LOW INCOME HOUSING ENERGY EFFICIENCY IMPROVEMENT PROGRAM FOR THE YUROK TRIBE OF NORTHERN CALIFORNIA

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A B S T R A C T

Housing on the Yurok Reservation in California is a major concern for the local tribal government. This report details a study of the energy situation for housing of the Yurok Tribe to provide a framework for implementing housing energy efficiency to benefit low-income members of the tribal community residing in substandard housing. The report briefly details the history of the reservation as it pertains to the current housing situation, as well as the authors personal context of living for 16 years in the reservation town of Klamath, CA. The analysis draws on information obtained from mixed methods, including information collected from the Yurok Tribal Government, members of the reservation communities of Klamath, CA and Weitchpec, CA, and energy simulations for homes located on the reservation. Replacement of woodstoves, air sealing of the home and installing improved insulation are considered as the most likely housing retrofits that could potentially see quality of life benefits for the tribal members served. The intervention with the most financial benefit for the tribal members and the least costly for the tribal government was the implementation of a program to install improved woodstoves in tribal homes and improve wood storage for people without adequate means to keep it dry. Due to the prevalence of wood fuel for heating on the reservation, this intervention could lead to financial benefits for tribal members exceeding $1,000 per household in resources annually with investments that are on the order of $3000-$4000 per project for the tribe. These improvements can also be looked at from a cultural perspective, as they attempt to address housing issues in a manner that

prioritizes wood heating, which will allow the local population to continue using the heating fuels that they have used traditionally. The broader findings of this work indicate that there is potential for the Yurok Tribe to implement housing energy efficiency interventions for tribal members that could bring significant social and economic benefits to the tribe as a whole.

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I N T R O D U C T I O N

Energy efficiency has been, and will continue to be, one of the most important issues facing rural communities in the United States. Among these communities, some of the most highly impacted are those of Native American tribes (DoE, 2017). It is well documented that residents of Native American communities have a high rate of poverty, and a report published by the U.S. Department of Health and Human Services and the Centers for Disease Control and Prevention, reported that as recently as 2010 roughly 24.4% of Native American adults were considered to be poor (Barnes, 2010). This situation becomes very apparent when looking into the housing landscape of tribal communities, and the impact of inefficient homes and appliances that serve residents, potentially leading to increased financial costs or potential health risks. The low-income situation that is present on many reservations leads to a potentially large need for energy efficiency improvements to homes, especially older homes that may not have been properly maintained for various reasons.

The purpose of this report is to detail the current issues surrounding housing needs within the Yurok Tribe Reservation in northern California, and to lay out a plan of action to introduce energy efficiency interventions that would be most feasible given the financial constraints and cultural factors of the Yurok Tribe, primarily through retrofits to existing tribal homes. Interventions are suggested that take into consideration aspects of the reservation such as the prevalence of wood usage and other culturally significant factors. These improvements are suggested based on the specific needs of the Yurok

community, and attempt to take full use of any potential housing interventions that are specifically relevant to the energy uses common on the Yurok Reservation. Consultation with officials in both the Planning Department of the Yurok Tribe as well as the Yurok Indian Housing Authority (YIHA) is a critical component to creating a plan that would take the specific needs of the Yurok community into consideration.

The housing needs on the Yurok Reservation are quite varied overall, with some homes in need of more significant renovations than others. This variation in the level of need for households on the reservation creates a need to understand the general housing situation as a baseline case. Due to this range of potential living conditions, interventions that could potentially benefit tribal members regardless of the physical state of their home are of primary interest in this study. Due to the various situations that tribal residents may be in regarding their housing situations, this report will detail multiple approaches and materials that could be utilized by future tribal housing projects. This will allow for the most flexibility moving forward with future projects and will enable the tribal government to better handle specific needs and situations.

Since financial concerns are always going to be one of the top priorities for projects like these, and because this plan should be able to be used as a motivation or justification for future grant opportunities, a basic economic analysis of all material and equipment recommendations were carried out to properly justify all recommendations. These analyses are designed to allow for the tribal government to see the potential future savings on certain energy efficiency projects, or for members of the tribal community to

be better informed of the financial benefits of future retrofit projects. However, it did not seem reasonable to restrict the types of analysis to those that would be purely financial in nature. This analysis was primarily motivated by personal experiences growing up on the reservation, as well as information gathered from other individuals belonging to the Yurok Tribe related to home energy concerns.

Addressing the housing issues present on the Yurok Reservation could go a long way in improving the quality of life for the members of the tribe who could be served. To provide appropriate interventions for the tribal community, institutional interactions, community surveying and a techno-economic model were developed to provide as much information as possible for the tribe to utilize in the future. There is certainly potential for energy efficiency intervention programs to be implemented to some degree in the future, and various elements that could be addressed in these potential programs are detailed in this report. Interventions were designed to potentially be implemented for the low-income community that will be served and include relatively standard improvements to the building shell, such as improved air sealing and insulation. In addition, the prevalence of wood heating on the reservation was taken into heavy consideration, and improvements to this area of home energy use was found to likely be the most feasible option for the Yurok Tribe overall.

LITERATURE REVIEW

I reviewed a range of topic areas to support this work, starting with past work done with the Yurok Tribe in the area of housing and documents that shed light on the various cultural factors present on the reservation that may potentially impact the implementation of housing retrofit projects on the Yurok Reservation. These were instrumental in determining the types of housing interventions that are potentially feasible by incorporating preference for reliance of local resources for energy needs, and identifying the potential issues that could come from attempting to implement more traditional building interventions. Additional documentation relating to past energy related projects that were pursued by the tribe are also discussed in order to provide context into the tribe's general energy related interests over time. Documentation related to the various aspects of home performance contracting, and its distinctions from more typical home improvement plans, was also consulted for this report. This allowed for the design of a potential future program that would be able to optimize interventions for tribal members on a case by case basis, as other research done on the reservation indicated a strong need for a diverse set of potential solutions for these tribal members energy needs.

Yurok Reservation Background

The Yurok Reservation is located in northern California along the Klamath River, and stretches from Klamath, CA near the mouth of the river and stretches up the Klamath

river to Weitchpec, CA. The reservation covers an area of approximately 85 square miles (220 km2), and as of the 2016 United States census, it was reported to be home to at least 1,238 people, though this figure may have increased since this time (American Factfinder, 2016). The land on the reservation is densely covered in trees and other foliage. People that live on the reservation live in a wide variety of locations, from small neighborhood communities to homes located in very remote areas of the surrounding forests. The climate in the region is relatively mild, with heavy winds and rainfall typical in the fall and winter months (US Climate Data, 2018).

The area covered by the reservation can be seen in Figure 1, as well as the past lands that tribe controlled before the area was settled. While the reservation covers a fairly small area along the Klamath River compared to their ancestral land, the majority of the people who reside on the reservation live in Klamath, CA (approximately 800 residents, or roughly 60%). Of the remaining residents, only around 100 reside in the next largest town on the reservation, Weitchpec, CA. The rest of the tribal members living on the Yurok Reservation are located in the even more rural areas between the two towns, along the length of the river. A section of the Klamath River Valley can be seen in Figure 2.

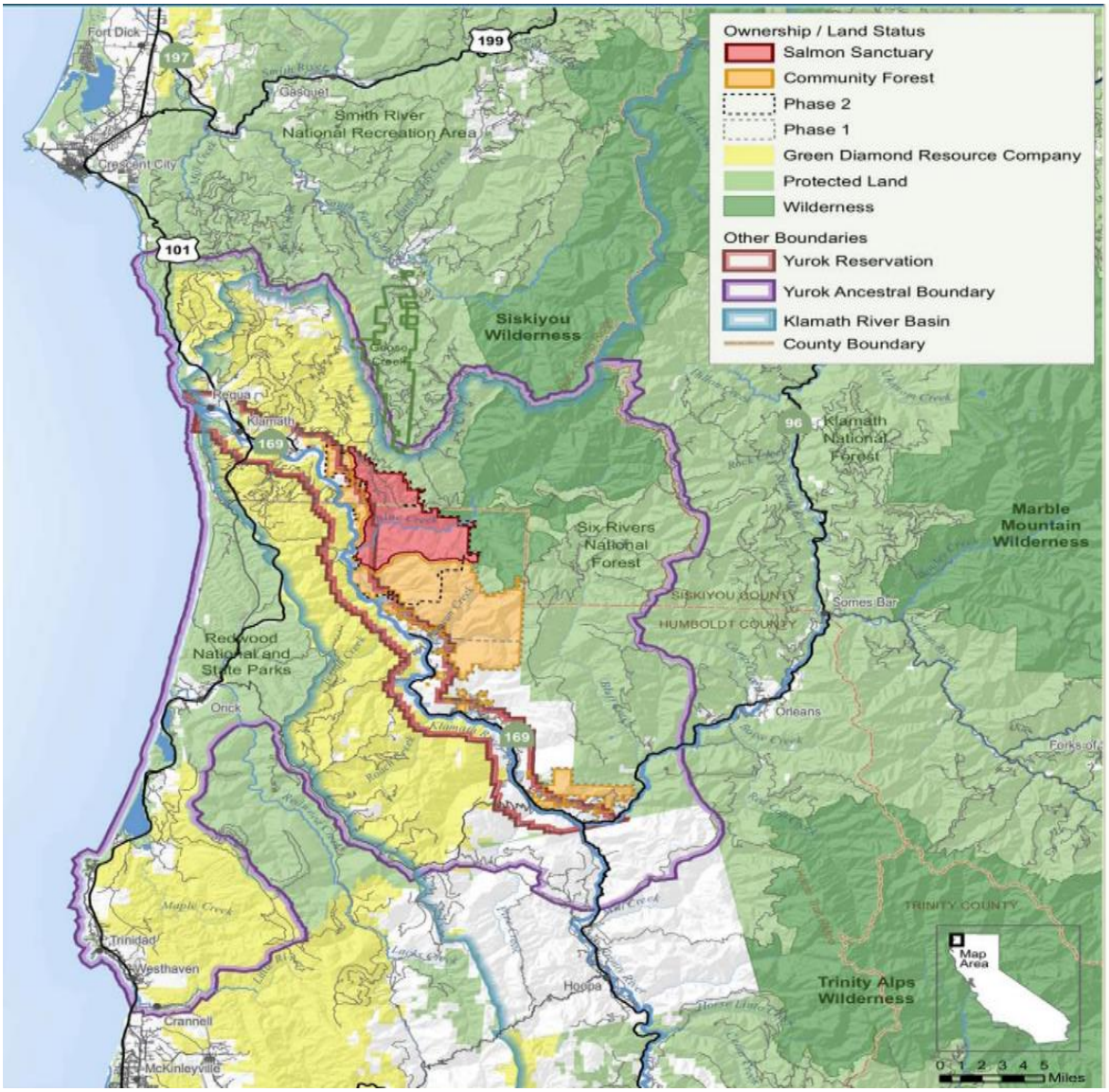

Figure 1: Map of the Yurok Reservation and surrounding areas (WesternRivers, 2013).

Figure 2: Image of the Klamath River Valley (Pintrest, 2018)

Unlike many settlements in the United States, the people living on the Yurok Reservation are on land that has been part of their culture for 1,000's of years. The history of the people and land is intertwined and important to understand for context in this study. The work "A Yurok Forest History" by Lynn Huntsinger (2011) provides a detailed look at the history and culture of the Yurok people both before and after European contact. The Yurok people have always held their ancestral lands as one of the most important aspects of their tribal life, and many generations of Yurok families have

grown up on the reservation lands. Use of all of the available resources on the reservation is considered an essential aspect of life, as the tribal people can use these resources for medicinal and other purposes (depending on the particular resource being utilized). The piece also discusses the importance placed on the local environment by the Yurok Tribe, and how the forest management practices of the tribe should be re-implemented in the area. Many members of the tribe utilize the resources that can be acquired in the local forests for cultural and general uses. Some foliage in the area can be used to create baskets and parts of traditional tribal regalia, and wood is used a cooking fuel and as one of the most common sources of household heating on the reservation (Huntsinger, 2011).

While forest management practices are not strictly within the scope of this report, a proper understanding of the Yurok Tribe's connection to the land, and particularly the Klamath River, is important in recommending any potential home energy efficiency measures that might be able to take advantage of some of these natural resources (e.g., wood for heating). The River in particular, has been a major source of sustainability and self-sufficiency for the Yurok Tribe since before European contact (Huntsinger, 2011). The most important resource acquired from the river for the tribal members are the salmon that regularly swim up the river for spawning. In recent decades, large hydroelectric dams have impeded this essential resource for the tribe, and caused contentions between the tribe and the large utility company responsible for building and operating the dams. These areas of the reservation must be carefully considered, and any

potential project would need to be analyzed to ensure minimal impacts to both the surrounding forest area of the reservation, as well as the Klamath River.

In order to assure that the efficiency measures recommended by this plan for the existing homes on the Yurok Reservation were in compliance with state regulations, the 2015 draft of the "California Existing Buildings Energy Efficiency Action Plan" by the California Energy Commission (CEC) was consulted. The plan is designed to lay out a "10-year roadmap" for California and its currently existing building infrastructure. It is possible that housing projects on the Yurok Reservation do not necessarily need to comply with the building codes/regulations of the state, since housing funding and projects on the reservation are processed by the Yurok Indian Housing Authority (YIHA) which is part of the sovereign entity of the Yurok Tribe as a whole.

The five goals presented in the plan are titled as follows:

- Goal 1: Increased Government Leadership In Energy Efficiency
- Goal 2: Data-Driven Decision Making
- Goal 3: Increased Building Industry Innovation and Performance
- Goal 4: Recognized Value of Energy Efficiency Upgrades
- Goal 5: Affordable and Accessible Energy Efficiency Solutions (2015)

The CEC plan, and its general structure, could also be used in conjunction with the recommendations provided in this report to begin finalizing a more comprehensive future energy plan that would include all of the major building sectors of the Yurok Nation. As

stated by the CEC, “The EBEE Action Plan is organized around five central goals and informed by a uniting vision for the future of California’s existing buildings” (2015). These goals were set up by the CEC in such a way that they could be applied to all of the building sectors addressed in their plan. This comprehensive framework allows for certain key points to be addressed as the plan is enacted, some of which would be critical for successful implementation of a tribal energy plan. All of these goals could be very influential in the creation of a Yurok Residential Energy Plan. The first three goals can be used as a framework for the tribe to attempt to develop the initial stages of the intervention projects, while the last two have potentially the most impact on projects that are being carried out on the reservation.

It is essential that the members of the tribe who might potentially take part in energy efficiency projects understand the extent of the benefits that the project will provide within the specific circumstances present on the Yurok Reservation. It is important that any project that is proposed be economically feasible for both the tribal government, and the individual tribal members benefiting from the project. There are also additional constraints due to the nature of conducting projects on the reservation. Many of the homes on the reservation are in extremely remote areas, making projects more difficult to carry out for these residents compared to those living in the towns along the reservation. There are also specific resource needs that have to be addressed when implementing projects on the reservation due to cultural norms and practices that has led to large amounts of wood usage (Huntsinger, 2011). Due to this dynamic, the CEC report

is used primarily as a guideline for structure and general recommendations for efficiency measures, though the feasibility of the recommendations will be considered under the context of potentially limiting factors specific to the Yurok Tribal Government and the reservation as a whole, rather than to the state of California in general.

Yurok Energy Infrastructure Situation

The Yurok Tribe has been attempting to address issues related to their energy infrastructure for at least the last two decades. These efforts have largely been due to lack of reliable energy resources for certain tribal members, especially elders and those who live in the most rural parts of the reservation. The types of projects that the tribe has researched in the past has ranged from community capacity building for projects to small-scale solutions for individual tribal members/families, and even independent, utility scale generation for areas of the reservation (Zoellick, et al., 2011). It is important to note the context of the energy situation on the reservation as a whole when considering appropriate interventions. This includes the ways in which the tribe has attempted to address these various issues over time. The idea of potential energy independence has been an ongoing interest of the Yurok Tribe for some time but would require significant investment by the tribal community and tribal government to support and implement measures that would allow for this independence (Zoellick, et al., 2011).

Due to the lack of grid reliability and incomplete access to the grid along the Yurok Reservation, the prospect of being able to install more reliable, and tribally

operated energy is a priority and was one of the main driving forces behind a 2011 study conducted by the Schatz Energy Research Center (SERC). The "Yurok Tribe Wind and Hydro Energy Feasibility Study" was conducted with the assistance of key members of the Yurok Tribe, from various areas within the tribal government, in order to determine the potential economic feasibility of renewable generation sources that could have potentially been implemented along the reservation. Some of the tribal departments that were involved in this project were the Yurok Tribe's Planning Department, Fisheries Department, Forestry Department, and Environmental Program. The Directors of these departments were consulted during the course of the research, as well as other members of the Yurok Tribal Government. Some of these tribal government members (e.g. the Planning Director) were also consulted for this current project as well. The primary motivation for the 2011 project was stated in the report as "to examine the opportunity to develop wind and hydroelectric power sources on the Yurok Reservation for wholesale back to the grid" (Zoellick, et al., 2011). Due to the reservation's geographic location, the potential renewable energy resources available vary between areas of the reservation. The study also looked at the potential options available to the tribe for selling their generated electricity back to the utility providers.

The environmental conditions were tested in the locations that were determined suitable for the renewable generation sources in the study by SERC. There was wind speed data logging for the McKinnon Hill site and flow rate monitoring of Pecwan and Ke'pel creeks. An economic screening "was conducted based on the revenue generation

potential and estimated project costs" (Zoellick, et al., 2011) and discussed projects that were deemed potentially economically feasible for the Yurok Tribe at the time: a 1.5MW hydroelectric generation system located on Pecwan Creek.

The McKinnon Hill ridge site was not feasible due to both lack of available infrastructure, as well as complicated land rights issues surrounding certain parcels of privately owned tribal land (Zoellick, 2011). After further economic analysis was conducted on the final generation site on Pecwan Creek, recommendations were then made to the tribe regarding the need for grant finding to initiate the project. It also noted that, even for this final site "the electrical distribution infrastructure serving the project site will need to be substantially upgraded to support the Pecwan Creek hydroelectric project" (Zoellick, 2011). This statement would indicate that there is likely a need for better electrical infrastructure on the reservation, a point that is also supported by findings found during the course of researching this report.

This lack of sufficient infrastructure inhibits both the ability of the tribe to implement new energy efficiency projects on the reservation, as well as general difficulties meeting the energy generation needs of those in the parts of the reservation where the grid is weak or nonexistent. It was estimated in the report that if the tribe was able to secure a source of grant funding for a portion of the up-front cost to implement the Pecwan Creek hydroelectric project (approximately $9.5 million with the necessary grid improvements), that they would see a net present value of the project of up to $2.9 million over a 50 year timeframe based on a "5% discount rate, a debt financed project at

5% interest for 30 years, and a 10% grant" (Zoellick, 2011). However, as of the writing of this thesis report, the Pecwan Creek hydroelectric project has yet to be implemented by the tribe. This is likely due to the prohibitive nature of both having to secure grant funding for the project, and having to upgrade existing utility infrastructure. This would indicate that there are more factors at play for this implementation of tribal energy projects than just whether or not the project seems economically feasible on paper.

One of the common issues that faces households located on the Yurok Reservation (especially in the regions located further up the Klamath River), is the availability/reliability of electrical services in the area. Certain sections of the Yurok Reservation are in an area where the electricity grid does not reach some homes and businesses, and this can cause some understandable quality of life issues in these areas. Some of these issues include a necessary reliance on diesel generators for homes, which could cause air quality concerns for residents, especially the elderly and those with small children. This also impacts other sectors on the reservation, such as schooling, when some tribal schools are also located in off grid areas, relying on diesel for their primary energy needs as well.

The Yurok Tribe has attempted to implement multiple projects in order to improve energy availability/reliability for certain tribal members in these affected areas. One of these projects was the Yurok Tribe's Alternative Energy Project, proposed by the tribe and published by the American Solar Energy Society in 1999. This early energy plan for the tribe was conducted by Kelso Starrs & Associates, LLC and the Energy and

Resources Group at UC Berkeley. This report shows the desire for tribal run energy systems has been an interest for them for nearly 20 years stating, “What makes this project particularly interesting is that the tribe will own, operate, and maintain the alternative energy systems, and will meter and bill for the electricity used by tribal member customers” (Starrs & Jacobson, 1999). To this day, the tribe still is pursuing projects related to energy independence and access, including the interventions detailed in this report.

The Yurok Tribe Alternative Energy Project described in the report 20 years ago was to be an effort by the tribe to both become more energy independent, and to implement renewable generation sources that could be owned and operated by the tribe, for the tribal members. The project was inspired by the profound lack of up-river utility services located on the reservation stating that “only 15% of households currently have what they or the tribe consider ‘adequate’ electricity service” (Starrs & Jacobson, 1999). Access to grid electricity remains a challenge today in many of the same areas. The system was designed to take advantage of both a solar PV system and hydroelectric generation for their electricity service. The system was then put through a pilot project phase in order to determine ongoing costs for the project, as well as potential rates that tribal members would have to pay for the service. The results of this pilot project showed that, at the time, on-going maintenance costs for the project made the bills that the tribal rate payers faced prohibitively high. It also determined that the hydroelectric generation option was the more feasible choice for electricity generation. It should be noted that, due

to the significant drop in the cost for solar generation since 1999 (from approximately $12/W in 1999 to $4/W in 2015), that the feasibility of solar generation could be a more appealing option for the tribe (Roberts, 2016). The observations were then used to make future recommendations to the tribe if they decided to continue to pursue the project (Starrs & Jacobson, 1999). Unfortunately, the Yurok Tribe Alternative Energy Project did not leave the pilot stage, and the energy situation in the up-river area has not improved greatly since the pilot project was attempted.

The issue of access to energy continues to be a major problem for some members of the Yurok Tribe. Due to the remote nature of many of the residences on tribal land, especially in the up-river area, some tribal members go without the most basic of energy needs. Due to limitations of the grid infrastructure in the area, certain tribal households are not connected to either electricity, or telephone lines.

Off-grid tribal residents face great risks as well due to the additional lack of local emergency services in the area, and the inability to communicate with any neighboring cities/towns. In 2004 the Yurok Tribe and Winzler & Kelly Consulting Engineers of Eureka, CA, conducted a survey of Yurok Tribal residents who lived off of the local electric grid (Rakestraw, 2005). The survey included 75 tribal households, and contained questions regarding the occupants demographic information, as well as the types of services they feel that they need, or that they would use if they had access to. The studies primary goal was to determine the level of household telephone need on the Yurok Reservation, but also detailed other information related to the homes energy situation that

was relevant for determining household phone need. The study found information related to the construction and energy needs of primarily low income tribal homes (Rakestraw, 2005). The study found that approximately 70% of homes surveyed used a diesel generator for their electricity to power lighting in their homes.

Two additional pieces of information were found in this report that are of particular significance to this report, primarily the data regarding home construction. They survey found that approximately 92% of residences were built over a crawl space, indicating potential energy saving measures to install insulation under the floor of homes. It was also reported that approximately 30% of homes surveyed had an attic, though there was no indication as to how many homes had both an attic and a crawl space (Rakestraw, 2005).

Another residential energy efficiency project in the mid-2000's led to a report published by the Schatz Energy Research Center that described need for residential energy and worked to develop capacity among Yurok Tribal Government and members. The primary survey information on housing characteristics is a useful benchmark against which to measure survey results that were independently conducted for this project. Of the 52 homes that were surveyed in the SERC report, 35 (or 67%) of the homes surveyed reported using wood as their primary heating source (Engel, 2007). The study also surveyed 24 homes in more detail to determine areas that the homes might have needed improvement. It was reported that 11 of the 24 homes required additional or new insulation, and 12 of the 24 homes required better air sealing (Engel, 2007). Both areas

are addressed in the interventions proposed for tribal members in this report. The report also looked at the feasibility of installing solar the rooftops of these homes as well, an intervention which will briefly be discussed later in this report.

Tribal Demographics

As of the writing of this report, the most recent source of economic data regarding Yurok tribal members was the 2016 United States Census information obtained from the United States Census Bureau (American Factfinder, 2016). However, since the majority of the people living on the reservation are considered to be members of the tribe, this data can serve as a general landscape for the local economy. As of the 2016 census 54.1% of the Yurok population was not part of the civilian labor force, and 11.1% of the population that was in the labor force were unemployed. This figure is more than twice the national average reported by the Bureau of Labor Statistics of 4.7% for that year. Additionally, the median household income for tribal members was $28,333 in the year 2016, compared to the national average of $57,617 (American Factfinder, 2016). This all results in the unfortunate fact that, according to the United States Census Bureau, about 20% of Yurok families and 25% of Yurok individuals fell below the national poverty line in the year 2016.

The Author's Personal Context

Having the experience of living in Klamath, CA the majority of my life, I can personally state that these 2016 figures are consistent with my families experience living on the reservation from 1992-2008. Many families still struggle to earn enough to feed everyone, and many tribal members go without basic modern essentials, such as electricity. For many on the reservation, including myself when living there, the only feasible source of heat is wood burning, whether it be in a fire pit outside, or a wood burning stove inside the home. These economic, and household struggles of tribal members come into view when looking over some current homes located on the reservation that are examples of those that would require major structural improvements to support traditional residential weatherization projects. The following homes in Figures 3 and 4 are located on the upriver section of the reservation, and give a good example of the severe need in some of these cases.

Figure 3: Residence of a Yurok tribal member, located near Weitchpec, CA. (Photo Courtesy of the Yurok Tribe)

Figure 4:Additional tribal residences on the Yurok Reservation. (Photo Courtesy of the Yurok Tribe).

This is only a small sample of some of the dwellings that members of the Yurok Tribe live in. Additional residences were consulted in person for the purposes of this report, and will be discussed in more detail later in this report. The housing situation for some tribal members is one of the most important needs that must be addressed. Due to the condition of some of these homes, it is unlikely that most renovations or energy efficiency improvements would be economically feasible for these residents. This would depend on the level of physical degradation of the home. In the cases of homes with standing water on the property, severe mold or pest problems, or other significant structural problems, the most cost-effective method is likely to rebuild from the ground up.

The primary take away from the literature that was reviewed for this project is that the energy needs and interests on the reservation are quite varied in scope. A broad take-away is that high-cost projects such as renewable generation will have difficulties being implemented without significant outside funding sources. The proposed interventions in this report were designed in a manner that looked at the specific needs that have been previously addressed for tribal homes, rather than addressing generation issued on the reservation. This approach could be more financially realistic for the tribe to implement on some level and has the potential to improve the overall quality of life for the tribal members served.

M E T H O D S

I approached this research project with a combination of institutional engagement with the Yurok tribal government, a small-scale household survey (N=26), and techno-economic analysis of alternatives for energy efficiency investment in existing homes. My goal was to develop a future plan of action to address the current housing needs of low income members of the Yurok Tribe. These methods were chosen due to the need to address the various aspects of life on the reservation that could affect the types of housing interventions that are the most practical for tribal members.

Outreach to the tribal government helped me determine the appropriate types of projects that could be pursued on the reservation. This included both interactions and discussions with key members of the tribal government (specifically their Planning and Housing Departments), and meeting with members of the Yurok community to discuss the types of issues that the members of the Yurok Tribe find most important to their lives.

Understanding the household situations on the Yurok Reservation was a key component of this report, so in order to obtain the perspective of some of the tribal members on the issues relating to their home energy needs, a survey of households on the reservation was conducted. The survey was small scale, only covering 26 homes between the towns of Klamath, CA and Weitchpec, CA. Assuming that there are approximately three occupants per household, this would represent about 9% of the population of the reservation (American Factfinder, 2016). These homes were selected subjectively in the

small neighborhoods and rural surrounding areas to get a good idea of the overall housing situation on the reservation based on my understanding of the range in housing. The topics covered by the survey included information related to the individual's status with the Yurok Tribe, demographic information such as their household income ranges, and general questions related to the types of energy usages that they utilized on a regular basis. This information was key in informing the types of interventions that would likely be appropriate for many tribal members. It also gave insight into the various culture and economic factors present on the reservation that would affect project implementation or success. The survey documents used for this project were approved by the Humboldt State University Institutional Review Board and can be found in Appendix C[1].

I used a techno-economic analysis to estimate the possible savings from energy efficiency interventions that were based on my background research and survey findings. Models for this analysis were generated using the U.S. Department of Energy's program known as eQuest (DoE2, 2009). The models were designed to simulate housing conditions for the tribal members at various levels of energy efficiency interventions, including base models that considered worst case scenario housing situations based on survey observations. The energy savings for the tribal members was approximated by using these simulations to estimate the annual heating demands for the tribal households. It was determined that the most important aspect of home energy usage to analyze was

[1] The methods used in this study were reviewed and approved through Humboldt State University's Institutional Review Board (IRB# 17-083).

the potential heating needs for those living on the reservation. These models were used to estimate annual energy usage based on the heating load needed for each simulated home. Due to woodstoves being used by approximately 65% of Yurok tribal households as their primary heating source, it was deemed appropriate to use wood as the fuel most critical to analyze for this project (Engel, 2007). Once energy simulations were done, the annual usage was compared with information on the energy content of wood to determine an approximate amount of wood usage (Engineering Toolbox, 2018). After the estimated usage was calculated using a spreadsheet, the approximate cost for the tribal members wood usage was also computed. The data from these simulations can be found in the Results of this report

Housing parameters and various parameters for these models can be found in later sections of this report and in Appendix B. This model, however, is likely to overestimate the amount of wood usage in the households, since people typically do not manage wood heating in a way that would keep the home at a consistent temperature throughout the day. Additionally, the temperature that a home would be heated to on average would likely differ from home to home, depending on the homeowners' preferences. The housing interventions that were determined to be appropriate for the tribe were uniquely determined due to the prevalence of wood fuel as the main heating source for most tribal members. As a result, this report looks specifically at homes that are, at least in part, heated by some sort of woodstove across all of the reservation (Engel, 2007). In order to further support the approximation of costs, price estimates for labor and materials were

taken from a local contractor who had done work with the Yurok Tribe and other low-income clients. These pricing estimates were the primary factor used to estimate the potential up-front costs to the tribe for any proposed project.

R E S U L T S

The various methods discussed above were combined to form a number of potential housing energy interventions for the reservation. Using a multi-faceted approach to research the appropriate types of interventions for the specific situations present on the reservation allowed for potential solutions to be tailored to the unique needs found in the area. The needs of the tribal community were determined using a combination of institutional research and community surveys. Key members of the Yurok Tribal Government were consulted to determine the general needs of the community, and the types of projects that the Yurok Tribe would generally be interested in pursuing. For a more individualized assessment of the housing needs of the reservation, a brief energy survey was conducted with households on the reservation. To determine the technical aspects of the interventions, a combination of eQuest modeling and excel economic analysis is utilized to determine the potential benefits that the tribal members could see annually for a given intervention.

Institutional Research

To inform my institutional understanding, I was in regular contact with key members of the tribal government sectors that would relate to tribal housing over the course of this study including the Yurok Tribe Planning Director; as well as the Assistant Planning Director. Over the course of my research, I met with at least one of them on 6 separate occasions to discuss elements of the project.

During our first meeting, general information related to specific tribal energy needs were addressed, and the great need for improvements to tribal housing was discussed in detail. In this initial meeting, the Planning Director also brought up the need for a general energy plan to lay out a roadmap for the tribe's future energy investments. In subsequent meetings, information related to current and past projects with the tribe and other agencies was discussed. The general scope of the tribal housing need was provided by the Assistant Planning Director, who supplied some images and data related to the current housing landscape on the reservation. Example projects laid out in this plan (with the exception of simply building a new wood storage area), as well as all of the specific energy needs of the tribe were designed after thorough consultation with the Planning Directors.

The Director of the Yurok Indian Housing Authority (YIHA) gave insight on issues relating to housing regulations and potential labor issues for tribal projects. YIHA is particularly interested in employment aspects of tribal housing projects, especially those that are done in the more remote up-river locations. According to the 2016 US Census, there is an estimated overall unemployment rate on the Yurok Reservation of 23% (American Factfinder, 2016). This is essentially six times higher than the current estimated national unemployment rate of 4.1% (NCSL, 2018). This obviously indicates a need for additional employment opportunities on the Yurok Reservation, jobs that could potentially be created alongside a housing energy efficiency intervention program implemented by the tribal government.

A primary concern is that the cost for traditional EE projects might be prohibitive, due to both the lack of tribal contractors qualified for projects; and, the high cost of non-tribal contractors. These concerns were echoed by the tribe's Planning Department. The Director of YIHA also brought up several project ideas that could optimize the use of tribal lands for housing, including possibly building fourplex housing units for multiple tribal families, in order to house more people per available piece of land. Others noted that the duplex (or more larger numbers of connected housing units) design may be challenged by tribal members who are not likely to tolerate more than one other family per dwelling, due to the local culture.

In addition to personal interviews I was present for a tribal community meeting, held in Weitchpec, CA near the end of July 2017 at which this project was one of the topics. During this meeting, the general structure of this project was detailed for the attendees, and community members described some specific needs that had yet to be addressed by tribal government officials. Many of the needs discussed during this meeting show a large need for better tribal infrastructure in the upriver locations of the reservation, including energy systems. The topics are summarized in Table 1 below.

Table 1: Discussion points made during the tribal community meeting at the Weitchpec office of the Yurok Tribal Government in July 2017.

Key Discussion Points from Community Meeting	Relevant to home EE?
Improved Public Transport for Elders	No
Overharvesting of Trees for Wood	Yes
Agricultural Runoff on the Upper Klamath River	No
Unreliability of the Electrical Grid	Yes

Though many of the needs discussed are not in the scope of this report, such as the need for better transportation for tribal elders, this is still a key energy service for the people on the reservation. This particular issue also happens to disproportionately affect the disabled and/or elderly tribal members living in more remote areas of the reservation. It was stated that many of the elderly rely on the shuttle system run by the tribal government in the Weitchpec area, and that some of the elders were currently not living in an area where the shuttles stopped near their home. During the community meeting, the fact that more needs to be done to help this community was made very clear by all of those in attendance.

Some concerns that were considered to be relevant this report were concerns related to potential over harvesting of local forests for fuel wood to heat homes and cook. Wood is a key resource utilized by those living on the Yurok Reservation, with approximately two-thirds of households utilizing wood as their primary heating source (Engel, 2007). This has led some members of the tribal community to become concerned about the prospect of some tribal members over harvesting trees to stockpile wood for the cold and wet winter months.

It was also brought up that there were potential concerns related to local water quality due to runoff from livestock located on farms along the Klamath River. This could prove to be a large local health concern if left untreated, and it is recommended that chemical tests on the local water supply be carried out before any project is carried out.

Finally, concerns related to the reliability of local electricity for the members of the upriver community were discussed. This issue was largely brought up due to the risk that it can pose to elderly tribal members, since there are no major medical facilities located within less than a one-hour drive away. The situation is made worse for some residents due to some areas in on the upriver portion of the reservation having no grid connection at all, as the electric grid does not fully extend into some parts of the reservation.

The meetings described above were critical in allowing me to obtain a key understanding of the tribal government and how it interacts with the community as a whole. My meetings with the administrators of the Planning Department and YIHA gave me insight into the various challenges that face tribal members who are living on the reservation. It also brought to light some limitations and concerns the Yurok Tribe as far has regarding their potential capacity to carry out projects due to financial constraints and other social issues found on the reservation.

Using a work force that is, at least in part, composed of local tribal members will likely be a major factor in any successful project, as it would raise community support for projects and lead to potential economic benefits for the tribal government and certain tribal members. Discussions with YIHA emphasized the opportunity and need to strengthen the tribal workforce to contribute to community-building projects like this, as were concerns raised regarding the consistency of tribal workers under certain circumstances. Understanding the extent of these limitations, both from the institutional

perspective and the community perspective, was a key factor in determining the types of projects that would be proposed in this report; as well as some of the delivery suggestions made for those projects.

Residential Energy Survey

In order to sufficiently motivate the implementations detailed in the rest of this report, a small-scale residential energy survey (N=26) was conducted on the Yurok Reservation between the dates of January 13th and 14th 2018. The goal was to identify current housing needs on the reservation, and to gain a better understanding of the current housing landscape on the Yurok Reservation.

Due to the sparse population of the region, several locations were chosen in the two towns (Klamath and Weitchpec, CA) that were surveyed. The sampling was opportunistic, with a general goal to visit households that have a range of wealth and housing infrastructure. There are large differences in housing quality in the different areas of Klamath, as well as due to the sparseness of the homes in the Weitchpec area. In the case of Klamath, the areas of Requa, Hunter Creek, and the Klamath town site were chosen as the areas for the surveys to be conducted. These areas in Klamath were selected as, from personal experience living there, selecting only one housing area would leave out much of the diversity in the housing stock of the area. For example, focusing only on the Klamath townsite would only represent homes that are newer in comparison to other

areas of Klamath. Sample pictures of some of the homes that were allowed to be photographed are given in Figures 5 and 6.

Figure 5: Yurok residence surveyed in the up-river portion of the Yurok Reservation.

Figure 6:Yurok residence surveyed in the up-river portion of the Yurok Reservation.

One of the most common themes presented by those who were interviewed was a general sense of dissatisfaction with the assistance available to those on the reservation with challenging housing needs from a basic infrastructure perspective; many homes have basic structural or construction deficiencies that need fixing before further investment in the structures. Some residents discussed major housing concerns, such as black mold and rat infestations, that were not able to be covered by any housing programs currently offered by the tribe. This issue of substandard housing is too complicated to address directly in the content of this report, as the Yurok Tribe is limited in their

available resources for funding specific types of housing renovations (e.g., based on programs for funding through the federal government).

As a precursor to EE improvement of any home is fixing any issues that are directly hazardous to occupants, which should certainly be one of the major points of consideration for any tribal housing project. There is also the possibility of creating a program that would at least attempt to mitigate the severe housing issues, such as mold issues, pest infestations, and gaps in the exterior of the some of the homes on the reservation. This type of program would complement the types of energy efficiency and home performance renovations that are being proposed by this report. Since these major concerns will make the implementation of these projects next to impossible for these homes. For any solution that is proposed by this report, a home must be generally structurally sound in order to see any meaningful benefits.

Another issue raised by multiple people during the survey was that many members of the Yurok Tribe have significant housing needs but do not live on the reservation. Due to the limited region that the reservation covers in terms of land area, many of the members of the Yurok Tribe live on lands that are not technically located on the reservation. These homes present an additional complicated situation, as support from some members of the tribe who may not reside on reservation land may be needed for future projects. These homes could presumably be eligible for improvements through other home improvement programs on the state and federal level. The potential funding sources for these types of projects are likely to remain the same for projects both on and

off the reservation. This issue is noted due to numerous instances of people surveyed complaining about a lack of programs for those who live off of the reservation.

The root of many challenges I identified is poverty and lack of access to resources. There are a large number of survey participants who reported earning less than $25,000 annually (~65%). Figure 6 shows the aggregated results for all 26 of the surveys collected. This information shows us key information related to the general income levels of those on the reservation, primarily the prevalence of low-income household in the area.

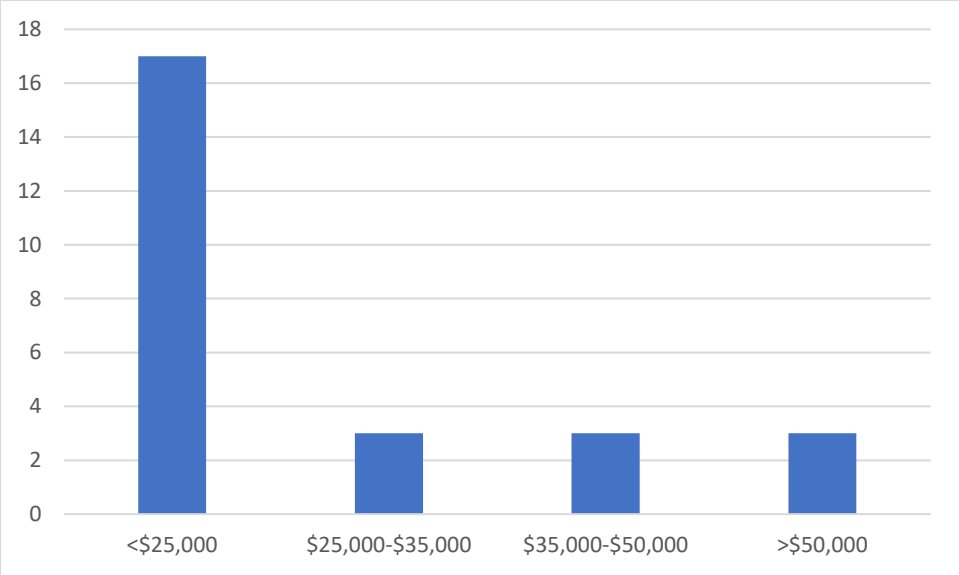

Figure 7:Aggregate household income data collected during the Residential Energy Survey.

As a long-term result of poverty on (and off) the reservation, it is unlikely that many households in the area will be able to afford any significant improvements to their homes through their own income. Due to the extreme levels of poverty that also plague

the region, it is not a feasible solution for tribal families in this situation to find new housing, unless such housing is provided for them.

Some of the homes surveyed on the reservation were reported to have no insulation in the structure whatsoever. In some cases, homes such as these were also reported to have sever mold and pest issues, while having to serve as sufficient housing for multiple generations of one or more families. These conditions raise considerable concerns for the safety of some tribal families on the reservation and are certainly issues that should be addressed when drafting any official documentation related to the housing plans for extremely low-income families on the reservation. While there are certainly large costs associated with improving some of these residences, many of which are explained in the Cost Analysis section of this report, there are also potentially lower cost improvements that could at least be made on a short-term basis.

Roughly 50% of the households surveyed claimed to have "adequate" insulation, but the actual amount of insulation in the homes were not measured. This is approximately in line with information gained from past surveys done regarding household energy on the Yurok Reservation of roughly 48% of homes needing additional insulation (Engel, 2007). In at least 3 instances, residents claimed to have no insulation whatsoever, often with children residing in the home as well. It is also possible that homeowners in some residences were not aware of insulation issues in their homes. A more complete inspection of any home that may be looked at for energy efficiency or

home performance improvements would have to be thoroughly inspected to ensure that there is, in fact, sufficient insulation installed in the home.

Another factor that is important for understanding energy concerns for tribal members is the prevalence of wood heating on the reservation. The majority of homes in both the Klamath and Weitchpec areas either regularly relied on wood in times of power outages, or outright used wood as the primary heating source in the home. Electricity the second most common source of heating for homes, and was generally more prevalent in the Klamath region (14 out of 16 homes), with the Weitchpec area containing a larger proportion of homes that utilized gas (propane) heating on occasion (7 out of 10 homes). This is also in line with the previous surveys done on the reservation, which reported approximately 70% of homes use wood heating in some way (Engel, 2007). It should be noted as well, that many of the homes with electric heating, but no woodstove, claimed to want to acquire a woodstove in the future. The most common reason for this was the lack of reliability of the local grid infrastructure, even in the Klamath area, and the likelihood of being without power (and subsequently heat) for an extended period of time during the winter months. With many homes containing at least one tribal elder, as well as many homes that also contained young children, the potential health risks associated with long power outages in these colder times of the year in increased dramatically with no back-up heating source.

It is not surprising that the most common form of heat on the reservation (in both the Klamath and Weitchpec areas) is wood-fueled heat. Wood usage is of major cultural

importance to the Yurok Tribe, and the act of gathering and burning wood is part of many traditional tribal practices. It is also a very convenient source of heating for those who are physically able to gather sufficient quantities for their homes. Wood donations to those tribal members who are not able to harvest their own could help to alleviate this issue. Wood stoves are used mostly for heat; but, also on a small scale for cooking since many traditional ways that wood is used for cooking on the reservation (such as for smoking salmon) are done in areas outside of the main home. The primary time that the wood stoves were used for cooking were during the instances of power outages during the winter months. Overall, households with wood stoves have generally more heat and cooking security than those in the area who do not.

There are a host of other energy concerns that can effect some tribal members on a case by case basis. For example, almost no one on the reservation uses propane; and, those that do only use it on a very limited basis. One woman explained to me that she had been given a fifty-dollar-tank of propane when she moved into her rental home (tribal owned) three years prior, and had never used it. She stated that the tank was still sitting in a closet; and, she, "…wished that I had the fifty dollars to spend on my utilities.". There she stood, a single mom in a house with five children, with inadequate insulation and high energy bills. The house she lives in, along with several others in the subdivision where she lives, are tribal owned. These houses are stick built homes, approximately fifteen years old, that were built by an out-of-area speculator. The project went into bankruptcy and was purchased by the tribe.

Newer homes that are being made available to tribal members are another avenue for improving living situations; but, these homes are not necessarily well-built structures. In a recent development that was built, the living room/kitchen/dining areas are open concept. The homes are all two stories, so the fact that these homes contain only one woodstove, on the lower floor, results in a need to use much larger amounts of firewood to heat the entire living space since heat rises to the upper story and people who are in the lower part of the house will continue to need additional heating. This creates a scenario in these structures that consumes larger amounts of energy to heat in the winter than a more compact home.

Weatherization was another energy issue that a number of households voiced concerns about. These concerns were primarily concerning the home current windows, with many of the participants wanting to replace single pane windows in their homes. However, as will be discussed later, the windows would be an expensive and labor-intensive intervention. However, weather stripping and insulation are two forms of energy improvements that would be inexpensive; and, some households could possibly do their own installation.

There were some additional energy related concerns raised by some of the tribal members who participated in the survey, including solar generation and small-scale hydroelectric generation. Solar is being utilized on a very minor scale, with only 1 homeowner claiming to be currently utilizing it, but many people were interested in solar applications. Some individuals even asked if I were involved in the possible

acquiring/installing of solar panels or equipment. This was, I would suggest, the most frequently mentioned energy upgrade in conversation with survey participants. Some people stated that they have panels; but, are in the process of installing them (or will install them when the weather permits). The excitement and enthusiasm for solar was common.

During the survey, I only encountered one household with hydro-electric power in their plans. They were a young couple that use solar as their main form of energy. Their goal is to be completely off-grid by the end of summer 2018. Their enthusiasm was overwhelming; and, they could not say enough about the need for alternative energy sources.

A common thread among the interviewees was the need for a more organized plan in providing necessary housing or energy plans, but a the wide-range of housing on the reservation makes it hard to apply a one-size-fits-all solution. The type of structures on the reservation are as varied as the land they stand on. Tribal land, fee land, private land, stick built houses, modular homes, old and dilapidated, newer and well-built: there are as many types of housing as there are people occupying them. There were approximately 15 younger families surveyed, as well as some elderly tribal members and a few middle and upper-middle class residents.

The general data regarding the home owners' responses regarding their home construction is presented in Figure 8. Overall, the distribution between stick-built homes and modular homes was somewhat close, with 16 living in a stick-built home, while 10

homeowners resided in modular units. Among the 26 houses I visited, there were no consistent patterns relating the general quality of the home and its construction type. Both good and deficient qualities of construction were found among stick-built and modular housing.

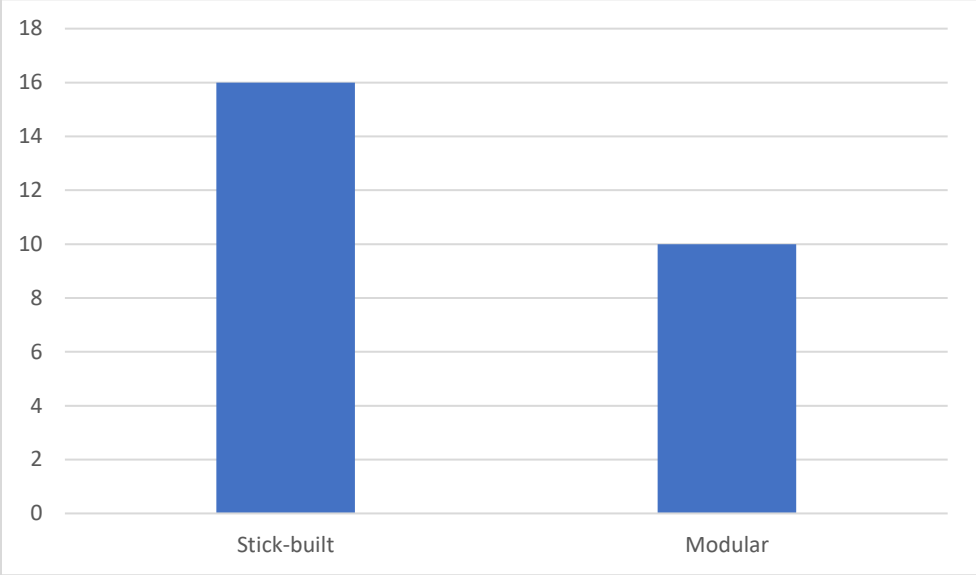

Figure 8: Home construction classifications for surveyed households (N=26).

It is possible that significant structural issues present in a tribal members home could cause significant issues in the implementation of energy efficiency interventions. In some extreme cases, the homes could potentially be in poor enough condition that the only feasible solution would be to completely rebuild; as opposed to implementing energy efficiency and home performance improvements that would not see much if any benefits for the homeowners. But, this is not so obvious, or even doable, for the people who dwell in these types of homes. Some of these have housed generations of families.

Some are still housing multiple generations within the walls of one dwelling-whatever that dwelling may be.

The age of the homes in both of the surveyed areas was also a concern for multiple homeowners. Of the 26 households surveyed, 12 reported that their homes were over 25 years old, with a few outliers claiming that their homes were over 100 years old. This information indicates that many homes on the reservation are old, and potentially in need of major structural renovations. The aggregate data taken regarding the age of the home owners homes is presented in Figure 9.

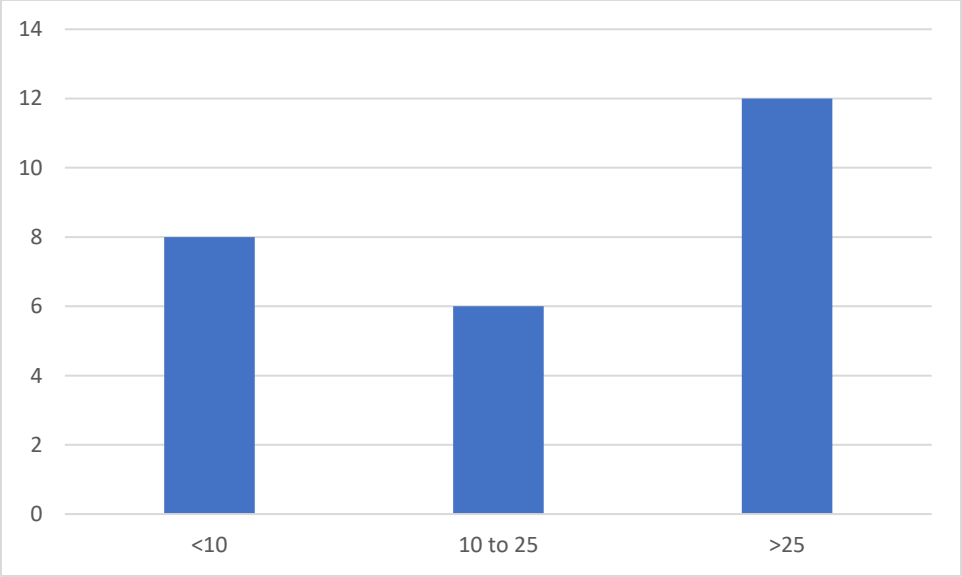

Figure 9: Chart of home age ranges reported during the survey.

Several of the homeowners surveyed listed better weatherization as a major improvement that they would be interested in. Many older homes in particular were, in

some cases, reported to have serious water leakage problems during the frequent winter rains. The older homes were also more likely to rely entirely on wood as their primary heating source. This combination of sometimes unreliable and uneven heating in older homes, has resulted in some very serious housing problems for some of the people. These homes were also some of the few examples of homes that had been in the same family for multiple generations. The information collected from the survey regarding the ways in which the homes were constructed was useful in determining the types of homes that should be focused on as the priorities for this plan.

In the context of tribal housing it is important as well to recognize the potential cultural value associated with leaving housing as-is. It was initially anticipated that there would be a large number of households in the surveyed areas that had been passed down between generations of the same family. However, out of the 26 surveys that were completed, only 6 of the households surveyed reported that their home had been in their family for more than a generation. Therefore, in most cases, the potential issue of sentimental attachment to the home itself could be fairly minimal for most on the reservation, making the prospect of larger renovations or replacement more palatable for the tribal members who might benefit from home energy efficiency improvements and do not live in inherited homes. In one case though, the fact that the homeowners residence was considered a local landmark led to some hesitance related to wanting to implement potentially extensive structural renovations.

Coping with an unreliable grid is required for life on the reservation. During the course of the survey, the majority of the people who were questioned claimed to not make use of any sort of additional generator during times of power outages, which is known to be frequent in both the Klamath and Weitchpec areas. It is possible, especially with the small sample size, that this observation is a statistical anomaly, and that a more thorough investigation of potential household energy sources in the region may find more of a reliance on these secondary sources of electricity on the reservation.

In the homes that without alternative power or heating supply, there is increased risk of negative impacts on the homeowners (especially the tribal elders) during the winter months. Considering the frequent power outages that those on the reservation face on a regular basis, as well as the fact that little to nothing will likely be done in the near future to remedy that situation, a potential policy implementation for the tribe could be a program to provide power generators to households in need during potential long winter power outages. This could also potentially reduce the frequency, or at least the severity, of construction related issues surrounding mold and rot in homes on the reservation, by reducing the number of potential hours in which there can be no consistent heat regulation in the home. This is another reason that wood heating is one of the most important energy resources on the Yurok Reservation, as it allows for the homeowners to keep their home warm and dry during potential outages in the winter months.

Many of the trends that have been discovered during the conducting of this survey are consistent with the findings from the 2005 Winzler & Kelly report that focused on the

residential energy and telephone needs on the reservation. In that report, they found the average annual income of households on the reservation (out of 75 homes surveyed) was "less than $12,500", with 48% of the households making less than $15,000 annually, and 28% of households not disclosing their income (Winzler & Kelly, 2005). The trend of prevailing severe poverty in the area has been consistent for over a century.

The home construction I documented is consistent with the 2005 findings as well, with approximately 73% of their surveyed homes being stick-built compared to roughly 62% in the current survey (Winzler & Kelly, 2005). There was a higher ratio of modular homes found in the current survey, with roughly 38% of current homeowners living in modular units compared to 17% in the previous study. No travel trailer owners/renters were surveyed for the current report, compared to approximately 10% in the previous survey (Winzler & Kelly, 2005). One pieces of information that was surprisingly difficult to obtain from homeowners during my survey was the type of land that the homes were built on. The vast majority of those who were surveyed were not aware if their home was located on Yurok Indian Housing Authority (YIHA) land, fee land, or trust land. The 2005 report found roughly 50% of homeowners on fee status land, 44% on trust status land, and only 5% unsure. It would be safe to assume that these numbers have actually remained somewhat consistent over the years, and this discrepancy likely stems from a potential gap in homeowner knowledge.

Institutional Analysis

Based on my findings in the institutional analysis and survey I worked to find possible retrofit and renovation concepts that deal with the most pressing current housing issues faced by the community and could be delivered within the constraints of the community. This tentative list of upgrade priorities has been decided for homes on the Yurok Reservation includes addressing building shell concerns for homes and improving the efficiency of wood heating in tribal homes.

There are large concerns in the area with moisture, mold, and insufficient building shell issues in tribal homes; thus the main priority for retrofits or upgrades to homes should be in energy and heating efficiency. Since there is such a wide range of needs found on the reservation, the specific types of interventions would likely have to be figured out on a case by case basis. There were some institutional concerns relating to the feasibility for the tribe to be able to implement many home energy interventions, primarily due to a perceived lack of capacity for these types of projects on the reservation. Issues related to the creation of jobs, and the necessity that programs be available for primarily low-income households, were the two largest factors that had to be addressed for these programs to potentially be successful. However, there was a set of potentially feasible interventions that could be implemented on the Yurok Reservation in nearly all cases. These areas were the efficiency of the woodstove in the home, improving the air sealing of the home, and adding insulation in the sections of the home that are the most vulnerable to heat loss.

Identifying/Modeling Technology Options:

Since the primary focus of this project is to provide the tribe with the most realistic and feasible solutions for low-income tribal households on the reservation, it is important to ensure that any improvements that are done are likely to result in better energy efficiency for the households while keeping the costs of projects at a minimum. The interventions were chosen based attempting to achieve the largest energy savings that they could potentially provide to the tribal members, while minimizing their overall cost to the Yurok Tribal Government.

My approach to techno-economic modeling included factoring in the various unique aspects of tribal homes, primarily the prevalence of wood use for heating, and determining the interventions that would lead to the best cost/benefit ratio possible for the tribal government and the tribal members receiving the interventions. To scope out and determine possible effective retrofit and energy efficiency projects, a professional contractor from the Humboldt County area was consulted. This professional, who both specialized in renewable energy and energy efficiency related projects, and who had experience with low-income projects, gave valuable insight into the types of projects that would be realistic for these homes considering the budget constraints and the local climate. A combination of the the eQuest modeling, Excel calculations, and the information that was obtained from the professional contractor were the primary tools used to determine the most appropriate interventions on the reservation.

The most critical insight from the professional contractor I interviewed was to look at all of these projects from the perspective of overall home performance, and not simply energy efficiency. This means viewing the home as a system, where all of the important "layers" of the home have to be implemented in such a way that each element complements the next. The primary areas of the home that would be of interest to the tribe as far as energy retrofit projects are concerned are the house envelope (which will be broken down into two primary components later in this section), and the homes heating and ventilation (HVAC) systems (including wood stoves). These areas are both essential to address for proposed building interventions to be feasible, as the most cost effective improvements to tribal homes are from improvements to these areas.

By looking at the potential projects from the perspective of home performance, many unnecessary or ineffective measures can be eliminated from consideration immediately. Home performance professionals, including the one consulted for this report, would only consider about 4 general measures appropriate for a low-income situation due to cost constraints. These four areas, in descending order of impact/importance are:

1.) Wood Stove Replacement / Improvement

2.) Air Sealing

3.) Insulation

Woodstoves

Both current and previous surveys estimate that approximately 70% of tribal members use wood stoves as their primary heating source in their home (Engel, 2007). There were two potential interventions that were considered related to woodstove prevalence on the reservation, improving the wood storage space in the case of tribal members who are using wet wood, and replacing inefficient woodstoves for tribal members. While there were no technical inspections done while researching this report, visual observations of heating units in the surveyed homes would indicate a high likelihood that currently installed wood stoves would have to be replaced in some homes. In addition to potential air quality issues stated above, older or improperly installed woodstoves will also lead to increase wood usage for the tribal members throughout the year. This increases the financial or physical burden placed on those who rely on wood heat. Replacement of woodstoves in tribal members homes has significant potential as a low-cost measure to be implemented on the reservation. If the there is a significant enough change in the cost to tribal members finances and/or quality of life, there is the possibility that a project that only replaces the woodstoves in tribal members homes could still be an effective one overall. This is especially critical in the case of home performance contracting, as the HVAC system of the home is always the first aspect that will be addressed, as it can greatly affect the air sealing and insulation phases of a project (Chitwood, 2010).

An additional sometimes overlooked consideration is the local climate with a wintertime rainy season, and its potential effects on the quality of the wood fuel used by the tribal members. Due to the frequent rain storms on the reservation, proper dry wood storage is also a top priority if a project hopes to optimize annual fuel use. It was found that utilizing wet wood for heating nearly doubled the amount of wood needed to maintain a consistent temperature throughout the year. In addition to this, the large amount of additional smoke that is created from burning wet wood increases concerns relating to indoor air quality as well. As a result, there was some consideration made as to some potential low-cost methods to ensure that the fuel wood is kept reasonably dry throughout the year. This is a key initial step in successfully implementing these interventions effectively, though it is highly likely that most tribal members who rely on wood as a primary heating source have some way to ensure their wood is kept dry throughout the year out of necessity, it should still be part of the initial phases of all projects to ensure this is the case. This intervention has the potential of being the single most impactful measure if implemented properly. Due to the high reliance on wood heating on the reservation, optimizing the wood use for any tribal members is likely to see a major benefit for them either socially or financially.

Air Sealing

After improving wood stove efficiency, air sealing could be a very cost-effective option for improvement (Chitwood, 2010). For this measure, if tribal labor is to be employed, the tribe would first need to invest in professional equipment that would

determine the level of air infiltration in the house, as well as a precise determination of whether the measures would be effective for improving home performance. This allows the tribe to know, on a case by case basis, whether individual homes would stand to benefit from upgrades, or if certain homes are too structurally unsound or degraded for feasible improvement. Preliminary tests are essential, as air sealing also has the potential to reduce indoor air quality, especially in homes that are potentially burning large amounts of wood for their heating. In some homes, air sealing could potentially lead to more indoor air quality issues than the potential reduction in fuel use would justify, especially in homes with older or improperly installed woodstoves. Any projects that are carried out should be tested both before and after interventions are applied, to ensure no unforeseen issues arise.

In the case of air sealing a tribal members home, the tribe could potentially find additional ways in which to save money. As this intervention requires no major specific training, the tribe could potentially use Yurok Tribal contractors to carry out air sealing jobs with no additional equipment needs besides materials and the initial house inspection as specified above. According to the home performance professional who was consulted, as well as supporting information from a guide on Measured Home Performance which was compiled from the experiences of various home performance professionals in the state of California, the most advantageous areas to focus on in a typical home would be the attic and crawl space (Chitwood, 2010). Generally speaking, these areas of the home are the most at risk for air infiltration, especially if there is little to no insulation in these

spaces, or if that insulation was not properly installed. Air sealing these areas will help to seal the home's envelope (which is generally considered as the walls and insulation of the home) and ensure that any additional measures will be as effective as possible. If we were to improperly seal any areas of air infiltration in the home, and then install better insulation, we would significantly decrease the relative effectiveness of the insulation overall. In some cases, moisture that could be caused from unsealed gaps in the homes envelope can cause insulation to deteriorate, leading to the need for additional projects, and a significant financial loss for the project (Chitwood, 2010). For this reason, special care should be taken by the tribe to ensure that any individuals carrying out air sealing interventions be properly trained on the best practices for this application, to minimize potential losses. It was approximated by the professional contractor that the cost range for air sealing would be $1.00-$1.50 per square foot of the home. This measure is likely to gain additional benefits for the tribe when combined with the wood related measures above. Improving the air sealing of the house will further reduce the amount of heating that is needed for tribal members to keep their homes at a consistent and comfortable temperature.

Insulation

Due to the financial constraints that will be present for these projects, efficient use of additional insulation will be a key aspect of successful implementation. The areas of the home that are likely to see the largest benefits from reinstalling or improving the insulation are the attic and crawl spaces of the homes. These areas are typically the places

where the most heat is lost in the home, especially if the insulation is absent or improperly installed (Chitwood, 2010).

The insulation has to be carefully planned out and installed carefully around any particular heat sources that may be nearby (such as the chimney for the woodstove). This is due to the fact that, in most cases, the primary areas of the home that are targeted by home performance contractors for insulation are the homes attic and/or crawlspace. To avoid potential fire hazards after projects have been carried out, heat sources that could come in contact with the insulation, such as lighting fixtures and wood stove chimneys, must have heat barriers installed around them, and in some cases these elements of the home may have to be replaced. These variables will, of course, affect the price of any given project; but, the advantages and benefits to doing the job properly in the first iteration greatly outweigh the potential losses from improper installation or piecemeal projects, even if those projects have more appealing up-front costs (Chitwood, 2010). This is due to the cost prohibitive nature of the spray foam insulation that would be needed to insulate the crawl space of the home. It is not recommended to use fiberglass batt insulation in the crawl space of the homes, as this is likely to sag if not installed properly, leading to a decrease in effectiveness. It was also noted by the professional contractor, that the cost to hire the proper laborers to install the batt insulation in a crawl space in a manner that would not lead to sagging issues, would likely increase the installation cost to a point where it would be more cost effective to invest in spray foam anyway. To be consistent with California building code requirements, this foam should

be rated at R-19. For the attic space, blown in insulation would be used after the space was properly sealed. In cases where it might be necessary, the attic space may already have some amount of old insulation that would be removed using a gas-powered vacuum. The estimated cost to the tribe for this type of vacuum would be approximately $5000. Though the financial benefits seen by the tribal members receiving these interventions could justify this initial investment for this intervention, which can be seen in the Cost Estimates and Funding section of this report.

Integrated Processes for Heating Improvement

For these interventions to be successfully implemented, the areas of concern in the house must be addressed in the appropriate order to ensure the maximum effectiveness. The first area that should be addressed in these projects is the need for better wood storage and woodstove replacement. Once these factors have been dealt with, the home can then proceed to the air sealing process, if it is determined to be feasible from that point. Once the home has gone through the air sealing process, then the next potential room for performance improvement would be properly insulating the attic and/or crawl space of the home (the attic would be the easier area to insulate properly according to the contractor I worked with, but many tribal homes do not have attic spaces) (Winzler & Kelly, 2005).

Tribal Labor Potential

Implementing labor from tribal members for these projects could be a major benefit to the tribe in many ways. During my discussions with YIHA, the issue was proposed that there is not a significant amount of work available for tribal members. tribal contractors reportedly have a very difficult time finding consistent work on the reservation, forcing them to work for outside companies in areas off the reservation. This lack of potential labor in the area can be seen in the unemployment rate on the reservation of approximately 24%, indicating a severe need for more job creation in the area (American Factfinder, 2016). There were also potential cultural complications that were raised by YIHA, primarily the fact that many tribal members feel uncomfortable with outside people being on their property, especially in the case of long and intrusive processes like these energy interventions. By creating jobs in conjunction with implementation of energy efficiency interventions, there could be more community support for the programs, as this feeling would likely be alleviated by having the work crews also be (at least in part) tribal members. These jobs could be created for much of the initial inspection/energy audit phase of these projects, as well as building the woodshed, air sealing and potentially the insulation. The professional contractor stated that would be required for these aspects of the projects would be able to be done by essentially any professional contractor, including any that already work for the Yurok Tribe. There would likely need to be some outside contracting done for the installation of

new woodstoves, as there are numerous fire dangers that could be caused if these stoves are improperly installed (Chitwood, 2010).

According to the professional contractor consulted, the tribe would likely be able to break even on the investment of the $5000 gas-powered vacuum (in terms of financial benefits to the assisted tribal members) within 10 to 15 projects. This investment is highly recommended, as it would allow a degree of agency for the tribe to initiate projects and potentially carry out some projects with only tribal labor. It would also serve for all of the projects that are conducted, which makes the investment relatively reasonable when compared to the estimated average cost per project.

Unfortunately, there are also reportedly some issues regarding properly training tribal members to work on contracting projects according to the Director of YIHA. The specific reasons for the training concerns were primarily the fact that, in the past, tribal members would not feel that the amount of effort in training was worth the small number of projects that they might be able to work. According to YIHA, there were some reported instances of tribal members leaving training programs part way through for various reasons. Making the benefits apparent to the tribal members who are in training for these programs will be a key step in ensuring success of future projects. It is recommended that the tribal government attempt to coordinate as much community outreach and input for these projects as possible, as this will likely increase the likelihood of convincing tribal members that their current efforts will bring benefits in the relatively

near future (both for the people receiving the housing interventions, and financially for the workers being trained to carry out the projects).

By attempting to use tribal labor to reduce the costs of inspection and air sealing of the homes, the Yurok Tribe could address two issues currently of interest to them on the reservation. With the proper level of community outreach and education, tribal members would be able to see the overall benefits of implementing housing interventions like the ones proposed in this report, and there might be a higher level of interest from potential tribal contractors if consistent work was likely to result from such a program. This could result in additional benefits for the tribe as a whole, both in improving the quality of life of the tribal members receiving the housing interventions, and in providing jobs for other members of the tribe as well.

Energy Modeling

Working towards practical guidelines for properly addressing tribal energy issues through the lens of home performance, I modeled the set of possible interventions I described in the previous section (improvements to wood stove efficiency, air sealing, and insulation) to estimate the energy and cost savings from each to help inform feasibility. I used the eQuest modeling software to create these simulations, with "before and after" cases for projects on tribal homes that follow a logical order (DOE-2, 2016). The goal of the modeling work was to determine the amount of benefit that tribal members might be able to receive in terms of energy usage based on the various types of

interventions that were proposed. Since there is a high likelihood that projects with a high upfront cost would not be immediately feasible for the tribe at this point, it was important to see which interventions would yield the most overall benefits for both the members receiving the interventions, and the tribal government.

I designed the energy modeling to include sensitivity to household size with three different size homes; these represent a wide range of different residences that were seen on the reservation during the conduction of the survey for this report. The homes were sized as 1000 ft^2, 1500 ft^2, and 1800 ft^2 each, and three different versions of the homes were modeled: one with insufficient insulation and significant air infiltration, one with improved air sealing, and one with both improved air sealing and insulation. A summary of these measures are summarized in Table 2. The building specifications used for these models can be found in Appendix B.

Table 2: Summary of proposed energy efficiency interventions.

Measure	Assumed Value(s)	Justification
Heating	70°F	High heating load for maximum fuel usage
Annual Occupancy	100%	High heating load for maximum fuel usage
Wood Shed	N/A	Increased efficiency of dry wood.
Woodstove	Efficiency: 50%-75%	Less annual wood usage
Air Sealing	3-1 Air Change(s)/Hour	Improved heating efficiency
Insulation	R-7 – R-19	Improved heating efficiency

The initial model was considered as the situation before home performance projects were conducted, with R-7 insulation in the walls and about 3 Air Changes Per Hour (ACH) to simulate a drafty and poorly insulated home. To simulate the types of homes that were seen during the survey, it was assumed for these models that no insulation was installed in the attic or crawlspace of the home. The initial models were also designed to have higher levels of air infiltration than the improved homes, which were reduced to 1 ACH, to simulate the advantages of air sealing. The most improved version of the homes were then constructed as though R-19 rated insulation was inserted into the attic and crawl spaces, in addition to reducing the air infiltration.

Once the models were created, simulations were carried out using eQuest to estimate the general energy usage in the homes over the course of a typical year. Graphics and tables summarizing this data were also generated within eQuest and are shown in Figures 10 through 14 below. For the purposed of the analysis in this report, the "space heating" loads were the primary concern. I simulated the space heating as though it is supplied by an electric heater, and these values are later adjusted to estimate how much wood would be required to match the simulated heating load. There is no built-in option for modeling wood heat. The general patterns for all of the homes in Figures 10-13 was relatively consistent between the models. Heating loads are the highest during the winter months, and reach their minimum during the month of July. Overall heating loads also increase significantly as the area of the homes increase.

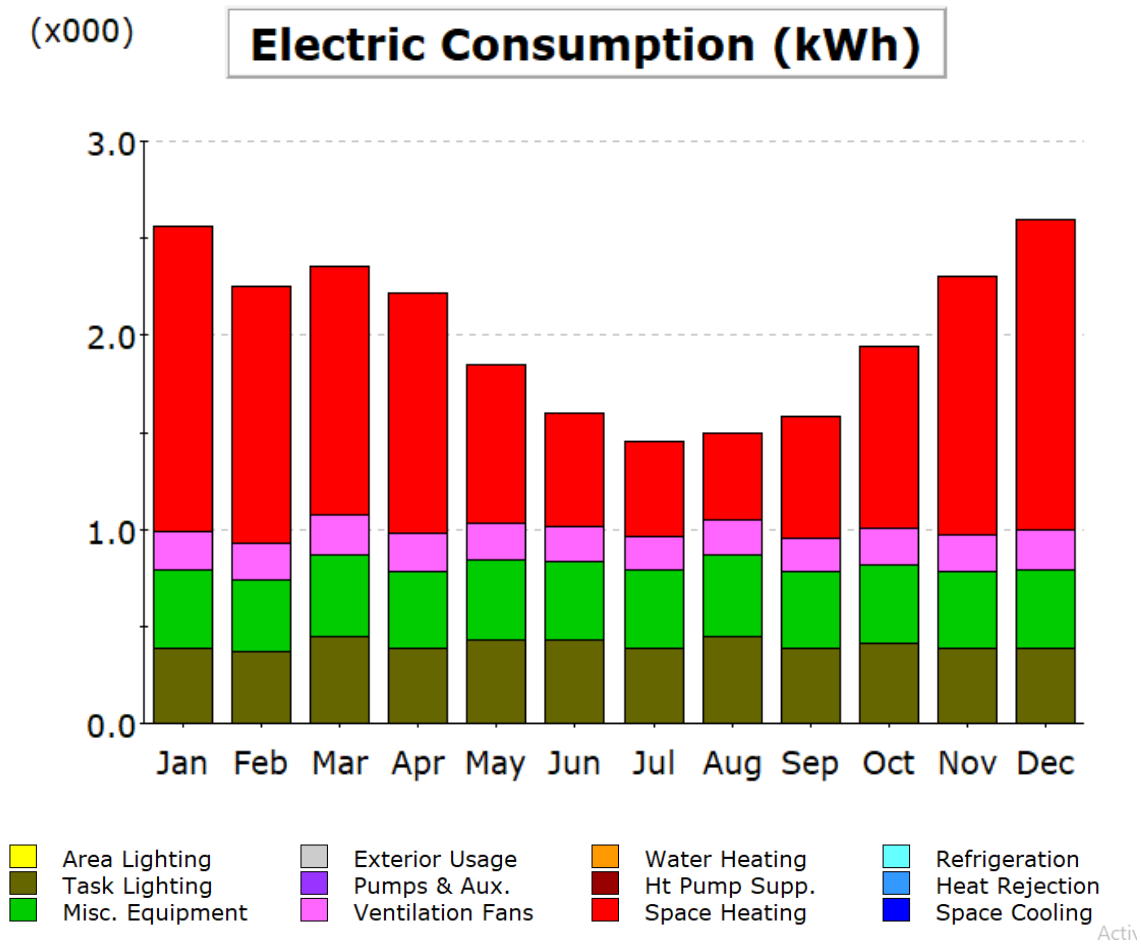

Figure 10: eQuest chart for electricity consumption in a 1000 ft^2 home in Klamath, CA (Baseline).

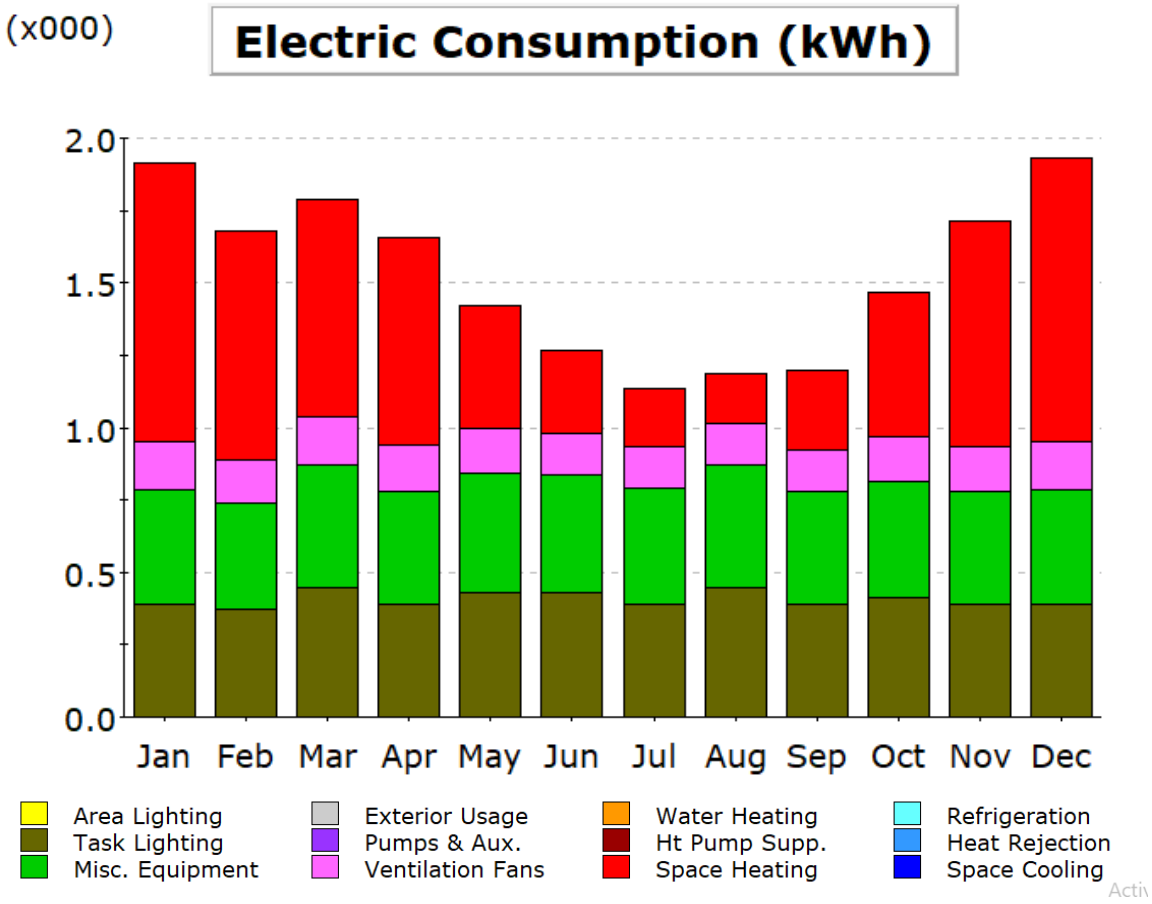

Figure 11: eQuest chart for electricity consumption in a 1000 ft^2 home in Klamath, CA (Air sealing, improved R-19 insulation in attic and crawlspace).

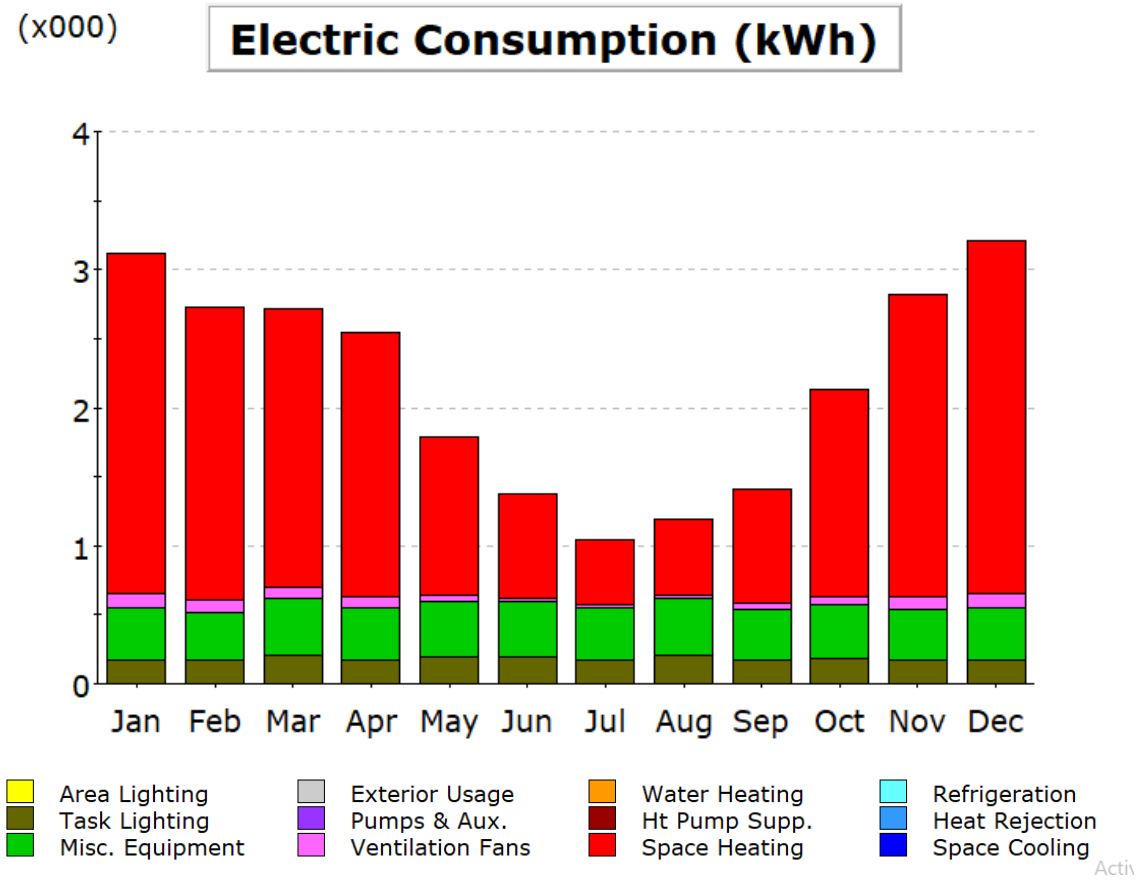

Figure 12: eQuest chart for electricity consumption in a 1800 ft^2 home in Klamath, CA (Baseline).

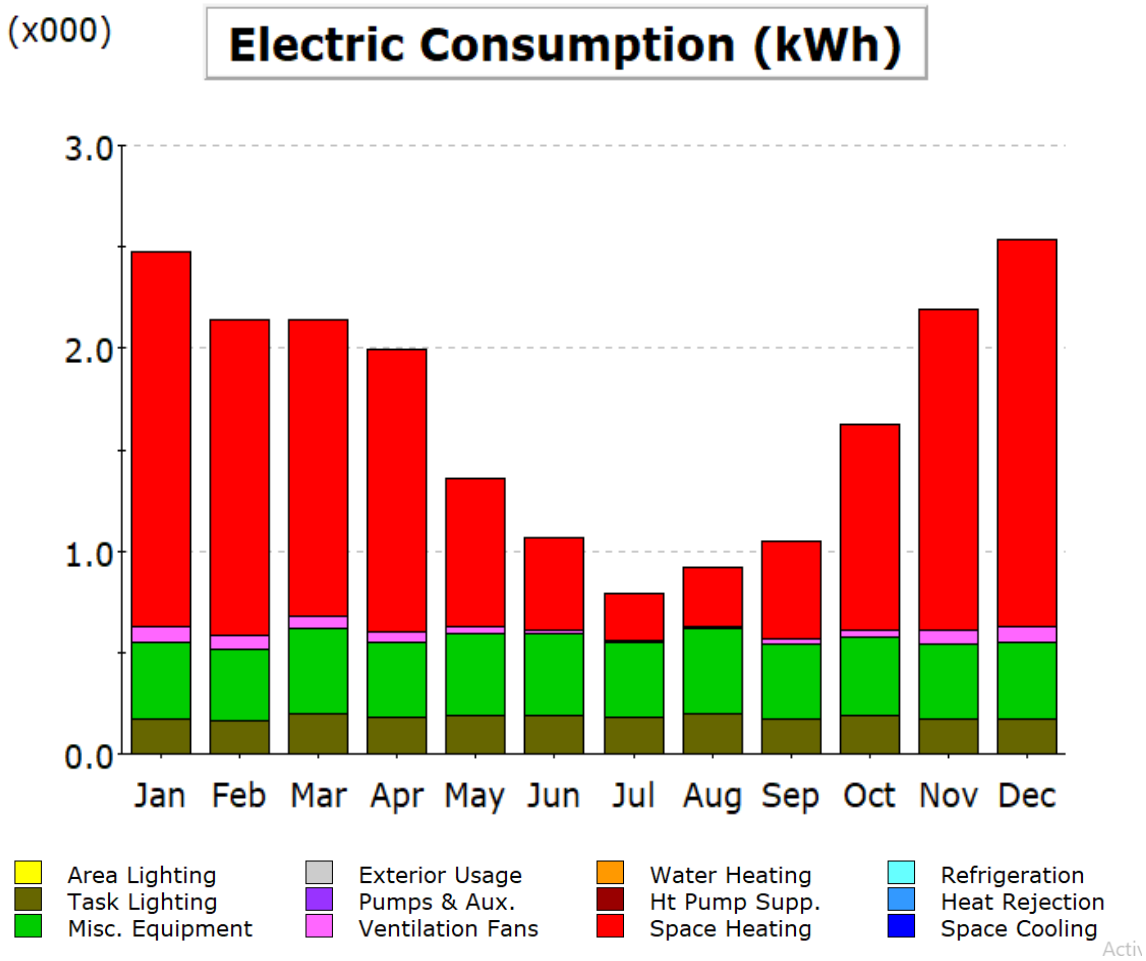

Figure 13: eQuest char for electricity consumption in a 1800 ft^2 home in Klamath, CA (Air Sealing, Improved R-19 in attic and crawlspace).

Tables detailing the estimated electricity usage of the simulated homes can be found in Appendix A. It can clearly be seen from the charts above, however, that the majority of the electricity usage in the homes was from heating, which shows that the majority of energy demand on the reservation is in this area. The heating load simulated from eQuest was used as a proxy for wood heating, allowing for the conversion of who much would these heating loads would require. The homes presented in the simulations were assumed to be heated to an average of 70°F. This result should be considered a base

case, as it is unlikely that tribal members would heat their homes to this high temperature throughout the year. This is discussed further in a brief sensitivity analysis of these results in the Synthesis section of this report. It was assumed that the home would generally be occupied during all times of the year in the model, to estimate the maximum energy usage for a home under these conditions. Thus in the figures above the electricity usage for heat in the homes should be interpreted as wood use (loosely), and this makes the overall electricity use estimates significantly higher than the national average in all cases if they are compared as-is. Due to the cool climate of the Klamath region, the heaters were run at some point during the entire year, with the most usage coming in the winter months, as expected.

I used the output from eQuest to estimate the costs to tribal members for wood heating on an annual basis, and for comparing reductions in wood use across the scenarios I modeled. Considering the various types of potential situations that could be found on the reservation, primarily due to the diversity in the types of housing situations that were observed, the model was designed to allow for changes in particular inputs to adjust the model based on a specific situation. This should allow for maximum flexibility in potential estimate moving forward, as the types of interventions will likely range from simply building a better area for wood storage, to a full intervention utilizing all potential technologies proposed in this report.

A key factor for estimating wood consumption to meet a particular heating load is the moisture content. I used two factors for both wet and dry wood to estimate how much

wood is required to heat (by adjusting the energy density estimates in terms of kJ/kg and kWh/kg). I estimated the energy density is 0.2209 kg/kWh for dry wood and 0.3871 kg/kWh for wet wood (EngineeringToolbox, 2018). I also developed a mixed energy density factor for a "typical" scenario of approximately 90% dry wood, and 10% wet: 0.2375 kg/kWh. These values are summarized in Table 3 below.

Table 3: Assumed variable values for eQuest Models.

Wet Wood Coeff. (kWh/kg)	Dry Wood Coeff. (kWh/kg)	Assumed Weight of Wood (kg/m^3)	Approximate Weight of Cord(kg)	Approximate Cost of Cord ($)
2.583	4.5278	550	1993	200

Other inputs that are able to be changed within the model include the energy efficiency of the woodstoves in question, the assumed weight of the wood (in kg/m^3), the volume of a cord of wood, the assumed cost of a cord of wood, and (as a key input) the energy consumption of the eQuest models in kWh. The price per cord of wood was assumed to per $200/cord, though many of the members of the tribe collect their own firewood either from their own property, or from other locations on the reservation. This means that the actual cost of energy in each real-world scenario will likely vary greatly, though the savings in terms of usage should still remain approximately the same, regardless of the cost of the wood itself. Information relating to how costs were calculated can be found in Appendix A and Appendix B of this report. It is highly unlikely that tribal members will be able to store wood in such a way that it would be 100% dry when used. To adjust for this factor, it was assumed that, if the tribal members

was able to construct or have built a shed for wood storage, that about 90% dry wood would be achievable. For the three cases where the woods stove was untouched during the interventions (baseline, only air sealing, and air sealing with improved insulation), the fuel efficiency of the wood stove was assumed to be around 50%. A summary of this information can be found in Table 4.

Table 4: Summary of information used in energy models.

Models	Characteristics
Baseline	No interventions: 100% wet wood, 50% efficient woodstove, 3 ACH, R-7 insulation.
Woodshed	90% dry wood, no other interventions
Woodshed + Woodstove	90% dry wood, 75% efficient woodstove
Air Sealing	1 ACH, R-7 insulation, 90% dry wood, 75% efficient woodstove.
Air sealing and Insulation	1 ACH, R-19 insulation, 90% dry wood, 75% efficient woodstove.

The proposed interventions are set up in such a way that all higher-level interventions include all other interventions as well. This is done to maximize the potential improvements that these interventions can bring. As was stated earlier, interventions such as adding insulation can be negatively impacted by improper air sealing and other structural issues. By layering the interventions in the manner presented in Table 4, it allows for homes that might not be structurally sound enough for new insulation, or even air sealing, some potential for efficiency improvement. Specifications within the eQuest models and cost spreadsheet were then used to simulate each of the potential housing units, with each of the potential home performance improvements

(including only replacing the wood stove), as well as their annual heating costs in terms of wood consumption. Graphs detailing the approximate savings for the various housing units can be found in Figures 14-16 below.

Figure 14: Estimated energy costs for wood heating for 1000ft^2 homes on the Yurok Reservation.

Figure 15: Estimated energy costs for wood heating for 1500ft^2 homes on the Yurok Reservation.

Figure 16: Estimated energy costs for wood heating for 1800ft^2 homes on the Yurok Reservation.

The biggest improvement to annual costs for the houses I modeled is from improving the efficiency of the woodstoves in the homes through two means – ensuring wood is dry and the stove is efficient. Overall costs for the various levels of housing interventions were determined using the assumed costs and eQuest energy usage data. It should be noted that the cost for using wet wood to heat the 1500 ft^2 simulation was $2,700, with the cost for using wood that was 90% dry being about $1,700. This would result in a difference for wet and 90% dry wood of about $1,000. This indicates that, in the case of tribal members using wet wood, it would likely be viable to simply improve the location that that tribal member stores their wood to reduce the level of moisture exposure. This result is consistent through all of the models, with benefits increasing as the size of the home increases. I would suggest that this intervention, or something similar, be seriously considered for implementation in the future. For the three cases where the woods stove was considered to be untouched during the interventions (baseline, only air sealing, and air sealing with improved insulation), the fuel efficiency of the wood stove was assumed to be around 50%. This case would likely simulate an older, or improperly installed, heating unit. From general observations made during the course of the survey conducted for this report, this is likely going to be the case in many homes that are in need on energy interventions. For the two remaining cases, the efficiency of the unit was assumed to be approximately 75%, which is more in line with an efficient, properly installed wood stove unit (EPA, 2018). The information obtained through these simulations gave useful insight into the potential interventions available to the tribe and the roughly estimated economic impact of each potential intervention

scenario for the tribal members receiving the energy improvements to their homes. From the data obtained and shown in Figures 14-16, the most influential improvement, in terms of annual savings is simply improving wood storage areas and the efficiency of the woodstoves. This would also likely be paired with some sort of improved form of wood storage, to ensure relatively dry wood as this was also a major contributor to annual costs, as can be seen in the difference in costs. This is certainly the most cost-effective solution if it is viable in the situation.

Cost Estimates and Funding

The estimated cost to clear old insulation in a home and install heat barriers to protect new insulation from hot spots, like lighting or the chimney, was $1.00-$1.50 per square foot from the professional contractor consulted for this report. The cost of the insulation was for the attic was estimated to be $1.00-$1.50 per square foot. This would lead to an estimated upfront project cost between $2000-$3000 for just the attic of a 1000 square foot home. For the crawl space, the estimated cost of insulation was estimated at $2.00 per square foot, due to additional training needed to clear and properly install the insulation. This would make the cost for the crawl space of a 1000 square foot home to be approximately $4000. In combination with the rate of $1.00-$1.50 for air sealing, which would cost between $1000-$1500, the total estimated cost for a proposed home performance intervention is between $7000-$8500, which is in line with standards within the field (Chitwood, 2010). Assuming that the cost of a more efficient wood stove for a project would be in the range of $2000-$2500 (Porters, 2018); and, that the cost for

inspection (blower door test, visual inspections, etc.) and installation would follow roughly the same costs as for the other home performance interventions of approximately $1000-$1500 for a 1000 ft^2 home, then it would potentially only cost the tribe $3000-$4000 per project for this intervention, or less than half of the cost of the proposed air sealing and insulation interventions (HomeAdvisor, 2018). Replacing the woodstove only would likely be the most appealing scenario in many cases on the reservation, primarily due to the financial constraints that the tribe is likely to face relating to these projects. Improved wood storage could also be added to these interventions if necessary, and this would likely only increase costs by a few hundred dollars at most, as there is the possibility of being able to construct an improved wood storage area without outside assistance for some tribal members. This data is summarized in Table 5 below.

Table 5: Breakdown of housing intervention costs up-front costs.

	1000 ft^2 Model	1500 ft^2 Model	1800 ft^2 Model
Wood Shed	$100-500	$100-500	$100-500
Woodstove	$2,000-$2,500	$2,000-$2,500	$2,000-$2,500
Inspection	$1,000-$1,500	$1,500-$2,250	$1,800-$2,700
Air Sealing	$1,000-$1,500	$1,500-$2,250	$1,800-$2,700
Insulation	$6,000-$7,000	$7,000-$8,500	$7,600-$9,400
Total for all measures	$10,500-$13,000	$12,500-$16,000	$13,600-$17,800

A simple payback period for each project was constructed by comparing the estimated annual energy savings for the interventions and the estimated costs. This payback period is highly sensitive to the amount of fuel used by the tribal members who

receive the intervention. This issue is discussed further in the Synthesis section of this report.

Table 6: Estimated payback periods for the proposed interventions in years.

	Estimated 1000 Payback (yrs)	Estimated 1500 Payback (yrs)	Estimated 1800 Payback (yrs)
Woodshed	< 1	< 1	< 1
Woodstove	~5	~3	~3
Air Sealing	~6	~5	~4
Insulation	~11	~9	~7

Potential Future Technologies

Due to the limited nature, and extent, of some of the potential efficiency upgrades and retrofit projects proposed in this report, it is important to carefully consider the types of technologies that could also potentially be used as the tribe seeks to implement a new housing project that might be able to take advantage of newer technologies in the future. These interventions, while not potentially feasible for the tribe at this point in time, are still important to consider if there is future potential for expanding their energy efficiency intervention program, and include solar and micro-hydro generation. Certain aspects of design for both current and future tribal housing projects, such as the inclusion of woodstoves in most homes, are unlikely to be changed in any significant way. Due to the availability and cost of wood on the reservation, along with many tribal members living off-grid (or with unreliable service), wood heat is one of the most essential aspects of the Yurok way of life. While there is a definite need to address potential timber consumption

concerns in this area, that is not within the scope of this report. However, any future housing projects should include an option for wood heating, such as a simple woodstove for heating and cooking, as shown in Figure 17.

Figure 17: Arada Faringdon 16 Woodstove, actual rated efficiency 77% (EPA, 2016)

Since the upriver residences (those closer to the town of Weitchpec, CA) have significantly more access to solar resources throughout the year than the more coastal, downriver sites. For upriver homes, implementation of roof mounted solar systems, like the one shown in Figure 19, could be utilized as a means of reducing annual utility costs or providing power to off-grid houses depending on the surrounding tree-cover (which can challenge the feasibility of solar). As the costs of solar PV drops, the possibilities could improve.

Figure 18: Image of a standard roof mounted solar system for a residence. (WiseEnergy, 2014)

Due to many of the tribal residents being in relatively close proximity to the creeks that flow off of, or into, the Klamath River, micro-hydro systems such as that pictured in Figure 8 could be a potential energy alternative for some, especially those who live on more remote, off grid properties on the reservation. The size of the system would depend on the specific tribal members energy needs, but would likely be much smaller in most cases than the system shown. These systems could potentially provide sufficient power for a single family tribal residence, provided it is near enough to a creek or stream with an adequate average flow rate. Some of the residents who were surveyed for the current report indicated that they currently made use of micro-hydro technology on their properties, showing that this is certainly an area worth exploring for some residents on the reservation in the future. This was also supported by information found from SERC previously, indicating that flows in many of the off-river creeks and streams could theoretically support some level of micro-hydro generation for the tribe (Zoellick, et al., 2011). An example of a potential micro-hydro generator is shown in Figure 19.

Figure 19: Example photo of a Canyon Hydro Micro-Hydro generation system (Canyon Hydro, 2014).

Due to the sensitive nature of larger dams along the main channel of the Klamath River, and their impact on the local Salmon runs (a major source of both food and trade for many in the Yurok community), no projects are proposed that would place any hydroelectric system along the main length of the river. It should be stated that this will not resolve all issues related to the local fish populations, as these small systems can still have a negative impact, though there are some turbines designed to be less impactful on fish populations (DoE, 2011). However, a potential concern for renewable generation projects along the Yurok Reservation, especially small hydro and solar power, is the inherent intermittency of the energy resources due to the local climate. For those who would rely on purely small hydro generation, the low flow rates in many creeks and streams that would be suitable for generation, could result in extended power outages. Similarly, for those relying only on solar power, the typical levels of cloud cover during

the Winter is also likely to cause generation deficits and reliability concerns for households not connected to the grid.

In general, any future technology that is adopted by the tribe must be able to fulfill the basic energy needs of the people on the reservation. It is common knowledge for those who have lived a significant amount of time on the reservation (16 years, personally) that there are many areas of the up-river parts of the reservation that are completely without grid connections. This has been an issue for over 20 years, yet efforts to extend grid connections to these areas have yet to result in success. There is potential to alleviate some of the issues present in these areas if implementation of programs that could install and maintain solar and/or hydroelectric generation systems for these tribal members who desire more energy security.

S Y N T H E S I S

There are potentially significant opportunities for the Yurok Tribe to implement some level of housing energy efficiency intervention program for low-income tribal members on the reservation. These interventions range in terms of complexity from simply building/repairing the residents wood shed, to a larger scale energy efficiency intervention potentially including woodstove replacement, air sealing and improved insulation. The potential costs and benefits of these programs are summarized in Table 7 below:

Table 7: Estimated costs and benefits for tribal housing interventions (1500ft^2 model data shown).

	Expected Household Annual Savings (From Baseline)	Cost For Intervention	Estimated Lifetime of Intervention	Tribal Labor?	Cultural Priority
Wood Shed	$1,000	$500	Variable	Yes	High
Woodstove	$1,600	$2,000-$2,500	>10 years	Maybe	High
Air Sealing	$1,700	$3,000-$4,500	>10 years	Yes	Low
Insulation	$1,800	$7,000-$8,500	>10 years	Maybe	Low

It is possible that interventions only including these measures could be accomplished by the Yurok Tribe for a per project price of between $3000 and $4000 if the tribe only implements a program to address woodstoves and wood storage on the reservation. If the tribe wished to pursue a more complete home performance project that involved air sealing and replacing insulation in the home, the tribe would likely have

individual project costs closer to $7000-$8500 (Chitwood 2010). This would mean that the woodstove/storage only options would certainly be an appealing prospect for the tribe, as the most limiting factor for implementation of any project is the ability for the tribe to secure adequate funding.

Another consideration that could help to increase the benefits from these programs would be the use of tribal labor for these projects. This has the potential of creating social benefits by potentially reducing the high unemployment rate of approximately 23% on the reservation (American Factfinder, 2016). This increase in labor force would also probably see a substantial increase in quality of life, especially for elders on the reservation who would not have to use nearly as much wood throughout the year, reducing their potential usage by up to 6000 kg of wood and reducing additional and unnecessary work for these tribal members as well. This allows for the potential jobs created from these programs to also support the cultural and energy needs of the community overall. There is also the possibility that, since this is such a tightly knit and supportive community, that those who find themselves with excess wood after receiving interventions might be willing to donate some of that wood to those with greater need.

Beyond this foundational improvement, there is also the possibility for additional improvements using home performance contracting. The primary areas of improvements in this scenario would be properly air sealing the home and installing additional or improved insulation in the attic and crawl spaces of the homes in question. These projects would very likely additionally reduce the potential energy usage of a tribal members

home even further but would come at a higher cost per project for the tribe, making it harder to make projects economically feasible. These additional measures would likely increase the cost per project to over $10,000 depending on factors such as the size of the house, and the types of interventions that would be needed for the specific situation. These additional interventions are also highly limited by the level of improvements that need to be made to a house.

These results are also highly sensitive to changes in interior temperature throughout the year. Since it is unlikely for tribal members to heat their homes to the simulated 70°F all year, a brief sensitivity analysis was done on the simulated data to determine the savings under a lower average heating load. Data for the simulation of a 1500 ft^2 home heated to 60°F throughout the year can be seen in Figure 20 below.

Figure 20: Estimated costs for a 1500 ft^2 tribal home heated to 60°F throughout the year.

This change in heating profile significantly changed the savings potential for tribal members annually, giving households on average only 35% of the financial benefit of the homes modeled at 70°F. This would indicate that the effectiveness of implementing interventions will be highly dependent on the individual tribal members heating habits. This would also result in significantly increasing the time it would take for the Yurok Tribe's investment to be paid back in terms of benefits for tribal members.

In many cases on the Yurok Reservation, the costs to get certain homes to a point where interventions such as air sealing and insulation would be possible, would cause the projects to be far to cost prohibitive to be feasible. This is one reason that initial inspections of the homes should be carried out by the tribe in each case, to avoid losing funds on homes that are too far gone to be practically improved using the methods described in this report. Additionally, the types of funding sources available for these projects for the tribe at the time of writing are quite limited. The most likely source of potential funding would be from the California Low Income Weatherization Program. This program secures the bulk of its funding from sources such as the Low Income Home Energy Assistance Program (LIHEAP) and the federal Weatherization Assistance Program (WAP). It is highly recommended that the tribe attempt to seek out any and all potential funding sources for these projects, as they could go a long way to potentially improving the quality of life for those tribal members that would be able to receive these improvements.

The Yurok people are fighting for the very right to protect their food source, the Klamath River that has given them fish, eel, and even ceremonial products. Money, as in dollars and cents, is utilized the same as canned fish and eel. Trade in these staples is still utilized as a mainstay in the economy of the tribal population. This is important to address in reference to the housing/energy issues. One cannot so easily trade for housing needs or energy upgrades. Most households, or close friends and relatives would be very ready to get on board with helping each other in installations or building. The main problem with accomplishing home improvements on the reservation lies in the ability for those in need to obtain the necessary materials for these improvements. Tribal labor could potentially help in addressing these issues, as this in-kind labor support could be used for any of the interventions that have been discussed, provided that the labor force is sufficiently trained. This labor could certainly reduce the potential negative impact of the simpler interventions, such as the wood shed and stove replacement, which are the most important proposed interventions when considering all of the cultural and regional factors at play on the reservation.

C O N C L U S I O N

The results obtained while compiling this report suggest that there are potentially significant quality of life and energy efficiency improvements that can be implemented on homes located on the Yurok Reservation. The most likely feasible solution for homes on the reservation would be a home inspection and installation of an improved wood heating unit in the home and improving wood storage to keep wood dry and efficient. This is due to the large reliance on wood heating on the reservation, which is culturally rooted and enables resiliency to loss in electricity or income for outside fuels. Reducing the consumption of wood is the recommended avenue for focusing EE investments that reduce the cost of energy for tribal members.

Additional measures could be potentially useful in certain cases, such as air sealing and additional insulation; however, these interventions are also likely to be too cost prohibitive for the tribe to be able to carry out many projects that would require those interventions. However, there could be labor and workforce opportunities created by the implementation of these projects which could potentially offset some of these financial losses on a social level (as well as financial for the tribal members receiving the jobs).

Some additional measures were discussed due to high levels of interest within the community, as determined through a survey of a sample of homeowners on the Yurok Reservation, like solar and battery systems. None of these additional energy efficiency, generation, and reliability improvements are likely to be feasible for the tribe given

current income and resource constraints, though these could still be potentially useful resources for future projects, if funding becomes less restrictive and as the technology cost falls.

The primary motivation for these projects should be improving the quality of life of low income tribal members who must live in substandard housing on the reservation. However, potential funding restrictions from lack of a diversity of state and federal funding sources for these projects could severely restrict the tribe's ability to carry out projects.

Hopefully, the information contained within this report will be able to be implemented by the Yurok Tribe to improve the quality of life of many of the underserved members of the tribal community. My work suggests a program to improve woodstoves and wood storage on the reservation is the most feasible and valuable, as these measures are likely to be beneficial overall for tribal life and provide significant savings in wood fuel required with relatively low upfront cost. The most reasonable path forward would be to implement a pilot program to inspect tribal homes, improve wood storage areas, and install wood stove upgrades. You are looking at a displaced people. Their ancestors had their lands taken from them; and, this is what they now have as a little piece of their heritage to call their own. Their grandparents, father, mother, aunt, uncle, cousins, siblings, children, may have been born and died in the very place where they now live. To view a place so sacred as a mere "roof over your head" is not a

concept that any tribal person is going to understand. Whatever it may be, it is their home.

It is critical that any program that is implemented is done so with the support and understanding of the tribal community in general. There is an opportunity for the tribal government to create a program that will allow for more work for tribal members (as inspectors and contractors for projects), and an overall improvement of the quality of life for the low-income members of the community that are in need of housing interventions. This project could also contribute to a more comprehensive tribal energy plan that would seek to address the needs of the greater Yurok community.

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APPENDIX A: MODELED HOUSEHOLD ENERGY USE

This appendix contains Tables A.1-A.9, which detail eQuest energy usage data for the various models consulted for this report.

Table A.1: eQuest table of energy usage for a 1000 square foot tribal home (no intervention).

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	2.63	2.37	2.35	2.32	1.61	1.25	1.06	1.01	1.32	1.79	2.38	2.73	22.84
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.34	0.32	0.35	0.34	0.33	0.31	0.31	0.30	0.31	0.33	0.34	0.35	3.92
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.40	0.37	0.42	0.39	0.42	0.41	0.40	0.42	0.39	0.41	0.39	0.40	4.80
Task Lights	0.39	0.37	0.45	0.39	0.43	0.43	0.39	0.45	0.39	0.41	0.39	0.39	4.87
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3.77	3.42	3.57	3.44	2.78	2.39	2.16	2.19	2.41	2.93	3.50	3.87	36.43

Table A.2: eQuest table of energy usage for a 1000 square foot tribal home (air sealing only).

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	1.57	1.33	1.28	1.24	0.81	0.59	0.48	0.45	0.62	0.94	1.33	1.60	12.25
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.20	0.19	0.20	0.20	0.19	0.18	0.18	0.18	0.18	0.19	0.20	0.21	2.29
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.40	0.37	0.42	0.39	0.42	0.41	0.40	0.42	0.39	0.41	0.39	0.40	4.80
Task Lights	0.39	0.37	0.45	0.39	0.43	0.43	0.39	0.45	0.39	0.41	0.39	0.39	4.87
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	2.56	2.25	2.36	2.22	1.85	1.60	1.45	1.49	1.58	1.95	2.31	2.60	24.21

Table A.3: eQuest table of energy usage for a 1000 square foot tribal home (air sealing and improved insulation).

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	1.12	0.94	0.91	0.87	0.54	0.38	0.28	0.25	0.37	0.62	0.93	1.15	8.36
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.18	0.17	0.18	0.18	0.17	0.16	0.16	0.16	0.16	0.17	0.18	0.19	2.06
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.40	0.37	0.42	0.39	0.42	0.41	0.40	0.42	0.39	0.41	0.39	0.40	4.80
Task Lights	0.39	0.37	0.45	0.39	0.43	0.43	0.39	0.45	0.39	0.41	0.39	0.39	4.87
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	2.09	1.85	1.96	1.83	1.55	1.37	1.23	1.28	1.31	1.61	1.88	2.12	20.10

Table A.4: eQuest table of energy usage for a 1500 square foot tribal home (no intervention).

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	4.20	3.80	3.90	3.89	2.82	2.26	1.87	1.88	2.28	3.01	3.85	4.31	38.07
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.48	0.45	0.49	0.47	0.46	0.43	0.43	0.43	0.43	0.46	0.47	0.49	5.47
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.03	0.03	0.04	0.03	0.04	0.04	0.03	0.04	0.03	0.04	0.03	0.03	0.43
Task Lights	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.07
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	4.72	4.29	4.43	4.40	3.32	2.73	2.35	2.35	2.75	3.51	4.36	4.84	44.05

Table A.5: eQuest table of energy usage for a 1500 square foot tribal home (air sealing only).

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	2.69	2.27	2.32	2.25	1.58	1.23	0.99	1.00	1.23	1.75	2.31	2.69	22.32
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.27	0.25	0.28	0.27	0.26	0.24	0.24	0.24	0.24	0.26	0.27	0.28	3.10
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.03	0.03	0.04	0.03	0.04	0.04	0.03	0.04	0.03	0.04	0.03	0.03	0.43
Task Lights	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.07
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3.01	2.56	2.64	2.56	1.89	1.52	1.27	1.29	1.51	2.05	2.62	3.01	25.91

Table A.6: eQuest table of energy usage for a 1500 square foot tribal home (air sealing and improved insulation).

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	2.37	1.98	2.04	1.97	1.37	1.06	0.84	0.85	1.05	1.50	2.01	2.36	19.40
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.26	0.24	0.26	0.25	0.25	0.23	0.23	0.23	0.23	0.25	0.25	0.26	2.95
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.03	0.03	0.04	0.03	0.04	0.04	0.03	0.04	0.03	0.04	0.03	0.03	0.43
Task Lights	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.07
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	2.67	2.26	2.35	2.27	1.66	1.33	1.11	1.12	1.32	1.79	2.30	2.66	22.85

Table A.7: eQuest table of energy usage for an 1800 square foot tribal home (no intervention).

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	5.61	5.34	5.34	5.22	3.80	3.00	2.54	2.56	3.13	4.16	5.34	5.91	51.94
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.58	0.54	0.59	0.57	0.55	0.52	0.52	0.52	0.52	0.56	0.57	0.59	6.60
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.11	0.10	0.12	0.11	0.12	0.11	0.11	0.12	0.11	0.11	0.11	0.11	1.32
Task Lights	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.44
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	6.33	6.01	6.09	5.93	4.50	3.67	3.20	3.24	3.79	4.86	6.05	6.65	60.30

Table A.8: eQuest table of energy usage for an 1800 square foot tribal home (air sealing only).

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	3.58	3.23	3.19	3.05	2.08	1.59	1.31	1.36	1.68	2.42	3.25	3.72	30.46
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.32	0.30	0.33	0.31	0.30	0.28	0.29	0.28	0.29	0.31	0.31	0.33	3.66
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.11	0.10	0.12	0.11	0.12	0.11	0.11	0.12	0.11	0.11	0.11	0.11	1.32
Task Lights	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.44
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	4.04	3.67	3.67	3.50	2.54	2.03	1.74	1.80	2.11	2.87	3.71	4.19	35.88

Table A.9: eQuest table of energy usage for an 1800 square foot tribal home (air sealing and improved insulation).

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	3.01	2.69	2.65	2.52	1.65	1.26	1.02	1.05	1.34	1.96	2.71	3.13	24.99
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.30	0.28	0.30	0.29	0.28	0.26	0.26	0.26	0.26	0.28	0.29	0.30	3.37
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.11	0.10	0.12	0.11	0.12	0.11	0.11	0.12	0.11	0.11	0.11	0.11	1.32
Task Lights	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.44
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3.45	3.10	3.11	2.95	2.09	1.67	1.43	1.48	1.74	2.39	3.14	3.58	30.13

APPENDIX B: EXAMPLE EQUEST MODELING INPUTS

This appendix contains, Figures B.1-B.6 which show eQuest input information for the 1500 ft^2 model consulted for this report.

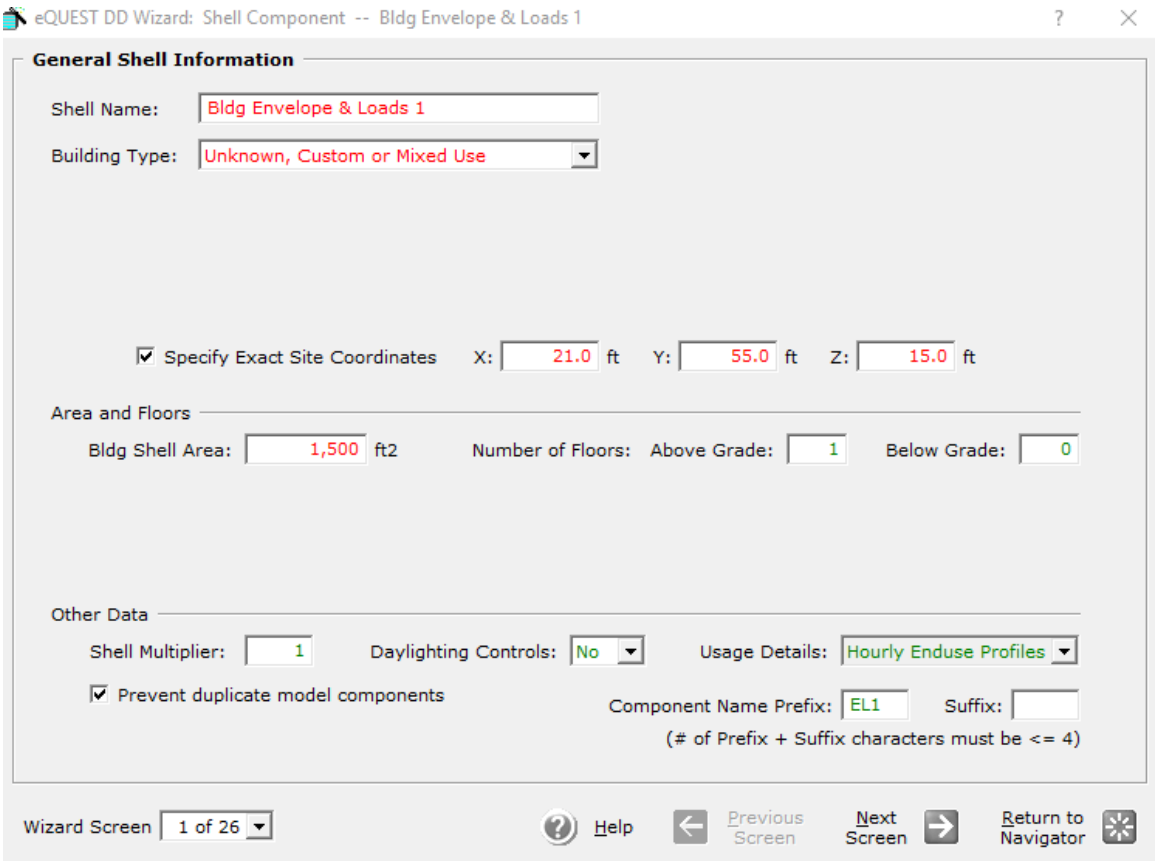

Figure B.1: eQuest data input information for 1500 ft^2 home.

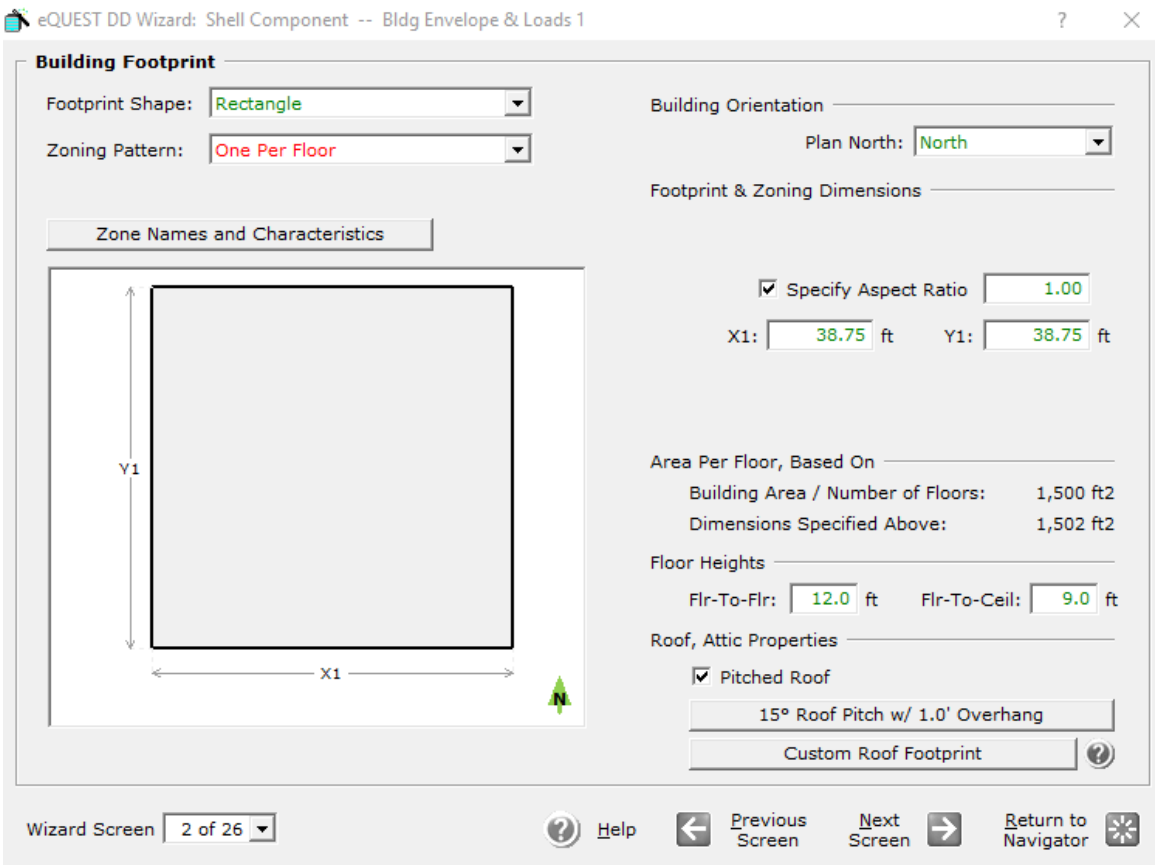

Figure B.2: eQuest data input information for 1500 ft^2 home.

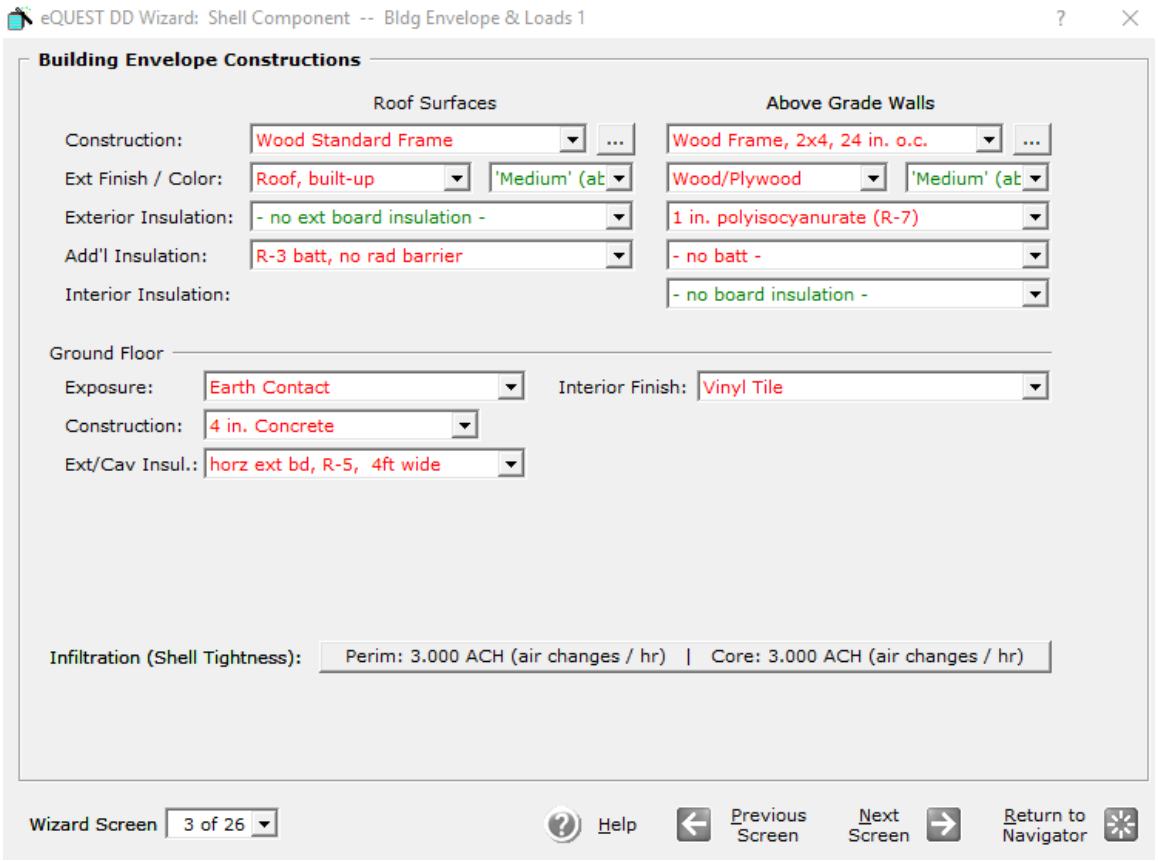

Figure B.3: eQuest data input information for 1500 ft^2 home.

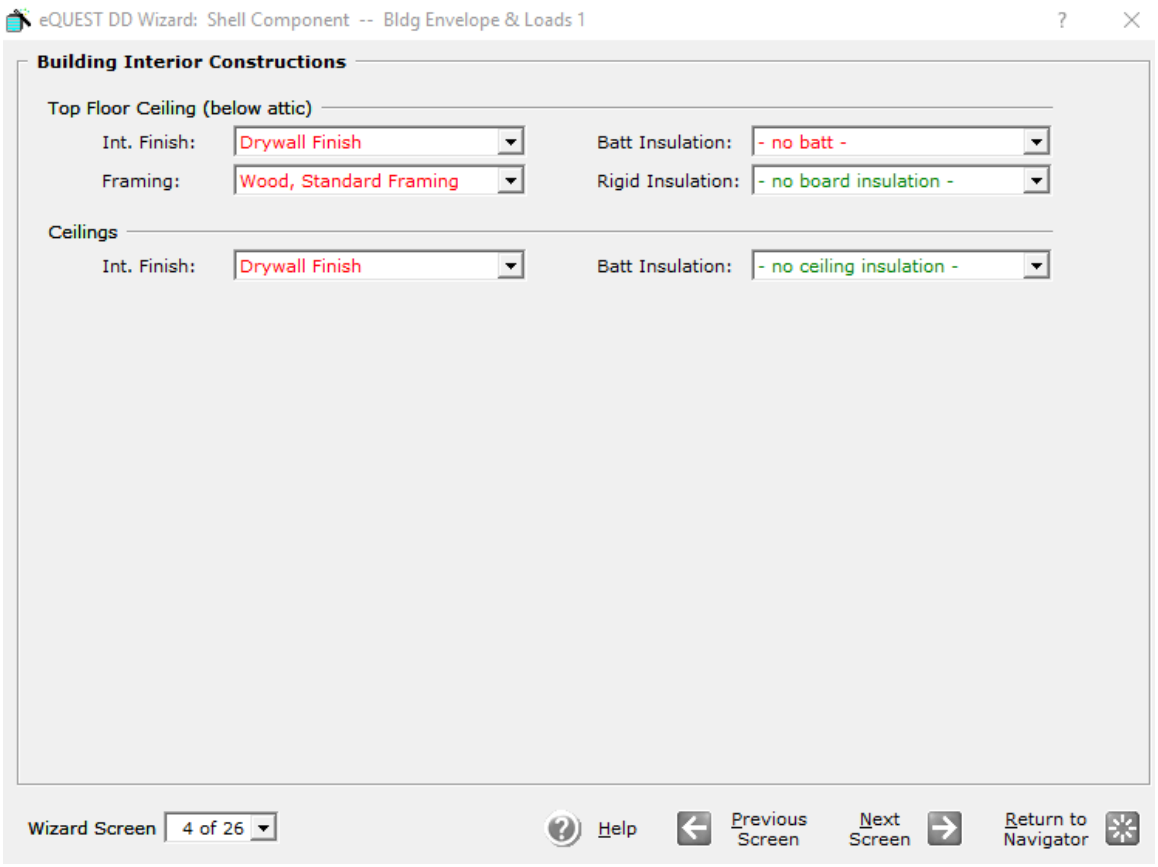

Figure B.4: eQuest data input information for 1500 ft^2 home.

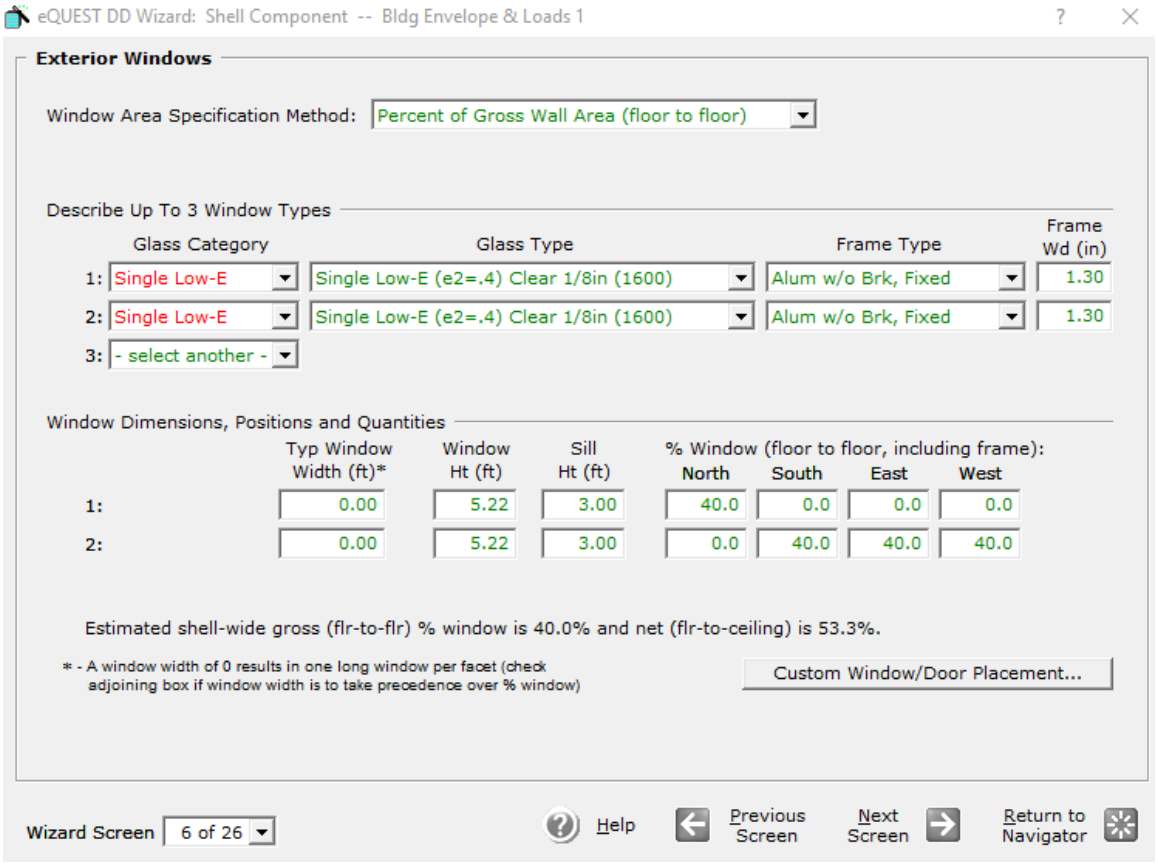

Figure B.5: eQuest data input information for 1500 ft^2 home.

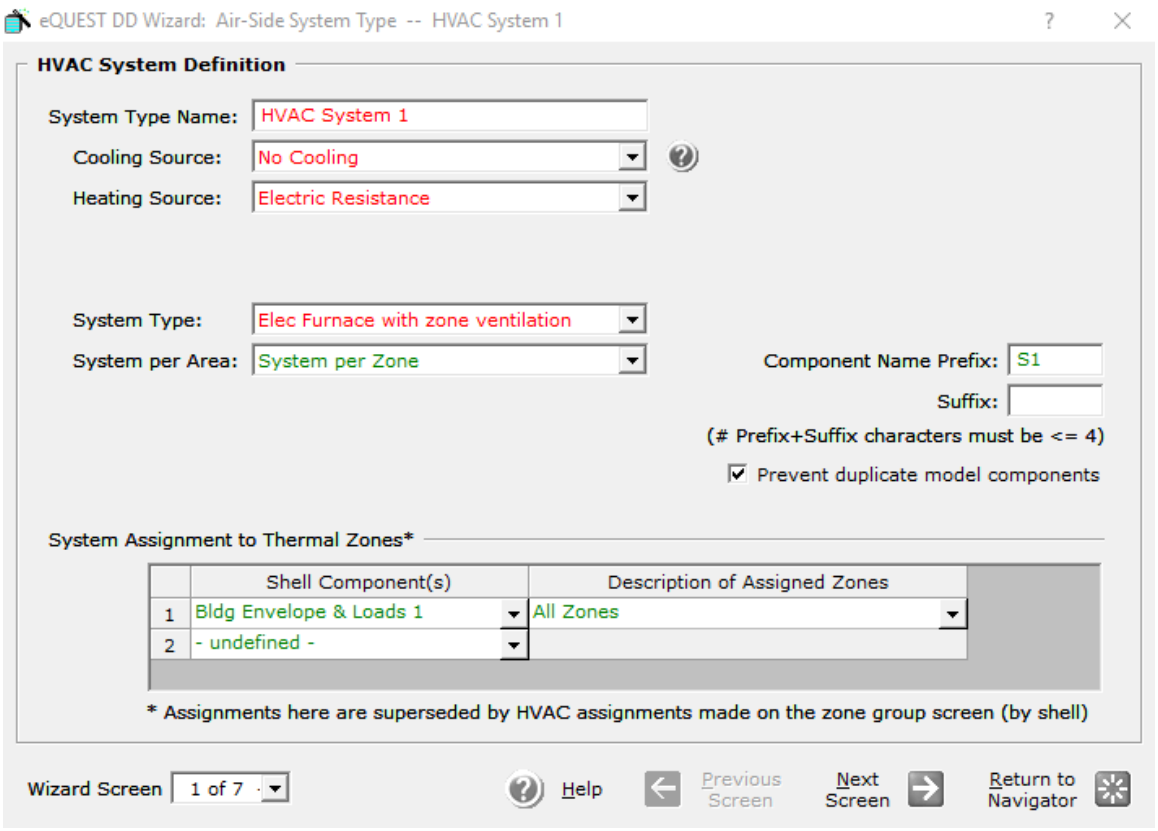

Figure B.6: eQuest data input information for 1500 ft^2 home.

APPENDIX C: RESIDENTIAL ENERGY SURVEY SHEET

This appendix contained the residential energy survey that was used in the reservation towns of Klamath and Weitchpec, CA.

Residential Energy Survey:

Please fill out the following questions as thoroughly as possible. Please note that you do not have to answer any questions that you are not comfortable with.

1.) Are you a Tribal Member, if so which Tribe?

2.) How many adults reside in your household?

3.) What is your households' annual income?

<$25,000 $25,000-35,000 $35,000-50,000

>$50,000

4.) How old is your home (in years)?

<10 10-25 >25

5.) Is this an inherited (family) home?

6.) How is your home constructed?

Stick-built Modular Travel Trailer

7.) Does your home have adequate insulation?

8.) Is the house located on:

Yurok Indian Housing Authority (YIHA) land Fee land Trust land

9.) Have you qualified for LIHEAP in the last year?

10.) Do you: Own or Rent your home?

11.) Do you have electricity?

12.)What is your primary area heating source?

13.) Does your home use a woodstove? If so, is it used for more than heating (cooking, etc.)?

14.) Does your home utilize propane for heating or cooking?

15.) How do you heat your water?

16.) Does your household use a diesel generator?

17.) Does your home utilize any renewable generation (solar, small hydro, etc.)?

18.)What percentage of your annual income do you approximately spend on energy?

<1% 1-2% >2%

19.) What is your primary concern related to your homes energy usage?

20.) What is your most desired household energy improvement?

21.) Do you have any additional comments?