CALIFORNIA ENERGY COMMISSION

Energy Research and Development Division

FINAL PROJECT REPORT

Advancing Biomass Combined Heat and Power Technology

Supporting Rural California, the Environment, and the Electrical Grid

Gavin Newsom, Governor

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PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation and bring ideas from the lab to the marketplace. The CEC and the state's three largest investor-owned utilities—Pacific Gas and Electric Company, San Diego Gas & Electric Company and Southern California Edison Company—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The CEC is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

Advancing Biomass Combined Heat and Power Technology: Supporting Rural California, the Environment, and the Electrical Grid is the final report for the Advancing Biomass Combined Heat and Power Technology to Support Rural California, the Environment, and the Electrical Grid project (Contract Number EPC-14-082) conducted by Sierra Institute for Community and Environment. The information from this project contributes to the Energy Research and Development Division's EPIC Program.

For more information about the Energy Research and Development Division, please visit the CEC's research website (www.energy.ca.gov/research/) or contact the CEC at 916-327-1551.

ABSTRACT

Community-scale biomass energy represents an opportunity to link renewable energy generation with forest restoration, reduced wildfire risk, and rural economic development. The Plumas Health and Human Services Center biomass facility blends biomass boiler technology with an organic Rankine cycle electricity generator to provide heat and power to a county office building, lowering and stabilizing its electrical consumption. This facility demonstrates how multiple benefits can be achieved through the targeted implementation of advanced renewable combined heat and power technology based on woody biomass in the commercial and institutional building sector.

This project demonstrated that combining heat and power generation with heat use is essential to the economics of community-scale biomass energy; combustion of dry fuel improves overall system operations and efficiencies while increasing cost savings and reducing emissions; and organic Rankine cycle power generation from biomass is best suited when it supplements heat-led systems to improve economics.

With credit due to a dedicated project team and partners, this project has been a success, and it demonstrates the viability of biomass heat and power applications at a community scale in rural forested communities of California. Sierra Institute will continue to serve as a resource and support entities in Plumas County and beyond that have interest in biomass energy, as part of its commitment to building capacity, promoting replication, and sharing lessons learned from its work. It is essential that entities interested in biomass energy recognize and value the variety of co-benefits these systems provide and consider more than just cost. Capital costs of biomass boilers are higher than fossil fuel boilers, but will likely have reduced operational costs and more stable fuel pricing, and importantly contribute to restoration of California's forests and help California achieve its carbon neutrality goals.

Keywords: Biomass, organic Rankine cycle, thermal energy, wood utilization, community-scale, district energy, rural communities, forest health, economic development.

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EXECUTIVE SUMMARY

Introduction

Communities in the rural, forested, and mountainous regions of California often experience peak electrical loads during the winter months due to a reliance on outmoded electric heating, heat pumps with poor performance, and fuel switching from oil and propane to electricity when fossil fuel prices spike. These regions are not served by inexpensive natural gas pipelines, so critical institutions (such as schools, hospitals, county offices, and so on) must rely on expensive fossil fuels for heating. Because many rural forest communities have higher than average rates of unemployment, aging populations, and a small tax base, the expense and volatility of fossil fuel markets can place a financial strain on these institutions, underscoring the value of biomass power.

These communities are also challenged to meet air quality standards during the winter months due to air inversions in the valleys, heavy reliance on wood-burning stoves, and open pile burning of yard waste and by-products of forest thinning. Further, these areas are increasingly threatened by catastrophic wildfires, the result of unnaturally dense forests and the effects of climate change that threaten landscapes and the safety of residents and infrastructure, including the electrical grid.

Biomass heating systems offer an opportunity to address these challenges in rural forested parts of California. By generating high-quality heat sourced from local renewables, biomass heating systems can reduce heating costs for buildings with a high heat demand that are otherwise limited to heating with fossil fuels or through an already-strained electrical grid. Forest biomass, which includes all parts of the tree and brush, is a locally abundant, renewable natural resource that can serve as an alternative source of fuel for public institutions with high heat demand. Biomass heating facilities also offer an outlet for waste forest biomass material, a byproduct of forest restoration, and for the much-needed reduction of hazardous fuels throughout California. By developing an outlet for byproducts resulting from hazardous fuels reduction work that would otherwise be burned in a pile or in a wildfire, these facilities help improve air quality and reduce emissions from pile burning and wildfires, as well as avoid climate-degrading gases like methane from waste material decomposing on the forest floor. In doing so, they contribute to restoring California's forests and help California achieve its carbon neutrality goals.

The advantages of community-scale biomass energy are well proven and widespread in Europe and some parts of northeastern United States. Most successful examples of thermal biomass facilities work because of the wide variety of benefits to the owners beyond economic benefits, which is the reason many biomass heating projects are in schools, public buildings, and facilities run by nonprofit organizations.

Unfortunately, high capital costs, lack of familiarity with the technology, and the risk-averse nature of impoverished rural communities in California and the western United States have limited development of such systems. As a response, Sierra Institute sought to develop a community-scale biomass energy facility at a government building in Quincy in Plumas County to serve as a demonstration of opportunities for use of forest biomass while also generating renewable energy locally.

Prior to this project, the Plumas County Health and Human Services Center experienced high energy costs due to reliance on electric boilers that were installed to preheat water and compensate for an under-sized geothermal field and poorly performing heat pumps. The building's demand was significant on an already-strained rural electrical grid, and the county was burdened with high electricity costs to keep the building warm in the winter months. Plumas County had an urgent need for a solution as heat pumps at this building were failing due to being overworked from trying to extract heat from nearly freezing supply water from the under-sized geothermal field.

Project Purpose

The Plumas County Health and Human Services Center biomass facility was developed to demonstrate how to achieve multiple economic and environmental benefits through targeted implementation of advanced renewable biomass combined heat and power technology in the commercial and institutional building sector. It is the first community-scale biomass-fired heat and power system in a district energy application in California. The project is unique because it represents an innovative link among well-tested boiler technology; specific state laws and policies regarding increased use of forest biomass; direct economic, environmental, and community health benefits for ratepayers; state statutory energy goals; and clean energy jobs in California.

Project Goals and Objectives

The goals in developing this project were to demonstrate and set the prototype for community-scale biomass heat and power in rural communities to:

- Reduce demand on the electric grid at peak and non-peak times.
- Reduce costs to ratepayers by increasing the coefficient of performance of heat pump systems at the Plumas County Health and Human Services Center, eliminating electric boiler use at the center.
- Advance an emerging technology in California and increase understanding of the effectiveness of biomass as a source of renewable energy.
- Reduce reliance on fossil fuels at Feather River College.
- Demonstrate the intersection of California Energy Commission program goals and community and environmental needs.

In addition, the project would reduce wildfire risk, revitalize a local forest products economy, and reduce Plumas County's reliance on an inefficient and failing geothermal system.

Project objectives were to:

- Generate 35 kilowatts of electricity.
- Provide up to 400 kilowatts of thermal energy to the Health and Human Services Center.
- Save $40,000 in electricity costs per year.
- Reduce demand peak by 205 kilowatts.
- Increase markets for forest biomass by 815 tons.

- Keep energy dollars local and reduce total energy spending by the county and community college.

Project Approach

This project evolved from a Plumas Energy Efficiency and Renewables Management Action Plan that the Sierra Institute and Plumas County stakeholders developed in 2012 with support from a California Energy Commission planning grant. The plan sought to identify, develop, and begin to implement a renewable energy plan for Plumas County focused on use of forest biomass — one of the county's most abundant sources of renewable energy.

The facility incorporates organic Rankine cycle electrical generation technology to further reduce the Plumas County Health and Human Services Center's demand on the grid. Organic Rankine cycle technology is not yet commercially used in California; however, this technology coupled water-to-water heat pumps that can greatly reduce electrical demand while also producing renewable power.

Project planning for the Plumas Health and Human Services Center facility was a collaborative effort with a technical advisory committee primarily made up of Plumas County government officials. The committee included several members from the original Plumas Energy Efficiency and Renewables Management Action Plan planning effort. It informed project development at a local scale, and supported the project through regulatory approval processes at the county level. This group met quarterly to plan for the project, provide guidance on project development and approval processes, and identify barriers and solutions to successfully develop the facility.

The project team encountered numerous challenges, including management-related and community acceptance issues, payment delays and unanticipated costs, and a multitude of operations and commissioning issues.

Sierra Institute led efforts to address non-technical barriers, including navigating approval processes with risk-averse county governments, chip supply and hauling, and public outreach and public acceptance work through all stages of the project. The technical advisory committee also played an important role in addressing non-technical issues. High Sierra took a lead role in working through technical barriers, with remote support from Kohlbach and other equipment providers. Local contractors played a critical role in providing input to project development and to work through technical and non-technical issues.

Project Results

Construction and installation of the Plumas Health and Human Services Center biomass facility occurred from August 2017 to April 2018, and system commissioning immediately followed. The facility operated through most of the 2018 – 2019 heating season, and after working through the remaining outstanding commissioning challenges, the facility was in full operation for the entire 2019 – 2020 heating season. This project has been deemed a success overall, and it demonstrates the viability of biomass heat and power applications at a community-scale in rural forested communities of California. The facility has already motivated additional entities in Plumas County to explore opportunities to convert to biomass heat to save heating costs, to upgrade existing outdated heating infrastructure, and to support local efforts in advancing important fuels reduction work to reduce the risk of wildfire while also stimulating the local forest products economy.

Lessons learned following completion and first-year operations of this facility can inform a wide audience, including rural counties in California wishing to convert to biomass heat and policy makers seeking to advance policy on forest restoration, reduction of wildfire risk, rural economic development, renewable energy generation, and more. Lessons learned include:

1. Combined heat and power generation and heat use are essential to the economics of community-scale biomass energy.
2. System operations are improved with dry fuel, including increased energy content per bin delivery, improved efficiency of combustion leading to increased time between bin deliveries, reduced emissions, and improved cost savings.
3. Liquid loop radiator cooling tower is an essential piece of equipment for the Kohlbach biomass boiler coupled with organic Rankine cycle power generator system.
4. Biomass systems require involvement and oversight to manage fuel procurement, fuel quality, and fuel hauling for efficient operations but that is likely little different from launching any new fuel procurement and distribution program.
5. Organic Rankine cycle power generation from biomass is best suited when it supplements heat-led systems to improve economics.

Recommendations for future community-scale biomass energy projects include:

1. Program system controls and set points on an hour-by-hour basis to produce electricity only when most economical.
2. Connect additional heat users to the system.
3. Improve fuel specifications, including setting a standard for moisture content, and procure driest fuel possible.
4. Cultivate an understanding that innovation and new technology commissioning takes time and setbacks are part of the process.
5. Build in contingencies to budget in advance to reduce risk.
6. Ensure that the boiler operator is committed to the success of the facility.

Sierra Institute further recommends that rather than perform additional research on the already well-proven technology, efforts be made to increase investment in this technology to bring down already-high capital costs for equipment given the multitude of environmental and socioeconomic benefits community-scale biomass energy provides a given rural forested community. Biomass facility operators should also focus efforts on long-term fuel procurement, fuel pile management to keep fuel dry and consistent with specifications, and efficient fuel storage systems that match available trucks and infrastructure in the local community.

Technology/Knowledge Transfer/Market Adoption (Advancing the Research to Market)

The Sierra Institute has taken the lead role in promoting replication of this project to other potential users and informing policy to promote increased use of biomass technology in California.

To foster a widespread recognition of the important role community-scale biomass use plays in both forest health and rural economic development conversations and to promote investment in such facilities, Sierra Institute has shared project results through numerous presentations at conferences, meetings, workshops, panel presentations, and a webinar; by creating videos and establishing a website; and by hosting site visits for a variety of audiences. These audiences include biomass facility developers and those in the biomass industry, state and federal natural resource management agency personnel, policy makers seeking to advance policy on forest restoration/reduction of wildfire risk/rural economic development/renewable energy generation, other Plumas County entities expressing interest in converting to biomass heating, the California Energy Commission's EPIC forum in early 2020, and others. Through its Rural Community Development Initiative program and capacity-building program associated with wood use (funded by the Sierra Nevada Conservancy), the Sierra Institute has also shared information with rural forested communities throughout California.

Near- and mid-term target markets for community-scale biomass heat and power facilities include additional county or government-owned buildings, hospitals, and schools throughout Plumas County. Sierra Institute has identified two candidates for near-term markets, one of which has recently received grant funding to support installation of a thermal biomass system on-site. Long-term target markets include additional rural forested communities across California, working to identify outlets for woody biomass and also to upgrade outdated and aging fossil-fuel using heating infrastructure.

Because this project served as a demonstration for community-scale biomass heat and power, it has already attracted attention both locally and statewide on opportunities for biomass technology.

Benefits to Ratepayers

The Plumas Health and Human Services Center Biomass facility offers economic and environmental benefits to ratepayers.

The facility reduces demand on the local electrical grid at peak and off-peak times through elimination of the electric-fired boiler that was used to heat the building and through generation of power during peak electrical demand times. Decreased energy demand and decreased grid strain will reduce costs to ratepayers. Ratepayers will also benefit from greater electricity reliability and increased safety by decreasing peak demand and providing on-site electrical generation.

Environmentally, a biomass energy system will help to meet state statutory energy goals by using local, renewable forest resources. In addition, the Plumas Health and Human Services Center biomass facility offers an outlet for wildfire risk reduction thinning treatments, therefore reducing risk of catastrophic wildfire in a fire-prone region. Though the scale is too small to have a widespread effect, this project demonstrates how infrastructure investment can affect landscape treatment, particularly at the local scale. Sierra Institute has fielded a number of calls from locals who want to bring their wood waste from local clearing projects to the Health and Human Services Center for clean burning.

Reducing wildfire risk also helps improve air quality and reduce harmful emissions from pile burning and wildfires that compromise human health. Wildfire risk reduction in general also increases ratepayer safety and protects infrastructure such as electric transmission lines that are otherwise threatened during a wildfire event.

In summary, many stakeholders are recognizing the use of woody biomass technology to generate heat and power as an important solution for using wood waste, spurring rural economic development, supporting state energy and environmental goals, and providing local environmental and economic benefits to ratepayers.

CHAPTER 1: Introduction

Project Background

Communities in the mountainous Sierra Nevada region of California, like Quincy, often experience peak electrical loads during the winter months due to a reliance on outmoded electric resistance heating, heat pumps with poor coefficient of performance (COP), and fuel switching from oil and propane to electricity when fossil fuel prices spike. These communities are also increasingly at risk of severe wildfires, the result of unnaturally dense forests and the effects of climate change that threaten landscapes and the safety of both residents and infrastructure, including the electrical grid.

Lack of access to natural gas means critical institutions in rural mountain counties of the Sierra (schools, hospitals, and other public facilities with high heat demands) rely on expensive fossil fuels or electricity to meet their heating needs. In any given year the prices of these fuels can fluctuate dramatically, and public institutions, funded with taxpayer dollars, often must speculate on price volatility during the summer months. In these communities with high rates of unemployment, aging populations, and a relatively small tax base, the expense and volatility of fossil fuel markets place financial strain on these institutions.

Furthermore, several communities in Plumas County, for example, are challenged to meet air quality standards established by local air districts during the winter months due to air inversions in the valleys, heavy reliance on residential wood-burning stoves, and open pile burning of yard waste and other woody debris. In 2015, the city of Portola in eastern Plumas County was designated as a federal nonattainment area for fine particulate matter, meaning it had exceeded the federal standard for certain criteria pollutants. Other communities in Plumas County are close to being designated nonattainment areas as a result of wildfire and pile burn smoke impacts, reliance on outdated wood stoves, and use of old diesel boilers (personal communication, Northern Sierra Air Quality Management District). The consequences for nonattainment take the form of expensive fines, limited economic development opportunities, and suspension of transportation infrastructure upgrades. Additionally, disposal of forest biomass through open pile burning in the national forests that surround Plumas communities along with wildfires also challenge communities to avoid non-attainment designation and result in harmful emissions to the local community, posing risks to human health.

California's Forest Health Crisis

California's 33 million acres of forest land, a quarter of which are national forests, are critical source watersheds in California. These forests provide timber, water, hydropower, and a multitude of ecosystem services to downstream urban users. Forests are invaluable to rural communities spread across California's landscape for in-woods jobs, sawmill work, and the tourism industry.

Forests of California, however, are in dire need of restoration. Unnaturally dense forest stands following a century of fire suppression and forest management practices have resulted in weakened forested structures more susceptible to wildfire and insect-driven mortality. Wildfire and widespread tree mortality threaten ecological health of critical watersheds and carbon stores, as well as the safety of communities within these landscapes.

Plumas County's forests are no exception, and a variety of groups are working to advance hazardous fuels reduction and forest restoration activities to promote healthy, resilient landscapes in the face of climate change and increasing risk of high severity wildfire. Unfortunately, thinning small diameter trees and removing flammable biomass material is expensive, and contractors implementing this work are challenged by lack of markets and outlets for the low-value biomass material. As a result, forest restoration treatments are either left undone or the biomass material is left piled in the woods and burned at a later date when already-limited air quality windows allow. Thus, to adequately combat California's forest health crisis, it is imperative to develop processing infrastructure and local markets for biomass material. Biomass energy systems are an ideal outlet for biomass as they use ground and chipped biomass material, the least valuable wood product material and the most common residual from forest restoration treatments on the landscape, and convert it into renewable energy.

Project Overview

Forest biomass, a waste byproduct of forest restoration and hazardous fuels reduction activities throughout rural forested areas of California, is a locally abundant, renewable natural resource that can serve as a source of fuel for biomass energy systems. Public institutions in rural areas with high heat demand are generally the most appropriate places for community-scale biomass energy, due to the higher cost of biomass-wood fired boilers.

With support from a California Energy Commission (CEC) planning grant, Sierra Institute and Plumas County stakeholders developed the Plumas Energy Efficiency and Renewables Management Action Plan (PEER MAP) in 2012. The PEER MAP process sought to identify, develop, and begin to implement a renewable energy plan for Plumas County focused on use of forest biomass — one of the county's (and the region's) most abundant sources of renewable energy. The PEER MAP ultimately identified a plan for a countywide network of biomass heating systems at public buildings with high heat demand, drastically reducing heat costs for entities by converting from fossil fuel-fired systems to systems using locally sourced and abundant low cost fuel. Sierra Institute modeled potential savings based on current costs, heat demand, and cost of heating with wood chips for various schools, hospitals, Forest Service offices, and county buildings in Plumas County, identifying a total savings of almost $200,000 per year — a significant cost for a small and impoverished rural area.

The Plumas County Health and Human Services Center (HHSC) in the county seat of Quincy was included in the PEER MAP assessment. Prior to this project, the 53,000-square foot (ft^{2}) building suffered from high energy costs due to reliance on electric boilers that were installed to pre-heat water and compensate for an undersized geothermal field and poorly performing heat pumps. The building's demand was significant on an already-strained rural electrical grid, and the county was burdened with high electricity costs to keep the building warm in the winter months. Plumas County recognized the urgency in the need for a solution as heat pumps at this building began to fail due to being overworked from trying to extract heat from nearly freezing supply water from the undersized geofield.

As a response, Sierra Institute in partnership with Plumas County and High Sierra Community Energy Development Corporation submitted a proposal in 2015 to the California Energy Commission's Program Opportunity Notice 307 to fund installation of a wood chip-fired combined heat and power facility at the HHSC to address the heating and energy challenges faced by the county. The initial proposal included the adjacent Feather River College dormitories as a user of heat from the biomass boiler system, to replace the college's aging propane wall heater units in its dormitories. The grant was awarded to Sierra Institute for $2.6 million.

By connecting the HHSC to a biomass combined heat and power district energy system that produces both electricity and thermal energy from forest biomass generated from fire risk reduction activities, the electrical consumption of HHSC is lowered and stabilized. Because this project maximizes electrical power production during the peak heating season, it helps increase grid security and reliability by reducing peak electrical demand. This solution proposed would reduce costs to ratepayers through decreased demand and decreased grid strain, helping to meet state statutory energy goals by using local, renewable forest resources. Another key multifaceted objective of the project was to utilize biomass waste material to help improve forest health conditions, reduce the risk of high severity wildfire, and create local employment opportunities.

This project demonstrates how the targeted implementation of advanced renewable combined heat and power technology based on woody biomass in the commercial and institutional building sector can achieve multiple benefits. This project is unique because it represents an innovative link between well-tested boiler technology, specific state laws and policies regarding increased use of forest biomass, direct economic, environmental, and community health benefits for ratepayers, state statutory energy goals, and clean energy jobs in California.

Benefits of community-scale biomass energy include:

1. Stable, low heating costs
2. Decreased reliance on fossil fuels
3. Affordable, local, abundant fuel source
4. Improved air quality, reduced black carbon emissions
5. Improved forest and watershed health, reduced risk of catastrophic wildfire
6. Job creation

Project Goals and Objectives

Goals

- Reduce demand on the electric grid at both peak and non-peak times.
    - Produce heat and power on site at the Plumas County Health and Human Services Center (HHSC) to eliminate an electric boiler and reduce demand on the grid.
    - Deliver unused power from the organic Rankine cycle (ORC) energy generation process back to the grid to further reduce demand on the grid during both peak and non-peak times.

- Reduce costs to ratepayers by increasing the coefficient of performance of heat pump systems at the Plumas County HHSC, eliminating electric boiler use at the facility.
- Advance an emerging technology in California and increase understanding of the effectiveness of biomass as a source of renewable energy.
    - Establish the biomass combined heat and power system as the first step toward implementing a network of biomass heating systems at public buildings in Plumas County. The use of waste heat generated on the back end of the electricity generation cycle (using organic Rankine cycle technology) makes it the first of its kind in California.
    - Introduce this system as a prototype for the ways in which renewable energy generation can be successfully integrated into the grid in an efficient and financially sound manner, for use of local renewable resources to generate energy in California's rural remote forested communities, and to demonstrate improved efficiencies by using the waste heat generated on the back end of the electricity generation cycle.
- Reduce reliance on fossil fuels at Feather River College.
- Demonstrate the intersection of EPIC goals and community and environmental needs.
    - Link renewable energy generation with forest restoration, reduced wildfire risk, and rural economic development.

Objectives: Evaluation of Success

The objectives of this project were to fund design, engineering, and construction of a biomass combined heat and power facility that:

- Generates 35 kilowatts (kW) of electricity.
- Saves $40,000 in electricity costs per year.
- Reduces demand peak by 205 kW.
- Increases markets for forest biomass by 815 tons.
- Keeps energy dollars local and reduce total energy spending by the county and community college.

Technical Advisory Committee

This project was born out of the PEER MAP project funded by the CEC in 2013, which involved regular meetings of an advisory body of community stakeholders. Many of those individuals participated in this project's ad-hoc advisory committee as well (or the technical advisory committee per CEC deliverables), particularly county employees.

Members included:

- Lori Simpson, Plumas County Supervisor District 4
- Randy Wilson, Plumas County Planning Director
- Dony Sawchuk, Plumas County Facilities Director
- Jonathan Kusel, Sierra Institute

- Camille Swezy, Sierra Institute
- Andrew Haden, High Sierra Community Energy Development Corporation
- Craig Settlemire, Plumas County Counsel
- Nick Boyd, Feather River College Facilities Director

This group met quarterly to plan for the project and identify barriers and solutions to successfully develop the facility. Meeting notes can be found in the Agreement's deliverables file. For example, Technical Advisory Committee meetings allowed the project team to collaboratively decide on the following project milestones:

1. Advancing a third-party ownership model, in which Sierra Institute assumes ownership of the facility and responsibility for its development. Sierra Institute spends the first year of operations commissioning and proving up the facility, and after one year of successful operations, ownership is transferred to the county. This reduces risk for the county and lessens its involvement in the development of the facility. A series of contracts were set up with the county to allow this model to be implemented: Ground Lease, Thermal Energy Services Agreement (sets a billing mechanism for Sierra Institute to bill the county for heat), an Ownership Transfer Agreement, and a County Match Agreement.
2. Determining how to effectively present the project to the Plumas County Board of Supervisors for approval to move forward with construction.
3. Ensuring all permitting and other pre-development needs are worked out, and that shifts in design to effectively match the county's needs and available budget are identified.
4. Deciding to construct boiler building out of cross-laminated timber and further the demonstration of innovative wood utilization technologies.

Figure 1: Members of Technical Advisory Committee Breaking Ground for Construction, August 2017

Source: Sierra Institute for Community and Environment

CHAPTER 2: Project Approach

Technological Innovation

The practice of combusting wood to generate heat is not a new concept, and biomass boiler technology for district heat applications have been commercially deployed in European communities for some time. Additionally, there are a number of biomass heat applications at some United States public buildings in Vermont, Montana, and Oregon, all of which have operated successfully since being installed.

While biomass-fired heat is a well-proven technology, the Plumas County Health and Human Services Center (HHSC) project innovation is its application of a biomass boiler linked with organic Rankine cycle electricity generation technology, all interconnected to a geofield and water-source heat pump distribution system at an office building.

Figure 2: Observation Portal to Combustion Chamber

Source: High Sierra Community Energy Development Corporation

Providing district heating and electric generation to a county office building demonstrates how biomass use can be adapted to a variety of scenarios in a rural forested area. The project also integrates specific state laws and policies regarding increased use of forest biomass; direct economic, environmental, and community health benefits for ratepayers; state statutory energy goals; and clean energy jobs in California.

Organic Rankine cycle (ORC) technology represents a cutting-edge innovation in the field of electricity production from forest biomass in a district heat application as it converts waste heat to electricity in a relatively high efficiency manner compared to general steam turbine technology. ORC systems generally require little maintenance and have more favorable operating pressures compared to steam turbines. A drawback to the technology is the low temperatures of the condenser water on the back end of the power production cycle, typically around 80°F (27°C). While this is usually not hot enough to provide commercial space heat or industrial process heat, it is ideal for water-to-water heat pumps, making the HHSC an ideal fit for ORC technology. An ORC generator coupled to water-to-water heat pumps can significantly reduce electrical demand, while simultaneously producing renewable power.

The biomass boiler (Figure 3) at the Plumas County HHSC is a Kohlbach K8 400 kW woody biomass-fired pressurized hot water boiler rated at 1,365 MBH output, featuring a sloped moving grate, two distinct primary and secondary combustion zones with a refractory arch above each, flu gas recirculation, an ash collection and storage system, and a Kohlbach multicyclone dust collection system with ash receptacle.

Figure 3: Plumas Health and Human Services Center Biomass Boiler Fired Up

Source: High Sierra Community Energy Development Corporation

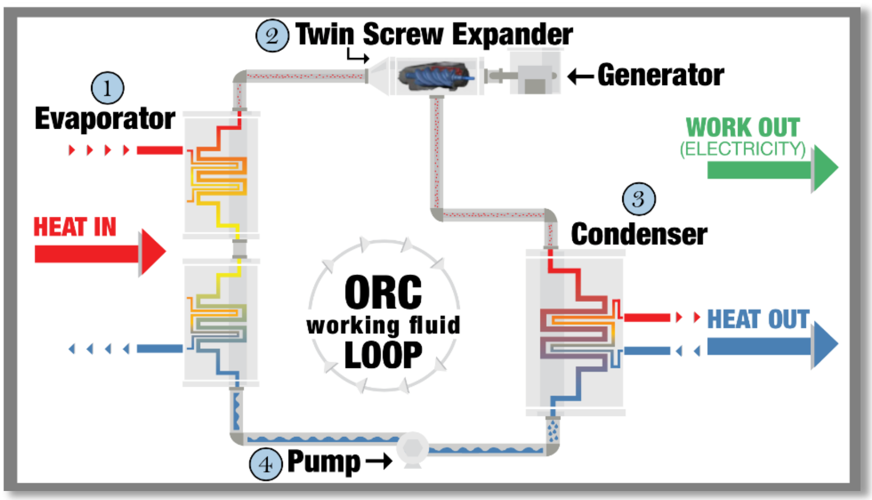
The boiler is fed by two storage bins, both lined with hydraulically actuated "walking floor" conveyors to move chips into a ram feed stoker that feeds the boiler's furnace. While there are a multitude of biomass boiler models and manufacturers, selection of this Kohlbach model was important in that it can operate with unprocessed "hog fuel" as its feedstock.

Given that this system is the first community-scale biomass boiler installation in Plumas County, Sierra Institute identified flexibility in feedstock requirements as one of the most important factors in selecting a boiler. Most biomass boilers for district heating applications require a refined, clean chip, and use of these systems typically requires screening and additional handling of wood chip fuel. Given that most product is sourced from hazardous fuels reduction and forest restoration activities, Sierra Institute wanted to ensure that this material could be used directly in the boiler with minimal processing to keep fuel costs low, one of the driving objectives of this facility.

To advance build-out the PEER MAP vision and incentivize installation of additional biomass boiler systems in Plumas County, Sierra Institute has installed a wood chip processing operation at an industrial site in Crescent Mills, 30 minutes north of Quincy. This facility is set up to screen fines, bark, and oversized pieces from ground or chipped slash material coming from forest restoration projects, ultimately producing a clean boiler chip. Offering a clean chip product will lessen the perceived risk of converting to biomass heat by local entities and allow for installation of less expensive boiler systems that have stricter feedstock requirements and require "clean chips."

The Kohlbach boiler sends 240°F water to an Electratherm Power+ ORC power generator rated at 35 kW electric output. The hot water is used to evaporate a refrigerant fluid and create a high-pressure vapor that expands through a twin-screw expander, spinning a generator to produce electricity. A condensing unit then converts the vapor back to liquid at 80°F (27°C), and the condenser water then flows to the water-source heat pumps at HHSC. The heat pumps will return the water at 58°F (14°C). This water can be further dissipated in the geofield if desired. This unique arrangement allows relatively low temperature water (80°F [27°C]), or "waste heat," from the ORC power unit to be used fully; normally water at this temperature would be considered waste. See Figure 4 for a visual of the ORC process.

Figure 4: Organic Rankine Cycle Process

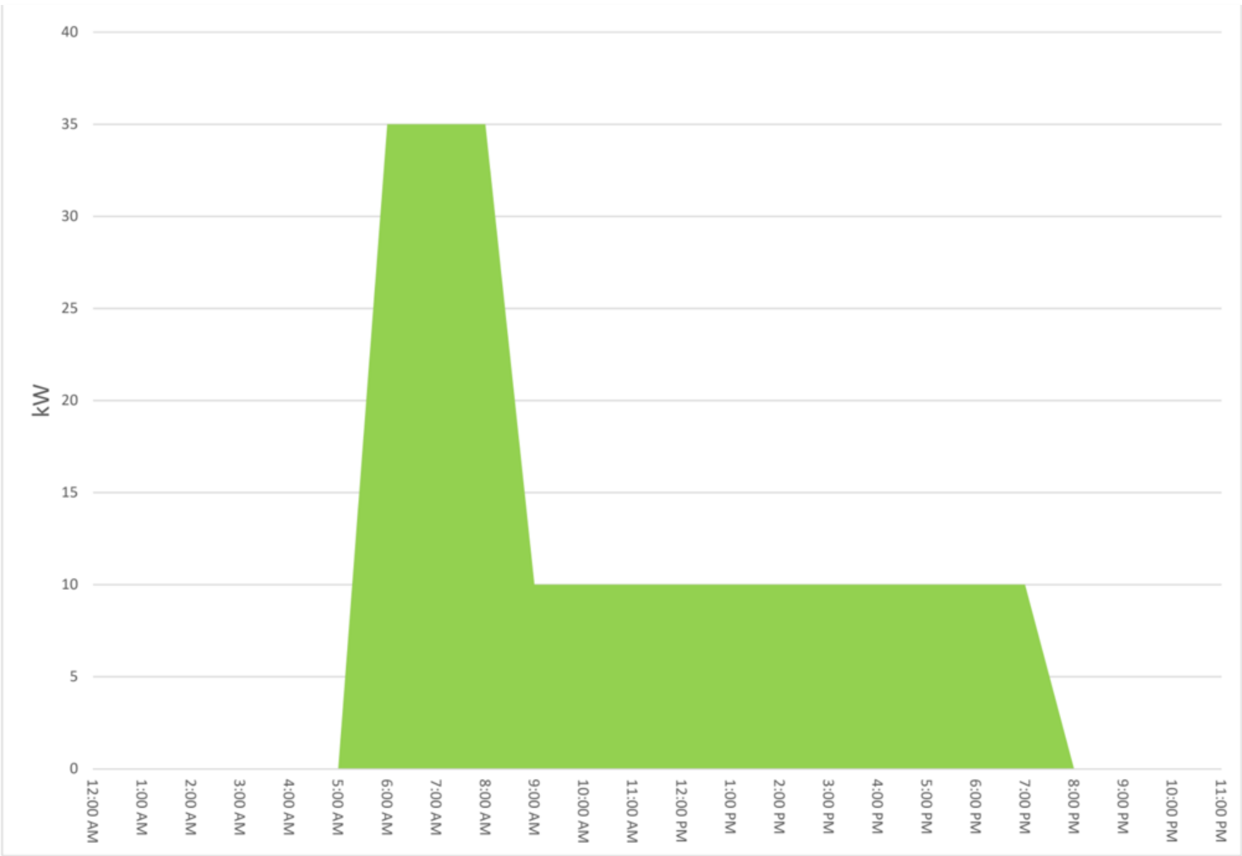


Source: ElectraTherm

Prior to installation of this biomass system, the county was using an undersized and highly inefficient geofield to heat the HHSC — in the winter months, the geofield would supply heat pumps with water sometimes as cold as 28°F (–2°C). The building's heat pumps were failing, with some having to be replaced, as a result of being overworked. The county identified the need for replacement heating as a priority. Now, through supplying 80°F (27°C) to the heat pumps, the system is boosting the county's efficiency by giving them warmer water, and this use of the "waste heat" from the ORC results in little loss to efficiency in the entire energy generation process. With warmer water, the heat pumps operate more effectively and efficiently.

The system operates seasonally, when there is thermal (heat) demand from the HHSC, generally November – April. Electricity generation offsets the power consumed on site and reduces the overall demand peak during winter months when electric usage is at its highest. Whenever the county is heating, the ORC is also providing power, thus reducing the demand on the local electrical grid. It is set up to operate under different scenarios — power led, heat led, or heat only (Figure 5).

Figure 5: Organic Rankine Cycle Peak Shaving Schedule



Source: High Sierra Community Energy Development Corporation

A propane boiler is installed on site to serve as both a backup heat source and also to provide heat in the "shoulder seasons" of October and April when morning temperatures are cold but daytime temperatures are high enough that they don't warrant a need for heat.

This system is also unique in that it is interconnected with the geofield that existed at the HHSC prior to installation of the biomass facility. The geofield is undersized for the heat demand of HHSC and by itself is inadequate to heat the building throughout a winter season. Connecting heated water from the biomass system to the geofield allows the field to serve as a "battery" for waste heat during power-led operations. In shoulder seasons, the geofield can be used to pre-heat water for the geofield before it is boosted to the desired temperature by the biomass system.

Generation of renewable energy by the ORC reduces demand on an already-stressed electrical grid. The system produced a total of 12,440 kilowatt-hours (kWh) as of April 12, 2019, when the biomass system was turned off for the summer season when the demand for heat ended. In a regular operating year with consistent heat production, it is projected to produce approximately 52,600 kWh per year. The system reduces demand on the electrical grid by targeting energy generation during peak demand times as needed — coinciding with the general times at which heat demand is also present. Figure 5 illustrates this demand "shaving" schedule; the green curve shows peak power production occurring in morning hours when heat demand is also at its highest.

Fuel Supply, Storage, and Delivery

The Plumas HHSC biomass facility uses woody biomass chips as fuel. Wood chips are stored on site within the boiler building in two enclosed bins, which can be rotated in and out to be refilled as needed. The bottom of the bins have hydraulically actuated "walking floor" conveyors to move chips into a ram feed stoker that feeds the boiler's furnace. Each bin has a 45 cubic yard of 6 bone dry ton/12 green ton holding capacity, and can provide enough fuel to run the boiler for 2 to 5 days depending on the heat demand (that is, more fuel in January versus April) and the moisture content of the fuel.

The system automatically switches to the other bin when one is empty, giving the fuel supplier 2 to 5 days to refill before fuel runs out. Bin pick up and drop off takes approximately 5 to 10 minutes. Bins are enclosed in the building positioned on concrete pedestals. This storage setup allows for a "clean" approach in that wood chips are kept within containers and are refilled off site, minimizing the mess and disruptions to the parking lot for the HHSC.

The bins require a standard roll-off truck to be moved. This has proved a challenge to the project team given the limited number of roll-off trucks in the Plumas County area. A local contractor manufactured a temporary roll-off truck to tide the project over in its first year of operations until a more modernized truck could be purchased (Figure 6).

Figure 6: Roll-Off Truck Returns Full Bin to Boiler Building

Source: Sierra Institute for Community and Environment

Sierra Institute purchased a roll-off truck in December 2019 to continue building out the community-scale wood energy vision for Plumas County.

This challenge also offers the opportunity to revitalize entrepreneurial opportunities related to wood use and is elaborated on further in Chapter 3.

Community-Scale Innovation

Biomass electricity has long had an important role in California's renewable energy portfolio, with close to 1,000 megawatts (MW) of biomass power generating capacity in the state in the mid-1990s. In general, community-scale wood energy (and community-scale wood use in general) is a unique and new niche in California's energy portfolio and forest products manufacturing. There are other small-scale biomass heating systems in operation or in development in California, but the installation at the Plumas County HHSC featuring both heat and power generation at a community-scale is the only one of its kind in the state.

The Plumas County HHSC installation is estimated to use between 450 and 600 bone dry tons per year of biomass material, the equivalent to thinning roughly 45 to 60 acres of forest land. While community-scale wood energy applications do not create a large demand for biomass relative to the scale of acreage of forest restoration needed, these systems generate a multitude of other benefits to the community, and with replication can get to an appropriate scale and turn hazardous fuels reduction forest thinning around homes into a source of useable and inexpensive renewable energy.

Cross-Laminated Timber Building Innovation

To further the demonstration of innovative uses for wood, the project team decided to construct the boiler building out of cross-laminated timber (CLT), making it California's first full CLT building (Figure 7 and Figure 8).

Figure 7: Construction of Cross-Laminated Timer Building

Source: Sierra Institute for Community and Environment

Figure 8: Completed Biomass Boiler Building

Source: High Sierra Community Energy Development Corporation

CLT is an engineered wood product consisting of several layers of cross-sectional lumber, generating structurally sound panels that can be used for walls and roofs of buildings. Studies have shown CLT to be at least as fire and seismically safe as concrete and steel, and it has a better carbon intensity profile than both, as it maintains sequestered carbon in a building product. The biomass boiler building consists of 5-ply CLT walls, and 7-ply CLT roof panels. CLT material was purchased from Structurlam Products, and all panels were erected in two days. A time lapse video of construction is available on Sierra Institute's website.

Nonprofit-County Partnership and Building Capacity

To alleviate the burden of project implementation on Plumas County, this project was advanced under a third-party development and ownership approach. Under this model, Sierra Institute assumed ownership of the facility and was responsible for its development, from engineering to construction to system commissioning and a first full year of operations, with technical support from developer High Sierra Community Energy Development Corporation. This allowed the facility to be "proved up" and for commissioning kinks to be worked out. The county will assume long-term ownership as a turnkey installation, with assurance that the project functions as designed in 2020.

A series of contracts were set up between Sierra Institute and Plumas County to formalize this approach:

- Ground Lease for the area of property on which the biomass installation is developed, with Plumas County as the lessor and Sierra Institute as the lessee.
- Thermal Energy Services Agreement to establish a billing mechanism for Sierra Institute to bill the county for heat, using set rates that are derived from both fixed and variable costs of operating the system.

- Ownership Transfer Agreement to set the terms of transferring ownership of the system from Sierra Institute to Plumas County.
- County Match Agreement to formally commit Plumas County to its $400,000 match fund commitment to the EPIC grant. This match was applied to construction costs related to the boiler building, its foundation, and trenching to the HHSC.

Following completion of construction and installation of the biomass system, the project developer, High Sierra Community Energy Development Corporation, took a lead role in system commissioning and training Plumas County Facility Services staff in how to operate the facility (Figure 9). The long-term goal is to build Plumas County's capacity to operate this innovative facility independently. By the end of the first year of operation, the county already had been trained and assumed most of the operational duties.

Figure 9: High Sierra Community Energy Development Corporation Owner Trains Plumas County Facilities Staff on Ash Bin Removal

Source: Sierra Institute for Community and Environment

Project Timeline

The project development timeline is shown in Table 1. Mechanical installation is shown in Source: Sierra Institute for Community and Environment

Figure 10.

Table 1: Project Timeline

Program of Work	Dates
Initial project planning Exploration of regulatory approval processes Assessment of pre-development needs Regular convenings of Technical Advisory Committee	September 2015–September 2016
Engineering and development of drawings (mechanical, electrical, civil, structural, including for cross-laminated timber building, architectural, and geotechnical)	July 2016–August 2017
Construction: Earthwork	August 2017–October 2017
Construction: Structural—foundation	October 2017–December 2017
Construction: Cross-laminated timber panel installation and building construction	December 2017
Construction: Building siding, roofing, fixtures, lighting, and so on	December 2017–April 2018
Construction: Mechanical installation, plumbing, electrical, pipe insulation	January 2018–May 2018
Ribbon-cutting ceremony	April 2018
Construction completion	May 2018
System commissioning	June 2018, and September–November 2018
Full operations	December 2018–April 2019, December 2019

Source: Sierra Institute for Community and Environment

Figure 10: Kohlbach Furnace Being Unloaded and Installed

Source: Sierra Institute for Community and Environment

Interconnection Process Summary

Initially the project was expected to connect to the Pacific Gas and Electric's (PG&E) grid through PG&E's Net Energy Metering (NEM) or NEM Aggregation (NEMA) program. The NEM program allows customers who generate their own energy to serve their energy needs directly on site and receive a financial credit on their bill for any surplus energy fed back to the utility. NEM generators were previously limited to 1MW capacity; as of December 2016, NEM generators have no capacity limit, but can only be sized up to the customer's annual load.

Ultimately, based on a recommendation from the project electrical engineers, the system did not connect through NEM and instead installed a meter that would only spin forward (that is, without a formal "net metering" process), while still accounting for energy generated by the biomass system as a credit to the facility. Reasons for this change included downsizing of the electrical generation capacity from 65 kW to 35 kW following the loss of Feather River College as a heat user to the system, as well as a lengthy and complicated NEM process that stalled the NEM application. The project team pursued the NEM process from March 2016 through April 2017, a much longer time period than anticipated.

The online applications for NEM/NEMA are focused on wind and solar, which created some issues to adapt to biomass. PG&E contacts offered little support in navigating its systems or to move the NEM application through the process. Following December 2016 changes to the NEM program, and because PG&E contacts were challenged/confused by the project as a biomass combustion system versus solar, wind, or biogas digester, the project team withdrew from the NEM application process.

CHAPTER 3: Results, Challenges, and Lessons Learned

Results of the project substantiate its overall success. In addition, given the innovative nature of this community-scale approach to biomass energy in California, challenges in planning, construction, and operations were inevitable, and the project provided its fair share. The project team and its many contractors, collaborators, and stakeholders combined their determination and creativity to overcome all hurdles and are pleased to share the multitude of important lessons learned in the interest of encouraging and supporting replication of this system and helping other rural forested communities of California avoid similar challenges.

Project Results

The Plumas County Health and Human Services Center biomass facility was developed to demonstrate how to achieve multiple economic and environmental benefits through targeted implementation of advanced renewable biomass combined heat and power technology in the commercial and institutional building sector. The project was successful in the following ways:

- Reduced demand on the electric grid at both peak and non-peak times.
  - Produced heat and power on site at the HHSC to eliminate an electric boiler and reduce demand on the grid.
  - Delivered unused power from the ORC energy generation process back to the grid to further reduce demand on the grid during both peak and non-peak times.
  - Reduced demand peak by 205 kW.
  - Generated 35 kW of electricity.
- Reduced costs to ratepayers by increasing the coefficient of performance of heat pump systems at the Plumas County HHSC and eliminating electric boiler use at the center, saving $40,000 in electricity costs.
- Advanced an emerging technology in California and increased understanding of the effectiveness of biomass as a source of renewable energy.
  - Established the biomass combined heat and power system as the first step toward implementing a network of biomass heating systems at public buildings in Plumas County. The use of waste heat generated on the back end of the electricity generation cycle (using organic Rankine cycle technology) makes it the first of its kind in California.
  - Introduced this system as a prototype for the ways in which renewable energy generation can be successfully integrated into the grid in an efficient and financially sound manner, for use of local renewable resources to generate energy in California's rural remote forested communities, and to demonstrate improved efficiencies by using the waste heat generated on the back end of the electricity generation cycle.

- Demonstrated the intersection of EPIC goals and community and environmental needs.
    - Linked renewable energy generation with forest restoration, reduced wildfire risk, and provided rural economic development in the form of clean energy jobs.
    - Increased market for forest biomass by 815 tons.
    - Kept energy dollars local and reduced total energy spending by the county.
    - Demonstrated the ability to reduce wildfire risk, revitalize a local forest products economy, and reduce Plumas County's reliance on an inefficient and failing geothermal system.

Planning, Engineering, and Construction Challenges

The novelty of the project necessitated a large engineering team to adequately include relevant experience to ensure project success. In addition, technology, engineering, and construction organizations with experience in projects of this nature are limited or altogether nonexistent. Coordinating numerous players for such a novel project challenged the relative inexperience of Sierra Institute and other project stakeholders and proved to be burdensome to the project timeline and budget. However, the interest, passion, and "can do" attitude of the engineering and construction contractors overcame the challenges and proved vital to the project's success.

Unforeseen Financial Challenges

The EPIC-funded project led by the Sierra Institute involved new technology, but it was also a construction project that required funding advances to secure delivery of equipment and that provided inevitable unforeseen expenses and circumstances. The EPIC program is not designed to address construction projects efficiently. Consequently, grant reimbursement delays and unanticipated costs outside the grant's scope posed a financial burden on smaller, rural contractors as well as Sierra Institute, all of whom carried construction, equipment, and supply costs, sometimes for many months. For example, discovery of an underground stream directly under the building site required $30,000 of earth work and drain installation, causing Sierra Institute to secure additional funding for mitigation.

Risk-Averse Nature of Rural County Governing Boards

Implementing novel concepts and innovative projects involves risk, which can be difficult for a rural, cash-strapped local government to absorb. Despite the urgent need for a heating system replacement at the county Health and Human Services Center; the availability of grant funds to cover majority of engineering, construction, equipment, and installation costs; and a clear case for the multitude of benefits provided by this system, several Plumas County board of supervisors members felt the project was too risky to take on. Fostering community buy-in proved to be a challenge to Sierra Institute in the early stages of project planning. Ultimately the Plumas County board approved to move forward with facility construction in July 2017, and construction launched August 2017.

Operations and Commissioning Challenges

Following completion of construction in May 2018, the biomass facility underwent initial start-up/commissioning with support from Kohlbach technicians in June and September 2018.

Additional system commissioning lasted through December 2018, particularly for the controls system and for sensors on the fuel bins that detect when fuel is needed to be pushed out of the bins into the stoker and into the boiler. Starting in January 2019, the entire system began full operation with minimal disruption, until wet winter conditions and a failure to adequately protect wood chip fuel piles from moisture resulted in an overly wet fuel supply: fuel moisture content exceeded the tolerance level of the technology for clean combustion.

For the remainder of the heating year, the project team directed the focus for commissioning toward identifying dry sources of fuel so the facility could resume first year operations and data collection so EPIC reporting could continue.

The following are primary challenges related to system commissioning and operations as identified by the project team.

Fuel Supply and Storage

Fuel procurement, storage, and hauling for this small-scale biomass system constitute the bulk of the project innovation for this facility. Large, industrial-scale biomass power facilities that generate at least 20 MW of power are often co-located with sawmills or have long-term supply contracts with private timber companies for wood chips to fuel the systems. The HHSC system is small-scale and thus competes in a different market than the larger biomass facilities. Plus, another primary objective of this facility is to use forest restoration byproducts to support increased fuels reduction activities around the community of Quincy, generally on federal U.S. Forest Service land.

Sierra Institute spent considerable time working to secure feedstock from federal forests through partnerships with various agency personnel from the Plumas and Lassen National forests, with community groups like the Plumas Fire Safe Council and with local logging contractors. The goal was to procure material, ideally through long-term contracts like a stewardship contract with the Plumas or Lassen National Forest and haul this material for processing and storage at Sierra Institute's wood products yard in Crescent Mills. Sierra Institute installed wood chip screening equipment at this Crescent Mills wood products campus site in June of 2019 to be able to produce clean, even-sized boiler chips for use in biomass heating systems throughout Plumas County, per the PEER MAP Energy Vision. While the entire fuel supply for the 2019 – 2020 heating season has been secured, considerable effort is still needed to obtain feedstock guarantees to ensure sufficient long-term supply of wood chips. Despite months of work with both the Plumas and Lassen National forests along with Region 5 of the agency, Forest Service budgeting processes constrain the commitments forest staff can make. Subsidy for high-hazard fuel to Bioenergy Renewable Auction Mechanism facilities has also constrained supply from industrial private timberland owners, as they have made commitments from their land that both limits supply and increases the cost of whatever excess might remain.

Sierra Institute launched a large landscape project on both nearby national forests that will likely generate additional supply in late 2020. Large fires like the Camp Fire in Paradise have also increased available supply locally as there is a dearth of places to take hazard trees from post-fire restoration work. In fact, for the 2019 – 2020 winter season, Sierra Institute procured biomass from Camp Fire cleanup operations through a local logger (Figure 11).

Figure 11: Wood Chips Stored at Crescent Mills Wood Use Campus

Source: Sierra Institute for Community and Environment

Additional material was secured from a nearby forest thinning operation with haul costs subsidized by the Plumas Fire Safe Council. The success of Sierra Institute's Crescent Mills wood products campus will likely increase both availability and security of future chip supplies.

Fuel Hauling

The biomass boiler system is located in the parking lot area for the Plumas County Health and Human Services Center, thus it was important to design an on-site wood chip storage and ram-feed system that minimizes clutter and wood chip messes in the HHSC parking lot (Figure 12).

Figure 12: Wood Chip Storage Bins Inside Boiler Building

Source: High Sierra Community Energy Development Corporation

With this notion, the project team opted for a storage design involving two storage bins that hold roughly 45 cubic yards, or 12 green tons, of biomass each — when one bin is empty, a fuel hauler can pick up the bin and take it to the site where wood chips are stored to be refilled. The fuel hauler then returns the full bin to the boiler building.

However, the bins require a standard roll-off truck to transport them for off-site loading. This has challenged the project team given the limited number of roll-off trucks in the Plumas County area — the only other roll-off trucks in operation in Plumas County are part of solid-waste hauling enterprise Waste Management's vehicle fleet, and despite local employee interest in helping, the local office of this enterprise has not been given permission by the company to transport bins.

A local contractor converted an old log truck into a roll-off truck in November 2018 (Figure 13).

Figure 13: Roll-Off Truck Empties Wood Chips from Bins

This truck is no longer in operation due to California Air Resources Board emissions compliance issues.

Source: High Sierra Community Energy Development Corporation

This truck was used to haul wood chips for the HHSC through the end of 2019, but its old age and non-compliance with the California Air Resource Board (ARB) truck emissions for 2020 compelled the Sierra Institute to purchase a new (used) roll-off truck with independent funding. With use of this vehicle (that itself will be challenged to meet California ARB compliance in 2021), fueling operations have been successful. Sierra Institute was compelled to purchase this truck to assure seamless fuel delivery and because the economics associated with fueling one boiler will not justify independent business purchase of a vehicle.

In partnership with a local independent logging operation that is working to provide fuel for the HHSC system long term, Sierra Institute will need to secure a newer roll-off truck for 2021 that will meet California ARB regulations long-term and to serve more than one boiler if additional systems come on-line in Plumas County. Sierra Institute has initiated conversations with the Northern Sierra Air Quality Management District in hopes of securing financial support for a new California ARB-compliant roll-off truck. The fundamental challenge, however, remains: justifying high capital investment costs, such as a roll-off truck, for community-scale biomass energy systems.

With preliminary grant funding approval by the Sierra Nevada Conservancy, another biomass-powered boiler may be built at Quincy High School in 2020 – 2021. This will help tip the economics of investment in fueling system components.

Prolonged Commissioning Time

Prolonged commissioning time is needed as operators become familiar with new technology, fuel providers adapt to fuel specifications, and developers address final commissioning needs.

Figure 14: Cleaning Upper Furnace

A boiler technician demonstrates how to clean the upper furnace.

Source: Sierra Institute for Community and Environment

Commissioning can make first year reporting difficult as results are not necessarily representative of normal operating conditions. For the initial operating year in 2018 – 2019, the biomass boiler ran for a fraction of the heating season due to a number of commissioning-related issues, including faulty ram-feed sensors, high moisture content of the fuel that exceeded boiler specifications, and mitigation of smoke concerns resulting primarily from high moisture fuel. In addition, the ORC power generator system was operated for only part of the time that the boiler was operating due to some commissioning issues, and therefore did not mitigate high fuel costs for thermal energy generation with a commensurate income from electricity generation as it was designed to do. Therefore, the available data is limited as a predictor of future operations, and these first-year operations are not expected to be representative of future, more normalized performance.

Wood Fuel Moisture Content

Wet fuel challenges the boiler's ability to maintain desired operating temperatures, to function efficiently, and to operate in compliance with its air permit.

Above-average rain and snow events in winter of 2019 affected wood fuel for the whole northern Sierra and southern Cascade region. Larger biomass cogeneration facilities, such as Sierra Pacific Industries in Quincy and Collins Pine Company in Chester, secure dry sources of fuel to maintain consistent operations. They, too, struggled to secure useable chips during the 2018 – 2019 winter (based on personal communication with plant managers). However, these larger cogeneration facilities produce significantly higher heat compared to that of the HHSC biomass facility and can maintain hot furnace temperatures capable of drying fuel as it combusts, thereby allowing use of fuel with a higher moisture content.

The Kohlbach furnace at the Plumas HHSC biomass facility is rated for fuel up to 55 percent moisture content. Amid an above-average wet winter, HHSC's fuel storage ended up at roughly 70 percent moisture content by mid-February. The high moisture content of the product was exacerbated by the fact that the fuel had fines (needles), dirt, and bark present, all of which easily retain moisture. Fuel pile managers of other biomass boilers in the region indicated that it is easier to manage for moisture content with "clean" and processed piles of wood chips. Combustion of wood fuel with this high a moisture content at HHSC resulted in a cascading negative effect on system operations, including poor combustion efficiencies (more energy is spent attempting to combust wet material, and wet material has a relatively lower BTU content), smoke emissions from the stack, and overall suboptimal operations.

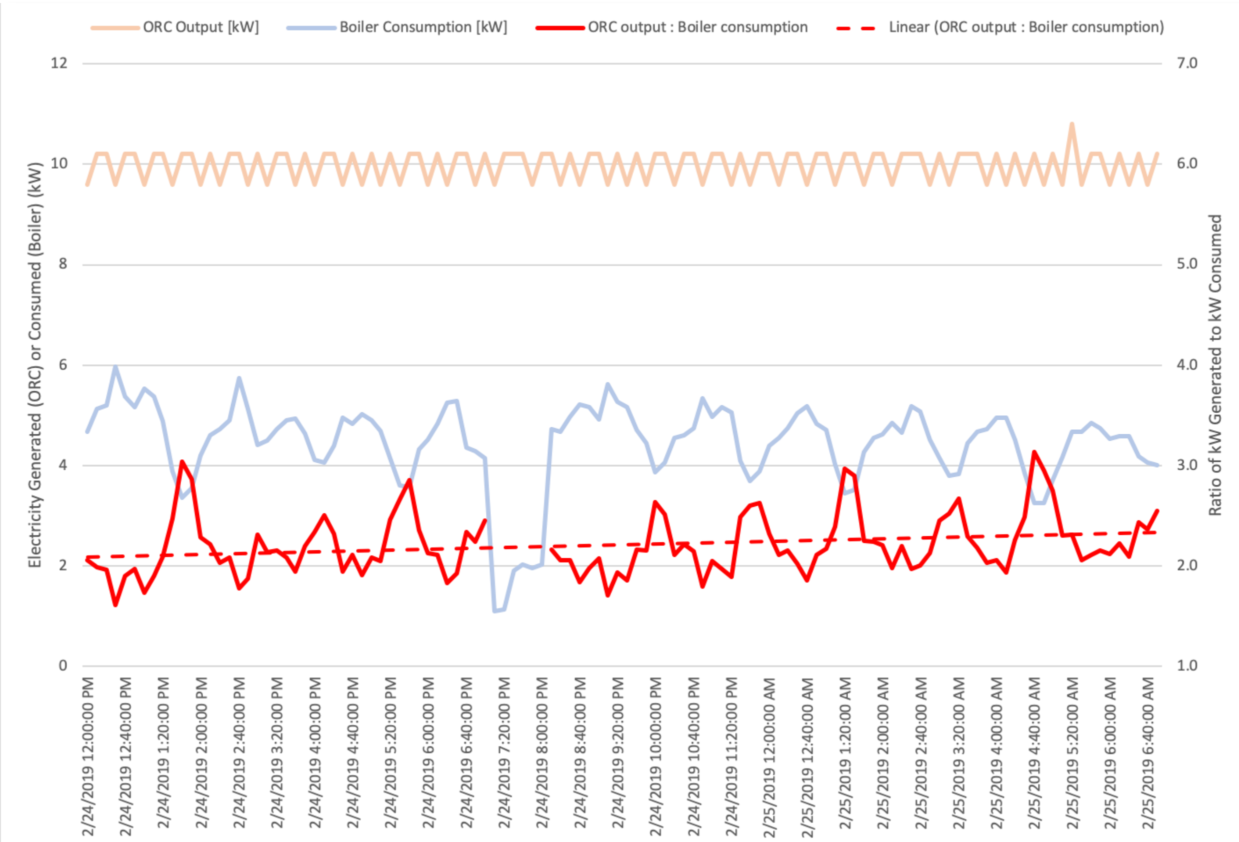
Combustion of wet fuel (Figure 15 and Figure 16) required consistently high temperatures in the furnace both to meet system efficiencies and keep the facility in compliance with its permit to operate from the Northern Sierra Air Quality Management District. The boiler system consumed wet fuel at a faster rate as it burned through more fuel to maintain the needed temperature for efficient operations, which is roughly 1,100°F (590°C). While this initially seems contrary to the reality that dry wood burns faster than wet wood, the issue lies within varying BTU content, or the amount of energy in the product. Dry wood chips have a higher BTU content than wet wood chips, allowing the system to meet desired temperatures faster, creating less demand for fuel over time, and requiring less work to produce thermal energy. Wet fuel does the opposite and, as a result, added above-normal operating costs.

Wet wood above the specified moisture content tolerance made it difficult for the boiler furnace to remain above the threshold at which point wood gas experiences secondary combustion — 1,100°F (590°C). Smoldering and visible emissions from the stack are more likely when the fire box is below this temperature threshold.

Instances of smoldering and visible emissions occurred more often in the afternoon as outside temperatures rose and the heat demand from HHSC dropped, sending the boiler into "slumber mode," resulting in lower firebox temperatures and smoldering. To address this issue, operations ran the ORC generator in a "power-led" scenario, maximizing energy production and requiring more heat from the boiler, keeping the boiler temperatures high. However, under this power-led scenario, the system generated more thermal energy than is required for the HHSC demand, which meant excess heat had to be dumped (and put to waste) through the liquid loop radiator and geofield to dissipate the heat. Furthermore, a power-led operating scenario requires more wood fuel and more frequent fuel deliveries, which increased operating costs. This issue is expanded upon in the Lessons Learned section.

Figure 15 illustrates the frequency that the firebox temperature was below 1,100°F (590°C) due to wet fuel and due to the boiler's output being too large for heat demand only from HHSC, following Feather River College's withdrawal from the project, expanded upon in Oversized System Design later in this chapter.

Figure 15: System Operations with 55 Percent Moisture Content Fuel



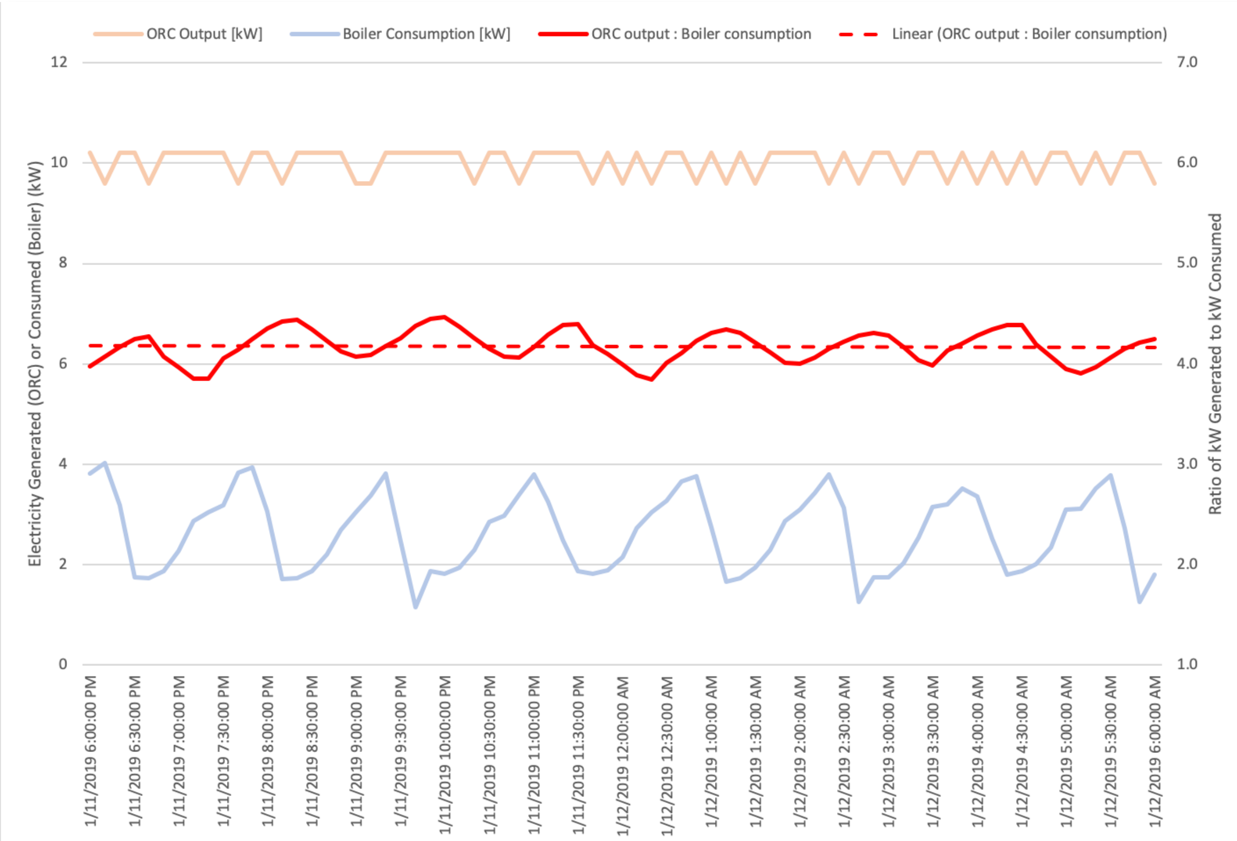
System operations with 55 percent moisture content fuel show a much lower ratio of power production to power consumption by the boiler system (less than 3:1) compared to 35 percent.

Source: High Sierra Community Energy Development Corporation

Increased power consumption can be attributed to a more active fuel infeed system (as the system burns through wet fuel faster to maintain high temperatures) and boiler fans working harder to produce energy from lower quality fuel.

The ratio of power produced by the ORC to power consumed by the boiler is higher with lower fuel moisture content. With increased power production, the facility can function as originally designed — to reduce the HHSC building's power consumption and save the county money — rather than primarily producing power to cover demand from the boiler plant. Figure 15 illustrates the lower efficiency of the ORC electricity production during periods of wet fuel use. The ratio of power produced to the parasitic load of the boiler plant (kW produced by ORC: kW consumed by boiler) is much higher when fuel conditions are dry (Figure 16).

Figure 16: System Operations with 35 Percent Moisture Content Fuel



System operations with 35 percent moisture content fuel show a higher ratio of power production to boiler power consumption (more than 4:1) than at 55 percent.

Source: High Sierra Community Energy Development Corporation

Figure 17: Example of Low-Quality, High-Moisture Content Fuel

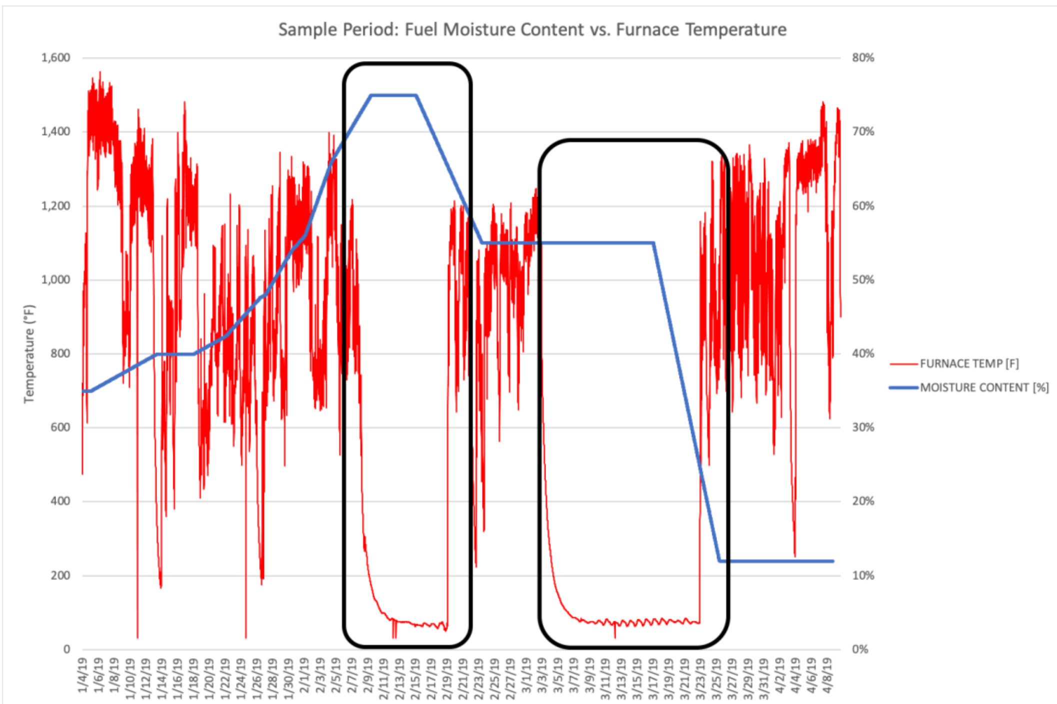
Source: Sierra Institute for Community and Environment

Figure 18: Wet Wood Chip Fuel Supply

Wood chip fuel supply became too wet to continue burning. The condensation can be seen on the bags, which are labeled with their measured moisture content.

Source: High Sierra Community Energy Development Corporation

Figure 19: Biomass Boiler Furnace Temperature in Relation to Wood Fuel Moisture Content



Moisture content curve shown here is approximate, based on several observations. With high fuel moisture, furnace temperatures are lower, sometimes requiring the furnace to be shut off to prevent smoking.

Source: High Sierra Community Energy Development Corporation

To mitigate this wet fuel issue in the future, Sierra Institute procured dry chips prior to the heating season (Figure 20 and Figure 21). These chips were also covered to shed rain and snow. In the future, fuel piles will be managed in a way to maintain desired moisture content levels. Sierra Institute installed equipment on its Crescent Mills site (25 minutes north of Quincy) capable of screening wood chips and other ground product from forest restoration projects, ultimately generating a cleaner product free of bark and fines. This product will be further managed to maintain desired moisture content through the winter and then be sold to the Plumas HHSC biomass facility and other biomass systems as they come on-line in Plumas County, consistent with the PEER MAP vision. A recent grant from the Sierra Nevada Conservancy enables the Sierra Institute to build a chip storage shed that will ensure dry fuel throughout the heating season.

Figure 20: Dry Fuel, Ideal Feedstock for Efficient Boiler Operation

Source: Sierra Institute for Community and Environment

Figure 21: Testing Dry Fuel for Moisture Content

Source: Sierra Institute for Community and Environment

Oversized System Design

At the time of application Feather River College was a project partner that was going to receive heat for up to four dormitories on property immediately adjacent to that of the HHSC. Not long after the grant was awarded, Feather River College withdrew from the project because staff had been dedicated to another long-term college project. Uncertainties associated with staffing and by the board — including the concern about the viability of the project — led the college to withdraw.

The project team downsized the boiler, but it is still oversized to meet the heat demand of HHSC: the boiler's output is 1,365 MBH, and rated input for HHSC's heat pumps is 865 MBH, so about 37 percent of the boiler's capacity is unused. The boiler was downsized to respond to reduced heat demand and to achieve operational efficiencies for the HHSC and required installation of cooling towers to vent excess heat. Modifications created uncertainty in project development and had a cascading effect on system sizing and subsequent operations.

As it turns out, the smaller boiler may still have the capacity to heat the Feather River College dormitories, and there may be renewed interest on the part of the college to purchase heat. Successful year one operations have no doubt contributed to this renewed interest.

Time Needed to Build Capacity and Advance Innovation

The entire system was designed to require limited operations management and oversight, unlike industrial-scale biomass power facilities. However, due to the novel nature of this system to the Plumas County area, considerable time was spent in system and operations management by the project team in the first year of operations, from system controls to procuring fuel supply to contractor management to working through transportation and hauling issues. As mentioned, lack of experience with projects of this nature contributed to time needed to acquire the knowledge for all aspects of the system to run smoothly and to be efficiently integrated. The commitment of the various partners, particularly the county facilities staff along with the construction contractor among others, facilitated learning and successful adaptive project implementation.

Delay in Meter Reading and Data Logging

Completion of BTU meter reading controls and enabling data logging was delayed due to licensing issues. Changes had to be made to the boiler plant's supervisory control and data acquisition (SCADA) system to monitor and record the output from the BTU meter. The SCADA system was provided by the boiler's manufacturer, and the design consultant High Sierra Community Energy did not have a software license to modify the programming. High Sierra Community Energy has since acquired this software license and is in the process of making the needed changes. Acquisition of this software license will aid in future boiler development projects in Plumas County.

Lessons Learned

- Combined heat and power generation and heat use are essential to the economics of community-scale biomass energy. Biomass energy systems are generally most cost effective when sized and operated as heat-led systems, with electricity produced as a secondary product, as demonstrated by the Plumas HHSC biomass facility. Maximizing electricity production necessitates a larger generation of thermal energy, requiring more wood fuel use and higher operational costs. Higher costs can be offset if sufficient value is realized through heat and power cost savings; however, without sufficient heat demand, cost savings are limited to electricity use savings. Table 2 shows that electricity savings never surpass fuel costs, let alone all additional operating costs. This illustrates the point that electricity should only be generated when value is also generated by the thermal energy produced (for example, in the morning when heat demand is also high), or when additional value is gained (for example, by peak shaving or a premium payment for electricity).

Table 2: Comparison of Electrical Savings and Wood Fuel Costs at Various Gross Outputs of Organic Rankine Cycle Power Generation Capacity

Gross Power Output of ORC (kW)	Boiler Output (MBH)	Projected Wood Fuel Use (tons/24 hours)	Net Electrical Savings ($/24 hours)	Wood Fuel Cost ($/24 Hours)
35	1,493	4.22	$93	$190
30	1,280	3.62	$80	$163
25	1,066	3.02	$67	$136
20	853	2.41	$53	$109
15	640	1.81	$40	$81
10	427	1.21	$27	$54

Source: High Sierra Community Energy Development Corporation

- Proper fuel management is critical. Although the Kohlbach furnace system is capable of handling wet fuel, all system operations are improved with dry fuel, including increased energy content per bin delivery, improved efficiency of combustion, reduced emissions, and improved cost savings. This highlights the importance of fuel management—well-thought-out procurement and storage processes that maintain appropriate moisture contents and fuel quality are essential to the success of small-scale biomass energy. This point underscores the importance of not only chip procurement but also storage or management of fuel to assure moisture content is within the desired range of boiler operating efficiencies.
- The liquid loop radiator cooling tower is an essential piece of equipment for this system as it allows the boiler to dissipate excess (waste) heat to maintain the furnace temperatures required to combust high moisture content fuel and to avoid producing visible emissions.
- Although biomass systems themselves can be designed to be mostly "hands-off," they require more involvement and oversight to manage fuel procurement, fuel quality, and fuel hauling for efficient operations compared to a fossil fuel heating system. A community/project owner should be aware of this from both a cost and personnel perspective. It is one of the reasons Sierra Institute has launched the Crescent Mills Wood Utilization Campus and is in the process of securing needed equipment and infrastructure to support biomass facilities, ranging from a modernized roll-off truck to a fuel storage shed and a wood chip truck dump, among other equipment.

- ORC power generation from biomass is best suited when it supplements heat-led systems to improve economics. A power-led scenario results in poor operating economics as it increases wood fuel demand, therefore increasing fuel costs as it produces more waste heat than can be used. The amount of power generated is insufficient to offset costs of production. Table 2 illustrates that savings from "power only" mode would never alone cover operating costs, demonstrating the importance of production of thermal energy for HHSC heat with this facility, as it makes up the balance of operating costs from thermal savings and/or sales to break even.

CHAPTER 4: Technology/Knowledge/Market Transfer Activities

Regional and Statewide Replication

Community-scale biomass energy generation in investor-owned utility territory in California might offer an attractive option to biomass developers due to the ease of interconnection — this facility is small enough that it does not require a power purchase agreement with an investor-owned utility to be successful. Replication of this facility around the county will allow for increased scale of impact, like further reduction in grid demand and increased utilization of low-value wood.

Promoting replication of this facility has been a leading priority for Sierra Institute since the onset of this project. Sierra Institute and project partners have shared lessons learned and insight to other entities in Plumas County that have expressed interest in converting to biomass heating systems, and to additional rural forested communities throughout California per its Rural Community Development Initiative program.

Figure 22: Representatives from Sierra Institute, High Sierra, and California Energy Commission

Onsite meeting between Sierra Institute, High Sierra, and California Energy Commission Agreement Manager during construction, February 2018.

Source: Sierra Institute for Community and Environment

Because this project served as a demonstration for community-scale biomass heat and power, it has already attracted attention both locally and statewide regarding opportunities for biomass technology. High capital costs of these small-scale biomass facilities will continue to be a challenge for widespread adoption, but Sierra Institute feels optimistic as grant funding available for projects that support forest restoration is increasing in California following recent catastrophic wildfires and subsequently released California Governor's Executive Orders B-52-18 of May 2018 and N-05-19 of September 2019.

Successful completion of this system has drawn attention from other entities in Plumas County, as it demonstrates biomass heat as a reliable, renewable, low-cost alternative to propane and other fossil fuels. CAL FIRE and the California Department of Corrections recently announced a plan to move forward with installation of biomass boilers at various Conservation Camps in California, including already designed projects in Trinity and Modoc Counties. A community services district in the Lake Tahoe area has also expressed interest in developing a similar system in their community. Staff from this community services district toured the HHSC facility in 2019 and identified that they want a similarly robust biomass boiler that can handle hog fuel from local fuels reduction efforts.

Near and mid-term target markets for community-scale biomass heat and power facilities include adoption by additional county or government-owned buildings, hospitals, and schools throughout Plumas County. Sierra Institute has identified two candidates for near term markets, one of which has recently received grant funding to support installation of a thermal biomass system on-site. Pending board approval, construction of this facility could launch in 2020.

Long-term target markets include additional rural forested communities across California and working with them to identify outlets for woody biomass and to upgrade outdated and aging fossil-fuel using heating infrastructure.

Knowledge Transfer: Building Local Capacity

Development of the Plumas HHSC biomass facility provided a tremendous opportunity to bring technological innovation to rural Plumas County. Local contractors who led the construction process (for both the development of the cross-laminated timber building and installation of the biomass system) are now familiar with technology and processes needed for development of these facilities, and have experience to draw and build from for future biomass energy development projects in Plumas County. These local contractors can serve as a resource for contractors in other areas that pursue community-scale biomass energy systems as well.

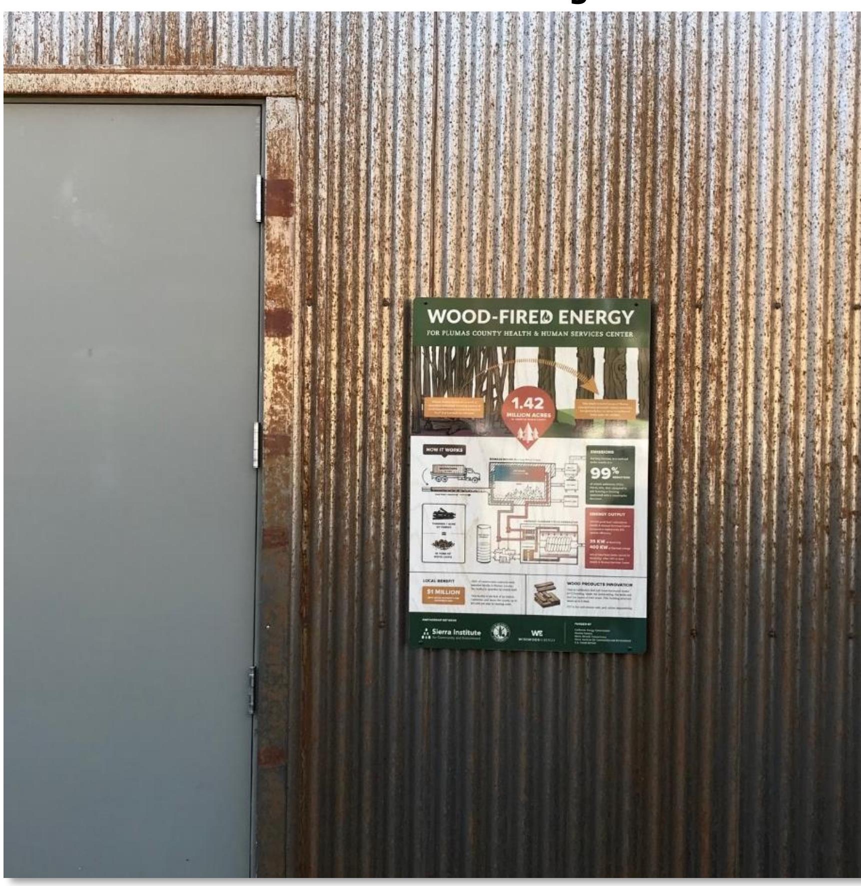
Plumas County Facility Services workers are now trained in biomass boiler operations and have taken on management of the system in stride. This facility has sparked interest of a variety of groups, including local community stakeholders, state policy makers, forestry industry representatives, community services district representatives from other areas, and others. Sierra Institute and Plumas County have provided many site tours of the facility. Its completion has helped put Quincy on the map for natural resource management groups and agencies based in Sacramento and other more distant locales.

With development of future systems, there is now opportunity for collaboration among boiler operators or facilities staff from different entities (county, schools, other government entities) in Plumas County. With the recent funding from the Sierra Nevada Conservancy, another installation involving a biomass-fired boiler at Quincy High School is under consideration by the Plumas Unified School District. The school district has indicated that with such support it will likely welcome a biomass boiler to replace a fossil fuel boiler well beyond its useful life, in part inspired by the success of the HHSC boiler, as well as the funding support from Sierra Nevada Conservancy.

Public Outreach

To foster a widespread recognition of the important role community-scale biomass use plays in both forest health and rural economic development conversations, and to promote investment in such facilities, Sierra Institute has shared and presented results from this project to a variety of audiences. These audiences include stakeholders from rural counties in California wishing to convert to biomass heat, biomass energy developers and those in the biomass industry, state and federal natural resource management agency personnel, state task forces on tree mortality and forest restoration, to state legislative staffers, and more. An infographic is on display at the boiler building for the public to learn more about the biomass system and the benefits of biomass energy (Figure 23).

Figure 23: Facility Infographic Displayed on Boiler Building for Public Viewing



Source: Houston Construction

Project Presentations

Presentations about this project were made at the following events:

- California Energy Commission EPIC Symposium, Folsom, CA. December 2015
- Western State Wood Energy Team Conference, Fresno, CA. November 2017

- Tree Mortality Task Force, Utilization Working Group Meeting, Sacramento, CA. February 2018
- Webinar on Forest Health and Woody Biomass Utilization, hosted by Sierra Business Council. February 2018.
- Informational panel on forest restoration and wood utilization for California legislative staffers, hosted by the Nature Conservancy. Sacramento, CA. May 2018
- California Forest Management Task Force Meetings September and December 2018
- Resource Legacy Fund Board Meeting April 2019; site visit, May 2019.
- Northern California Community Loan Fund site visit, July 2019.
- Rural Community Development Initiative Workshops, 2015–2019
- Land Conservation Summit, Lake Tahoe, October 2019
- Testimony provided to Assembly Natural Resources Committee Hearing on innovative forest products, December 2019
- EPIC Forum: Powering Resilient Communities through Innovative Technologies, February 2020.

Media Plumas HHSC Biomass Facility:

Press releases

- "Biomass boiler debuts April." Plumas News. March 18, 2018. https://www.plumasnews.com/biomass-boiler-debuts-april-6/
- "Biomass project ribbon cutting draws a crowd." Plumas News. April 13, 2018.
- https://www.plumasnews.com/biomass-project-ribbon-cutting-draws-a-crowd/
- "Sierra Institute biomass heating project to break ground." Biomass Magazine. August 9, 2017. http://biomassmagazine.com/articles/14591/sierra-institute-biomass-heating-project-to-break-ground
- "Solving a Heat Load Hardship." Biomass Magazine. November 3, 2017. http://biomassmagazine.com/articles/14786/solving-a-heat-load-hardship

Videos

- "Baseload Renewable Energy from Biomass in California." Electra Therm. November 2018. https://www.youtube.com/watch?v=6TIVCrwh6P8
- "CLT Construction Time Lapse Quincy California." Sierra Institute for Community and Environment. February 2018. https://www.youtube.com/watch?v=FcY4csyo4TY&feature=emb_title
- "Sierra WIP Stories: Quincy Biomass Boiler Project." Sierra Nevada Conservancy. October 2018. https://www.youtube.com/watch?v=9AAnZtmcjqM&feature=emb_title
- "Synergy: A Sierra Institute Film." Sierra Institute for Community and Environment. January 2020. https://www.youtube.com/watch?v=mSQdLdzKjuk&t=4s

Other

- Photos and general project information from Sierra Institute website: https://sierrainstitute.us/plumas-hhsc-biomass-project/

Ribbon-Cutting Ceremony

A ribbon-cutting ceremony in April 2018, drew attendance from more than 60 partners and community members, as well as representatives from the California Energy Commission, Sierra Nevada Conservancy, U.S. Forest Service, state and federal legislators, local government, and more (Figure 24). This event successfully promoted excitement about wood use projects within our community and garnered attention statewide from agency officials, policy makers, and others.

Figure 24: April 2018 Ribbon-Cutting Attracted Public Attention

Source: Plumas News

Information Dissemination Moving Forward

This project was intended to serve as a demonstration of community-scale biomass heat and power based in a rural forested part of California. Rather than releasing research results to demonstrate findings, the successful installation and operations of this facility deem it a success. Updates and general information on this facility are currently on [Sierra Institute's website](#).

Sierra Institute will continue to serve as a resource and support entities in Plumas County and beyond that have interest in converting to biomass energy, as part of its commitment to building capacity, promoting replication, and sharing lessons learned from its work.

As the State of California embarks on a five-year program of investment in forest restoration and wildfire risk reduction activities totaling a billion dollars, Sierra Institute will continue to advocate for funding for community-scale biomass heat and power to use restoration byproducts while simultaneously promoting rural economic development and generating renewable energy.

CHAPTER 5: Conclusions and Recommendations

With high costs of fossil fuels, increasing threat of destructive wildfire to California's forested communities, and a need to upgrade outdated heating systems at public entities in impoverished rural areas, community-scale biomass energy represents a unique opportunity to link renewable energy generation with forest health, reduced wildfire risk, and rural economic development.

The Plumas HHSC biomass facility demonstrates how multiple benefits can be achieved through the targeted implementation of advanced renewable combined heat and power technology based on woody biomass in the commercial and institutional building sector. Providing district heating and electric generation to a county office building demonstrates how biomass use can be adapted to a variety of scenarios in a rural forested area. This project draws together specific state laws and policies regarding increased use of forest biomass; direct economic, environmental, and community health benefits for ratepayers; state statutory energy goals; and clean energy jobs in California.

With credit to a dedicated project team and partners, this project has been deemed a success overall. It demonstrates the viability of biomass heat and power applications at a community-scale in rural forested communities of California. The facility operated through most of the 2018 – 2019 heating season, and after working through the remaining outstanding commissioning challenges, the facility was in full operation for the entire 2019 – 2020 heating season. The facility has already motivated additional entities in Plumas County to explore opportunities to convert to biomass heat to save heating costs, to upgrade existing outdated heating infrastructure, and to support local efforts that advance important fuels reduction work to reduce the risk of wildfire while also stimulating the local forest products economy.

Primary lessons learned include the confirmation that combining heat and power generation with heat use is essential to the economics of community-scale biomass energy, combustion of dry fuel improves overall system operations and efficiencies while increasing cost savings and reducing emissions, and organic Rankine cycle power generation from biomass is best suited when it supplements heat-led systems to improve economics.

Recommendations for Community-Scale Biomass Energy

Drawing from this experience, the project team offers a number of recommendations, including that owners and operators of community-scale biomass energy systems be prepared to focus energy into fuel procurement and fuel quality management.

It is important to note that this project would not have happened without EPIC grant funding from the California Energy Commission. Financing is one of several barriers to more widespread development of community-scale biomass energy because capital costs of these facilities are high. But they can have relatively rapid returns on investment due to low operational costs compared to fossil fuel-fired systems. Sierra Institute recommends that entities wanting to see more of these systems as well as those interested in converting to biomass energy recognize and value the variety of co-benefits these systems provide and consider more than just cost.

1. Program system controls and set points on an hour-by-hour basis to produce electricity only when it is most economical (when sufficient heat demand from HHSC exists such as in the early morning and coldest days, or to reduce peak power demand on the grid) or to meet other objectives. Optimizing system controls to address changing demands throughout the days, months, and seasons in which the system is operational can produce the greatest possible net decrease in electricity and fossil heat consumption while also being economically favorable for all parties.
2. Connect additional heat users to the system, such as the Feather River College dormitories, to increase heat demand and keep the system in baseload operations for more hours of the year, thus improving overall performance.
3. Improve fuel specifications, including setting a standard for moisture content, and procure the driest fuel possible. Dry fuel improves system operations and efficiencies and burns cleanly, ensuring the facility can operate within its air permit. The Kohlbach furnace has demonstrated that fuel quality is less a concern than moisture content. This system can combust wood chips of all sizes, even firewood, but high moisture content compromises system operations and efficiencies. To mitigate this, fuel should be sourced in the spring and summer for it to dry out, be stockpiled, and then be covered or stored through the heating season to prevent it from getting wet. The project team recommends that community-based organizations wishing to develop small-scale biomass energy consider establishing a procedure for regular testing of fuel quality (for example, when fuel is first sourced, once it is in storage, and periodic deliveries, at least until supplier trust is established), and to establish a protocol for handling the situation if the specification threshold is exceeded (for example, refuse the fuel, obtain a discount from supplier, re-screen, or other options). Procuring on a bone-dry-ton basis would allow for fair pricing of fuel with fluctuating moisture content. This will likely require an entity to manage a centrally located wood chip processing yard to generate a high quality fuel source.
4. Cultivate an understanding that innovation takes time and setbacks are inevitable. Advanced wood energy systems require longer commissioning periods so that new system operators and fuel providers can become accustomed to system operations and parameters. Owners, operators, air quality regulators, and the community would all benefit from recognizing the need for the extended learning period necessary to optimize system performance.
5. Build in budget contingencies in advance to reduce risk. Development of community-scale biomass energy projects in rural areas is generally led by nonprofits or community groups attracted to the wide variety of benefits these systems provide to the environment and local economy. However, these entities are generally inexperienced in renewable energy development, have limited capital capacity, and should anticipate the inevitable setbacks and unexpected challenges. Proposal budgets and reserves need to adequately address and respond to the inevitable project surprises.

6. Ensure that the boiler operator is committed to the success of the facility. It should be noted that the current operational success of the Plumas HHSC system can be credited to the facility operator on staff with the Plumas County Department of Facility Services.
7. Work with any involved investor-owned utility to establish a flexible and responsive relationship. A single and knowledgeable point of contact and a clear process with clear timelines for responses are essential for projects with interconnection agreements to succeed.
8. Investment in wood use technology is essential for it to succeed in the near term. Economically disadvantaged rural areas and institutions, be they counties, school districts, or other public entities, are highly unlikely to select biomass technologies because of the capital cost and perceived risks. Investment in the landscape restoration will not succeed if there is not development of wood utilization infrastructure.
9. Gather a manageable number of creative and experienced collaborators for the project team.

This project was intended to serve as a demonstration of community-scale biomass heat and power based in a rural forested part of California. Sierra Institute will continue to serve as a resource and support entities in Plumas County and beyond that have interest in converting to biomass energy, as part of its commitment to building capacity, promoting replication, and sharing lessons learned from its work.

As California embarks on a five-year program of investment in forest restoration and wildfire risk reduction activities totaling a billion dollars, Sierra Institute will continue to advocate for funding for community-scale biomass heat and power to use restoration byproducts because these systems are essential to the success of forest restoration work, will lead to more forest restoration, and will simultaneously advance rural economic development while generating renewable energy to support state goals to reduce greenhouse gas emissions.

CHAPTER 6: Benefits to California and Ratepayers

This Plumas HHSC facility is the first community-scale biomass-fired heat and power system in a district energy application in California. It represents an innovative link among well-tested boiler technology, specific state laws and policies regarding increased use of forest biomass, direct economic, environmental, and community health benefits for ratepayers, state statutory energy goals, and clean energy jobs in California.

Economically, ratepayer benefits include greater electricity reliability and increased safety by decreasing peak demand and providing on-site electrical generation. Reducing electricity consumption at peak and off-peak times at a public facility can lower costs to ratepayers locally and on the grid in general. Benefits also accrue to entities that can use thermal heat and electricity and have forest biomass from fire safe or other activities that they would otherwise have to pay to dispose of, like a community services district.

Environmentally, the Plumas HHSC biomass facility generates an outlet for wildfire risk reduction thinning treatments and in the process reduces the risk of catastrophic wildfire in a fire-prone region. Wildfire risk reduction increases ratepayer safety and protects infrastructure such as electric transmission lines that are otherwise threatened during a wildfire event. Reduction of wildfire risk also helps improve air quality and reduce harmful emissions from pile burning and wildfires that compromise human health. The Plumas HHSC biomass system uses 400 tons of wood chips per year and in so doing provides a local outlet for low-value biomass wood material and supports forest restoration activities in Plumas County. This restoration work promotes forest health and reduces the risk of wildfire on 45 to 60 acres per year that threaten communities and electrical infrastructure. By reducing the risk of wildfires, subsequent cleanup, infrastructure repair, and environmental damage may be avoided, thus saving ratepayers money over many years.

Construction of this facility injected almost one million dollars into the local economy through use of local contractors, and operations will continue to support local work through use of locally sourced labor and wood fuel.

Generation of renewable energy by the organic Rankine cycle reduces demand on an already-stressed electrical grid. The system produced a total of 12,440 kWh as of April 12, 2019, when the biomass system was turned off for the summer season when the demand for heat ends. In a regular operating year with consistent heat production, it is projected to produce approximately 52,600 kWh per year. The system reduces the electrical grid's peak demand by targeting energy generation during peak demand times as needed — coinciding with the general times at which heat demand is at its highest. The Plumas HHSC biomass facility eliminated the county's use of an electricity-powered boiler that was previously used to pre-heat water to compensate for an undersized geothermal field and inefficient water source heat pumps.

Elimination of the electric-fired boiler that was used to heat the building also reduced demand on the local electrical grid, as does generation of power during peak electrical demand times.

The decreased demand and decreased grid strain will reduce costs to ratepayers and help to meet state statutory energy goals by using local, renewable forest resources. Advanced wood energy systems have the unique ability to produce power during peak demand times as needed, increasing their value to the grid. This value could be even greater if the system interconnection allowed for electricity to be sent to the grid during peak periods to offset peak loads elsewhere.

Another benefit of community-scale biomass energy generation is the ease of interconnection — this facility is small enough that it does not require a power purchase agreement with an investor-owned utility to be successful. Replication of this facility around the county will allow for increased scale of effects, such as further reduction in grid demand and increased use of low-value wood.

LIST OF ACRONYMS

Term	Definition
ARB	California Air Resources Board
CLT	cross-laminated timber
COP	coefficient of performance
EPIC	Electric Program Investment Charge
HHSC	[Plumas County] Health and Human Services Center
MBH	
NEM	net energy metering
NEMA	net energy metering aggregation
ORC	organic Rankine cycle
PEER MAP	Plumas Energy Efficiency and Renewables Management Action Plan
SCADA	supervisory control and data acquisition

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