in response to these challenges. This research does not prescribe policy solutions or advocate for particular policy recommendations, but rather highlights opportunities for future policy development for policymakers at both state and federal government levels.

APPENDIX A. TOTAL GREEN TON PER YEAR AND MW PRODUCED AGGREGATED BY STATE

State	Gt/Yr.	Production
Alabama	5,397,000	536.7
Arkansas	3,093,000	309.3
Arizona	270,000	27
California	4,115,000	368.5
Colorado	120,000	12
Florida	2,024,000	202.4
Georgia	5,096,000	509.6
Idaho	120,000	12
Kentucky	523,000	52.3
Louisiana	2,962,000	296.2
Massachusetts	2,800	0.28
Maryland	38,000	3.8
Maine	3,675,000	367.5
Michigan	790,000	79.0
Minnesota	2,342,000	234.2
Mississippi	2,791,000	279.1
Montana	37,500	3.75
North Carolina	3,757,000	375.7
New Hampshire	200,000	20.0
New Jersey	3,000	0.3
New York	452,800	45.28

Ohio	230,000	23.0
Oklahoma	578,000	57.8
Oregon	3,199,700	329.97
Pennsylvania	90,2000	90.2
South Carolina	400,4000	400.4
Texas	1,703,000	170.3
Tennessee	1,844,000	184.4
Virginia	2,175,000	217.5
Washington	2,751,000	274.1
Wisconsin	1,338,000	120.84
TOTAL	**56,533,800**	**5602.72**

CHP Totals

*6,044,500 gt/yr proposed/idle/closed

Thermal Totals

State	**Gt/Yr**	**Production**
Alaska	9,381	1.3341
Arizona	5	.0005
California	100,000	10
Colorado	27,592	2.7592
Connecticut	30,000	3
Georgia	220	0.22
Iowa	0	0
Idaho	47,800	4.78
Illinois	0	0
Indiana	56,300	5.63
Kentucky	756	0.0756
Massachusetts	37,350	3.87
Maryland	50,000	5

Maine	253,738	25.7338
Michigan	14,050	1.54
Minnesota	932,185	93.2185
Missouri	15,765	1.5765
Montana	46,440	5.264
North Carolina	50,000	5
North Dakota	1,800	.18
Nebraska	15,700	1.57
New Hampshire	235,218	24.1518
New Mexico	211,150	21.115
New York	202,560	20.256
Ohio	13,650	1.365
Oregon	1,994	0.883
Pennsylvania	80,400	8.04
Rhode Island	29,500	2.95
Tennessee	150,500	15.05
Virginia	34,000	3.4
Vermont	380,984	38.5644
Washington	90,000	9
Wisconsin	71,629	7.1629
Wyoming	50	.005
TOTAL	**3,190,717**	**322.6953**

*209707 gt/yr proposed/idle/closed

Power Totals

State	Gt/Yr	Production
California	2,970,000	291
Florida	2,370,000	237
Georgia	750.000	75
Hawaii	70,000	7
Massachusetts	170,000	17
Maine	1,880,000	188
Michigan	1,940,000	194
Minnesota	1,210,000	121
North Carolina	500,000	50
New Hampshire	2,170,000	217
New York	600,000	60
Pennsylvania	80,000	8
South Carolina	180,000	18
Texas	2,080,000	221
Virginia	3,397,000	403
Vermont	720,000	72
Washington	1,060,000	10
Wisconsin	700,000	70
TOTAL	**22,097,750**	**2259**

*450,000 gt/yr proposed/idle/closed

APPENDIX B: KEY INFORMANT INTERVIEW GUIDES

Social and Political Acceptability

1. Describe the social and political acceptability of forest bioenergy development in your region or other areas of the country you're familiar with.
   a. What do you see as the major social acceptability barriers?
   b. Political?
   c. Is there a difference between the social/political acceptability of using forest bioenergy for thermal vs electric?
   d. What about supply vs production?

2. From a social or political acceptability perspective, which case studies, biomass facilities, or projects should we be aware of for further investigation?

3. What elements of existing or proposed projects triggers negative social or political responses?
   a. Describe when/where these responses occur.

4. What is the role of existing policy in either positively or negatively affecting acceptability?
   a. Are there certain policies which trigger positive responses?
   b. Are there certain policies which trigger negative responses?
   c. Is there a difference between state or federal policies responses?
   d. How do state or federal policies like regulations or taxes affect biomass for energy?

5. What could be done to increase acceptability of current or planned bioenergy facilities?
   a. How could new state or federal policy affect bioenergy acceptability?

6. **6.** Of all the social and political challenges discussed, which represent the most significant obstacles hindering progress?

7. **7.** From a social acceptance perspective or otherwise, what else would you add to your responses?

Supply Chain Logistics

1. **1.** Describe the main challenges with forest biomass feedstock supply in your region or other areas of the country you're familiar with?

2. **2.** From a supply chain perspective, which case studies, biomass facilities, or projects should we be aware of for further investigation?

3. **3.** What are existing supply chain gaps to meeting woody biomass energy demand?

    - **a.** How do markets for other forest products influence opportunities for removing biomass?
        - **i.** How well does biomass compete with traditional products? Synergies?
    - **b.** How does logger capacity influence opportunities for removing biomass?
        - **i.** Probing: skills/equipment/number/age?

4. **4.** How do forest disruptions like wildfire, drought, invasive species, and disease affect biomass availability in your area?

5. **5.** What is the role of existing policy in either positively or negatively affecting bioenergy development?

   a. How do state or federal policies like financial incentives or feedstock contracts affect development?
   b. How have non-forest policies like taxes influence bioenergy production?
   c. How could new state of federal policy affect supply for current or planned facilities?

6. What other types of innovations or policy changes could increase forest bioenergy production for current or future facilities?

7. Of all the supply chain challenges discussed, which represent significant obstacles hindering progress?

8. From a supply chain perspective or otherwise, what else would you add to your responses?

Markets and Economic Development

1. What is the current state of thermal or electricity markets for forest bioenergy in your region or other areas of the country you're familiar with?

2. From a market perspective, which case studies, biomass facilities, or projects should we be aware of for further investigation?

3. How have policies affected investments in bioenergy projects in your area?
   a. What state or federal policies most influence electricity and thermal markets for bioenergy? Most facilitate or constrain?

4. How do you see energy markets changing, and how will that create opportunities or challenges for forest bioenergy?

   a. What type of incentives like production tax credits or off-take agreements could encourage private sector investments in biomass thermal or electricity production?

5. How has bioenergy production stimulated the economy or provided employment opportunities?
   a. Where has forest bioenergy production led to new jobs or economic development?
   b. What is the potential for bioenergy to affect economic development?
      i. What could be done to increase the economic impact of forest bioenergy?
      ii. How could new state or federal policy affect the economic impact of forest bioenergy?

6. Of all the market and economic development challenges discussed, which represent significant obstacles hindering progress?
7. From a market perspective or otherwise, what else would you add to your responses?

APPENDIX C: CASE STUDY INTERVIEW GUIDES

Case Study #1 - ARP Loyalton, California

- **Who am I:** [Interviewer] Member of a research team from different universities funded by the *USDA Office of the Chief Economist*.
- **Study:** The economic, social, or policy challenges and opportunities for forest bioenergy development across the nation.
- **Goals:** To better understand the viability of forest bioenergy, particularly when linked to wildfire risk reduction, forest restoration, and community development.
- **How:** By understanding local, regional, and national market strategies and policies to overcome barriers to utilization and/or expand investment opportunities.
- **Why you:** Because of your first-hand knowledge and experience as a [business owner, supplier, elected official, etc.] facilitating biomass utilization.

Biomass is defined as the by-product of management, restoration, and hazardous fuel treatments, including trees and woody plants (limbs, tops, needles, leaves). ***Biomass utilization*** is the use of biomass resulting in the production of a full range of wood products including timber, engineered lumber, pulp and paper, bioenergy and bio based products like plastics, ethanol, and biodiesel.

Background and Context

- Please introduce yourself. What is your role? How long have you worked in this capacity?
- What are the types of activities taking place to utilize forest biomass for heat or power generation in the region?
- What other <u>types</u> of forest product markets exist in the area (*e.g., pellets, energy, dimension lumber, OSB, engineered products, roundwood*)?

Landscape Challenges and Strategies

- What is the key challenge facing forested landscapes in your area?
- What was done to overcome those challenges?
    - What efforts worked and how did they affect progress? (*give examples*)
    - What efforts did not work and how did that affect progress? (*give examples*)

Market Challenges and Strategies

- Why did you undertake your project?
- What is the market(s) for the products from your facility?
- What is/are the key market challenges facing bio-energy in your area?
- What was done to overcome those challenges?
    - What efforts worked and how did they affect progress? (*give examples*)
    - What efforts did not work and how did that affect progress? (*give examples*)

Wood Supply Challenges and Strategies

- What is the source of wood for your facility?
- What is/are the key wood supply challenges facing bio-energy in your area?
- What was done to overcome those challenges?
    - What efforts worked and how did they affect progress? (*give examples*)
    - What efforts did not work and how did that affect progress? (*give examples*)

Social Challenges and Strategies

- Please tell me about community or stakeholder support or opposition to the bio-energy facility?
- What was done to overcome those challenges?
    - What efforts worked and how did they affect progress? (*give examples*)
    - What efforts did not work and how did that affect progress? (*give examples*)

Policy Challenges and Strategies

- Tell me about the BioRAM policy.
- What problem is it intended to address?
- What mechanisms does it employ?
- How effective would you gauge the policy to be to date? What have been the results?
- What are some areas for improvement?
    - What is being done or could be done to address these shortcomings?
- Have there been any unintended consequences?
- What happens to bio-energy markets at the end of the five-year period?
- Bioenergy markets face competition from low-cost fossil fuels. How has BioRAM impacted the ability to compete with fossil fuel sources of energy?
- Bioenergy markets also face competition from other renewables. How has BioRAM impacted the ability of bioenergy to compete with other renewables?
- How do existing state or federal policies operate in relation to one another?
    - Identify how specific state or federal policies are well-aligned across your supply chain to stimulate production? That inhibits production?
    - Are there opportunities to coordinate/link specific actions through policy?

    - To what degree are policies aligned with local wood energy investment challenges (e.g., permitting, financing)?
- Are there significant changes that your business has contemplated, or are currently contemplating, but have not made? What is prohibiting you making those changes?

Concluding Questions

- Anything else you would like to add? Something we didn't ask that you thought we should?
- Are there other people we should speak with?

Case study #2 - Deerhaven Renewable [formerly Gainesville Renewable Energy Center]

- **Who am I:** [Interviewer] Member of a research team from different universities funded by the *USDA Office of the Chief Economist*.
- **Study:** The economic, social, or policy challenges and opportunities for forest bioenergy development across the nation.
- **Goals:** To better understand the viability of forest bioenergy, particularly when linked to wildfire risk reduction, forest restoration, and community development.
- **How:** By understanding local, regional, and national market strategies and policies to address barriers to utilization and/or expand investment opportunities.
- **Why you:** Because of your first-hand knowledge and experience as a [business owner, supplier, elected official, etc.] facilitating biomass utilization.

Biomass is defined as the by-product of management, restoration, and hazardous fuel treatments, including trees and woody plants (limbs, tops, needles, leaves). ***Biomass utilization*** is the use of biomass resulting in the production of a full range of wood products including timber, engineered lumber, pulp and paper, bioenergy and bio based products like plastics, ethanol, and biodiesel.

Background and Context

- Please introduce yourself. How long have you worked in this capacity?
- What is your relationship to the Deerhaven Renewable facility (DHR, formerly known as the Gainesville Renewable Energy Center, or GREC)?

Landscape Challenges

- Are there continued opportunities for bioenergy in the Gainesville/Northern Florida area?
- Are there challenges facing bioenergy in the Gainesville/Northern Florida area? If so, has anything been done to address those challenges?

  - What efforts worked and how did they affect progress? (*give examples*)
  - What efforts did not work and how did that affect progress? (*give examples*)
- Has market uncertainty affected your work with DHR? What has been the role of policy in either easing or exacerbating uncertainty?
- Has the changing management/ownership structure of the DHR affected your operations?

Social Challenge and Strategies

- Tell me about community or stakeholder support or opposition for DHR since its inception?
- Has support/opposition changed over time? How and why?
- Has anything been done to overcome opposition to DHR?
  - What efforts worked and how did they affect progress? (*give examples*)
  - What efforts did not work and how did that affect progress? (*give examples*)

Policy Challenges and Strategies

- Have specific local, state, or national policies affected the design or operation of DHR? *(give examples)*
- How influential would you gauge policy to be in influencing the viability of DHR?
- Have there been any unintended consequences of policy on DHR operations?
- Has policy affected your work with DHR, specifically, or bioenergy, generally? If so, how?
- Have you taken any particular action in direct response to existing or proposed policies that would affect DHR, specifically, or bioenergy, generally?

[For relevant academic/government representatives and owners/ operators of open bioenergy facilities or suppliers]

Market and Supply Challenges and Strategies

- What is the source of feedstock material for DHR?
- Has DHR faced any feedstock challenges? If so, has anything been done to address those challenges?
    - What efforts worked and how did they affect progress? (*give examples*)
    - What efforts did not work and how did that affect progress? (*give examples*)
- Have these challenges evolved as the DHR operation has evolved?
- Bioenergy markets face competition from renewables and low-cost fossil fuels. Has local, state, or national policy impacted the ability for DHR to compete with other sources of energy?

[For relevant academics/government representatives, community leaders, elected officials, and other industry representatives]

Landscape Challenges and Strategies

- What are the key [energy/economic/forest management] challenges in the Gainesville/Northern Florida area?
- Have these challenges evolved as the DHR operation has evolved?
- Does bioenergy have the potential to help address [energy/economic/forest management] challenges?
    - If yes, has anything been implemented along these lines, and what were the results? (*give examples*).

- If no, what other investment or management opportunities do you think would help? (*give examples*).

Concluding Questions

- Where do you think the DHR facility will be in 5 years?
- What lessons would you would pass on to other [business owners, suppliers, communities…] considering bioenergy in their community?
- Anything else you would like to add? Something we didn't ask that you thought we should?
- Are there other people we should speak with about the DHR facility?

Case study # 3 Xcel Energy and Laurentian Energy Authority

- **Who am I:** [Interviewer] Member of a research team from different universities funded by the *USDA Office of the Chief Economist*.
- **Study:** The economic, social, or policy challenges and opportunities for forest bioenergy development across the nation.
- **Goals:** To better understand the viability of forest bioenergy, particularly when linked to wildfire risk reduction, forest restoration, and community development.
- **How:** By understanding local, regional, and national market strategies and policies to address barriers to utilization and/or expand investment opportunities.
- **Why you:** Because of your first-hand knowledge and experience as a [business owner, supplier, elected official, etc.] facilitating biomass utilization.

Biomass is defined as the by-product of management, restoration, and hazardous fuel treatments, including trees and woody plants (limbs, tops, needles, leaves). ***Biomass utilization*** is the use of biomass resulting in the production of a full range of wood products including timber, engineered lumber, pulp and paper, bioenergy and bio based products like plastics, ethanol, and biodiesel.

Background and Context

- Please introduce yourself. How long have you worked in this capacity?
- What is your relationship to Laurentian Energy Authority (LEA) or its individual facilities in Virginia or Hibbing, MN?

General Challenges and Strategies

- Are there continued opportunities for bioenergy in the Northern Minnesota area?
- Are there challenges facing bioenergy in the Northern Minnesota area? If so, has anything been done to address those challenges?

    - What efforts worked and how did they affect progress? (*give examples*)
    - What efforts did not work and how did that affect progress? (*give examples*)
- Has forest or electricity market uncertainty affected your work with Laurentian Energy? What has been the role of policy in either easing or exacerbating uncertainty?
- As I understand it, the LEA facilities were repowered coal units. Did that decision to repower present any technical or economic issues that affected your operations?
- As I understand it, LEA involved municipal-owned utilities operating under a PPA with an IOU. Has that market and ownership structure affected your operations?

Social Challenges and Strategies

- Tell me about community or stakeholder support or opposition for LEA or its individual facilities since the decision to repower from coal?
- What about the decision to end the PPA?
- Has support/opposition changed over time? How and why?
- Has anything been done to overcome opposition to LEA's decision to repower? To end the PPA?
    - What efforts worked and how did they affect progress? (*give examples*)
    - What efforts did not work and how did that affect progress? (*give examples*)

Policy Challenges and Strategies

- Have specific local, state, or national policies affected the design or operation of LEA or its individual units? *(give examples)*

- How influential would you gauge policy to be in influencing the viability of LEA's bioenergy operations?
- Have there been any unintended consequences of policy on LEA's operations?
- Have you taken any particular action in direct response to existing or proposed policies affecting LEA, specifically, or bioenergy, generally?

[For relevant academic/government representatives and owners/operators of open bioenergy facilities or suppliers]

Market and Supply Challenges and Strategies

- What was the source of feedstock material for LEA or the particular facility you worked with?
- Has LEA or its individual facilities faced any feedstock challenges? If so, has anything been done to address those challenges?
    - What efforts worked and how did they affect progress? (*give examples*)
    - What efforts did not work and how did that affect progress? (*give examples*)
- Were there efforts to pursue so-called closed-loop or purpose-grown energy crops for use by LEA? If so, did those efforts present any specific challenges or demonstrate opportunities?
- Has local, state, or national policy impacted the ability for LEA to compete with other sources of energy?

[For relevant academics/government representatives, community leaders, elected officials, and other industry representatives]

Landscape Challenges and Strategies

- What are the key [energy/economic/forest management] challenges in the Northern Minnesota area?
- Have these challenges evolved as LEA's operations have evolved?
- Does bioenergy have the potential to help address [energy/economic/forest management] challenges in the Northern Minnesota area?
    - If yes, has anything been implemented along these lines, and what were the results? (*give examples*).
    - If no, what other investment or management opportunities do you think would help? (*give examples*)
- What do you expect to happen now that the PPA has been cancelled?

CONCLUDING QUESTIONS

- Where do you think the LEA will be in 5 years with respect to bioenergy?
- Are there other people we should speak with about the LEA or its individual facilities?

Case Study # 4- Bridgewater Power, Ashland NH

- **Who am I:** [Interviewer] Member of a research team from different universities funded by the *USDA Office of the Chief Economist*.
- **Study:** The economic, social, or policy challenges and opportunities for forest bioenergy development across the nation.
- **Goals:** To better understand the viability of forest bioenergy, particularly when linked to wildfire risk reduction, forest restoration, and community development.
- **How:** By understanding local, regional, and national market strategies and policies to address barriers to utilization and/or expand investment opportunities.
- **Why you:** Because of your first-hand knowledge and experience as a [business owner, supplier, elected official, etc.] facilitating biomass utilization.

Biomass is defined as the by-product of management, restoration, and hazardous fuel treatments, including trees and woody plants (limbs, tops, needles, leaves). ***Biomass utilization*** is the use of biomass resulting in the production of a full range of wood products including timber, engineered lumber, pulp and paper, bioenergy and bio based products like plastics, ethanol, and biodiesel.

Landscape Challenges and Strategies

- What is/are the key challenge(s) facing forested landscapes in your area?
- What was done to overcome those challenges?
    - What efforts worked and how did they affect progress? (*give examples*)
    - What efforts did not work and how did that affect progress? (*give examples*)
- What is/are the key market challenges facing bio-energy in your area?
- What has been does to address these challenges?

Wood Supply Challenges and Strategies

- What is the source of raw materials for bio-energy facilities in your area?
- What is/are the key wood supply challenges facing bio-energy in your area?
- What was done to overcome those challenges?

Social Challenges and Strategies

- Please tell me about community or stakeholder support or opposition to bio-energy facilities?
- What was done to overcome those challenges?
    - What efforts worked and how did they affect progress? (*give examples*)
    - What efforts did not work and how did that affect progress? (*give examples*)

Policy Challenges and Strategies

- What problem are SB 129 and SB 365 programs intended to address?
- What mechanisms do they employ?
- To what extent has these policy vehicles been able to overcome challenges mentioned above?
- How effective would you judge the policy to be to date? What have been the results?
- Could you point to any areas for improvement?
    - What is being done or could be done to address these shortcomings?
- What happens to bio-energy facilities participating in the program at the end of the five-year period?
- Have there been any unintended consequences?
- How have SB 129 and SB 365 impacted the ability to compete with fossil fuel sources of energy?

- How have they impacted the ability of bioenergy to compete with other renewables?
- How do existing state or federal policies operate in relation to one another?
- Can you point to examples where specific state or federal policies are well-aligned across the supply chain to stimulate production?
  - What about the reverse?

Concluding Questions

- Anything else you would like to add? Something we didn't to ask that you though we should?

APPENDIX D – CASE STUDY CODEBOOK

CODES	CODING INSTRUCTIONS	EXAMPLES
Barrier	Code if mention of specific barrier to the use of biomass for energy in the past, present, or future	1.Yes, I was saying a lot of these facilities weren't set up to handle mill residues, which would have been a lot, a more, an inexpensive easier feedstock for these facilities than going out and collecting tops and limbs in the woods 2. Where we are, if you talk about landscape problems, within 30 minutes we just did a [inaudible 00:13:13] which is a minimum residual, and we actually withdrew the bid a day before it was due in, because my forester said, "Steve, it's not the material. The material's there, it's 23 miles away by truck, it's getting it out of there." 3. So, biomass was never going to get recontracted under this program that doesn't recognize any value to the base load qualities of biomass facility, and the environment benefits, the

		forest health benefits, the air quality benefits, the greenhouse gas emissions benefits, beyond the renewable attributes, our RPS program just doesn't recognize that. It tries to looking very technology-neutral but in fact, it is anything but technology-neutral right now.
Community_ Engagement	Code if mention of community or social aspect (e.g., advocacy, pressure/support) to past, present, or future use of bioenergy	1.that keeping this biomass plants operating was critical to the health of the forest as well as the rural community employment. Our plant employees 25 direct and maybe 100 indirect, you only needed to see what's happened to the town of Loyalton, which was basically a dying town, has turned around overnight. 2. No, not opposition. I would say, well, there’s just been no energy around it. There hasn't been a lot of strict opposition, except for maybe solar and wind lobbies. But I mean, people are just, they’re just kind of very neutral about it. They don’t really, they’re not excited about it. I wouldn’t say, they’re, they’re not going to be out there picketing, there’s just not a lot of interest in general around it.

Societal benefits	Code if mention of the societal benefits of a facility, biomass utilization, or forest management. Benefits include: rural economic development, drinking water, reduced fire risks, etc.	1. that keeping this biomass plants operating was critical to the health of the forest as well as the rural community employment. Our plant employees 25 direct and maybe 100 indirect, you only needed to see what's happened to the town of Loyalton, which was basically a dying town, has turned around overnight. 2. So it sounds like that, even though this program isn't necessarily raising bioenergy up to a point where it could compete with other renewables, they're building a constituency of people who understand the role of bioenergy in these forests' health and community wildfire protection questions, as well as the economic development part.
Education	Code if mention of public education or information regarding the role of using biomass to support forest	1. forest products sector hasn't been great about telling the story that trees are a renewable resource and we need to manage our forests because of hazardous fuels and forest health and all those things that are really kind of, in my mind,

	management or energy purposes relating to the past, present, or future of bioenergy	coming back to haunt us now because we haven't been telling our story enough to the public. 2. But then in general I also think that there needs to be and there remains a lot of educational opportunities surrounding the role of biomass or forest biomass for generating energy and electricity, etc., where, because it is a, an abundant resource here in Minnesota and certainly our, historically our economy has been, been tied to quite strongly to the use of forest biomass for generating energy
Markets and economics	Code if mention of financial aspect to past, present, or future use of bioenergy, including, rural economic development and cost compared to other energies. Key words include: cost, expense, price point, economics, bids, affordability, profit, revenue, job creation, job retainment	1.We can't even bid because the economics of bidding are 60, $70 a ton to get it out, because the forest service themselves did not price in their bids for logging the materials handling of the residuals. 2. How much is it going to cost for me to get this material? How do I solve for this right? What happened is many of them said screw it I'm just going to bid it in at 120 bucks, if they don't like it screw them I'll just shut down the plant, I was already

	(particularly in reference to rural areas), least-cost best-fit, cost-competitive, capital, or financing	planning on closing the plant anyway. It's not like a ... Loyalton is a new investment they have $15 million in new capital. All these other plants were already existing they had no new capital investment, they had existing employees, everything was warm. For them the risks against the returns were enormous, and so each of the first five and ultimately of the seven, the only reason we did well, I had zero options. 3. Jumping to the sliding scale of 50, 60, 80 so 50 year one 60 year two, and then 80 starting for the last three years, would be uneconomic and is frankly exactly what that was the unintended consequence, of changing the market from $30 dollars of bone dry ton to numbers I've seen. By the way this is for the record its being recorded, we've seen very recent numbers as high as $65 of bone dry ton being offered for material that would have otherwise come to our plant. We can't afford to pay it, we very directly told the supplier.
Energy markets	Code if mention of unfair or uneven competition within the	1. I know it's hard to compete with natural gas that, when they burn it and when they increase power at two cents a kilowatt or

	energy sector or renewable energy market	one cent a kilowatt and here you are trying to do, burning biofuels at eight or ten cents and you can't, power companies don't pay that. 2. The cost to the utility purchasing the energy is the, the largest challenge. There's other "green energy" sources that are more readily available, a lot more established, have received a lot more state incentives over the last decade, and thus have developed a lot further than wood energy. So that, that's the biggest challenge is the cost competitiveness at this point. And then of course the, the low price of fossil fuels has been working against us for the last few years as well.
Forest markets	Code if mention of forest product, electricity, or energy market aspect to past, present, or future use of bioenergy. Key words include: supply, demand, market distortion, forest	1. But I look at the challenges that we have. Mostly it's related to, I think supply and output for getting rid of our product. So if we're selling sawlogs or timber, biomass, all that stuff is having more than, we got one mill in town, Sierra Pacific Industries, so that's pretty much where 95% of our material goes. Biomass, Honey Lake Power, Greenleaf Power up in Wendel, was one of our main outlets. But 120 miles one way for the majority of our

	products, product outlets, price, competition	projects doesn't make it profitable. For us to try and find a outlet for gettin' rid of these products, has been a challenge. The sawlog, not so much, but when you look at your biomass, your nonmerchable material, that's where it's difficult to get out of the woods. 2. Well, we're gonna see changes to the market before then. I think some plants are gonna have to take their drop-down price, in which case we'll see higher prices of energy with no high hazard zone material being consumed. And hopefully, at the end of five years, for those plants that have the option to extend their contracts, they will be able to continue extending their contracts.
Operations costs	Code if mention of high costs associated with past, present, or future bioenergy use	1. In essence, it's crazy because we might the supply in the mountains, but we can't pay the price and the higher cost of plants sometimes

		2. So, what we have heard loud and clear from industry is you know what, we can't make a living. We can make a living with saw logs, but the bio-mass is not paying for itself.
Environmental conditions	Code if mention of ambient environmental or resource conditions (e.g., air quality, forest management, water quality, GHGs, wildfire, habitat) associated with or affected by past, present, or future use of bioenergy	1. Certainly a lot of people have been coming around, not because of BioRAM, just because of all that talk about mortality. So we get bigger players interested in putting in export pellet facilities or export chip facilities. There's been more movement about that. There's more discussions about trying to amend the limitation of export, and the prohibition of export of government logs. Billions, tens of billions of dead forestry, of dead trees in the southern Sierras especially. 2. So we have a lot of stand density issues, with stand density issues you know, they become forest health issues, insect disease, a lot higher level of susceptibility to [inaudible 00:03:41] in the environment with drought, insects, and it's got a lot of overstocked stands, and they're very susceptible to potential catastrophic fire, because when they do burn, they burn very hot and move very rapidly, very destructive.

Facility characteristics	Code if mention of characteristics unique to the facility	1. For my plant, I can't speak for any of the others although I've spoken to each one of them. I have 212 acres, I have massive infrastructure on my site, and therefore I have a capacity, uniquely I have the capacity to attract a CLT plan. A specialty saw mill that does slabs and [fletches 00:51:24]. We can attract data centers, because we have large fiber optic capacity that happens to wander through the single main street of Loyalton. Our goal is to attract businesses onto the site, so that 15 or 12 megawatts of my power can be continuously used along with steam, along with hot water on the site, after the contract. That's my single remaining goal.
Governance_ administrative	Code if mention of governance or administrative aspect (e.g., contracting, management, bids, approvals, reviews) to past, present, or future us of bioenergy	1. The variability definitely affects their operations, kind of how they choose to ramp it up and down, you know feedstock availability. In terms, in terms of DHR, I wouldn't say it's, you know, it exists, so they just kind of use it as they see fit. They, they look at the marginal costs of that source versus everything else and kind of blend it in there.

		2. We chose to make an investment in a plan to last 25 more years. That was a strategic decision at the time, which in retrospect I'm now looking and saying well why bother? Why was I so nice to build the plant for the last 25 more years? I did look at the site day one and say there's no reason we should be selling power over the fence in five years' time. That was once I realized that I was going to be only stuck with a five year contract. I said well screw this we can surely come up with a better solution for ourselves. I think everybody has honestly agreed with me, that the future for us is inside the fence. We've got one grant given to us, we've got to start proving that in.
Contracting	Code if mention of contracting, issuing bids, or other administrative factors relating to past, present, or future bioenergy development	1. Correct and that was the forest service standard back prior to '96. If you went and looked at bids issued in '92, '93, '94, '95, '96 although I don't think anybody's had a PhD on it, you'll find that all the tenders in the US required the logger to retain ownership and be obligated for complete removal. Then they backed that off to well just get it, stack it and put it down at a suitable landing, it can be accessed by a third party contractor.

		What happened it cost 3, $400,000 top put a big document together for a logging contract. 2. If you didn't meet it they effectively there's lots of people will tell you differently, but bottom line is they will terminate the contract. The contract will become economic therefore the parties will mutually agree to terminate. That's the end result of what happens under these contracts.
Political influences	Code if mention of political aspect to past, present, or future use of bioenergy	1. And there's always ongoing [inaudible] uncertainties with leadership within some of those communities, whereby a lot of work goes into it and you get decision-makers familiar with a lot of the different factors that need to be considered in these types of developments and then election cycles happen and you get new people in and then you start from, you know, kind of, you know step one again. So there's there's always those types of challenges around these often times pretty significant decisions that need to be made at a local level and so I think that that has also plagued some of the potential opportunities

		that are out there for expanding some of the development of those types of systems
Synergistic relationships	Code if mention of the role of synergy or relationships between actors creating barriers or opportunities for bioenergy	1. when you are on the saw mill side, you've got all kinds of good things you can do. For instance, in as I talk to saw mill operations, I was just up in Canada meeting with saw mill owners, all of them said the same thing. They said we couldn't exist without our biomass plant. We encourage you to encourage others to recognize being on your site would be extremely valuable 2. With as far as their operational capabilities for a variety of reasons, but the ones that are very successful, they're always usually aligned with a saw mill because they can rely on that saw mill waste to make up during those lean times. And I think that's something you know already.
Opportunity	Code if mention of specific opportunity for future bioenergy installation or continued use	1. guys of the 200 plus biomass Cogen plants I will say, I used biomass and Cogen interchangeably here, but the ones that are integrated to industrial operations, will be the only ones left.

		2. When you stacked it all up, you got 330,000 tons of fiber times $50. You had a margin within an hour's drive that was very respectable.
Outcome	Code if mention of specific result due to bioenergy installation, continued use, abandonment, or policy. Key words include: result of, intended consequence, because of,	1. That mill was closed in 2002 and torn down. Predominantly because of new federal policies that had been introduced into the US forest systems in the mid-1990s to constrict logging, constrain activities in the national forests. This was based on public will, as you recall. So that was one of maybe 50 sawmills in California and Oregon that closed down between the late 1990s, and the end of say 2009, but of the site itself, still had the biomass plant. The Cogen biomass plant ran as a standalone generator under a contract in California ISO system. That closed in 2010 largely because the utilities said, "We're not interested in buying a new contract, good luck." 2. Well if it was set up to keep bio plants running, they've been tremendously effective. Has it helped in ensuring that roughly I'm just going to use a rough number 1.5 million green tons have been removed from the national forest, yes. Has it now

		expanded to seven with [inaudible 00:50:25] and Loyalton? That's maybe two million a year it's coming off the landscape, very effective. Is it well considered for the long term no, the impact on the national forest on a four year and 11 month, 30 day plan, no. You and I both know that, the forest need 20 years stewardship contracts, they need 20 year plans.
Policy	Code if mention of specific policy initiatives (e.g., incentives, mandates) relating to past, present, or future use of bioenergy	1. Predominantly because of new federal policies that had been introduced into the US forest systems in the mid-1990s to constrict logging, constrain activities in the national forests. 2. Well if it was set up to keep bio plants running, they've been tremendously effective. Has it helped in ensuring that roughly I'm just going to use a rough number 1.5 million green tons have been removed from the national forest, yes. Has it now expanded to seven with [inaudible 00:50:25] and Loyalton? That's maybe two million a year it's coming off the landscape, very effective. Is it well considered for the long term no, the impact on the national forest on a four year and 11 month, 30

		day plan, no. You and I both know that, the forest need 20-year stewardship contracts, they need 20 year plans.
Need-based policy	Code if mention of action due to environmental disasters such as wildfires, drought, insects or disease	1. It was designed to respond to the governor's proclamation, this proclamation saying "we have a lot of dead trees, we need to do something about them". And essentially, the dead tree argument was used to keep winning these plants that would have otherwise been shut down. And once they're shut down they're very hard to bring back. There's a lot of things, but the main thing, it wasn't long term it was more seen as a bridge to a better solution. 2. the program was set up to deal with this very immediate hazard of 120 million dead trees in the Sierra, and what you're talking is kind of rethinking the program so that it can deal with that, but also deal with the current and evolving threat of these large-scale wildfires on the landscape.

Policy flexibility	Code if mention of, or lack of, characteristics of flexibility relating to policy	1. Yeah, I know if they would, if there's more flexibility in that high hazard zone or they can use product outside the high hazard zone would also make a good, would make it more attractive for purchasers to get that material there. The way we designated those was by watershed, so a lot of this stuff should be designated by forest and with whole forest completely because we get about 99% of our forest. All that stuff is in a high hazard zone when it comes to insects and disease, or wildfire protection. Whether that policy can be changed or has changed to allow that material to go there and sell off for an attractive price would be beneficial. 2. The forest health issues. And the rest don't have that solution. So, BioRAM today is successful, it could be hugely successful with an expanded definition of the type of fuel it can take, but they still have a biomass industry that needs a more complete, long term solution.
Policy uncertainty	Code if mention of inconsistent policy or uncertainty relating to	1. At the last minute they increased they being the utilities, politically enforced the CTUC public utilities commission to mandate, not 20% which is what the forest service said. Not

	the past, present, or future of bioenergy use	30%but 60 to 80% of all the content of material coming in to each of this biomass plants, would have to be from very selected sections of the national forest system. They were deemed tier one tier two high has. That was literally done in a conference meeting, never disclosed until they issued it. The five prospective bidders because [inaudible 00:46:30] had to go out to bid with the utilities the 3D and IOUs, that was a mandate. The mechanics of it the intent of these plants remember were running at the time this legislation was being put in place. 2. there was some uncertainty about whether biomass would be considered renewable or not. So we, you know, built the biomass plant, obviously, under the expectation that it would be deemed renewable, but that was called into question. Recently it was decided that biomass, generally if you have good forest and supply chain logistics and checks and balances for the sources of your fuel that it is renewable, replenished, then it’s deemed renewable. So that was one policy question that was looming overhead for us

Unintended policy consequences	Code if mention of unintended or unexpected consequences resulting from implementing a policy, supplying a facility, establishing a contract, or other actions relating to past, present, or future use of bioenergy	1. Its meaning that hundreds of thousands of tons of ag residuals either have to be burned or otherwise disposed of. So BioRAM displaced or disrupted that side path where most of the plants in the areas we talked about.
Precedent	Code if mention of specific factor or pattern associated with past experience with bioenergy that 'sets the stage'	1. As I mentioned before, the IRP recommended 50 MW. And so, I think GRU offered or GRU released annotation to negotiate for biomass facilities up to 50 MW, or maybe it was up to 75, and we had an offer from Gainesville Renewable Energy Center for a 100MW unit, and the heat rate, the efficiency, was a lot better compared than the other offers because of its size. And so at that time, the decision was made to, to go with that and just find a buyer for the other 50 MW. Well, that never came to fruition at the prices that were in our PPA. So we ended up swallowing the entire 100MW, which is, you know, how a lot of the rate pressure came in.

		2. You bought the facility with the intention to sell renewable power under the open access provisions to data centers, and other people who'd be interested in green power. Then you later realized that that was not enough, because that law had been rescinded.
Supply chain logistics	Code if mention of a supply chain, logistics, or transportation aspect to past, present, or future use of bio-energy	1. There are a couple paper consumers that will take paper grade chips, but essentially my point is the suppliers that work in the bioenergy sector supplying these facilities are specialized and have typically additional equipment costs because they also work in those other wood energy, excuse me, wood product sectors. So they've go specialized equipment to feed these type of facilities, and of course, like any equipment there’s maintenance and, and for example, walking floor trailers really, that’s not a, a typical requirement for a logger working in Northern Minnesota, that's a, a specialty piece of equipment they would have to purchase to supply these types of facilities. So that’s part of it, is the, the specialized equipment that they need to feed these facilities.

Lack of resources	Code if mention of lack of truck drivers, loggers, funding, etc. relating to the supply chain for past, present, or future bioenergy development	1. When I look back 15 years ago, even 10 years ago, we had a lot more loggers out there. And a lot smaller loggers that, you know, they had chippers, you know, they had all the equipment to remove the saw log, of course the fellow munchers and the hot saws. But we lost a lot of that capacity. Now we have very few, a very limited amount of the folks that are in the logs business here. It has carved the California air resources for placing very stringent regulations on trucks, and not only trucks, but chippers and about 6-7 years ago those air quality regulations came into play. 2. I think almost any newspaper you would pick up nationwide would point to a truck driver crisis around the country. And I think that's especially true in the wood markets because hauling wood pays less than a lot of the other you know potential opportunities for truck drivers out there. So everybody's always looking for drivers and not enough drivers, not enough drivers on the road.

Technology_ transportation	Code if mention of technology including equipment, advancements, engineering, and/or technical support	1. There are not a lot of other wood consuming facilities that aren't wood energy facilities that would take chips or grindings, it's pretty much a pulp wood, saw log dominated market. There are a couple paper consumers that will take paper grade chips, but essentially my point is the suppliers that work in the bioenergy sector supplying these facilities are specialized and have typically additional equipment costs because they also work in those other wood energy, excuse me, wood product sectors. So they've go specialized equipment to feed these type of facilities, and of course, like any equipment there's maintenance and, and for example, walking floor trailers really, that's not a, a typical requirement for a logger working in Northern Minnesota, that's a, a specialty piece of equipment they would have to purchase to supply these types of facilities. So that's part of it, is the, the specialized equipment that they need to feed these facilities. 2. I think that without some significant technological advances that can be proven not only at the pilot and, kind of, semi

	commercial-scale you're going to see biomass continue to struggle to find real widespread adoption.