Renewable Energy Sovereignty

Master Plan

Prepared for:

Bear River Band of Rohnerville Rancheria

266 Keisner Road
Loleta, CA 95551

August 23, 2016

Prepared by:

REDWOOD ENERGY
DATA + DESIGN + EDUCATION

and

Freshwater Environmental Services

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1.0 INTRODUCTION

As part of a grant funded by the California Affordable Housing and Sustainable Communities, Redwood Energy was hired by the Tribal Council of the Bear River Band of the Rohnerville Rancheria to develop a Renewable Energy Sovereignty Master Plan for the Tribe. This Master Plan is a practical guide, with options and costs illustrated, so the Bear River Band can use renewable energy in perpetuity for their people's needs, control the energy infrastructure within their sovereign tribal boundaries, and provide leadership in addressing climate change.

The Energy Sovereign Plan includes Energy Codes for new buildings and retrofits of the existing buildings. The efficiency Codes enable each residence to generate all its energy on the roof with no additional energy from the tribal micro-grid, but more energy-intensive users like the Casino, Pump and Play, water treatment facilities and Hotel require enough energy that an off-site energy source is necessary, such as commercial wind turbines, a biomass generator and/or acres of photovoltaic solar arrays.

Storing energy is an additional cost to generating energy, and electrochemical batteries (e.g. Lithium-Ion, Lead Acid, and Aquion saltwater batteries) are often 10 times more expensive per stored unit of energy than generating the energy. However, some renewable energy is often only available at certain times of the day or year (e.g. solar, wind) while some is available year round (e.g. geothermal, biomass), so energy storage vs. carefully timed renewable production is an important design consideration for a micro-grid.

When energy storage is necessary, using an electric battery to store energy used to meet thermal loads (e.g. space heating and domestic hot water) is very expensive--10 to 20 times more than using the electricity in the moment. It is far less expensive to use the excess energy in the moment to increase the temperature of the hot water storage tank, which is effectively thermal storage of energy that can be used within about 24 hours.

An example would be heating a 50-100 gallon tank to 160F during the 10-2pm solar maximum each day with a heat pump and turn the system off until the next day, rather than storing electricity in a battery to operate the heat pump later in the evening. The balance of electrical energy needed for lighting and plug loads can be met with a battery that is now 1/3 as big as necessary had thermal storage not been used.

To provide clarity for the design and construction team, the Codes are primarily illustrations with limited writing—a picture is worth a thousand words in design and construction. The cost-effective efficiency design practices are additionally compliant with Energy Star v.4. allowing the Bear River Band to compete for federal grant funds.

The Community-Scale Renewable Energy and Energy Storage Analysis illustrates that while many options exist for the Bear River Band as they develop a 100% renewable fuel mix for their Tribe, some options are much more cost-effective than others. This guidance is specific to the Tribe’s energy use, energy resources and maritime climate, but the Analysis can still provide valuable guidance for others who wish to make their Tribe or other political institution (nations, states, cities, universities) a carbon-neutral community.

Lastly, we authored an overview to explain the process of developing this Energy Sovereignty Plan and additionally created a small documentary movie to further guide other Tribes and political entities to follow in the footsteps of the Bear River Band, which is included in the Master Plan.

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It was truly a pleasure and an inspiration to work on this project. We would like to extend our sincerest gratitude and appreciation to the Tribal Council of the Bear River Band of the Rohnerville Rancheria for this incredible opportunity.
Sincerely,
Sean Armstrong, Jenna Bader, Courtney Brown of Redwood Energy

APPENDIX A

PLANNING GUIDE FOR RENEWABLE ENERGY SOVEREIGNTY MASTER PLAN

Planning Guide for Renewable Energy

Sovereignty Master Plan

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ATTACHMENTS

1.0 BACKGROUND INFORMATION

The Bear River Band of the Rohnerville Rancheria is located in Loleta, California in the Pacific Northwest. The Rancheria is located on top of a hill above the CA-HWY 101, with a sunny Southwest facing hillside that is ideal for Solar Power and the North Pacific wind swells blow right past the Tribe, providing the best location in the County for harnessing Wind Power. Of roughly 300 Tribal Members at Bear River, the majority of them are Youth Members, and the Energy Sovereignty Plan is a large effort towards securing a future for the next generations.

The Tribal Council received a California Grant to help the Tribe pursue 100% on-site renewable energy, and they will eventually disconnect from the electric and gas companies and be entirely energy sovereign. In December of 2015, a local ZNE Consulting firm, Redwood Energy, was hired to develop an energy sovereignty plan. Methods for achieving this goal included: analyze utility bills and perform baseline audits to better understand the existing conditions and energy consumption, provide ZNE retrofit recommendations, create a residential ZNE Building Code for existing and new construction, develop an energy generation and storage plan based on the improved energy consumption of the Rancheria, and define several opportunities for financing options towards energy sovereignty.

2.0 METHODS

2.1 Baseline Energy Audit

To Create an Energy Sovereignty Master Plan, the first and most important step is to assess a baseline of how much energy the Tribe uses. For this, we used one year of Electric and Gas Bill data, broken down by buildings and by months to understand the actual demand throughout the year. This data was the most valuable information in determining the energy consumption at existing conditions, so we could predict the energy demand after a 25% - 50% energy efficiency retrofit.

Next, we performed baseline energy audits of the Casino, Hotel, Pump and Play, Tobacco Traders, HR Building, Gaming Office, Water Treatment Center, and (9) out of (62) Homes.

The baseline energy audits targeted buildings with the highest energy consumption to analyze specific plug loads, HVAC equipment, and lighting. We also pulled information from existing building plans to help model energy in EnergyPro Version 8 Software, and manually re-created Architectural plans for our models when building plans could not be found.

This process was the most time consuming of all tasks, mainly due to many hours on-site investigating. This task included documenting the building components, searching for building plans, coordinating with Building Managers and Home Owners, data entry, and creating EnergyPro Energy Models. We had a team of two auditors performing the on-site audits and a team of (10) student interns from Humboldt State University to help recreate building plans and perform the plug load and lighting analyses of the Casino and Hotel.

In the future, it would be helpful to acquire as many building plans as possible in digital format for the Energy Modeler. Digital plans are the most efficient way to review a large project. The next most efficient way is with paper plans, and the least efficient way to model the Tribe's energy consumption is to re-create building plans with dimensions, energy components, insulation values, etc.

On-site inspections are recommended for all buildings that use a sizable amount of energy. The purpose for this is to have conversations with Residents and people who use these buildings, getting an understanding of the issues, age of the buildings, etc. On-site inspections allow for thorough investigation of existing conditions including plug loads, construction techniques, infrared camera images of insulation quality, and more.

2.2 Energy Efficiency Retrofit Recommendations

After Energy Models have been generated with EnergyPro, the next step is to identify the equipment with the highest energy consumption and provide all-electric, energy efficient products with associated costs for replacement. Most recommendations include fuel-switching from gas to electric equipment, cost-effective options for building envelope improvements, including additional attic insulation, wall insulation, crawlspace insulation, and of course, fixing any unhealthy and/or unsafe conditions along the way. The retrofit recommendations should be guided by the 7th generation principle, using the least amount of resources and providing the least environmental impact, while creating buildings that will last multiple generations.

When presenting deep-efficiency recommendations to the Tribal Council, we recommend scheduling check-in meetings along the way to discuss any new findings. Education is a hugely unrecognized component in all aspects of these large-scale energy sovereignty projects; it's important to shed light on ***why*** things are suggested, and have collaborative conversations to make the best proposal for the Tribe.

2.3 Residential ZNE Building Code, New Construction and Existing Construction

We broke down the following Checklists for guidance on the Building Code: EnergyStar for Homes Revision 8, ZNE Ready Homes, Build It Green's Green Point Rated Program, EPA's Indoor AirPlus, WaterSense, International Living Future Institute's Living Building Challenge, Samoa Green Home Guide for Historic Home Restoration, Enterprise Green Communities Certification, and the 2013/2016 California Building Code Energy Efficiency Standards.

We pulled all information we wanted to add to our Energy Sovereignty Building Code and created a Microsoft Word document with sub-topics from each manual, linked to their original source. Then, we took the information from that compiled list and formatted a template in Microsoft Powerpoint for our Building Code. We created our Energy Sovereignty Building Code based on the Best Practices in energy efficiency, sustainability and health. Next, we added photographs to make a photo-heavy Building Code, which is intended to contain more explicit detail with less text. Another reason we created a photo-based Building Code is to capture the attention of a wider audience of Building Code users.

2.4 Energy Generation and Storage Plan

Data analysis for the Energy Generation and Storage Plan was largely based upon (2013-2014) Utility Bill Data for the Tribes's existing buildings, and local wind data from the Tribe's existing wind turbines. Redwood Energy's local expertise of the sun patterns in the Marine Climate of Loleta, CA and Zero Net Energy (ZNE) design strategies in California Energy Commission's (CEC) Climate Zone 1, helped determining multiple scenarios of creating energy sovereignty for the Bear River Band.

Leading technologies in battery storage and renewable energy generation were researched to find the most cost-effective, non-toxic, least environmentally disturbing methods of creating long-term energy sovereignty. The Energy Generation and Storage Plan includes multiple options for implementation, with an emphasis on providing 100% renewable energy generation and storage to the Tribe in the winter months, which are the most challenging, as there is less sunshine potential for Photovoltaic (PV) panels.

Many of the scenarios suggested in the Energy Generation and Storage Plan include a biomass generator as a means for producing enough energy to supply the demand in these difficult winter months. Biomass, however, is an expensive technology to implement, and the fuel for the biomass plant is at high demand in Humboldt County, due to Local Utility shifts towards Community Choice Aggregation.

Several alternative scenarios were created after weekly meetings with a Tribal Council Member, as we shifted our focus more towards solar and wind power with battery storage, and away from the biomass strategy.

2.5 Energy Sovereignty Financing Report

The Energy Sovereignty Financing Report was created based upon research by the Redwood Energy team to develop a list of current funding options available. Potential funding sources are scattered through the Federal Government, including: USDA, Bureau of Indian Affairs, EPA, Department of Energy and HUD, and many California State resources. The Financing report includes options for Residential Development and Community Scale Micro-Grid funding.

2.6 Final Master Plan

The Master Plan is a culmination of all the previous parts of the Energy Sovereignty Plan for Bear River. We checked-in monthly during our 6-month contract to keep up-to-speed on deliverables, providing draft outlines, draft templates, draft documents, then ultimately, final documents that were formatted by Freshwater Environmental Services, a Fisheries and Water Consulting firm in Humboldt County.

3.0 SHORT FILM PROJECT

Throughout the scope of Redwood Energy's work with the Bear River Band, we had all agreed upon creating a video documentation of our collaborative efforts. The Short Film includes a description of the Tribe's goals towards energy sovereignty, with interviews from Tribal Members, members of our team, and is intended to serve as a tool to help other Tribe's follow pathways towards Tribal Zero net Energy.

APPENDIX B

BASELINE ENERGY AUDIT REPORT WITH RECOMMENDED IMPROVEMENTS AND COST ANALYSIS

Baseline Energy Audit Report with Recommended Improvements and Cost Analysis

Prepared for:

Bear River Band of Rohnerville Rancheria

266 Keisner Road
Loleta, CA 95551

August 23, 2016

Prepared by:

and

Freshwater Environmental Services

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1.0 INTRODUCTION

1.1 Summary of Existing Conditions and Recommendations

To create the circumstances that allow the Bear River Tribe to create its own clean, renewable energy, the Tribe will need to eliminate gas-fueled equipment in its' buildings and invest in efficiency retrofits. Once the gas-fueled equipment is retrofitted to efficient electric equipment, the balance of solar, wind, biomass and batteries that the Tribe elects to install will generate enough electricity on-site to cover all energy demands of the Bear River Tribe.

The Bear River Casino building represents approximately 80% of the entire energy consumption, and the internal Casino slot machines and Uninterrupted Power Supply (UPS) battery back-ups use approximately 70% of the Casino's energy budget, with the balance consumed by the Heating, Ventilation and Air Conditioning (HVAC) equipment and Lighting. The slot machines generate hundreds of times more income than their energy bills, so the reasonable place to pursue efficiency is reducing or eliminating the equally energy-intensive battery back-ups—our audit indicates the battery back-ups, which are wired one to every two slot machines, use about as much energy as the machines themselves. The final balance of energy generation should include reliable back-up power (e.g. biomass generation and/or a very large bank of batteries) that reduces or eliminates the need for a second set of energy using and expensive batteries, such as those within the Uninterrupted Power Supply equipment.

Electrification of the buildings generally means removing the gas burning water heaters and space heating equipment and replacing them with "heat pumps," which are compressors like those in refrigerators and air conditioners that are plumbed to deliver heat rather than remove heat. Many times the same compressor can be wired and plumbed to do space heating, water heating, air conditioning and even commercial refrigeration (e.g. for the Pump and Play). Similarly, the gas equipment used to cook have electric equivalents, from induction cooktops to electric deep fat fryers. It is a matter of matching the right equipment to the need, which this report attempts to do with cost-effective alternative equipment.

This report outlines each building, in order from highest electricity users to lowest, with an analysis of Redwood Energy's site audits of existing conditions, modeled energy consumption, utility bill data and the recommended product replacements, including a cost analysis. As electrification of California generally proceeds there are more equipment options and brands entering the market every year. The retrofits will take many years, so these product recommendations are current to the products offered in 2016.

2.0 CASINO

2.1 Building Information

Address	11 Bear Paws Way
Year Built	2004, Updated 2014

2.2 Baseline Audit

2.2.1 Methods

In February, 2016, Redwood Energy performed a full-scale energy audit of the Bear River Casino. This audit entailed detailed documentation of the existing lighting, Heating, Ventilation and Air Conditioning (HVAC) equipment, kitchen appliances, and plug loads at Bear River Casino. The energy audit was performed on the casino floor, including the café and bar, and quantified the amount of slot machines, identified each model of slot machines and any other appliances that consume energy such as televisions, ATMs and vending machines. All HVAC equipment, kitchen equipment, and indoor appliances were logged, photographed and quantified to estimate the plug loads consumption of the Bear River Casino building.

2.2.2 Baseline Audit Photographs of Existing Equipment

Photographs of existing HVAC and Kitchen equipment at Bear River Casino are included in **Appendix A-1**.

2.2.3 Existing Conditions

The condition of the Bear River Casino is fairly new with good insulation in the attic and walls, as indicated on the building plans. The lighting is fairly efficient, with mostly CFL's and LED lighting inside and High Pressure Sodium lamps outside. The Heating, Ventilation and Air Conditioning (HVAC) equipment has a few pieces that are all-electric and or new replacements that can remain in the Zero-Net Energy retrofits. The HVAC and Kitchen equipment is largely fueled by natural gas, which will not be a part of the future at Bear River, per the following recommendations. The plug loads using the most energy in the Casino are the (350) slot machines, (175) Uninterrupted Power Supplies (UPS)'s and (67) large flat screen televisions and (53) computers and monitors in the back offices.

2.2.4 Detailed Building Analysis

Redwood Energy performed a full site energy audit, then modeled its' energy consumption using EnergyPro Non-Residential software, based on building inputs from a Redwood Energy site inspection and verified with building plans. The Econ-2 Report is included in **Appendix A-2***.* Redwood Energy used Utility Bill Data for the Bear River Casino to verify existing conditions versus modeled conditions. Therms of natural gas used at the Casino were estimated values from the Bear River Hotel.

2.3 Existing Equipment and Retrofit Recommendations with Cost Analysis

Redwood Energy recommends that all gas-fueled equipment be replaced with all-electric equipment to prepare for the 100% all-electric energy sovereignty micro-grid. Additionally, follow these recommendations to decrease overall energy consumption by at least 25%:

- Uninterrupted Power Supply equipment should be removed as other back-up energy supply becomes available, such as a biomass burning plant or a large-scale battery bank.
- HVAC equipment should have efficiency ratings that meet or exceed current Energy Star standards—in 2016 the equipment would have an HSPF between 9 and 14, and a SEER between 15 and 34.
- Hot Water should be generated with a heat pump with an Energy Factor of 3.4 or greater when specifying smaller Hot Water tanks, or a Coefficiency of Performance of 3.5 or greater for commercial boiler systems.
- All applicable HVAC equipment with electro-mechanical drive systems should have Variable Frequency Drive's (VFD)'s installed to regulate the fan/motor speed, which will reduce energy consumption of the equipment by 50%.
- Kitchen equipment replacements should include induction stovetops and Energy Star rated electric equipment.
- Appliances should be replaced with Energy Star products at the end of their useful life
- Outdoor lights should be Energy Star, Dark-Sky compliant, LED lighting with photocell sensors and motion controls.
- Indoor lights should be Energy Star, LED lighting with motion sensors for lights in the back offices, mechanical rooms, etc.

The table below summarizes the existing conditions and equipment at Bear River, with comments including the existing Brand Name, Model #, energy ratings, etc. Additionally, the table includes recommended methods and products for energy efficiency retrofits, along with associated costs to install. The following recommendations are intended to provide a pathway for reducing energy consumption, while fuel-switching to all-electric in an effort to support the Band's energy sovereignty goals.

Building Envelope		
Existing Component	**Comments**	**Recommended Improvement**
Wall Insulation	R-19, studs are 16" on center	---
Attic Insulation	R-38 batt insulation	---

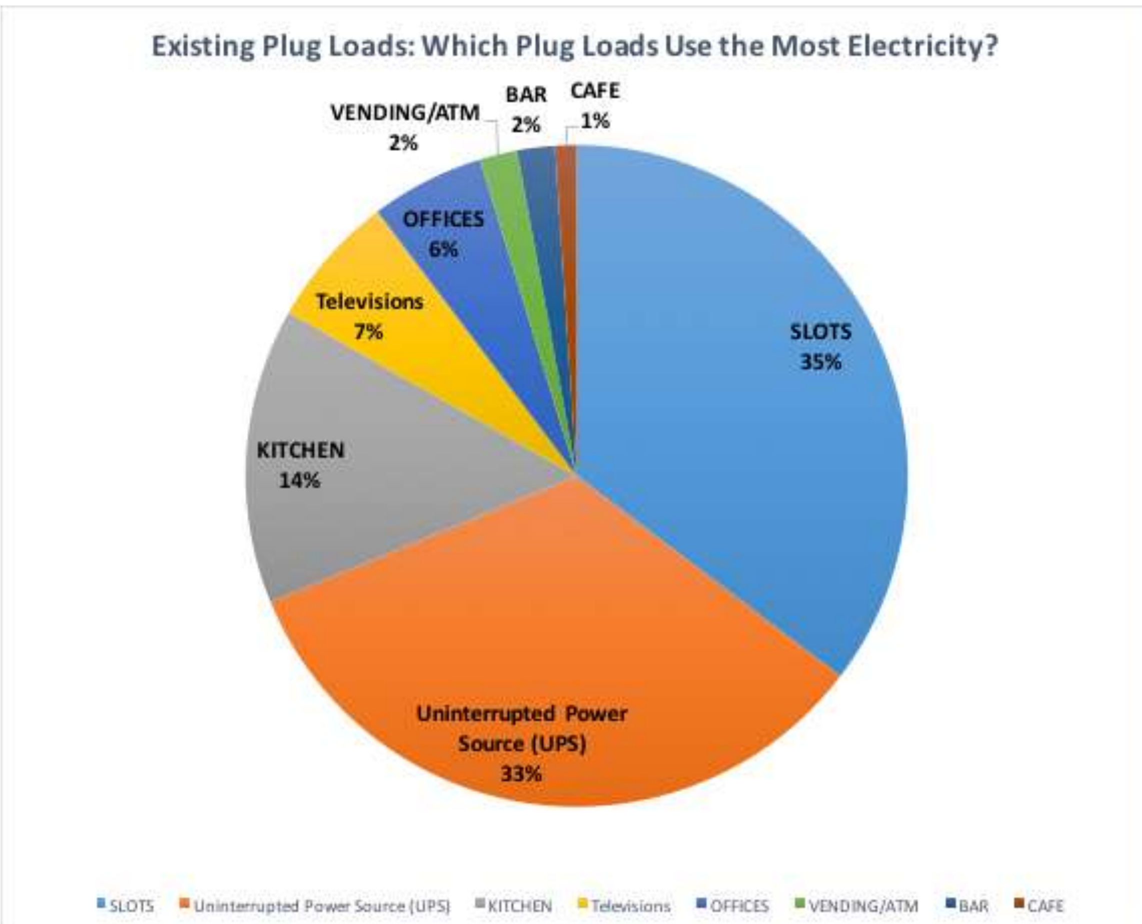
HVAC Equipment				
Quantity	**Existing Equipment**	**Comments**	**Recommended Improvement**	**Estimated Cost to Install (Product + Labor)**
2	Air-cooled Scroll Package Chillers	Trane, 30 Tons each.	Air-to-Water or Air-to-Refrigerant Heat Pumps	$2,000 per ton of capacity, total $120,000
1	Ice Maker Condenser	Manitowoc/ Omnitemp	Ice maker can remain, but when replaced at the end of it's useful life, replace with a more efficient product.	No replacement
1	Supply Fan	Trane	The gas furnace capability of this fan should be disabled during the fuel-switching process, but the fan can likely be re-used with no removal or replacement required.	No replacement
1	Central furnace	AAON, all-in-one central furnace, 18 Tons.	Replace with an Aermec NRP or Mitsubishi R2 HVAC system, either in place or linked to a central system.	$2,000 per ton of capacity, total $36,000
1	Central furnace	AAON, all-in-one central furnace, 25 Tons.	Replace with an Aermec NRP or Mitsubishi R2 HVAC system, either in place or linked to a central system.	$2,000 per ton of capacity, total $50,000
2	Energy Recovery Ventilators	Alliance Air Products	Energy Recovery Ventilators (ERV)'s can remain, they work well with the improved design.	No replacement
1	AC Compressor for Security Room	American Standard	At the end of it's useful life, replace with a more efficient model to save 30-50% of the energy. Replace with 29+ SEER rating Mitsubishi heat pump.	$ 5,000.00
1	Data Chiller	Data Air Inc.	Data chiller can remain until it's time to be replaced with a higher performance model, but refrigerant from a central Mitsubishi R2 or Aermec NRP could do the job as well.	$2,000 per ton of capacity, total $6,000
1	Air Exchanger for Kitchen	Modine, rooftop unit, very old.	Replace with a more efficient air exchanger in near-term rehab. Recommend high efficiency commercial heat pump package unit.	$ 10,000.00

1	Exhaust fan for Kitchen, large	Rooftop fan from Kitchen exhaust hoods	Exhaust fans appear to be in good working order. Hire a mechanical engineer to commission and optimize the fan energy use and perform air balancing tests.	$ 2,000.00
4	Exhaust fan for Kitchen, small	Rooftop fans from Kitchen exhaust hoods	Exhaust fans appear to be in good working order. Hire a mechanical engineer to commission and optimize the fan energy use and perform air balancing tests.	$ 8,000.00
1	Air Handler	Valent Unison, Model #PVA400	Air Handler can remain. Add a Variable Speed Drive, if possible, to educe it's energy consumption by 50%.	$ 2,000.00
1	Split Heat Pump	Samsung, Model #AQX12VFUAGM	Heat pump can remain.	No replacement
1	Water Heater Tank	Rheem Ruud, Natural gas tank, 72 gallons, 80% thermal efficiency, Model #G75-75N-2	Replace tank with a Sanden CO2 heat pump because it is a split system with an outside compressor.	$2,100 for a 2.5-3.5 Ton unit, sufficient for additional space heating
			Total:	**$ 241,100.00**

Kitchen Equipment

Quantity	Existing Equipment	Comments	Recommended Improvement	Estimated Cost to Install (Product + Labor)
3	Evaporative Coolers for Walk-In Refrigerators	OmniTemp, R-404-A refrigerant	Evaporative coolers can remain, but when replaced at the end of useful life, replace with a more efficient product.	No replacement
2	Deep Fryers	Pitco, Solstice Supreme	Replace with an Energy Star model with 90% efficiency	$ 11,000
1	Gas range grill	Delfield, 10 gas burners, Model # C0836-36AM, 18,000 BTU/burner	Replace gas grill with induction range grill, commercial size. Product: Lang RI36S-ATE or equivalent.	$ 12,500
1	Double deck convection oven	Sunfire, Model # SDG-1, 80,000 BTU, convection oven	Replace with electric convection oven	$ 5,300
1	Convection Oven	Montague	Replace with electric convection oven	$ 3,000
4	Undercounter Refrigerators	Delfield, Model # 4427N-6	Replace with Energy Star rated undercounter refrigerators	$2,400 for 60" long, 16 cubic feet replacement
1	Pizza Oven	Blodgett, natural gas, Model # C0836	Replace with electric triple deck pizza oven	$ 10,900
1	Commercial Freezer	McCall	Replace with Energy Star freezer	$2,000 for 49 cubic feet replacement
2	Food Warmers	Hatco, Glo-Ray, electric warmers, Model # GRAH-36, rated at 800 Watts	Food warmers can stay in place and do not appear to have a more efficient alternative.	No replacement
			Total:	**$ 47,100**

Plug Loads				
Quantity	Existing Equipment	Comments	Recommended Improvement	Estimated Cost to Install (Product + Labor)
350	Slot Machines	Some Energy Star machines	---	No replacement
175	Uninterrupted Power Supply (UPS)	Backup battery supplies, one UPS per two slot machines	Remove backup battery supplies for slot machines	Remove
67	Televisions (TV)	Flat screen televisions, mostly 50" sc	Energy Star replacements	$ 16,750
53	Computers and Monitors	Back offices, some Energy Star equipment	Energy Star replacements	$ 21,200
			Total:	**$ 37,950**



Lighting				
Quantity	**Existing Equipment**	**Comments**	**Recommended Improvement**	**Estimated Cost to Install (Product + Labor)**
36	Exterior Lights	High Pressure Sodium, Halogen, and T-8 fluorescent lamps	LED replacements, Dark-Sky Compliant, Energy Star rated lamps with photocell sensors	$ 7,200
450	Interior Lights	Back Offices and Kitchen: T-8 fluorescents, CFL recessed can lights, CFL desk lamps. Casino Floor: LED and CFL recessed lights, T-5 fluorescent display tubes, LED PAR DJ lights, halogen track lamps, and hundreds of miniature atmospheric LED lights that were counted as a single fixture.	LED replacements, Energy Star rated lamps with motion sensor controls	$ 36,000
			Total:	**$ 43,200**

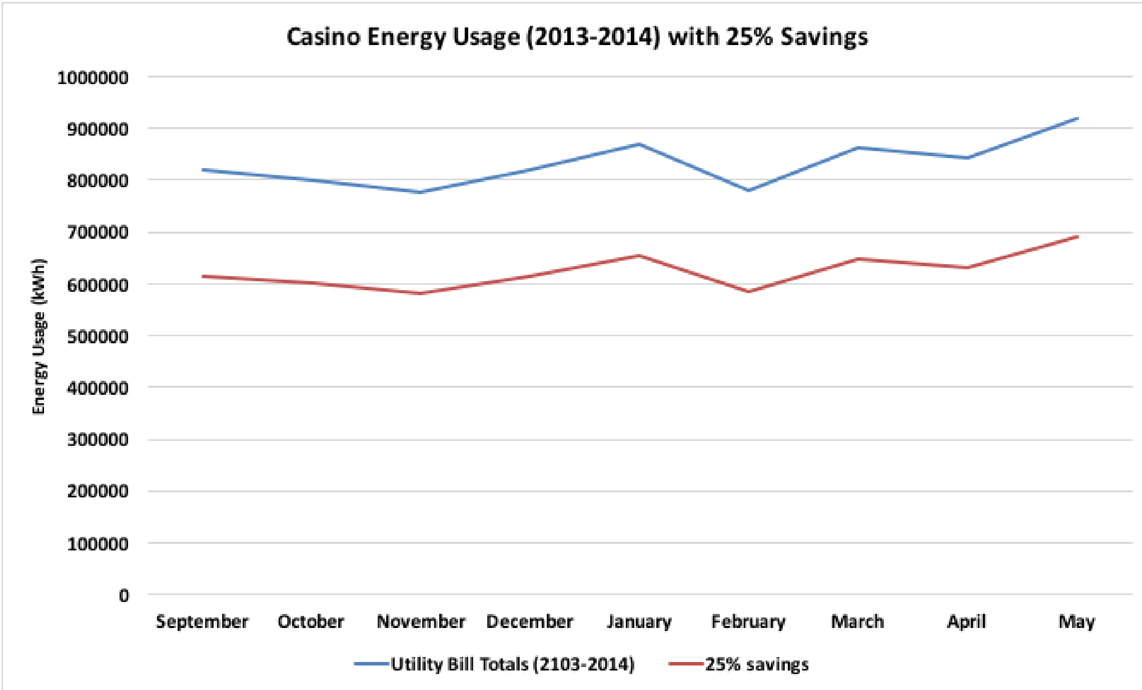
Gas Consumption (Therms/year)	
Existing	**44,437**
Improved, 100% savings	**0**

Electricity Consumption (kWh/year)	
Existing	**10,253,662**
Improved (includes 25% overall savings + additional kWh's from fuel-switching*)	**8,390,247**

*Fuel-switching to all-electric will increase the kWh/year electricity consumption of the Casino by roughly 700,000 kWh's.

Cost to achieve 25% - 50% overall energy savings	**$ 369,350.00**

Solar Panels Saved by Efficiency	**1.9 MW**
Cost savings of 1.9 MW Solar Array	**$ 5,589,000**


Casino Energy Usage (2013-2014) with 25% Savings
Energy Usage (kWh)
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
September
October
November
December
January
February
March
April
May
Utility Bill Totals (2103-2014)
25% savings

3.0 HOTEL

3.1 Summary

The energy audit of the hotel consisted of entering the six different room types, including four different suites, as well as the common areas to evaluate the unique room types, dimensions lighting and components. During these audits, all appliances were documented photographically and the specifications were identified. All lights in the rooms were counted as well as each lighting fixture in the common areas and the dining room. The kitchen in the hotel was audited in order to identify accurate plug loads. All other information for the Hotel was documented using the Building Plans, dated 2011.

3.2 Building Information

Address	11 Bear Paws Way
Year Built	2011

3.3 Baseline Audit

3.3.1 Methods

In February, 2016, Redwood Energy performed an in-depth energy audit of the Bear River Hotel. This audit entailed detailed documentation of the existing lighting, Heating, Ventilation and Air Conditioning (HVAC) equipment, kitchen appliances, and major plug loads at Bear River Hotel. The energy audit was performed in the unique hotel rooms and suites, including the conditioned hallways, staircases and elevators. The first floor lobby, offices, banquet hall, bar, restaurant and kitchen were audited as well to document lighting and equipment. All HVAC equipment, kitchen equipment, and indoor appliances were logged, photographed and quantified to estimate the plug loads consumption of the Bear River Hotel.

3.3.2 Existing Conditions

The Bear River Hotel is a new facility, containing a first floor with a lobby, restaurant, bar, commercial kitchen, ballroom, pool and salon. The second, third and fourth floors include hotel rooms and suites with conditioned corridors, a housekeeping area on each floor, and elevators on each side of the Hotel. The Hotel employs a combination of natural gas and electric heating, ventilation, and air conditioning (HVAC) units for common spaces. The hotel rooms are each equipped with energy efficient, electric packaged terminal air conditioning (PTAC) units and share water heating with three large boilers located in the equipment room. The kitchen includes natural gas cooking equipment and large walk-in refrigerators. The lighting throughout the Hotel commons areas and rooms are efficient LED, CFL, and/or T-5 fluorescent lamps.

3.3.3 Detailed Building Analysis

Redwood Energy performed a full site energy audit to better understand the Bear River Hotel energy loads. Results of the detailed analysis are outlined in the summary tables below, along with recommended equipment replacements and estimated costs to install. All cost estimations are based on either actual cost to purchase and install the product locally, similar equipment costs for purchase and installation, or estimated values when no other source exists. The building was modeled using Energy Pro Non-Residential and Residential software, based on building inputs from a Redwood Energy inspection and verified with building plans. The Econ-2 for Residential spaces (hotel rooms) is included in **Appendix B-1**.

3.4 Existing Equipment and Retrofit Recommendations with Cost Analysis

Redwood Energy recommends that all natural gas equipment be replaced with all-electric equipment to prepare for the 100% all-electric energy sovereignty micro-grid. Additionally, follow these recommendations to decrease overall energy consumption by 25% or more:

- HVAC equipment should have efficiency ratings that meet or exceed current Energy Star standards—in 2016 the equipment would have an HSPF between 9 and 14, and a SEER between 15 and 34.
- Hot Water should be generated with a heat pump with an Energy Factor of 3.4 or greater when specifying smaller Hot Water tanks, or a Coefficiency of Performance of 3.5 or greater for commercial boiler systems.
- All applicable HVAC equipment with electro-mechanical drive systems should have Variable Frequency Drive's (VFD)'s installed to regulate the fan/motor speed, which will reduce energy consumption of the equipment by 50%.
- Kitchen equipment replacements should include induction stovetops and Energy Star rated electric equipment.
- Appliances should be replaced with Energy Star products at the end of their useful life
- Outdoor lights should be Energy Star, Dark-Sky compliant, LED lighting with photocell sensors and motion controls.
- Indoor lights should be Energy Star, LED lighting with motion sensors for lights in the back offices, mechanical rooms, etc.

The table below summarizes the existing conditions and equipment at Bear River, with comments including the existing Brand Name, Model #, energy ratings, etc. Additionally, the table includes recommended methods and products for energy efficiency retrofits, along with associated costs to install. The following recommendations are intended to provide a pathway for reducing energy consumption, while fuel-switching to all-electric in an effort to support the Band’s energy sovereignty goals.

Building Envelope		
Existing Component	**Comments**	**Recommended Improvement**
Wall Insulation	R-19, studs are 16" on center	---
Attic Insulation	R-38 batt insulation	---

HVAC Equipment				
Quantity	**Existing Equipment**	**Comments**	**Recommended Improvement**	**Estimated Cost to Install (Product + Labor)**
1	Pool equipment, Ceiling heater	Markel HF15103, 11.2 MBH capacity, 400 CFM, horizontal unit	Air-to-Water or Air-to-Refrigerant Heat Pumps	$2,000 per ton of capacity, $4,000
5	Cabinet Unit heaters, for stairwells	Markel 6333B052013, 17.1 MBH capacity, 250 CFM, wall units, no efficiency data.	Electric heater units can remain.	No replacement
4	Ductless split AC	Mitsubishi MSZ/MUZ-GE12NA, 9,12,12,33 MBH capacity, SEER 21, 20.5, 20.5, 14.5, wall units, serving the workshop, elevator, IT and laundry rooms, respectively	AC units can remain	No replacement
36	Fan units	Varying CFM, serving kitchen hoods, house keeping, mechanical, pool equipment, electric data, hotel bathrooms, and electric rooms.	Replace fans with Variable frequency drive fans and add variable speed drives, where applicable to save 50% - 65% of the energy consumed.	$2,000 per unit, $72,000
1	Makeup Air Handling Unit	Greenheck DGX-118_H32, Direct gas fired, rooftop unit serving the Kitchen hood. 8,960 CFM, 435 MBH capacity.	Replace with an all-electric, energy efficient air exchanger in near-term rehab.	$2,000 per ton of capacity, $72,000
1	Air Conditioner Unit	Liebert V5035A, DX Electric heater, 17.2 MBH capacity, 5,500 CFM, serves IT room, no efficiency data.	Electric heater units can remain.	No replacement
1	Dehumidifier unit for pool	3,000 CFM, serves pool area, located on the roof.	Electric heater units can remain. Add variable frequency drive fans and variable speed drive to save 50% - 65% of energy consumed.	$ 2,000.00
111	Packaged Terminal AC Units	McQuay PDHA2012EMAE, Air cooled DX/ Electric, 9.8 EER, 12.7 MBH capacity, serves hotel rooms and corridors.	Electric heater units can remain. At the end of their useful life, replace with similar units with higher efficiency ratings.	No replacement
6	Packaged Air Handling Units-DX/Gas	Trane YSC 060, YSC 081, YCD 150, YCD 300, YCD 240, YSC 102. DX-gas units, Input MBH: 64, 64, 270, 400, 350, 180, Tons capacity: 5,5,15,25,20,7, respectively.	Replace with an Aermec NRP or Mitsubishi R2 HVAC system, either in place or linked to a central system.	$2,000 per ton of capacity, $154,000
1	Packaged Rooftop Air Handler Unit	AAON RN007-3-A-000-3K9, Output MBH: 120, CFM: 2,800	Replace with an Aermec NRP or Mitsubishi R2 HVAC system, either in place or linked to a central system.	$2,000 per ton of capacity, $20,000
			Total:	**$ 324,000.00**

Lighting				
Quantity	Existing Equipment	Comments	Recommended Improvement	Estimated Cost to Install (Product + Labor)
-	-	-	All outdoor lighting should be LED, Dark-Sky Compliant, Energy Star rated lamps with photocell sensors.	$250 per fixture, $5,000
775	Interior Lights	Common Lobby 1st floor: LED,CFL recessed can lights, and T-5 fluorescent lamps overhead. Hotel Room Hallways and Common Areas floors 2-4: LED,CFL recessed can lights, and T-5 fluorescent lamps overhead.	Add motion sensors to all common area lights. Lights can remain. At the end of their useful life, replace with LED, Energy Star rated lamps throughout.	$ 17,825
			Total:	**$ 22,825**

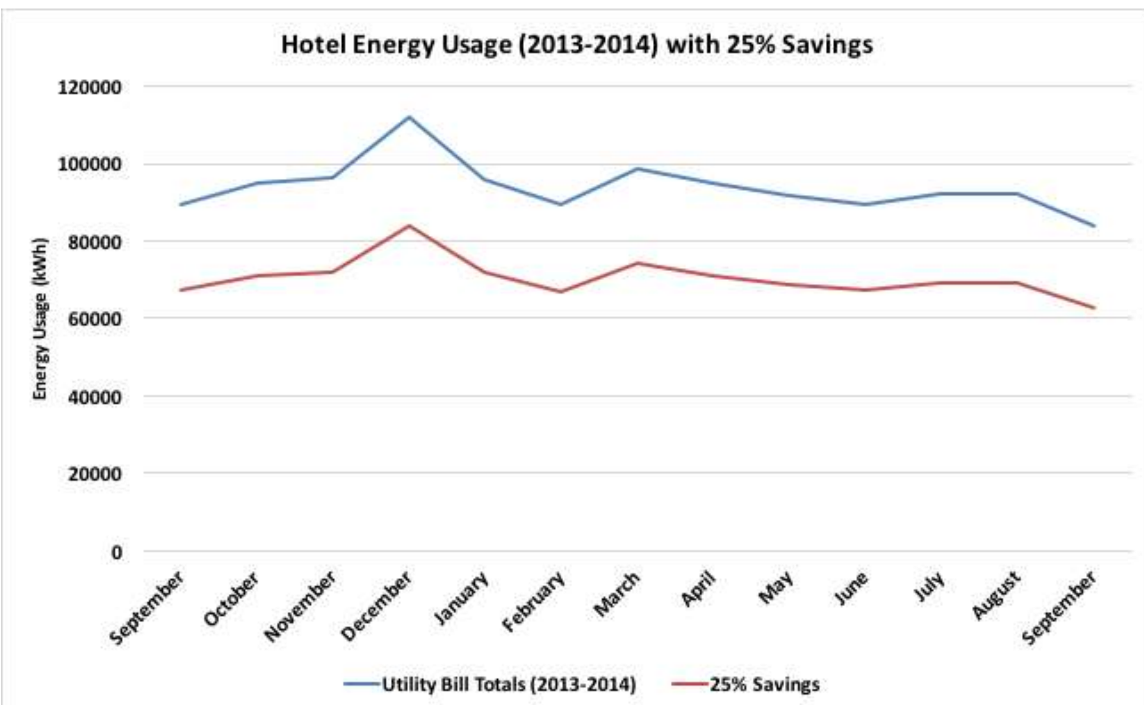
Gas Consumption (Therms/year)	
Existing	**44,437**
Improved, 100% savings	**0**

Electricity Consumption (kWh/year)	
Existing	**1,137,239**
Improved (includes 25% overall savings + additional kWh's from fuel-switching*)	**1,552,929**

*Fuel-switching to all-electric will increase the kWh/year electricity consumption of the Hotel by roughly 700,000 kWh's.

Cost to achieve 25% - 50% overall energy savings	**$ 346,825.00**

Solar Panels Saved by Efficiency	**380 kW**
Cost Savings of 380 kW Solar Array	**$ (1,140,000)**



4.0 PUMP & PLAY

4.1 Summary

For the energy audit of the Pump & Play, both the interior and exterior were audited. All appliances inside the marketplace were photographed in order to accurately identify and gather the associated specifications. All slot machines were counted and the quantity of each model was assessed to determine the overall plug load of the Pump & Play. The recommendations provided are based on the information collected during this audit.

4.2 Building Information

Address	10 Bear Paws Way
Year Built	N/A

4.3 Baseline Audit

4.3.1 Methods

In March, 2016, Redwood Energy performed an energy audit of the Pump and Play building. This audit entailed detailed documentation of the existing lighting, Heating, Ventilation and Air Conditioning (HVAC) equipment, kitchen appliances, and plug loads at the Pump and Play. The energy audit was performed on the Market side and the Casino side of the building, including the back rooms and security office. All HVAC equipment, market equipment, casino slot machines, lighting and indoor appliances were logged, photographed and quantified to estimate the plug loads consumption of the Bear River Pump and Play building.

4.3.2 Baseline Audit Photographs of Existing Equipment

Photographs of existing HVAC equipment at Bear River Pump and Play are included in **Appendix C-1**.

4.3.3 Existing Conditions

The condition of the Pump and Play building is fair to good. The HVAC equipment looks to be near the end of useful life, and older T-8 fluorescent lamps make up a majority of the lighting throughout. The market refrigerators are mostly all Energy Star rated.

4.3.4 Detailed Building Analysis

Redwood Energy performed a full site energy audit to better understand the energy loads of the Pump and Play building. Results of the detailed analysis are outlined in the summary tables below, along with recommended equipment replacements and estimated costs to install. All cost estimations are based on either actual cost to purchase and install the product locally, similar equipment costs for purchase and installation, or estimated values when no other source exists. The building was modeled using Energy Pro Non-Residential software, based on building inputs from a Redwood Energy inspection. The Econ-2 for Non-Residential spaces is provided in **Appendix C-2**.

4.4 Existing Equipment and Retrofit Recommendations with Cost Analysis

Redwood Energy recommends that all natural gas equipment be replaced with all-electric equipment to prepare for the 100% all-electric energy sovereignty micro-grid. Additionally, follow these recommendations to decrease overall energy consumption by 25%-50%:

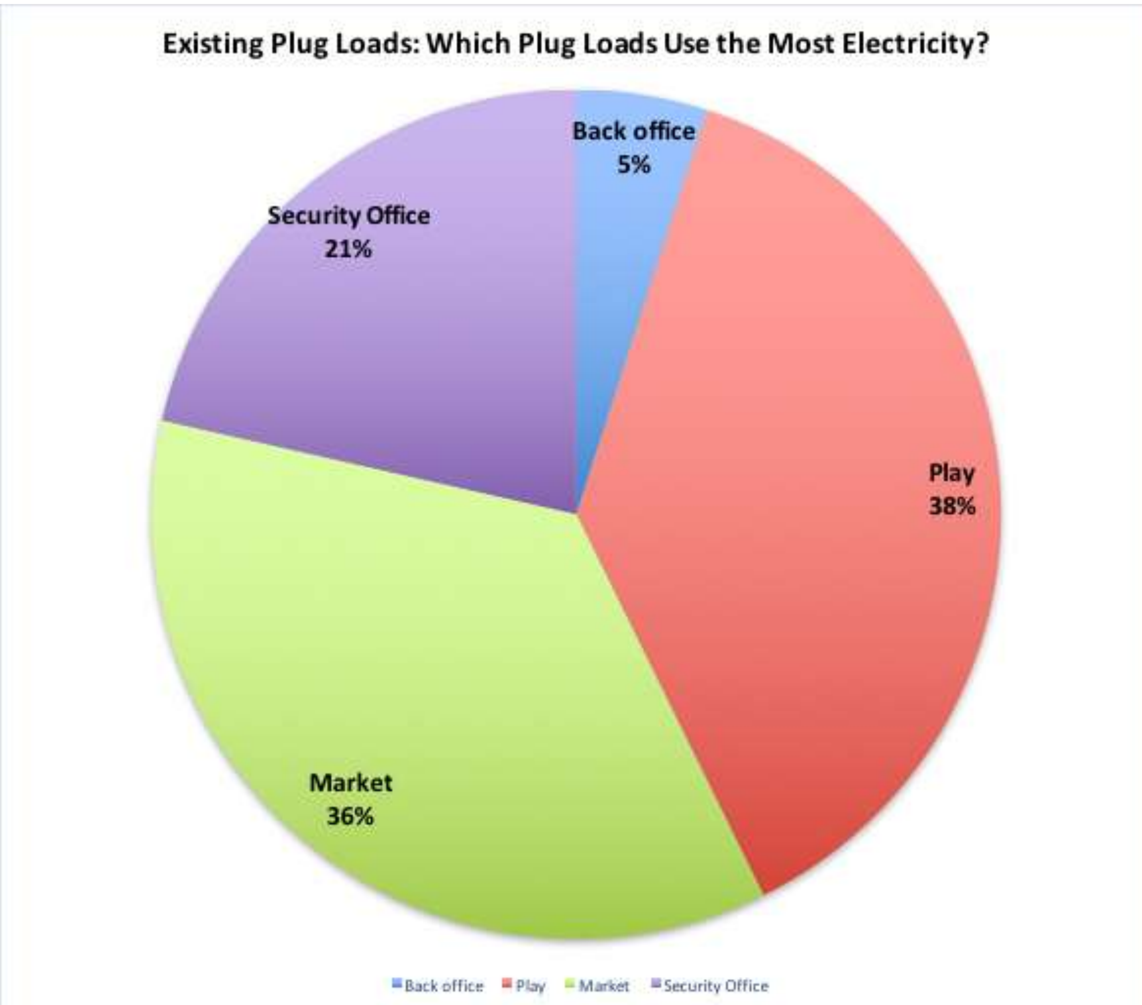
- HVAC equipment should have efficiency ratings that meet or exceed current Energy Star standards—in 2016 the equipment would have an HSPF between 9 and 14, and a SEER between 15 and 34.
- Hot Water should be generated with a heat pump with an Energy Factor of 3.4 or greater when specifying smaller Hot Water tanks, or a Coefficiency of Performance of 3.5 or greater for commercial boiler systems.
- All applicable HVAC equipment with electro-mechanical drive systems should have Variable Frequency Drive's (VFD)'s installed to regulate the fan/motor speed, which will reduce energy consumption of the equipment by 50%.
- Market equipment replacements should include Energy Star rated refrigerators and equipment.
- Appliances should be replaced with Energy Star products at the end of their useful life
- Outdoor lights should be Energy Star, Dark-Sky compliant, LED lighting with photocell sensors and motion controls.
- Indoor lights should be Energy Star, LED lighting with motion sensors for lights in the back offices, mechanical rooms, etc.

The table below summarizes the existing conditions and equipment at Bear River, with comments including the existing Brand Name, Model #, energy ratings, etc. Additionally, the table includes recommended methods and products for energy efficiency retrofits, along with associated costs to install. The following recommendations are intended to provide a pathway for reducing energy consumption, while fuel-switching to all-electric in an effort to support the Band's energy sovereignty goals.

Building Envelope		
Existing Component	**Comments**	**Recommended Improvement**
Wall Insulation	R-19, studs are 16" on center	---
Attic Insulation	R-38 batt insulation	---

HVAC Equipment				
Quantity	**Existing Equipment**	**Comments**	**Recommended Improvement**	**Estimated Cost to Install (Product + Labor)**
2	Remote compressor units for walk-in refrigerator	Larkin units, Copeland 3 HP motor, connected to 3-fan evaporators in the walk-in refrigerators	Units can remain until it's time to be replaced with a higher performance model, but refrigerant from a central Mitsubishi R2 or Aermec NRP could do the job as well. Add VFD's to motor to cut energy use in half.	$2,000 per ton of capacity, total $6,000
1	Natural gas condenser fan	Armstrong, Model # 4PGE15E60110LP-1A	Mitsubishi R2 HVAC system, either in place or linked to a central system. OR link to Sanden CO2 heat pump water heater to provide space heating and water heating from one	$2,000 per ton of capacity, total $4,000
1	AC Mini split	Fijutsi Halcyon Inverter, 18,000 BTU cooling	Replace with an Aermec NRP or Mitsubishi R2 HVAC system, either in place or linked to a central system.	$2,000 per ton of capacity, total $10,000
1	Tankless water heater	Rheem tankless water heater powered by propane fuel. 0.94 EF, 199,900 BTU max. input	Replace tank with a Sanden CO2 heat pump because it is a split system with an outside compressor.	$2,100 for a 2.5-3.5 Ton unit, sufficient for additional space heating
			Total:	**$ 22,100**

Plug Loads				
Quantity	Existing Equipment	Comments	Recommended Improvement	Estimated Cost to Install (Product + Labor)
35	Slot Machines	Some Energy Star machines	---	No replacement
18	Uninterrupted Power Supply (UPS)	Backup battery supplies, one UPS per two slot machines	Remove backup battery supplies for slot machines	Remove
18	Refrigerator cases	(7)/(18) refrigerators are Energy Star.	Replace (11) refrigerators with Energy Star models.	$ 4,000
5	Televisions (TV)	Flat screen televisions, mostly 50"	Energy Star replacements	$ 1,250
			Total:	**$ 5,250**



Lighting				
Quantity	**Existing Equipment**	**Comments**	**Recommended Improvement**	**Estimated Cost to Install (Product + Labor)**
13	Exterior Lights	High Pressure Sodium, Halogen, and T-8 fluorescent lamps	LED replacements, Dark-Sky Compliant, Energy Star rated lamps with photocell sensors	$ 2,600
124	Interior Lights	Market: T-8 linear fluorescent lamps with a few LED's, incandesents and CFL lamps. Casino side: CFL recessed can lights, LED PAR DJ lights, halogen track lamps, and atmospheric LED lights.	LED replacements, Energy Star rated lamps with motion sensor controls	$ 9,920
			Total:	**$ 12,520**

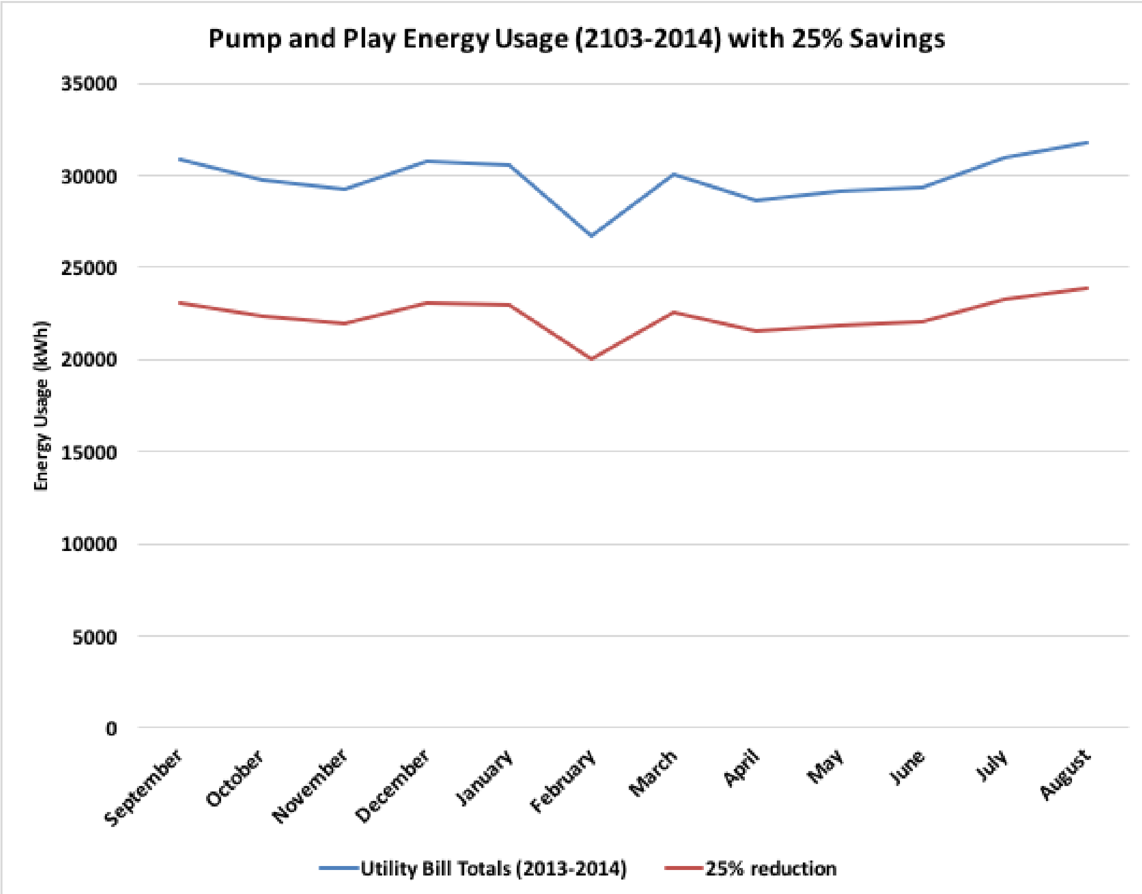
Gas Consumption (Therms/year)	
Existing	**8,000**
Improved, 100% savings	**0**

Electricity Consumption (kWh/year)	
Existing	**357,879**
Improved (includes 25% overall savings + additional kWh's from fuel-switching*)	**468,409**

*Fuel-switching to all-electric will increase the kWh/year electricity consumption by roughly 200,000 kWh's.

Cost to achieve 25% - 50% overall energy savings	**$ 39,870**

Solar Panels Saved by Efficiency	**90 kW**
Cost savings of 90 kW Solar Array	**$ (270,000)**



Pump and Play Energy Usage (2103-2014) with 25% Savings
35000
30000
25000
20000
15000
10000
5000
0
Energy Usage (kWh)
September
October
November
December
January
February
March
April
May
June
July
August
Utility Bill Totals (2013-2014)
25% reduction

5.0 HUMAN RESOURCES & ACCOUNTING

5.1 Summary

For these audits, the Human Resources offices were audited first and then the Accounting offices were audited second. Within the Human Resources each appliance was photographed and documented in order to identify the specifications and the plug loads of each appliance. Additionally, the common rooms were audited and the types and quantity of lights were assessed. For confidentiality purposes, the audit of the Accounting offices included a basic sweep of the offices with no photographs taken. Assumptions were made as to the exact types of machines/appliances but the quantity was recorded. This audit included all of the offices, as well as the break room but was not inclusive of any machines or appliances for the offices that were newly constructed.

Address	Bear River Drive
Year Built	N/A

5.2 Baseline Audit

5.2.1 Baseline Audit Photographs of Existing Equipment

Photographs of existing HVAC equipment at Bear River HR/Accounting Building are included in **Appendix D-1**.

5.3 Existing Equipment and Retrofit Recommendations with Cost Analysis

Redwood Energy recommends that all gas-fueled equipment be replaced with all-electric equipment to prepare for the 100% all-electric energy sovereignty micro-grid. Additionally, follow these recommendations to decrease overall energy consumption by 25% or more:

- HVAC equipment should have efficiency ratings that meet or exceed current Energy Star standards—in 2016 the equipment would have an HSPF between 9 and 14, and a SEER between 15 and 34.
- Hot Water should be generated with a heat pump with an Energy Factor of 3.4 or greater when specifying smaller Hot Water tanks, or a Coefficiency of Performance of 3.5 or greater for commercial boiler systems.

The table below summarizes the existing conditions and equipment at Bear River, with comments including the existing Brand Name, Model #, energy ratings, etc. Additionally, the table includes recommended methods and products for energy efficiency retrofits, along with associated costs to install. The following recommendations are intended to provide a pathway for reducing energy consumption, while fuel-switching to all-electric in an effort to support the Band's energy sovereignty goals.

Building Envelope

Existing Component	Comments	Recommended Improvement
Wall Insulation	R-19, studs are 16" on center	---
Attic Insulation	R-38 batt insulation	---

HVAC Equipment

Quantity	Existing Equipment	Comments	Recommended Improvement	Estimated Cost to Install (Product + Labor)
1	Direct Vent Forced Air Furnace	Aire Flo, 75,000 BTU, 21.9 kW	Replace with Sanden CO2 Heat Pump that will work for water heating and space heating.	$2,100 for a 2.5-3.5 Ton unit, sufficient for additional space heating
1	Gas Furnace	Aire Flo, 100,000 BTU	Replace with an Aermec NRP or Mitsubishi R2 HVAC system, either in place or linked to a central system.	$2,000 per ton of capacity, total $22,000
2	Propane water heater tank	(1) State Select, propane-fueled, 33,500 BTU - (1) Rheem, similar rating	Replace tank with a Sanden CO2 heat pump that will work for water heating and space heating as a split system with an outside compressor.	$2,100 for a 2.5-3.5 Ton unit, sufficient for additional space heating
			Total:	**$ 28,300**

Lighting

Quantity	Existing Equipment	Comments	Recommended Improvement	Estimated Cost to Install (Product + Labor)
179	Interior and Exterior Lights	Exterior: CFL and High Pressure Sodium. Interior: T-8 Linear Fluorescent and CFL lamps.	lamps. Add photocell sensors, motion sensors and Dark-Sky Compliant additions for outdoor lighting.	$ 17,900
			Total:	**$ 17,900**

Gas Consumption (Therms/year)	
Existing	2,000
Improved, 100% savings	0

Electricity Consumption (kWh/year)	
Existing	93,856
Improved (includes 25% overall savings + additional kWh's from fuel-switching*)	130,392

*Fuel-switching to all-electric will increase the kWh/year electricity consumption by roughly 60,000 kWh's.

Cost to achieve 25% - 50% overall energy savings	$ 46,200

Solar Panels Saved by Efficiency	30 kW
Cost savings of 30 kW Solar Array	$ (90,000)

6.0 TOBACCO TRADERS

6.1 Summary

The Tobacco Traders building was audited by Redwood Energy in March, 2016 to verify existing conditions based off of the Building plans. The building is in excellent condition, as it was built four years ago. During the audit, HVAC equipment, lighting, appliances and the water heater were photographed and documented in order to identify the components' specifications and the plug loads.

Address	260 Keisner Road
Year Built	2014

6.2 Baseline Audit

6.2.1 Baseline Audit Photographs of Existing Equipment

Photographs of equipment at Tobacco Traders are included in **Appendix E-1**.

6.3 Existing Equipment and Retrofit Recommendations with Cost Analysis

Since the Tobacco Traders building is newly constructed, our retrofit recommendations are minimal. Redwood Energy recommends that all gas-fueled equipment be replaced with all-electric equipment to prepare for the 100% all-electric energy sovereignty micro-grid. Additionally, follow these recommendations to decrease overall energy consumption by 25% or more:

- HVAC equipment should have efficiency ratings that meet or exceed current Energy Star standards—in 2016 the equipment would have an HSPF between 9 and 14, and a SEER between 15 and 34.
- Hot Water should be generated with a heat pump with an Energy Factor of 3.4 or greater when specifying smaller Hot Water tanks, or a Coefficiency of Performance of 3.5 or greater for commercial boiler systems.

The table below summarizes the existing conditions and equipment at Bear River, with comments including the existing Brand Name, Model #, energy ratings, etc. Additionally, the table includes recommended methods and products for energy efficiency retrofits, along with associated costs to install. The following recommendations are intended to provide a pathway for reducing energy consumption, while fuel-switching to all-electric in an effort to support the Band’s energy sovereignty goals.

Building Envelope		
Existing Component	**Comments**	**Recommended Improvement**
Wall Insulation	R-19, studs are 16" on center	---
Attic Insulation	R-38 batt insulation	---

HVAC Equipment				
Quantity	**Existing Equipment**	**Comments**	**Recommended Improvement**	**Estimated Cost to Install (Product + Labor)**
1	Central Gas Furnace	Lennox, Model # LENNOX EL 296UH045XE36V, 96% AFUE, 44/29 Input MBH	Replace with an Aermec NRP or Mitsubishi R2 HVAC system, either in place or linked to a central system. OR link to Sanden CO2 heat pump water heater to provide space heating and water heating from one piece of equipment.	$2,000 per ton of capacity, total $8,000
1	Horizontal Gas Furnace	Lennox, Model # LENNOX EL-269UH110XE60C, 96% AFUE, 110/72 Input MBH	Replace with an Aermec NRP or Mitsubishi R2 HVAC system, either in place or linked to a central system. OR link to Sanden CO2 heat pump water heater to provide space heating and water heating from one piece of equipment.	$2,000 per ton of capacity, total $16,000
1	Split AC Condenser	Lennox, Model # LENNOX 14ACX-018-230-2, 14.0 SEER, 14 MBH Sensible Cooling Capacity	Replace with an Aermec NRP or Mitsubishi R2 HVAC system, either in place or linked to a central system.	$2,000 per ton of capacity, total $8,000
1	Split AC Condenser	Lennox, Model # LENNOX 14ACX-048-230-2, 14.0 SEER, 36 MBH Sensible Cooling Capacity	Replace with an Aermec NRP or Mitsubishi R2 HVAC system, either in place or linked to a central system.	$2,000 per ton of capacity, total $16,000
1	Tankless water heater	Rheem tankless gas water heater, 157 MBH	Replace tank with a Sanden CO2 heat pump because it is a split system with an outside compressor.	$2,100 for a 2.5-3.5 Ton unit, sufficient for additional space heating
			Total:	**$ 52,500**

Lighting				
Quantity	**Existing Equipment**	**Comments**	**Recommended Improvement**	**Estimated Cost to Install (Product + Labor)**
14	Exterior Lights	CFL recessed lamps and pronged CFL lamps.	LED replacements, Dark-Sky Compliant, Energy Star rated lamps with photocell sensors	$ 2,800
251	Interior Lights	CFL recessed lighting throughout with additional smaller LED display lights, CFL track lights and T-8 linear fluorescent lamps.	LED replacements for linear fluroescent lamps and CFL's. Replace with Energy Star rated lamps with motion sensor controls	$ 12,080
			Total:	**$ 14,880**

Gas Consumption (Therms/year)	
Existing	**2,500**
Improved, 100% savings	**0**

Electricity Consumption (kWh/year)	
Existing	**189,350**
Improved (includes 25% overall savings + additional kWh's from fuel-switching*)	**202,013**

*Fuel-switching to all-electric will increase the kWh/year electricity consumption by roughly 60,000 kWh's.

Cost to achieve 25% - 50% overall energy savings	**$ 67,380**

Solar Panels Saved by Efficiency	**12 kW**
Cost savings of 12 kW Solar Array	**$ 36,000**

7.0 BEAR RIVER DRIVE HOMES

7.1 Summary

The Bear River Band's homes are a mix of types, ages, building strategies and equipment. However, the strategies to support the Tribe's Energy Sovereignty are similar:

- more insulation to reduce the Space Heating loads
- highly efficient electric heat pumps for Space Heating and Domestic Hot Water, and Energy Star appliances and Lighting
- maximizing the use of inexpensive "thermal storage" with a hot water tank set to 150F-160F
- minimizing the use of expensive battery storage, such that only enough electricity is stored to meet the peak needs of a winter night, with enough rooftop solar to meet all energy needs during the day and store enough for the night.

In this way the homes can be cost-effectively powered with renewable energy, and they can additionally be independent of the Tribe's larger micro-grid, such as the current state of the Community Building relative to PG&E's grid, or they can be powered by the Tribe's micro-grid, which may have less-expensive renewable energy created at a larger scale.

Address	(10 Homes) 18-46 Bear River Drive
Year Built	1992; Add-ons: 2000

7.2 Baseline Audit

7.2.1 Methods

In February, 2016, Redwood Energy performed an energy audit of (10) Bear River Drive Homes. These audit entailed detailed documentation of the existing lighting, Heating, Ventilation and Air Conditioning (HVAC) equipment, kitchen appliances, and plug loads in the homes along with drawings to replicate building plans for energy models. All HVAC equipment, lighting and indoor appliances were logged, photographed and quantified to estimate energy demands of the Bear River Drive Homes.

7.2.2 Baseline Audit Photographs of Existing Equipment

Photographs of Bear River Drive Homes are included in **Appendix F-1**.

7.2.3 Existing Conditions

The condition of the Bear River Drive Homes range from poor to fair, in terms of sealed building envelope, indoor health, foundation and structural issues, insulation quality, and energy consumption. The HVAC equipment in the homes are mostly new propane furnaces, and incandescent, CFL and older T-8 fluorescent lamps make up a majority of the lighting throughout. Most homes audited have a propane water heater tank, propane stoves, a washer and dryer, and non-Energy Star appliances.

7.2.4 Detailed Building Analysis

Redwood Energy performed a full site energy audit to better understand the energy loads of the Bear River Drive Homes. Results of the detailed analysis are outlined in the summary tables below, along with recommended equipment replacements and estimated costs to install. All cost estimations are based on either actual cost to purchase and install the product locally, similar equipment costs for purchase and installation, or estimated values when no other source exists. The building was modeled using Energy Pro Residential software, based on building inputs from a Redwood Energy inspection. The Econ-2 for Residential spaces is provided in **Appendix F-2**.

7.3 Existing Equipment and Retrofit Recommendations with Cost Analysis

The table below summarizes the existing conditions and equipment at Bear River, with comments including the existing Brand Name, Model #, energy ratings, etc. Additionally, the table includes recommended methods and products for energy efficiency retrofits, along with associated costs to install. The following recommendations are intended to provide a pathway for reducing energy consumption, while fuel-switching to all-electric in an effort to support the Band's energy sovereignty goals.

Bear River Dr #34 represents smaller homes from 900 - 1,300 sq.ft.			
Existing Component	**Comments**	**Recommended Improvement**	**Estimated Cost to Install (Product + Labor)**
R- Walls	Inconsistent insulation, gaps and compression	Add R-8, 2" thick interior cork siding, either below a new layer of drywall **OR**	$10/sf inside, $10,800 **OR**
		If siding is damaged, add 2" thick exterior cork siding with siding replacement.	$13/sf outside including siding removal and adding structural ACX plywood, $14,000
R- Roof	Inconsistent insulation, gaps and compression	Add formaldehyde-free R-19 blown cellulose or fiberglass batts	1.68/sf of R-19 (.$67/sf materials, $1.01/sf labor), $2,500
Slab:	Uninsulated	Optional: Add R-8, 2" thick interior cork siding under the finish floor	$10/sf inside, $15,000
Windows	Aluminum-frame, single-pane	Replace only if glass panes are broken or not safe.	No replacement
Water Heater	Rheem Fury, Water heater tank, propane-fueled, 30,000 BTU/HR Input, EF=0.62	Micro-grid enabled high-temperature Heat Pump EF =3.39, 29,000 BTUs, Recommended product: GE Geospring or Sanden CO2 Heat Pump	$ 2,500.00
Furnace	Williams, gravity wall heater, broken	Ductless Minisplit: HSPF 12+, Recommended product: Mitsubishi, Unico for small ducts	$4500 for wall-mount
Gas Stoves and Electric Stoves	Propane	Induction Stove	$1,400
		Total:	**$ 38,300**

Bear River Dr #42 represents larger homes from 1,300 - 1,700 sq.ft.			
Existing Component	**Comments**	**Recommended Improvement**	**Estimated Cost to Install (Product + Labor)**
R- Walls	Inconsistent insulation, gaps and compression	Add R-8 insulation to the walls, using either cork siding interior or exterior, insulated panels, or rigid insulation.	$12/sf, $8,000 to $14,000
R- Roof	Inconsistent insulation, gaps and compression	Add formaldehyde-free R-19 blown cellulose or fiberglass batts	1.68/sf of R-19 (.$67/sf materials, $1.01/sf labor), $2,500
Slab:	Uninsulated	None	None
Windows	Vinyl, dual-pane	Replace only if glass panes are broken or not safe.	No replacement
Water Heater	Rheem Criterion, Water heater tank, propane-fueled, EF=0.8	Micro-grid enabled high-temperature Heat Pump EF =3.39, 29,000 BTUs, Recommended product: GE Geospring or Sanden CO2 Heat Pump	$ 2,500.00
Furnace	Trane XR95 central furnace, AFUE 0.95	Heat Pump with ducted fan coil: HSPF 11+, Recommended Product: Unico, Sanden CO2, or Mitsubishi MXZ-4C36NAHZ	$ 6,000.00
Gas Stoves	Propane	Induction Stove	$1,400
[2] Electric Stoves	Electric Stove	Replace with Induction	$1,400
		Total:	**$ 24,800**

Electricity Consumption (kWh/year)	
Existing for all (10) homes	**53,284**
Improved, (includes 43% overall savings + additional kWh's from fuel-switching*)	**92,908**

*Fuel-switching to all-electric will increase the kWh/year electricity consumption of the Homes by roughly 40,000 kWh's.

Cost to achieve 43% overall energy savings for (10) homes	**$ 302,000**

Gas Consumption (Therms/year)	
Existing	**5,094**
Improved, 100% savings	**0**

Solar Panels Saved by Efficiency	**40 kW**
Cost savings of 40 kW Solar Array	**$ (120,000)**

8.0 MODEL HOMES A, B, C, D, E AND TISH-NON VILLAGE HOMES E, F

8.1 Summary

The Bear River Band's homes are a mix of types, ages, building strategies and equipment. However, the strategies to support the Tribe's Energy Sovereignty are similar:

- More insulation to reduce the Space Heating loads
- Highly efficient electric heat pumps for Space Heating and Domestic Hot Water, and Energy Star appliances and Lighting
- Maximizing the use of inexpensive "thermal storage" with a hot water tank set to 150F-160F
- Minimizing the use of expensive battery storage, such that only enough electricity is stored to meet the peak needs of a winter night, with enough rooftop solar to meet all energy needs during the day and store enough for the night.

In this way the homes can be cost-effectively powered with renewable energy, and they can additionally be independent of the Tribe's larger micro-grid, such as the current state of the Community Building relative to PG&E's grid, or they can be powered by the Tribes's micro-grid, which may have less-expensive renewable energy created at a larger scale.

Address	28-375 Carroll Road
Year Built	2012

8.2 Baseline Audit

8.2.1 Detailed Building Analysis

Redwood Energy performed an energy analysis of the Model Homes based on the Building Plans and ran the information through the Energy Pro software to generate energy consumption estimates. Results of the detailed analysis are outlined in the summary tables below, along with recommended equipment replacements and estimated costs to install. All cost estimations are based on either actual cost to purchase and install the product locally, similar equipment costs for purchase and installation, or estimated values when no other source exists. The homes were modeled using Energy Pro Residential software, based on building inputs from the Building Plans provided by the Bear River Housing Department. The Econ-2 for Residential spaces is provided in **Appendix G-1**.

8.3 Existing Equipment and Retrofit Recommendations with Cost Analysis

The table below summarizes the existing conditions and equipment at Bear River, with comments including the existing Brand Name, Model #, energy ratings, etc. Additionally, the table includes recommended methods and products for energy efficiency retrofits, along with associated costs to install. The following recommendations are intended to provide a pathway for reducing energy consumption, while fuel-switching to all-electric in an effort to support the Band's energy sovereignty goals.

Existing Component	**Existing Specs**	**Recommended Improvement**	**Estimated Cost to Install (Product + Labor)**
R-19 Walls	Spray foam insulation	Add R-8, 2" thick interior cork siding, either below a new layer of drywall **OR**	$10/sf inside, $10,800 **OR**
		If siding is dmaged, add 2" thick exterior cork siding with siding replacement.	$13/sf outside including siding removal and adding structural ACX plywood, $14,000
R-30 Roof	Fiberglass	Add formaldehyde-free R-19 blown cellulose or fiberglass batts	1.68/sf of R-19 (.$67/sf materials, $1.01/sf labor), $2,500
Slab:	1" Rigid insulation beneath 4" Slab	Optional: Add R-8, 2" thick interior cork siding under the finish floor	$10/sf inside, $15,000
Windows	Milguard EnergyStar	Replace only if glass panes are broken or not safe.	No replacement.
Furnace (propane)	AFUE= .84 20,500 BTU	Heat Pump with ducted fan coil: HSPF 11+ (mitsubishi MXZ-4C36NAHZ)	$ 5,000.00
Gas Fireplace	Xtraordinair	Ductless Minisplit: HSPF 12+	$ 4,500.00
Munchkin Boiler for Radiant Floor	AFUE= .92 19,000 BTU	Recommended that house abandon radiant floor and run ductwork from retrofitted HSPF 11 heat pump (e.g. Carrier Greenspeed), OR Optional: Install Sanden CO2 Heat Pump that can be plumbed to the radiant floor and domestic hot water.	$2000 to additionally duct rooms without radiant floor OR $12,000 for Sanden CO2 heat pump and whole-house duct work
Gas Fire On-demand, all pipes insulated; Energy Star	EF=.86 11,000 BTU	Micro-grid enabled GE Geospring Heat Pump EF =3.39, 29,000 BTUs ($2,500) **OR**	$ 2,500.00
		Sanden CO2 Heat Pump for DHW and Hydronic Space Heating ($8000)	$ 8,000.00
Range (propane gas)	Gas Stove	Induction Stove	$ 1,400.00
Refrigerator; Energy Star	Energy Star Refrigerator	Keep existing	No replacement.
		Total:	**$27,700 - $54,400**

Electricity Consumption (kWh/year)	
Existing for all (41) homes	226,014
Improved, (includes 38% overall savings + additional kWh's from fuel-switching*)	419,759
*Fuel-switching to all-electric will increase the kWh/year electricity consumption of the Homes by roughly 200,000 kWh's.	

Cost to achieve 43% overall energy savings for (41) homes	$ 1,683,050

Gas Consumption (Therms/year)	
Existing	20,691
Improved, 100% savings	0

Solar Panels Saved by Efficiency	150 kW
Cost savings of 150 kW Solar Array	$ (450,000)

9.0 COMMUNITY CENTER

9.1 Summary

The Community Center is currently powered by solar panels and micro-wind generators, and can remain as-is to achieve Energy Sovereignty for the Bear River Band. Alternatively, it can eventually be included in the larger micro-grid to allow excess energy generated by the solar-and-wind power system to support the Tribe's energy needs, although in the future, a retrofit may be pursued when the equipment is past its' useful life.

10.0 RECREATION CENTER (NEW CONSTRUCTION)

The new Recreation Center was under construction and was not included in the scope of this report. However, the product recommendations are similar to those for the Hotel. Redwood Energy recommends that all natural gas equipment be replaced with all-electric equipment to prepare for the 100% all-electric energy sovereignty micro-grid. Additionally, follow these recommendations to decrease overall energy consumption by 25% or more:

- HVAC equipment should have efficiency ratings that meet or exceed current Energy Star standards—in 2016 the equipment would have an HSPF between 9 and 14, and a SEER between 15 and 34.
- Hot Water should be generated with a heat pump with an Energy Factor of 3.4 or greater when specifying smaller Hot Water tanks, or a Coefficiency of Performance of 3.5 or greater for commercial boiler systems.
- All applicable HVAC equipment with electro-mechanical drive systems should have Variable Frequency Drive's (VFD)'s installed to regulate the fan/motor speed, which will reduce energy consumption of the equipment by 50%.
- Kitchen equipment replacements should include induction stovetops and Energy Star rated electric equipment.
- Appliances should be replaced with Energy Star products at the end of their useful life
- Outdoor lights should be Energy Star, Dark-Sky compliant, LED lighting with photocell sensors and motion controls.
- Indoor lights should be Energy Star, LED lighting with motion sensors for lights in the hallways, offices, mechanical rooms, etc.

11.0 GAMING OFFICE

11.1 Summary

The Gaming Office was audited in March, 2016 and is similar to the Bear River Drive homes in size, location, and date of construction. Within the Gaming Office, the gravity wall heater, gas storage tank water heater, lighting, and appliances were photographed and documented in order to identify the specifications and the plug loads of each appliance. The Gaming Office is fueled by propane gas for the wall heater and water heater, similar to the Bear River Drive homes.

Address	30 Bear River Drive
Year Built	1994

11.2 Existing Equipment and Retrofit Recommendations with Cost Analysis

Redwood Energy recommends that all gas-fueled equipment be replaced with all-electric equipment to prepare for the 100% all-electric energy sovereignty micro-grid. Additionally, follow these recommendations to decrease overall energy consumption by 25% or more:

- HVAC equipment should have efficiency ratings that meet or exceed current Energy Star standards—in 2016 the equipment would have an HSPF between 9 and 14, and a SEER between 15 and 34.
- Hot Water should be generated with a heat pump with an Energy Factor of 3.4 or greater when specifying smaller Hot Water tanks, or a Coefficiency of Performance of 3.5 or greater for commercial boiler systems.
- Appliances should be replaced with Energy Star products at the end of their useful life
- Outdoor lights should be Energy Star, Dark-Sky compliant, LED lighting with photocell sensors and motion controls.
- Indoor lights should be Energy Star, LED lighting with motion sensors for lights in the hallways, offices, etc.

The table below summarizes the existing conditions and equipment at Bear River, with comments including the existing Brand Name, Model #, energy ratings, etc. Additionally, the table includes recommended methods and products for energy efficiency retrofits, along with associated costs to install. The following recommendations are intended to provide a pathway for reducing energy consumption, while fuel-switching to all-electric in an effort to support the Band’s energy sovereignty goals.

Building Envelope

Existing Component	Comments	Recommended Improvement	Estimated Cost to Install (Product + Labor)
Wall Insulation	R-13	Add insulation to make walls R-19. Add insulated siding material to the outside or non-invasive cork siding to the interior for added insulation.	$10,800 OR $13/sf outside including siding removal and adding structural ACX plywood, $14,000
Attic Insulation	R-38 batt insulation	Add insulation to make the attic R-49. Add blown-cellulose or recycled cotton batt insulation for a healthy building.	1.68/sf of R-19 (.$67/sf materials, $1.01/sf labor), $2,500
		Total:	**$ 14,900**

HVAC Equipment

Quantity	Existing Equipment	Comments	Recommended Improvement	Estimated Cost to Install (Product + Labor)
1	Gravity Wall Furnace	Williams, 60% AFUE	Replace with Sanden CO2 Heat Pump that will work for water heating and space heating.	$2,100 for a 2.5-3.5 Ton unit, sufficient for additional space heating
1	Gas Tank water heater	Rheem, propane gas, 40 gallon tank, 34,000 BTU	Replace tank with a Sanden CO2 heat pump that will work for water heating and space heating as a split system with an outside compressor.	
			Total:	**$ 4,200**

Lighting				
Quantity	**Existing Equipment**	**Comments**	**Recommended Improvement**	**Estimated Cost to Install (Product + Labor)**
25	Interior and Exterior Lights	T-8 Linear Fluorescent and CFL lamps indoor and outdoor.	LED replacements, Dark-Sky Compliant, Energy Star rated lamps with photocell sensors	$ 2,500
			Total:	**$ 2,500**

Gas Consumption (Therms/year)	
Existing	**720**
Improved, 100% savings	**0**

Electricity Consumption (kWh/year)	
Existing	**7,800**
Improved (includes 25% overall savings + additional kWh's from fuel-switching*)	**6,570**

Cost to achieve 25% - 50% overall energy savings	**$ 26,850**

Solar Panels Saved by Efficiency	**2 kW**
Cost savings of 2 kW Solar Array	**$ 6,000**

12.0 CONCLUSIONS

12.1 Benefits Of Energy Efficiency

If the Bear River Band implements all of the above recommended energy efficiency retrofits, including fuel-switching from propane and natural gas to electric, they will prevent the wasted installation of ***$2.6 Million*** worth of solar panels, avoiding ***880 kW's*** of demand. Additionally, every year they run an all-electric micro-grid, they will be reducing the carbon dioxide emissions by ***176,069 Therms/year***, which is equivalent to the amount of carbon sequestered from ***24,193 tree seedlings*** grown for 10 years OR ***884 acres*** of US forests in one year.

Redwood Energy recommends implementing the Casino and Hotel improvements first, since they represent approximately 80% of the Tribe's energy consumption. As energy efficiency is improved, add renewable energy to the micro-grid in stages, allowing time to review energy data and make incremental adjustments to the total energy load.

12.2 Digital Supplemental Documents

Additional supplemental documents are provided as a digital PDF packet. The packet includes information and work completed by Redwood Energy during the process of auditing existing buildings, researching existing equipment, and modeling existing conditions. Documents in the digital PDF packet include:

- Casino
    - Energy Models
        - Non-Residential ECON-1
        - Non-Residential ECON-2
        - Non-Residential PERF-1C
        - .BLD files
    - Kitchen Equipment
        - Existing Equipment Spec Sheets
        - FishNick Energy Reports for Existing energy use vs. Upgrades
    - HVAC Equipment
        - Existing Equipment Spec Sheets
        - Existing Equipment Nameplate photos
        - HVAC Sheets from Bear River Casino Building Plans
- Hotel
    - Energy Models
        - Residential ECON-2
        - Non-Residential ECON-2
        - Residential PERF-1C
        - Non-Residential PERF-1C
        - .BLD files

- Pump and Play
    - Energy Models
        - Non-Residential ECON-2
        - .BLD files

- Homes
    - Energy Models
        - Residential ECON-2 for Bear River Drive Homes and newer Model Homes
        - .BLD files
        - CF-1R
    - HVAC Equipment
        - Existing Equipment Spec Sheets
        - Existing Equipment Nameplate photos

APPENDIX A-1

<u>CASINO</u>
BASELINE AUDIT PHOTOGRAPHS OF EXISTING EQUIPMENT

Casino Audit
HVAC Equipment
Chillers

Quantity	Existing Equipment	Existing Specifications
2	Air Cooled Scroll Package Chillers	Trane; 30 Tons, (450V, 80/100A)

Casino Audit
HVAC Equipment
Ice Maker Condenser

Indigo Series Remote Condenser

Condenser Indigo Model	Matching Ice Machine	Condenser			
		Electrical Service*	Amperage	Weight lbs.	Weight kgs.
JC-0495	500	115/60/1	2.3	76	34
JC-0895	606	208-230/60/1	1.0	76	34
JC-0995	906, 1000	208-230/60/1	1.0	85	39
JC-1395	1400, 1800	208-230/60/1	1.0	96	44

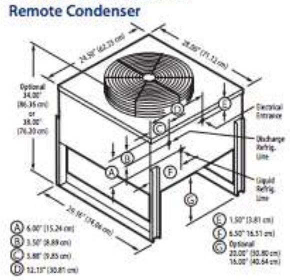
* 230/50/1 available. Consult factory. HACR circuit breakers can be used in place of fuses.

Standard Interconnecting Refrigerant Lines

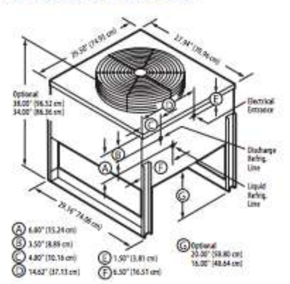
Model		Line Length ft.	Line Length cm.	Weight lbs.	Weight kgs.
R(*)-20-R-404A	20	600	11	5	15
R(*)-35-R-404A	35	1,050	17	8	20
R(*)-50-R-404A	50	1,500	24	11	20

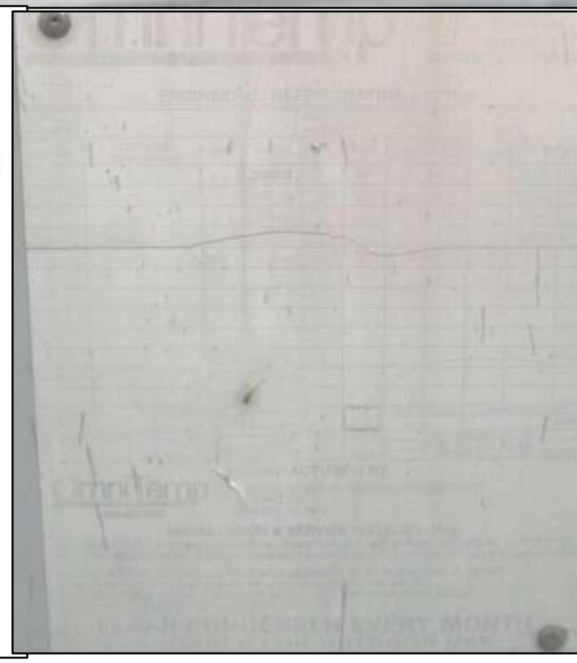
* RT prefix for Series 500, 6060, 850, and 1000.
RL prefix for Series 1400 and 1800. Order separately.

JC-0495, JC-0895, JC-0995 Remote Condenser



JC-1395 Remote Condenser





Quantity	Existing Equipment	Existing Specifications
1	Ice Maker Condenser Circuit, outdoor	Manitowoc/ Omnitemp, (208/230V, 1A)

Casino Audit
HVAC Equipment
Supply Fan (VFD)

Quantity	Existing Equipment	Existing Specifications
1	Supply Fan (VFD)	Trane, connected to natural gas, (208/230V, 60/85A)

Casino Audit
HVAC Equipment
Central Furnace

Quantity	Existing Equipment	Existing Specifications
2	Central Furnace, all in one	Aaon; one unit is 25 Tons, the other is 18 Tons. Both units fueled by natural gas.

Casino Audit

HVAC Equipment

Energy Recovery Ventilator (ERV) Units

Quantity	Existing Equipment	Existing Specifications
2	Energy Recovery Ventilator Units	Alliance Air Products, new equipment, (460V, 80A)

Casino Audit
HVAC Equipment
AC Compressor for Security Room

Quantity	Existing Equipment	Existing Specifications
1	AC Compressor for Security Room	American Standard, (200/300V, 20A)

Casino Audit
HVAC Equipment
Data Chiller

Quantity	Existing Equipment	Existing Specifications
1	Data Chiller	Data Air Inc.

Casino Audit
HVAC Equipment
Air Exchanger for Kitchen

Quantity	Existing Equipment	Existing Specifications
1	Air Exchanger for Kitchen	Modine rooftop unit, no nameplate available

Casino Audit
HVAC Equipment
Exhaust Fans for Kitchen


Quantity	Existing Equipment	Existing Specifications
1 Large	Exhaust Fan from the kitchen	Rooftop fan, no nameplate available
4 Small	Exhaust Fans from the kitchen	Rooftop fans, no nameplate available

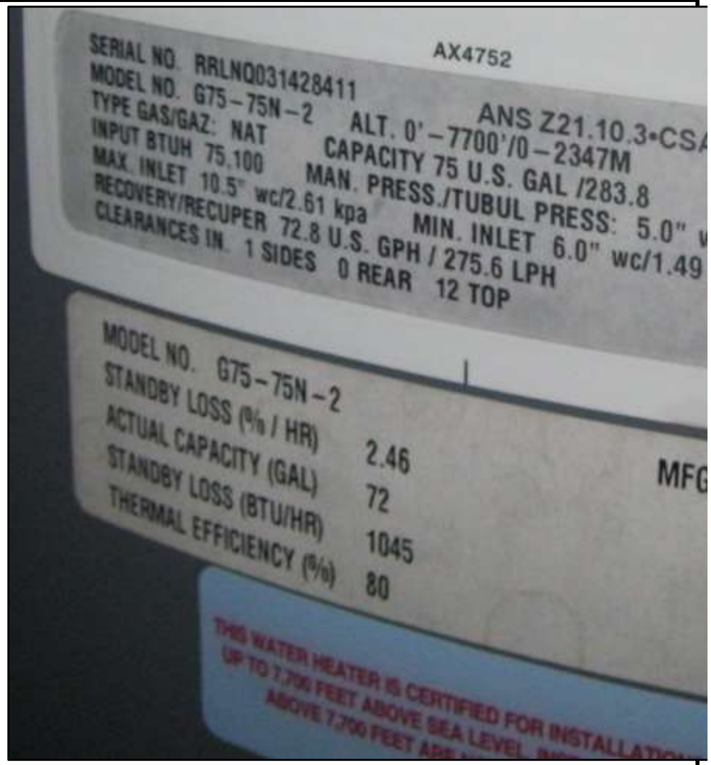
Casino Audit
HVAC Equipment
Air handler

Quantity	Existing Equipment	Existing Specifications
1	Air handler, all in one, rooftop unit	Valent Unison, Model #PVA400, (115 Volts, 1.5 Amps)

Casino Audit
HVAC Equipment
Split Heat Pump

Quantity	Existing Equipment	Existing Specifications
1	Split Heat Pump	Samsung, Model #AQX12VFUAGM, (208/230 V, 3.9 A)

Casino Audit
Water Heater Tank



Quantity	Existing Equipment	Existing Specifications
1	Natural Gas Water Heater Tank	Rheem Ruud, Model#G75-75N-2, 72 gallons, 75,100 BTU, Therml efficiency=80%

Casino Audit

Kitchen Equipment

Large Walk-in Refrigerators with Evaporator coils

Quantity	Existing Equipment	Existing Specifications
3	Large Walk-in Refrigerators containing (2) evaporative coolers, each	OmniTemp, R-404-A

Casino Audit
Kitchen Equipment
Deep Fryers

Quantity	Existing Equipment	Existing Specifications
2	Deep fryers	Pitco, Solstice Supreme

Casino Audit
Kitchen Equipment
Gas Range Grill

Quantity	Existing Equipment	Existing Specifications
1	Gas Range Grill	Delfield, 10 gas burners, Model # C0836-36AM, 18,000 BTU per burner

Casino Audit
Kitchen Equipment
Gas Convection Oven

Quantity	**Existing Equipment**	**Existing Specifications**
1	Double-deck gas convection oven	Sunfire, Model# SDG-1, 80,000 BTU/hr, 115 Volts, 9.4 Amps, single phase

Casino Audit
Kitchen Equipment
Convection Oven with Large Burners

Quantity	Existing Equipment	Existing Specifications
1	Convection oven with large burners on top	Montague

Casino Audit
Kitchen Equipment
Under-Counter Refrigerator

Quantity	Existing Equipment	Existing Specifications
4	Under-counter Refrigerators	Delfield, Model #: 4427N-6, 115 Volts, 7.2 Amps

Casino Audit
Kitchen Equipment
Pizza Oven

Quantity	Existing Equipment	Existing Specifications
1	Pizza Oven, natural gas fuel	Blodgett, Model #: C0836

Casino Audit
Kitchen Equipment
Commercial Freezer

Quantity	Existing Equipment	Existing Specifications
1	Commercial Freezer	McCall

Casino Audit
Kitchen Equipment
Food Warmers

Quantity	Existing Equipment	Existing Specifications
2	Food Warmers	Hatco, Glo-Ray, Model # GRAH-36, 200 Volts, 3.8 Amps, 800 Watts

APPENDIX A-2

CASINO
ECON-2 ENERGY MODEL REPORTS

Energy Upgrade Recommendations ECON-2

Project Name	Documentation Author *Redwood Energy*
Project Address ,	Author Address ,

Recommended Improvements	Description	Annual Savings	Est. Cost to Install	Savings	
				Site	TDV

Annual Results	Energy Cost			Electricity (kWh)			Fossil Fuel (therms)		
End Use	Existing	Improved	Savings	Existing	Improved	Savings	Existing	Improved	Savings
Space Heating	*$0*			*3*			*5*		
Space Cooling	*$0*			*96,290*			*0*		
Fans	*$0*			*121,443*			*0*		
Pumps	*$0*			*12,883*			*0*		
Domestic Hot Water	*$0*			*0*			*6,563*		
Indoor Lighting	*$0*			*130,952*			*0*		
Outdoor Lighting	*$0*			*0*			*0*		
Appliances/Plug Loads	*$0*			*108,571*			*0*		
Ancillary	*$0*			*0*			*0*		
Renewables	*$0*			*0*			*0*		
TOTAL	***$0***			***470,141***			***6,568***		

CO_2 (lbs/year)	Existing	Improved	Savings
Electricity	*0*		
Fossil Fuel	*0*		
TOTAL	***0***		

Climate Zone:	*1*
Electric Rate:	
Gas Rate:	
Floor Area:	*43,054*
Type:	*Nonresidential*

Average Demand (kW)	*123.05*		
TDV Energy (kBtu/ft^2-yr)	*247.60*		

The estimated operating costs shown in this report are dependent upon many factors. The construction and conservation features of the project clearly are important. Equally important is the thermostat setting. How the thermostat is used, appliance use, and occupant interaction all influence the annual operating cost. The estimates provided in this report are based on typical conditions; your actual usage will vary.

APPENDIX B-1

HOTEL
ECON-2 ENERGY MODEL REPORTS

Energy Upgrade Recommendations ECON-2

Project Name	Documentation Author *Redwood Energy*
Project Address ,	Author Address ,

Recommended Improvements	Description	Annual Savings	Est. Cost to Install	Savings	
				Site	TDV

Annual Results	Energy Cost			Electricity (kWh)			Fossil Fuel (therms)		
End Use	Existing	Improved	Savings	Existing	Improved	Savings	Existing	Improved	Savings
Space Heating	$0			9,961			275		
Space Cooling	$0			60,886			0		
Fans	$0			55,703			0		
Pumps	$0			0			0		
Domestic Hot Water	$0			0			2,544		
Indoor Lighting	$0			100,218			0		
Outdoor Lighting	$0			0			0		
Appliances/Plug Loads	$0			60,216			0		
Ancillary	$0			0			0		
Renewables	$0			0			0		
TOTAL	**$0**			**286,984**			**2,819**		

CO_2 (lbs/year)	Existing	Improved	Savings
Electricity	0		
Fossil Fuel	0		
TOTAL	**0**		

Average Demand (kW)	81.62		
TDV Energy (kBtu/ft^2-yr)	180.00		

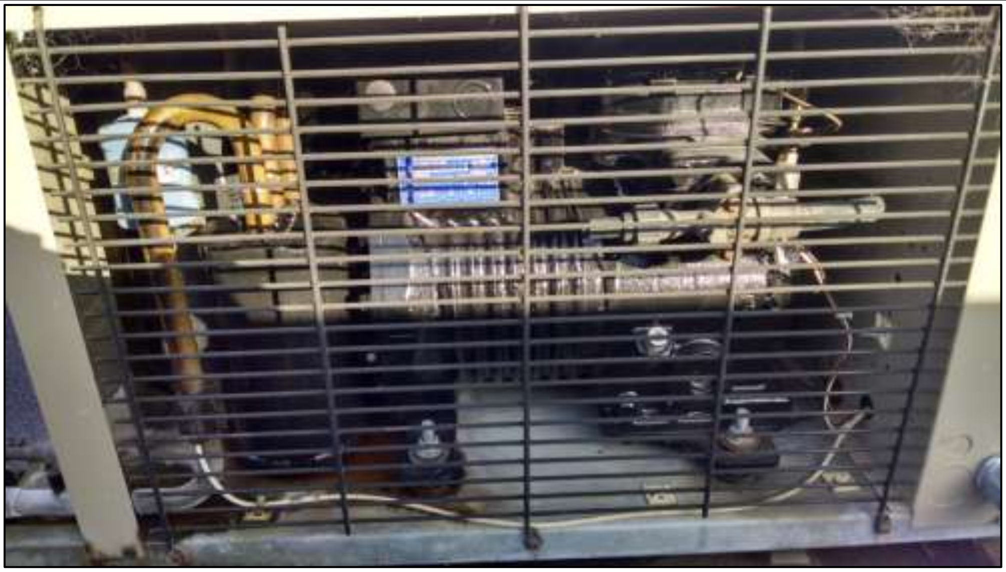
Climate Zone:	1
Electric Rate:	
Gas Rate:	
Floor Area:	35,517
Type:	Nonresidential

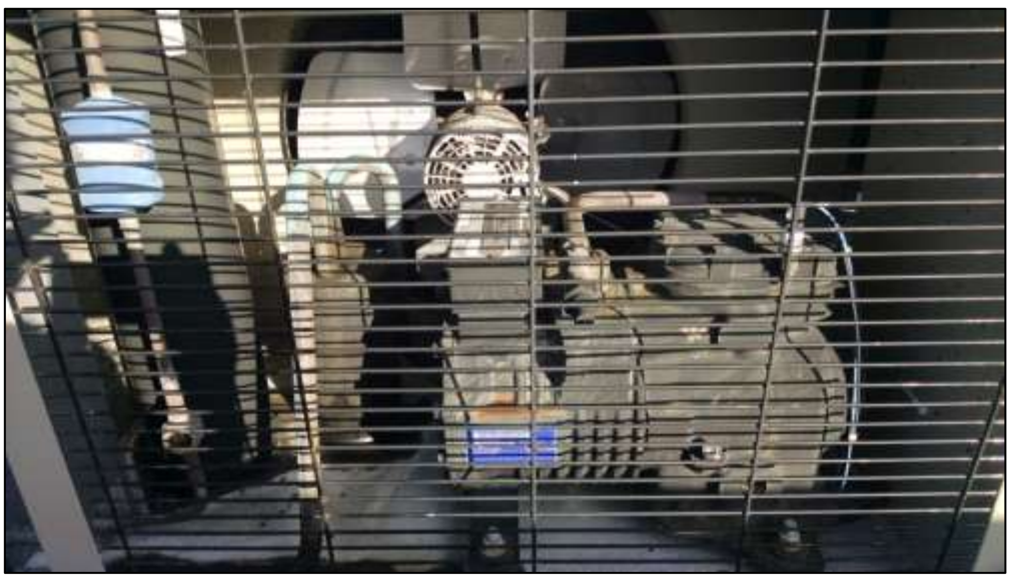
The estimated operating costs shown in this report are dependent upon many factors. The construction and conservation features of the project clearly are important. Equally important is the thermostat setting. How the thermostat is used, appliance use, and occupant interaction all influence the annual operating cost. The estimates provided in this report are based on typical conditions; your actual usage will vary.

APPENDIX C-1

<u>PUMP AND PLAY</u>
BASELINE AUDIT PHOTOGRAPHS OF EXISTING EQUIPMENT

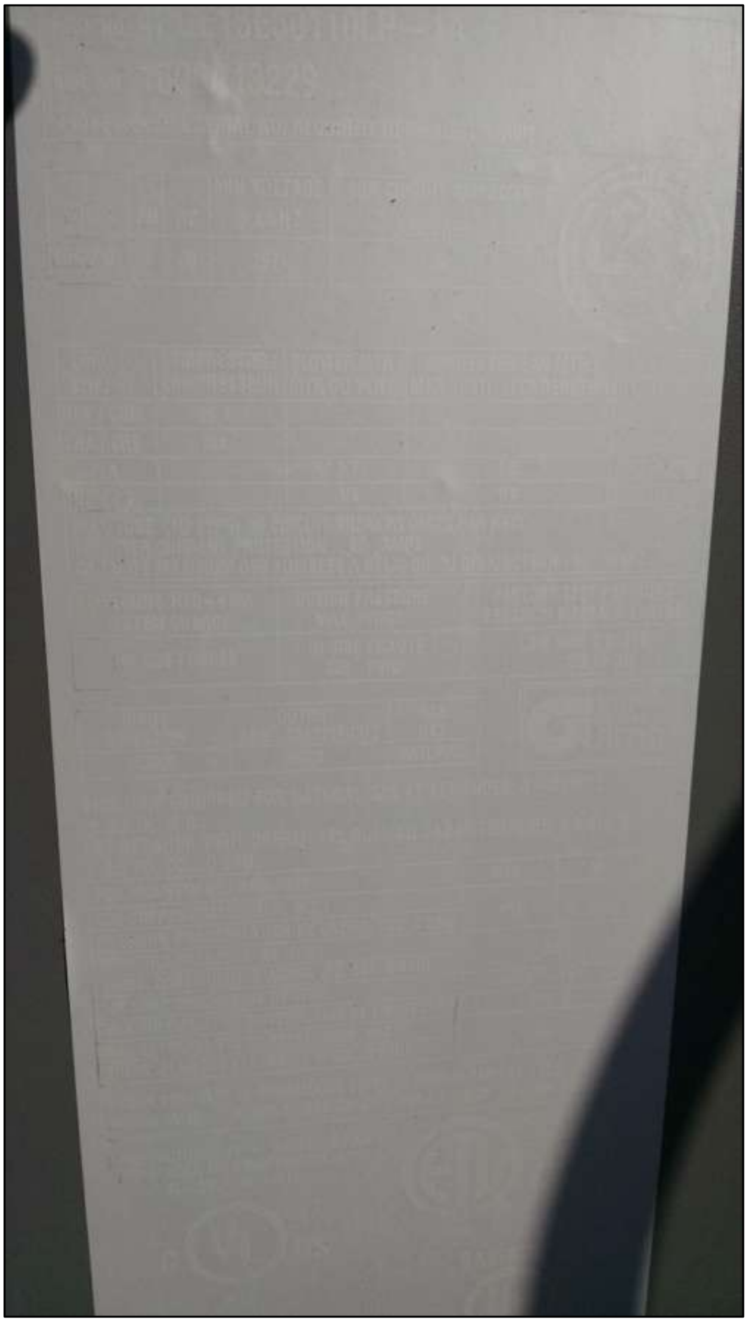
Pump and Play
HVAC Equipment
Walk-in Refrigerator Compressors





Quantity	Existing Equipment	Existing Specifications
2	Small remote unit, compressor for walk-in refrigerator, 3-fan evaporators	Larkin units, *Copeland* 3 HP Motor 208/230 Volts (12 Amps)

Pump and Play
HVAC Equipment
Condenser Fan



Quantity	Existing Equipment	Existing Specifications
1	Natural gas air unit, condenser fan, outdoor	*Armstrong* Model #: 4PGE15E60110LP-1A 208/230Volts (18 Amps) 60Hertz

Pump and Play
HVAC Equipment
AC Mini Split

Quantity	Existing Equipment	Existing Specifications
1	Mini split AC , outdoor unit	*Fujitsu Halcyon Inverter* 208/230 Volts 16 Amps 18,000 BTU

Pump and Play
HVAC Equipment
Tankless Water Heater

Quantity	Existing Equipment	Existing Specifications
1	Tankless water heater, propane	*Rheem,* 0.94 EF, 199,900 BTU max. input

APPENDIX C-2

PUMP AND PLAY
ECON-2 ENERGY MODEL REPORTS

Energy Upgrade Recommendations ECON-2

Project Name	*Pump & Play*	Documentation Author	*Redwood Energy*
Project Address	*16 Bear River Dr.* *Loleta, CA 95551*	Author Address	*,*

Recommended Improvements	Description	Annual Savings	Est. Cost to Install	Savings	
				Site	TDV

Annual Results	Energy Cost			Electricity (kWh)			Fossil Fuel (therms)		
End Use	Existing	Improved	Savings	Existing	Improved	Savings	Existing	Improved	Savings
Space Heating	*$0*			*1,024*			*1,019*		
Space Cooling	*$0*			*5,585*			*0*		
Fans	*$0*			*4,287*			*0*		
Pumps	*$0*			*0*			*0*		
Domestic Hot Water	*$0*			*0*			*586*		
Indoor Lighting	*$0*			*19,852*			*0*		
Outdoor Lighting	*$0*			*0*			*0*		
Appliances/Plug Loads	*$0*			*13,615*			*0*		
Ancillary	*$0*			*0*			*0*		
Renewables	*$0*			*0*			*0*		
TOTAL	***$0***			***44,363***			***1,605***		

CO_2 (lbs/year)	Existing	Improved	Savings
Electricity	*0*		
Fossil Fuel	*0*		
TOTAL	***0***		

Average Demand (kW)	*14.92*		
TDV Energy (kBtu/ft^2-yr)	*262.92*		

Climate Zone:	*1*
Electric Rate:	
Gas Rate:	
Floor Area:	*4,654*
Type:	*Nonresidential*

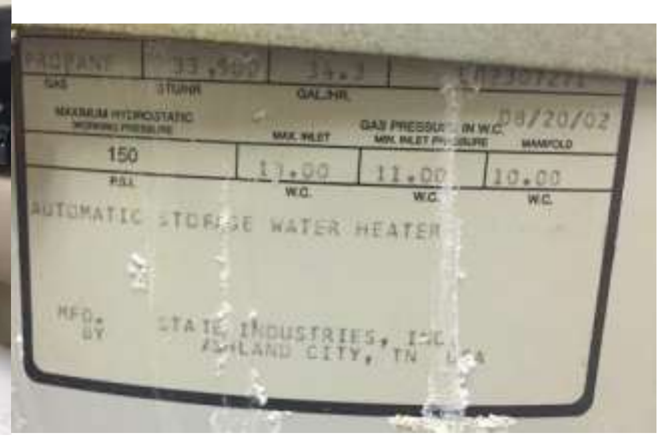
The estimated operating costs shown in this report are dependent upon many factors. The construction and conservation features of the project clearly are important. Equally important is the thermostat setting. How the thermostat is used, appliance use, and occupant interaction all influence the annual operating cost. The estimates provided in this report are based on typical conditions; your actual usage will vary.

APPENDIX D-1

HR/ACCOUNTING
BASELINE AUDIT PHOTOGRAPHS OF EXISTING EQUIPMENT

HR/Accounting
HVAC Equipment

<table>
<tr><td>[1] Direct Vent Forced Air Furnace

Aire Flo
75,000 BTU; 21.9 kW</td><td></td></tr>
<tr><td>[1] Gas Furnace
Aire Flo
100,000 BTU</td><td></td></tr>
<tr><td>[1] State Select propane heater
33,500 BTU</td><td> 
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[1] Rheem gas water heater	

APPENDIX E-1

TOBACCO TRADERS
BASELINE AUDIT PHOTOGRAPHS OF EXISTING EQUIPMENT

Tobacco Traders
HVAC Equipment

[1] Central Furnace	In Attic- No photo, No data
[1] Rheem gas water heater, tankless, Prestige Energy Star	 

APPENDIX F-1

BEAR RIVER DRIVE HOMES
BASELINE AUDIT PHOTOGRAPHS OF EXISTING EQUIPMENT

Bear River Drive Homes
HVAC Equipment

<table>
<tr>
<td>[6] Furnace; Propane Gas
AFUE .80/.90</td>
<td> 
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</tr>
<tr>
<td>[4] Standard Wall Furnace</td>
<td></td>
</tr>
<tr>
<td>[8] Propane Gas Tank

32,000 BTU; EF=80.5</td>
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</table>

[2] Propane Gas Tankless	 
[7] Propane Gas Stoves [3] Electric Stoves	 

APPENDIX F-2

BEAR RIVER DRIVE HOMES
ECON-2 ENERGY MODEL REPORTS

Energy Upgrade Recommendations — ECON-2

Project Name	*Bear River Dr. Homes #31*	Documentation Author	*Redwood Energy*
Project Address	*31 Bear River Dr.* *Loleta, CA 95551*	Author Address	,

Recommended Improvements	Description	Annual Savings	Est. Cost to Install	Savings Site	Savings TDV
Roof Insulation	*Type = R-30 + R-19 Cavity Insulation = 30.0 R-Value Rigid Insulation = 19.0 R-Value*	*$0*	*$0*	*1.4 %*	*1.3 %*
Wall Insulation	*Type = R-13 + R-8 exterior Cavity Insulation = 13.0 R-Value Rigid Insulation = 8.0 R-Value*	*$0*	*$0*	*11.6 %*	*10.7 %*
HVAC System	*Name = Mitsubishi MXZ-4C36NAHZ (correct) Type = Split DX Heating = Split Heat Pump Efficiency = 10.10 HSPF Cooling = Split Heat Pump SEER = 15.80 EER =*	*$0*	*$0*	*34.3 %*	*28.3 %*
Domestic Hot Water Heater	*Name = GE Appliances GEH50DEED** EF 3.39 Type = Heat Pump Volume = 50.0 gal Efficiency = 3.390 EF*	*$0*	*$0*	*19.5 %*	*14.1 %*
All Improvements	*All Energy Efficiency Upgrades Included*	*$0*	*$0*	*57.7 %*	*46.9 %*

Annual Results	Energy Cost			Electricity (kWh)			Fossil Fuel (therms)		
End Use	Existing	Improved	Savings	Existing	Improved	Savings	Existing	Improved	Savings
Space Heating	*$0*	*$0*	*$0*	*0*	*2,983*	*-2,983*	*364*	*0*	*364*
Space Cooling	*$0*	*$0*	*$0*	*9*	*4*	*5*	*0*	*0*	*0*
Fans	*$0*	*$0*	*$0*	*558*	*194*	*364*	*0*	*0*	*0*
Pumps	*$0*	*$0*	*$0*	*0*	*0*	*0*	*0*	*0*	*0*
Domestic Hot Water	*$0*	*$0*	*$0*	*0*	*1,297*	*-1,297*	*184*	*0*	*184*
Indoor Lighting	*$0*	*$0*	*$0*	*985*	*985*	*0*	*0*	*0*	*0*
Outdoor Lighting	*$0*	*$0*	*$0*	*114*	*114*	*0*	*0*	*0*	*0*
Appliances/Plug Loads	*$0*	*$0*	*$0*	*3,333*	*3,333*	*0*	*0*	*0*	*0*
Ancillary	*$0*	*$0*	*$0*	*0*	*0*	*0*	*0*	*0*	*0*
Renewables	*$0*	*$0*	*$0*	*0*	*0*	*0*	*0*	*0*	*0*
TOTAL	***$0***	***$0***	***$0***	***4,999***	***8,911***	***-3,912***	***549***	***0***	***549***

CO_2 (lbs/year)	Existing	Improved	Savings
Electricity	*0*	*0*	*0*
Fossil Fuel	*0*	*0*	*0*
TOTAL	***0***	***0***	***0***
Average Demand (kW)	*0.85*	*0.79*	*0.06*
TDV Energy (kBtu/ft^2-yr)	*264.57*	*140.57*	*124.00*

Climate Zone:	*1*
Electric Rate:	
Gas Rate:	
Floor Area:	*1,285*
Type:	*Single Family*

Improvements above shown with singular savings benefit for individual measures

The estimated operating costs shown in this report are dependent upon many factors. The construction and conservation features of the project clearly are important. Equally important is the thermostat setting. How the thermostat is used, appliance use, and occupant interaction all influence the annual operating cost. The estimates provided in this report are based on typical conditions; your actual usage will vary.

Energy Upgrade Recommendations — ECON-2

Project Name	Bear River Dr. Homes #42	Documentation Author	Redwood Energy
Project Address	42 Bear River Dr. Loleta, CA 95551	Author Address	,

Recommended Improvements	Description	Annual Savings	Est. Cost to Install	Savings	
				Site	TDV
Roof Insulation	Type = R-30 + R-19 Cavity Insulation = 30.0 R-Value Rigid Insulation = 19.0 R-Value	$0	$0	1.5 %	1.4 %
Wall Insulation	Type = R-13 + R-8 exterior Cavity Insulation = 13.0 R-Value Rigid Insulation = 8.0 R-Value	$0	$0	11.2 %	10.2 %
HVAC System	Name = Mitsubishi MXZ-4C36NAHZ (correct) Type = Split DX Heating = Split Heat Pump Efficiency = 10.10 HSPF Cooling = Split Heat Pump SEER = 15.80 EER =	$0	$0	27.9 %	21.6 %
Domestic Hot Water Heater	Name = GE Appliances GEH50DEED** EF 3.39 Type = Heat Pump Volume = 50.0 gal Efficiency = 3.390 EF	$0	$0	19.1 %	13.2 %
All Improvements	All Energy Efficiency Upgrades Included	$0	$0	51.6 %	39.9 %

Annual Results	Energy Cost			Electricity (kWh)			Fossil Fuel (therms)		
End Use	Existing	Improved	Savings	Existing	Improved	Savings	Existing	Improved	Savings
Space Heating	$0	$0	$0	0	2,978	-2,978	307	0	307
Space Cooling	$0	$0	$0	10	4	6	0	0	0
Fans	$0	$0	$0	554	194	360	0	0	0
Pumps	$0	$0	$0	0	0	0	0	0	0
Domestic Hot Water	$0	$0	$0	0	1,383	-1,383	176	0	176
Indoor Lighting	$0	$0	$0	1,156	1,156	0	0	0	0
Outdoor Lighting	$0	$0	$0	158	158	0	0	0	0
Appliances/Plug Loads	$0	$0	$0	3,671	3,671	0	0	0	0
Ancillary	$0	$0	$0	0	0	0	0	0	0
Renewables	$0	$0	$0	0	0	0	0	0	0
TOTAL	**$0**	**$0**	**$0**	**5,548**	**9,544**	**-3,996**	**483**	**0**	**483**

CO_2 (lbs/year)	Existing	Improved	Savings
Electricity	0	0	0
Fossil Fuel	0	0	0
TOTAL	**0**	**0**	**0**
Average Demand (kW)	0.76	0.77	-0.01
TDV Energy (kBtu/ft^2-yr)	205.79	123.73	82.05

Climate Zone:	1
Electric Rate:	
Gas Rate:	
Floor Area:	1,570
Type:	Single Family

Improvements above shown with singular savings benefit for individual measures

The estimated operating costs shown in this report are dependent upon many factors. The construction and conservation features of the project clearly are important. Equally important is the thermostat setting. How the thermostat is used, appliance use, and occupant interaction all influence the annual operating cost. The estimates provided in this report are based on typical conditions; your actual usage will vary.

APPENDIX G-1

<u>MODEL HOMES</u>
ECON-2 ENERGY MODEL REPORTS

Energy Upgrade Recommendations — ECON-2

Project Name	*Bear River Homes Model A*	Documentation Author	*Redwood Energy*
Project Address	*120 Carroll Rd* *Loleta, CA 95551*	Author Address	,

Recommended Improvements	Description	Annual Savings	Est. Cost to Install	Savings Site	Savings TDV
Roof Insulation	*Type = R-30 + R-19 Cavity Insulation = 30.0 R-Value Rigid Insulation = 19.0 R-Value*	*$0*	*$0*	*1.3 %*	*1.2 %*
Wall Insulation	*Type = R-19 Wall + R-8 interior Cavity Insulation = 19.0 R-Value Rigid Insulation = 8.0 R-Value*	*$0*	*$0*	*6.1 %*	*5.6 %*
HVAC System	*Name = Mitsubishi MXZ-4C36NAHZ (correct) Type = Split DX Heating = Split Heat Pump Efficiency = 10.10 HSPF Cooling = Split Heat Pump SEER = 15.80 EER =*	*$0*	*$0*	*29.9 %*	*23.0 %*
Domestic Hot Water Heater	*Name = GE Appliances GEH50DEED** EF 1 Type = Heat Pump Volume = 50.0 gal Efficiency = 3.390 EF*	*$0*	*$0*	*16.8 %*	*11.2 %*
All Improvements	*All Energy Efficiency Upgrades Included*	*$0*	*$0*	*49.2 %*	*37.2 %*

Annual Results	Energy Cost			Electricity (kWh)			Fossil Fuel (therms)		
End Use	**Existing**	**Improved**	**Savings**	**Existing**	**Improved**	**Savings**	**Existing**	**Improved**	**Savings**
Space Heating	*$0*	*$0*	*$0*	*0*	*3,441*	*-3,441*	*312*	*0*	*312*
Space Cooling	*$0*	*$0*	*$0*	*4*	*3*	*2*	*0*	*0*	*0*
Fans	*$0*	*$0*	*$0*	*593*	*227*	*367*	*0*	*0*	*0*
Pumps	*$0*	*$0*	*$0*	*0*	*0*	*0*	*0*	*0*	*0*
Domestic Hot Water	*$0*	*$0*	*$0*	*0*	*1,308*	*-1,308*	*151*	*0*	*151*
Indoor Lighting	*$0*	*$0*	*$0*	*1,006*	*1,006*	*0*	*0*	*0*	*0*
Outdoor Lighting	*$0*	*$0*	*$0*	*120*	*120*	*0*	*0*	*0*	*0*
Appliances/Plug Loads	*$0*	*$0*	*$0*	*3,374*	*3,374*	*0*	*0*	*0*	*0*
Ancillary	*$0*	*$0*	*$0*	*0*	*0*	*0*	*0*	*0*	*0*
Renewables	*$0*	*$0*	*$0*	*0*	*0*	*0*	*0*	*0*	*0*
TOTAL	***$0***	***$0***	***$0***	***5,098***	***9,479***	***-4,381***	***463***	***0***	***463***

CO_2 (lbs/year)	Existing	Improved	Savings
Electricity	*0*	*0*	*0*
Fossil Fuel	*0*	*0*	*0*
TOTAL	***0***	***0***	***0***
Average Demand (kW)	*0.65*	*0.72*	*-0.06*
TDV Energy (kBtu/ft^2-yr)	*230.83*	*145.05*	*85.77*

Climate Zone:	*1*
Electric Rate:	
Gas Rate:	
Floor Area:	*1,320*
Type:	*Single Family*

Improvements above shown with singular savings benefit for individual measures

The estimated operating costs shown in this report are dependent upon many factors. The construction and conservation features of the project clearly are important. Equally important is the thermostat setting. How the thermostat is used, appliance use, and occupant interaction all influence the annual operating cost. The estimates provided in this report are based on typical conditions; your actual usage will vary.

Energy Upgrade Recommendations ECON-2

Project Name	*Model B Type Home*	Documentation Author	*Redwood Energy*
Project Address	*28 Carroll St.* *Loleta, CA 95551*	Author Address	,

Recommended Improvements	Description	Annual Savings	Est. Cost to Install	Savings Site	Savings TDV
Roof Insulation	*Type = R-30 + R-19 Roof Attic Cavity Insulation = 30.0 R-Value Rigid Insulation = 19.0 R-Value*	*$0*	*$5,161*	*1.3 %*	*1.2 %*
Wall Insulation	*Type = R-19 Wall + R-8 (interior) Cavity Insulation = 19.0 R-Value Rigid Insulation = 8.0 R-Value*	*$0*	*$15,120*	*6.2 %*	*5.6 %*
HVAC System	*Name = Mitsubishi MXZ-4C36NAHZ (correct) Type = Split DX Heating = Split Heat Pump Efficiency = 10.10 HSPF Cooling = Split Heat Pump SEER = 15.80 EER =*	*$0*	*$3,300*	*29.7 %*	*22.8 %*
Domestic Hot Water Heater	*Name = GE Geospring 3.39 Type = Heat Pump Volume = 50.0 gal Efficiency = 3.390 EF*	*$0*	*$3,700*	*17.0 %*	*11.5 %*
All Improvements	*All Energy Efficiency Upgrades Included*	*$0*	*$27,281*	*49.3 %*	*37.2 %*

Annual Results	Energy Cost			Electricity (kWh)			Fossil Fuel (therms)		
End Use	Existing	Improved	Savings	Existing	Improved	Savings	Existing	Improved	Savings
Space Heating	*$0*	*$0*	*$0*	*0*	*3,749*	*-3,749*	*335*	*0*	*335*
Space Cooling	*$0*	*$0*	*$0*	*4*	*3*	*2*	*0*	*0*	*0*
Fans	*$0*	*$0*	*$0*	*621*	*227*	*394*	*0*	*0*	*0*
Pumps	*$0*	*$0*	*$0*	*0*	*0*	*0*	*0*	*0*	*0*
Domestic Hot Water	*$0*	*$0*	*$0*	*0*	*1,358*	*-1,358*	*162*	*0*	*162*
Indoor Lighting	*$0*	*$0*	*$0*	*1,107*	*1,107*	*0*	*0*	*0*	*0*
Outdoor Lighting	*$0*	*$0*	*$0*	*145*	*145*	*0*	*0*	*0*	*0*
Appliances/Plug Loads	*$0*	*$0*	*$0*	*3,573*	*3,573*	*0*	*0*	*0*	*0*
Ancillary	*$0*	*$0*	*$0*	*0*	*0*	*0*	*0*	*0*	*0*
Renewables	*$0*	*$0*	*$0*	*0*	*0*	*0*	*0*	*0*	*0*
TOTAL	***$0***	***$0***	***$0***	***5,451***	***10,162***	***-4,711***	***498***	***0***	***498***

CO_2 (lbs/year)	Existing	Improved	Savings
Electricity	*0*	*0*	*0*
Fossil Fuel	*0*	*0*	*0*
TOTAL	***0***	***0***	***0***
Average Demand (kW)	*0.68*	*0.74*	*-0.06*
TDV Energy (kBtu/ft^2-yr)	*219.67*	*137.93*	*81.74*

Climate Zone:	*1*
Electric Rate:	
Gas Rate:	
Floor Area:	*1,488*
Type:	*Single Family*

Improvements above shown with singular savings benefit for individual measures

The estimated operating costs shown in this report are dependent upon many factors. The construction and conservation features of the project clearly are important. Equally important is the thermostat setting. How the thermostat is used, appliance use, and occupant interaction all influence the annual operating cost. The estimates provided in this report are based on typical conditions; your actual usage will vary.

Energy Upgrade Recommendations ECON-2

Project Name	TISH NON VILLAGE- MODEL F (4 BED)	Documentation Author	Redwood Energy
Project Address	27 CARROLL RD. LOLETA, CA 95551	Author Address	,

Recommended Improvements	Description	Annual Savings	Est. Cost to Install	Savings Site	Savings TDV
Roof Insulation	Type = R-30+R-19 Roof Attic Cavity Insulation = 30.0 R-Value Rigid Insulation = 19.0 R-Value	$0	$0	0.0 %	0.0 %
Wall Insulation	Type = R-19 Wall + R-8 exterior cork siding Cavity Insulation = 19.0 R-Value Rigid Insulation = 8.0 R-Value	$0	$0	7.9 %	7.2 %
HVAC System	Name = Mitsubishi MXZ-4C36NAHZ (correct) Type = Split DX Heating = Split Heat Pump Efficiency = 10.10 HSPF Cooling = Split Heat Pump SEER = 15.80 EER =	$0	$0	31.0 %	23.3 %
Domestic Hot Water Heater	Name = GE Geospring 3.39 Type = Heat Pump Volume = 50.0 gal Efficiency = 3.390 EF	$0	$0	16.9 %	11.7 %
All Improvements	All Energy Efficiency Upgrades Included	$0	$0	50.5 %	38.0 %

Annual Results	Energy Cost			Electricity (kWh)			Fossil Fuel (therms)		
End Use	Existing	Improved	Savings	Existing	Improved	Savings	Existing	Improved	Savings
Space Heating	$0	$0	$0	0	4,174	-4,174	393	0	393
Space Cooling	$0	$0	$0	0	0	0	0	0	0
Fans	$0	$0	$0	794	385	409	0	0	0
Pumps	$0	$0	$0	0	0	0	0	0	0
Domestic Hot Water	$0	$0	$0	0	1,451	-1,451	182	0	182
Indoor Lighting	$0	$0	$0	1,287	1,287	0	0	0	0
Outdoor Lighting	$0	$0	$0	191	191	0	0	0	0
Appliances/Plug Loads	$0	$0	$0	3,930	3,930	0	0	0	0
Ancillary	$0	$0	$0	0	0	0	0	0	0
Renewables	$0	$0	$0	0	0	0	0	0	0
TOTAL	**$0**	**$0**	**$0**	**6,202**	**11,419**	**-5,217**	**575**	**0**	**575**

CO_2 (lbs/year)	Existing	Improved	Savings
Electricity	0	0	0
Fossil Fuel	0	0	0
TOTAL	**0**	**0**	**0**
Average Demand (kW)	0.56	0.71	-0.16
TDV Energy (kBtu/ft^2-yr)	208.60	129.40	79.20

Climate Zone:	1
Electric Rate:	
Gas Rate:	
Floor Area:	1,788
Type:	Single Family

Improvements above shown with singular savings benefit for individual measures

The estimated operating costs shown in this report are dependent upon many factors. The construction and conservation features of the project clearly are important. Equally important is the thermostat setting. How the thermostat is used, appliance use, and occupant interaction all influence the annual operating cost. The estimates provided in this report are based on typical conditions; your actual usage will vary.

APPENDIX C

ENERGY SOVEREIGNTY BUILDING CODE EXISTING CONSTRUCTION

Energy Sovereignty Building Code

Existing Construction

Prepared for:

Bear River Band of Rohnerville Rancheria

266 Keisner Road
Loleta, CA 95551

August 23, 2016

Prepared by:

Redwood Energy
Data + Design + Education

Freshwater Environmental Services

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EXECUTIVE SUMMARY

Redwood Energy was hired by the Bear River Band of Rohnerville Rancheria's Tribal Council to consult and develop a Zero-Net Energy (ZNE) Building Code and a Renewable Energy plan to propose on-site renewable energy for the entire Bear River Tribe. The Energy Sovereignty Building Code is a guidance tool for future Residential construction retrofits at Bear River. The Energy Sovereignty Building Code promises Net-Positive Renewable Energy homes that help maintain a large interconnected and balanced micro-grid. The all-electric micro-grid is entirely energy independent, fueled only by renewable energy, with on-site energy storage in non-toxic Aquion saltwater batteries.

Redwood Energy conducted baseline audits of the properties and followed Best Practices in Sustainability, Performance, Health and Safety to create this Energy Sovereign Building Code for the Bear River Tribe.

The Energy Sovereignty Building Code is partially funded through a California North Coast Grant offered by the Strategic Growth Council, and issued with help from the North Coast Resource Partnership and the West Coast Watershed.

The following Organizations directed many guiding principles you will find within this Building Code:

- **(BIG)Build It Green** Green Point Rated (GPR) New and Existing Construction Rating System
- **Energy Star** HVAC Manuals and Rater Checklist, Revision 8
- **(ILFI)International Living Futures Institute** Living Building Challenge Certification and Red List Approved Products Guide
- **California Building Code**, 2013 and 2016 Energy Efficiency Standards, Title 24, Part 6
- **(EPA) Environmental Protection Agency** WaterSense and Indoor Air Plus
- **(DOE) Department of Energy** Zero Energy Ready Checklist
- **Enterprise Green Communities** Multifamily Affordable Housing New and Existing Certifications
- **Samoa Green Home Guide**, Sean Armstrong, Danco Communities
- **Redwood Energy** Project Comparison of 8 Zero-Net Energy Affordable Housing Communities in CA, Climate Zone 1

EXECUTIVE SUMMARY

In an effort to promote local job/skills training and opportunities for Tribal Members, the Energy Sovereignty Building Code requires funding be set aside for a Job Training Program for Tribal Members.

- It is our goal that for all internal work, Tribal Members shall receive priority job opportunities in addition to extensive Green Building Training before construction crews can begin Construction.
- At least (10) Tribal Members will be recruited by the Tribal Council and given the opportunity to participate in an extensive ZNE Building Education Program for at least 1-year geared towards Job Training. Members will be trained and Certified to perform the Construction and PV installation work and long-term Maintenance duties for all components of the Building Code.

1 SITE AND DESIGN

1.1 Stormwater and Infiltration

- Rain gardens

1.2 Waste Diversion

1.3 Permeable Hard Surfaces

1.4 Zero Net Carbon

1.1 STORMWATER

Stormwater control and infiltration

Stormwater from impervious features (roof, sidewalk, etc.) shall be directed towards infiltration features and away from the foundation to prevent moisture damage. This can be accomplished by choosing one or more of the following:

- Rain gardens (gravel basin planted with wetland plants) –see next page for more details on Rain gardens
- Bioswales (a shallow, wide ditch planted with wetland plants)
- Detention ponds (a deep and wide infiltration basin)
- Living roofs on outbuidings such as the garage

Rain gardens utilize a natural, healthy soil profile with good infiltration rates of 1”/hour or more.

Bioswales help mitigate flooding by directing the water downhill and are used in place of traditional concrete gutters.

Detention ponds with filtration plants can help the water as it enters, sending clean water to the undergound aquifer.

Living roofs absorb rainwater, reducing the amount of runoff from a building. They require structural reinforcements and a super sealed moisture barrier.

1.1 STORMWATER- HOW TO DESIGN RAINGARDENS

Foundation Drainage towards Rain Garden

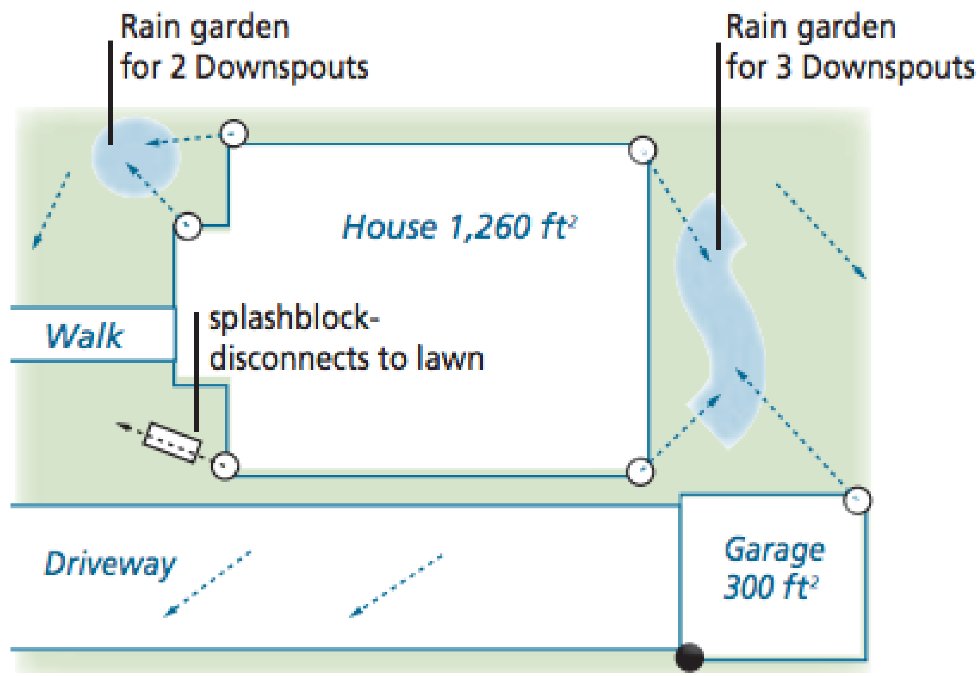
Plan each home with built-in stormwater drainage to a rain garden.

To properly size a rain garden, follow the 10% rule, as shown below:

Make sure your rain garden is large enough to drain the water directed to it within 36 hours. This keeps water from stagnating and mosquitoes from breeding. Size your rain garden to be at least 10% of the area that drains to it.

* For example, if 500 square feet of rooftop drains to your rain garden, the rain garden should be at least 50 square feet.

roof area	*sizing factor*	*rain garden size*
500 sq. ft.	x 10%	= 50 sq. ft. (or 5′ x 10′)



1.2 WASTE DIVERSION

Construction and Demolition Waste

- **Provide a recycling bin for construction waste that can divert a minimum of 60% of construction materials as measured by volume or weight from the landfill. This will save both construction costs and the environment. Diverted materials can include:**
  - Framing wood and unpainted drywall can be chipped on-site and tilled into the ground
  - Rock, asphalt and cement are all reused locally for road base
  - Metal waste is a high value recycled material
  - Paper & cardboard are much less expensive to recycle than landfill
  - Topsoil & trees that cannot be saved can be sold or donated for reuse in the community
  - Carpet is less expensive to recycle than landfill

Wood becomes Mulch

Drywall becomes a gypsum soil amendment

Shingles become aggregate

Masonry becomes landscaping material/ fill

1.3 PERMEABLE HARD SURFACES

Permeable Hard Surfaces

- Asphalt roadways and driveways shall be a permeable road type, typified by 2’ of un-compacted river run gravel with 4-6” of asphalt with a larger grade of rock and more bitumen to allow water to penetrate into the road bed. This road section is used on all Caltrans roadways. Pavers or pervious concrete shall be used for all hard surfaces instead of solid asphalt that block water from returning to the soil.

Pervious concrete

Permeable pavers

1.4 ZERO NET CARBON

Mitigation

- **Purchase a one-time carbon offset of 200 tons of CO2 per home equivalent for the embodied carbon footprint of the construction project. In 2016 the price of a single ton of CO2 sequestration credit is $12, and the entire home offset would be $2400 in forestry investment.**

This carbon offset cash can be invested locally in forests maintained by the City of Arcata, purchased online as part of the larger California Cap and Trade carbon market, or developed onsite by the Bear River Tribe via planting Redwood groves and similar native trees on open land.

Redwood Trees are among the fastest-growing trees on Earth, storing carbon at the fastest rate yet studied by Botantists—by the time they have grown to two feet in diameter in 20-30 years, they have sequestered 1 Ton of CO2 in their wood. One house, creating 200 Tons of CO2 equivalent gases during construction, represents about 100 redwood trees grown for 50-60 years.

2 LANDSCAPING

2.1 Code Minimum

2.1 CODE MINIMUM

- No petrochemical fertilizers or pesticides shall be used on-site.
- Use organic gardening practices at all times
- Invest in fruit trees around all homes and throughout the Rancheria to provide an abundant food forest for all Tribal Members. There are many fruit tree varieties that grow in the region, including the following varieties, to name just a few:
    - Panamint Nectarine
    - Frost Peach
    - Pink Pearl Apple
    - Sweet Scarlet Goumi
    - Muscat Table Grapes.
- Keep plants away from the exterior siding of all buildings using the following rule of thumb:
    - Plant stems no closer than 36” from the building foundation, and trim bushes, grass, plants, etc. back so they are at least 6” away from the building envelope at all times.

3 BUILDING ENVELOPE

3.1 Code Minimum Summary

3.2 Introduction

3.3 Additions / Alterations

3.4 Foundation

- Repair
- Alterations

3.5 Walls

- Air-sealing
- Insulation

3.6 Windows and Doors

- Code minimum
- Recommended products

3.7 Ceiling and Roof

- Code minimum
- Insulation

3.8 Flashing and Moisture Control

3.9 Insulation

3.1 BUILDING ENVELOPE CODE MINIMUM SUMMARY

Component	R-Value
Foundation	R-4 beneath floor in crawlspace or above floor cork insulation under finish floors
Walls	R-21 in 2x6 walls + R-8 insulated siding (cork product) or R-8 insulation beneath siding
Attic	R-49

Component	U-Value	Solar Heat Gain Coefficient
Window	≤ 0.30 to keep heat inside the residence	≥ 0.5 to encourage passive solar heating in winter
Door	≤ .2 insulated door	Not Applicable to doors

Performance Test	Performance Standard	Method
Sealed Building Envelope	See Chapter 8	Visual inspection of sealed envelope before enclosing exterior walls
Insulation	See Chapter 8	Visual inspection of all insulation installation before adding drywall
Air tightness	See Chapter 8	Pressurizing house fan (“blower door) to measure leakiness
HVAC air flow	See Chapter 8	HERS Testing of supply and return air flow
Rooftop flashing	See Chapter 8	Third party verification of flashing installation

3.2 BUILDING ENVELOPE INTRODUCTION

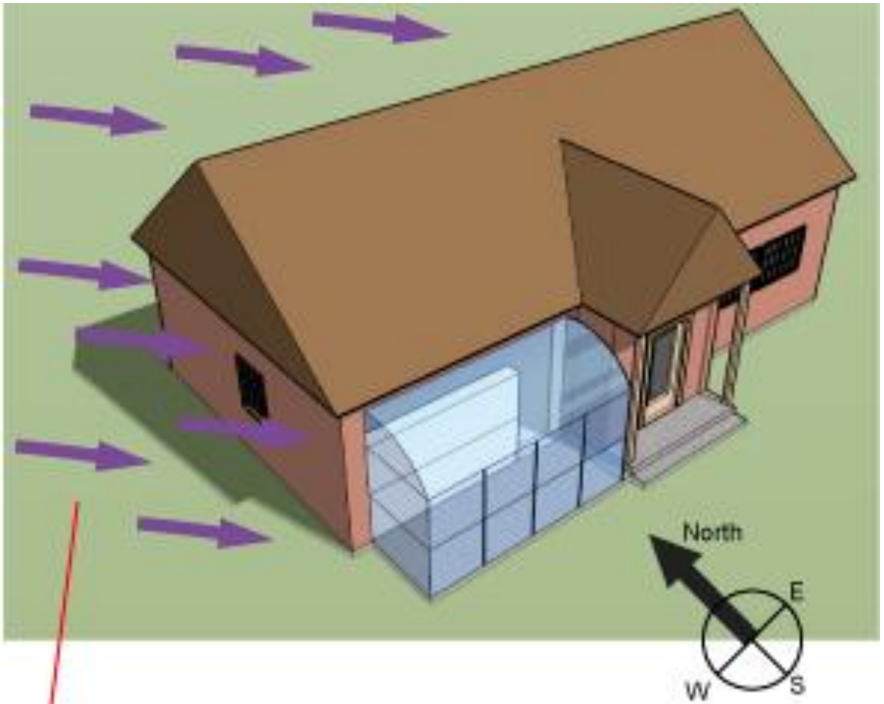
The Building Envelope is essentially the shell of the building, or the parts of the building that are exposed to the outdoor elements. The Building Envelope includes the foundation, walls, windows, doors, and the roof.

To build a Zero-Net Energy Home that can sustain itself on a limited solar energy budget in the cold winter months, the Building Envelope must be well-insulated, tightly sealed and well ventilated. Additionally, the building should provide natural daylight for occupant health and happiness as well as heat gain on sunny days.

Add a sunroom on the West side of the homes to store heat in the evenings when the sun sets, and provide a space for Tribal Members to grow their own food year-round.

- **<u>Insulation-</u>** Add insulation that will pass Quality Insulation Installation Inspections

- **<u>Windows-</u>** In most cases, replacing windows in the home is not a cost effective process. If funding from free weatherization RCEA programs are offered or if the exterior siding is deteriorating; then windows in the existing home need replacing.
    - The replaced windows must follow the new construction building code standards. This includes: flashing to window sills, pine-framed windows that re-use existing glass windows, and caulk sealant surrounds the window sills with a sealed building envelope around new window upgrades.



Prevailing winds from the north and the west have the potential to infiltrate the house if tight construction is not used. When attempting to secure joints, it may be prudent to start on those sides of the house.

3.3 ADDITIONS / ALTERATIONS

Sun Room

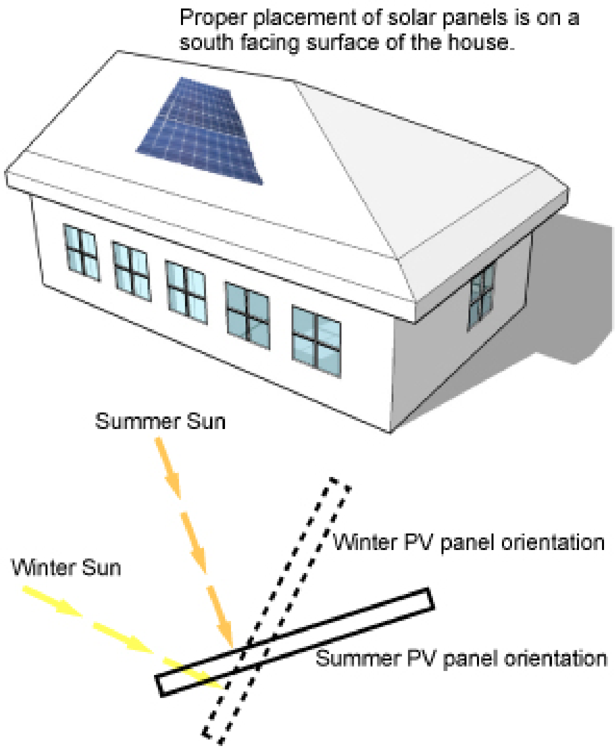
- Add a sun room on West-facing wall, if possible.

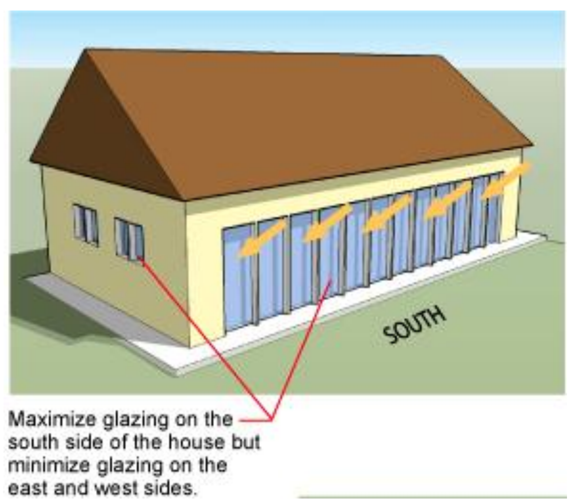
Windows

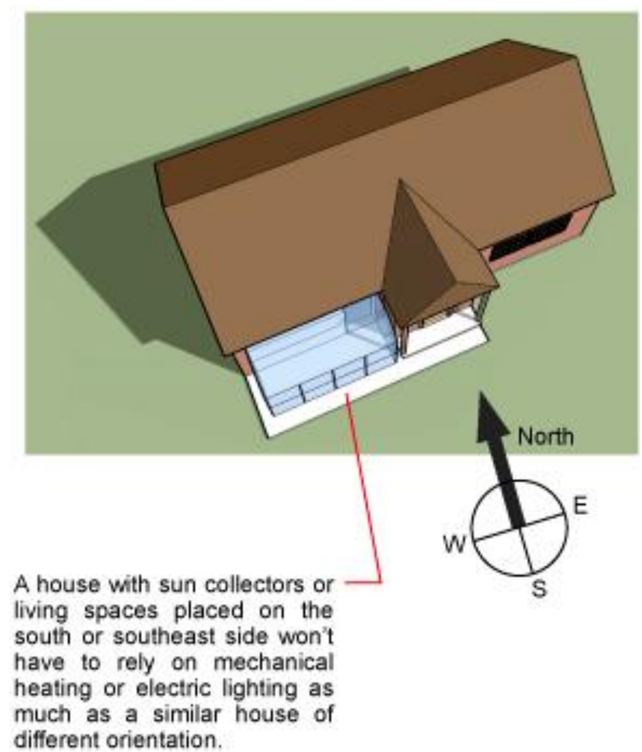
- Minimize operable windows facing Northwest into high-speed winds.
- Add plenty of South-facing windows and minimize North-facing windows.

Solar-Ready Rooftop

- The house should have at least 700sf of usable Southeast to Southwest facing roof for solar electric panels.







3.4 FOUNDATION, REPAIR

<u>Fix Cracks in Foundation</u>

- For cracks up to ¼” in exterior foundation walls, seal with cement grout or epoxy injection. If cracks come back, then it might be a settlement issue and need foundation repair by a foundation expert.
- For cracks larger than ¼” or deep cracks that may or may not be load-bearing, contact a foundation expert to assess the work that would need to be done.

Solution: Epoxy injection

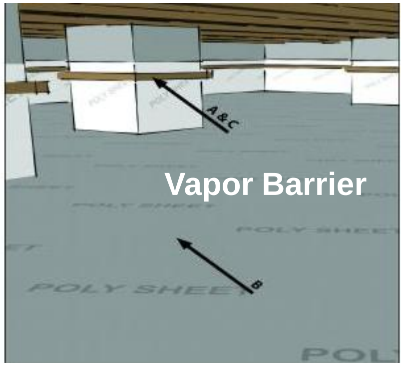
Example: Foundation crack of potential concern

3.4 FOUNDATION, ALTERATIONS

Vapor barrier

- Cover entire crawlspace floor with a durable ***6 mil thick plastic sheeting***

    1. For proper installation, overlap the sheets, pin them to the ground, seal the seams with tape and then apply mastic over the tape. Next, carry the vapor barrier up the foundation wall above the level of the exterior soil.



Air Barrier and Insulation

- Seal all floor joist above crawlspace with ***open-cell spray foam*** insulation

    1. Install open-cell foam with a thickness layer of at least 5” in between all floor joist above the crawlspace

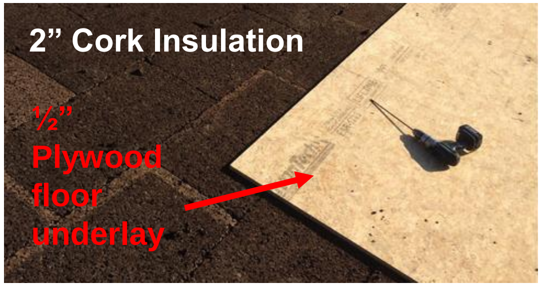
Structural Pest Control

- Use Structural Pest Controls on Interior and Exterior spaces

    1. Add corrosion-proof ***rodent/bird screens*** for openings that cannot be caulked and/or sealed
    2. Seal entire building envelope to keep out unwanted pests
    3. Keep wood siding at least ***12 inches above the soil*** to ensure no pests (termites) will reach the wood siding

Floor Insulation

- Add at least R-4 insulation to the floor under the floor joists or above.
- For above-floor installations (Recommended method), ***add 2” insulation*** (Recommended product: cork insulation) ***to R-4*** below a ½” plywood flooring underlayment.

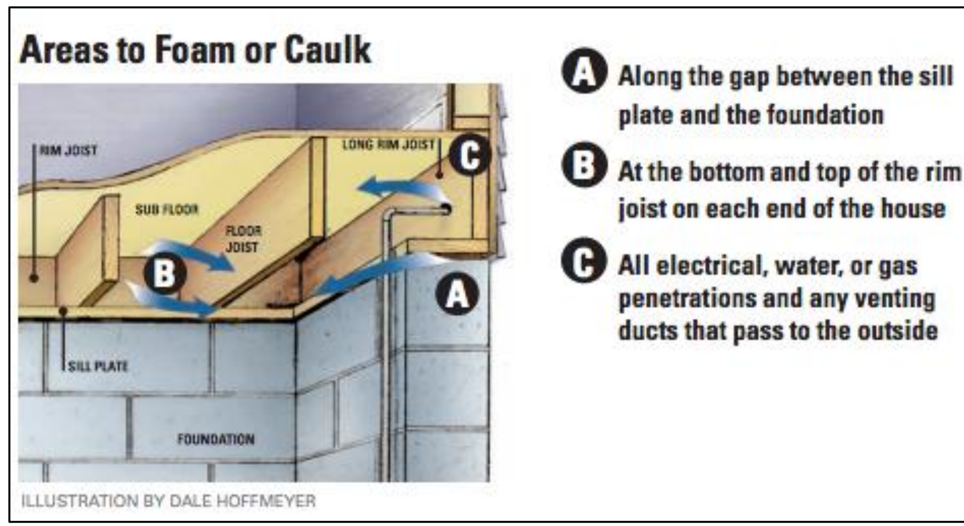


3.5 WALLS, AIR-SEALING

- **Air seal above-grade cracks, gaps, and intersections adjacent to conditioned space to minimize air leakage.**
  - Air seal between the sill plate and the sub-floor with caulk, foam, or an equivalent material
  - Air seal the bottom and top of rim joists on each end of the house
- **Add sealants around vents and flashing.**
- **Seal all gaps and holes with caulk or spray foam to air seal the home.**
  - Caulk is best for sealing gaps or cracks that are ¼ inch or less.
  - Spray foam is best to fill gaps from ¼ inch – 3 inches.
  - Seal penetrations like holes for wires, water supply pipes, water drain pipes, etc.

Sealed above-grade sill plates

Un-sealed sill plates



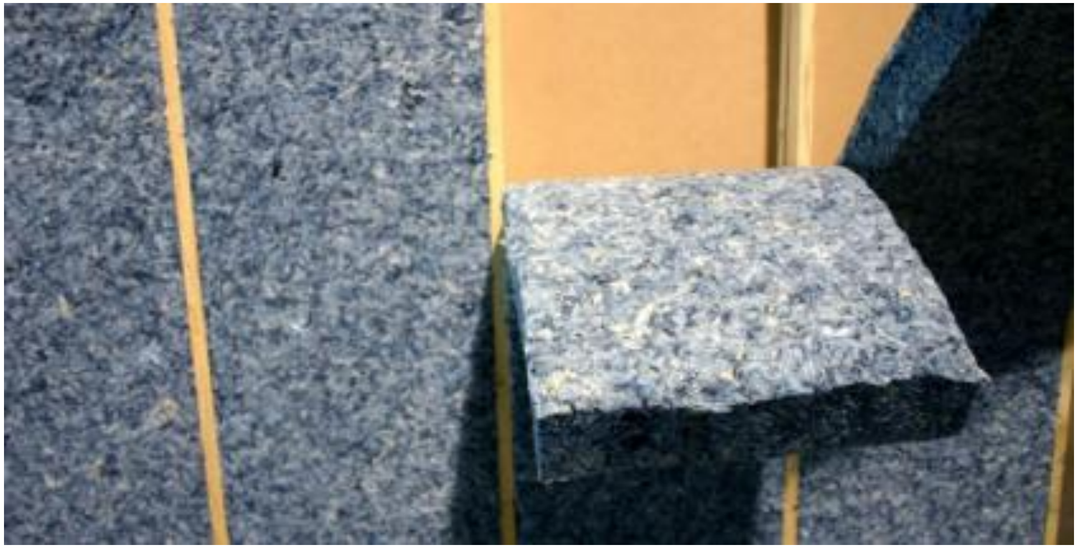
3.5 WALLS, INSULATION

R-21 Wall Insulation

Add insulation to existing walls to achieve **R-21 walls** by choosing ***one of the following*** methods:

- Interior: Add R-8 interior wall insulation with 2” cork siding applied to the interior walls
- Add recycled-cotton batt insulation to wall cavity to achieve R-21 walls
- Exterior: Add R-8 exterior wall insulation beneath siding, if siding is damaged beyond repair and needs to be replaced

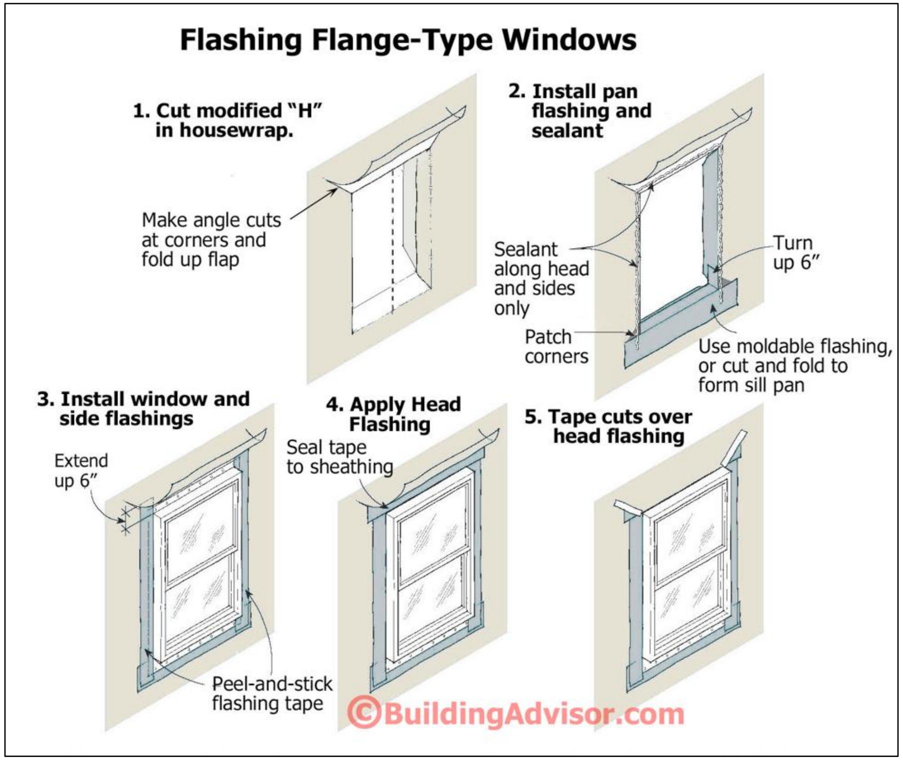
Exterior Cork Siding



Recycled Cotton batt insulation

3.6 WINDOWS AND DOORS, CODE MINIMUM

- **If windows are being replaced; make best efforts to keep glass and reframe with pine-framed windows**
  1. Add flashing under window sill and keep a continuous seal to the vapor barrier
  2. Ensure a continuous sealant of flashing and insulation around window frame
- **If glass is damaged or the entire window must be replaced:**
  1. Use solid-wood window framing. Paint and maintain wood window frames or use fiberglass exterior cladding.
  2. Passive solar-friendly insulated windows with a U-Value = 0.30 or less, SHGC=0.5 or more.
     - No low-e coating on the windows, which increases heating loads by blocking the warming effect of sunlight and disrupts natural sleep by blocking infrared radiation
- **If windows are not being replaced,**
  1. Use solid-wood window framing. Paint and maintain wood window frames or use fiberglass exterior cladding.
  2. Seal the perimeter with a no-VOC caulk sealant



3.6 WINDOWS AND DOORS, RECOMMENDED PRODUCTS

Recommended Product		Product Brand and Source
Furnishings	LouverShade (Light harvesting window cover)	Louver shade (CA)
Doors	Graham Serenity Wood Door, Graham Serenity Wood Door, Malman Serenity Wood Door, Malman Thermal Fused Door, Fiberglass Reinforced Polyester Door (FRP)	ASSA-ABLOY (Iowa, USA)

3.7 CEILING AND ROOF, CODE MINIMUM

Roof, Code Minimum

- ***Class D*** "High wind speed" shingles for peak 90mph winds: Tested to ASTM D3161
- ***Dark colored shingles*** to keep the house warm in the winter, such as CertainTeed "Patriot" shingles
- Cover all penetrations with ***flashing*** (Recommend copper flashing)
- ***Add sealants around vents and flashing***
- **Attic hatch door shall have R-49 insulation**

Attic Ventilation

- Attic must have sufficient ventilation:
  1. 1/150 method used to provide adequate amount of ventilation.
  2. Attic space is 1600 square feet, approximately 10.7 square feet of vents is required

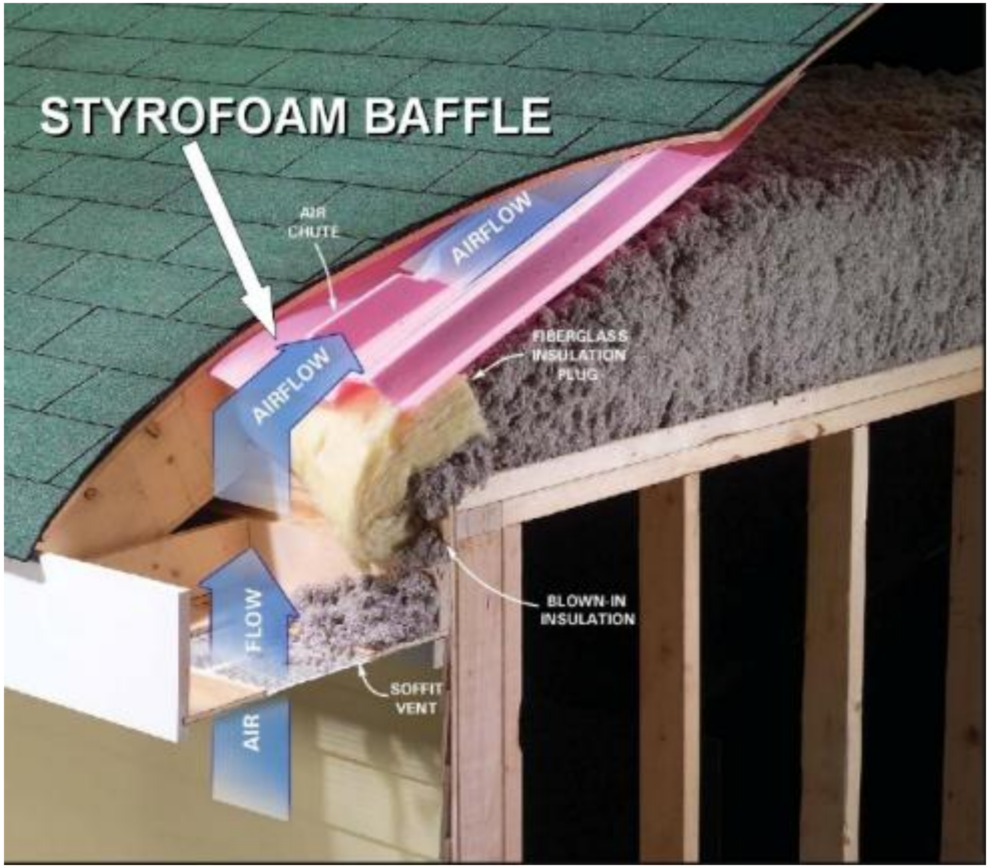
3.7 CEILING AND ROOF, INSULATION

Attic Insulation

- Attic insulation to be at least R-49 insulation. Use either eco-friendly batt insulation or naturally eco-friendly blown-cellulose insulation, at least 15.3 inches thick.
- Attic hatch door to have R-49 insulation
- Add a styrofoam baffle or a piece of cardboard to act as a baffle, which will allow airflow and prevent ice-damming in the attic.

Access Hatch, with Deck, Fully Blown to R-49.

Blowing cellullose insulation to R-49 in attic



3.8 FLASHING AND MOISTURE CONTROL

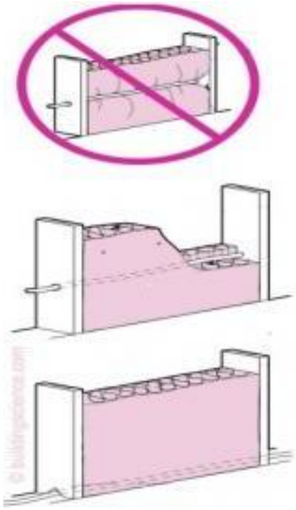
- Flashing to be installed underneath roofing materials to prevent moisture from traveling through the building joints.
- Properly flash all roofs, windows, doors, utility penetrations, deck connections to the structure, and any other joints where water may enter the home.
- Water should naturally flow away from the building through the use of overhangs, downspouts and sloped yards.
- Flashing to be installed properly on all penetrations and joints such as windows, doors, siding, roofing, roof valleys, decks, sill plates, railings, balconies, chimneys, pipes, vents and utility penetrations.

3.9 INSULATION

Quality Insulation Installation (Resources in Appendix)

- Gently wrap an even layer of recycled cotton batt insulation on all external walls, with no gaps or compressed areas.
- Add blown-in cellulose insulation to the attic spaces or add a continuous, even layer of recycled cotton batt-insulation, with no gaps or compressed areas.
- Pre-cut batt insulation to fit wall cavities, sliced to fit around wires, pipes, and any other wall obstructions.

Component	Code Minimum R-Value
Walls	R-21 + R-8
Slab	R-8
Attic	R-49



4 HVAC

4.1 Code Minimum

4.2 Ducts

- Quality installations
- Duct sealing

4.3 Heating

- Option 1
- Option 2
- Option 3 Multifamily /Commercial

4.4 Whole House Ventilation

- Whole House
- Bathroom and Kitchen

4.5 Air Balancing

4.6 Controls

4.1 CODE MINIMUM

Generating space heating for Bear River's energy efficient homes is best done with a heat pump water heater, the same device that will also heat the domestic hot water. A heat pump water heater produces heat efficiently, and more importantly stores it in an insulated tank for use when the sun goes down. The heat energy is then best delivered with a hydronic fan coil through insulated ducts, with the balanced ventilation system exhausting air through an Energy Recovery Ventilator to recapture ~25% of exhaust heat.

Water heating is discussed in the HVAC section because in the Bear River ZNE homes, the water heaters act as thermal batteries, storing energy overnight with heat gained during the day that can be used for water or space heating in the home. High temperature heat pump water heaters can store water up to 180°F to hold energy in water rather than a traditional electric battery. When this system is combined with a thermostatic mixing valve, no water exiting the tank will be above 120°F, keeping residents safe from scalding. These high temperature thermal batteries are a fraction of the cost of electric batteries and will help maintain a balanced micro-grid, creating energy sovereignty at the Bear River Rancheria.

During low-power events for the Bear River Rancheria micro-grid, Residents will be able to turn off their water heaters and use stored energy for at least 12 hours to supply air and water heating.

EXISTING COMPONENTS	ALTERATIONS	ALTERATIONS CODE MINIMUM
Ducts	**Duct Insulation**	**R-4**
Gas Furnace	**Heat Pump with ducted fan coil**	**HSPF 12+, SEER 19+**
Gas Water Heater	**Heat Pump Water Heater**	**GE Geospring Heat Pump OR Sanden CO_2 Heat Pump**
Ventilation	**Add Energy Recovery Ventilator (ERV)**	**1.0 Sone or Less**
Fireplace	**Ductless mini-split**	**HSPF 12+**
Radiant Flooring	**Disconnect existing boiler**	**None**

4.2 DUCTS

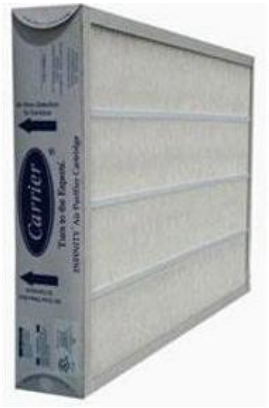
Locating the Ducts

- All ducts shall be located in ***conditioned space***

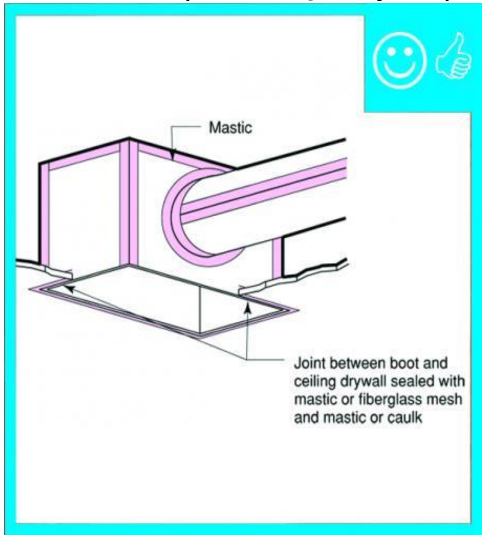
Installing the Ducts

- Use ***duct mastic*** on all duct joints, duct seams, and all return and supply ducts
    1. Duct mastic to be applied "as thick as a nickel"
- All ducts must have at least ***R-4 insulation***
- All duct systems sized according to ***ACCA Manual D*** (HVAC-D 5).
- Seal joint between boot and ceiling drywall with ***fiberglass mesh and mastic or caulk***
- Ducts shall be ***cleaned thoroughly*** prior to installing registers, grilles, and diffusers, and verify HVAC filters are new and clean.
    1. Bathroom and Kitchen: MERV 12 filters
    2. Main HVAC system: MERV 16 filters
- During Construction, all duct openings (registers, supply grilles, etc.) shall be covered and sealed to keep ducts clean during the Construction phase. Ducts can be uncovered/ revealed at the final stage of Construction, prior to Quality Inspections performed by a HERS Rater.

R-4 Insulated Duct



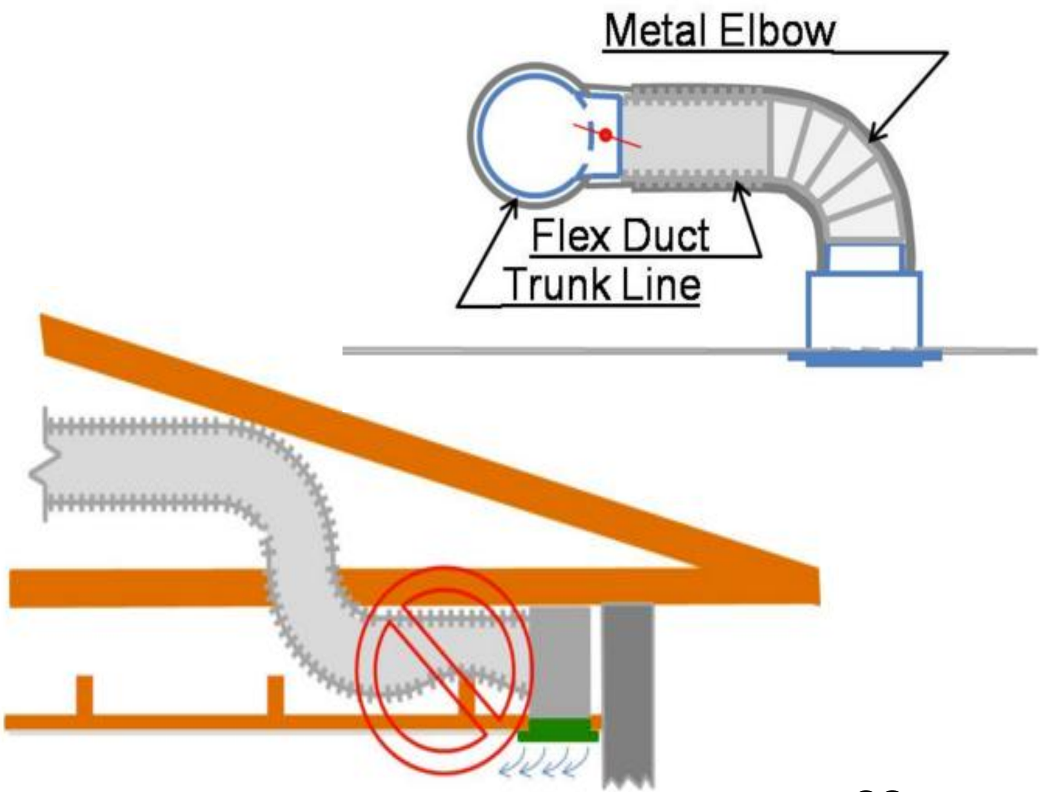
Merv 16 filter



Quality Duct Installation: Duct Mastic

4.2 DUCTS, QUALITY INSTALLATIONS

- **Install ductwork without kinks, sharp bends, or excessive coiled flexible ductwork in spaces that fit them without compacting them. This slows air flow and wastes energy.**
- **Support flexible duct at intervals:**
  - Install supports at a minimum of every 5 ft. to prevent sagging
  - Install support at least 1 in. wide, without compressing the ducts and the duct installation.
- **If there is fear of compressing the flex duct when making a 90-degree turn in a tight space, use a metal elbow**
  - Use a metal duct elbow instead of flex duct at boot connections to prevent compression



No excessive bends in flex ducts

4.2 DUCTS, SEALING

Create durable, airtight duct seams

- Before ducts are sealed, duct seams need to be mechanically fastened (using sheet-metal screws for galvanized ducts and compression straps for flex duct).
- To secure seams in round galvanized ducts up to 12 inches in diameter, use at least three #8 screws per joint. To secure ducts over 12 inches in diameter, use five #8 screws per joint.
- For securing joints in rectangular galvanized duct, use at least one #8 screw per side.
- Install mastic "as thick as a nickel."
- Cracks or seams wider than 1/16 or 1/8 inches need to be repaired with fiberglass mesh as well as mastic.
- Don't forget to seal collar connections between plenums and duct take-offs.

Seal joints in flex ducts

- The duct boot or coupling should be inserted at least 2 inches into the end of the ducts. The fitting should be attached to the inner sleeve or the flex duct with a drawband (clamp) or #8 screws.
- Seal the joint between the inner section of the duct and the fitting with high-quality mastic.
- Seal the exterior vapor-barrier sleeve with a drawband and tape.

Duct Quality Insulation: Duct Mastic

4.3 HVAC, OPTION 1

Code Minimum

- **HSPF= 12+**
- **SEER= 19+**

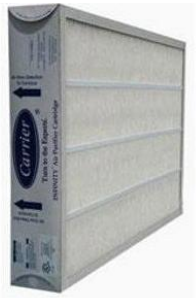
(2) Electric Heat Pump Water Heaters with high temperature heat storage functionality.

Tank #1 for Water heating, set to 140 °F - 180 °F, as needed for demand. Tank #2 for Space heating, set to 180 °F, as needed for energy storage.

80+ gallons
Located in garage, install to manufacturers specifications. Timed to run only during the day.

Unico Air delivery and return Fan Coil Unit uses high speed and low volume delivery. Located in drop-ceiling or interior closet.

Energy Recovery Ventilator (ERV) recovers heat, energy and moisture.
Located in drop-ceiling.



Install a MERV 16 filter, unless Manufacturers specifications say otherwise.

Highly efficient ceiling fan, located in the living room for cooling. Recommended Product: Big Ass Fan

4.3 HVAC, OPTION 2

Code Minimum

- **HSPF= 12+**
- **SEER= 19+**

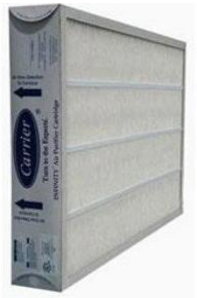
(1) Sanden CO2 Water Heater with high temperature heat storage functionality and Heat Pump Compressor for space heating only.

Tank for Water and Space heating set to 180 °F, as needed for demand and energy storage.

80+ gallons
Located in garage, install to manufacturers specifications.
Timed to run only during the day.

Unico Air delivery and return Fan Coil Unit, uses high speed and low volume delivery. Located in drop-ceiling or interior closet.

Energy Recovery Ventilator (ERV) recovers heat, energy and moisture.
Located in drop-ceiling.



Install a MERV 16 filter, unless Manufacturers specifications say otherwise.

Highly efficient ceiling fan, located in the living room for cooling. Recommended Product: Big Ass Fan

4.3 HVAC, OPTION 3, MULTIFAMILY / COMMERCIAL HVAC OPTION

Code Minimum

- Follow CEC values for COP values and temperatures proposed by AHRI for large heat-pump boilers, as follows:

Outside air temp	COP	Water Temperature
17	1.95	120
47	2.65	120
100	3.5	120

*For DHW use, the unit must also be able to produce hot water when the air temperature is 100°F.

Recommended: Aermec system to provide Heating and Air Conditioning and Water Heating for all. It is an air to water heat pump and can be sized up to hundreds of tons.

Alternatively, the Panasonic City Multi R2 high temperature model can be used to handle the energy loads. It is an air to refrigerant heat pump and increases in 10-ton increments.

4.4 VENTILATION, WHOLE HOUSE

Whole House Ventilation Code Minimum

- HVAC equipment efficiency rating shall be greater than SEER= 19
- Install Low Sone Supply and Exhaust fans, 1.0 Sone or less
- Energy Recovery Ventilator (ERV)
    - A spot energy recovery ventilator (ERV) recovers heat, energy and moisture.
    - Not to be installed into any bathrooms or kitchen of the home to ensure moisture control within the system.

MERV 12 Filter Box

Living Space	1,920 (ft^2)
Bedrooms	3
Air flow required (cfm)	49.2
System air flow (cfm)	200

ASHRAE 62.2-2007:
[Conditioned Area / 100] + [(7.5) * (Number of Bedrooms+1)]

Required CFM ASHRAE Standard and the supplied air flow

Recommended Product		Product Brand and Source
Whole House Ventilation	Energy Recovery Ventilator (ERV)	Panasonic Whisper Comfort Sport FV-04VE1

4.4 VENTILATION, BATHROOM AND KITCHEN

Ventilation Code Minimum

- Local mechanical exhaust ventilation is forced outdoors in the Bathroom and Kitchen, meeting ASHRAE 62.2.
- Install vent fans in Kitchen, Bathroom and Laundry room.
- Install vents in gable ends or a combination of soffit and ridge vents.

Bathroom:

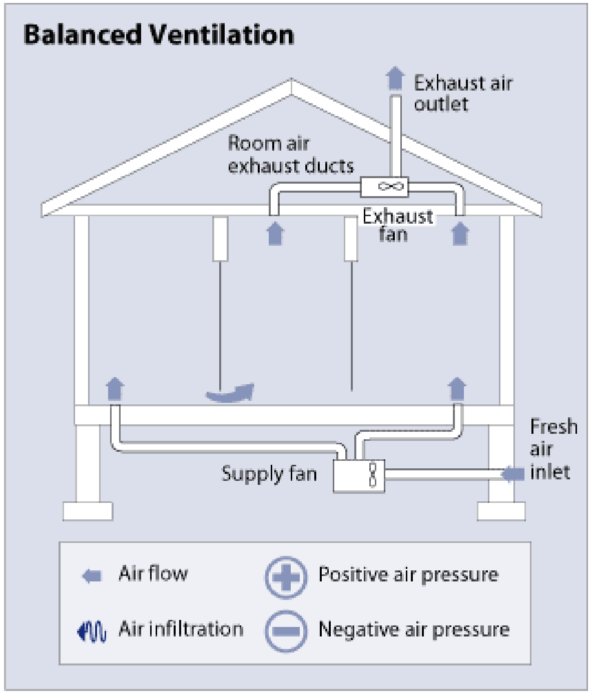
- "Panasonic WhisperGreen", or equivalent exhaust fan.
- Air sources fed through a filter box with a MERV 12 filter prior to being ducted into the bathroom.
- Bathroom exhaust fans shall have an exhaust rate of at least 50 CFM.

Kitchen:

- "Broan Elite RM50000", or equivalent range hood that is vented directly to the outdoors.
- Ducting is split into a T joint, where air is blown underneath the kitchen cabinet through a 3 x 12 inch rectangular duct and a 5 inch in the ceiling.

4.5 AIR BALANCING

- Design to comply with ASHRAE 62.2, and Balance air systems within 25% of ASHRAE standards
- **Pressure Balance Options:**
  - Bedroom pressure –balanced using any combination of transfer grills, jump ducts, dedicated return ducts, and/or undercut doors to achieve a Rater measured pressured differential ≤ 3 Pa



Ducted Returns

Guide describing how to install ducted returns to provide conditioned air to all parts of the house and return stale air to the furnace for reconditioning.

Transfer Grilles

Guide describing how to install transfer grilles at each bedroom ensure a continuous flow of heating and cooling even when the doors are closed.

Jump Ducts

Guide describing how to install jump ducts at each bedroom ensure a continuous flow of heating and cooling even when the doors are closed.

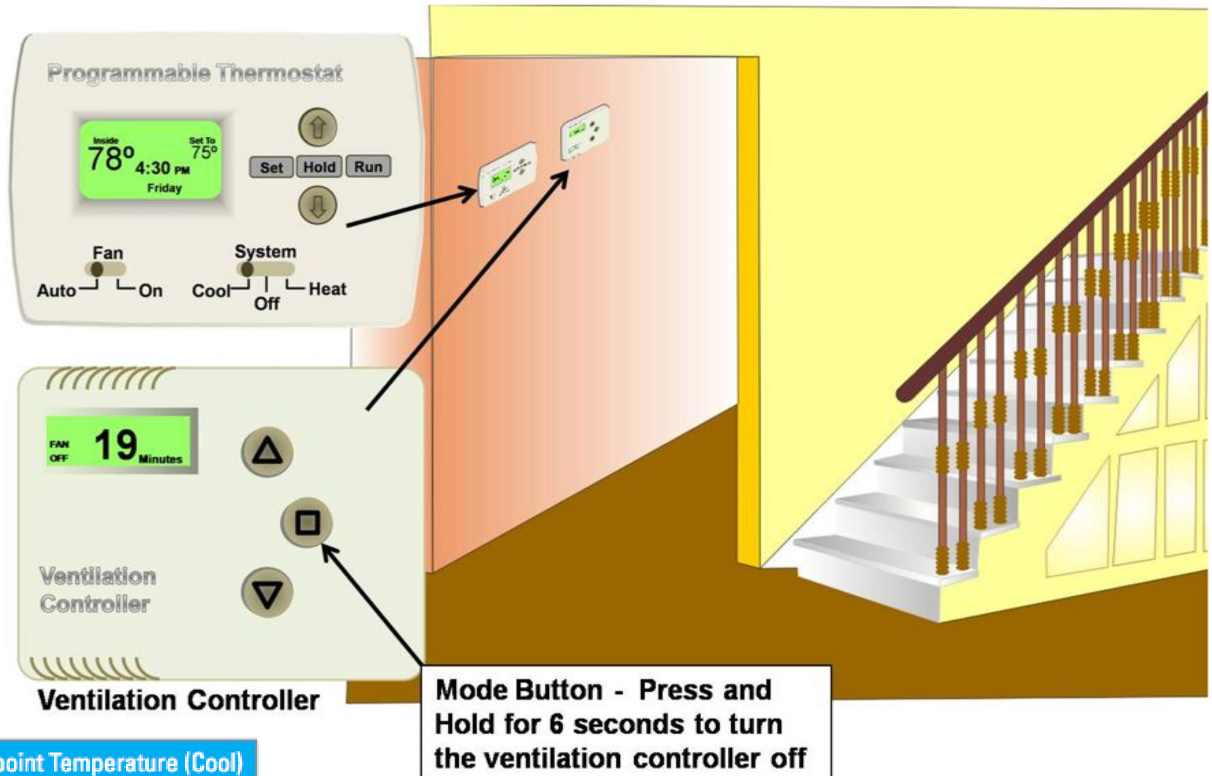
Undercut Doors

Guide describing how to cut the doors at each bedroom ensure a continuous flow of heating and cooling even when the doors are closed.

4.6 CONTROLS

- **Programmable thermostat**
  - Install Energy Star rated programmable/ setback thermostats in the hallway with recommended temperature for heating and cooling season.
- **Carbon Monoxide (CO) and Volatile Organic Compound (VOC) overrides**
  - Install controls that regulate fan speed based on the level of VOC and CO concentration in a space to promote Indoor Air Quality.
- **Clearly label ventilation controls for occupants with Energy Star recommended temperatures (pictured below)**

Greenheck VOC Controls

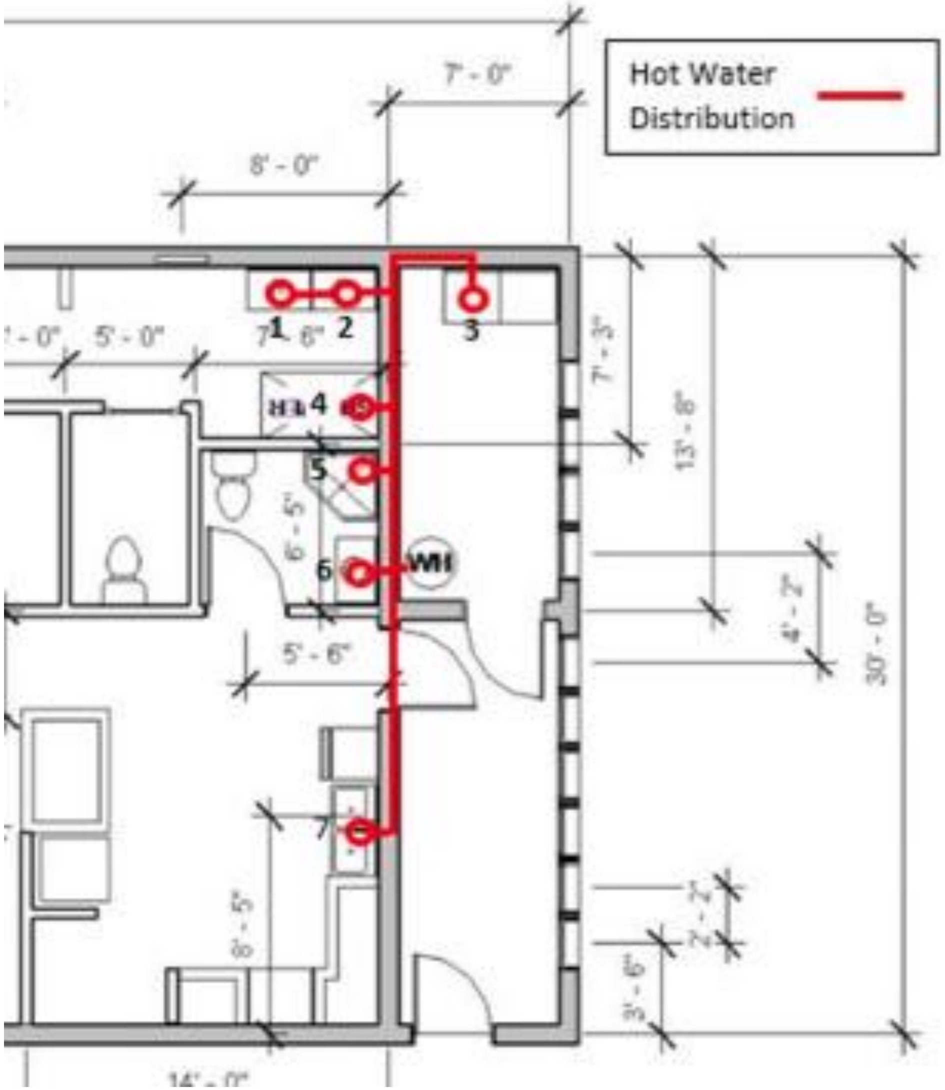


Setting	Time	Setpoint Temperature (Heat)	Setpoint Temperature (Cool)
Wake	6:00 a.m.	< 70° F	> 78° F
Day	8:00 a.m.	Setback at least 8° F	Setup at least 7° F
Evening	6:00 p.m.	< 70° F	> 78° F
Sleep	10:00 p.m.	Setback at least 8° F	Setup at least 4° F

5 PLUMBING

5.1 Code Minimum

5.2 Efficient Fixtures



5.1 CODE MINIMUM

- Water use and release from homes must work in harmony with the natural flows of the site and its natural environment and 100% of the projects water must come from rainwater catchment or from closed loop water systems, purified without the use of chemicals.
- All stormwater and water discharge, including grey and black water must be treated onsite and managed through re-use, closed loop system, or infiltration.
- If replacing, all new hot water pipes must be 3/8” to reduce wasted hot water with 1” R-4 insulation around the pipes.
- If rebuilding house, ideally all hot water fixtures should be located near the Water Heater tank (example below) to reduce wasted hot water in transit.

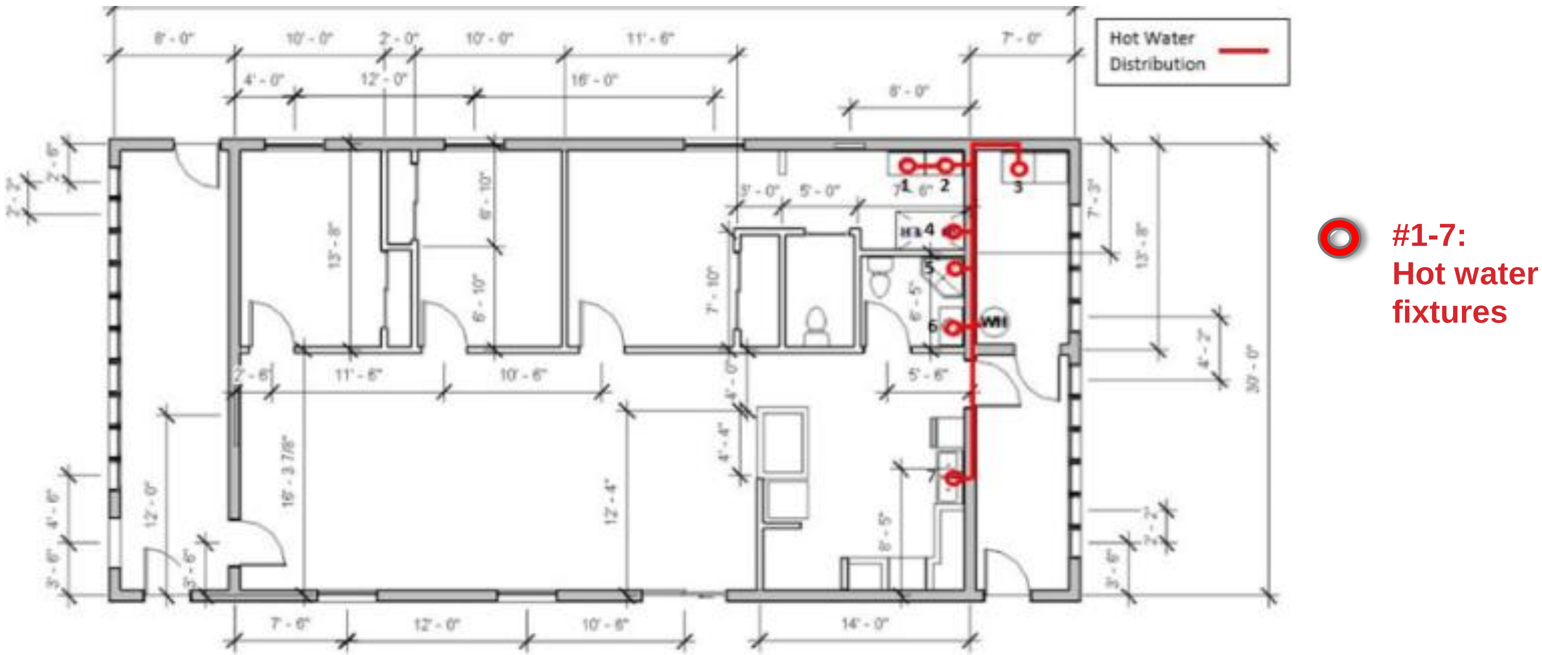


Figure 24. Hot water distribution layout

5.2 EFFICIENT FIXTURES

Bathroom sink faucets

- WaterSense Labeled, Less than 1 gpm.

Kitchen sink faucets

- Swivel aerator with a pause valve.

Shower head fixture

- Evolve 1pgm or less.

Toilets

- ToTo brand 1.28 gpf or less, PVC-free.

Recommended Product		Product Brand and Source
Toilet/Water Fixtures	Eco Drake 1.28 gpf Toilet, PVC-Free	TOTO USA (Georgia)

6 LIGHTING AND APPLIANCES

6.1 Code Minimum

6.2 Built-In Entertainment

6.3 Controls and Energy Monitors

6.1 LIGHTING AND APPLIANCES, CODE MINIMUM

- Replace appliances for only EnergyStar rated lights and appliances such as refrigerators, dishwashers, clothes washers and bathroom fans.
- For Cooking, replace all cooking stoves with Induction Stoves**.**




APPLIANCE	ENERGY STAR MIN. STANDARD (EFS=Exceeds Federal Standard)	BEYOND ENERGY STAR
Refrigerator	EFS by 20%	Frigidaire & Miele models EFS by up to 33%. SunFrost RF-12 (locally manufactured) EFS by 46%
Dishwasher	EFS by 41%	Bosch & Asko models EFS by over 141%
Clothes washer	EFS by 37%	Whirlpool, LG, Samsung models EFS by over 110%

6.2 BUILT-IN ENTERTAINMENT EQUIPMENT

- Built-in entertainment centers shall be installed in the living room of every home to promote the use of Energy Star Televisions and Built-in speakers.

Samsung
UN58H5005AF, UN58H5202AF

MSRP	$799.99
Screen Size	58
Resolution	1920 x 1080
Display Type	LCD
Automatic Brightness Control?	Yes
Annual Energy Use (kWh)*	70
Annual Cost to Operate**	$8

Features:

- Full HD 1080p Reveals a More Stunning TV Experience
- Enjoy the Details in Fast Moving Images with Clear Motion Rate 120
- Experience a Better Color Spectrum with Wide Color Enhancer Plus

Samsung
UN55J6200AF, UN55J6520AF

MSRP	$699.99
Screen Size	54.64
Resolution	1920 x 1080
Display Type	LCD
Automatic Brightness Control?	Yes
Annual Energy Use (kWh)*	69.3
Annual Cost to Operate**	$7.97

Features:

- LED TVs perform well in all lighting conditions
- 1080p resolution for stunning HD images
- Motion Rate 120
- Smart TV delivers a huge world of entertainment
- ConnectShare Movie
- Intelligent energy management

Energy Star Televisions

6.3 CONTROLS AND ENERGY MONITORS

LIGHTING

- Install light switch dimmers on interior lights.
- Install motion sensors on outdoor lights that automatically turn on when people walk by the home and automatically dim to low light levels when no motion is sensed. Connect these lights with photocell sensors that automatically turn on when the sun is setting and turn off when the sun is rising.

ENERGY MONITORING

- Install *Canary Instruments* Energy Monitor, or equivalent, in common area of each home to visualize real-time home energy consumption.

7 HEALTH AND MATERIALS

7.1 Code Minimum

7.2 Red List Materials

7.3 Wood Products

7.4 Entryway Design

7.5 Non-Toxic Paint

7.6 Finishes, Caulks, Sealants

7.7 Thermal and Moisture Control

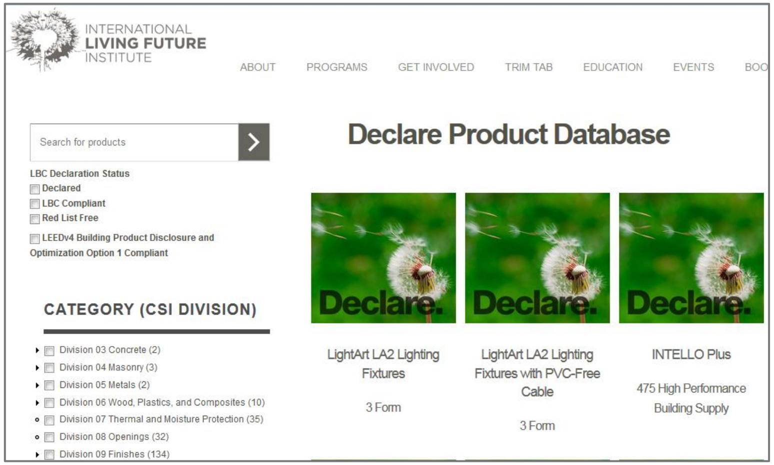
7.8 Flooring

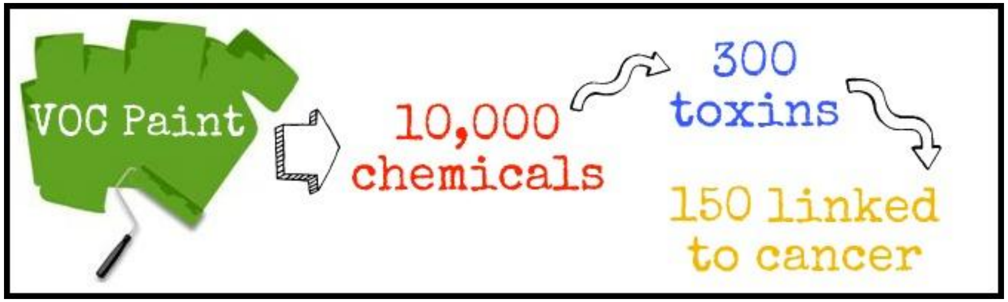
7.9 Pest Control

7.10 Recommended Product List

7.1 HEALTH, CODE MINIMUM

- No-VOC Paints to be used in construction.
- No Formaldehyde products to be used in construction.
- Design to comply with ASHRAE 62.2, and Balance air systems within 25% of ASHRAE standard.s
- Results from Indoor Air Quality test must pass before occupancy and nine months after occupancy.
- Smoking is prohibited within the project boundary.
- Do not install building materials with visible signs of water damage or mold.
- Do not enclose interior walls when insulation or framing members have high moisture content.
- Install a corrosion-resistant drain pan properly draining to a conspicuous point of disposal.
- Use corrosion resistant fasteners and hardware stainless steel, hot-dipped galvanized, and ceramic-coated products.
- Reference the International Living Futures Institute Declare Products Database for approved products to be used in Construction that include transparent product ingredients, source, and recyclability ratings (***https://living-future.org/declare-products***)





7.2 RED LIST MATERIALS

- Materials will be found on the "Declare Products" Database. This database provides the chemical content of each product provided by the manufacturer to keep harmful toxins out of the home.
- The following "Red List" contains a list of (11) materials, chemicals and elements known to pose serious risks to human health and the natural environment. For this reason, these materials shall not be purchased for the project.

- Alkylphenols
- Asbestos
- Bisphenol A (BPA)
- Cadmium
- Chlorinated Polyethylene and Chlorosulfonated Polyethlene
- Chlorobenzenes
- Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs)
- Chloroprene (Neoprene)
- Chromium VI
- Chlorinated Polyvinyl Chloride (CPVC)
- Formaldehyde (added)
- Halogenated Flame Retardants (HFRs)
- Lead (added)
- Mercury
- Polychlorinated Biphenyls (PCBs)
- Perfluorinated Compounds (PFCs)
- Phthalates
- Polyvinyl Chloride (PVC)
- Polyvinylidene Chloride (PVDC)
- Short Chain Chlorinated Paraffins
- Wood treatments containing Creosote, Arsenic or Pentachlorophenol
- Volatile Organic Compounds (VOCs) in wet-applied products[22]

7.3 WOOD PRODUCTS

- At least 50% of all structural wood used on each home shall be sustainably harvested from local sources and/or FSC-Certified wood.

Additional Recommended Products		Product Brand and Source
Wood	REII Landscaping Fence	The Reuse Everything Institute (Pennsylvania)
Wood	Nordic Joist, Nordic Lam, Nordic X-Lam	Nordic Engineered Wood (QC, Canada)

7.4 ENTRYWAY DESIGN AND SHOE STORAGE

- At the entryway of each home, design a built-in shoe rack to reduce the likelihood of tracking contaminants into the home. The design on the left can be a simple add-on, where the honeycomb design on the right is a more custom built-in storage option inspired by nature.

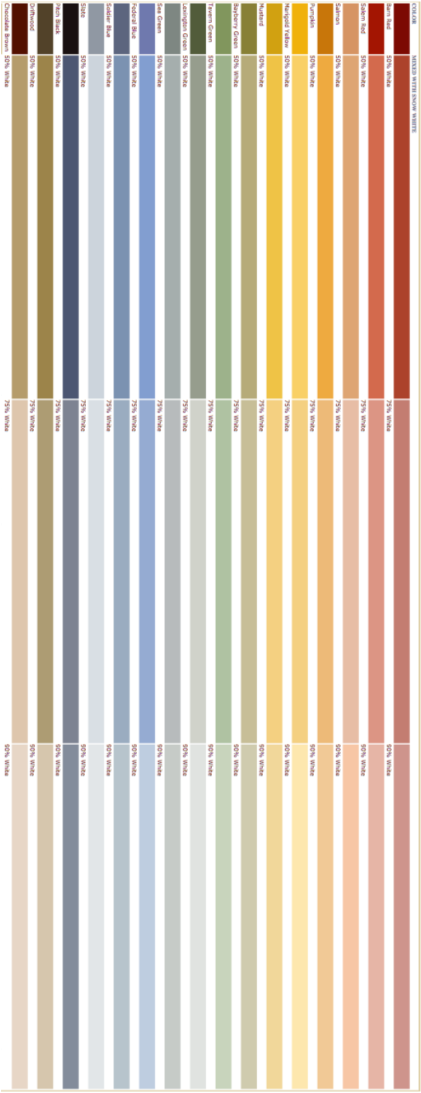
7.5 NON-TOXIC PAINT

PAINT:

- Use No-VOC *Milk Paint* throughout Interior and Exterior of the home. The definition "Zero-VOC" still allows products to contain 5 grams of toxic chemicals or every liter of product, but Milk Paint truly contains No-VOC's.
- Local milk (i.e. Humboldt Creamery) is recommended.

The Genuine Old-Fashioned Home-Made MILK PAINT

*Naturally **safe** Historic Paints since 1974*



ADVANTAGES

Produces an authentic Colonial or Shaker finish	Adheres to almost all clean, porous surfaces
Environmentally safe, non-toxic and anti-bacterial	Non-flammable
Dead flat finish.	Solvent free
Fast drying	Odorless when dry
Comes in deep rich colors	Longest lasting paint known
Colors can be blended, by the user, to produce many tints and shades.	Permanent colors; will not fade
Easily cleaned up with water	

PHYSICAL CHARACTERISTICS

Color: Comes in sixteen historical colors. Also available as a translucent base to which pigment can be added for an infinite variety of hues, tones and shades.	**Non-Flammable**
State: Dry Powder	**Non-Combustible**
Mixing Medium: Water	**Environmental Safety**: Biodegradeable and non-toxic
Mixing Temperature: Mixes best with warm water	**Thinner**: Water
VOC's: None - entirely solvent free	**Clean Up**: Soap and Water
Odor: Faint milky odor when wet, odorless when dry	**Drying Time**: Dry to the touch, 30 mins To re-coat, wait two hours. Cures and hardens over time.
Shelf Life: In sealed bag, indefinitely. As liquid, overnight, seal and refrigerate.	

AVAILABLE SIZES

one pint	6 oz. powder, plus water	covers approximately 35 square feet
one quart	12 oz. powder, plus water	covers approximately 75 square feet
one gallon	48 oz. powder, plus water	covers approximately 300 square feet

7.6 FINISHES, CAULKS AND SEALANTS

CAULKS AND SEALANTS:

- Use Zero-VOC caulks and sealants throughout. If these products cannot be found, use Low-VOC.

CABINETS, PARTICLEBOARD, ETC.

- Utilize third-party certified low-emission pressed wood materials that are designed to reduce human exposure indoors to individual VOCs.
  - Beware: Particle board and pressed wood materials commonly use formaldehyde. Purchase No formaldehyde products only.

Recommended Product		Product Brand and Source
Wood	Cabinets	Neil Kelly Cabinets (Portland,OR)
Wood	Collins Pine FreeForm Particleboard	Collins Companies (Oregon)

7.7 THERMAL AND MOISTURE CONTROL

- **Seal all homes with No-VOC or Low-VOC Joint and Seam Filler thoroughly to seal building envelope.**

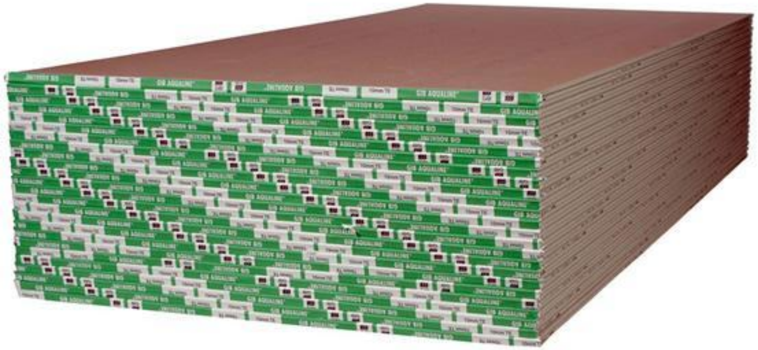
Recommended Product		Product Brand and Source
Thermal and Moisture Protection (Home Exterior)	WrapShield SA Self-Adhered System (A primerless self-adhered water-resistive vapor-permeable air barrier sheet membrane system with liquid flashing, 20 year warranty)	VaproShield (Chicago, USA)
Thermal and Moisture Protection	Prosoco R-Guard Joint & Seam Filler, FastFlash, Cat 5, AirDam, Cat 5 Rain Screen	PROSOCO (Kansas, USA)

7.7 MOISTURE CONTROL

- **<u>BUILDING MATERIALS:</u>** Do not install building materials with visual signs of mold.

- **<u>BATHROOMS:</u> Use *GIB Aqualine*** Plasterboard product, or equivalent, 13mm on the bathroom walls for moisture-resistant backing materials under ceramic tile. If using a single fiberglass shower enclosure, there is no need for extra backing material.

- **<u>BATHROOM TUB:</u>** Provide an extra 4" of tile surrounding the shower enclosure to protect walls from future water damage.



Recommended Product		Product Brand and Source
Finishes	10mm, 13mm GIB Aqualine Plasterboard, GIB Braceline/ Noiseline Plasterboard (13 mm GIB Aqualine® is specifically designed for bathrooms, laundries and kitchens. Its water resistant core contains special polymers to help prevent moisture penetration.)	Winstone Wallboards (NZ)

7.8 FLOORING

- Use only resilient flooring throughout the home
- Entryways shall contain traditional designs by alternating shades of color in the installation, similar to Bear River Hotel tile designs

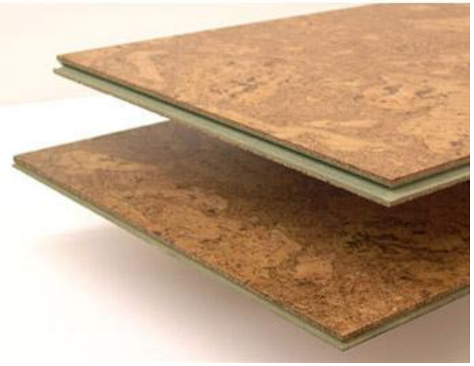
KITCHEN AND BATHROOMS

- Install Ceramic "Green Tile" in Kitchen and Bathrooms with Portland cement-based thin-set mortar and grout OR Marmoleum/ Linoleum sheet flooring with Low-VOC adhesive (Recommend Forbo i885m adhesive).

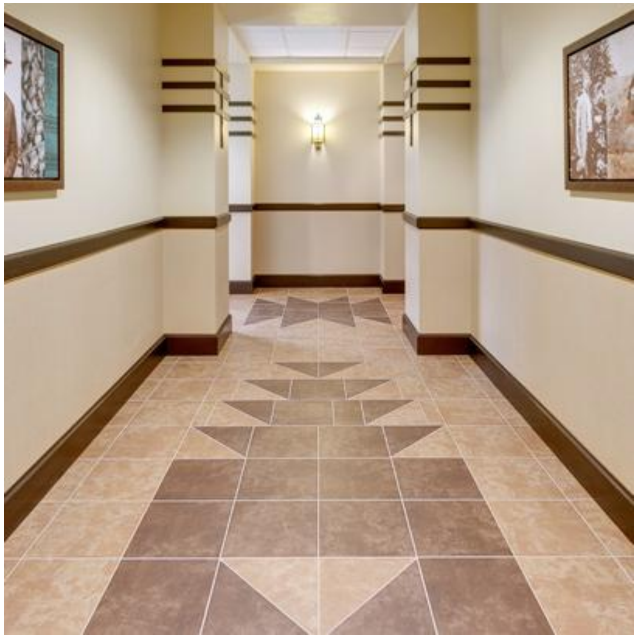
ENTRY, LIVING ROOM, HALLWAYS, BEDROOMS

- Install FSC-Certified locally milled Blue Pine wood with a natural beeswax sealant OR Ceramic Tile for Thermal Mass OR Cork Floors.

Cork Flooring



Soft wood Blue Pine Floors

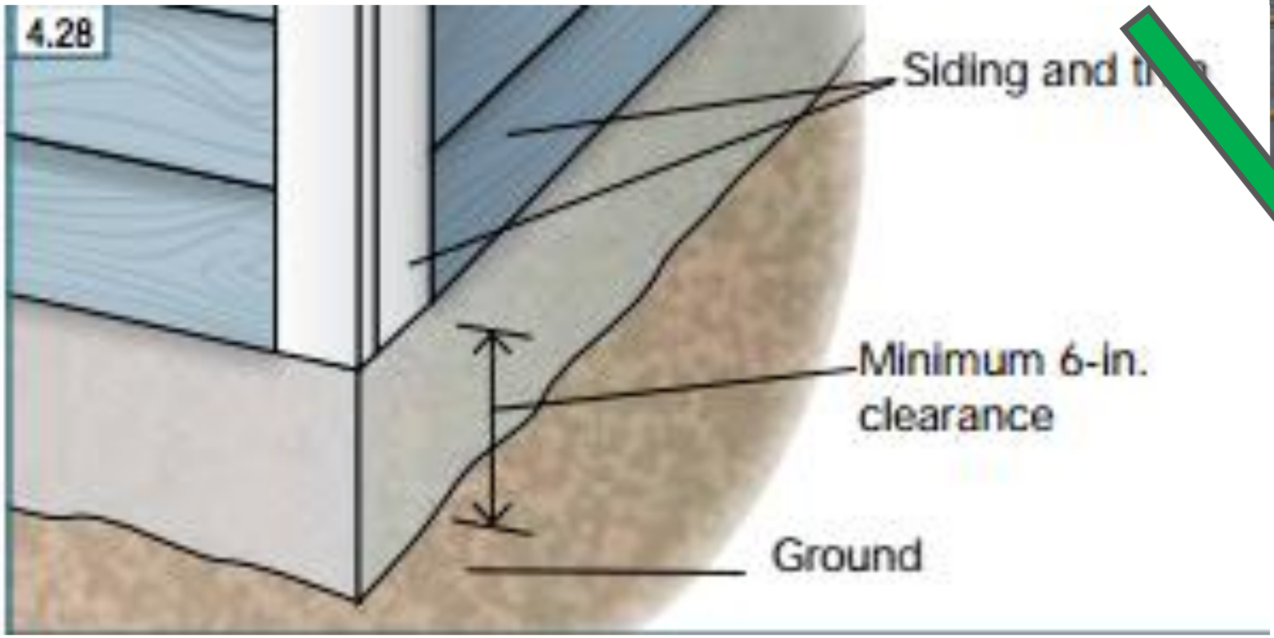


Bear River Hotel tile design in hallway

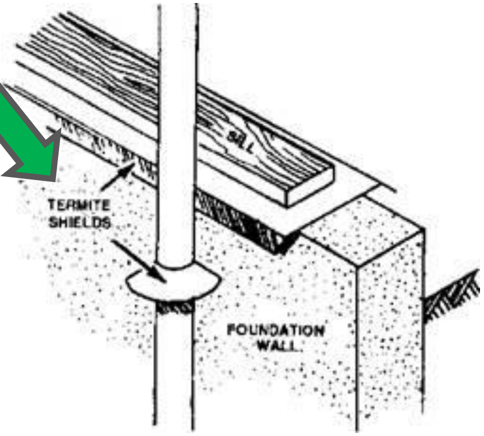
7.9 PEST CONTROL

- Seal all penetrations and joints between the foundation and exterior wall assemblies.
- Install corrosion-proof rodent/bird screens (e.g., copper or stainless steel mesh) for all building openings that cannot be sealed and caulked (e.g., ventilation system intake/exhaust outlets and attic vent openings).
- For additions, add Termite Shield around pipes and penetrations at the foundation level of the home to block termites from crawling up into the home.
- Wall Siding shall be no less than 6” above the ground level to keep wood from rotting and resist pest intrusion.

Termite Shields



Wall siding 6” above ground



Termite Shields

7.10 RECOMMENDED PRODUCT LIST

- **The following products are Approved Declare Products, and are recommended to be used in the Existing Homes Retrofit Construction at Bear River.**

Section	Product Type	Brand
Finishes	Exterior Oil	Natural House Company (NZ)
Finishes	ethos Modular Flooring, Powerbond ethos Cushion	Tandus Centiva (Georgia)
Finishes	EcoGrille (FSC Pacific Albus) wood ceiling panel, 1100 Cross Piece Grille/2100 Panelized Linear (FSC Hemlock)	9Wood (Oregon)
Finishes	ECOS WoodShield Interior Stain, Zero-VOC, ECOS WoodShield Satin Varnish, ECOS Interior Wall Paints	Imperial Paints (South Carolina)
Finishes	Linoleum Harmonium xf^2	Tarkett (Italy)

7.10 RECOMMENDED PRODUCT LIST

- **The following products are Approved Declare Products, and are recommended to be used in the Existing Homes Retrofit Construction at Bear River…**

Section	**Product Type**	**Brand**
Insulation (New construction, use un-faced)	EcoBatt Unfaced, Knauf Insulation IB Board	Knauf Insulation (USA)
Insulation (Attic for new construction)Finishes	GreenFiber Cellulose Insulation	US GreenFiber (USA)
Thermal and Moisture Protection	Havelock Wool Insulation	Havelock Wool (Nevada, USA)
Thermal and Moisture Protection	ENRGY 3 .E- Johns Manville Roofing Insulation Board	Johns Manville (Indiana, USA)

8 PERFORMANCE

8.1 Quality of Installation

8.2 Building Performance Verification

8.1 QUALITY INSULATION INSTALLATION

- **Verification of *Sealed building envelope* prior to exterior walls being enclosed.**
- **Verification of *quality of insulation installation* prior to interior walls being enclosed.**

Some components of QII to highlight include:

Sealing the Air Barrier: Seal all gaps around windows, doors, behind tubs and showers, etc. Caulk or seal all gaps in the air barrier greater than 1/8" with foam.

Correctly Sized Batts: Batt insulation should be cut to fit snugly at the sides and ends without gaps or buckling. It should not double over or be compressed and should be friction fit to cavities, or otherwise supported. Batt insulation should be split to fit around wiring or plumbing, and trimmed to fit around junction boxes.

Required U-factors (& associated R-Values equivalents) for Envelope Systems: Designers shall specify U-factors for assemblies shown in the Residential Appendix. Installers must follow specifications in order to meet QII requirements.

8.2 BUILDING PERFORMANCE VERIFICATION, PRIOR TO OCCUPANCY

- **Building Envelope HERS testing to verify no more than *2.5 air changes per hour @50 psi* through the building envelope.**
- **HERS Blower Door Test to verify *duct leakage less than 6%.***
- **Supply and Return *air flow HERS testing .***
- **Mechanical Ventilation HERS testing for *refrigerant charge.***
- **Third party verification for rooftop *flashing.***

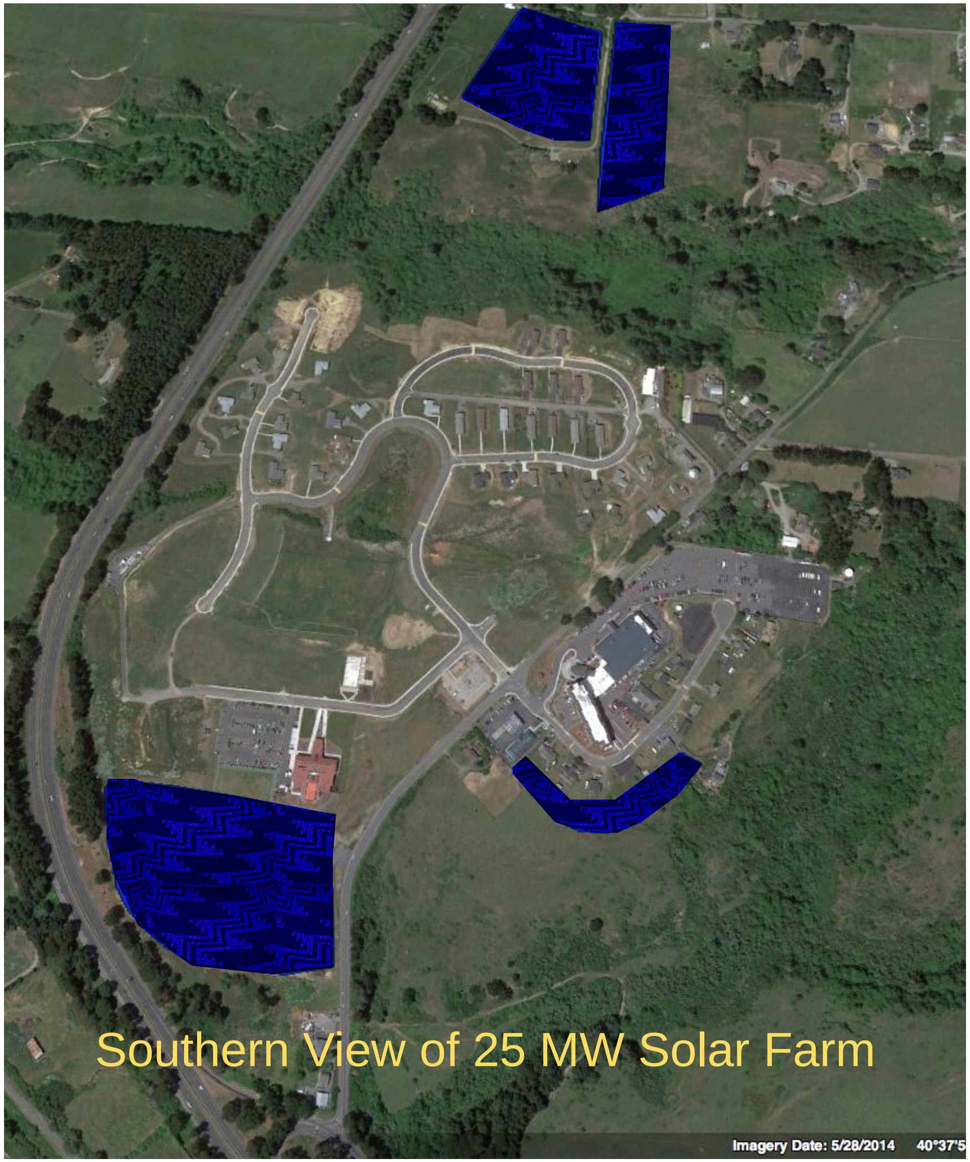
HERS Duct Blaster Test

HERS Blower Door Test

9.1 RENEWABLE ENERGY

9.1 PV Panels

9.2 Energy Storage



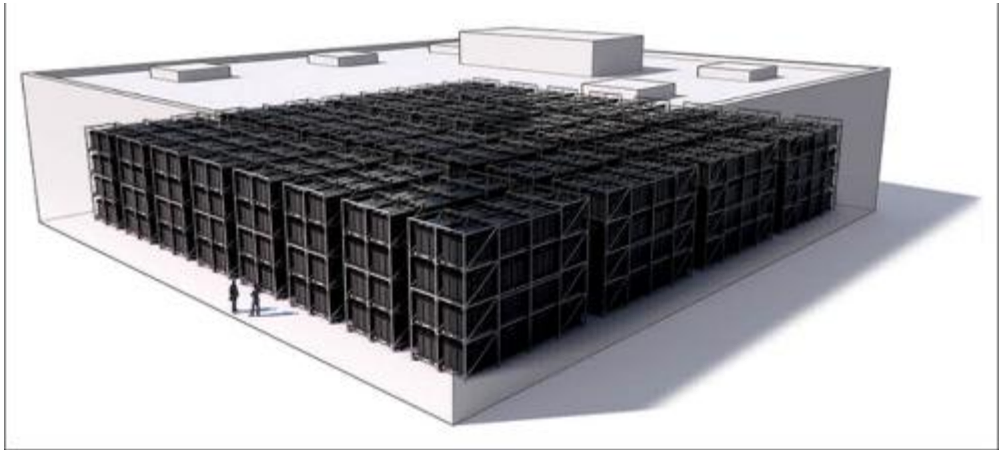
9.1 PV PANELS

- A 1,500 square foot house requires 12 kW's of PV to supply energy throughout the winter.
- The combined Aquion saltwater battery for each home must be sized to 11.5 kWh's.
- All Solar Panel and Roof Rack Installations shall be completed by Tribal Members after receiving proper training and certification through GRID Alternatives or a similar training and certification program.
  - Recommended installation: Install solar panels in a basket weave pattern along the hillside, much like the Wiyot baskets and basket cap

Elizabeth Conrad Hickox, Karuk (Karok) / Wiyot, 1872-1947, or Louise Hickox, Karuk (Karok), 1896-1967 Basket
About 1925
Wild grape root, myrtle sticks, hazel, maidenhair fern, yellow-dyed porcupine quills, and stag horn lichen

9.2 ENERGY STORAGE

The Bear River Band's Renewable Energy Micro-Grid will work in conjunction with Aquion brand deep-cycle batteries for energy storage. The Aquion batteries are non-toxic, saltwater batteries, adaptable to commercial and utility-scale systems like the 12MW energy storage needs of the Bear River Band.



Step 4	Determine Lifecycle cost of ownership				
Type	# Cycles	Wh Storage	Total Wh life of battery bank	Cost of Bank	Cost per kWh
Lead Acid	1500 x	27,789Wh	= 41.6MWh	$8,000	$0.19
Aquion AHI	3500 x	14,033Wh	= 49.1MWh	$8,400	$0.17

Aspen 48M Battery

The Aspen 48M is a parallel string of twelve Aspen 48S batteries configured as a single, palletized battery unit.
They can be connected in series up to 1,000 volts DC.

OPERATION & PERFORMANCE

Chemistry: Aqueous Hybrid Ion (AHI™)
Energy: 25.9 kWh (at a 20 hr discharge)
Cycle Life: 3,000 cycles (to 70% retained capacity)
Operating Temperature: -5 to 40°C ambient Certifications
Nominal Voltage: 48 V
Usable Depth of Discharge: 100%
Round Trip Efficiency: >90%

PHYSICAL CHARACTERISTICS

Dimensions: 1,159 x 1,321 x 1,504 mm (45.6 x 52.0 x 40.0")
Weight: 1,504 kg (3,309 lbs)

CERTIFICATIONS

Cradle to Cradle Certified™ Bronze
UL recognition in process
CE marked

WARRANTY

Limited Warranty: 5-year full plus 3-year prorated

10 EDUCATION

10.1 Resident Education

10.2 Job Training for Tribal Members

10.1 RESIDENT EDUCATION

- **Install Energy Monitors in each home that will provide real-time energy information with immediate feedback to Residents on their energy use. We recommend the Canary Instruments/Nexi device that plugs into the wall outlet and changes colors to indicate High energy use (red), average (yellow) and conservative energy use (green).**

- **The Tribal Council shall provide Community Meetings for Tribal Members twice every month for the first 3-months of occupancy to educate home owners and renters on their new homes. Additionally, provide home owners and renters with a brief packet highlighting the same topics discussed in-person.**
  - Education and Training should include a brief presentation touching on the following topics:
    - Renewable energy, energy storage, energy and water consumption in the home, HVAC and DHW equipment and how it is linked to energy storage and demand, HVAC controls, indoor air quality, and how to maintain the homes.

10.2 JOB TRAINING FOR TRIBAL MEMBERS

In an effort to promote local job/skills training and opportunities for Tribal Members, the Energy Sovereignty Building Code requires funding be set aside for a Job Training Program for Tribal Members.

- **For all internal work, Tribal Members shall receive priority job opportunities in addition to extensive Green Building Training before construction crews can begin Construction.**
- **At least (10) Tribal Members shall be recruited by the Tribal Council and given the opportunity to participate in an extensive ZNE Building Education Program for at least 1-year geared towards Job Training. Members will be trained and Certified to perform the Construction, mechanical and PV installation work and long-term Maintenance duties for all components of the Building Code.**

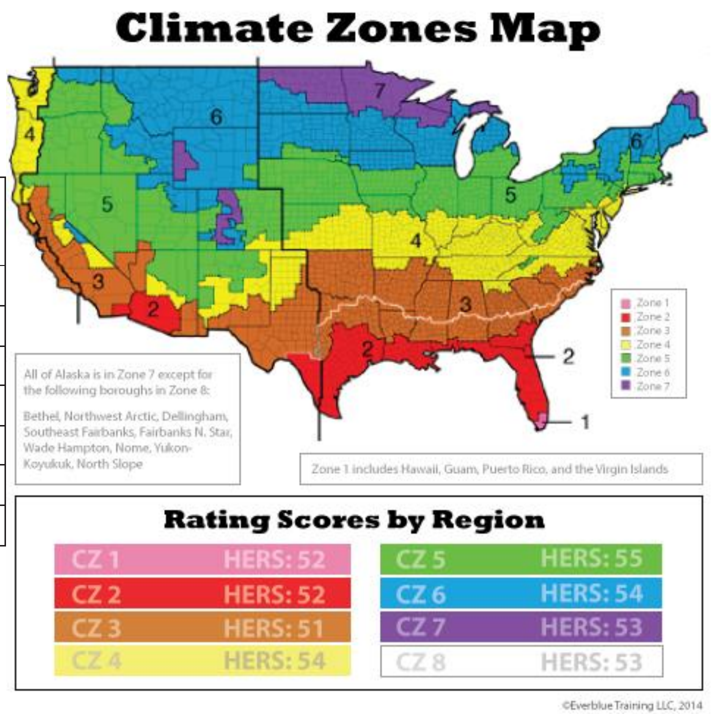
APPENDIX 1: INSULATION RECOMMENDATIONS FOR ALL CLIMATE ZONES

In Northern California, the Bear River Band is in Climate Zone 4 (Marine) as shown the on IECC 2009 Map below. The values in the Table below are the Energy Star recommendations for minimum efficiencies (U-Value) in various components of the home. The lower the U-Value, the more insulated a component is, and is better at resisting temperature differences.

TABLE 402.1.3
EQUIVALENT *U*-FACTORS[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT *U*-FACTOR	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR[d]	CRAWL SPACE WALL *U*-FACTOR[c]
1	1.20	0.75	0.035	0.082	0.197	0.064	0.360	0.477
2	0.65	0.75	0.035	0.082	0.165	0.064	0.360	0.477
3	0.50	0.65	0.035	0.082	0.141	0.047	0.091[c]	0.136
4 except Marine	0.35	0.60	0.030	0.082	0.141	0.047	0.059	0.065
5 and Marine 4	0.35	0.60	0.030	0.057	0.082	0.033	0.059	0.065
6	0.35	0.60	0.026	0.057	0.060	0.033	0.050	0.065
7 and 8	0.35	0.60	0.026	0.057	0.057	0.028	0.050	0.065

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.
b. When more than half the insulation is on the interior, the mass wall *U*-factors shall be a maximum of 0.17 in Zone 1, 0.14 in Zone 2, 0.12 in Zone 3, 0.10 in Zone 4 except Marine, and the same as the frame wall *U*-factor in Marine Zone 4 and Zones 5 through 8.
c. Basement wall *U*-factor of 0.360 in warm-humid locations as defined by Figure 301.1 and Table 301.2.
d. Foundation *U*-factor requirements shown in Table 402.1.3 include wall construction and interior air films but exclude soil conductivity and exterior air films. *U*-factors for determining code compliance in accordance with Section 402.1.4 (total UA alternative) of Section 405 (Simulated Performance Alternative) shall be modified to include soil conductivity and exterior air films.



Bear River Band is in Climate Zone 4 (Marine) on the IECC Map above.

APPENDIX 1 (CONT): INSULATION RECOMMENDATIONS FOR ALL CLIMATE ZONES

In Northern California, the Bear River Band is in Climate Zone 4 (Marine). The values in the Table below are the Energy Star recommendations for all IECC Climate Zones.

Zone	Add Insulation to Attic		Floor
	Uninsulated Attic	Existing 3–4 Inches of Insulation	
1	R30 to R49	R25 to R30	R13
2	R30 to R60	R25 to R38	R13 to R19
3	R30 to R60	R25 to R38	R19 to R25
4	R38 to R60	R38	R25 to R30
5 to 8	R49 to R60	R38 to R49	R25 to R30

Wall Insulation: *Whenever exterior siding is removed* on an

***Uninsulated* wood-frame wall:**

- Drill holes in the sheathing and blow insulation into the empty wall cavity before installing the new siding, and
- Zones 3–4: Add R5 insulative wall sheathing beneath the new siding
- Zones 5–8: Add R5 to R6 insulative wall sheathing beneath the new siding.

***Insulated* wood-frame wall:**

- For Zones 4 to 8: Add R5 insulative sheathing before installing the new siding.

Source: https://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_insulation_table

APPENDIX 3: HVAC RECOMMENDATIONS FOR ALL CLIMATE ZONES

In Northern California, the Bear River Band is in Climate Zone 4 (Marine). The values in the Table below are the Department of Energy's Zero Net Energy Ready Homes Target Home recommendations for HVAC system efficiencies.

Exhibit 2: DOE Zero Energy Ready Home Target Home [7, 20]

HVAC Equipment[21]			
	Hot Climates (2012 IECC Zones 1,2) [22]	**Mixed Climates** (2012 IECC Zones 3, 4 except Marine)	**Cold Climates** (2012 IECC Zones 4 Marine 5,6,7,8)
AFUE	80%	90%	94%
SEER	18	15	13
HSPF	8.2	9	10[23]
Geothermal Heat Pump	ENERGY STAR EER and COP Criteria		
ASHRAE 62.2 Whole-House Mechanical Ventilation System	1.4 cfm/W; no heat exchange	1.4 cfm/W; no heat exchange	1.2 cfm/W; heat exchange with 60% SRE
Insulation and Infiltration			

- Insulation levels shall meet the 2012 IECC and achieve Grade 1 installation, per RESNET standards.
- Infiltration[24] (ACH50): 3 in CZ's 1-2 | 2.5 in CZ's 3-4 | 2 in CZ's 5-7 | 1.5 in CZ 8

APPENDIX D

ENERGY SOVEREIGNTY BUILDING CODE NEW CONSTRUCTION

Energy Sovereignty Building Code

New Construction

Prepared for:

Bear River Band of Rohnerville Rancheria

266 Keisner Road
Loleta, CA 95551

August 23, 2016

Prepared by:

Redwood Energy
Data + Design + Education

Freshwater Environmental Services

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LIST OF ATTACHMENTS

EXECUTIVE SUMMARY

Redwood Energy was hired by the Bear River Band of Rohnerville Rancheria's Tribal Council to consult and develop a Zero-Net Energy (ZNE) Building Code and a Renewable Energy plan to propose on-site renewable energy for the entire Tribe. The Energy Sovereignty Building Code is a guidance tool for future Residential construction and retrofits at Bear River. The Energy Sovereignty Building Code promises Net-Positive Renewable Energy homes that help maintain a large interconnected and balanced micro-grid. The all-electric micro-grid is entirely energy independent, fueled only by renewable energy, with on-site energy storage in non-toxic Aquion saltwater batteries.

Redwood Energy conducted baseline audits of the properties and followed Best Practices in Sustainability, Performance, Health and Safety to create this Energy Sovereign Building Code for the Bear River Tribe.

The Energy Sovereignty Building Code is partially funded through a California North Coast Grant offered by the Strategic Growth Council, and issued with help from the North Coast Resource Partnership and the West Coast Watershed.

The following Organizations directed many guiding principles you will find within this Building Code:

- **(BIG)Build It Green** Green Point Rated (GPR) New and Existing Construction Rating System
- **Energy Star** HVAC Manuals and Rater Checklist, Revision 8
- **(ILFI)International Living Futures Institute** Living Building Challenge Certification and Red List Approved Products Guide
- **California Building Code**, 2013 and 2016 Energy Efficiency Standards, Title 24, Part 6
- **(EPA) Environmental Protection Agency** WaterSense and Indoor Air Plus
- **(DOE) Department of Energy** Zero Energy Ready Checklist
- **Enterprise Green Communities** Multifamily Affordable Housing New and Existing Certifications
- **Samoa Green Home Guide**, Sean Armstrong, Danco Communities
- **Redwood Energy** Project Comparison of 8 Zero-Net Energy Affordable Housing Communities in CA, Climate Zone 1

EXECUTIVE SUMMARY

In an effort to promote local job/skills training and opportunities for Tribal Members, the Energy Sovereignty Building Code requires funding be set aside for a Job Training Program for Tribal Members.

- It is our goal that for all internal work, Tribal Members shall receive priority job opportunities in addition to extensive Green Building Training before construction crews can begin Construction.
- At least (10) Tribal Members will be recruited by the Tribal Council and given the opportunity to participate in an extensive ZNE Building Education Program for at least 1-year geared towards Job Training. Members will be trained and Certified to perform the Construction and PV installation work and long-term Maintenance duties for all components of the Building Code.

1 SITE AND DESIGN

1.1 Location and Home Size

- Site
- Wetlands
- Home Sizes

1.2 Stormwater and Infiltration

- Rain gardens

1.3 Waste Diversion

1.4 Permeable Hard Surfaces

1.5 Zero Net Carbon

1.1 LOCATION AND HOME SIZE

Site

- No buildings shall be built within the 100-year flood plain, as defined by the most current FIRM map published by FEMA, the Federal Emergency Management Agency of the U.S. government.

Wetlands

- Maintain at least 50' distance from the documented edge of a wetland. A wetland has the combination of obligate wetland species and redoxomorphic characters to the soil such as gleying (deep blue/grey color change) of soil and/or rust bits from consistent water-logging.

Single Family Home Size: Design all future construction homes no larger than:

- Studio = 500 square feet
- 1 Bedrooms= 750 square feet
- 2 Bedrooms= 1050 square feet
- 3 Bedrooms= 1,300 square feet
- 4 Bedrooms= 1,600 square feet

Multifamily Apartment Size: Design all future construction homes no larger than:

- Studio = 500 square feet
- 1 Bedrooms= 700 square feet
- 2 Bedrooms= 900 square feet
- 3 Bedrooms= 1,150 square feet
- 4 Bedrooms= 1,350 square feet

1.2 STORMWATER

Stormwater control and infiltration

Stormwater from impervious features (roof, sidewalk, etc.) shall be directed towards infiltration features and away from the foundation to prevent moisture damage. This can be accomplished by choosing one or more of the following:

- Rain gardens (gravel basin planted with wetland plants) –see next page for more details on Rain gardens
- Bioswales (a shallow, wide ditch planted with wetland plants)
- Detention ponds (a deep and wide infiltration basin)
- Living roofs on outbuildings such as the garage or on extended overhangs to provide bird habitat

Rain gardens utilize a natural, healthy soil profile with good infiltration rates of 1”/hour or more.

Bioswales help mitigate flooding by directing the water downhill and are used in place of traditional concrete gutters.

Detention ponds with filtration plants can help the water as it enters, sending clean water to the undergound aquifer.

Living roofs absorb rainwater, reducing the amount of runoff from a building. They require structural reinforcements and a super sealed moisture barrier.

1.2 STORMWATER- HOW TO DESIGN RAINGARDENS

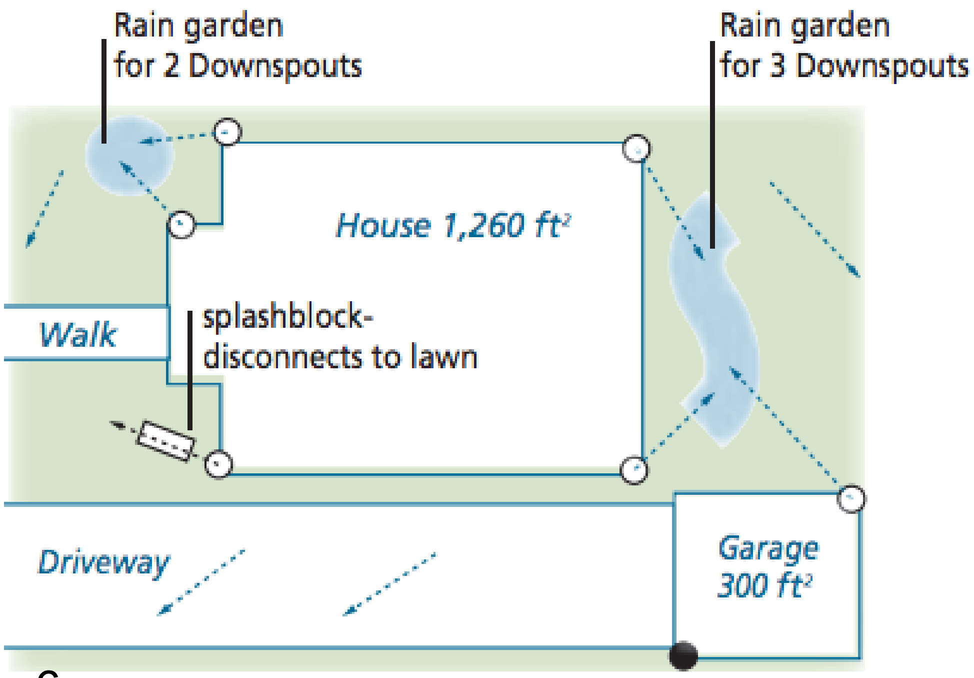
Foundation Drainage towards Rain Garden

- Plan each home with built-in stormwater drainage to a rain garden.

To properly size a rain garden, follow the 10% rule, as shown below:

Make sure your rain garden is large enough to drain the water directed to it within 36 hours. This keeps water from stagnating and mosquitoes from breeding. Size your rain garden to be at least 10% of the area that drains to it.
* For example, if 500 square feet of rooftop drains to your rain garden, the rain garden should be at least 50 square feet.

roof area	*sizing factor*	*rain garden size*
500 sq. ft.	x 10%	= 50 sq. ft. (or 5′ x 10′)



1.3 WASTE DIVERSION

Construction and Demolition Waste

- **Provide a recycling bin for construction waste that can divert a minimum of 60% of construction materials as measured by volume or weight from the landfill. This will save both construction costs and the environment. Diverted materials can include:**
  - Framing wood and unpainted drywall can be chipped on-site and tilled into the ground
  - Rock, asphalt and cement are all reused locally for road base
  - Metal waste is a high value recycled material
  - Paper & cardboard are much less expensive to recycle than landfill
  - Topsoil & trees that cannot be saved can be sold or donated for reuse in the community
  - Carpet is less expensive to recycle than landfill

Wood becomes Mulch

Drywall becomes a gypsum soil amendment

Shingles become aggregate

Masonry becomes landscaping material/ fill

1.4 PERMEABLE HARD SURFACES

Permeable Hard Surfaces

- Asphalt roadways and driveways shall be a permeable road type, typified by 2’ of un-compacted river run gravel with 4-6” of asphalt with a larger grade of rock and more bitumen to allow water to penetrate into the road bed. This road section is used on all Caltrans roadways. Pavers or pervious concrete shall be used for all hard surfaces instead of solid asphalt that blocks water from returning to the soil.

Pervious concrete

Permeable pavers

1.5 ZERO NET CARBON

Mitigation

- **Purchase a one-time carbon offset of 200 tons of CO_2 per home equivalent for the embodied carbon footprint of the construction project. In 2016 the price of a single ton of CO_2 sequestration credit is $12, and the entire home offset would be $2400 in forestry investment.**

This carbon offset cash can be invested locally in forests maintained by the City of Arcata, purchased online as part of the larger California Cap and Trade carbon market, or developed onsite by the Bear River Tribe via planting Redwood groves and similar native trees on open land.

Redwood Trees are among the fastest-growing trees on Earth, storing carbon at the fastest rate yet studied by Botantists—by the time they have grown to two feet in diameter in 20-30 years, they have sequestered 1 Ton of CO_2 in their wood. One house, creating 200 Tons of CO_2 equivalent gases during construction, represents about 100 redwood trees grown for 50-60 years.

2 LANDSCAPING

2.1 Code Minimum

2.1 LANDSCAPING, CODE MINIMUM

- No petrochemical fertilizers or pesticides shall be used on-site.
- Use organic gardening practices at all times
- Invest in fruit trees around all homes and throughout theTribe to provide an abundant food forest for all Tribal Members. There are many fruit tree varieties that grow in the region, including the following varieties, to name just a few:
  - Panamint Nectarine
  - Frost Peach
  - Pink Pearl Apple
  - Sweet Scarlet Goumi
  - Muscat Table Grapes.
- Keep plants away from the exterior siding of all buildings using the following rule of thumb:
  - Plant stems no closer than 36” from the building foundation, and trim bushes, grass, plants, etc. back so they are at least 6” away from the building envelope at all times.

3 BUILDING ENVELOPE

3.1 Code Minimum Summary

3.2 Introduction

3.3 Building Orientation

3.4 Foundation

- Drainage and vapor barrier
- Pest controls
- Slab edge insulation

3.5 Framing

- Code minimum
- Wiring through wall studs
- Interior wall intersections
- Corners
- Windows

3.6 Walls

- Rain-screens
- Air-sealing
- Insulation
- Drywall splicing
- Exterior flashing

3.7 Windows and Doors

- Code minimum
- Flashing
- Recommended products

3.8 Ceiling and Roof

- Code minimum

3.9 Flashing and Moisture Control

3.10 Insulation

3.1 BUILDING ENVELOPE CODE MINIMUM SUMMARY

Component	R-Value
Foundation	R-4 on top of slab, beneath flooring
Walls	R-21 in 2x6 walls + R-8 insulated siding (cork product) or R-8 insulation beneath siding
Attic	R-49

Component	U-Value	Solar Heat Gain Coefficient
Window	≤ 0.30 to keep heat inside the residence	≥ 0.5 to encourage passive solar heating in winter
Door	≤ .2 insulated door	Not Applicable to doors

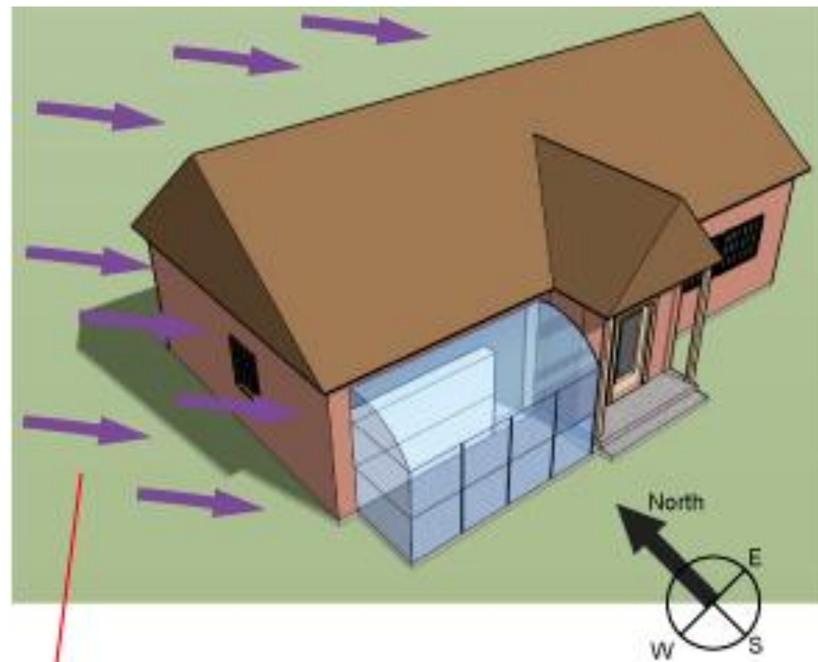
Performance Test	Performance Standard	Method
Sealed Building Envelope	See Chapter 8	Visual inspection of sealed envelope before enclosing exterior walls
Insulation	See Chapter 8	Visual inspection of all insulation installation before adding drywall
Air tightness	See Chapter 8	Pressurizing house fan ("blower door) to measure leakiness
HVAC air flow	See Chapter 8	HERS Testing of supply and return air flow
Rooftop flashing	See Chapter 8	Third party verification of flashing installation

3.2 BUILDING ENVELOPE INTRODUCTION

The Building Envelope is essentially the shell of the building, or the parts of the building that are exposed to the outdoor elements. The Building Envelope includes the foundation, walls, windows, doors, and the roof.

To build a Zero-Net Energy Home that can sustain itself on a limited solar energy budget in the cold winter months, the Building Envelope must be well-insulated, tightly sealed and well ventilated. Additionally, the building should provide natural daylight for occupant health and happiness as well as heat gain on sunny days.

Add a sunroom on the West side of the homes to store heat in the evenings when the sun sets, and provide a space for Tribal Members to grow their own food year-round.

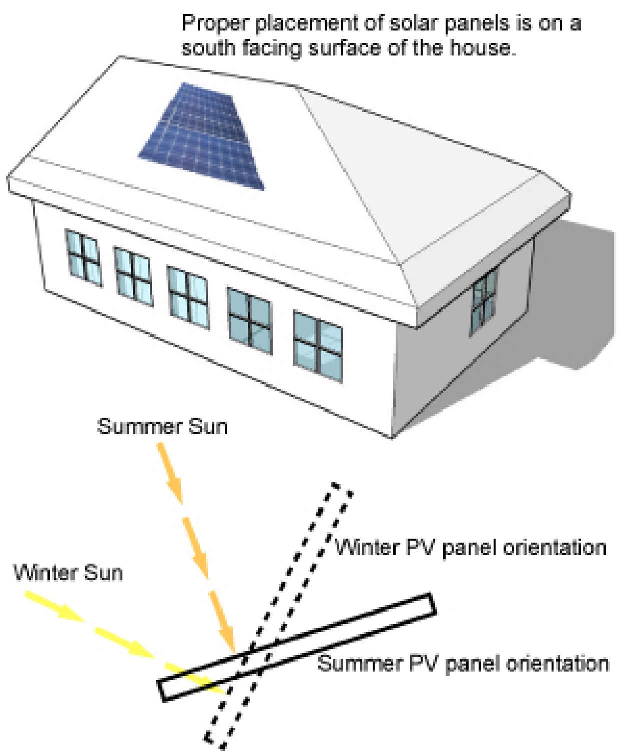


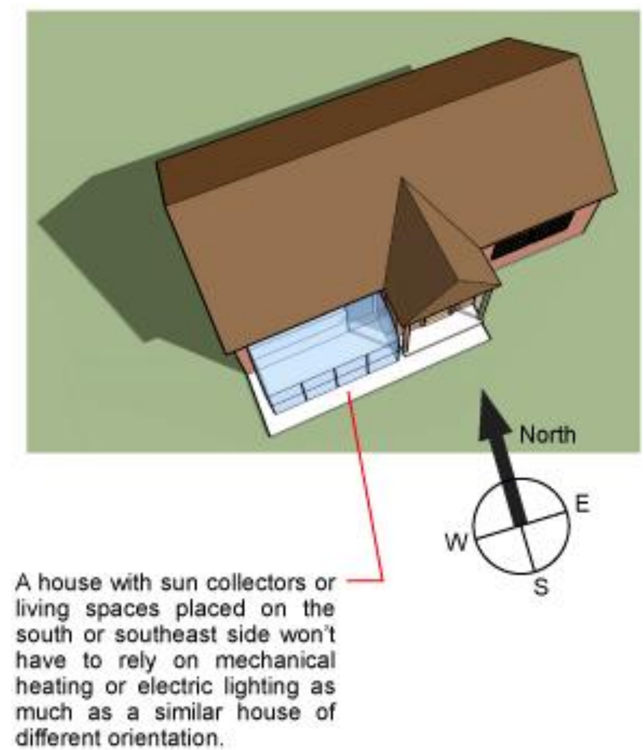
Prevailing winds from the north and the west have the potential to infiltrate the house if tight construction is not used. When attempting to secure joints, it may be prudent to start on those sides of the house.

3.3 BUILDING ORIENTATION

December has only ~40% of the solar energy as in June, yet Energy Sovereign homes must make all their energy year round. In order for residents to have enough affordable energy in the winter, houses must take advantage of their solar resource. Strategies include:

- A 1500 square foot house will take ~12kW of photovoltaic panels to be Energy Sovereign.
- Create solar array-friendly spaces able to hold 4kW on each of three aspects of the roof—East, South and West—to ensure energy generation from sunrise to sunset.
- Minimize operable windows facing Northwest into high-speed winds, and minimize windows facing North to reduce heat loss in the winter while ensuring sufficient daylight for bedrooms for residents to have healthy sleep patterns.
- Build enclosed sun porches to the East and West for passive solar heat gain, laundry line-drying in the winter, and comfortable semi-outdoor spaces to enjoy the sunrise and sunset.

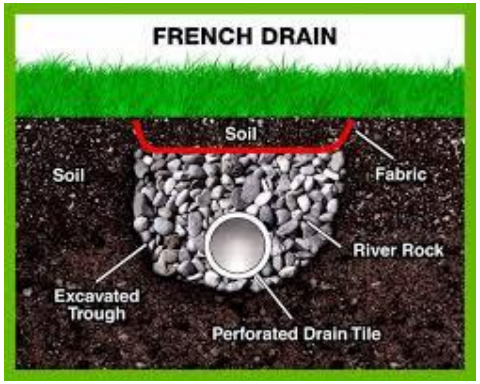




3.4 FOUNDATION, DRAINAGE AND VAPOR BARRIER

Foundation drainage

- Install a French Drain system outside the foundation wall and in the crawl space to divert any bulk water.



Vapor Barrier

- Install a vapor barrier below the concrete slab to seal the home from moisture intrusion at the ground level.

There **is no** polyethylene sheeting installed between the ground and the slab.

There **is** a polyethylene sheeting installed to provide a capillary break between the ground and slab.

3.4 FOUNDATION, PEST CONTROL

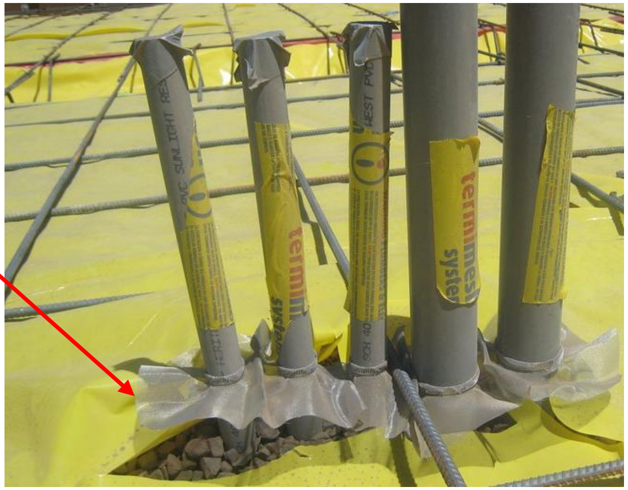
Structural Pest Control

- Use Structural Pest Controls during Construction

  1. Install a ***metal mesh Termite Shield*** (“Termishield”) around all foundation slab penetrations (such as pipes) and at the junction of the foundation or piers and the wall framing.
  2. Install a ***continuous rigid metal Termite Shield*** around exterior perimeter at the junction of the foundation or piers and the wall framing.
  3. Keep framing and siding materials at least 12 inches from the soil to ensure no pests (termites) will reach these materials

     *Remember to keep wood elements separate from concrete and soil to keep the wood from rotting over time.

TermiShield



3.4 FOUNDATION INSULATION, EDGES AND CORNERS

Air Barrier / Floor Insulation

- For Crawlspaces:
    1. Seal all floor joists with ***open-cell spray foam insulation*** at least 5.5 inches thick to act as an air barrier

- For Slab on-grade:
    1. Add R-4 insulation with 2” of cork insulation above slab

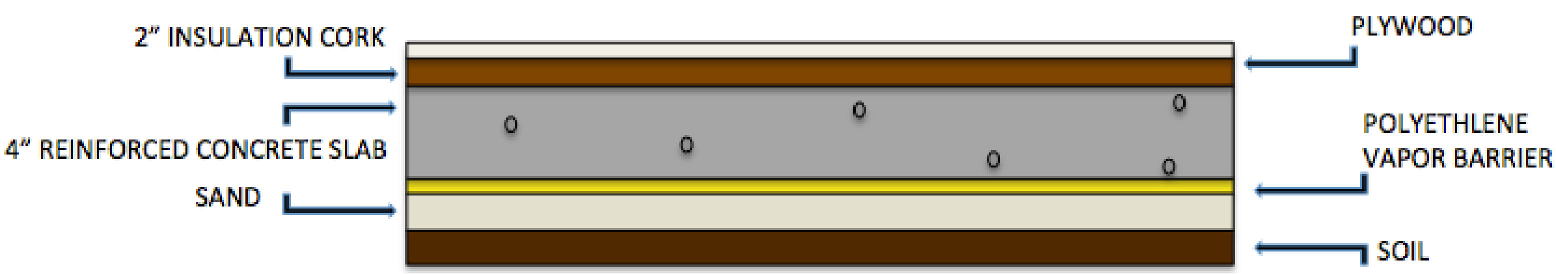
Floor Insulation

- The top or bottom* of the slab must be insulated to at least R-4 (Recommended product: cork or rigid foam insulation) on top of the slab. This insulation is below a ½” plywood flooring underlayment.

OR

- R-4 rigid foam insulation directly below the slab.

*When Side Walls are insulated with exterior rigid insulation from the soil to the walls, it can create a corridor, for termites to leave the soil and access the walls, so this method is recommended against.

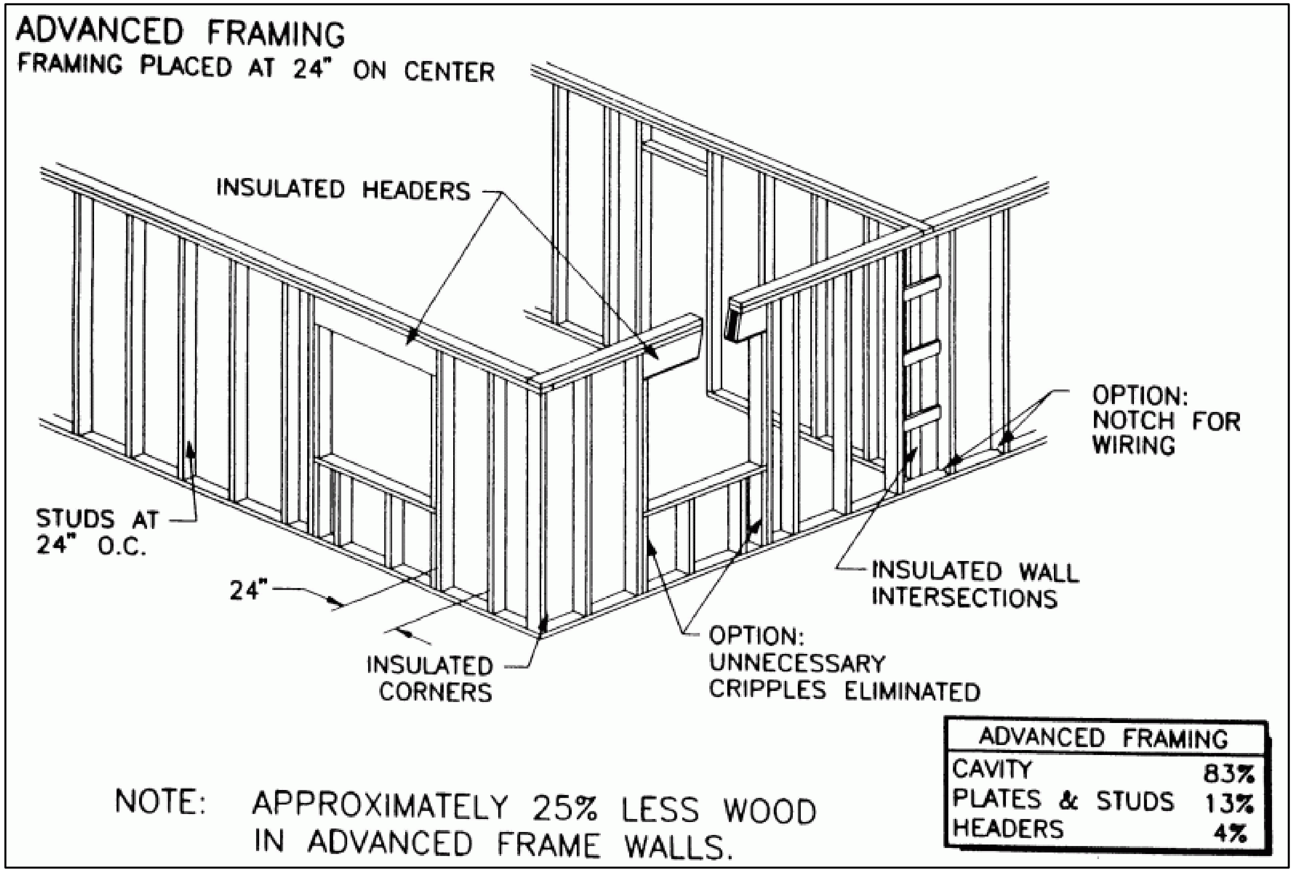


From the bottom up, here’s how the layers should go: soil, sand, polyethylene, concrete, cork siding, and plywood.

3.5 FRAMING, CODE MINIMUM

<u>Structural Framing Code Minimum</u>

- Joists, rafters and 2x6 studs at 16” on center where structural framing allows
- Non-load bearing door and window headers sized for load
- **FSC Certified Wood**
  - Dimensional lumber, studs and timber (i.e. Douglas-fir)
  - Panel products
- **Advanced Framing Techniques shall be used wherever possible**



3.5 FRAMING, WIRING THROUGH THE WALL STUDS

- Cut a hole on one end of framing studs and string electrical wiring through the hole at the floor level, making it easier to properly install wall insulation.

- Seal the studs to the plywood wall enclosure with low-VOC or no-VOC caulk to seal the building from the outdoor elements.

Source: Ann Edminster, ZNE Homes, 2016

3.5 FRAMING, INTERIOR WALL INTERSECTIONS

Wall Intersections

- Insulate Wall Intersections to ***R-21***

-Leave 1” gap at partition walls to slip insulation behind stud

OR

-Use “ladder blocking” to preserve open space behind partition wall studs

OR

-Drill holes into the framing to fill the cavity and fill with blown foam insulation (result of not planning ahead for the first two options)

1” gap to slip insulation behind stud

Ladder blocking to fit insulation behind studs

3.5 FRAMING, CORNERS

Corners

- Create a 2-Stud Corner on all exterior wall intersections to provide insulation that will prevent thermal bridging through the studs. This can be done by:
  1. Cutting and fitting rigid foam insulation
  2. Spraying foam into an air gap to completely fill the opening

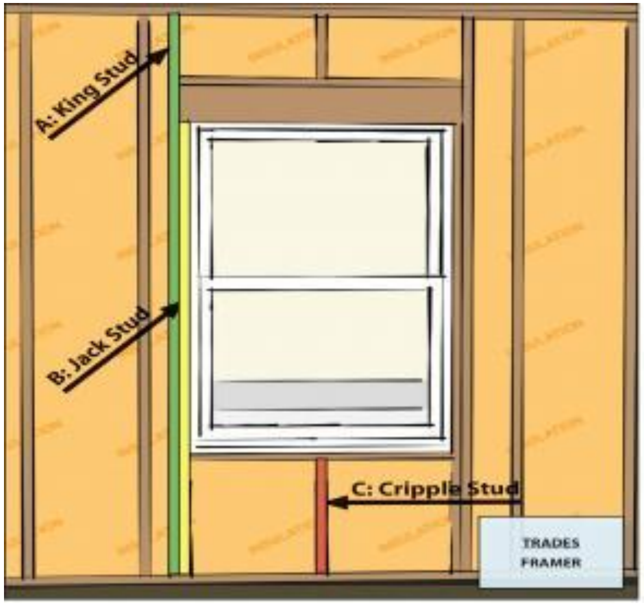
2-Stud Corner

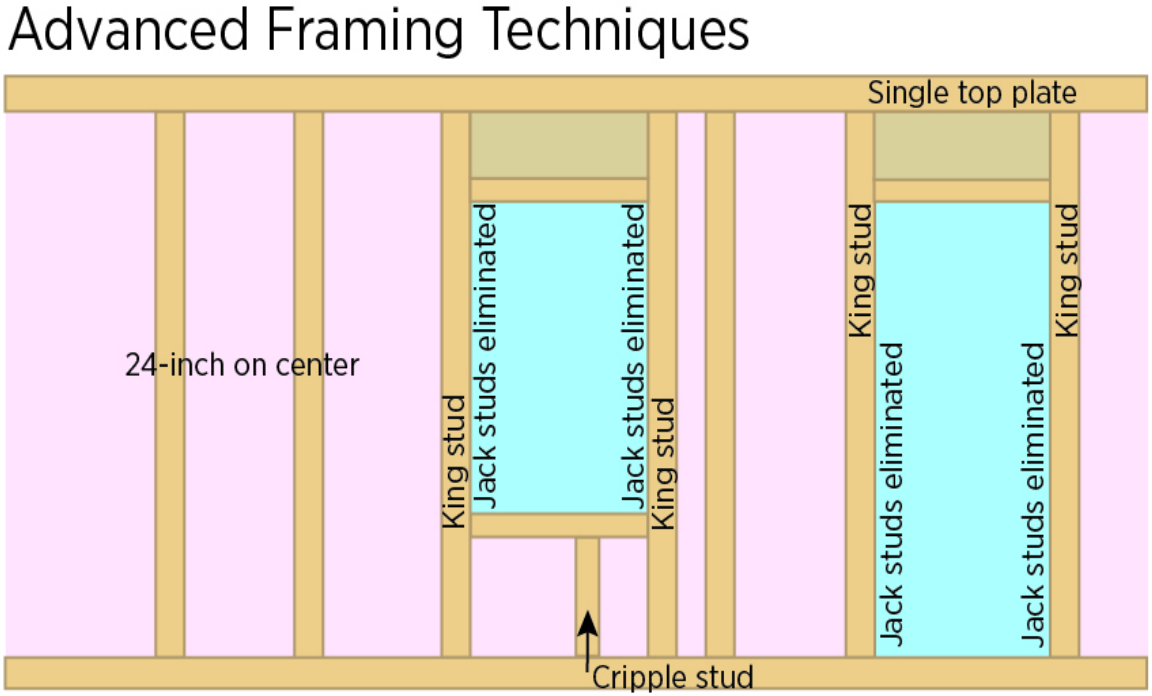
1” gap to slip insulation behind stud

3.5 FRAMING, WINDOWS

Advanced Window Framing

- Limit framing at all windows and doors to one pair of Kind Studs plus one pair of Jack Studs per window opening to support the header and sill to reduce "thermal bridging" through unnecessary framing. Use Cripple studs only as needed to maintain on-center stud spacing.

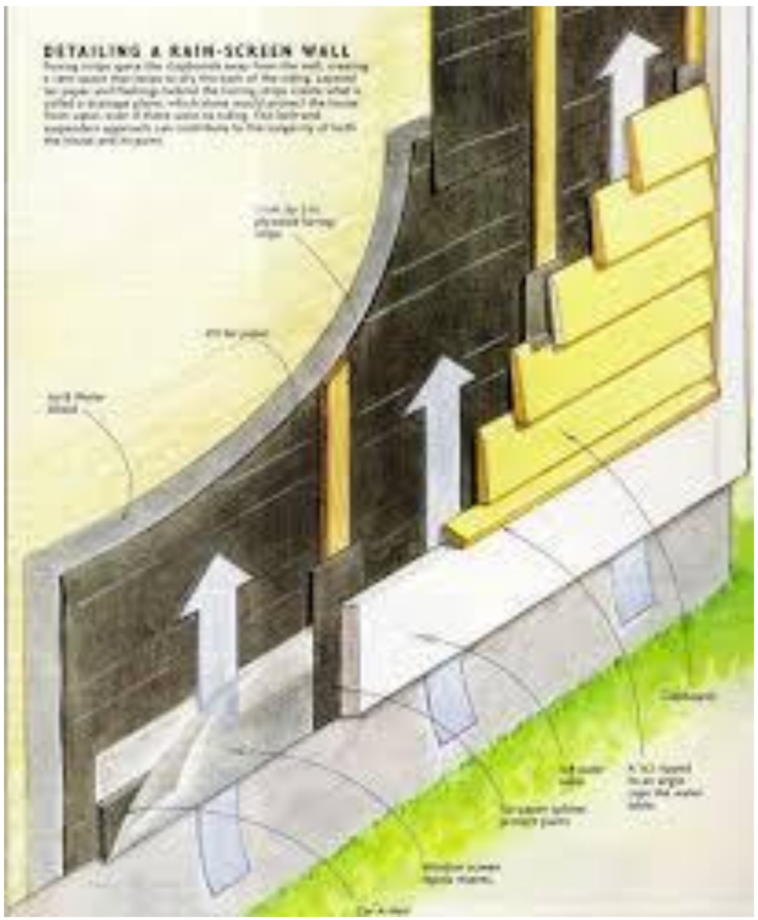




3.6 WALLS, RAIN-SCREENS

- **Install Rain-screen Walls (Resources in Appendix)**
- **Vapor barrier (e.g. tar paper) is required beneath siding, including commonly overlooked areas:**
  - Attic knee walls and skylight shaft walls
  - Walls adjoining porch roofs or attached garages
- **Interior/Exterior wall intersections insulated to R-21, the same as all other external walls**
- **Join horizontal tar paper with 6” overlap, vertical tarpaper by 2” overlap**

*See Appendix for Installing a Rain-screen with felt paper



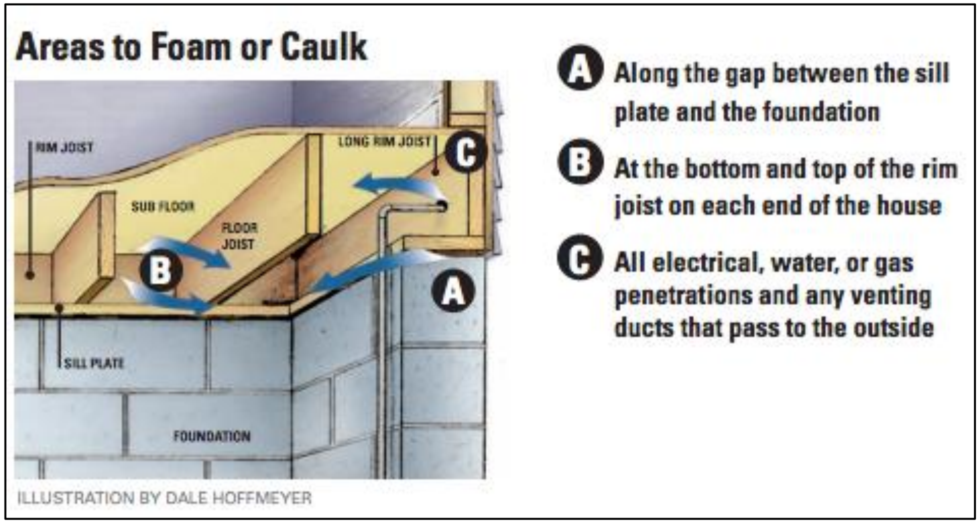
The building felt is not installed on the entire house.

The building felt is installed on all exterior walls and provides a complete drainage system.

Constructing a rain screen is somewhat costly and labor intensive. Installation is unconventional, so it requires rethinking of some details. Window and door trim must be padded out. Flashing should be extended back to the sheathing beyond the air space and under the housewrap. Door hinges may need to be extended, so doors can be fully opened. Roof overhangs at gable ends must be extended to cover thicker wall sections. The bottom of the air space must be covered with screening to prevent critters from entering the vent chamber. These and other accommodations are certainly doable, but involve more labor and materials than typical construction. In my opinion, rain screens are required fare for wet, wind-blown areas like the Pacific Northwest, exposed coastal environments and hilltop exposures. But, this approach is not required or cost-effective for most climates and construction budgets.

3.6 WALLS, AIR SEALING

- **Air seal above-grade cracks, gaps, and intersections adjacent to conditioned space to minimize air leakage.**
    - Air seal between the sill plate and the sub-floor with caulk, foam, or an equivalent material
    - Air seal the bottom and top of rim joists on each end of the house
- **Add sealants around vents and flashing.**
- **Seal all gaps and holes with caulk or spray foam to air seal the home.**
    - Caulk is best for sealing gaps or cracks that are ¼ inch or less.
    - Spray foam is best to fill gaps from ¼ inch – 3 inches.
    - Seal penetrations like holes for wires, water supply pipes, water drain pipes, etc.



Sealed above-grade sill plates

Un-sealed sill plates

3.6 WALLS, INSULATION

- **Wall Insulation = R-21 in walls + R-8 exterior siding**
- **Recommended products: Blown cellulose within walls, Thermacork exterior siding**

Blown-in cellulose, quality insulation installation

3.6 WALLS, DRYWALL SPLICING

- After insulation installation has been verified by a HERS Rater, install the drywall.
- Drywall splicing allows you to install drywall continuously without landing on a stud. Splice scrap wood to use for continuous drywall installation.

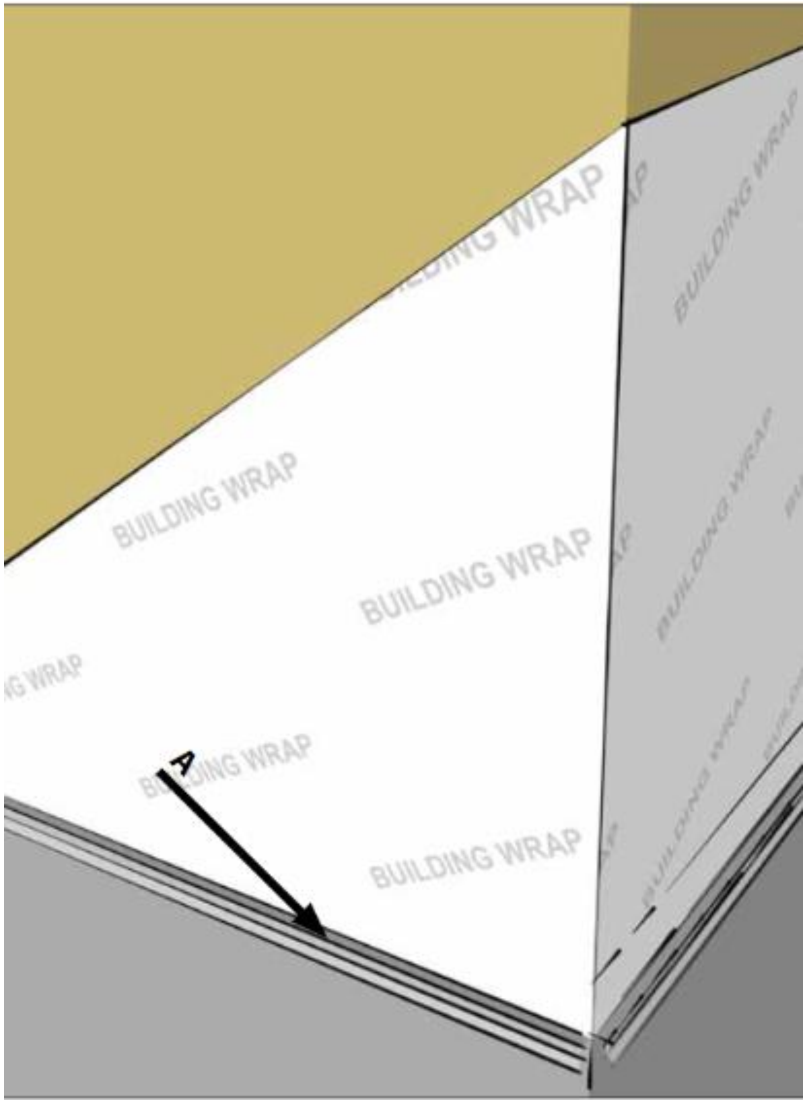
Source: Ann Edminster, ZNE Homes, 2016

3.6 WALLS, EXTERIOR FLASHING

Install flashing at the bottom of all exterior walls with weep holes included for masonry veneer and weep screed for stucco cladding systems, or equivalent drainage system

- If installing masonry veneer, install weep holes at all flashing locations such as the base of walls, above all window and door lintels, and above shelf angles.

- **Create a fully sealed continuous drainage plane behind exterior cladding laps over the flashing detail above. Additional bond-break drainage plane layer provided behind all stucco and non-structural masonry cladding wall assembles.**
  - Monolithic weather-resistant barrier (i.e., house wrap) sealed or taped at all joints.



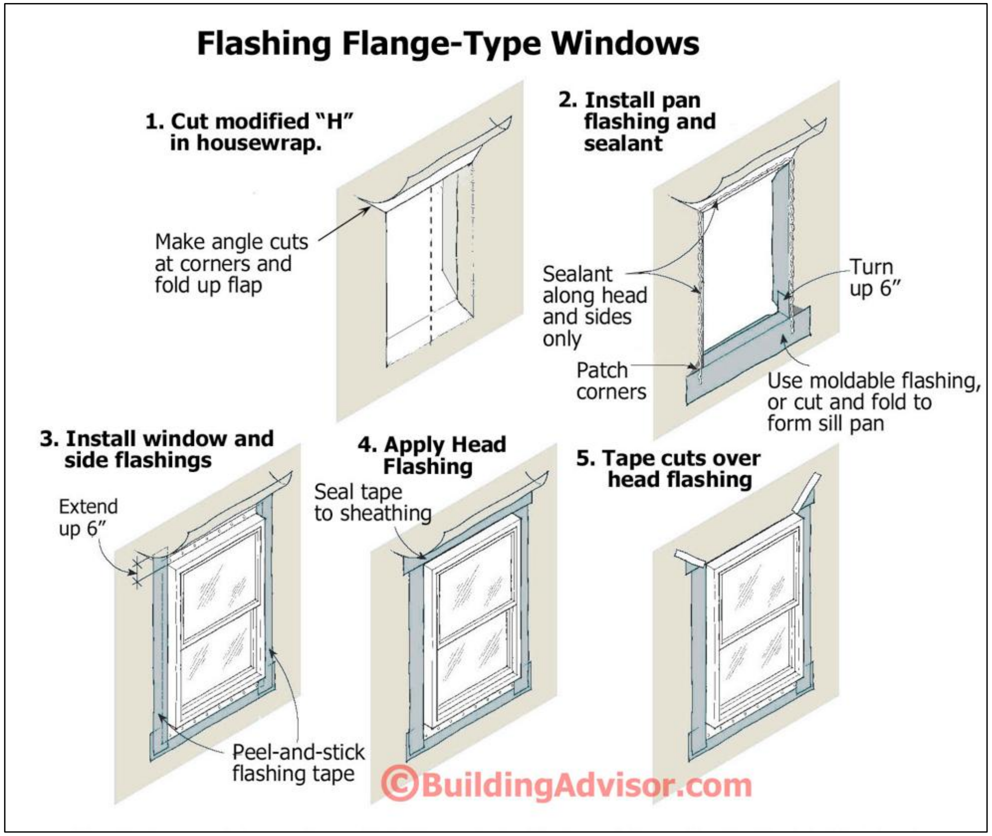
3.7 WINDOWS AND DOORS, CODE MINIMUM

- **Passive solar-friendly insulated windows with a U-Value = 0.30 or less, SHGC=0.5 or more.**
- **Do not use low-e coating on the windows, as the coating increases heating loads by blocking the warming effect of sunlight, and disrupts natural sleep by blocking infrared radiation**
- **Use solid-wood window framing. Paint and maintain wood window frames or use fiberglass exterior cladding.**
- **Ensure a continuous sealant of flashing and insulation around window frame**

3.7 WINDOWS AND DOORS, FLASHING

- **Add flashing under window sill. Flashing around windows and doors shall be sealed to the vapor barrier**

1. Install pan flashing at sills
2. Install side flashing that extends over the pan flashing
3. Install top flashing that extends over the side flashing



3.7 WINDOWS AND DOORS, RECOMMENDED PRODUCTS

Recommended Product		Product Brand and Source
Furnishings	LouverShade (Light harvesting window cover)	Louver shade (CA)
Doors	Graham Serenity Wood Door, Graham Serenity Wood Door, Malman Serenity Wood Door, Malman Thermal Fused Door, Fiberglass Reinforced Polyester Door (FRP)	ASSA-ABLOY (Iowa, USA)

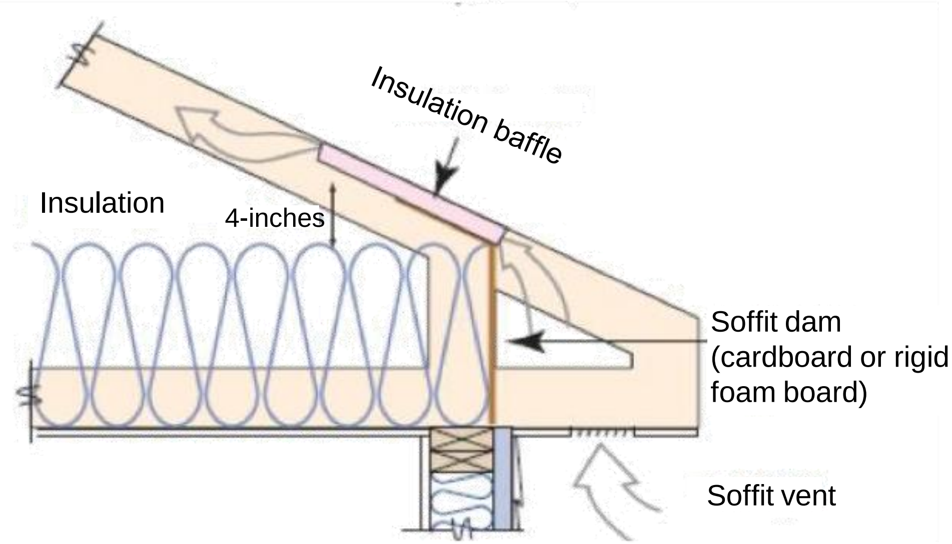
3.8 CEILING AND ROOF, CODE MINIMUM

- **Build an 18" Raised Heel Energy Truss to allow proper insulation in the attic.**
- **Roof overhangs are 1 ½ feet all-around the house.**
- **<u>Class D</u> "High wind speed" shingles for peak 90mph winds: Tested to ASTM D3161.**
- **Dark colored shingles to keep the house warm in the winter, such as CertainTeed "Patriot" shingles.**
- **Attic hatch door shall have R-49 insulation.**

<u>Attic Ventilation</u>

- Attic must have sufficient ventilation:
  1/150 method used to provide adequate amount of ventilation.
  Attic space is 1600 square feet, approximately 10.7 square feet of vents is required
- Install vents in gable ends or a combination of soffit and ridge vents.

Energy Truss
With full height insulation
(recommended)



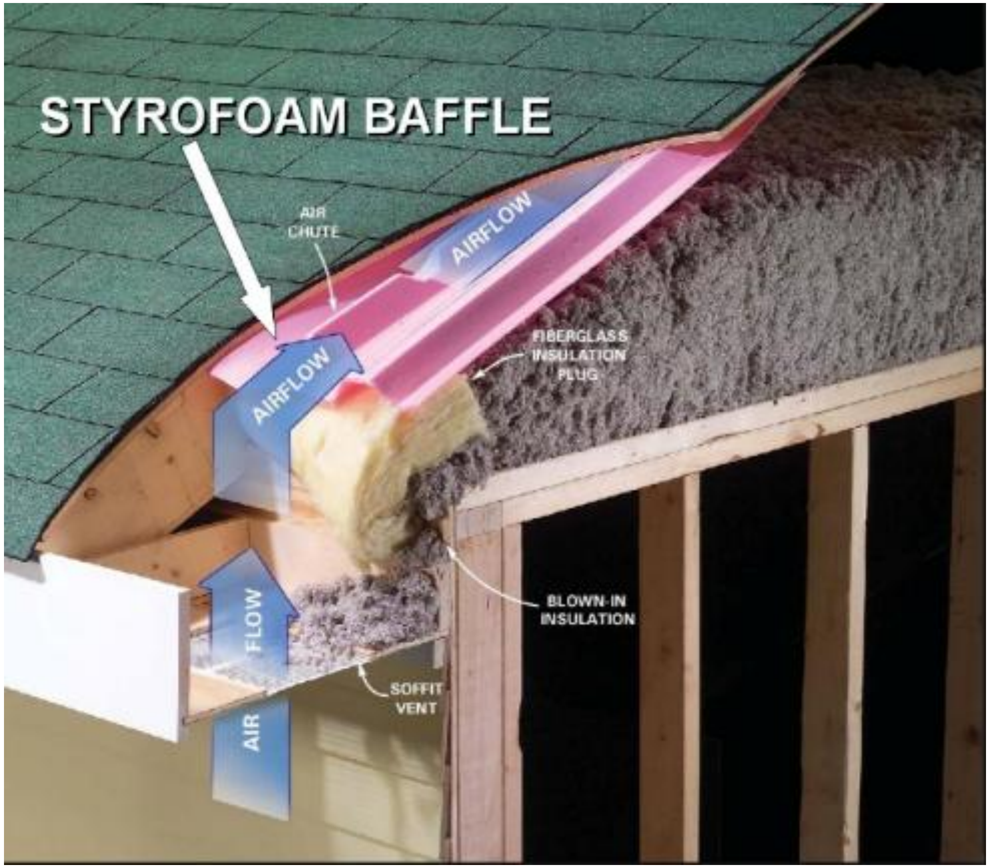
3.8 CEILING AND ROOF, INSULATION

Attic Insulation

- Attic insulation to be at least R-49 insulation. Use either eco-friendly batt insulation or naturally eco-friendly blown-cellulose insulation, at least 15.3 inches thick.
- Attic hatch door to have R-49 insulation.
- Add a styrofoam baffle or a piece of cardboard to act as a baffle, which will allow airflow and prevent ice-damming in the attic.

Access Hatch, with Deck, Fully Blown to R-49.

Blowing cellulose insulation to R-49 in attic



3.9 FLASHING AND MOISTURE CONTROL

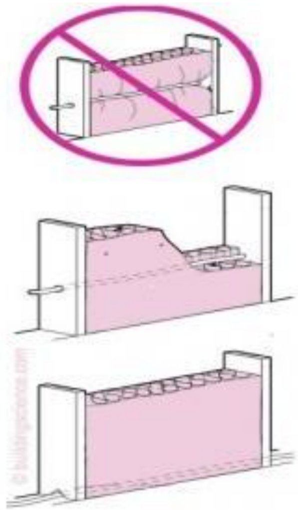
- Flashing to be installed underneath exterior siding and roofing materials to prevent moisture from traveling through the building joints.
- Properly flash all roofs, windows, doors, utility penetrations, deck connections to the structure, and any other joints where water may enter the home.
- Water should naturally flow away from the building through the use of overhangs, downspouts and sloped yards.
- Flashing to be installed properly on all penetrations and joints such as windows, doors, siding, roofing, roof valleys, decks, sill plates, railings, balconies, chimneys, pipes, vents and utility penetrations.

3.10 INSULATION

Quality Insulation Installation (Resources in Appendix)

- Gently wrap an even layer of recycled cotton batt insulation on all external walls, with no gaps or compressed areas.
- Add blown-in cellulose insulation to the attic spaces or add a continuous, even layer of recycled cotton batt-insulation, with no gaps or compressed areas.
- Pre-cut batt insulation to fit wall cavities, sliced to fit around wires, pipes, and any other wall obstructions.

Component	Code Minimum R-Value
Walls	R-21 + R-8
Slab	R-8
Attic	R-49



4 HVAC

4.1 Code Minimum

4.2 Ducts

- Quality installations
- Duct sealing

4.3 Heating

- Option 1
- Option 2
- Option 3 Multifamily /Commercial

4.4 Ventilation

- Whole house
- Bathroom and kitchen

4.5 Air Balancing

4.6 Controls

4.1 CODE MINIMUM

Generating space heating for Bear River's energy efficient homes is best done with a heat pump water heater, the same device that will also heat the domestic hot water. A heat pump water heater produces heat efficiently, and more importantly stores it in an insulated tank for use when the sun goes down. The heat energy is then best delivered with a hydronic fan coil through insulated ducts, with the balanced ventilation system exhausting air through an Energy Recovery Ventilator to recapture ~25% of exhaust heat.

Water heating is discussed in the HVAC section because in the Bear River ZNE homes, the water heaters act as thermal batteries, storing energy overnight with heat gained during the day that can be used for water or space heating in the home. High temperature heat pump water heaters can store water up to 180°F to hold energy in water rather than a traditional electric battery. When this system is combined with a thermostatic mixing valve, no water exiting the tank will be above 120°F, keeping residents safe from scalding. These high temperature thermal batteries are a fraction of the cost of electric batteries and will help maintain a balanced micro-grid, creating energy sovereignty at the Bear River Rancheria.

During low-power events for the Bear River Rancheria micro-grid, Residents will be able to turn off their water heaters and use stored energy for at least 12 hours to supply air and water heating.

COMPONENT	CODE MINIMUM
Duct Insulation	R-4
Heat Pump	HSPF=12+, SEER=19+
Heat Pump Water Heater	EF=3.0+
Energy Recovery Ventilator (ERV)	1.0 Sones or less

4.2 DUCTS

Locating the Ducts

- All ducts shall be located in ***conditioned space***.
- Supply ducts located in ***drop ceiling***.
- Return ducts at ***baseboard level*** to exhaust dust and VOCs from flooring materials.

Installing the Ducts

- Use ***duct mastic*** on all duct joints, duct seams, and all return and supply ducts.
    1. Duct mastic to be applied “as thick as a nickel”.
- All ducts must have at least ***R-4 insulation.***
- All duct systems sized according to ***ACCA Manual D*** (HVAC-D 5).
- Seal joint between boot and ceiling drywall with ***fiberglass mesh and mastic or caulk***.
- Ducts shall be ***cleaned thoroughly*** prior to installing registers, grilles, and diffusers, and verify HVAC filters are new and clean.
    1. Bathroom and Kitchen: MERV 12 filters
    2. Main HVAC system: MERV 16 filters

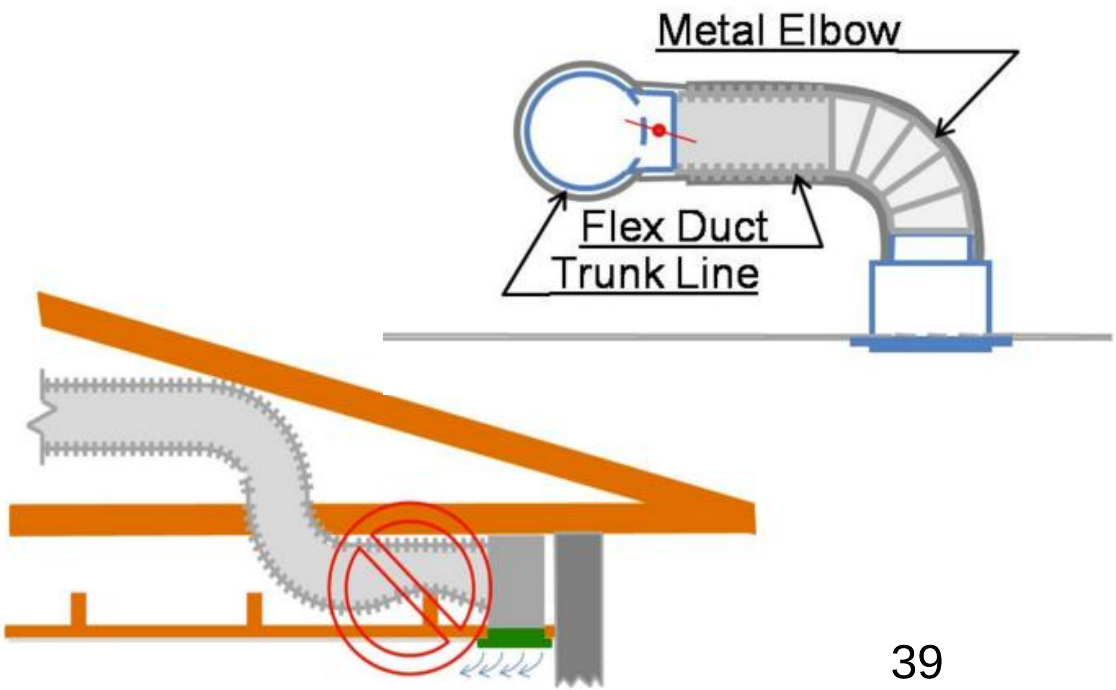
- During Construction, all duct openings (registers, supply grilles, etc.) shall be covered and sealed to keep ducts clean during the Construction phase. Ducts can be uncovered/ revealed at the final stage of Construction, prior to Quality Inspections performed by a HERS Rater.

R-4 Insulated Duct

Baseboard level Return Ducts

4.2 DUCTS, QUALITY INSTALLATIONS

- **Install ductwork without kinks, sharp bends, or excessive coiled flexible ductwork in spaces that fit them without compacting them. This slows air flow and wastes energy.**
- **Support flexible duct at intervals:**
  - Install supports at a minimum of every 5 ft. to prevent sagging.
  - Install support at least 1 in. wide, without compressing the ducts and the duct installation.
- **Provide sufficient cavity space for ducts**.
  - The height and width of a dropped soffit used to house ductwork should be the duct diameter plus the thickness of the insulation to prevent compression of the duct.
- **If there is fear of compressing the flex duct when making a 90-degree turn in a tight space, use a metal elbow**.
  - Use a metal duct elbow instead of flex duct at boot connections to prevent compression.



No excessive bends in flex ducts

4.2 DUCTS, SEALING

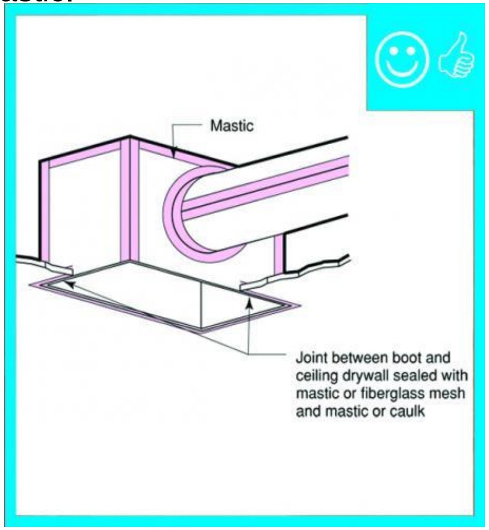
Create durable, airtight duct seams

- Before ducts are sealed, duct seams need to be mechanically fastened (using sheet-metal screws for galvanized ducts and compression straps for flex duct).
- To secure seams in round galvanized ducts up to 12 inches in diameter, use at least three #8 screws, per joint. To secure ducts over 12 inches in diameter, use five #8 screws per joint.
- To secure joints in rectangular galvanized duct, use at least one #8 screw per side.
- Install mastic "as thick as a nickel".
- Seams or cracks wider than 1/16 or 1/8 inch must be sealed/ repaired with fiberglass mesh as well as mastic.
- Seal collar connections between plenums and duct take-offs.

Seal joints in flex ducts

- Insert duct boot or coupling at least 2 inches into the end of the duct. Attach fitting to the inner sleeve of the flex duct with a drawband (clamp) or #8 screws.
- Seal the joint between the inner section of flex duct and the fitting with high-quality mastic.
- Seal the exterior vapor-barrier sleeve with a drawband and tape.

Quality Duct Installation: Duct Mastic



4.3 HVAC, OPTION 1

Code Minimum

- **HSPF= 12+**
- **SEER= 19+**

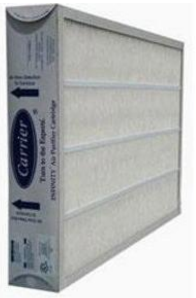
(2) Electric Heat Pump Water Heaters with high temperature heat storage functionality.

Tank #1 for Water heating, set to 140 °F - 180 °F, as needed for demand.
Tank #2 for Space heating, set to 180 °F, as needed for energy storage.

80+ gallons
Located in garage, install to manufacturers specifications.
Timed to run only during the day.

Unico Air delivery and return Fan Coil Unit, uses high speed and low volume delivery. Located in drop-ceiling or interior closet.

Energy Recovery Ventilator (ERV) recovers heat, energy and moisture.
Located in drop-ceiling.



Install a MERV 16 filter, unless Manufacturers specifications say otherwise.

Highly efficient ceiling fan, located in the living room for cooling. Recommended Product: Big Ass Fan

4.3 HVAC, OPTION 2

Code Minimum

- **HSPF= 12+**
- **SEER= 19+**

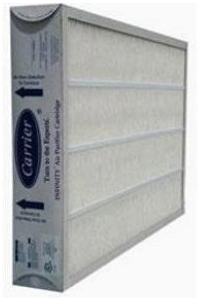
(1) Sanden CO2 Water Heater with high temperature heat storage functionality and Heat Pump Compressor for space heating only.

Tank for Water and Space heating set to 180 °F, as needed for demand and energy storage.

80+ gallons
Located in garage, install to manufacturers specifications.
Timed to run only during the day.

Unico Air delivery and return Fan Coil Unit, uses high speed and low volume delivery. Located in drop-ceiling or interior closet.

Energy Recovery Ventilator (ERV) recovers heat, energy and moisture.
Located in drop-ceiling.



Install a MERV 16 filter, unless Manufacturers specifications say otherwise.

Highly efficient ceiling fan, located in the living room for cooling. Recommended Product: Big Ass Fan

4.3 HVAC, OPTION 3, MULTIFAMILY / COMMERCIAL HVAC OPTION

Code Minimum

- Follow CEC values for COP values and temperatures proposed by AHRI for large heat-pump boilers, as follows:

Outside air temp	COP	Water Temperature
17	1.95	120
47	2.65	120
100	3.5	120

*For DHW use, the unit must also be able to produce hot water when the air temperature is 100°F.

Recommended: Aermec system to provide Heating and Air Conditioning and Water Heating for all. It is an air to water heat pump and can be sized up to hundreds of tons.

Alternatively, the Panasonic City Multi R2 high temperature model can be used to handle the energy loads. It is an air to refrigerant heat pump and increases in 10-ton increments.

4.4 VENTILATION, WHOLE HOUSE

Whole House Ventilation Code Minimum

- HVAC equipment efficiency rating shall be greater than SEER= 19
- Install Low Sone Supply and Exhaust fans, 1.0 Sone or less
- Energy Recovery Ventilator (ERV)
    - A spot energy recovery ventilator (ERV) recovers heat, energy and moisture.
    - Not to be incorporated into any bathrooms or the kitchen of the home to ensure moisture control within the system.

FV-04VE1 Two 4" Ducts

MERV 12Filter Box

Living Space	1,920 (ft^2)
Bedrooms	3
Air flow required (cfm)	49.2
System air flow (cfm)	200

ASHRAE 62.2-2007:
[Conditioned Area / 100] + [(7.5) * (Number of Bedrooms+1)]

Required CFM ASHRAE Standard and the supplied air flow

Recommended Product		Product Brand and Source
Whole House Ventilation	Energy Recovery Ventilator (ERV)	Panasonic Whisper Comfort Sport FV-04VE1

4.4 VENTILATION, BATHROOM AND KITCHEN

Ventilation Code Minimum

- Local mechanical exhaust ventilation is forced outdoors in the Bathroom and Kitchen, meeting ASHRAE 62.2.
- Install vent fans in Kitchen, Bathroom and Laundry room.
- Install vents in gable ends or a combination of soffit and ridge vents.

Bathroom:

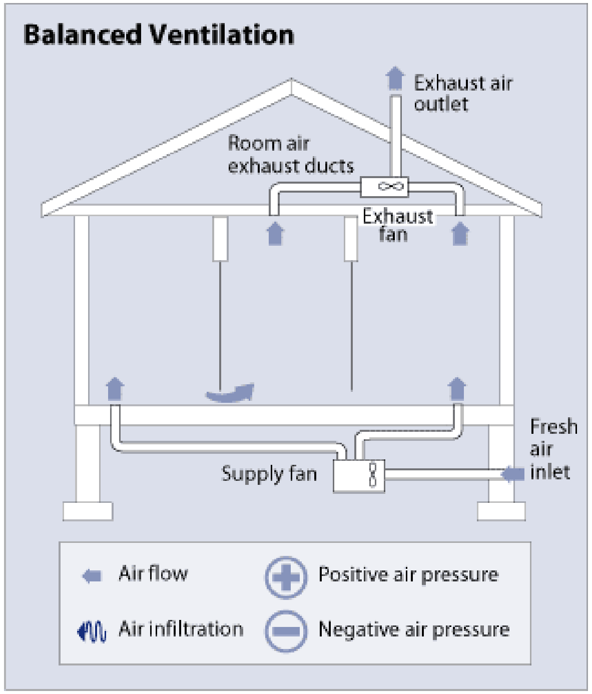
- "Panasonic WhisperGreen", or equivalent exhaust fan.
- Air sources fed through a filter box with a MERV 12 filter prior to being ducted into the bathroom.
- Bathroom exhaust fans shall have an exhaust rate of at least 50 CFM.

Kitchen:

- "Broan Elite RM50000", or equivalent range hood that is vented directly to the outdoors.
- Ducting is split into a T joint, where air is blown underneath the kitchen cabinet through a 3 x 12 inch rectangular duct and a 5 inch in the ceiling.

4.5 AIR BALANCING

- Design to comply with ASHRAE 62.2, and Balance air systems within 25% of ASHRAE standards.
- **Pressure Balance Options:**
  - Bedroom pressure –balanced using any combination of transfer grills, jump ducts, dedicated return ducts, and/or undercut doors to achieve a Rater measured pressured differential ≤ 3 Pa



Ducted Returns

Guide describing how to install ducted returns to provide conditioned air to all parts of the house and return stale air to the furnace for reconditioning.

Transfer Grilles

Guide describing how to install transfer grilles at each bedroom ensure a continuous flow of heating and cooling even when the doors are closed.

Jump Ducts

Guide describing how to install jump ducts at each bedroom ensure a continuous flow of heating and cooling even when the doors are closed.

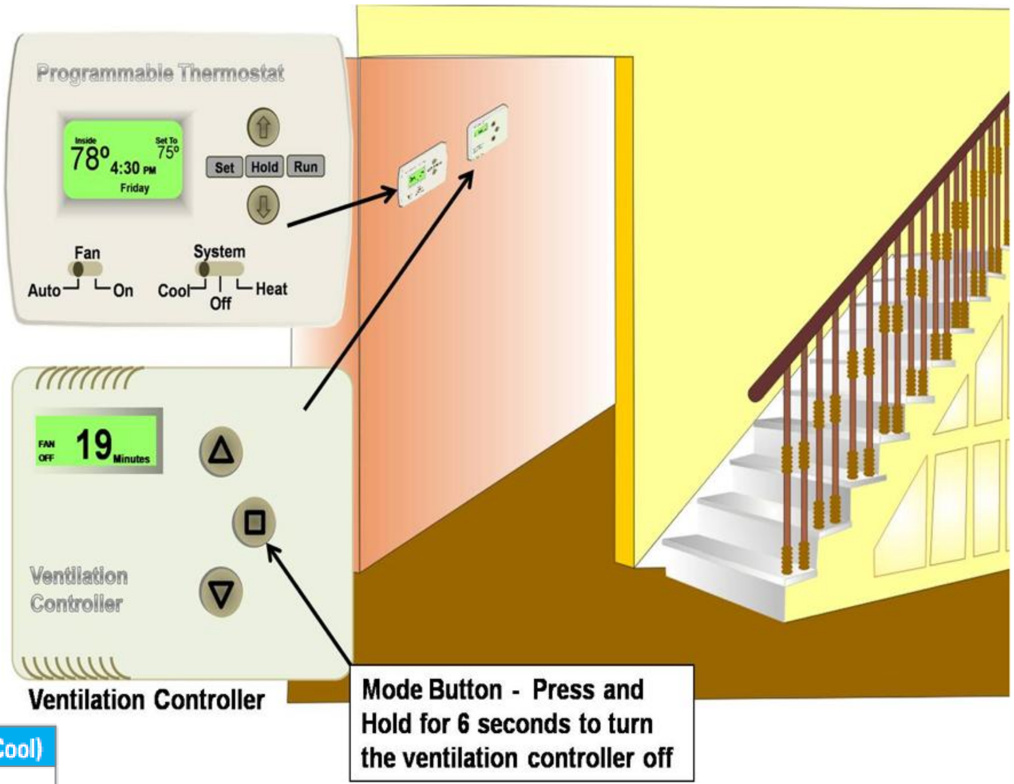
Undercut Doors

Guide describing how to cut the doors at each bedroom ensure a continuous flow of heating and cooling even when the doors are closed.

4.6 CONTROLS

- **Programmable thermostat**
  - Install Energy Star rated programmable/ setback thermostats in the hallway with recommended temperature for heating and cooling season.
- **Carbon Monoxide (CO) and Volatile Organic Compound (VOC) overrides**
  - Install controls that regulate fan speed based on the level of VOC and CO concentration in a space to promote Indoor Air Quality.
- **Clearly label ventilation controls for occupants with Energy Star recommended temperatures (pictured below)**

Greenheck VOC Controls



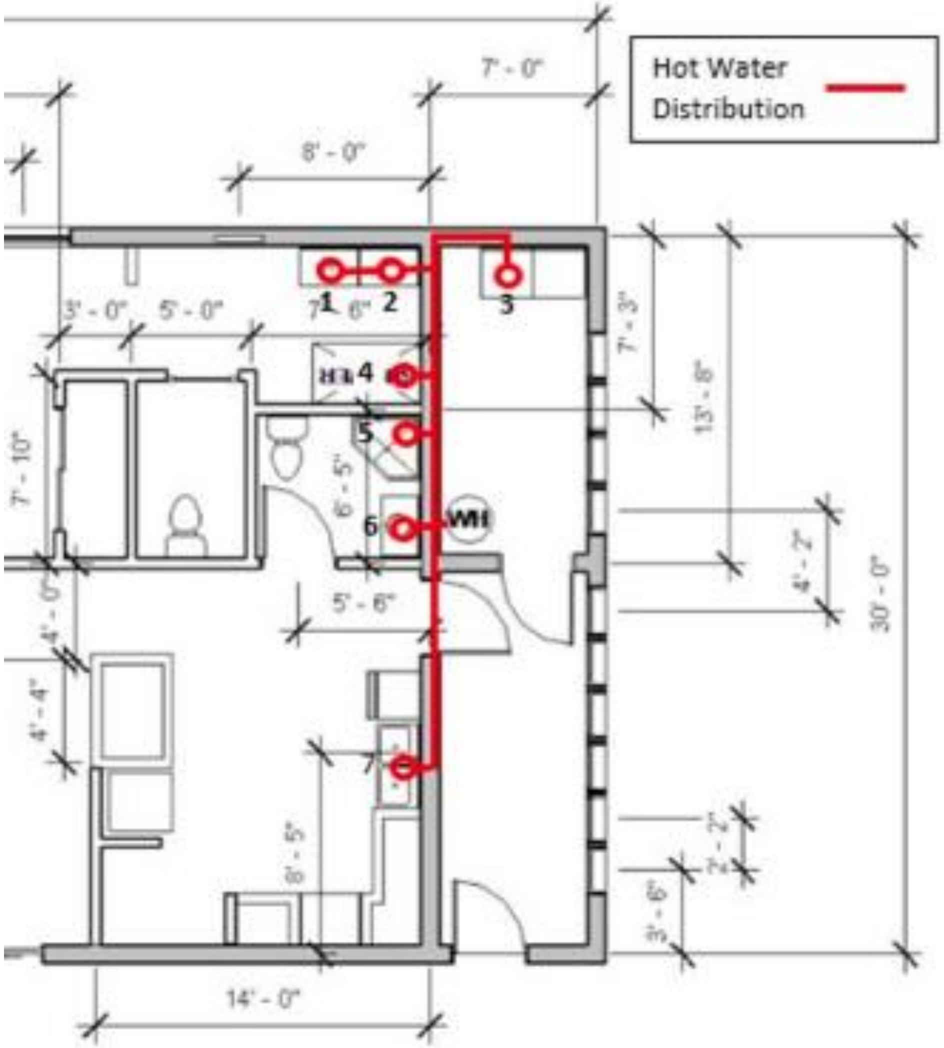
Setting	Time	Setpoint Temperature (Heat)	Setpoint Temperature (Cool)
Wake	6:00 a.m.	< 70° F	> 78° F
Day	8:00 a.m.	Setback at least 8° F	Setup at least 7° F
Evening	6:00 p.m.	< 70° F	> 78° F
Sleep	10:00 p.m.	Setback at least 8° F	Setup at least 4° F

5 PLUMBING

5.1 Code Minimum

5.2 Domestic Hot Water Design

5.3 Efficient Fixtures



5.1 CODE MINIMUM

- Water use and release from homes must work in harmony with the natural flows of the site and its natural environment and 100% of the projects water must come from rainwater catchment or from closed loop water systems, purified without the use of chemicals.
- All stormwater and water discharge, including grey and black water must be treated onsite and managed through re-use, closed loop system, or infiltration.
- All hot water pipes must be 3/8” to reduce wasted hot water with 1” R-4 insulation around the pipes.
- All hot water fixtures must be located near the Water Heater tank (example below) to reduce wasted hot water in transit.

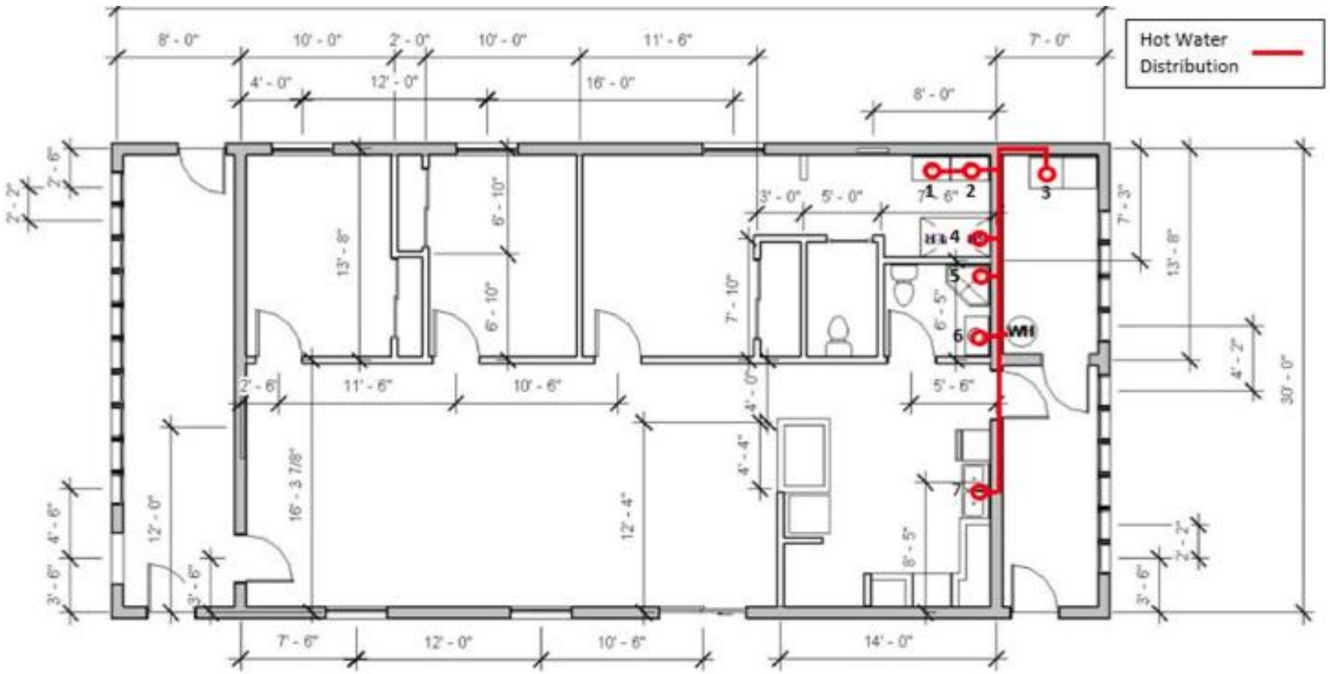


Figure 24. Hot water distribution layout

#1-7: Hot water fixtures

5.2 DOMESTIC HOT WATER DESIGN

Hot Water Distribution

- Use a Trunk and Branch design for hot water distribution.
- Use 3/8" copper pipes for trunks and branches.
- Adjust incoming water pressure to 60 PSI with a pressure regulator prior to entering the water heater to avoid equipment damage.

Pipe Insulation

- Insulate pipes with 1" thick R-4 closed-cell elastomeric insulation.

Closed-cell elastomeric insulation on copper pipes

5.3 EFFICIENT FIXTURES

Bathroom sink faucets

- WaterSense Labeled, Less than 1 gpm.

Kitchen sink faucets

- Swivel aerator with a pause valve.

Shower head fixture

- Evolve 1pgm or less.

Toilets

- ToTo brand 1.28 gpf or less, PVC-free.

Recommended Product		Product Brand and Source
Toilet/Water Fixtures	Eco Drake 1.28 gpf Toilet, PVC-Free	TOTO USA (Georgia)

6 LIGHTING AND APPLIANCES

6.1 Code Minimum

6.2 Built-In Entertainment

6.3 Controls and Energy Monitors

6.1 LIGHTING AND APPLIANCES, CODE MINIMUM

- Replace appliances for only EnergyStar rated lights and appliances such as refrigerators, dishwashers, clothes washers and bathroom fans.
- For Cooking, replace all cooking stoves with Induction Stoves.




APPLIANCE	ENERGY STAR MIN. STANDARD (EFS=Exceeds Federal Standard)	BEYOND ENERGY STAR
Refrigerator	EFS by 20%	Frigidaire & Miele models EFS by up to 33%. SunFrost RF-12 (locally manufactured) EFS by 46%
Dishwasher	EFS by 41%	Bosch & Asko models EFS by over 141%
Clothes washer	EFS by 37%	Whirlpool, LG, Samsung models EFS by over 110%

6.2 BUILT-IN ENTERTAINMENT EQUIPMENT

- Built-in entertainment centers shall be installed in the living room of every home to promote the use of Energy Star Televisions and Built-in speakers.

Samsung
UN58H5005AF, UN58H5202AF

MSRP	$799.99
Screen Size	58
Resolution	1920 x 1080
Display Type	LCD
Automatic Brightness Control?	Yes
Annual Energy Use (kWh)*	70
Annual Cost to Operate**	$8

Features:

- Full HD 1080p Reveals a More Stunning TV Experience
- Enjoy the Details in Fast Moving Images with Clear Motion Rate 120
- Experience a Better Color Spectrum with Wide Color Enhancer Plus

Samsung
UN55J6200AF, UN55J6520AF

MSRP	$699.99
Screen Size	54.64
Resolution	1920 x 1080
Display Type	LCD
Automatic Brightness Control?	Yes
Annual Energy Use (kWh)*	69.3
Annual Cost to Operate**	$7.97

Features:

- LED TVs perform well in all lighting conditions
- 1080p resolution for stunning HD images
- Motion Rate 120
- Smart TV delivers a huge world of entertainment
- ConnectShare Movie
- Intelligent energy management

Energy Star Televisions

6.3 CONTROLS AND ENERGY MONITORS

LIGHTING

- Install light switch dimmers on interior lights.
- Install motion sensors on outdoor lights that automatically turn on when people walk by the home and automatically dim to low light levels when no motion is sensed. Connect these lights with photocell sensors that automatically turn on when the sun is setting and turn off when the sun is rising.

ENERGY MONITORING

- Install *Canary Instruments* Energy Monitor, or equivalent, in common area of each home to visualize real-time home energy consumption.

7 HEALTH AND MATERIALS

7.1 Code Minimum

7.2 Red List Materials

7.3 Wood Products

7.4 Entryway Design

7.5 Non-Toxic Paint

7.6 Finishes, Caulks, Sealants

7.7 Thermal and Moisture Control

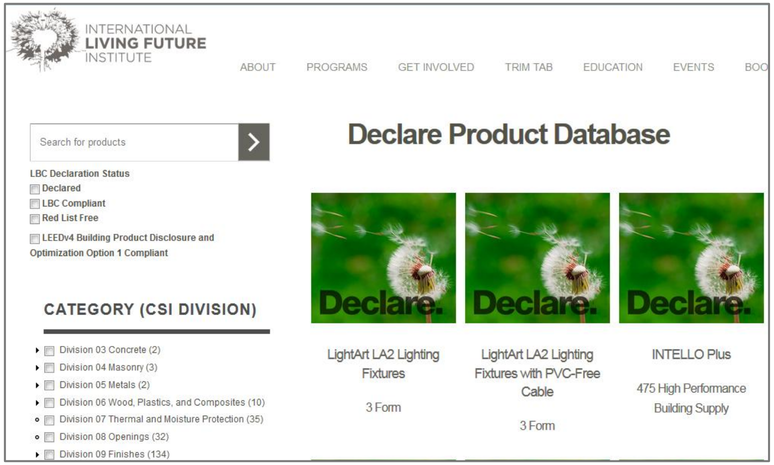
7.8 Flooring

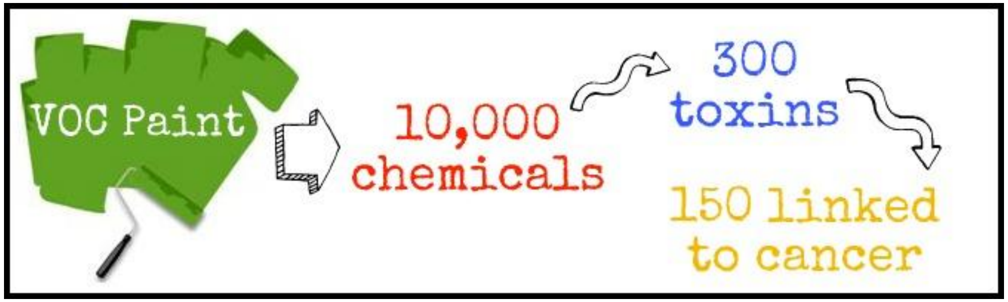
7.9 Pest Control

7.10 Recommended Product List

7.1 HEALTH, CODE MINIMUM

- No-VOC Paints to be used in construction.
- No Formaldehyde products to be used in construction.
- Design to comply with ASHRAE 62.2, and Balance air systems within 25% of ASHRAE standards.
- Results from Indoor Air Quality test must pass before occupancy and nine months after occupancy.
- Smoking is prohibited within the project boundary.
- Do not install building materials with visible signs of water damage or mold.
- Do not enclose interior walls when insulation or framing members have high moisture content.
- Install a corrosion-resistant drain pan properly draining to a conspicuous point of disposal.
- Use corrosion resistant fasteners and hardware stainless steel, hot-dipped galvanized, and ceramic-coated products.
- Reference the International Living Futures Institute Declare Products Database for approved products to be used in Construction that include transparent product ingredients, source, and recyclability ratings (***https://living-future.org/declare-products***)





7.2 RED LIST MATERIALS

- Materials will be found on the "Declare Products" Database. This database provides the chemical content of each product provided by the manufacturer to keep harmful toxins out of the home.
- The following "Red List" contains a list of (11) materials, chemicals and elements known to pose serious risks to human health and the natural environment. For this reason, these materials shall not be purchased for the project.

- Alkylphenols
- Asbestos
- Bisphenol A (BPA)
- Cadmium
- Chlorinated Polyethylene and Chlorosulfonated Polyethlene
- Chlorobenzenes
- Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs)
- Chloroprene (Neoprene)
- Chromium VI
- Chlorinated Polyvinyl Chloride (CPVC)
- Formaldehyde (added)
- Halogenated Flame Retardants (HFRs)
- Lead (added)
- Mercury
- Polychlorinated Biphenyls (PCBs)
- Perfluorinated Compounds (PFCs)
- Phthalates
- Polyvinyl Chloride (PVC)
- Polyvinylidene Chloride (PVDC)
- Short Chain Chlorinated Paraffins
- Wood treatments containing Creosote, Arsenic or Pentachlorophenol
- Volatile Organic Compounds (VOCs) in wet-applied products[22]

7.3 WOOD PRODUCTS

- At least 50% of all structural wood used on each home shall be sustainably harvested from local sources and/or FSC-Certified wood.

Additional Recommended Products		Product Brand and Source
Wood	REII Landscaping Fence	The Reuse Everything Institute (Pennsylvania)
Wood	Nordic Joist, Nordic Lam, Nordic X-Lam	Nordic Engineered Wood (QC, Canada)

7.4 ENTRYWAY DESIGN AND SHOE STORAGE

- At the entryway of each home, design a built-in shoe rack to reduce the likelihood of tracking contaminants into the home. The design on the left can be a simple add-on, where the honeycomb design on the right is a more custom built-in storage option inspired by nature.

7.5 NON-TOXIC PAINT

PAINT:

- Use No-VOC *Milk Paint* throughout Interior and Exterior of the home. The definition “Zero-VOC” still allows products to contain 5 grams of toxic chemicals or every liter of product, but Milk Paint truly contains No-VOC’s.
- Local milk (i.e. Humboldt Creamery) is recommended.

The Genuine Old-Fashioned Home-Made MILK PAINT

Naturally *safe* Historic Paints since 1974

ADVANTAGES

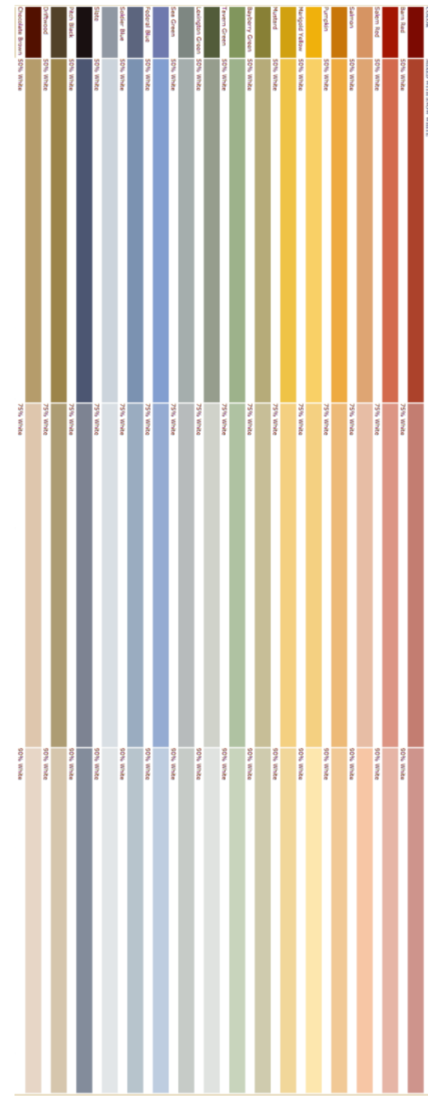
Produces an authentic Colonial or Shaker finish	Adheres to almost all clean, porous surfaces
Environmentally safe, non-toxic and anti-bacterial	Non-flammable
Dead flat finish.	Solvent free
Fast drying	Odorless when dry
Comes in deep rich colors	Longest lasting paint known
Colors can be blended, by the user, to produce many tints and shades.	Permanent colors; will not fade
Easily cleaned up with water	

PHYSICAL CHARACTERISTICS

Color: Comes in sixteen historical colors. Also available as a translucent base to which pigment can be added for an infinite variety of hues, tones and shades.	**Non-Flammable**
State: Dry Powder	**Non-Combustible**
Mixing Medium: Water	**Environmental Safety**: Biodegradeable and non-toxic
Mixing Temperature: Mixes best with warm water	**Thinner**: Water
VOC's: None - entirely solvent free	**Clean Up**: Soap and Water
Odor: Faint milky odor when wet, odorless when dry	**Drying Time**: Dry to the touch, 30 mins To re-coat, wait two hours. Cures and hardens over time.
Shelf Life: In sealed bag, indefinitely. As liquid, overnight, seal and refrigerate.	

AVAILABLE SIZES

one pint	6 oz. powder, plus water	covers approximately 35 square feet
one quart	12 oz. powder, plus water	covers approximately 75 square feet
one gallon	48 oz. powder, plus water	covers approximately 300 square feet



7.6 FINISHES, CAULKS AND SEALANTS

CAULKS AND SEALANTS:

- Use Zero-VOC caulks and sealants throughout. If these products cannot be found, use Low-VOC products.

CABINETS, PARTICLEBOARD, ETC.

- Utilize third-party certified low-emission pressed wood materials that are designed to reduce human exposure indoors to individual VOCs.
  - Beware: Particle board and pressed wood materials commonly use formaldehyde. Purchase No formaldehyde products only.

Recommended Product		Product Brand and Source
Wood	Cabinets	Neil Kelly Cabinets (Portland,OR)
Wood	Collins Pine FreeForm Particleboard	Collins Companies (Oregon)

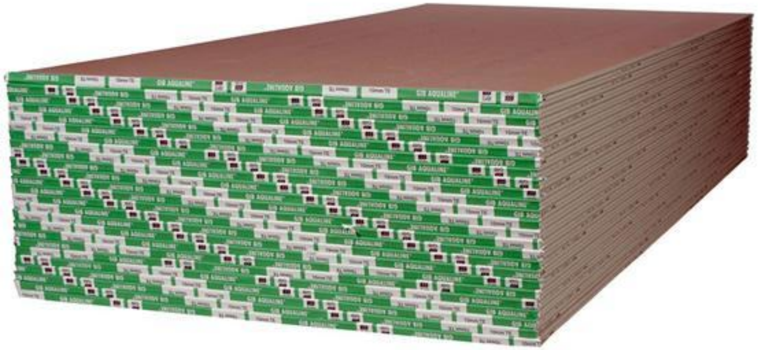
7.7 THERMAL AND MOISTURE CONTROL

- **Seal all homes with No-VOC or Low-VOC Joint and Seam Filler thoroughly to seal building envelope.**

Recommended Product		Product Brand and Source
Thermal and Moisture Protection (Home Exterior)	WrapShield SA Self-Adhered System (A primerless self-adhered water-resistive vapor-permeable air barrier sheet membrane system with liquid flashing, 20 year warranty)	VaproShield (Chicago, USA)
Thermal and Moisture Protection	Prosoco R-Guard Joint & Seam Filler, FastFlash, Cat 5, AirDam, Cat 5 Rain Screen	PROSOCO (Kansas, USA)

7.7 MOISTURE CONTROL

- **<u>BUILDING MATERIALS:</u>** Do not install building materials with visual signs of mold.
- **<u>BATHROOMS:</u> Use *GIB Aqualine*** Plasterboard product, or equivalent, 13mm on the bathroom walls for moisture-resistant backing materials under ceramic tile. If using a single fiberglass shower enclosure, there is no need for extra backing material.
- **<u>BATHROOM TUB:</u>** Provide an extra 4” of tile surrounding the shower enclosure to protect walls from future water damage.



Recommended Product		Product Brand and Source
Finishes	10mm, 13mm GIB Aqualine Plasterboard, GIB Braceline/ Noiseline Plasterboard (13 mm GIB Aqualine® is specifically designed for bathrooms, laundries and kitchens. Its water resistant core contains special polymers to help prevent moisture penetration.)	Winstone Wallboards (NZ)

7.8 FLOORING

- Use only resilient flooring throughout the home.
- Entryways shall contain traditional designs by alternating shades of color in the installation, similar to Bear River Hotel tile designs.

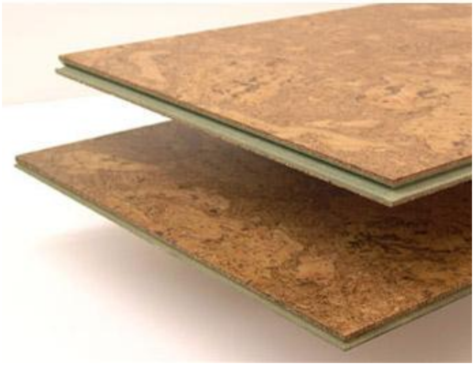
KITCHEN AND BATHROOMS

- Install Ceramic “Green Tile” in Kitchen and Bathrooms with Portland cement-based thin-set mortar and grout OR Marmoleum/ Linoleum sheet floring with Low-VOC adhesive (Recommend Forbo i885m adhesive).

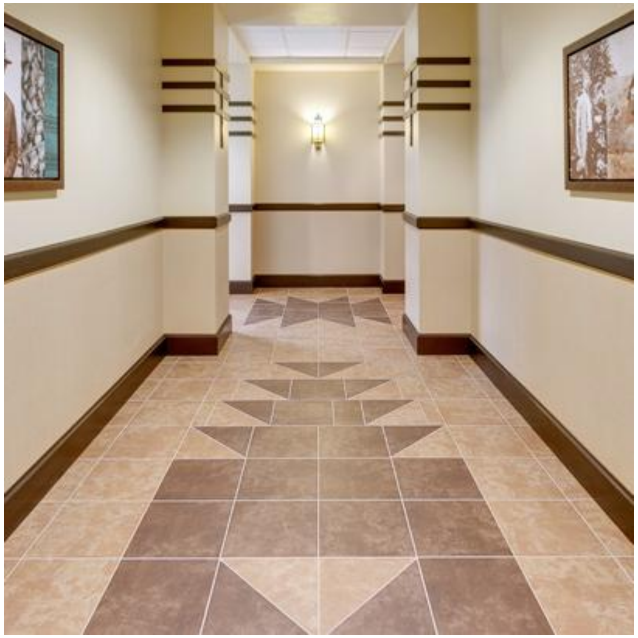
ENTRY, LIVING ROOM, HALLWAYS, BEDROOMS

- Install FSC-Certified locally milled Blue Pine wood with a natural beeswax sealant OR Ceramic Tile for Thermal Mass OR Cork Floors.

Cork Flooring



Soft wood Blue Pine Floors

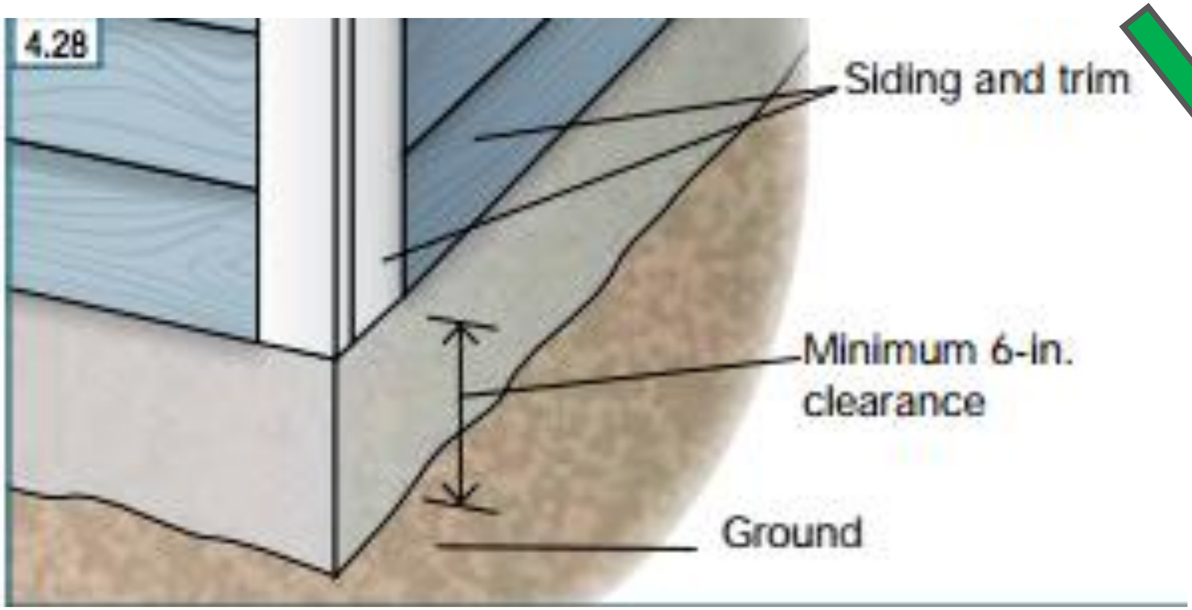


Bear River Hotel tile design in hallway

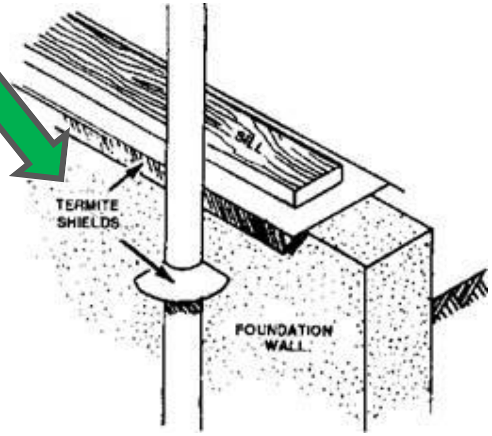
7.9 PEST CONTROL

- Seal all penetrations and joints between the foundation and exterior wall assemblies.
- Install corrosion-proof rodent/bird screens (e.g., copper or stainless steel mesh) for all building openings that cannot be sealed and caulked (e.g., ventilation system intake/exhaust outlets and attic vent openings).
- Add Termite Shield around pipes and penetrations at the foundation level of the home to block termites from crawling up into the home.
- Wall Siding shall be no less than 6” above the ground level to keep wood from rotting and resist pest intrusion.

Termite Shields



Wall siding 6” above ground



Termite Shields

7.10 RECOMMENDED PRODUCT LIST

- **The following products are Approved Declare Products, and are recommended to be used in the New Construction Homes at Bear River.**

Section	Product Type	Brand
Finishes	Exterior Oil	Natural House Company (NZ)
Finishes	ethos Modular Flooring, Powerbond ethos Cushion	Tandus Centiva (Georgia)
Finishes	EcoGrille (FSC Pacific Albus) wood ceiling panel, 1100 Cross Piece Grille/2100 Panelized Linear (FSC Hemlock)	9Wood (Oregon)
Finishes	ECOS WoodShield Interior Stain, Zero-VOC, ECOS WoodShield Satin Varnish, ECOS Interior Wall Paints	Imperial Paints (South Carolina)
Finishes	Linoleum Harmonium xf^2	Tarkett (Italy)

7.10 RECOMMENDED PRODUCT LIST

- **The following products are Approved Declare Products, and are recommended to be used in the New Construction Homes at Bear River…**

Section	Product Type	Brand
Insulation (New construction, use un-faced)	EcoBatt Unfaced, Knauf Insulation IB Board	Knauf Insulation (USA)
Insulation (Attic for new construction)Finishes	GreenFiber Cellulose Insulation	US GreenFiber (USA)
Thermal and Moisture Protection	Havelock Wool Insulation	Havelock Wool (Nevada, USA)
Thermal and Moisture Protection	ENRGY 3 .E- Johns Manville Roofing Insulation Board	Johns Manville (Indiana, USA)

8 PERFORMANCE

8.1 Quality of Installation

8.2 Building Performance Verification

8.1 QUALITY INSULATION INSTALLATION

- **Verification of *Sealed building envelope* prior to exterior walls being enclosed.**
- **Verification of *quality of insulation installation* prior to interior walls being enclosed.**

Some components of QII to highlight include:

Sealing the Air Barrier: Seal all gaps around windows, doors, behind tubs and showers, etc. Caulk or seal all gaps in the air barrier greater than 1/8" with foam.

Correctly Sized Batts: Batt insulation should be cut to fit snugly at the sides and ends without gaps or buckling. It should not double over or be compressed and should be friction fit to cavities, or otherwise supported. Batt insulation should be split to fit around wiring or plumbing, and trimmed to fit around junction boxes.

Required U-factors (& associated R-Values equivalents) for Envelope Systems: Designers shall specify U-factors for assemblies shown in the Residential Appendix. Installers must follow specifications in order to meet QII requirements.

8.2 BUILDING PERFORMANCE VERIFICATION, PRIOR TO OCCUPANCY

- **Building Envelope HERS testing to verify no more than *2.5 air changes per hour @50 psi* through the building envelope.**
- **HERS Blower Door Test to verify *duct leakage less than 6%.***
- **Supply and Return air flow HERS testing with *Duct Blaster Test.***
- **Mechanical Ventilation HERS testing for *refrigerant charge.***
- **Third party verification for rooftop *flashing.***

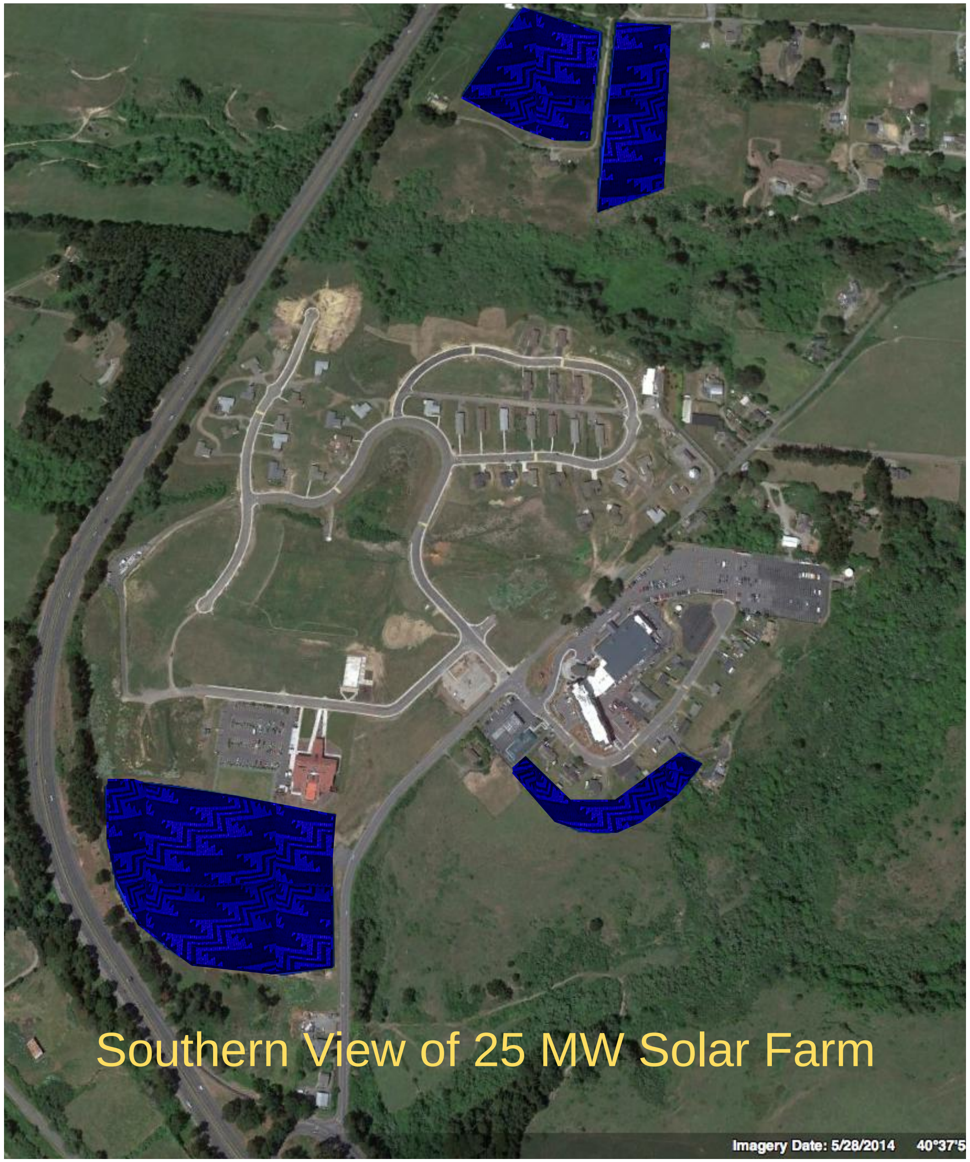
HERS Duct Blaster Test

HERS Blower Door Test

9 RENEWABLE ENERGY

9.1 PV Panels

9.2 Energy Storage



9.1 PV PANELS

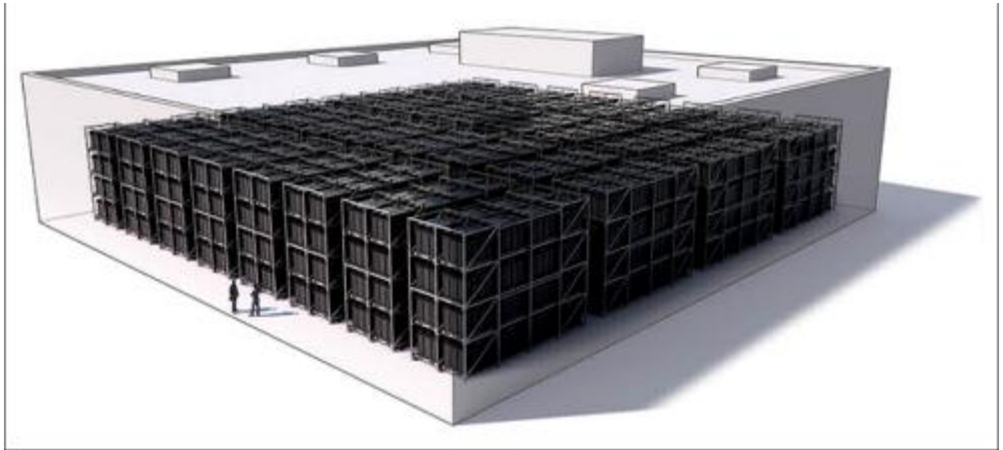
- A 1,500 square foot house requires 12 kW's of PV to supply energy throughout the winter.
- The combined Aquion saltwater battery for each home must be sized to 11.5 kWh's.
- All Solar Panel and Roof Rack Installations shall be completed by Tribal Members after receiving proper training and certification through GRID Alternatives or a similar training and certification program.
  - Recommended installation: Install solar panels in a basket weave pattern along the hillside, much like the Wiyot baskets and basket cap d

Elizabeth Conrad Hickox, Karuk (Karok) / Wiyot, 1872-1947, or Louise Hickox, Karuk (Karok), 1896-1967 Basket
About 1925
Wild grape root, myrtle sticks, hazel, maidenhair fern, yellow-dyed porcupine quills, and stag horn lichen

9.2 ENERGY STORAGE

AQUION ENERGY

The Bear River Band's Renewable Energy Micro-Grid will work in conjunction with Aquion brand deep-cycle batteries for energy storage. The Aquion batteries are non-toxic, saltwater batteries, adaptable to commercial and utility-scale systems like the 12MW energy storage needs of the Bear River Band.



Step 4	Determine Lifecycle cost of ownership				
Type	# Cycles	Wh Storage	Total Wh life of battery bank	Cost of Bank	Cost per kWh
Lead Acid	1500 x	27,789Wh	= 41.6MWh	$8,000	$0.19
Aquion AHI	3500 x	14,033Wh	= 49.1MWh	$8,400	$0.17

Aspen 48M Battery

The Aspen 48M is a parallel string of twelve Aspen 48S batteries configured as a single, palletized battery unit.
They can be connected in series up to 1,000 volts DC.

OPERATION & PERFORMANCE

Chemistry: Aqueous Hybrid Ion (AHI™)
Energy: 25.9 kWh (at a 20 hr discharge)
Cycle Life: 3,000 cycles (to 70% retained capacity)
Operating Temperature: -5 to 40°C ambient Certifications
Nominal Voltage: 48 V
Usable Depth of Discharge: 100%
Round Trip Efficiency: >90%

PHYSICAL CHARACTERISTICS

Dimensions: 1,159 x 1,321 x 1,504 mm (45.6 x 52.0 x 40.0")
Weight: 1,504 kg (3,309 lbs)

CERTIFICATIONS

Cradle to Cradle Certified™ Bronze
UL recognition in process
CE marked

WARRANTY

Limited Warranty: 5-year full plus 3-year prorated

10 EDUCATION

10.1 Resident Education

10.2 Job Training for Tribal Members

10.1 RESIDENT EDUCATION

- **Install Energy Monitors in each home that will provide real-time energy information with immediate feedback to Residents on their energy use. We recommend the Canary Instruments/Nexi device that plugs into the wall outlet and changes colors to indicate High energy use (red), average (yellow) and conservative energy use (green).**
- **The Tribal Council shall provide Community Meetings for Tribal Members twice every month for the first 3-months of occupancy to educate home owners and renters on their new homes. Additionally, provide home owners and renters with a brief packet highlighting the same topics discussed in-person.**
  - Education and Training should include a brief presentation touching on the following topics:
    - Renewable energy, energy storage, energy and water consumption in the home, HVAC and DHW equipment and how it is linked to energy storage and demand, HVAC controls, indoor air quality, and how to maintain the homes.

10.2 TRIBAL MEMBERS EDUCATION

In an effort to promote local job/skills training and opportunities for Tribal Members, the Energy Sovereignty Building Code requires funding be set aside for a Job Training Program for Tribal Members.

- **For all internal work, Tribal Members shall receive priority job opportunities in addition to extensive Green Building Training before construction crews can begin Construction.**
- **At least (10) Tribal Members shall be recruited by the Tribal Council and given the opportunity to participate in an extensive ZNE Building Education Program for at least 1-year geared towards Job Training. Members will be trained and Certified to perform the Construction, mechanical and PV installation work and long-term Maintenance duties for all components of the Building Code.**

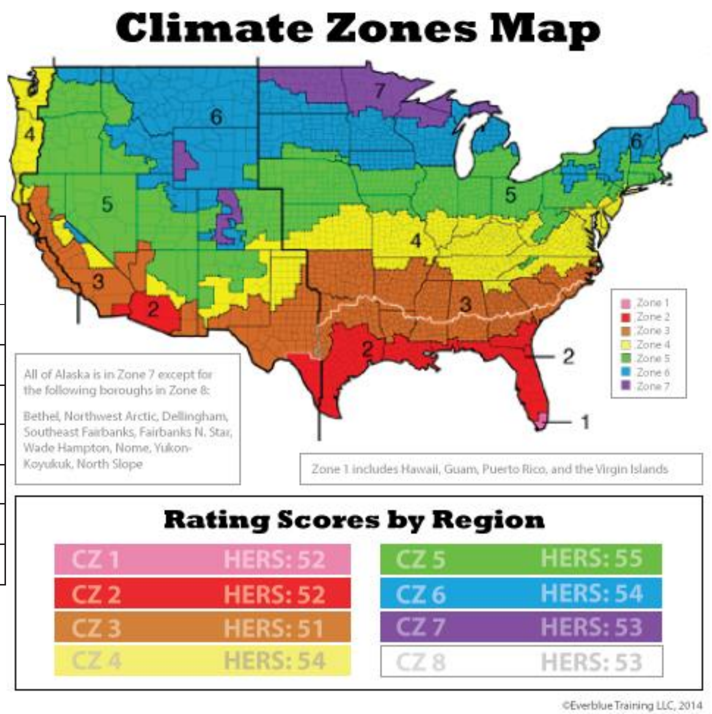
APPENDIX 1: INSULATION RECOMMENDATIONS FOR ALL CLIMATE ZONES

In Northern California, the Bear River Band is in Climate Zone 4 (Marine) as shown the on IECC 2009 Map below. The values in the Table below are the Energy Star recommendations for minimum efficiencies (U-Value) in various components of the home. The lower the U-Value, the more insulated a component is, and is better at resisting temperature differences.

TABLE 402.1.3
EQUIVALENT *U*-FACTORS[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT *U*-FACTOR	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR[d]	CRAWL SPACE WALL *U*-FACTOR[c]
1	1.20	0.75	0.035	0.082	0.197	0.064	0.360	0.477
2	0.65	0.75	0.035	0.082	0.165	0.064	0.360	0.477
3	0.50	0.65	0.035	0.082	0.141	0.047	0.091[c]	0.136
4 except Marine	0.35	0.60	0.030	0.082	0.141	0.047	0.059	0.065
5 and Marine 4	0.35	0.60	0.030	0.057	0.082	0.033	0.059	0.065
6	0.35	0.60	0.026	0.057	0.060	0.033	0.050	0.065
7 and 8	0.35	0.60	0.026	0.057	0.057	0.028	0.050	0.065

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.
b. When more than half the insulation is on the interior, the mass wall *U*-factors shall be a maximum of 0.17 in Zone 1, 0.14 in Zone 2, 0.12 in Zone 3, 0.10 in Zone 4 except Marine, and the same as the frame wall *U*-factor in Marine Zone 4 and Zones 5 through 8.
c. Basement wall *U*-factor of 0.360 in warm-humid locations as defined by Figure 301.1 and Table 301.2.
d. Foundation *U*-factor requirements shown in Table 402.1.3 include wall construction and interior air films but exclude soil conductivity and exterior air films. *U*-factors for determining code compliance in accordance with Section 402.1.4 (total UA alternative) of Section 405 (Simulated Performance Alternative) shall be modified to include soil conductivity and exterior air films.



Bear River Band is in Climate Zone 4 (Marine) on the IECC Map above.

APPENDIX 1 (CONT): INSULATION RECOMMENDATIONS FOR ALL CLIMATE ZONES

In Northern California, the Bear River Band is in Climate Zone 4 (Marine). The values in the Table below are the Energy Star recommendations for all IECC Climate Zones.

Zone	Add Insulation to Attic		Floor
	Uninsulated Attic	Existing 3–4 Inches of Insulation	
1	R30 to R49	R25 to R30	R13
2	R30 to R60	R25 to R38	R13 to R19
3	R30 to R60	R25 to R38	R19 to R25
4	R38 to R60	R38	R25 to R30
5 to 8	R49 to R60	R38 to R49	R25 to R30

Wall Insulation: ***Whenever exterior siding is removed*** on an

Uninsulated **wood-frame wall:**

- Drill holes in the sheathing and blow insulation into the empty wall cavity before installing the new siding, and
- Zones 3–4: Add R5 insulative wall sheathing beneath the new siding
- Zones 5–8: Add R5 to R6 insulative wall sheathing beneath the new siding.

Insulated **wood-frame wall:**

- For Zones 4 to 8: Add R5 insulative sheathing before installing the new siding.

Source: https://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_insulation_table

APPENDIX 3: HVAC RECOMMENDATIONS FOR ALL CLIMATE ZONES

In Northern California, the Bear River Band is in Climate Zone 4 (Marine). The values in the Table below are the Department of Energy's Zero Net Energy Ready Homes Target Home recommendations for HVAC system efficiencies.

Exhibit 2: DOE Zero Energy Ready Home Target Home [7, 20]

HVAC Equipment[21]			
	Hot Climates (2012 IECC Zones 1,2) [22]	**Mixed Climates** (2012 IECC Zones 3, 4 except Marine)	**Cold Climates** (2012 IECC Zones 4 Marine 5,6,7,8)
AFUE	80%	90%	94%
SEER	18	15	13
HSPF	8.2	9	10[23]
Geothermal Heat Pump	ENERGY STAR EER and COP Criteria		
ASHRAE 62.2 Whole-House Mechanical Ventilation System	1.4 cfm/W; no heat exchange	1.4 cfm/W; no heat exchange	1.2 cfm/W; heat exchange with 60% SRE
Insulation and Infiltration			
• Insulation levels shall meet the 2012 IECC and achieve Grade 1 installation, per RESNET standards.			
• Infiltration[24] (ACH50): 3 in CZ's 1-2 | 2.5 in CZ's 3-4 | 2 in CZ's 5-7 | 1.5 in CZ 8			

Bear River Band Rancheria 3 Bedroom Case Study New Construction Home

Renewable Energy Student Union

U.S. DOE Race To Zero Student Competition Volume I
7/27/16

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"The vision of the Bear River Band of Rohnerville Rancheria is shaping a secure healthy future by responsibly exercising sovereignty, investing in our people, refining and evolving as a tribal organization, preserving and revitalizing our culture while serving the best interests of all people."

Executive Summary

The Bear River Band of Rohnerville Rancheria is a federally recognized tribe composed of the Mattole and Eel River, Bear River and Wiyot people. They are based on 60 acres on Singley Hill in Loleta, California. Energy Sovereignty is an important goal for the tribe. The proposed micro-grid would use on-site solar and wind generation with electrical and thermal energy storage to meet all of the Tribe's energy needs. The Tribe's long term goal is to own and control the energy in their micro-grid and disconnect from the PG&E power infrastructure and the CPUC regulatory authority. The energy usage for the Bear River Band of Rohnerville Rancheria, for the years 2013 to 2014, can be seen in Figure 1.

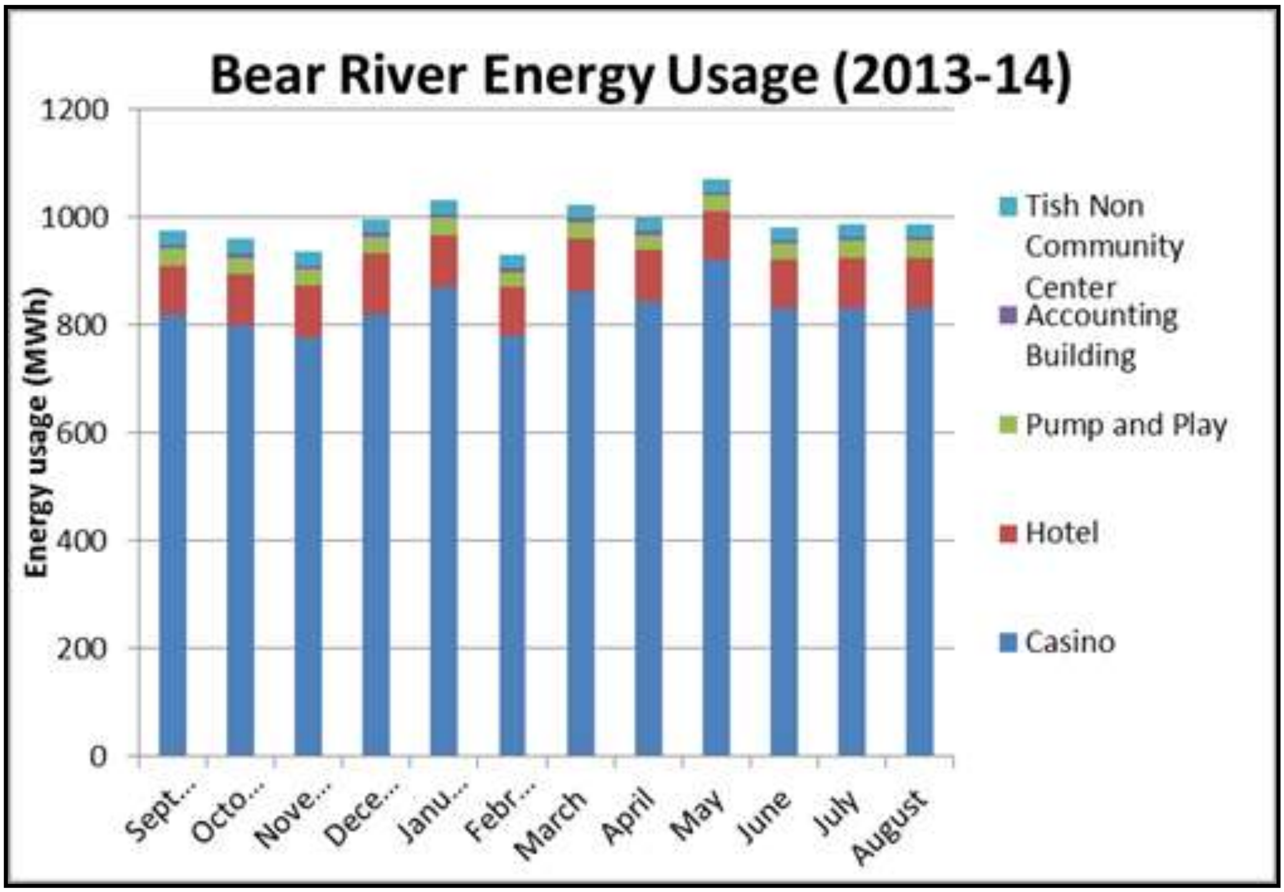

Figure 1. Bear River energy usage for the five main buildings for 2013-2014.

Energy Sovereign tribal housing will be a vital component of the Band's micro-grid, providing needed solar energy to the Tribe during times of excess solar production, but storing enough energy in thermal batteries (the 83 gallons of 190 F water used in the DHW and hydronic HVAC systems) to meet peak loads overnight until the sun returns. Even when sunlight and wind are scarce resources for the Tribe, the houses will be self-sufficient and Energy Sovereign.

As the Bear River Band develops their energy supplies over the next ten years, they will be grid-intertied and able to sell excess energy to meet local demands in the neighboring Humboldt County. Organizers of the local Community Choice Aggregation project, whereby Humboldt County takes on the role of PG&E to develop renewable energy supply, are optimistic that the Bear River Band's wind power resource can be sold under contract to Humboldt County.

Team Qualifications

Course Descriptions and Team Participants

Environmental Resources Engineering

The College of Natural Resources and Sciences offers a Bachelor's of Science degree in Environmental Resources Engineering. The coursework for this major prepares students for a wide variety of professional careers related to designing energy efficient buildings. The department has integrated building application designs into the following courses:

ENGR 313 - Systems Analysis: Microeconomics, systems analysis, and math modeling in environmental resources, allocation, linear and nonlinear optimization. Case studies in resource management.

ENGR 330 - Mechanics & Science of Materials: Physical properties of materials. Analyze stresses and deformations involving elastic behavior of materials. Tension, compression, torsion, and flexure. Combined stresses, static indeterminacy. Beams of two materials.

ENGR 331 - Thermodynamics & Energy Systems I: Thermodynamics' 1st and 2nd laws; thermodynamic properties of materials; thermodynamic processes; system and control volume analysis; application to energy systems.

ENGR 333 - Fluid Mechanics: Fluid properties; fluid statics; flow concepts; control volume analysis; continuity; energy and momentum concepts; boundary layer concepts; drag theory, flow measurements; flow in pipes/ducts; open channel flow; dimensional analysis and similitude.

ENGR 351 - Water Quality & Environmental Health: Water and air quality analysis. Physical, chemical, and biological factors of water and air quality. Introduction to drinking water and wastewater treatment processes. Engineering aspects of communicable disease control and exposure to toxic substances.

ENGR 410 - Environmental Impact Assessment: Enabling legislation that established environmental impact statements; EIS preparation; risk analysis; collecting data and evaluating its adequacy and accuracy; interpreting data; predicting impacts associated with proposed activities.

ENGR 416 - Transport Phenomena: Heat and mass transfer. Pollutant transport and assimilation in the environment.

ENGR 418 - Applied Hydraulics: Pipe networks; transient pipe flow; open channel flow; irrigation, drainage, and flood control; numerical methods for hydraulic analysis.

ENGR 471 - Thermodynamics & Energy Systems II: Continues ENGR 331. Applications of 2nd law of thermodynamics. Irreversibility, availability, power and refrigeration cycles, combustion, and phase equilibria.

ENGR 473 - Building Energy Analysis: Thermodynamics applied to energy analysis of buildings. Heating and ventilating systems; lighting; building envelopes; process loads. Analyze campus buildings.

ENGR 477 - Solar Thermal Engineering: Analyze and design solar thermal systems. Availability of solar radiation; collector operation; system performance; simulation models.

Environmental Science; Energy and Climate Emphasis

The College of Natural Resources and Sciences offers a Bachelor's of Science degree in Environmental Science with an Emphasis in Energy and Climate. The coursework within this major provides students with a foundation in climate-change related sciences not limited to concepts related to the ways that energy is produced and consumed on a societal level. Pertinent coursework within the major is as follows:

ENGR 305 - Appropriate Technology: Engineering technology principles. Energy, waste disposal, food production technologies. Lab exercises involve working systems at Campus Center for Appropriate Technology.

ENGR 371 - Energy Systems & Technology: Intro to key topics and technologies associated with modern energy systems. Covers principles of thermodynamics and electricity and their application to energy systems.

ECON 309 - Economics of a Sustainable Society: Interpret meaning of sustainable economy. Techniques for measuring economic performance using sustainability standard. Analyze domestic and international policies consistent with a sustainable economy**.**

ECON 450 - Energy Economics & Climate Policy: Intro to energy market economics and institutions. Climate-change policies and impacts. Economic tools for reducing greenhouse-gas emissions. Economic analysis of energy efficiency and renewable energy projects.

ENVS 370 - Energy, Technology & Society: Interdisciplinary course in energy, the environment, and society. Focuses on energy and climate change, integrating physical science, social science, and policy dimensions.

ENVS 410 - Environmental Science Practicum: Work locally to develop creative solutions to environmental problems. Critique opportunities and obstacles to innovative decision making.

ENVS 411 - Sustainable Campus: Environmental Science major's capstone. Systematic problem solving framework applied to making the campus sustainable.

CHEM 370 - Earth System Chemistry: Chemistry of the earth, including elemental cycling and speciation in the environment, the impact of man on biogeochemical processes, and the effects of climate change on the chemical/physical interactions occurring within and between the atmosphere, hydrosphere, and biosphere.

WSHD 458 - Climate Change & Land Use: Implications of climate change for terrestrial and aquatic resources. Overview of projected shifts in weather and climate. Influence of land use decisions on global carbon cycle in forests, agriculture and wetlands.

HUMBOLDT STATE UNIVERSITY

Environmental Resources Engineering

March 24, 2016

It has been my honor and pleasure to guide this determined group of students through the 2016 Race to Zero Student Design Competition:

Josue Candelario

Project Lead, Student: Environmental Resources Engineering, Humboldt State University

Josue is a Senior at Humboldt State University, with interests in water reuse technology, natural treatment systems, and building science. He is also part of the Society of Hispanic Engineers which encourages diversity in the engineering field. His past experience including helping in the 2015 American Society of Civil Engineers Water Infrastructure Report Card, and designing a sustainable water treatment unit as part of the American Society of Civil Engineers Wastewater treatment competition. His responsibilities include assessing indoor air quality, designing the domestic hot water distribution system, and choosing energy efficient and water saving appliances.

Andre Bernal

Project Lead, Student: Environmental Resources Engineering, EIT, Humboldt State University

Andre is a senior at Humboldt State University, with interests in building energy analysis, renewable energy technology, and applied hydraulics. He is also part of the Society of Hispanic Engineers which encourages diversity in the engineering field. His past experiences include a veteran of the 2015 ZNE competition, and conducted energy audits at the Bear River Band Rohnerville Rancheria. His responsibilities included overall project lead, energy analysis using REM/Rate and Energy pro.

Noe Martinez

Project Lead, Student: Environmental Resources Engineering, Humboldt State University

Noe is a Senior at Humboldt State University, with interests in promoting sustainable living and design, assisting low income communities, and helping empower the Hispanic Community. He is also part of the Society of Hispanic Engineers which encourages diversity in the engineering field. His past experiences include a being veteran of the 2015 ZNE competition, implemented appropriate technology in the Dominican Republic, and designed a filtration unit as part of the American Society of Civil Engineers Midpac competition. His responsibility include designing the building envelope, and acted as the liaison between RESU and the Bear River Band tribe.

Jacob Hurd

Project Lead, Student: Environmental Resources Engineering, Humboldt State University

Jacob is a senior at Humboldt State University with interests in renewable energy sources, architecture, and mechanical design. His past experiences include an engineering intern for the city of South Lake Tahoe, and research assistant for dielectrophoresis separation of algae in microfluidic devices at the University of Nevada Reno, and student assistant for the Cal-trans District 1. His responsibilities include architectural interior design.

Matthew Megill

Team Member, Student: Environmental Resources Engineering, Humboldt State University

Matthew is a junior at Humboldt state University with interests in zero net energy home design and biomimicry. His past experiences include working on a zero net energy house, which served as a case

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study for Southern California Edison in 2011, researching toxicity and outgassing of various building materials, and volunteering on a solar panel installation for a low income household.

Emily Klee

Project Lead, Student: Environmental Resources Engineering, Humboldt State University

Austin Anderson

Team Member, Student: Environmental Science, Energy and Climate, Humboldt State University

Austin is a senior at Humboldt State University interested in designing sustainable communities. He currently works at the Campus Center for Appropriate Technology (CCAT) which is a local non-profit organization. CCAT is a sustainable demonstration house on the Humboldt State campus.

Joseph Darby Radley

Team Member, Student: Environmental Science, Energy and Climate Humboldt State University

Darby is a senior at Humboldt State University interested in designing community energy systems in rural and low income communities. His past experiences includes redesigning an off-grid photovoltaic system at the Campus Center for Appropriate Technology (CCAT).

I hereby certify that all student team members listed above have completed the DOE Building Science Training course online and received certification.

Signature

3/24/2016

Date

Faculty Lead

Douglas Saucedo is a research engineer at the Schatz Energy Research Center and a visiting faculty member in Environmental Resources Engineering at Humboldt State University. His research interests include electric transportation, distributed power systems, microgrids, and renewable energy.

Doug holds a bachelor's degree in Environmental Resources Engineering from Humboldt State University, a master's degree in Mechanical Engineering from the University of California at Davis, and an Engineer in Training certificate in California. He plans to earn a doctorate of engineering and professional engineering license.

Industry Advisor

Sean Armstrong taught net-zero design at a demonstration house at Humboldt State University from 1999-2002, and has 12,000+ hours of experience as staff Project Manager with affordable housing developers Pacific Communities, Danco Communities, and the Redevelopment Agency of the City of Arcata. Sean was the first developer to use the California Utility Allowance Calculator (CUAC).

Community Advisors

Aileen Meyer- Bear River Band Secretary

Affiliated Students

- Troy Smith, Environmental Resources Engineering
- Maria Diaz, Environmental Resources Engineering
- Karl Harris, Environmental Resources Engineering
- Emily Higbee, Environmental Resources Engineering
- Casey Novell, Environmental Science, Energy and Climate
- Danny Ulhar, Environmental Science, Energy and Climate
- Courtney Brown, Environmental Management and Protection
- Brynn Allen, Film Major

Industry Partners

The team would like to give special acknowledgment to each and every one of the industry partners who assisted with the process that brought this dynamic project to culmination.

Redwood Energy

Redwood Energy is America's leading ZNE design firm, with thousands of ZNE-effort houses and apartments built since 2011, including more than 600 built to the Builder's Challenge/Challenge Home/Zero Energy Ready Home standards.

This project has been designed in conjunction with a contract procured by Redwood Energy to provide a path to energy sovereignty for the Bear River Band.

UNICO Company

The UNICO company, located in Arnold, MO, provided multiple analyses regarding HVAC system sizing and selection. The UNICO company used the Manual J8 calculation method to determine the appropriate size, and suggest a model HVAC system to be used for our final design. The UNICO company uses Wrightsoft software to perform their heating load calculations.

EnergySoft

EnergySoft, located in Novato, CA, provided the team with a temporary license for the EnergyPro 5.1 software used to perform home energy rating calculations (HERS).

Wrightsoft Corporation

WrightSoft Corporation provided the team with a temporary license for the Right-Suite Universal software used for heating load calculations. The heating load calculations were used to determine the appropriate size HVAC system to be integrated into the design of the home.

Design Constraints

The design of the house is based off the vision of the Bear River Band tribe leaders and how they see future homes being built in their community. On March 2, 2016 a community meeting was held to present the preliminary design and hear any concerns about the project. Aileen Meyer, a member of the Tribal council, expressed concerns on the use of radiant floor heating, and metal roofing. Radiant floor heating is considered a luxury by the community, and installment is discouraged due to lack of local expertise on proper maintenance and operation. Metal roofing is also discouraged in the area due to high winds that create uncomfortable noise for the occupants. Furthermore, they wanted to be energy sovereign homes so they requested large solar panels connected to batteries that will provide self sufficient homes for several days and net positive homes for the remainder of the days going beyond zero net energy ready homes criteria.

Community Meeting

A community meeting to present the preliminary design and hear concerns was carried out in the Bear River Band of the Rohnerville Rancheria community center on March 2, 2016. The architectural design incorporates several of ideas and concerns raised by the community.

The presentation was conducted during a community lunch and was carried out to understand their opinion about the design. The initial design included a circular window to appeal to the region's Native culture. This design selection was consulted with the community who appreciated the detail and did not oppose its use. Several members had significant input about their current houses and aspects they disagree with such as radiant floor heat and metal roofing. Leaders of this community such as Aileen Meyer, a member of the Tribal Council, and Manny, a local contractor, voice their discontent with the metal roofing due to the high winds in this area. Other important concern was the intensity of wind-driven rain and the issue it had in mold problems. The orientation of the structure was discussed and the members agreed that considering a structural detail to indulge in witnessing the sunset and sunrise is important to the community. This comments were considered and help cement the selections of constraints.

Design Goals

The Bear River Tribe has set a goal of 100% renewable energy sovereignty for their Tribe. The Tribe has an existing pilot study that encorporates wind and solar powered microgrid with battery storage to power their community facility. The tribal council is expanding on this pilot project to develop a 100% renewable energy microgrid for all owned buildings: community buildings, commercial buildings, wastewater treatment, and their residential housing.

The design goal of the proposed energy sovereign tribal housing is that these houses are a net-positive contribution to the microgrid, and never rely on the microgrid--they are either producing renewable energy or relying on stored energy. In this cloudy, cool maritime microclimate the design goal oriented the design to meet the peak loads, which are in the winter, and to be able to create thermal energy at all times with a compressor, never electric resistance.

This directed the DHW design towards a CO_2 heat pump, which do not use electric resistance back-up, and we integrated hydronic space heating to make dual use of the resulting resource of high-temperature water (160 F). This 83-gallon tank of 160 F water also provides sufficient thermal storage energy for the ~18 hours between the mid-day solar window when the tank can regenerate thermal energy with the electric compressor running off the energy from the PV solar array.

Electrical storage is supplied by salt-water based Aquion batteries, which are long-lasting and safe to store as well as being among the most cost-effective batteries per kWh stored. This storage is also sized for the 18-hour period between 3pm and 9am to ensure that all electrical needs can be met between daily influxes of solar energy from the roof without taxing the microgrid. Conservation of energy is key, and the Canary Instruments are provided to each residence to provide color-coded guidance to residents about their energy budget and usage to ensure they can manage their consumption and ensure Sovereignty over their energy.

Children and Tribal Elders are highly valued members of the Bear River Band, and great effort was made to ensure a safe, comfortable environment. This effort included local FSC-certified local flooring with a food-grade penetrating sealant true linoleum in the bathrooms and kitchen so infants are inhaling and touching safe surfaces. Additionally, all the building dimensions are

ADA compliant and designed to the Universal Design standards to safe encourage aging in place. Ventilation is designed for the safety of all residents, with additional make-up air to ensure ventilation systems provide clean, filtered air.

Architectural Design

The house is generated from Autodesk Revit 2016. The house is a simple detached house to keep the construction cost low so it will meet affordable tribal housing criteria. Various design elements are integrated into the house for the cultural significance of the tribe's traditional housing. Traditional houses were built with a west facing entry which is in a round opening, a large common area for living and dining, and a gable roof. Other design elements are due to weather conditions of the site, conservation desires and requests by the tribal members. Bear River Band experience strong wind carry rain that blows west to east and the tribal members want a spot to watch the sunrise and sunset. To meet the request of the tribal members the design has a front and rear solarium that provides excellent viewing for both sunrise and sunset while being protected from the frequent rainstorms. There is a round window across from the front door and the floor plan is a large open plan with the bedrooms right of the living space that is a reference to the tribe's traditional housing. To conserve hot water, the house has all the water facets grouped along one wall and the electric appliances were used to eliminate the need of natural gas. Although, this design is set with the front facing west, the design can be easily mirrored to face east for the houses across the street, the tribal members approved this alteration.

Constructability

Construction Schedule

The construction of the home is planned to be implement in an estimated 9 months. The house design is part of an expected 25 house project which is being planned with the Bear River Band. Each component was analyzed and time of implementation was estimated using a sample residential schedule for a 6,000 sq. ft. project. Comparison with a larger project provides a less conservative timeline which help with unplanned events which affect the progress of a building project. A detailed construction schedule is included in Volume II with the construction steps divided by different house sections. The schedule incorporates the preliminary work required before construction than covers task required for foundation, frame, HVAC, roof, plumbing, electrical, exterior and interior, and small details. Scheduled inspections are included when required but are the task considered most ambiguous item.

Financial Analysis

Assumptions

The Bear River Tribe is not required to adhere to all of the standards set by the United States government. According to the Bureau of Indian Affairs, a "federally recognized tribe is a tribal entity that is recognized as having a government to government relationship with the United States, with the responsibilities, powers, limitations and obligations associated with that designation". Since the Tribe has this recognition they have the right to govern themselves as they see fit. Although they are a sovereign Tribe, the tribal members still have the ability to benefit from certain federal programs, services, and protections which are contingent on the nature of their relationship with the United States. As stated in the executive summary, "the vision of the Bear River Band of Rohnerville Rancheria is shaping a secure healthy future by responsibly exercising sovereignty, investing in our people, refining and evolving as a tribal organization, preserving and revitalizing our culture while serving the best interests of all people". This was an integral part of the design and analysis because there are certain policies and fees included in the financial costs spreadsheet do not apply to them due to their rights as a sovereign Tribe. In line with their vision, it is important that they continue to invest in their people in ways that are economically viable and in the best interest of their tribe. Providing homes for those in their community creates and fosters a sense of community and provides a means to preserve and revitalize their culture through serving the community.

Building and construction costs were found in RSMeans unless otherwise noted in the justifications. These outside sources were either provided initially in the original justifications for the NAHB 2103 estimate or they were researched to align better and be more representative of the costs incurred in Humboldt County, Ca rather than on the national scale. Due to the remote location, the costs of most goods and services fluctuate depending on the distance from the project site, and discussed in the construction costs summary.

Construction Costs Summary

Designing a home for a Tribe provides economic savings that allow us to save residents money by avoiding state and federal property taxes and impact fees. It is important to us that the construction of this home, not only benefits residents but also benefits the Tribe as a whole, so we are purchasing local construction materials wherever possible. Buying local products reduces shipping costs and strengthens local economies. The flooring we are using is sustainably harvested Douglas Fir from the local forest and the paint we are using is made using milk purchased from Humboldt Creamery, which is located only a few miles from the project site in Fortuna, Ca.

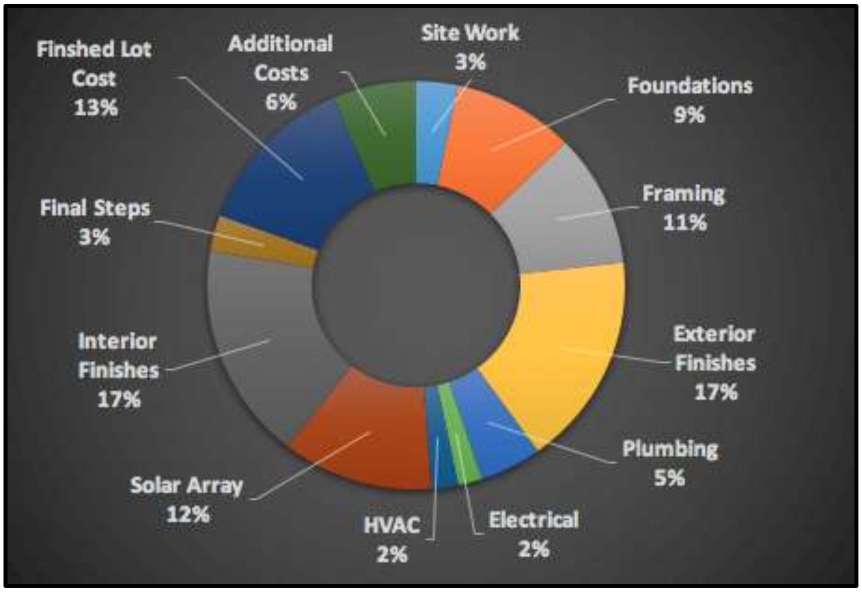

Figure 2. Capital cost pie chart.

Figure X. Breakdown of construction cost for the home. Each slice represents a percentage of the total cost of the home, $273,987.

The construction cost for the home comes out to $235,769 with a total cost of $273,987 which means affordable monthly payments of $851. The average price for a home in Humboldt County is $257,600, which is only about 10% less than the price of our home. This small additional cost provides residents with dramatically improved indoor air quality and complete energy sovereignty.

Table 1. Summary of financial costs.

Affordability	Cost ($)
Monthly Income	3975
Monthly Household Debt	240
Operations and Maintenance Costs	183
Monthly Utility Costs	36
Property Tax	N/A
Insurance	80
Mortgage Payment	860
Total Expenses	**1390**
Debt to Income Ratio	**35%**

Maintenance Costs

The maintenance costs associated with the PV system and the appliances installed in the home will be covered by the tribe as they arise. This analysis will not be included because the homeowner themselves will not be responsible for the costs incurred as replacements or repairs are needed. Due to different rates of usage by an individual the length of time each appliance is variable and thus difficult to analyze. The tribe's economic investment in their people is such that they make long-term decisions and these decisions are continuous, this is reflected above in the construction costs summary.

Table 2. Construction Costs Summary.

Year	Cost ($)	Yearly Payment ($)
0	275187	27399
1	247788	15138
2	232650	15138
3	217511	15138
4	202373	15138
5	187235	15138
6	172096	15138
7	156958	15138
8	141820	15138
9	126681	15138
10	111543	15138
11	96405	15138
12	81266	15138
13	66128	15138
14	50989	15138
15	35851	15138
16	20713	15138
17	5574	15138
18	-9564	15138
19	-24702	15138
20	-39841	15138

Payback Period

The total cost of the house is $275,187 with an annual payment from the occupants of $15,138. The yearly payment for the house considers the 7,425 kwh of electricity produced per the solar panels at a rate of $0.182/kwh. The 0th year of ownership includes the down payment for the house. The payback period shows that it would take 17 years for the occupants to pay off all total costs. This means that the occupants will pay off their loans 13 years earlier than anticipated based on the 30-year mortgage per the guidelines.

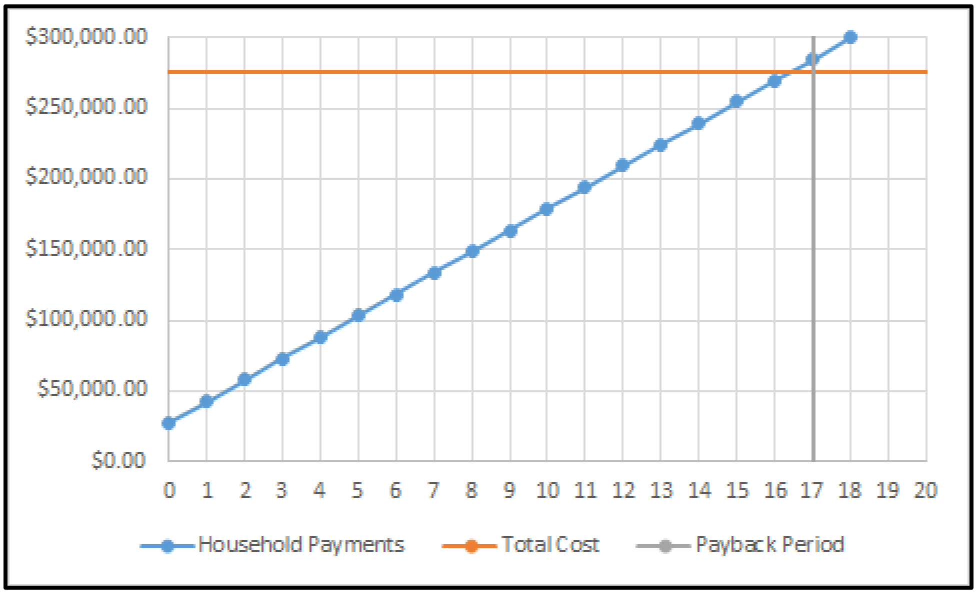

Figure 3. Payback period.

Energy Analysis

Software Used

Energy Pro RM 5.1

The software Residential CalRatePro V5.1 by EnergySoft was developed with CalCERTS to perform home energy rating calculations (HERS) for existing homes within California. This program will provide a HERS index that pinpoints how energy efficient the home is, and provides an economic analysis based on the inputted specifications. When using this software, it is possible to compare and contrast different alternatives for appliances and products being used within the home based on the HERS indexes that it provides. This software is used frequently within the energy field in California and is the reason that it was chosen as a comparative platform for this project (EnergySoft, 2014).

CEC-PV Calculator

This tool is used to input the monthly energy production of the system to the Energy Pro software analysis. The CEC-PV Calculator incorporates detailed inverter performance modeling and uses weather data from the 16 climate zones in California (as used by the Title 24 compliance calculations) (CEC, 2016). With inputs It provides the incentive value

REM/Rate

REM/Rate is one of the industry standards for HERS ratings and both home energy analysis and weatherization. This software was provided for use by the Department of Energy in this competition. In addition, REM/Rate works in conjunction rebate programs for energy efficiency in residential buildings (NORESCO, 2016).

HERs Index

The Home Energy Rating system also known as the HERs Index is a standard used to measure the energy efficiency of the building. The benefits of performing a home energy rating on a home are home operation efficiency and generate recommendations for modifications for energy savings (RESNET, 2016).

We decided to create and compare energy models in both EnergyPro and in REM/Rate for the purpose of this competition. With help from an industry sponsor, EnergySoft, it was possible to use EnergyPro CalRatePro V5.1 to complete part of the energy analysis. This decision was the product of the majority of the students participating in the Energy Analysis section will go on to work in California and ultimately use their software. As this competition is on a national scale, most groups will be using REM/Rate. We felt that it was necessary to also produce an energy model with REM/Rate in order for the judges to compare our analysis and findings to other groups in at the same scale. Both HERS indexes provided by both CalCERTS and REM/Rate are included and analyzed below.

Photovoltaic Design

The photovoltaic (PV) design uses high performance Sunpower Equinox system and Aquion battery storage. The south-facing roof is fully utilized with 33 modules rated at 11.88 kW DC for maximum energy production and coupled with a battery size of 5 S-line stack Aquion batteries rated at a load of 11.5 kWh. In comparison to conventional Solar Cells, SunPower Maxeon products produce 55 percent more energy within the first year of operation. Each cell contains a thick, vigorous connector, with unpredictable temperature changes, and a copper-backed design to help reinforce cell strength and corrosion resistance. Behind each panel are built-in micro-inverters to maximize energy production as can be seen in Figure 4.

Electrical Data	
	SPR-X22-360
Nominal Power (Pnom)[11]	360 W
Power Tolerance	+5/-0%
Avg. Panel Efficiency[12]	22.2%
Rated Voltage (Vmpp)	60.6 V
Rated Current (Impp)	5.94 A
Open-Circuit Voltage (Voc)	69.5 V
Short-Circuit Current (Isc)	6.48 A
Max. System Voltage	600 V UL & 1000 V IEC
Maximum Series Fuse	15 A
Power Temp Coef.	−0.30% / °C
Voltage Temp Coef.	-167.4 mV / °C
Current Temp Coef.	3.5 mA / °C

Operating Condition And Mechanical Data	
Temperature	−40° F to +185° F (−40° C to +85° C)
Impact Resistance	1 inch (25 mm) diameter hail at 52 mph (23 m/s)
Appearance	Class A+
Solar Cells	96 Monocrystalline Maxeon Gen III
Tempered Glass	High-transmission tempered anti-reflective
Junction Box	IP-65, MC4 compatible
Weight	41 lbs (18.6 kg)
Max. Load	Wind: 62 psf, 3000 Pa, 305 kg/m² front & back Snow: 125 psf, 6000 Pa, 611 kg/m² front
Frame	Class 1 black anodized (highest AAMA rating)

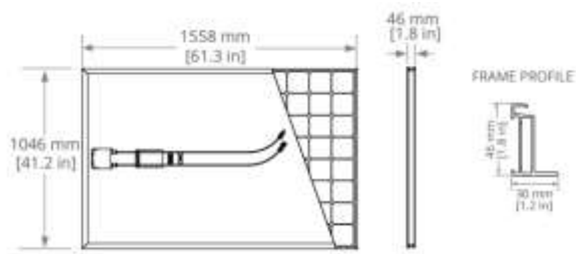

Figure 4. Summary of Equinox PV system.

Aquion Energy S-Line Battery Stack

The Aquion Energy S-Line Battery Stack products are the first batteries in the world to be Cradle to Cradle Bronze Certified. The battery serves as the perfect stationary long duration application for both homes and businesses. Utilizing cutting edge saltwater technology to outperform and outlast traditional batteries, based on Aquion's proprietary "Aqueous Hybrid Ion technology", there exists no heavy metals and no toxic chemicals. They are designed to be both non-explosive and fire retardant. The S-Line Battery Stacks are 2 kWh systems at 48V nominal, which can be connected via series or parallel for systems configurations as seen in Figure 5. Daily cycling applications for residential solar and off-grid energy management, make this product a feasible component to a zero net energy designed home.

Photovoltaic and Battery Storage Design Strategy

The investigation of the photovoltaic and battery storage design started at analyzing the solar resource of the project site. The site contains no shading issues; thus maximum solar gain is utilized. The placement of the Photovoltaic system was designed for the south facing roof to maximize energy production. The average daily solar insolation (kWh/m^2/day) at various tilts angles. The Klein and Theilacker (K-T) method was used for estimating the average insolation on a tilted surface. The K-T method is an analytical algorithm for calculating solar insolation on a tilted surface from horizontal surface. Horizontal data is readily available for select locations that have National Renewable Energy Laboratory solar radiation monitoring stations. The Renewable Energy Student Union manages a monitoring station at Humboldt State University where the data was utilized for this project. The K-T method can be used to optimize a panel tilt angle based on an annual summation of the insolation values. The methodology outputted the optimal tilt for solar insolation to be 32 degrees for the Bear River location; thus, a 7/12 (30.3) roof slope was selected for optimal energy production.

The battery storage system was sized based on Bear River's master plan of becoming Energy Sovereign. Battery storage was designed based on an off-grid system design approach from the Solar Energy International Photovoltaics Design and Installation Manual. The home should be self-reliant for the night time and morning before peak sun hours, thus a 0.5 days of autonomy was used to size the Aquion battery system. Figure 6 displays the sensitivity analysis of number of batteries with a days of autonomy. The results provided a battery system size of 5 batteries in series with a rate energy load of 11.5 kWh.

Figure 5. Aquion S-Line stack batteries.

S10-0080 Battery Stack

AQUION ENERGY

PRELIMINARY TECHNICAL INFORMATION

Aquion Energy's S10-0080 Battery Stack is the first cost-effective energy storage solution that is high-performance, safe and sustainable. Based on Aquion's patented Aqueous Hybrid Ion (AHI™) technology, the S10-0080 is designed for stationary, long-duration cycling applications.

PRODUCT INFORMATION

Time (h)	2	4	8	12	20
Current (A)	9.5	6.1	3.9	3.0	2.1
Capacity (Ah)	19	24.4	31.2	36	42
Energy (Wh)	777	1,130	1,485	1,690	1,940

Constant Current Discharge, 30°C

Voltage Range	40 to 59 Vdc
Nominal Capacity	42 Ah at 20 hour discharge, 30°C
Nominal Energy	1,940 Wh at 20 hour discharge, 30°C

OPERATION & PERFORMANCE

Cycle Life	>3,000 cycles
Operating Temperature Range	-5 to 40°C
Round Trip DC Efficiency	>85% at 20 hour discharge, 30°C
Charge / Discharge Modes	CC, CP, CV, AC ripple tolerant

Physical Characteristics

Height	935 mm (36.8")
Width	330 mm (13.0")
Depth	310 mm (12.2")
Weight	113 kg (249 lbs)
Certifications	UL Recognition Targeted

Connector

Amphenol AE H4 Connector

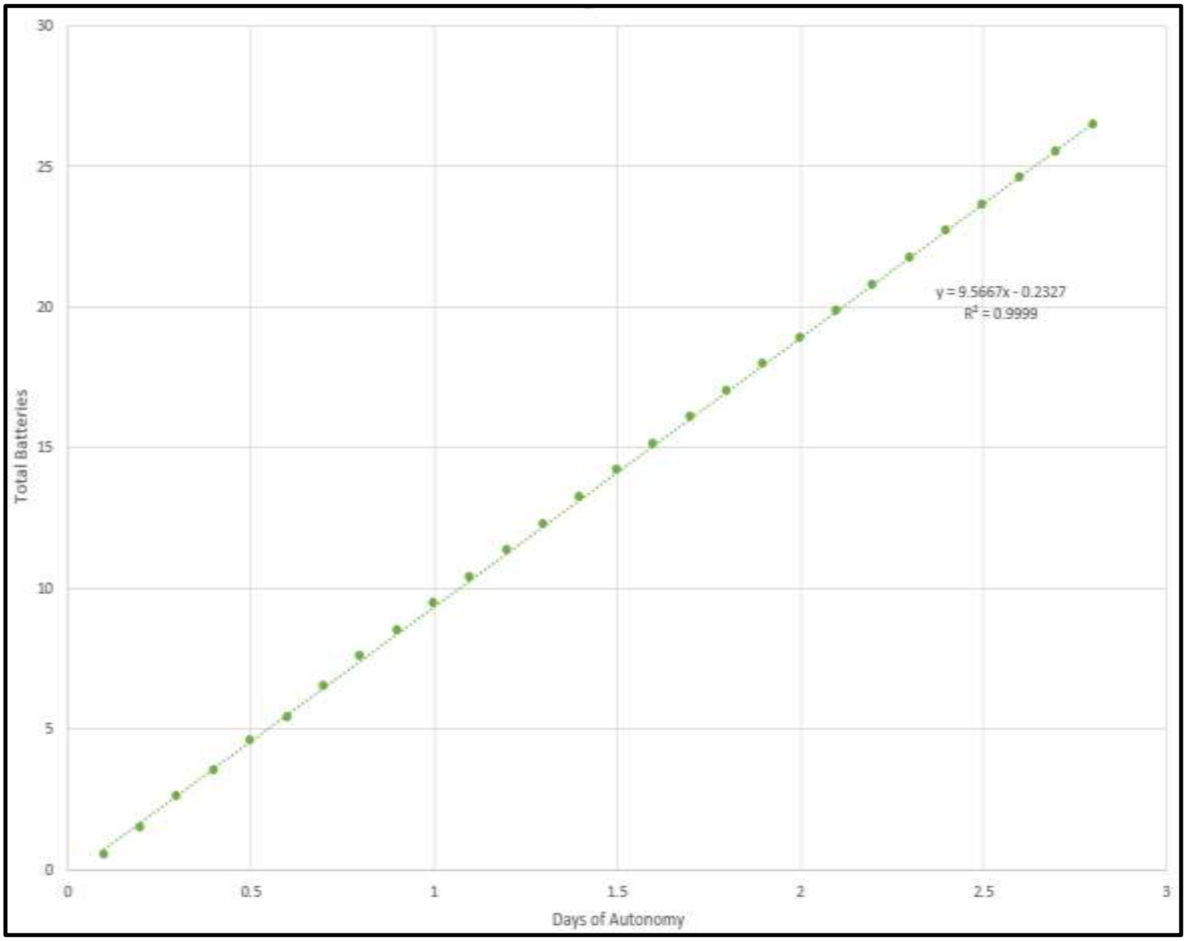

Figure 6. Sensitivity analysis of the number of batteries at varying days of autonomy.

Building Energy Analysis

The Energy Analysis includes an estimation of the total (annual) amount of energy consumption for the home that was determined through two different types of software, REM/Rate and Energy Pro RM 5.1. Two models were designed, one in Rem/Rate and the other in EnergyPro using the same values for our designed building. This was done to compare the results produced by both programs, which will further be discussed below. Our design loads are 9900 Btu/hr for heating, provided by Unico Company, and no cooling load.

The analysis was done with 579 square feet of photovoltaic panels on the south facing roof at a roof pitch with a south facing 7/12 (30.3°) roof pitch. Important considerations made for the PV panel design on the roof must account for the necessary orientation, degree, and weight load of the system on the roof. However, after consulting a structural engineer, he confirmed that the truss construction accounts for the 3 pounds per square foot when the construction plans take into consideration weather force load on the roof. The south facing roof has an area of 1,321 square feet, and the panels are placed 4 feet from the edge of the roofing due to current fire code regulations.

California Analysis Process

Energy Pro generated a graph showing monthly energy consumption for each load (***Figure 7***) and a total annual energy consumption of 6,942 kWh/year, with a HERs rating value of 59 without PV. With PV (Calculated with CEC PV Calculator), the solar energy annual production is 14,367 kWh/ year. With the PV production value, Energy Pro generated a HERs rating of -176, which is a net positive energy. To get near to zero net energy the annual solar energy production will need to be about 3917 kWh/year to generate a HERs rating of 59 with PV and -5 without PV. This excess energy is a critical component of the larger Energy Sovereign MicroGrid project, supporting other energy consumption in this Tribe. Pacific Gas and Electric generated rates for 2016 are $0.182 per kilowatt-hour in our region. Using this rate and the Energy Pro consumption rates, we found the consumption cost to be $1,263.44 per year. With PV implementation in Energy Pro, the home production rate and the Pacific Gas and Electric rate calculated a cost savings of $2,614.79.

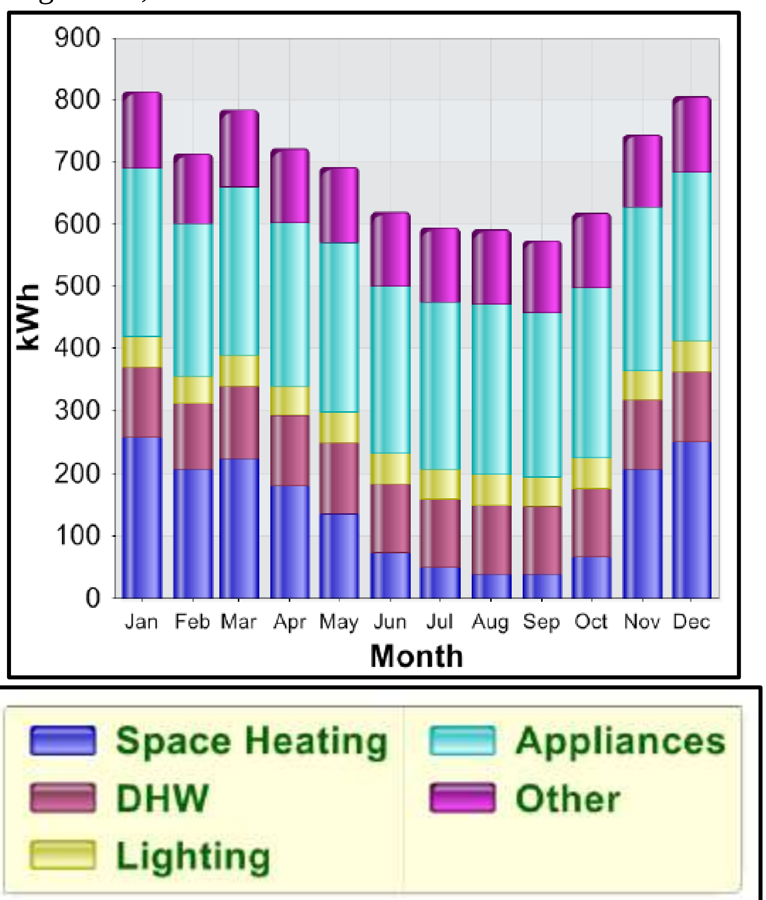

Figure 7. Monthly energy consumption for each load generated by EnergyPro 5.1.

National Analysis Process

REM/Rate generated an annual energy consumption of 7,093.02 kWh/year with a HERs rating of 46 without PV. Although, with PV the annual solar energy production is 15,387 kWh/year with a HERs rating of -54, generated by REM/Rate. Using the PG&E rates of $0.182 and the Energy Pro consumption, we determine the consumption cost to be $1,290.93 per year. With PV implementation in Energy Pro, the home production rate and the Pacific Gas and Electric rate calculated a cost savings of $2,800.43.

Energy Pro Vs. REM/Rate

Figure XX below, indicates the comparison of the energy consumption generated by both Energy Pro and REM/Rate. REM/Rate generated higher annual energy consumption (kWh/year) for lighting, appliances and space heating. In contrast, Energy Pro produced higher annual energy consumptions for fans and domestic hot water system (DHW). Overall, REM/Rate generated the highest energy consumptions for the loads.

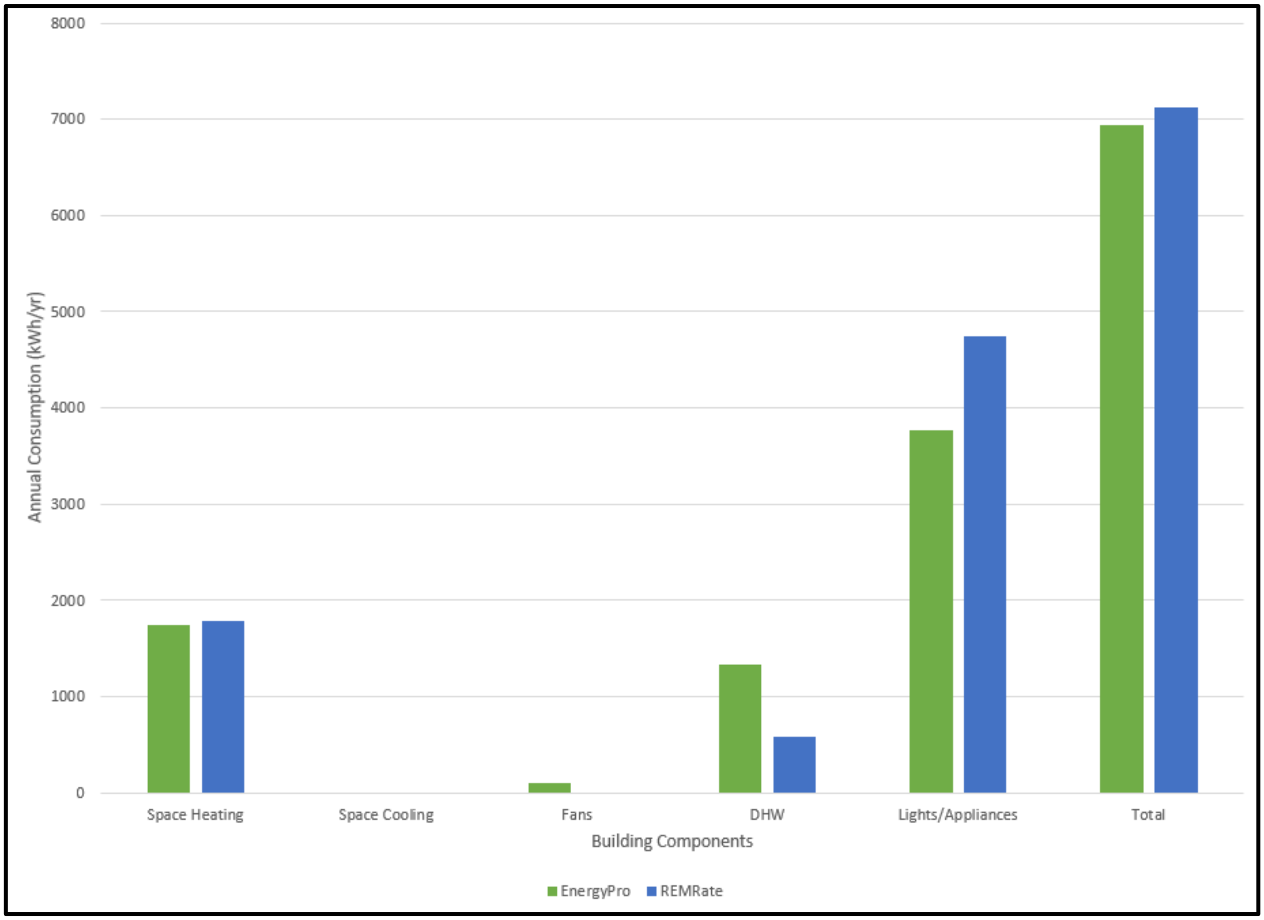

Figure 8. Energy consumption comparison of EnergyPro and REMRate

Envelope Durability

The building envelop is the most influential component affecting comfort level and energy losses. The location experiences a significant amount of wind-driven rain. The objective of the wall envelop is to integrate moisture and airflow control strategies, incorporate high R-value materials, reduce thermal bridging, and prevent potential health impacts of inhabitants and builders. Promoting sustainability is an important factor for material selection and is discussed in the following paragraphs.

The enclosure design incorporates control layers for moisture, air, and thermal movement through the building envelop. The layers of the wall from the outer environment to the condition space is as follows: thermal insulation, moisture control layer, and structure is similar for the slab, wall, and roof portion. This is shown in Figure 9.

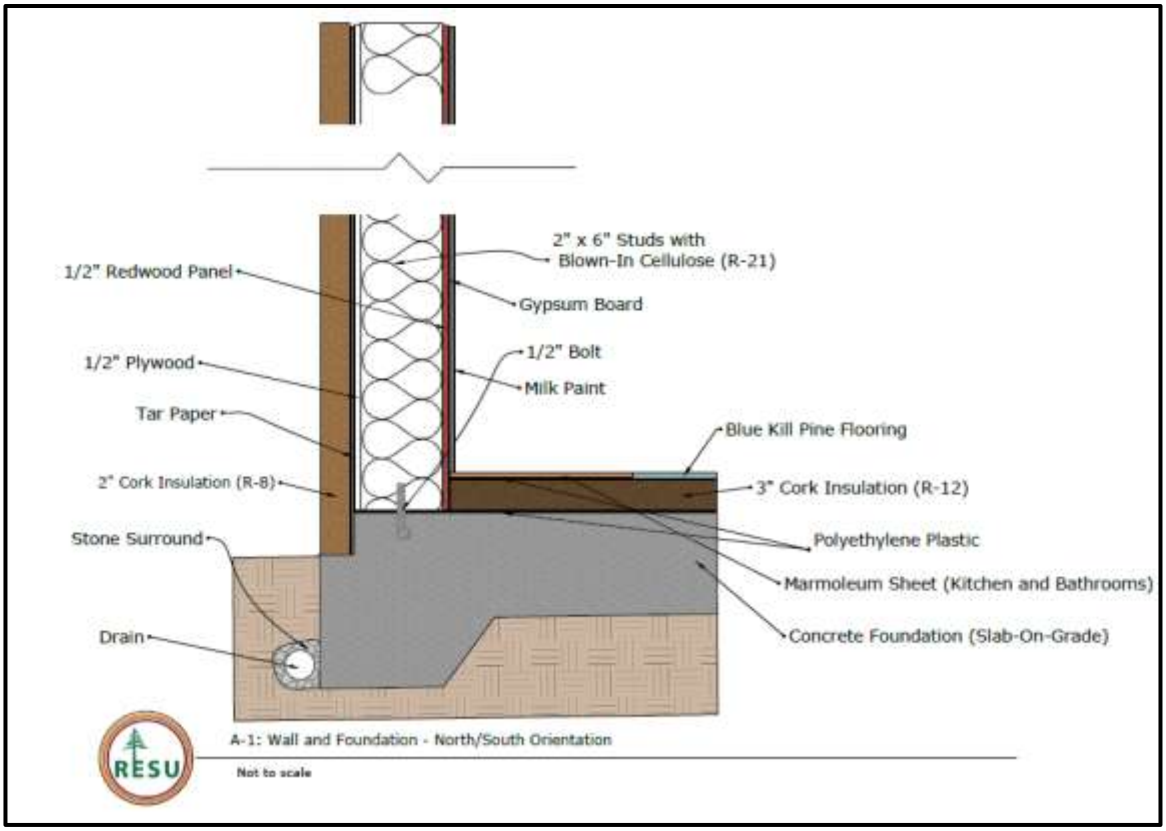

Figure 9. Foundation Slab.

The moisture control layer assists with the movement of vapor and prevention of prevalent mold problems in the location. A WUFI analysis is included to assist with the comparison of standard practices and the proposed design.

Foundation

The foundation is slab-on-grade because it required less harmful procedures such as foam insulation and it is economically more feasible. The foundation is surrounding by moisture control layer, insulated above with 2-inches of cork (R-8), and finished using marmoleum sheet and wood flooring. Other foundations such as perimeter foundation required tight sealing and a higher amount of insulation. This incorporate the use of spray foaming, which contains harmful compounds that requires a full body protection suit for the installer and is carried out in a small, enclosed space. Due to the conditions in which it is carried, many homes are not properly sealed which can lead to thermal bridging and inefficiencies. Even though this type of foundation is usually practiced it was not selected due to the potential health impacts it pertains. Slab-on-grade does not require such a step and is less demanding for implementation.

The foundation is only insulated on top due to the termite problems in the region. Even though adding perimeter insulation to the slab would increase the R-value, this would be an opportunity for the termites to bridge into the house insulation. Termites can cause structural as well as thermal efficiency issues. Additional exterior insulation helps control frost penetration near footing, but this is not a concern in this location. This type of insulation is recommended when wood is the installed as the finishing material.

The foundation is a 2-inch slab with a moisture control layer above. The vapor barrier for the foundation is planned to be polyethylene plastic sheeting known as Visqueen. Cork insulation is preferred due to the two types of flooring selected. A 2-inch layer or cork insulation is planned to be used. Carpets located on cold surfaces, such as concrete slabs, are particularly sensitive to dust mite growth. Wood is chosen over carpet due the health concerns. The type of wood used is Blue stain pine due to its economic benefits and the sustainability aspects. Blue kill wood is a product of a bacteria carried by a pine beetle which kills the tree (Front Range Lumber Company). This flooring is less expensive and can be found locally to the site. It is also aesthetically pleasing as shown in Figure 10.

Figure 10. Blue Stain Pine Flooring (Sustainable Lumber Corp).

The second type of flooring used is marmoleum sheet. This product is UL certified and is an alternative to vinyl flooring. It is considered chemical-free eco-friendly flooring. It has beneficial low cost, durability, and allergy and Asthma-Friendly certified. This material is credited for LEED points (Green Building Supply). This flooring is included in the bathroom and kitchen because of the water resistant properties of the material.

The adhesive used for the marmoleum is the forbo i885m, an acrylic polymer. This adhesive is moisture resistant, mildew resistant, and emits little to no odor. The Volatile Organic Compounds (VOC) emissions is 0 grams per liter as calculated per CA South Coast Rule 1168 (FORBO Fact Sheet). A possible alternative adhesive considered is beeswax, but is not an economically viable solution.

Exterior Wall

The west and east walls (solarium exterior walls), and the north and south exterior walls incorporate an outer 2-inch of cork insulation (R-8), moisture control layer, 1/4 plywood, 2x6 studs, ½ inch gypsum board, and milk paint. The wall cavity includes blown-in cellulose insulation (R-21). The west and east walls are semi-conditioned space serving multiple purposes such as solar heating gain, growing plants, hanging clothing to dry, and viewing sunrise and sunset.

The size of the studs required by code is 2”x4” but the selected studs are 2”x6” to provide more room for insulation. The spacing between each stud is 24-inch center instead of the conventional 16-inch center. The decision made to increase the stud spacing was to minimizes cost and the thermal bridging by the studs acting as conduits that draw warm air into the house during the summer, and cold air into the house during the winter.

The type of wood used for framing is Douglas-fir provided by Mendocino Humboldt Redwood, located two hours away from the Golden Gate Bridge. The wood is sustainably grown and assists with forest management operations with goals of improving aquatic habitat and old growth forest protection. This wood is selected to support local environmental efforts.

The wall is described from the outer environment to the conditioned space. The first layer in the external side of the wall is the ThermaCork insulation. The siding will incorporate a 2-inch cork insulation. The decision of utilizing cork as a siding and insulation is due to the sustainable characteristics and moisture performance with low absorptivity of water by to capillary action similar to Figure 11. The moisture factor resistance is MU 20. The durability without any loss of structure characteristics ranges from 50 to 60 years and has low embodied energy. This product also has a negative carbon footprint (Thermacork.com). The material selected for moisture control is the petroleum impregnated paper which is waterproof and used because of its durability with regards to wind and sun exposure (Green Building Advisor).

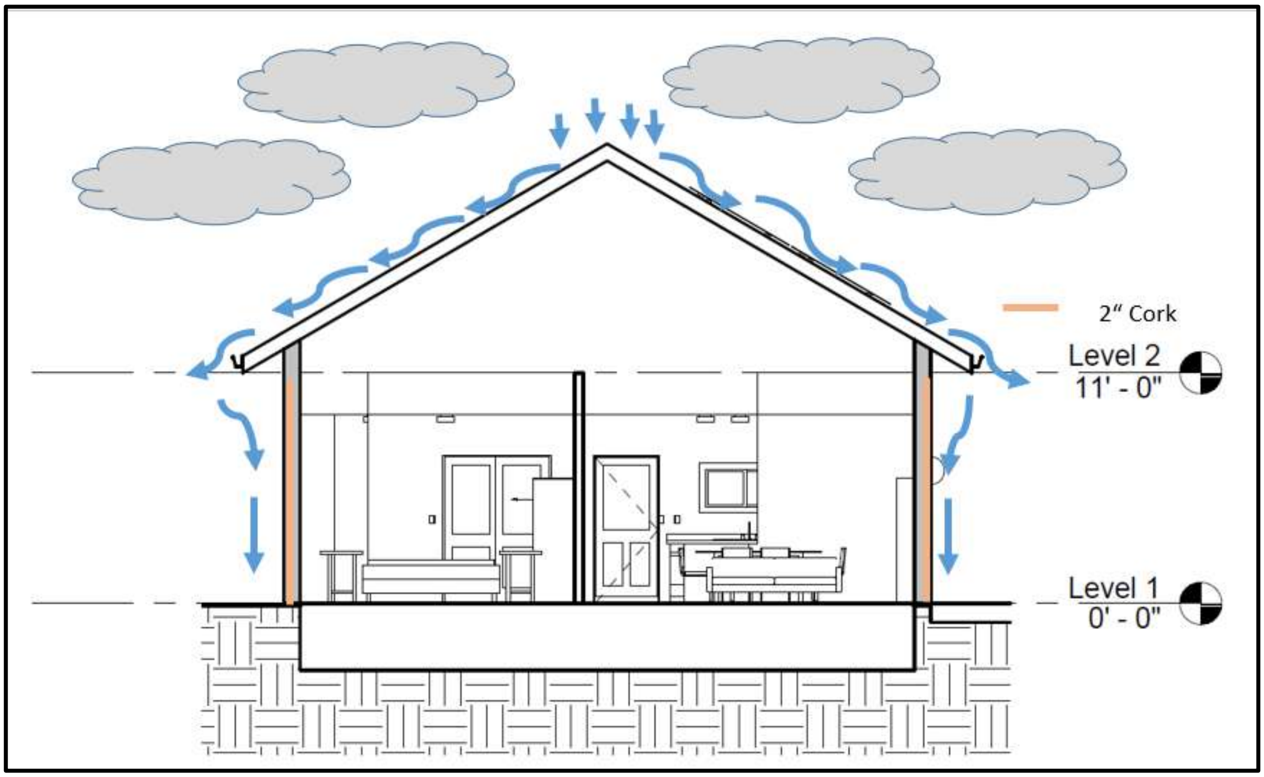

Figure 11. Rain Flow Down the House.

The following layer is ½ inch plywood. The selection of plywood over oriented strand board (OSB) sheathing is due to the high chemical content and the moisture control properties of OSB. The plywood contributes as an air barrier and is a water collector (Krieger). The insulation between the studs is going to be blown in cellulose (R-21). This insulation does not act as an air barrier or moisture barrier since it retains moisture. The cellulose can dry out if there is high air permeability. Without a drying step, moisture can be trapped and can cause problems. Insulating with cellulose provides higher thermal resistance when properly sealed and installation.

The next layer is a ½ inch gypsum sheetrock provided by USG. This material is fire resistant and the provider has an Environmental Product Declaration (EPD), and is committed to maximizing sustainability which can help towards LEEDs credits.

The interior will be painted using milk paint. The paint can be either obtained by a local provider of Old-Fashioned Milk Paint or can be made following the directions provided by Appropedia (for more information please refer to Volume II). The benefits of using milk paint include completely VOC free, anti-molding properties, and it repurposes materials considered to be waste (milkpaint.com). The paint contains borax (lime) which has antibacterial and anti-molding properties (Appropedia.org). Humboldt Creamery is within the vicinity of the location of this project providing an opportunity to carry this out.

Due to recent concerns, regarding the manufacturing practices involved in making vinyl products, the energy benefits of using wood, and all frames material. Wood frames are strong, aesthetically appropriate for historical neighborhoods, and provide adequate insulation making it an energy saver (Energy.org). A proper flashing membrane is necessary to drain water away from the exterior wall and penetration of water into the wall assembly (American Architectural Manufacturers association). Please refer to Volume II for more information. Due to the climate in Humboldt County, low e windows is not required and is not preferred because of the low cooling load for the building.

Roof

The configuration of the roof starting from the outermost layer is the cladding, then the control layers, and then the structure. Two different types of roof cladding are considered: metal cladding, and asphalt shingles. Because of the community member's concern about the acoustic performance of the metal and cladding during frequent high wind events, asphalt shingles were selected for the design of the house. The design of the roof includes dark colored shingles to act like a "warm roof", in contrast to the more commonly used "cool roof". The dark colored shingles of the "warm roof" have a lower reflectivity than light colored shingles, allowing for more heat absorption, which is ideal for the climate zone for the house. Shadow black colored CertainTeed Patriot architectural style shingles, with a 30-year warranty and rated for up to 110 mph winds, will be used for the roof cladding (CertainTeed, 2016).

Underneath the roof cladding are the control layers. Tar paper is used as the control layers for the roof. Underneath the tar paper is plywood, and then the roof trusses. The roof trusses incorporate an energy heel, as seen in Figure 12. The purpose of having an energy heel is to provide additional space to place the insulation without getting compressed. The height of the energy heel is based on the height of the insulation plus additional space to prevent blockage of the ventilation.

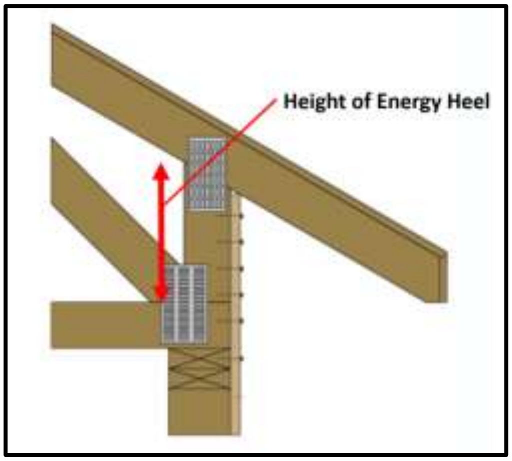

Figure 12. Energy heel.

Below the roof trusses is the attic space, where the insulation sits on top of the roof decking. The type of insulation used for the roof design is R-49 batt cellulose insulation. The R-value per inch of batt cellulose insulation is 3.21, so the required height of the cellulose insulation is 15.3 inches. The height of the energy heel is to be greater than 15.3 inches to provide room for ventilation. An additional height of 3.7 inches provides room for ventilation, so an energy heel height of 19 inches is used for the roof trusses.

The purpose of having an attic space is to provide room for storage, and allow for roof maintenance (i.e. check for leaks and pests). The attic space is ventilated for multiple reasons. The purpose of providing attic ventilation is to extend the lifetime of the roof, reduce the amount of moisture buildup, reduce the risk of mold and dry rot, reduce the amount of stagnant air, and to improve the house's air quality by removing unwanted gases and fumes. There is no duct work in the attic space, so having a ventilated attic space will not be a concern. The attic space is ventilated using two types of vents: intake vents, and exhaust vents. The 1/150 method was used to determine the required area needed to be ventilated. The 1/150 method states that for every 150 square foot of attic floor space, 1 square foot of ventilation is needed in order to provide an adequate amount of ventilation (ROSS Manufacturing, 2014). The attic floor space is 1600 square feet, so about 10.7 square feet of vents is required. The attic space is accessible through an attic hatch door, that is strategically placed for convenience reasons. It is considered best practice to place an attic hatch door near the front door of the house, so that a contractor can bring building materials such as insulation into the attic without having to transport the materials throughout the house. The attic hatch door is insulated to prevent any deficiencies between the conditioned living space and the attic space. The attic hatch door also has R-49 insulation.
The roof overhangs are 1 ½ feet all round the house. This size of overhang was correlated to the percent of wall which will experience problems by Building Science Corporation. The predicted percent of wall problems with the overhang length is 50 percent.

Analysis of Hygrothermal Performance

The hygrothermal performance of exterior wall was evaluated using the WUFI software. The software simulates the two dimensional heat and moisture transport through a multi-layer wall using parameters such as orientation, coating, and climate data. The ThermaCork insulation performance in the Pacific Northwest is currently been investigated by the building science company RHD by using data loggers throughout the wall assemblies in a project in Olympia, WA (smallplanetsupply.com). Information is not yet available for the WUFI model; therefore, the insulation was simulated as open cell polyurethane foam as a substitute. The expected capillary action occurring in the open cell polyurethane foam is greater than the cork insulation but less than closed cell polyurethane foam. This system was compared to the closed cell polyurethane foam, which is typically incorporated in construction in Northern California. The results are shown below in Figure 13. The relative humidity, shown in green, does not reach 100 percent, thus there are no predicted condensation in the wall. The plywood shows lower water content in the open cell foam. The close cell foam contained significantly higher water content in the cellulose insulation. This suggests higher drying potential in the selected design.

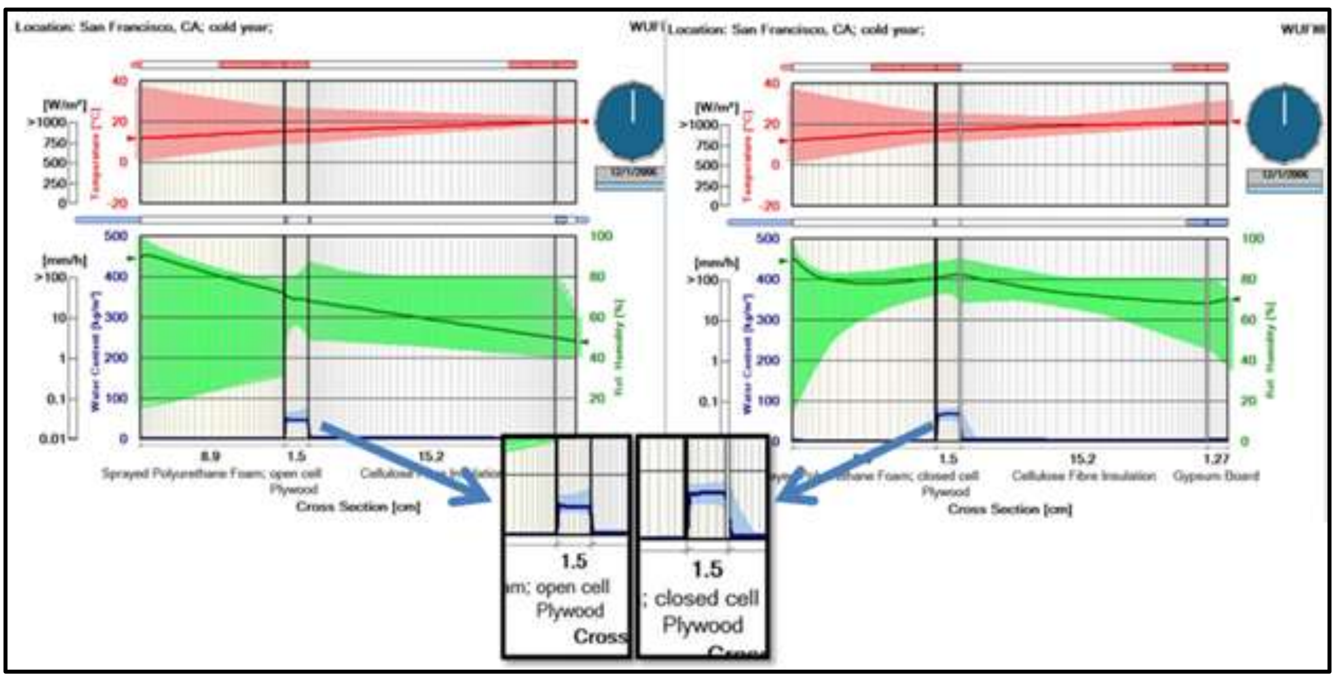

Figure 13. Hygrothermal analysis using WUFI ORNL V5.0.

Indoor Air Quality (IAQ) and Appliances

Air Quality

When designing this house, providing a safe and healthy living environment for all occupants was a chief concern. Special attention has been designated toward limiting exposure to toxic chemical emissions to as little as possible. More specifically, the goal is to provide an environment that is safe for those most vulnerable to exposure to toxins; that is babies, young children, and the elderly. Many products that claim to be VOC free, simply aren't. Instead, their VOC content is low enough that governing bodies deem it to be acceptable to advertise that they are VOC free. Exposure to pollutants like mold, VOCs, and combustion exhaust can have devastating short and long term health effects. To improve the air quality inside the home, source control measures are implemented, such as choosing free VOC or low emitting building material and choosing all electric equipment for the home to avoid source contaminants from combustions. The home is also adequately ventilated and exceeds the ASHRAE standard for residential ventilation.

Source Control

Building Material

The hardwood flooring is Douglas fir from local, sustainably managed forests. Marmoleum sheeting is installed in wet rooms like the bathroom and kitchen, which is advertised as chemical-free eco-friendly flooring. The marmoleum uses a forbo i885m adhesive, an acrylic polymer, that emits 0 grams of VOC's per liter (CA South Coast Rule 1168). The flooring types are all certified asthma & allergy friendly to prevent discomfort over long periods of use, unlike dust accumulating materials. They also meet or exceed California Air Resources Board (CARB) and California South Coast Air Quality Management District (SCAQMD) requirements.

The interior walls are insulated with blown in cellulose which have a total VOC less than 0.5 mg/m^3. Walls are painted using milk paint which is completely VOC free. Cork insulation is natural and contains no formaldehyde, heavy metals, or any other VOC found in other type of wall materials.

Combustion Sources

To reduce contaminants introduced into the household, combustions sources such as the water heater, stove, and furnace are replaced with all electric equipment. Common combustion appliances like the stove, water heater, and furnace are replaced with electric appliances to avoid any exposure to combustion related pollutants. The water heater, and furnace are further discussed in the domestic hot water, and space conditioning sections, respectively. The stove used in the household is a General Electric induction stove.

Ventilation

Proper ventilation is a key factor when designing any energy efficient building. The goal strived for, in this project, is to achieve the is to continuously supply residents with clean, outdoor air. The California building code requires us to adhere to ASHRAE 62.2-2007 when determining minimum ventilation rates. Due to the oceanic climate of Humboldt County, it was deemed appropriate to emphasize indoor air quality over sealing the building as tightly as possible.

ASHRAE 62.2-2007: [Conditioned Area/100]+[(7.5)*(Number of Bedrooms+1)]

Table 3. Summary of minimum ventilation CFM required.

Living Space (sq.ft.)	1920
Bedrooms	3
Airflow required (cfm)	49.2
system airflow (cfm)	200

In addition, MERV filters are used throughout the house to filter out particulates that may be introduced through ventilation. The Minimum Efficiency Reporting Value (MERV) is a measurement of how effective filters are at trapping particulates. To protect occupants, MERV 12 filters are installed in the bathroom air supply, and the kitchen air supply. A MERV 16 filter is installed in the main HVAC system and MERV 12 in line filter boxes are used to filter all the influent make-up air, which goes to the kitchen and bathrooms from the east and west solariums. This filter traps more than 80% of common indoor pollutants like lead, dust, and automobile exhaust.

Bathroom Fans

The bathrooms utilize adjustable Panasonic WhisperGreen exhaust fan, which can be seen in ***Figure 14*** on right. The fan operates at 50, 80, or 110 cfm and consumes 3.2W, 5.4W, or 9.8W, respectively. These are used to evacuate air directly to the outdoors through vertical chimneys, constructed of 4-inch galvanized metal ducts. These fans operate at 0.3 sones, which is significantly quieter than Energy Star’s 2.0 sone standard. The bathrooms also have fans feeding air into them from the west solarium. Each of these sources of air are fed through a filter box with a MERV 12 filter prior to being ducted into the bathroom.

Figure 14. Panasonic WhisperGreen exhaust fan.

Kitchen Range Hood & Fan

The chosen range hood model is the Broan Elite RM50000, which can be seen in **Figure 15**. The hood is 35” wide with a 2-½” overlap on each side. The hood is installed three feet above the cooktop, at a height of seven feet from the ground. The hood is 19 ⅝” deep, while the stove is 19 13/16” deep from the very front burner to the very back burner. The hood is fixed ½” off the wall with brackets

and a facade. The design ensure that virtually all cooking occurs underneath the covered area and the range hood is vented directly to the outdoors to ensure that PM 2.5, other fumes, and moisture are evacuated outside of the conditioned space.

The range hood operates with a maximum volumetric flow of 270 cfm. Left unbalanced, this alone could create a negative pressure throughout the house. For this reason, a 440 cfm Panasonic WhisperLine inline exhaust fan is installed to pump air from the solarium on the east side of the building. This fan is positioned in the air space between the ceiling and the attic and adjacent to the solarium. The fan, which has a variable airflow setting, is wired in series with the range hood. A professional electrician is responsible for calibrating this system. After calibration, the fan will the correct amount of power drawn to match the airflow of the range hood. The ability to do this is a feature unique to the Panasonic line of fans. The air is then fed through a filter box with a MERV 12 filter, which can be seen in Figure 16 via eight-inch ducting. This air filter and duct size is the primary reasoning behind having a fan with significantly higher power capabilities than the range hood. The ducting is then split into a T joint, where air is blown underneath the kitchen cabinets through a 3x12 inch rectangular duct and a 5 inch in the ceiling.

Figure 15. Broan Elite RM50000 range hood.

Figure 16. MERV 12 Filter.

Appliances

When available, energy star appliances were installed for use in the home. Table 4 shows the list of appliances purchased for the home. The products are chosen due to their low energy loads, cost, and quality of performance.

Table 4. Selected appliances

Appliance	Brand	Model	Rating	Energy	Cost ($)
Dryer	Speed Queen	LTEA5FSP153+	Energy Star	608 kWh/yr	1,000
Washer	Speed Queen	AFNE9BSP113TW01	Energy Star	69 kWh/yr	1,470
Refrigerator	Frigidaire	LFHT1831Q	Energy Star	363 kWh/yr	1,300
Induction Stove	GE	PHB920SJSS	Energy Star	8" 2500 W 11" 3700 W 6" 1800 W	2,000
Microwave	Hamilton Beach	P70B20AP-G5B		700 W	46

Toaster Oven	Elite Cuisine	EKA-9210XB-Black		1000 W	40
Computer	Lenovo	ThinkCentre M800z	Energy Star	132 kWh/yr	650
Television	Samsung 48 inch	UN48H4203AF	Energy Star	58 kWh/yr	700

Residential Energy Education

An energy monitor is installed to educate the residents on their energy consumption throughout the day. The monitor uses varying colors the occupants see as they walk through their home, and the different colored hues inform the occupants on their current energy usage (left side), and total energy usage for the day (right side).

Figure 17. Canary Instruments behavioral battery for increased energy efficiency.

The colors change from green (very low usage) to yellow, orange, red, and fuchsia (very high usage). One of the benefits of this energy monitor is that as the occupant intentionally tries to reduce plug load the lights change instantaneously.

Lighting

When designing the lighting of the home the lumens per square feet was considered for optimal lighting depending on what activity may happen in each room. A brief breakdown of lumens per meter square is given below. For all lighting fixtures, LED was chosen for the quality of the light and its longevity as a product. When comparing cost between LED and CFL, they both cost around the same and provide similar low wattage, which is better than the classic incandescent bulbs. LED was chosen over CFL because CFL's have a higher replacement rate, therefore costing the homeowner more over their home's lifespan. All the chosen fixtures are compatible with LED replacement bulbs, both 60 and 100 Watt. The Cree brand bulb was chosen to implement throughout the house because of it's optimal color index rating and reliability. Looking at time of use data on average for a detached family home, an analysis of operating hours was done to calculate the total kW/year, the resulting value being 315.94.

The layout of the lights was kept simple but efficient, with enough lighting for each room. In the daytime large bay windows in the living room provide light to the main body of the home. Two solariums are attached as semi conditioned spaces for enjoying the light comfort during any season. The lighting design provided switches by doorways and and two way switches where necessary to control the lighting at both sides of the room for convenience. The lighting in the living room and entryway provided softer sconce lighting with many outlets if future residents wish to expand lighting in that room. The kitchen overhead light is a three bulb fixture, providing the cooking space with a brighter light to accommodate the work area.

Table 5. Lighting time of use for different activities.

	Single Family Detached	Single Family Attached	Multifamily	Mobile Home	Average
Basement(s)	1.6	1.7	1.4	1.9	1.6
Bathroom(s)	1.6	1.6	1.6	1.6	1.6
Bedroom(s)	1.6	1.6	1.6	1.6	1.6
Closet(s)	1.4	1.4	1.3	1.4	1.4
Dining Room(s)	1.9	1.9	1.9	1.9	1.9
Exterior(s)	2.6	2.7	2.7	2.6	2.6
Garage(s)	1.5	1.5	1.5	1.6	1.5
Hall(s)	1.5	1.5	1.5	1.5	1.5
Kitchen(s)	2.3	2.3	2.3	2.3	2.3
Laundry / Utility Room(s)	1.5	1.4	1.3	1.5	1.5
Living / Family Room(s)	2.0	2.0	2.0	2.1	2.0
Office(s)	1.9	1.8	1.8	1.8	1.8
Other / Unknown	1.0	1.0	0.9	0.9	1.0
Average	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**

Table 6. Activity schedules and their respective lux value.

Activity	Illumination *(lux, lumen/m^2)*
Public areas with dark surroundings	20 - 50
Simple orientation for short visits	50 - 100
Working areas where visual tasks are only occasionally performed	100 - 150
Warehouses, Homes, Theaters, Archives	150
Easy Office Work, Classes	250
Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories	500
Supermarkets, Mechanical Workshops, Office Landscapes	750
Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres	1,000
Detailed Drawing Work, Very Detailed Mechanical Works	1500 - 2000
Performance of visual tasks of low contrast and very small size for prolonged periods of time	2000 - 5000
Performance of very prolonged and exacting visual tasks	5000 - 10000
Performance of very special visual tasks of extremely low contrast and small size	10000 - 20000

Source: http://www.engineeringtoolbox.com/light-level-rooms-d_708.html

Table 7. Summary of selected lighting fixtures.

Lighting Fixture Type	Light Fixture Specification	Model	Cost/Unit ($)	Quantity	Cost ($)
Inside Sconce	Glomar 1-Light Old Bronze Sconce	HD-044	33	3	100
Outside Light	Hampton Bay Black Outdoor Wall Lantern (2-Pack)	HD-4470TBK	30	4	120
Ceiling Flush Mount	Capital Lighting 2 Light Flush Mount	2711BB / 2713BB	23	8	184
Pendant Light	Hampton Bay Bristol Collection 1-Light Nutmeg Bronze Mini Pendant	FNK8991A	30	1	30
Outside Flush Light	Lithonia Dusk-to-Dawn Wall-Mount Outdoor Bronze LED Mini Single Flood Light	OLFL14PEBZM4	80	1	80
Kitchen Light	Hampton Bay 3-Light Brushed Nickel Semi-Flush Mount Light with White Shade	89543	65	1	65
Solarium Lights	1-Light Prairie Rock Interior Wall Sconce	V167122	28	5	140

Table 8. Energy usage for different types of lighting fixtures.

Fixture Type	Fixture Specification	W/Lamp	# of lamps	Time of Use (h/day)	Wh/day	kWh/yr
Inside Sconce	Glomar 1-Light Old Bronze Sconce	11	3	2	66	24.1
Outside Light	Hampton Bay Black Outdoor Wall Lantern (2-Pack)	16	4	2.6	166.4	60.7
Celling Flush Mount	Capital Lighting 2 Light Flush Mount	11	16	1.6	281.6	102.8
Pendant Light	Hampton Bay Bristol Collection 1-Light Nutmeg Bronze Mini Pendant	11	1	1.9	20.9	7.6
Outside Flush Light	Lithonia Dusk-to-Dawn Wall-Mount Outdoor Bronze LED Mini Single Flood Light	18	1	2.6	46.8	17.1
Kitchen Light	Hampton Bay 3-Light Brushed Nickel Semi-Flush Mount Light w/ White Shade	11	3	2.3	75.9	27.1
Solarium Lights	1-Light Prairie Rock Interior Wall Sconce	16	5	2.6	208	75.9

Space Conditioning

Heating Ventilation and Air Conditioning

The primary heating ventilation and air conditioning (HVAC) system comes courtesy of Unico, Inc. The layout of the vents are shown in Figure 18.

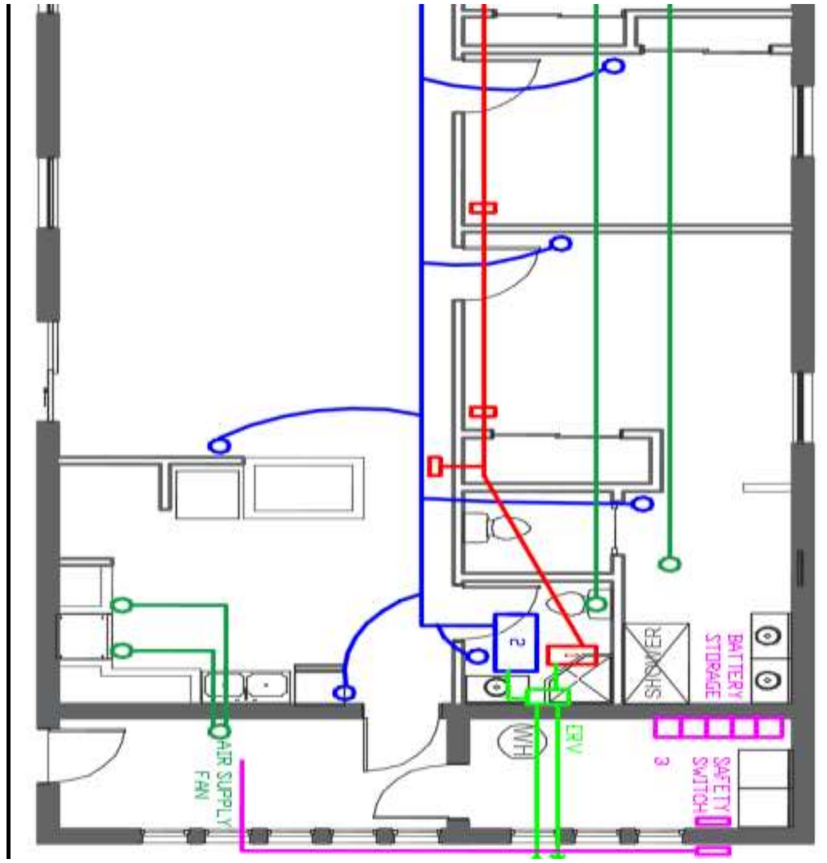

Figure 18. Space conditioning duct layout, and PV system layout.

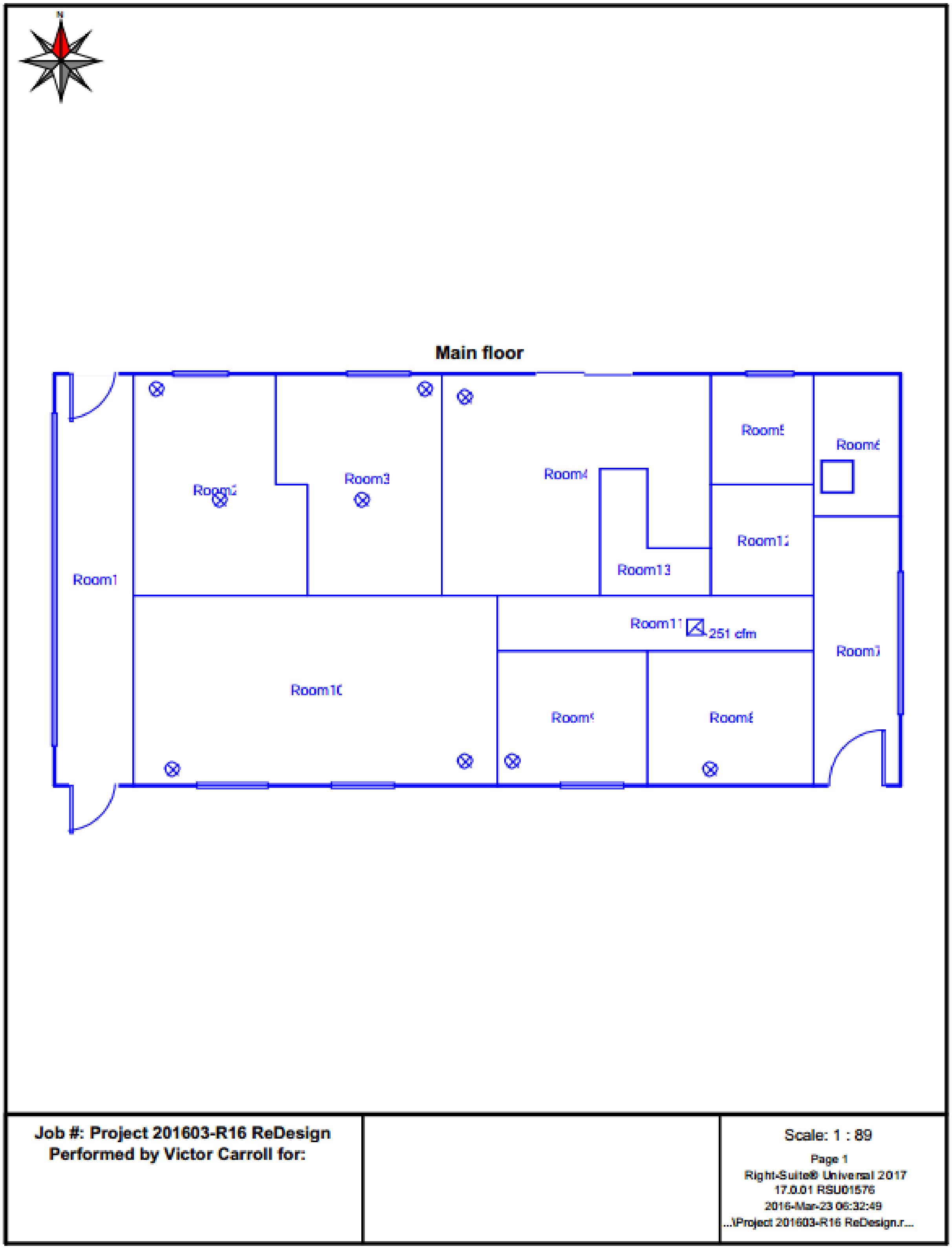

Figure 19. Supply air diffuser layout provided by Unico.

Table 9. Heating and ventilation requirements.

ID	Room	Area (sf)	ASHRAE 62.2 (cfm)	Heating Load (Btuh)	Heating AVF (cfm)
1	W. Solarium	130	0	0	0
2	Bedroom 1	140	12	1225	35
3	Bedroom 2	133	9	907	26
4	M. Bedroom	202	26	2721	78
5	M. Bathroom	46	0	0	0
6	Mechanical	50	0	0	0
7	E. Solarium	94	0	0	0
8	Kitchen	89	8	812	23
9	Dining	81	8	837	24
10	Living	276	21	2282	65
12	Bathroom	46	0	0	0
13	Master Closet	36	0	0	0
Total	**	**1323**	**83**	**8784**	**251**

Psychometric Chart Analysis

A psychometric chart analysis was performed using the University of California, Los Angeles, Department of Agriculture and Urban Design's Climate Consultant 6.0 software. This analysis was used to determine the comfort zone for the occupants that will be living in the home for the proposed site location. The comfort zone is represented in the blue region of the cart and can be seen in Figure 20. The dry bulb temperature ranges from 68 ^{o}F to 75 ^{o}F, and the wet bulb temperature ranges from 48 ^{o}F to 68 ^{o}F. The relative humidity ranged from 80% to 20%, and the humidity ratio ranged from 0.003 to 0.013 with respect to the preceding dry and wet bulb temperature ranges.

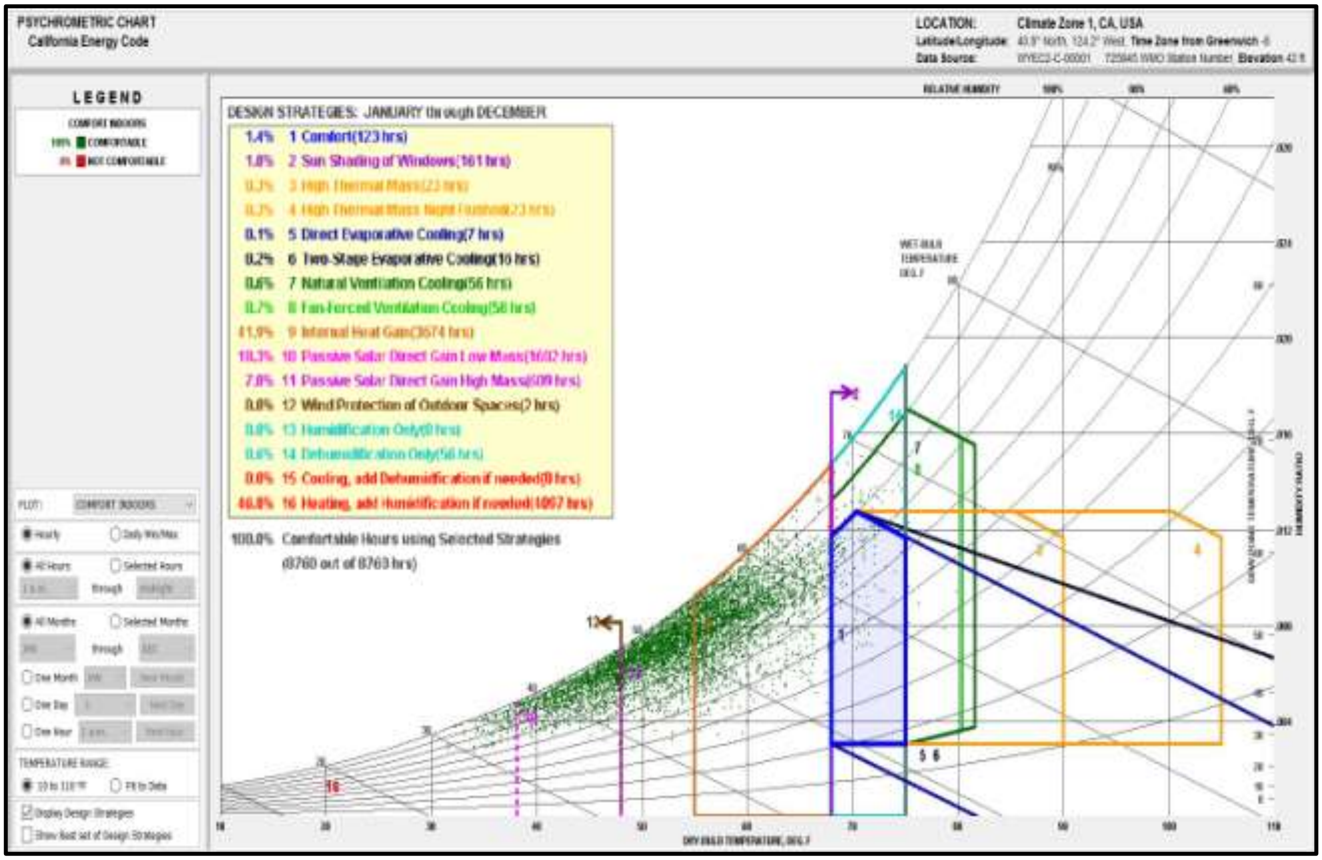

Figure 20. Psychrometric chart used for comfort levels.

UNICO Heating System

The UNICO M1218 Air Handler system (Figure 21), equipped with a Panasonic Whisper Comfort Ventilation Fan Spot Energy Recovery Ventilator (ERV) (Figure 22), is to be used as the space conditioning system. The M1218 system was chosen based on the airflow capacity for conditioned area of the home. The control board, for the M1218 system, is the AirCycler g2 (Figure 23) and is coupled with the dry-contact relay in the M1218 to turn on the (ERV) when needed. The M1218 system is to be used for heating applications only, and oriented for a horizontal flow path. The M1218 system uses heat from the hot water tank to heat the fan coil of the conditioning unit. The flow rate and temperature, required from the hot water tank, is to be 2 GPM and 120 ^{o}F respectively. The M1218 uses a series of small, 2-inch diameter, ducts to distribute the conditioned air throughout the home. The ERV combines some of the indoor air with the outdoor air to be distributed throughout the home, and this lessens the amount of energy required to heat the ambient air. The system is rated for an airflow capacity of 200 CFM, and requires 9900 Btuh to operate. The addition of the ERV will not be incorporated into any of the bathrooms or the kitchen of the home for moisture control within the system.

Figure 21. Unico M12 air handler.

Figure 22. AirCycler g2.

Figure 23. WhisperComfort Spot ERV

Domestic Hot Water

Residential hot water is one of the highest energy intensive components of the house. The focus of our design is to provide an energy efficient domestic hot water heater, and optimize the hot water distribution system to decrease delivery time.

The hot water demands will be met by the Sanden CO2 Heat Pump. It has an operating temperature of -15F to 110F that is resilient enough to withstand the cold weather which has an average low of 39F and an average high of 72F. An additional benefit from the water heater is its large holding capacity of 83 gallons which acts as a thermal battery, lessening the amount of energy required to heat up water.

Figure 24.* Sanden *CO2 Heat pump

Table 10. Specifications summary of the Sanden CO2 heat pump

Refrigerant Type	R744(CO_2)
Product Weight	56 kg
Thermal Capacity	4.5 kw *1
Power Consumption	1.0 kw *1
COP	4.5 *1
Heated Water Temp.	65 °C

*1 Ambient Temp. (Dry / Wet) 16°C / 17°C, Inlet Water Temp. 17°C, Outlet Water Temp. 65°C

The distribution system is a trunk and branch design which uses ⅜" copper for its trunks and branches (Figure 25). The piping is insulated with a 1" thick R-4 closed-cell elastomeric insulation to reduce heat loss during hot water transportation. The incoming water from the municipality ranges from 35-90 PSI which is adjusted to 60 PSI by a pressure regulator prior to going into the hot water heater to avoid any damage to the equipment. Water temperature coming out of the tank is 122F or higher and is mixed with cold water using a thermostatic mixing valve to deliver hot water at 120F. The system layout is designed to keep all hot water plumbing distance minimized to save energy, and water by providing short wait times. The estimated heating loads can be seen in Table 11.

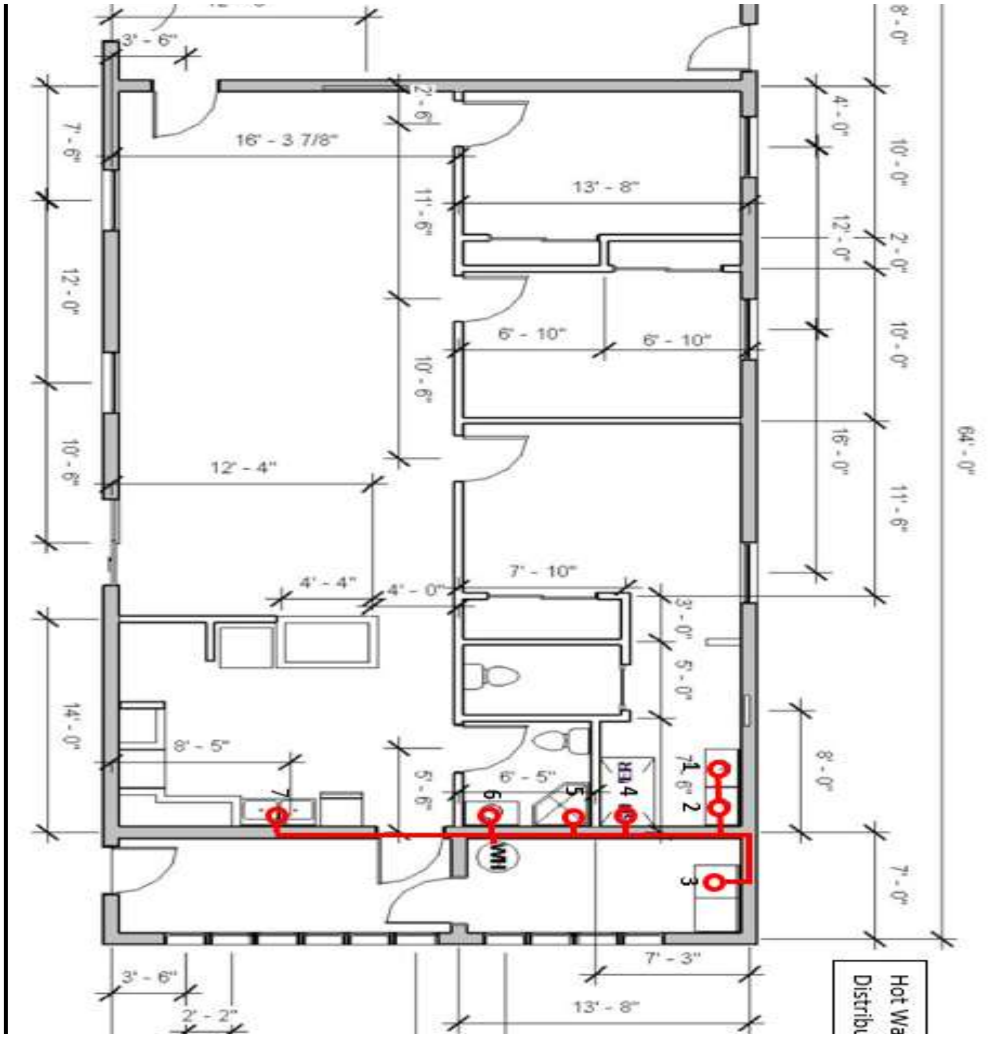

Figure 25. DHW pipe layout.

Table 11. Summary of the DHW sections.

Label	Room	Total Length (ft)	pipe diameter (in)	V_{water} (gal)	flow rate (gpm)	Wait time (sec)
1	Master Bedroom - Sink 1	18.0	3/8"	0.14	1	8
2	Master	20.0	3/8"	0.15	1	9

	Bedroom -Sink 2					
3	Washer	10.0	3/8"	0.08	2	2
4	Master Bedroom -shower	12.0	3/8"	0.09	1.5	4
5	Shared-shower	9.0	3/8"	0.07	1.5	3
6	Shared-sink	8.0	3/8"	0.06	1	4
7	Kitchen-sink	18.0	3/8"	0.14	1.5	5
	Heating Load (kwh/yr)	1333	Total V_{water} (gal)	0.72	Total time Wait time (sec)	35

Water Conservation

The fixtures chosen for the house follow the EPA's Water Sense guidelines. The Kitchen sink uses a Swivel aerator with a pause valve which slows water flow to 1.5 gpm and allows the occupant the ease of stopping water flow when washing dishes. Toilets in the house are ToTo brand which are designed to be used at 1 gpf, and all lavatory sinks use aerators that have flow rates of 1 gpm.

Figure 26. EPA WaterSense shower fixture.

To reduce the amount of water wasted while waiting for the shower to get warm, Evolve brand products are installed in the shared and master bedroom shower. These fixtures stop hot water from flowing down the drain once the water has reached 95F, and notify the occupant that hot water is available when the showerhead begins to trickle. When the occupant is ready to take a shower he/she pulls showerhead hanging cord to begin showering.

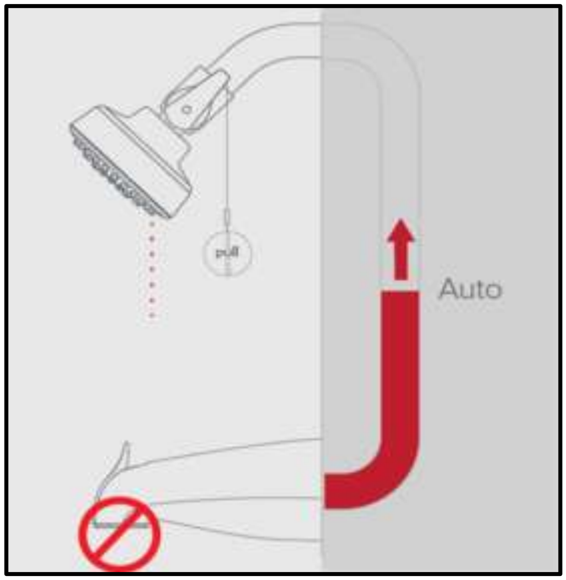

Figure 27. Flow control fixture.

The total water saved from installing water sense fixtures when compared to an average household is summarized in (Table 13). The baseline household water usage is for a 3-bedroom house and is provided by the 2013 California Plumbing code for calculating water savings.

Table 12. Water usage baseline.

WATER USE BASELINE					
FIXTURE TYPE	**CONSUMPTIO N (GPM)**	**DAILY USES**	**DURATIO N (MIN)**	**OCCUPAN TS**	**DAILY WATER USE (GAL)**
1.6 GPF TOILETS	1.6	5	1	4	32
LAVATORY FAUCET-2.2 GPM	2.2	8	0.25	4	18
KITCHEN SINK-2.2 GPM	2.2	6	0.25	4	13
SHOWERHEAD - 2.5 GPM	2.5	0.75	8	4	60
			TOTAL DAILY VOLUME		123

TOTAL ANNUAL VOLUME	44822

Table 13. Water savings.

WATER SAVINGS					
FIXTURE TYPE	**CONSUMPTION (GPM)**	**DAILY USES**	**DURATION (MIN)**	**OCCUPANTS**	**DAILY USE (GAL)**
TOILETS (1.0 GPF)	1	5	1	4	20
LAVATORY FAUCET (1.0 GPM)	1	8	0.25	4	8
KITCHEN SINK (1.5 GPM)	1.5	6	0.25	4	9
SHOWERHEAD(1.5 GPM)	1.5	0.75	8	4	36
				TOTAL DAILY VOLUME	73
				TOTAL ANNUAL VOLUME (GAL)	26,609
				ANNUAL SAVINGS	18214
				% REDUCTION	40.6

2016

Bear River Band Three Bedroom Case Study New Construction Home Volume II

Renewable Energy Student Union

U.S. DOE Race to Zero Student Design Competition

8/16/2016

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Design Rendering

Exterior

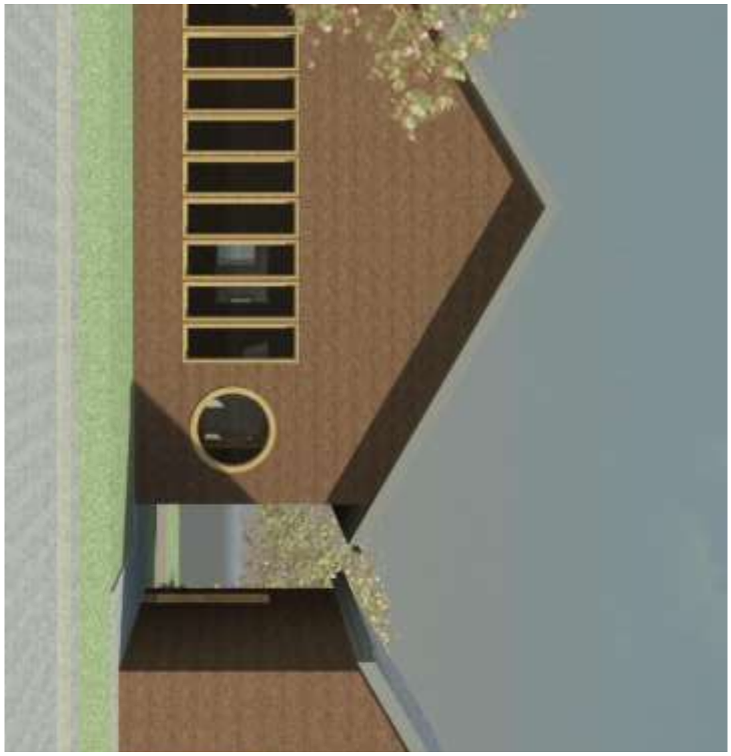


Figure 1. Front West Facing.

Figure 2: South Facing Exterior.

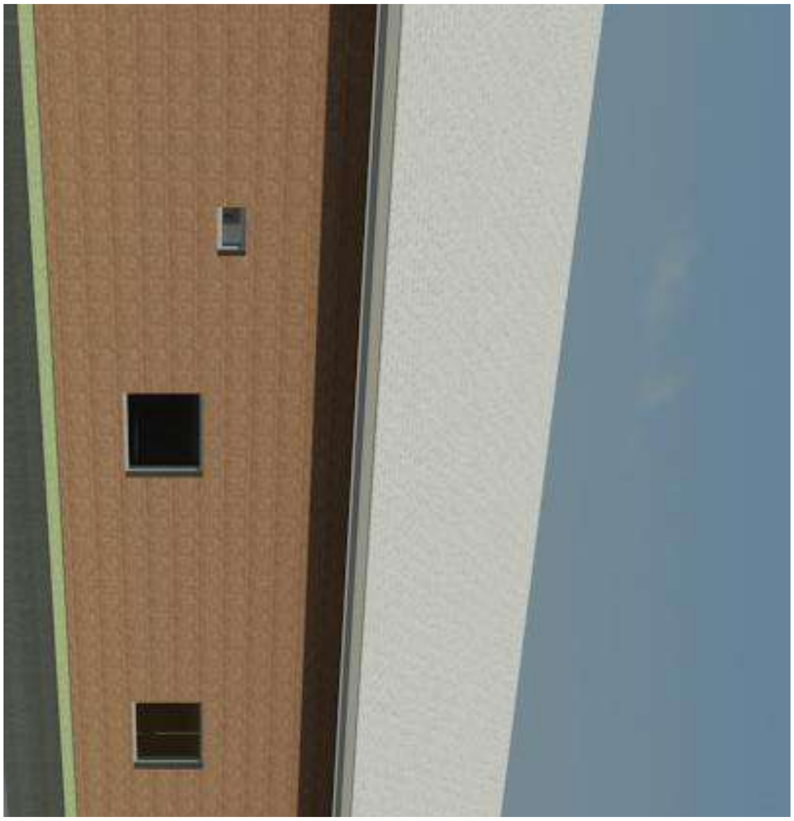


Figure 3: Back North Facing Exterior.

Interior

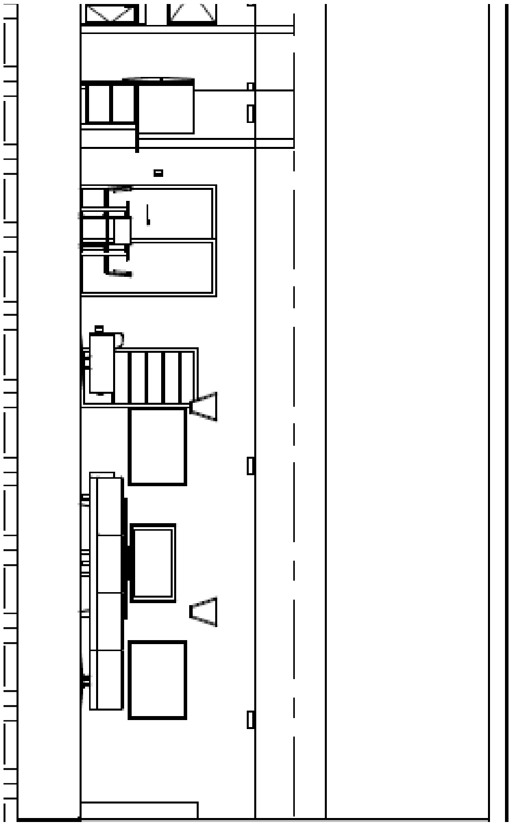


Figure 4: North Facing Interior.

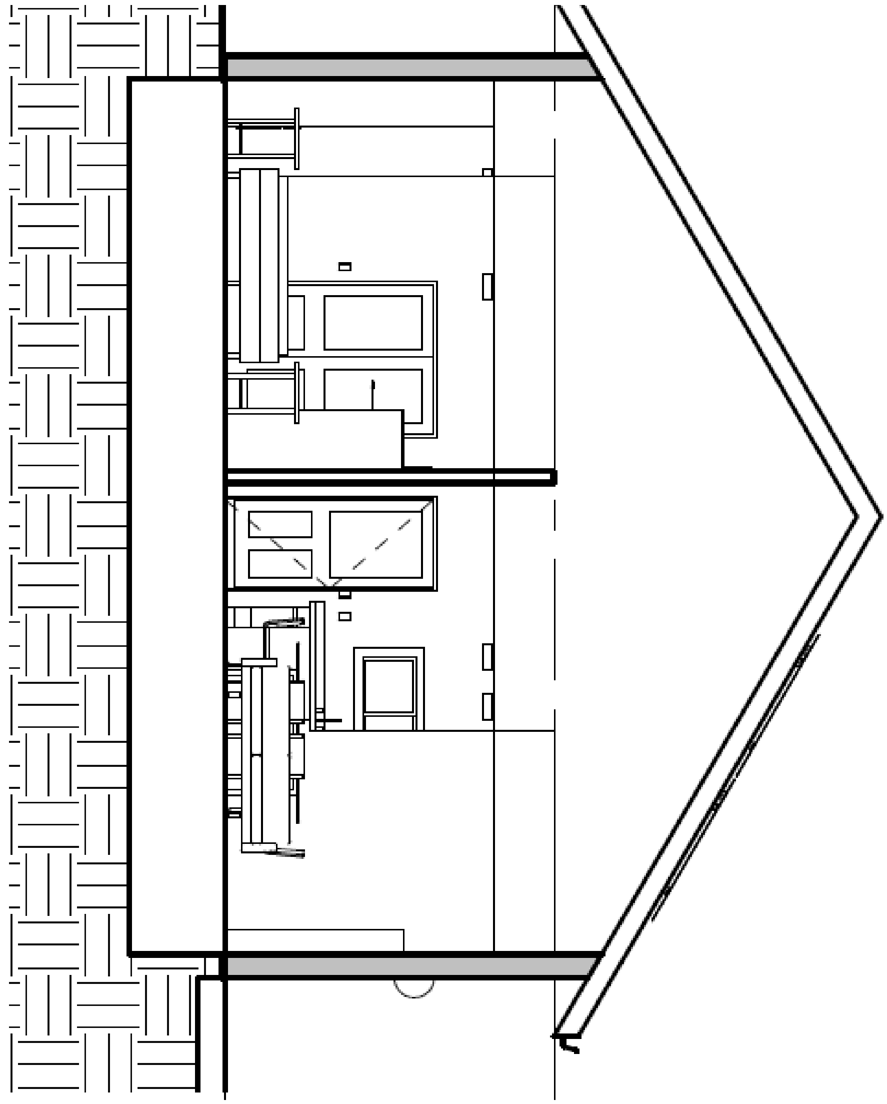


Figure 5: East Facing Interior (without Solarium).

Construction Drawing

Dimensioned Floor Plans

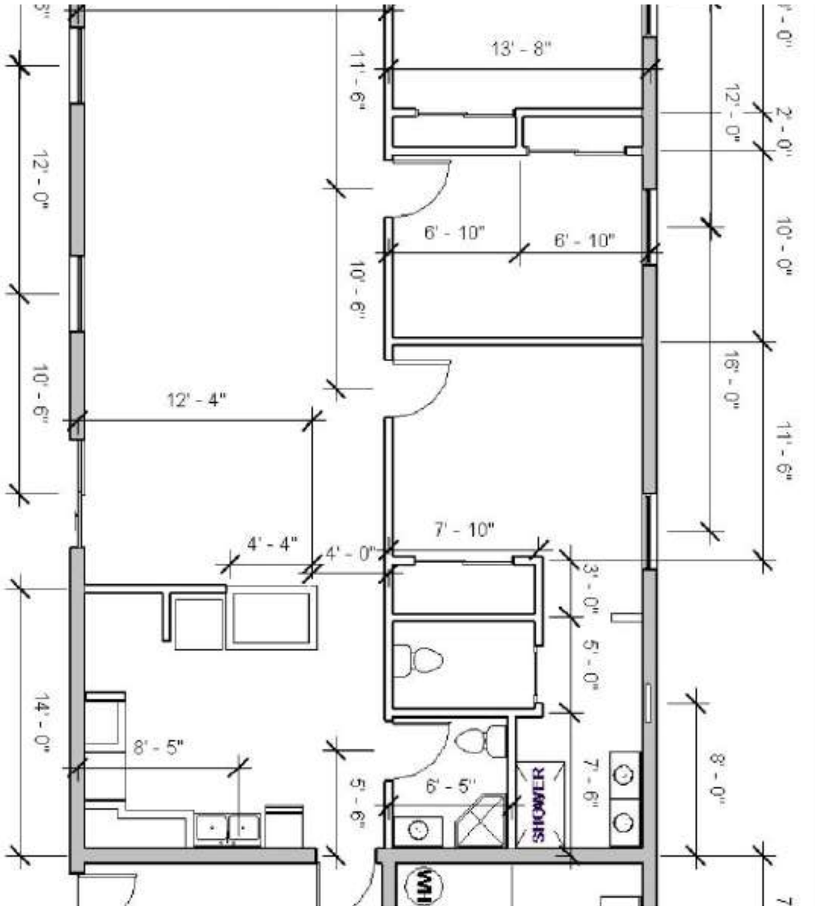


Figure 6: Floor Plans with Dimensions.

Building Sections

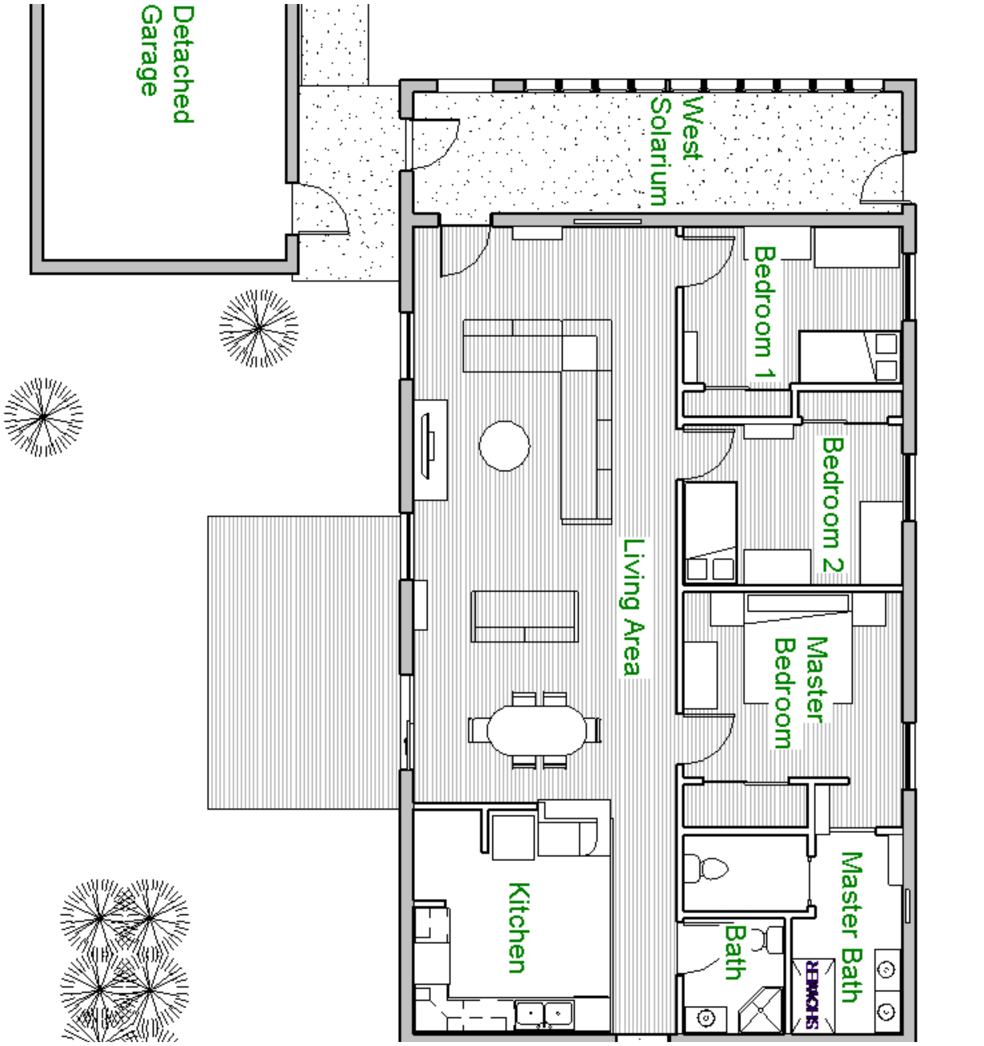


Figure 7: Design Plan with Building Sections.

Interior Details

Figure 8: Interior Living Space.

Figure 9: Interior Kitchen View.

Wall, Floor, and Roof Section

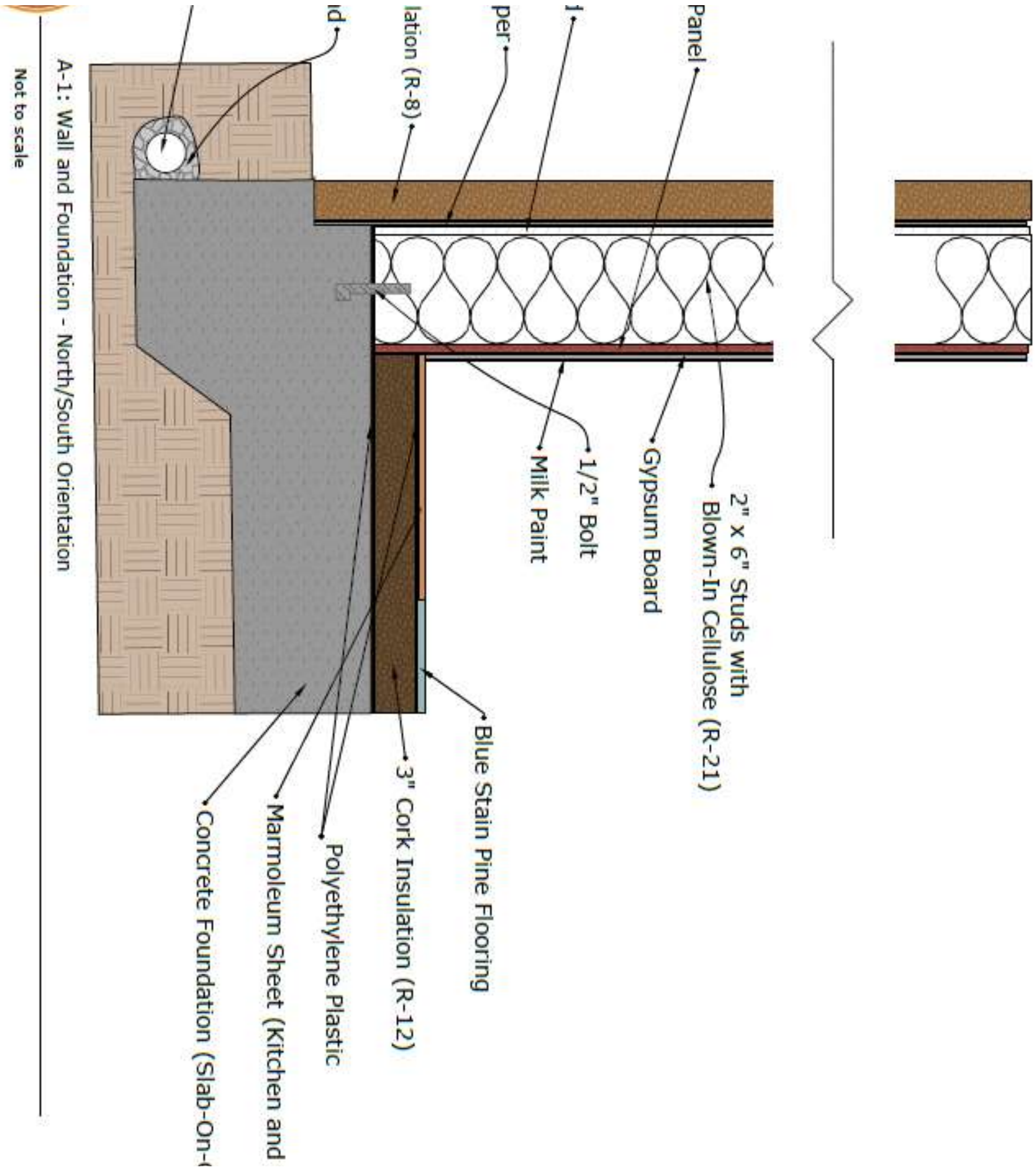


Figure 10. Foundation section.

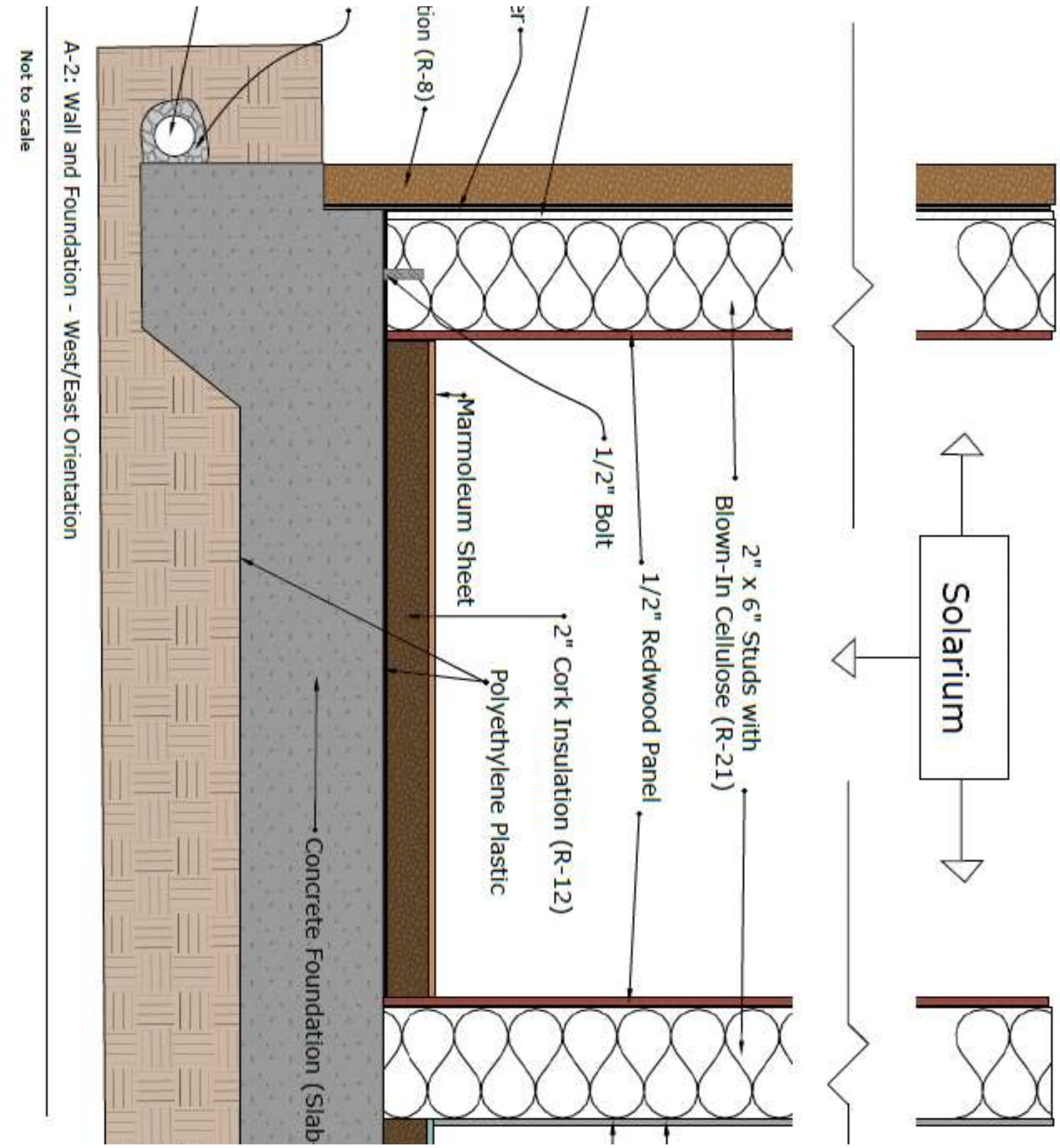


Figure 11. Solarium section.

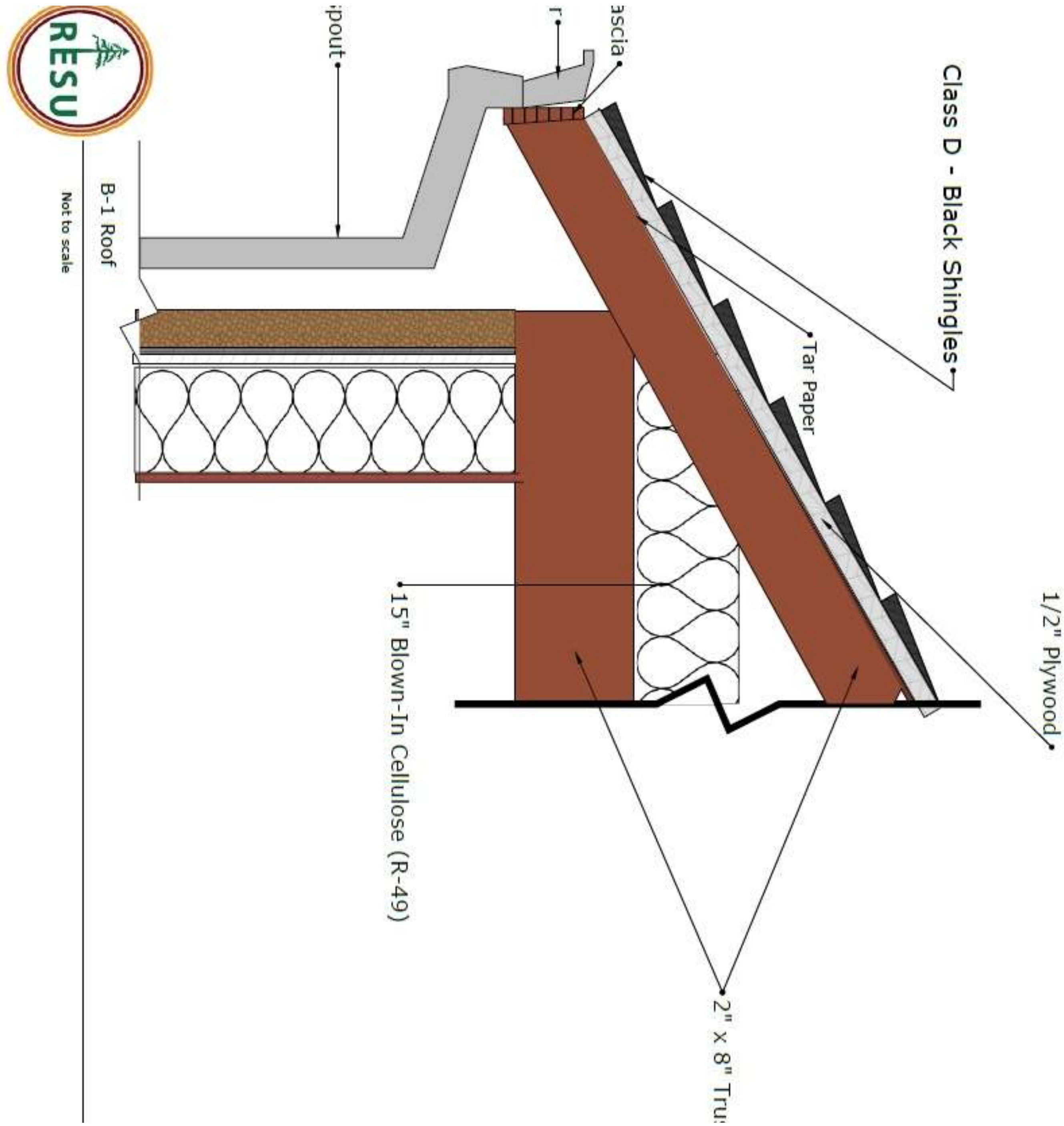


Figure 12. Roof section.

Window and Doors Details

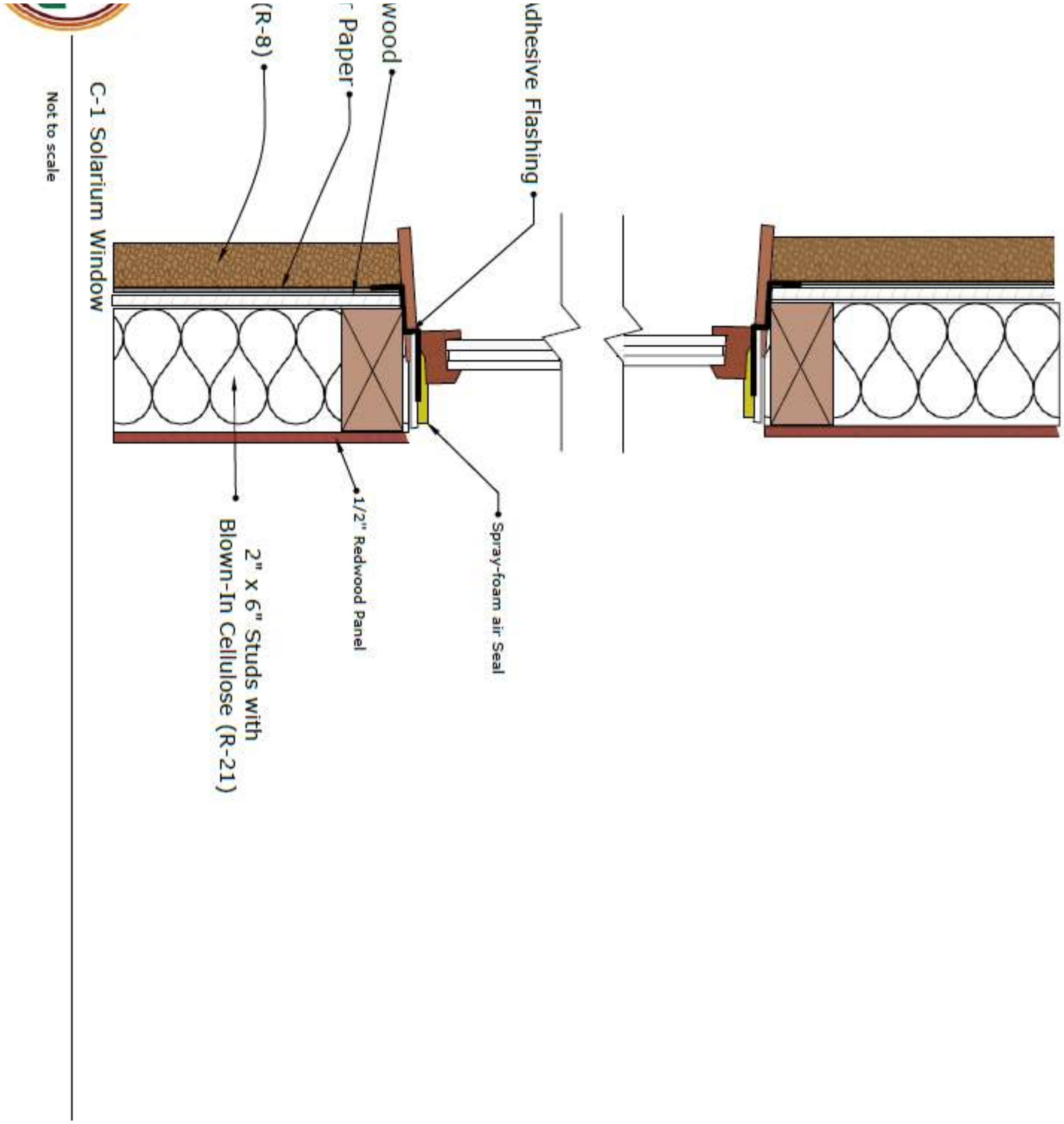


Figure 13. Wall section.

Table 1. Doors, Windows, and Mirrors.

	Description	Width (inches)	Length (inches)	Amount	Type
Doors	South-West 1	36	84	1	4-Panel Insulation Medium Oak Left-Hand Inswing with
	North-West 2	36	84	1	4-Panel Insulation Medium Oak

					Left-Hand Inswing with
	West Enty	36	84	1	4-Panel Insulation Medium Oak Right-Hand Inswing with
	Laundry Room	36	84	1	With window Thermotrue Oak Fiberglass
	South-East 2	36	84	1	With window
	Kitchen/ East Entry	36	84	1	With window
	Bedroom 1	36	80	1	Regular Therma-Tru Oak
	Closet Door 1	60	84	1	Double Slider
	Bedroom 2	36	80	1	Regular
	Closet Door 2	60	84	1	Double Slider
	Master Bedroom	36	80	1	Regular
	Master Closet	60	84	1	Double Slider
	Master Bathroom	36	84	1	Sindle Slider
	General Restroom	36	80	1	Regular Wood
Windows	**Description**	**Width (inches)**	**Length (inches)**	**Amount**	**Type**
	Glass Slider Door	64	84	1	Low-E 366 Without GBG's
	Multiple Location	48	36	8	Awning
	Kitchen/ East Entry	48	24	1	Slider
	Bathroom	24	12	1	Obscure
	Round Entrance	24.5	24.5	1	Triple Glazed
	Fixed Windows	2	6	20	Clear
	Item	**Price**	**Provider**	**Reference**	
Other	Mirror (Medicine Cabinet)	159.2	Homedepot	http://www.homedepot.com/p/Foremost-Naples-25-in-x-31-in-Surface-Mount-Medicine-Cabinet-in-Warm-Cinnamon-NACC2531/100426624	
	Mirror	87.2	Homedepot	http://www.homedepot.com/p/Foremost-Naples-32-in-L-x-24-in-W-Wall-Mirror-in-Warm-Cinnamon-NACM2432/202046270	

Air Sealing Details

The air sealing is carried out all through the construction. The blow door test with a smoke stick will be used to determine cracks and inefficiency in the envelop. The air sealing will incorporate the recommended aeroseal treatment by the Department of Energy. Furthermore, the DOE states that “...air movement accounts for more than 98% of all water vapor movement in building cavities (energy.gov). The material used by the design for moisture control is petroleum impregnated paper. Although, precautions, with regard to air quality must be taken, as a result of using this product, it was chosen due to its superior durability and waterproof properties (Green Building Advisor).

According to Sean Armstrong of Redwood Energy, a smokestick is used to identify point sources of air leakage. This is the method of chosen for assessing how airtight the Bear River house is. After this is done, caulking is used to fill any leaks or cracks.

According to the Department of Energy (DOE), controlling the movement of water vapor is crucial to maintaining effective air sealing, healthy indoor air quality, and an energy efficient building.

Blower door source: http://www.greenbuildingadvisor.com/blogs/dept/musings/blower-door-basics

Figure 14: Blow Door Test (Wikiomedia.org).

Mechanical Plans and Schedules

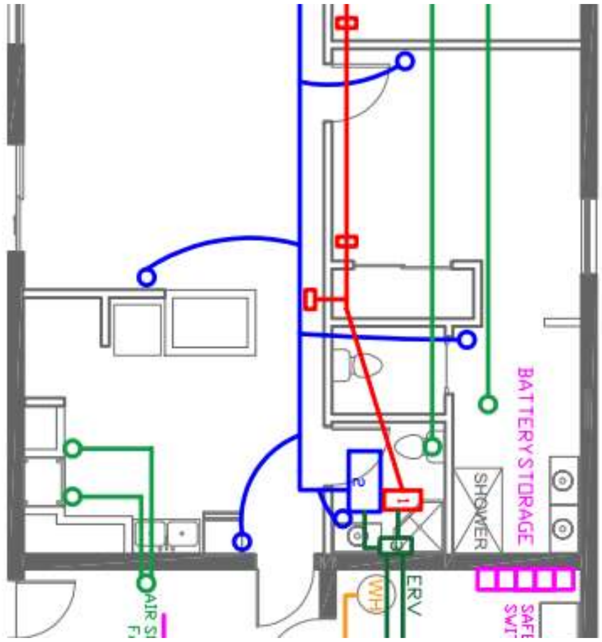


Figure 15. Mechanical Plan.

Plumbing Plan and Schedules

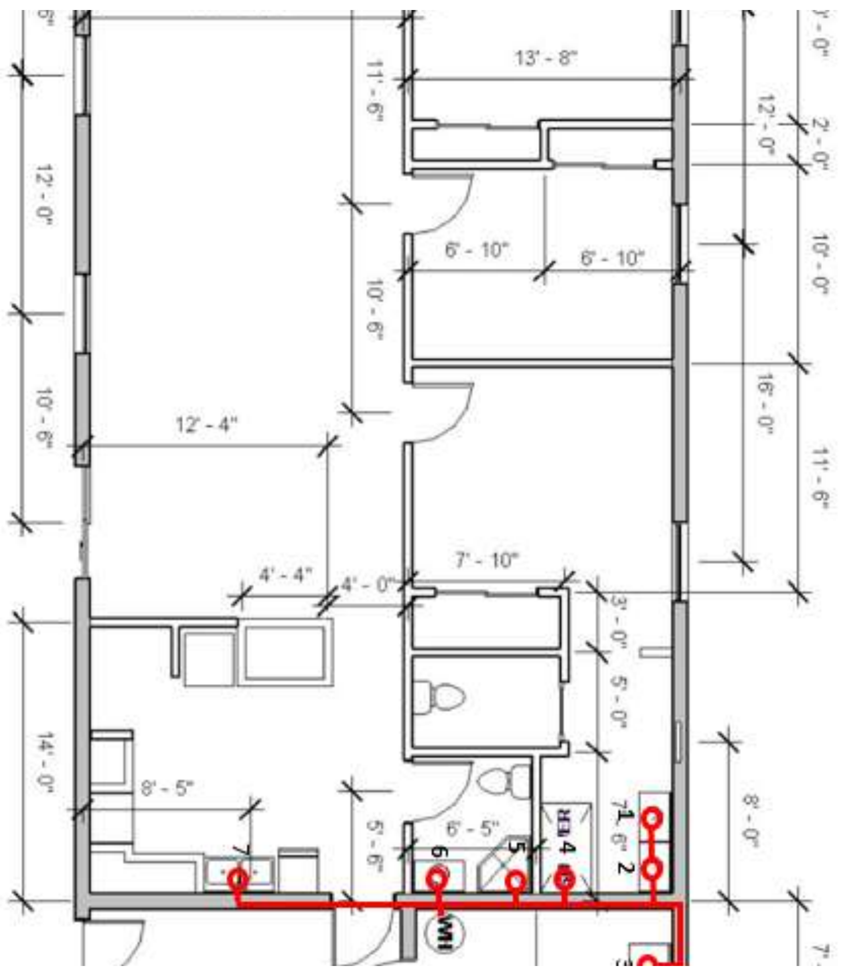


Figure 16: Hot Water Plumbing and Schedule.

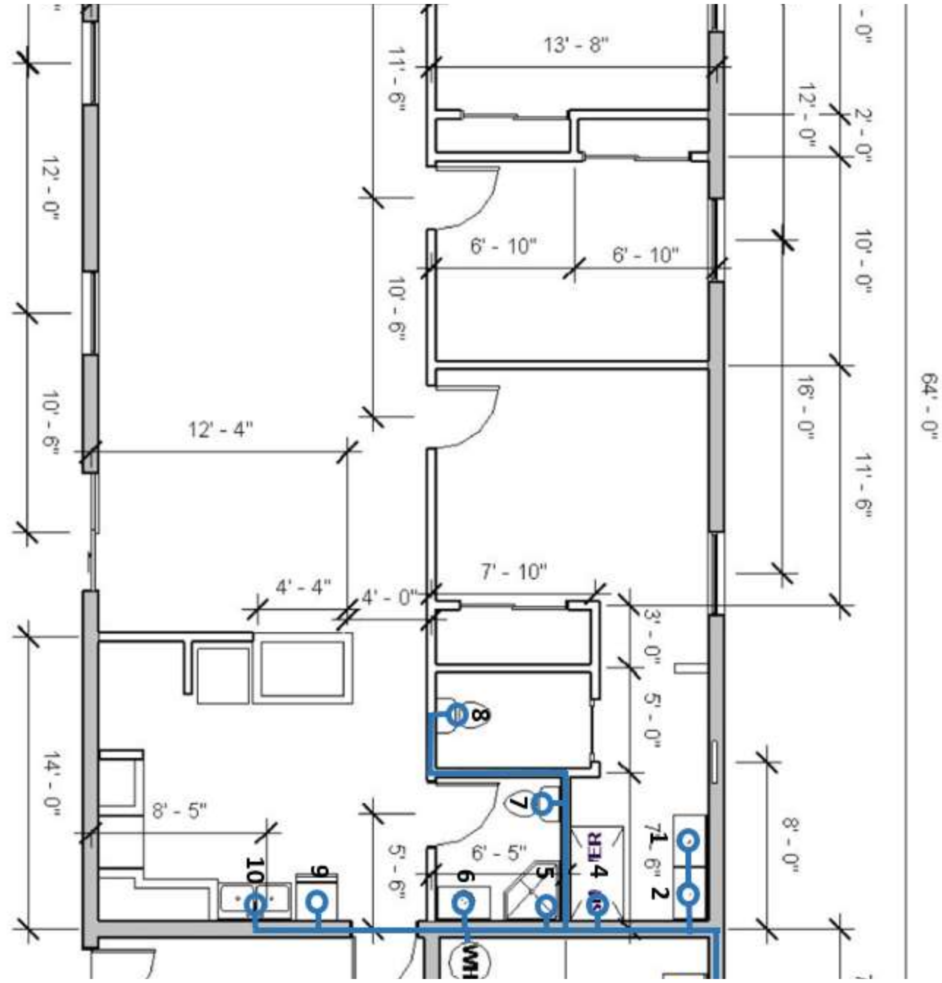


Figure 17: Cold Water Plumbing and Scheduling.

Electrical and Lighting Plans and Schedule

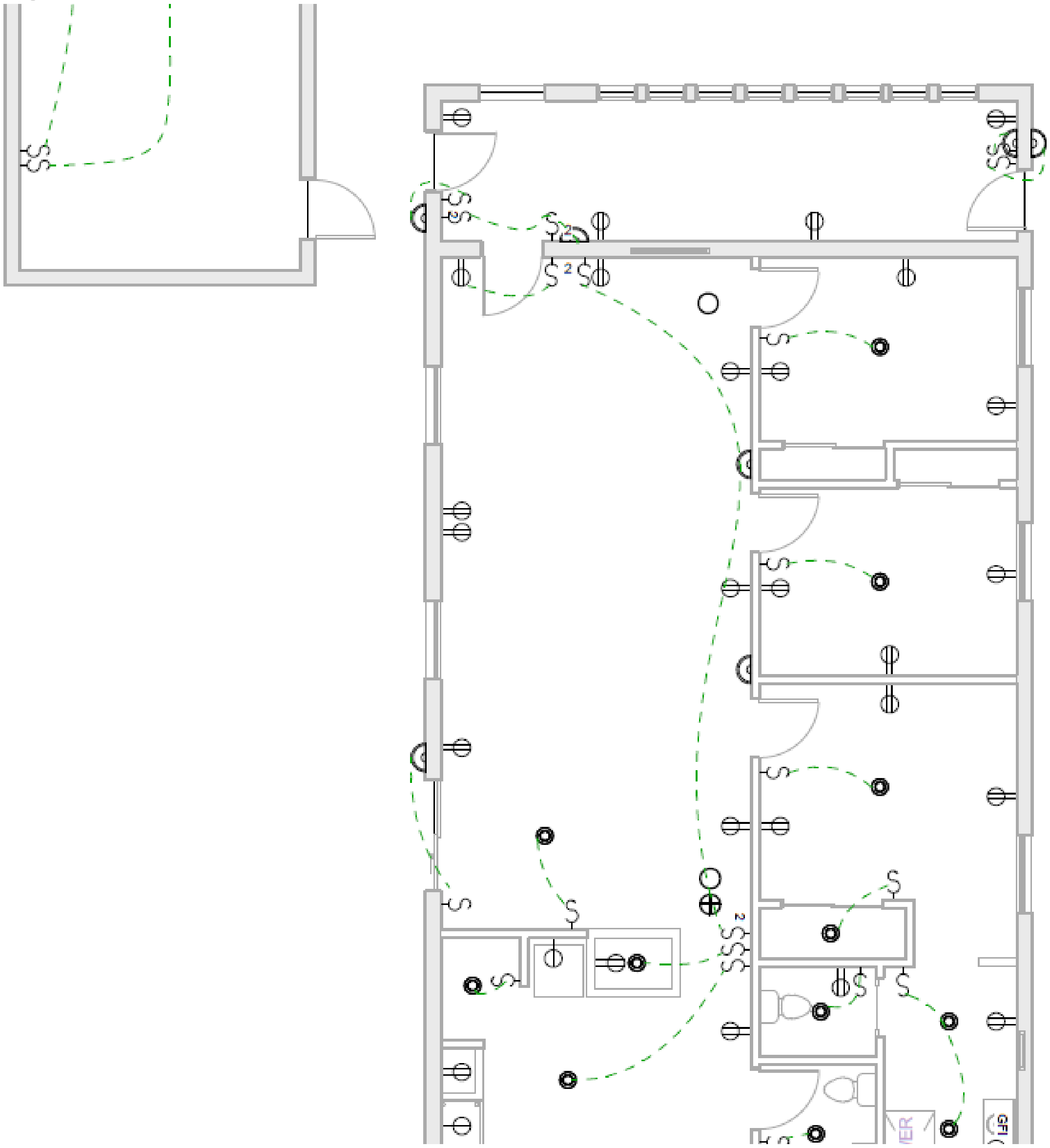


Figure 18: Electrical and Lighting Plans.

Construction Schedule and Size of the Project

Table 2. Construction schedule

Section	Task	Expected Duration (days)	Start Date	Finish
Preliminary Work	Print Construction Documents	1	4/1/2016	4/2/2016
	Bids and Contracts	24	4/2/2016	4/26/2016
	Grading and Building Permits	17	4/26/2016	5/13/2016
	File Building Permit Application	3	5/13/2016	5/16/2016
	Walk Lot w/ Owner	1	5/16/2016	5/17/2016
	Install Sediment Controls	2	5/17/2016	5/19/2016
	Building Permit Approved	1	5/19/2016	5/20/2016

Foundation	Clear Lot	3	5/20/2016	5/23/2016
	Foundation Excavation	2	5/23/2016	5/25/2016
	Install Reinforcing	1	5/25/2016	5/26/2016
	Pour Footing and Pin Footing	2	5/26/2016	5/28/2016
	Footing Inspection	1	5/28/2016	5/29/2016
	Foundation Certification	1	5/29/2016	5/30/2016
	Concrete Slabs	8	5/30/2016	6/7/2016
	Slab Inspection	1	6/7/2016	6/8/2016
	Prep Garage Slab	1	6/8/2016	6/9/2016
	Termite Treatment Garage Slab	1	6/9/2016	6/10/2016
	Pour Garage Slab	1	6/10/2016	6/11/2016
Rough Carpentry	Floor Deck Framing	4	6/11/2016	6/15/2016
	Floor Wall Framing	4	6/15/2016	6/19/2016
	Set Roof Trusses	7	6/19/2016	6/26/2016
	Frame Roof	5	6/26/2016	7/1/2016
	Frame Inspection	2	7/1/2016	7/3/2016
HVAC	HVAC Layout and Measure	1	7/1/2016	7/2/2016
	HVAC Rough-in	5	7/2/2016	7/7/2016
	HVAC Set Indoor Units	2	7/7/2016	7/9/2016
	HVAC Inspection	2	7/9/2016	7/11/2016
Plumbing	Plumbing Slab	2	7/9/2016	7/11/2016
	Plumbing Layout	1	7/11/2016	7/12/2016
	Plumbing Rough-in	5	7/12/2016	7/17/2016
	Plumbing Inspection	1	7/17/2016	7/18/2016

Section	Task	Expected Duration (days)	Start Date	Finish
Electrical Installation	Electric Rough-in	19	7/17/2016	8/5/2016
	Set Electric Boxes	2	8/5/2016	8/7/2016
	Install Electric Service Panel	2	8/7/2016	8/9/2016
	Electric Walkthrough	1	8/9/2016	8/10/2016
	Electrical Rough-wire	14	8/10/2016	8/24/2016
	Electrical inspection	0	8/24/2016	8/24/2016
Roofing	Plywood	5	8/24/2016	8/29/2016
	Roofing Paper Installed	3	8/29/2016	9/1/2016
	Stock Roof Shingles	1	9/1/2016	9/2/2016
	Install Roof Shingles	7	9/2/2016	9/9/2016

Exterior Wall	Plywood	3	9/9/2016	9/12/2016
	Tape and Flashing	5	9/12/2016	9/17/2016
	Insulation	5	9/17/2016	9/22/2016
	Moisture Layer	3	9/22/2016	9/25/2016
	Cork Siding	1	9/25/2016	9/26/2016
	Insulation Inspection	3	9/26/2016	9/29/2016
	Drywall / Redwood Panels	12	9/29/2016	10/11/2016
	Windows and Doors	5	10/11/2016	10/16/2016
	Caulk and Air Seal	2	10/16/2016	10/18/2016
Interior	Sand Drywall	1	10/16/2016	10/17/2016
	Floor (Marmoleum/ Blue Pine)	15	10/17/2016	11/1/2016
	Sand, Stain, Seal Hardwood	5	11/1/2016	11/6/2016
	Paint	15	11/6/2016	11/21/2016
	Install Interior Doors	5	11/21/2016	11/26/2016
	Caulk and Seal	21	11/26/2016	12/17/2016
Other Required Installations	Driveways	3	12/17/2016	12/20/2016
	Final Grade and Seed	3	12/20/2016	12/23/2016
	Install Fixtures	1	12/23/2016	12/24/2016
	Switch and Plug	2	12/24/2016	12/26/2016
	Door and Bath Hardware	2	12/26/2016	12/28/2016
	Gutter	3	12/28/2016	12/31/2016
	Final Building Inspection	1	12/31/2016	1/1/2017
Cleaning	Windows and Doors	1	1/1/2017	1/2/2017
	Final Clean	4	1/2/2017	1/6/2017

Energy Analysis

HERS Rating Documentation

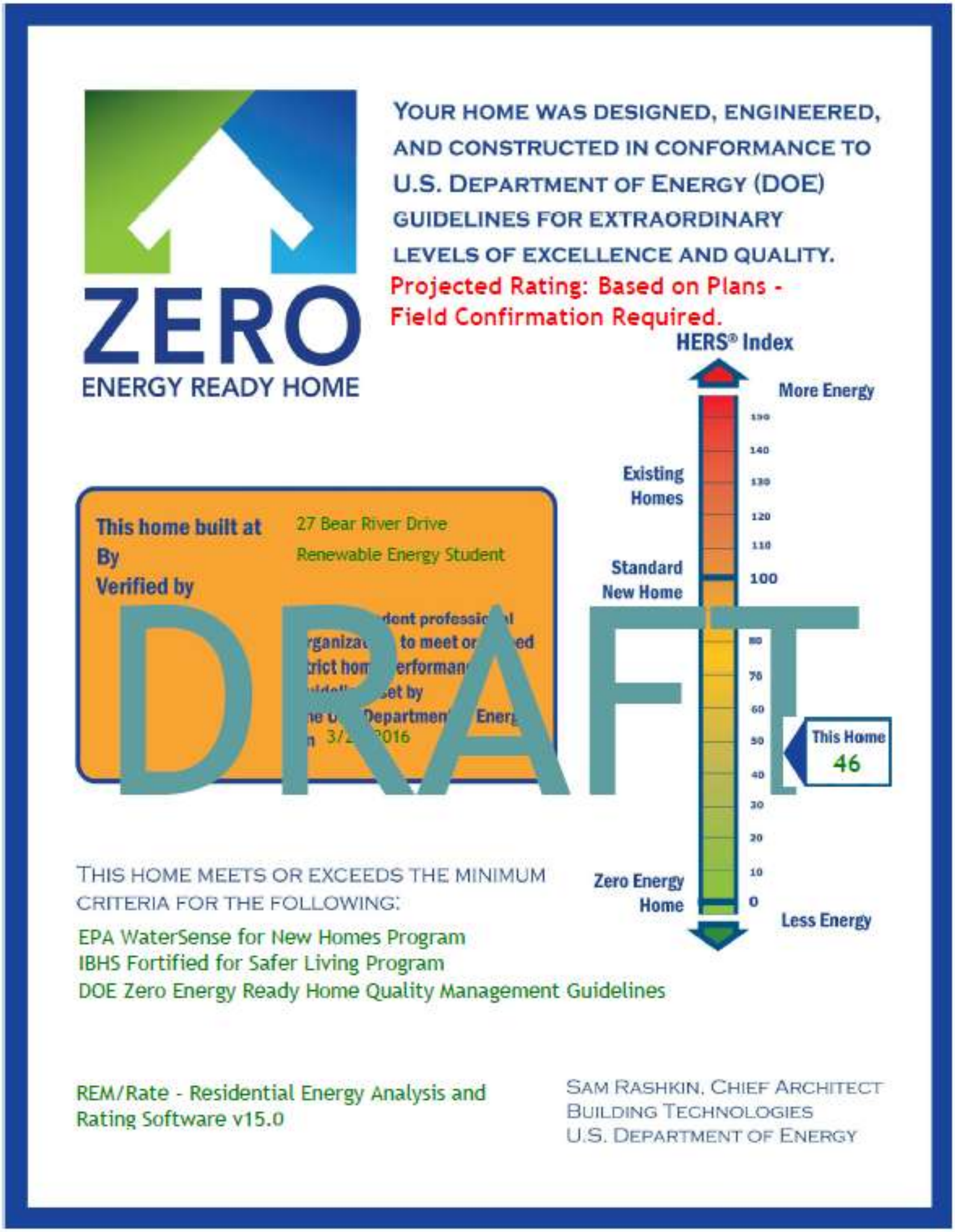


Figure 19: HERS Score without PV.

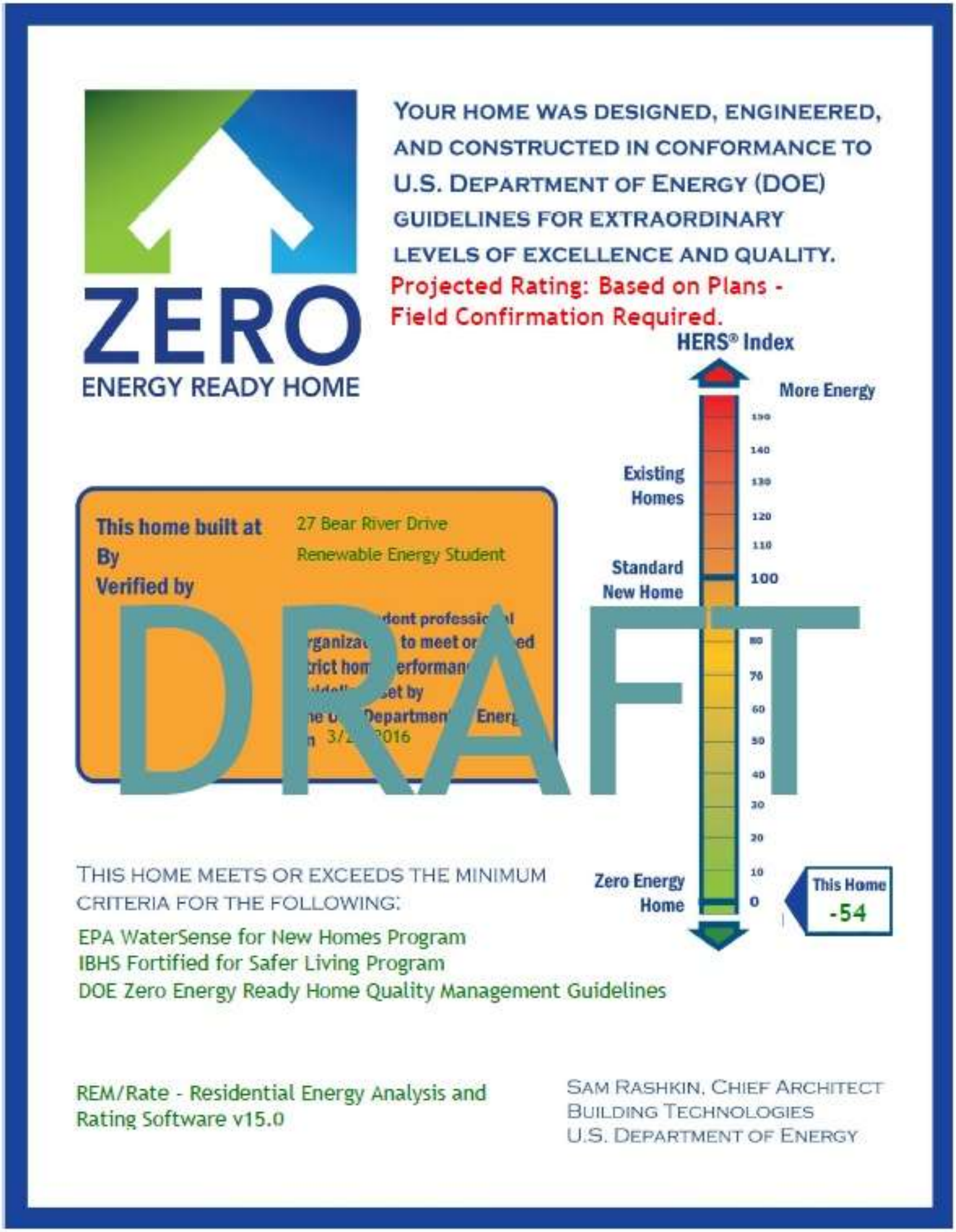


Figure 20: HERS Score with PV.

Financial Analysis

Table 3. Construction cost details.

Construction Cost Breakdown		NAHB 2013 Value Share of Construction Value	Per sq.ft.	Team Default Estimate for Share of Construction Value	Team Estimate Share of Construction Value	Team Estimate Per sq.ft.	Justification Required?	Justification/Notes
Site Work (A-E)		**$16,825.00**	**$6.45**	**$12,391.25**				
A	Building Permit Fees	$3,647.00	$1.40	$2,685.94	$2,505.00	$1.30	YES	http://www.humboldtgov.org/DocumentCenter/Home/View/188
B	Impact Fee	$3,312.00	$1.27	$2,439.22	$0.00	$0.00	YES	Sovereign Tribe--no fee imposed
C	Water & Sewer Fees Inspections	$4,346.00	$1.67	$3,200.74	$2,324.00	$1.21	YES	$1,937 Standard Sewage Disposal Permit, $387 State Small Water System Annual Fee http://humboldtgov.org/documentcenter/view/9946
D	Architecture, Engineering	$3,721.00	$1.43	$2,740.44	$2,740.44	$1.43	NO	
E	Other	$1,799.00	$0.69	$1,324.93	$1,324.93	$0.69	NO	
Foundation (F-G)		**$23,401.00**	**$8.98**	**$17,234.34**				
F	Excavation, Foundation, Concrete, Retaining walls, and Backfill	$23,028.00	$8.83	$16,959.63	$25,734.00	$13.40	YES	excavation: $2572, $23,162 Foundation; RSMean Online
G	Other	$373.00	$0.14	$274.71	$274.71	$0.14	NO	
Framing (H-L)		**$47,036.00**	**$18.04**	**$34,641.01**				
H	Framing (including roof)	$36,438.00	$13.98	$26,835.81	$24,221.40	$12.62	YES	5% add-on for FSC certified framing wood; RSMean Online
I	Trusses (if not included above)	$5,461.00	$2.09	$4,021.91	$0.00	$0.00	YES	included in framing
J	Sheathing (if not included above)	$2,332.00	$0.89	$1,717.47	$1,717.47	$0.89	NO	
K	General Metal, Steel	$1,604.00	$0.62	$1,181.31	$2,179.80	$1.14	YES	RSMeans Online;
L	Other	$1,201.00	$0.46	$884.51	$884.51	$0.46	NO	
Exterior Finishes (M-P)		**$35,473.00**	**$13.61**	**$26,125.11**				
M	Exterior Wall Finish	$16,867.00	$6.47	$12,422.19	$28,584.00	$9.00	YES	cork siding=$9/sq ft, $5 for materials, $4 for installation
N	Roofing	$7,932.00	$3.04	$5,841.75	$9,389.00	$4.89	YES	RSMean Online; using class D shingles ASTM D3161
O	Windows and Doors (including garage door)	$10,117.00	$3.88	$7,450.96	$8,051.00	$4.19	YES	Painted redwood framed low U, high SHGC windows; $3276 windows, 5 Exterior Doors @ $850 (Lowes), $525 Garage Door
P	Other	$557.00	$0.21	$410.22	$410.22	$0.21	NO	

Construction Cost Breakdown		NAHB 2013 Value Share of Construction Value	Per sq.ft.	Team Default Estimate for Share of Construction Value	Team Estimate Share of Construction Value	Team Estimate Per sq.ft.	Justification Required?	Justification/Notes
Major Systems Rough-ins (Q-T)		**$32,959.00**	**$12.64**	**$24,273.60**				
R	Electrical (except fixtures)	$9,967.00	$3.82	$7,340.48	$5,149.95	$2.68	YES	RSMeans Online
S	HVAC	$10,980.00	$4.21	$8,086.54	$5,700.00	$2.97	YES	Unico quote (Industry Sponser)
T	Solar Array	$189.00	$0.07	$139.19	$32,211.00	$16.78	YES	Solar Array = 579 sf of SunPower (55 sf/kw)$1100/kW less 30% rebates, 5Batteries @ $1600
Interior Finishes (U-AE)	**Insulation**	**$72,241.00**	**$27.71**	**$53,203.96**				
U	Insulation	$4,786.00	$1.84	$3,524.79	$3,877.27	$2.02	YES	Increased 10% for R-49 attic insulation, R-19 solarium insulation and and QII inspections
V	Drywall	$9,376.00	$3.60	$6,905.22	$4,569.00	$2.38	YES	Gypsum; RSMeans
W	Interior Trims, Doors, and Mirrors	$10,536.00	$4.04	$7,759.54	$1,046.00	$0.54	YES	4 Doors @$200 (solid core interior), 1 mirrors @$159, 1 mirror $87 (Home Depot)
X	Painting	$8,355.00	$3.20	$6,153.28	$7,383.94	$3.85	YES	20 Gallons at $48.95; old-fashion milk paint (milkpaint.com)
Y	Lighting	$3,008.00	$1.15	$2,215.33	$716.28	$0.37	YES	See Lighting Schedule
Z	Cabinets, Countertops	$12,785.00	$4.90	$9,415.88	$2,053.50	$1.07	YES	$1205 Cabinets, $848.50 (RSMeans Online)
AA	Appliances	$4,189.00	$1.61	$3,085.11	$7,169.00	$3.73	YES	Estimated using Online Cost including pots and pans for induction stove
AB	Flooring	$12,378.00	$4.75	$9,116.13	$17,280.00	$9.00	YES	Using local wood flooring and natural linoleum at an average cost of $9.00 sf, twice the industry average
AC	Plumbing Fixtures	$4,265.00	$1.64	$3,141.08	$1,570.54	$0.82	YES	Simple piping and set up requires less labor and materials
AD	Fireplace	$2,057.00	$0.79	$1,514.94	$0.00	$0.00	YES	No fireplace in project
AE	Other	$506.00	$0.19	$372.66	$372.66	$0.19	NO	
Final Steps (AF-AJ)		**$16,254.00**	**$6.23**	**$11,970.72**				
AF	Landscaping	$5,744.00	$2.20	$4,230.33	$125.74	$0.07	YES	10 bales Wheat Straw @ $7.48 (Lowes), $16.98 seeding @ 3 sacks (home depot); Landscaping is taken care of by Tribal Community
AG	Outdoor structures (deck, patio, porches)	$2,891.00	$1.11	$2,129.16	$2,129.16	$1.11	NO	
AH	Driveway	$3,741.00	$1.43	$2,755.17	$2,755.17	$1.43	NO	
AI	Clean up	$2,261.00	$0.87	$1,665.18	$1,665.18	$0.87	NO	

AJ	Other	$1,617.00	$0.62	$1,190.89	$1,190.89	$0.62	NO	
Other		$2,265.00	$0.87	$1,668.12				
	Total	**$246,454.00**	**$94.54**	**$181,508.12**	**$220,513.12**			

Table 4. Summary of sales price.

NAHB Sales Price Breakdown	2013 Value	Team Default Estimate	Team Adjusted Estimate	Justification Required?	Justification/Notes
Finished Lot Cost (including financing costs):	$74,509.00	$54,874.44	$35,668.39	YES	Tribal government is streamline with no significant fees, streamlined entitlement process, no Federal authority or permit enforcement costs. Estimate reduced by 35%
Financing Costs	$5,479.00	$4,035.11	$4,035.11	NO	
Overhead and General Expenses	$17,340.00	$12,770.55	$12,770.55	NO	
Marketing Cost	$4,260.00	$3,137.37	$1,000.00	YES	Bear River Band government staff will market to low-income tribal members
Sales Commission	$14,235.00	$10,483.73	$0.00	YES	Bear River Band government staff will market to low-income tribal members
Profit	$37,255.00	$27,437.68	$0.00	YES	Bear River will not make profit from sales
Total Sales Price	**$399,532.00**	**$294,246.99**	**$273,987.16**		

Table 5. Financial Analysis.

	Default Estimate	Value	Justification/Notes	Resources and Notes
Home Cost				
Construction Costs		$220,513		
Total Home Costs		$273,987		
Property Tax				
Property Tax Rate	0.0115	$0		Sovereign Tribe therefore no property taxes are paid
Annual Property Tax	3986	$0		
Financing				
Annual Interest Rate	0.045	$0	Average Humboldt County Mortgage %	Bear River Band loan rates are set at Inflation/Cost of Living
Years		$30		
Payments per Year		$12		
Number of Payments		$360		
Down payment	69316	$27,399	10% of Total Home Cost	Down payment assistance available through Bear River Band
Principle Amount		$246,588		
Monthly Payment		-$851		
Affordability				
Annual Median Family Income (MFI)	52250	$47,704	Humboldt County Average ($43157)	http://www.census.gov/did/www/saipe/data/interactive/saipe.html; insufficient data for tribe taking average of Humboldt County Average and National Avg provided
Monthly Utility Costs				
Electricity	111	$5	Minimum monthly charge for PG&E	http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf
Natural Gas	31	$0		http://www.allconnect.com/lp-gas/natural-gas-usage-calculator.html
Water	18	$31	San Francisco, Family of Four	http://www.circleofblue.org/waternews/2010/world/the-price-of-water-a-comparison-of-water-rates-usage-in-30-u-s-cities/
Other		$0	None	Solar Lease Cost
Total		$36		
Debt to Income Ratio				

	Default Estimate	Value	Justification/Notes	Resources and Notes
Monthly Household Debt (0.5% MFI)	261	$239		
Operations and Maintenance Costs	196	$183	Humboldt County--Family of 4	http://www.irs.gov/Businesses/Small-Businesses-&-Self-Employed/Local-Standards-Housing-and-Utilities
Monthly Utility Costs	160	$36		
Property Tax	332	$0		
Insurance	79	$79		
Mortgage Payment	1405	$851		
Calculated Debt to Income Ratio		35%	Homeownership Affordability Target is 38%	

APPENDIX E

COMMUNITY-SCALE RENEWABLE ENERGY AND ENERGY STORAGE ANALYSIS

Community-Scale Renewable Energy

And Energy Storage Analysis

Prepared for:

Bear River Band of Rohnerville Rancheria

266 Keisner Road
Loleta, CA 95551

August 23, 2016

Prepared by:

and

TABLE OF CONTENTS

1.0 INTRODUCTION

The Bear River Band of the Rohnerville Rancheria is a sovereign Native American Tribe along the bluffs of the Eel River Valley in Humboldt County, CA. The Tribe currently purchases energy from the local utility provider Pacific Gas & Electric (PG&E), which burns fossil fuels; however their goal is to achieve Energy Sovereignty using 100% renewable sources. To replace the power previously delivered by PG&E the Tribe hired Redwood Energy to size a microgrid that could reliably meet the needs of Tribe owned properties and businesses. These properties and businesses include the Bear River Hotel and Casino, the Tish Non Community Center, the Pump and Play wastewater treatment facility, and a small accounting building. The first step to sizing a microgrid is to understand the energy demands of the buildings involved. The following report discusses the impacts of different options, then lays out in detail three reasonable pathways towards energy sovereignty, each with different costs, benefits, and land demands. Scenario 3, using a up to 1.6MW of biomass production and 300kW of wind power, is the least-cost option.

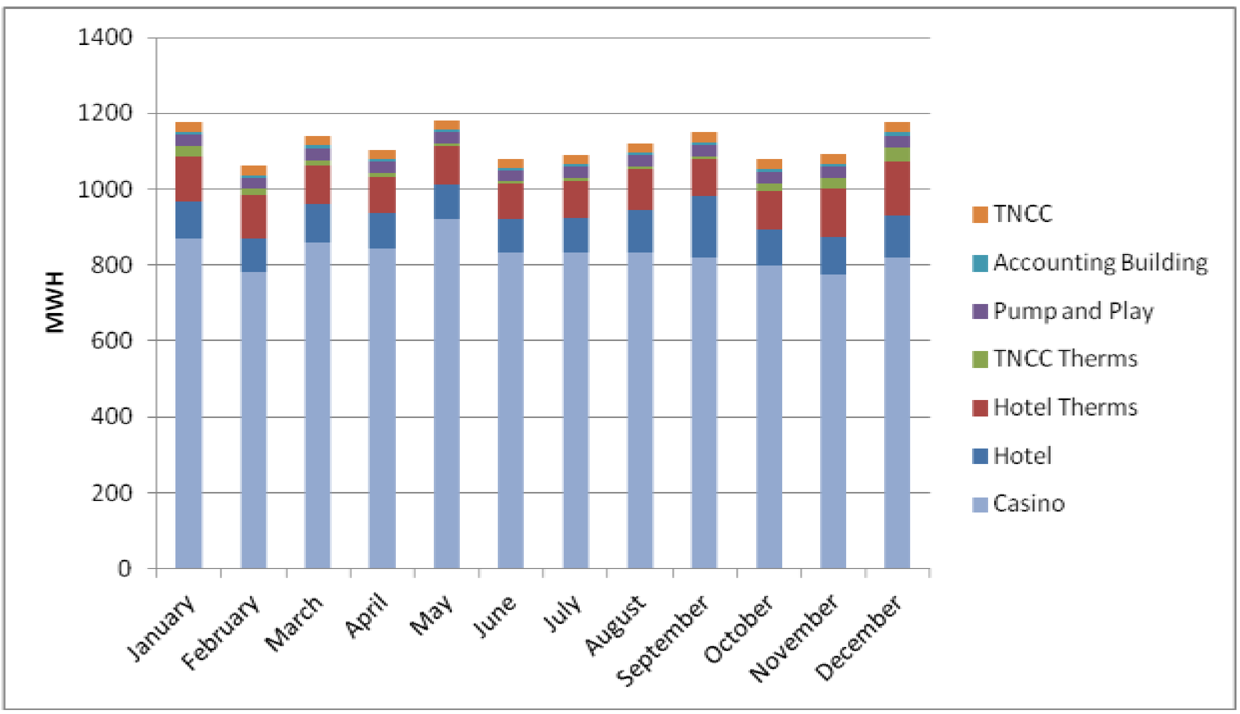


Figure 1: Bear River Band Energy Usage 2013-2014 (based on PG&E statements) for community-owned facilities

2.0 METHODS AND ASSUMPTIONS

2.1 Energy Consumption

The Bear River Band provided Redwood Energy with energy bills for the previous two years, which were analyzed both from a monthly, daily and hourly perspective to determine when energy was needed and when it could be supplied with different energy types. The microgrid needs to be extremely reliable to meet the constant and financially significant energy use of the casino. Solar and wind resources suffer from intermittency, so significant time was devoted to analyzing the energy production for times when energy would predictably be in short supply, such as the summer months when the wind energy decreases to ~15% of that in of the rest of the year, winter months when solar production is 40% of the summer peak, the nighttime when solar energy is entirely unavailable, and times of the day when wind power is less available.

2.2 SOLAR

Solar production data per kilowatt of solar panels was sourced from the California Energy Commission from local weather stations and confirmed with production of solar arrays being monitored in nearby Fortuna. Larger solar arrays (50kW-200kW) priced by public bids and installed in Fortuna, Ferndale, Eureka and Arcata cost $2400/kW, and $10/kW annual maintenance for a ground mounted solar array. Each 1kW photovoltaic require 55 ft.2 and would have a lifespan of at least 25 years of warrantied production, and 30+ years of near-peak production.

2.3 WIND

The Tribe was recently the subject of wind resource analysis and recommendations from the U.S. National Renewable Energy Lab (NREL) with additional monitoring by a group from Humboldt State University. The NREL analysis provided the data used in this report for the energy production of a Northern 100kW wind turbine they recommended as a best-fit for the Bear River Band. Each turbine costs roughly $500,000 to purchase with an additional $6800 in maintenance fees per turbine each year. The Northern 100 kW wind turbines have a lifespan of about 20 years.

2.4 BIOMASS

The Schatz Energy Research Center at Humboldt State University recently produced the RePower Humboldt Strategic Plan for the Redwood Coast Energy Authority, and that report states that biomass has a particularly important future in Humboldt County's energy future. Biomass plants already produce 30% of Humboldt County's energy, and this report states that responsible forestry management that figure could raise to 55% (100 MW). Biomass generation appears to be one of the most promising energy sources for projects in Humboldt County.

2.5 BATTERY STORAGE

Battery storage is a common way to accommodate the intermittency of wind and solar. Storing energy from peak solar and wind events would allow the Tribe to redistribute that energy when it was needed. Unfortunately current battery technology on the MW scale is expensive, environmentally destructive, and incapable of storing large amounts of energy for long periods of time. Batteries on this scale also have a maximum lifespan of about 10 years, but can degrade within 5 years if used heavily or left partially uncharged for a significant length of time, depending on the battery type. The less batteries used, the better for the budget and the environment.

3.0 SINGLE ENERGY SOURCE SCENARIOS

One option that was reviewed as a part of the scoping of the Energy Sovereign Micro-grid was simple, single source energy supply from either wind or solar arrays. The Bear River Band has a very hospitable site for wind development, as demonstrated by multiple reports. However, this wind resource is intermittent and falls to 1/7th of the monthly production of other months during the relatively calm months of July, August and September. With 81 industrial scale wind turbines the Tribe could meet its energy needs for nine of the twelve months of the year, but would need more than 570 of these wind turbines to meet the energy demand of the summer months, and additional batteries would be needed.

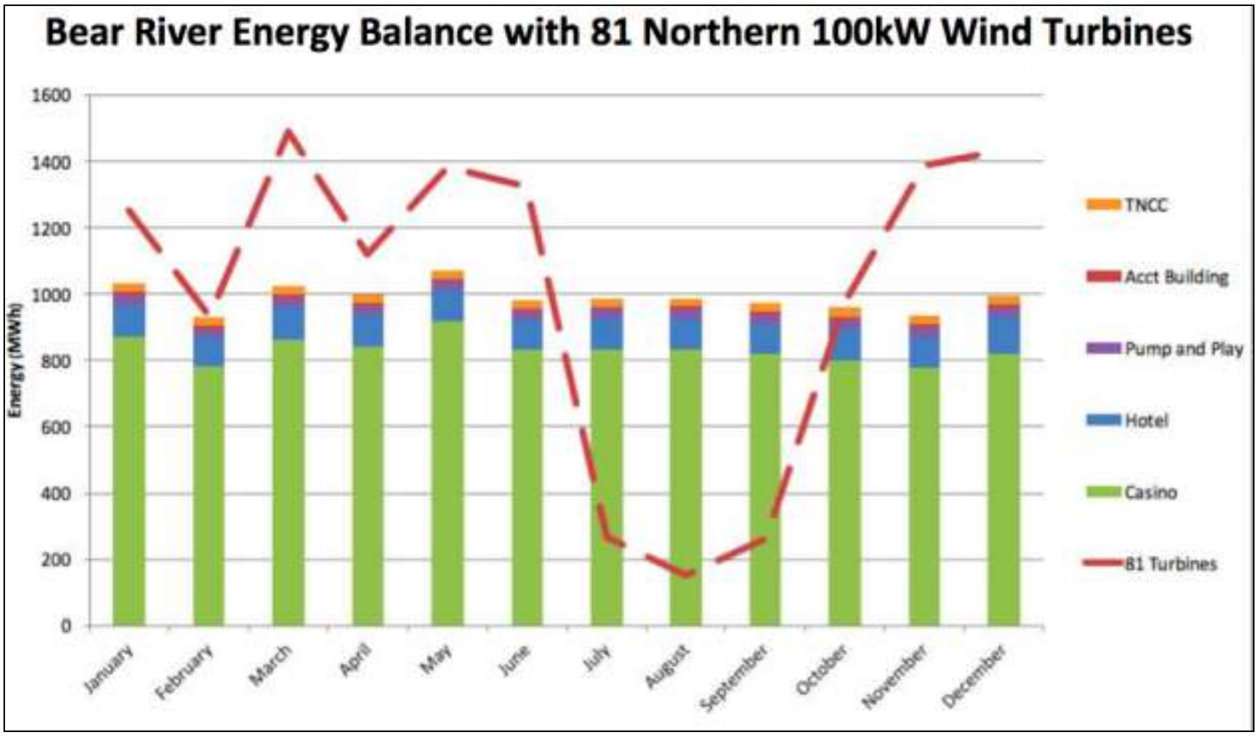


Figure 2: A wind-only micro-grid

The same single-source study was performed with solar power, which illustrates the significant excess energy produced during the spring through fall months, but the months of November, December and January are so dark that even 25 acres filled solid with solar panels cannot meet the energy needs—30 acres is about enough—and realistically a 30 acre array would need 40 or more acres when spaced for shading and access is included. The Tribe's representative, Edwin Smith, confirmed that neither the space required for a solar-only or wind-only microgrid was available, and from this determination the analysis proceeded to mix resources and additionally include biomass energy production.

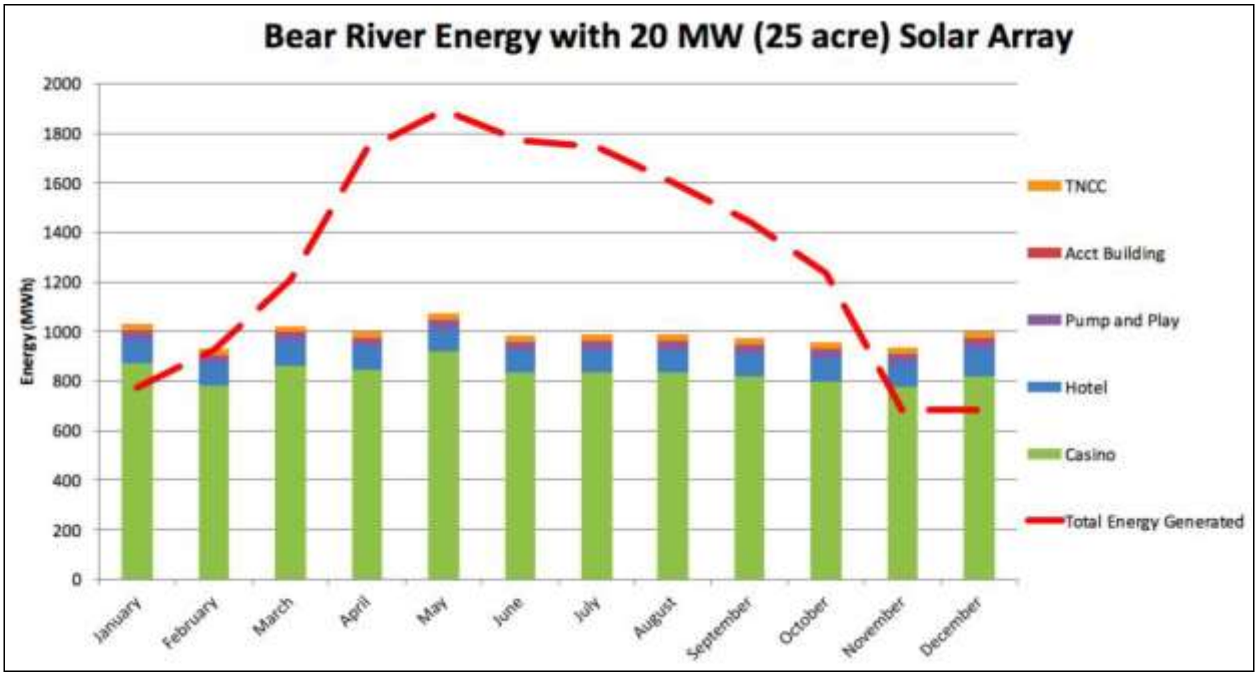


Figure 3: A solar-only microgrid

4.0 SCENARIO 1: BIOMASS GENERATION FOR THE CASINO AND A MIX OF RENEWABLE ENERGY AND STORAGE FOR ALL OTHER BUILDINGS

4.1 Introduction

The casino has a consistent and large energy load that ranges between 1000-1200kW per hour, which is challenging to meet dependable intermittent resources like wind and solar power that are weather dependent and seasonally available. By meeting the casino's needs with biomass purchased from local forests the Tribe can simply address that large power use in a reliable and renewable manner, while using less expensive and intermittent solar and wind power with energy storage for the much smaller loads of the hotel, community center, wastewater treatment facility, and the accounting building.

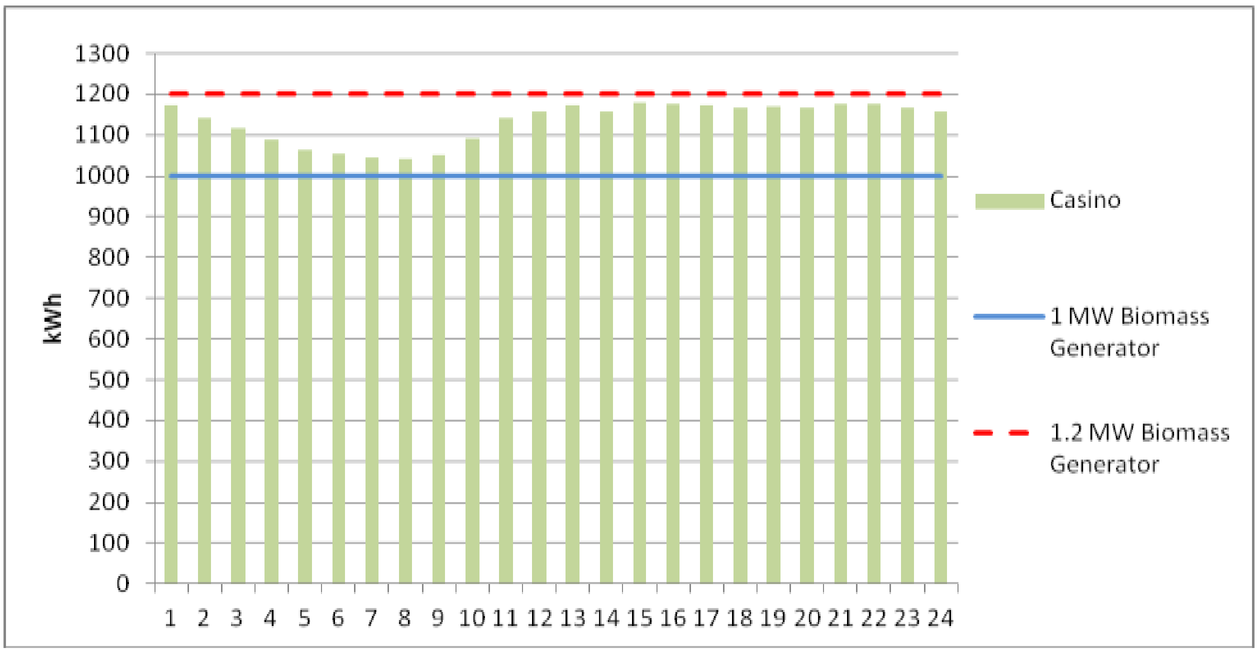


Figure 4: Hourly Average Energy Profile for Bear River Casino with various biomass generators

4.1.1 Biomass Generator

A 1.2 MW biomass generator, such as those found in projects of this size in India, China, and Kenya would be an appropriate match to meet the Casino's peak demand and hourly energy use.

Figure 5: 1.2 MW Fengyu biomass generator in China

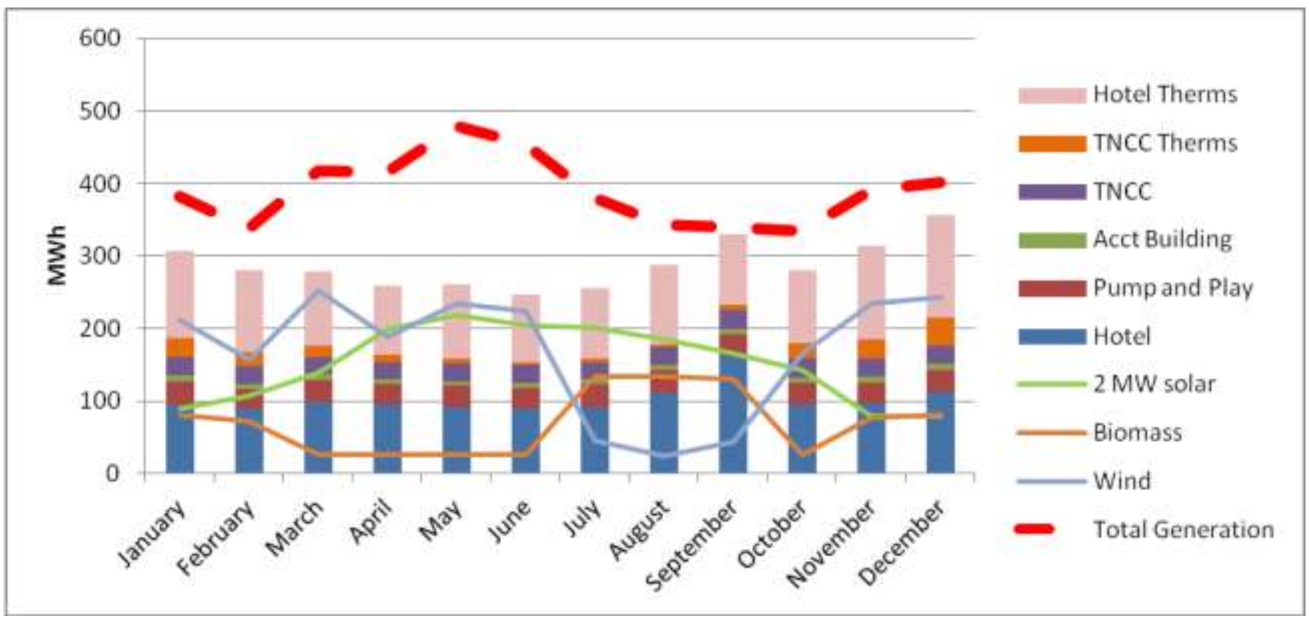


Figure 6: Energy Profile for non-casino buildings w/ 2 MW Solar Array, 1 MW Wind Farm, 10 Small Biomass Generators, and 2 MW of Battery Storage

4.2 Overview

For this scenario we decided to design a smaller microgrid that would meet the energy demands of the four buildings shown above. This allowed us to cut 6 MW of solar array from Scenario #1. In Scenario 2 we proposed installing a 2 MW solar array, a 1 MW wind farm, 10 small biomass generators, and 2 MW of battery storage.

4.2.1 Two MW Solar Array

A 2 MW ground mounted solar array would cover approximately 2.5 acres of land, which is significantly less than the 10 acre (8 MW) solar array proposed in Scenario 1. We project that this array will produce **1810 MWh annually** (50% of annual usage).

4.2.2 One MW Wind Farm

The graph above shows the anticipated annual production from 10 Northern 100kW wind turbines. Since the Rancheria is only 150 acres, putting up this many wind turbines could be difficult. Based on onsite data we anticipate a wind farm of this size would produce about **2025 MWh annually** (60% of the annual usage).

4.2.3 Hourly Energy Profile

Net generation is not enough to consistently keep the lights on so for all of these scenarios the hourly breakdown of energy consumption versus production is extremely important.

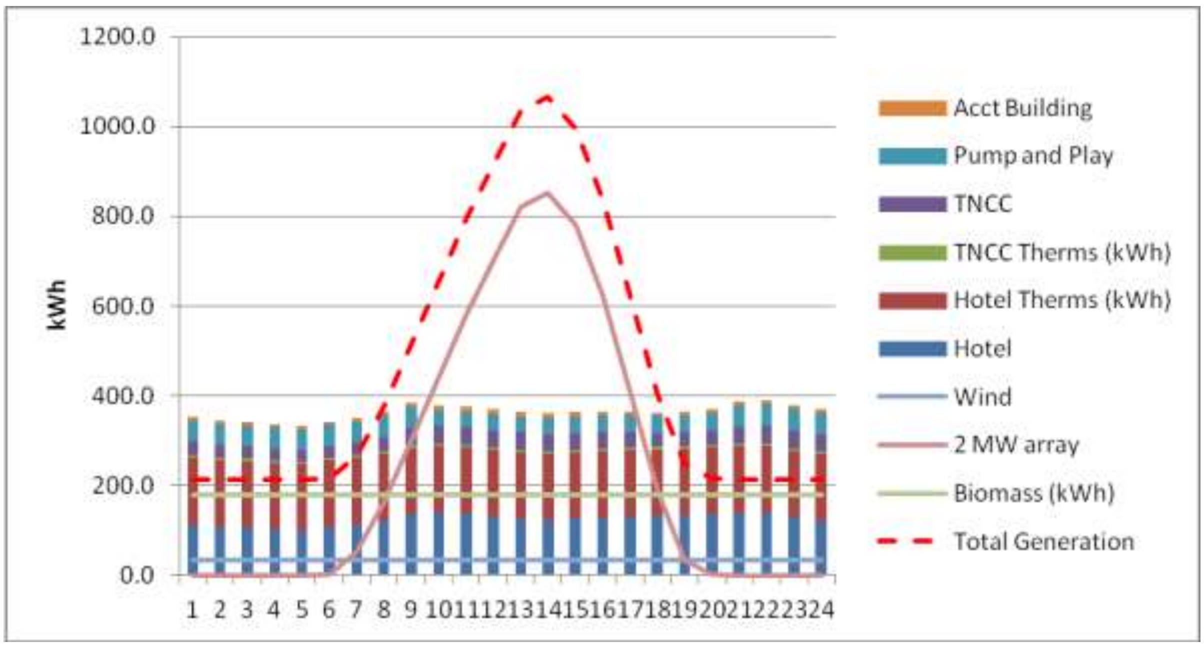


Figure 7: Hourly Breakdown for an average September day

Even though the above scenario generates enough electricity to satisfy the four building's daily demand but during the hours where the usage is higher than the total generation power will need to be provided by batteries. In this scenario we have all 10 small biomass generators operating continuously to minimize the amount of battery storage. An average September day would require roughly **1.8 MWh** of battery storage, which is more than any other month.

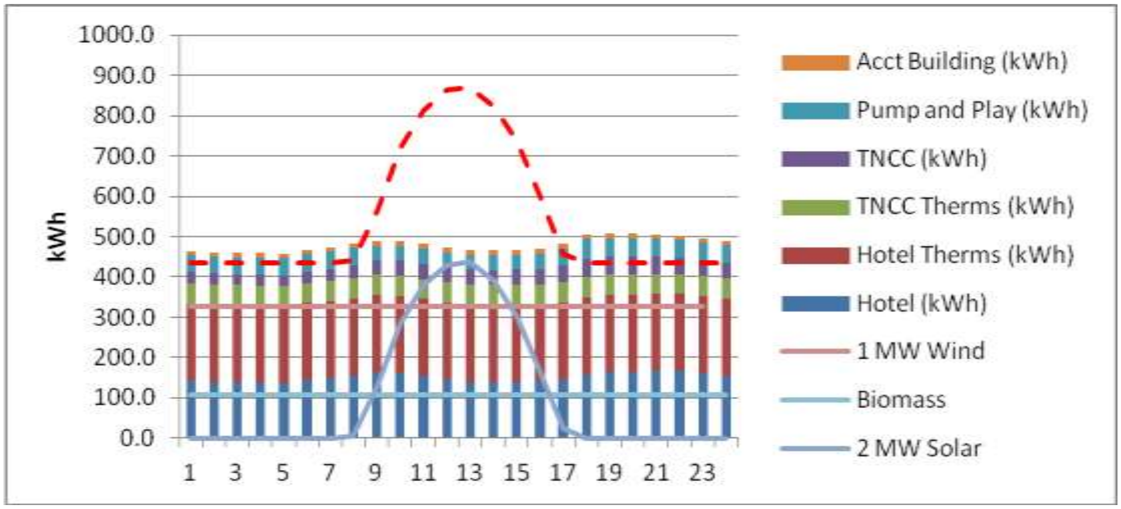


Figure 8: Hourly Energy Breakdown for an average December day

December is a month when the Tribe would not be able to rely on very much solar production. Fortunately, the data shows that December is one of the most productive months for wind generation. The large amount of wind would allow the Tribe to turn off multiple biomass generators which would increase longevity without compromising energy flow.

4.2.4 Ten Small Biomass Generators

In this scenario we are recommending that the Tribe purchase 10 Power Pallet PP20 Biomass Generators. These generators can continuously output 18 kW @ 60V and required 2.5 lbs. of woody biomass per kWh. These biomass generators are a powerful tool to mitigate the intermittency of wind and solar because they can be turned on when only when needed. For example, in months with a lot of solar production like July, or a lot of wind production like October, we can turn off some generators. This will allow us to extend the life of the machines, increase the Tribe's resiliency, and cut down on the amount of battery storage needed. Since trees grow using sunlight, wood chips represent stored solar energy. Utilizing this stored solar energy is more environmentally friendly that relying on large battery storage systems that requires lots of precious metals that or often mined in environmentally destructive ways. These generators would produce about **800 MWh annually** (24% of annual usage).

4.2.5 Two MW Battery Storage

Unfortunately this scenario doesn't allow us to consistently meet 100% of energy demand without some form of large scale battery storage. Ionex currently has modular 1 MW battery storage systems that come inside of a standard shipping container. Batteries of this size usually cost roughly $100/kW and need to be replaced every 10 years.

Figure 9: Ionex 1 MW battery in a shipping container

4.3 Conclusion

Separating the casino from the other four buildings allowed us downsize the proposed solar array from 8 MW (10 acres) to 2 MW (2.5 acres). This would save the Tribe millions of dollars in installation and maintenance costs over the life of the array. The10 Power Pallet PP20 biomass generators would make up for the decreased solar, and they don't suffer from intermittency issues. In addition to decreasing the size of the solar array, having continuously running biomass generators allows us to reduce the amount of battery storage the Tribe would need to maintain a reliable stream of energy. This scenario would net the Tribe **1200 MWh** that it could sell back to PG&E

.

Integrated Approach	Annual Cost	
Solar	$	5,400,000.00
Wind	$	6,360,000.00
Casino Biomass 1 MW	$	4,875,000.00
Biomass	$	367,542.00
Batteries	$	200,000.00
Total	**$**	**17,202,542.00**

Table 1: Cost Analysis for Installation and Maintenance of **Scenario 1**

5.0 SCENARIO 2: INTEGRATED RENEWABLES APPROACH

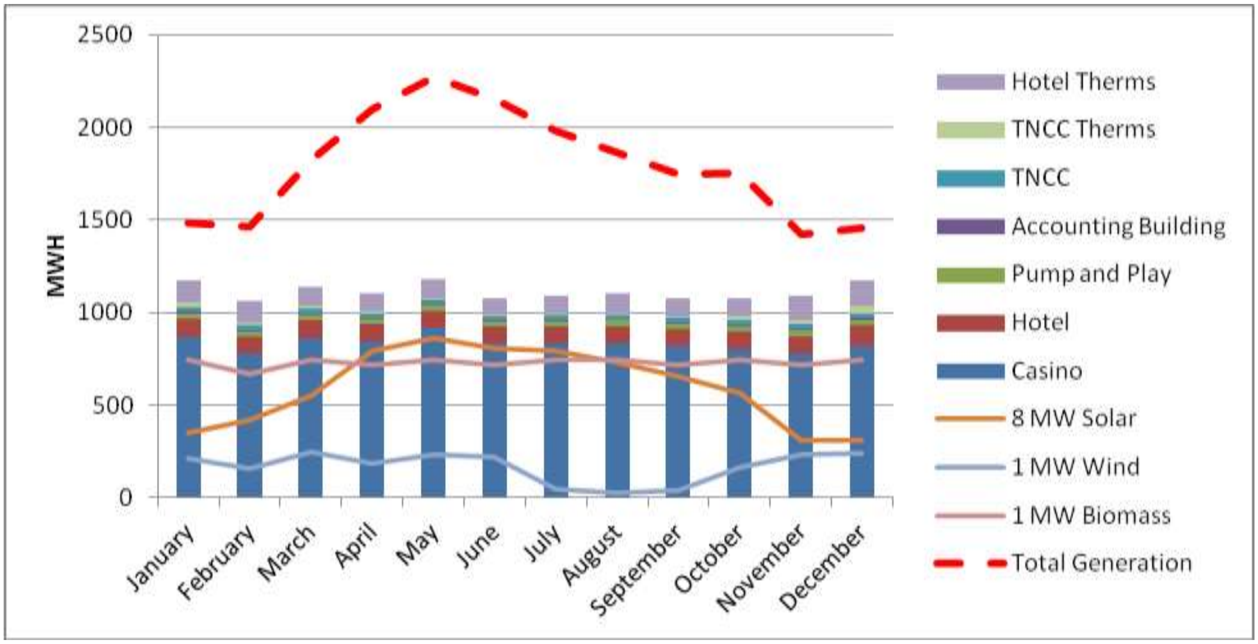


Figure 10: Bear River Energy Profile with 8 MW Solar Array, 1 MW Wind Farm, 1 MW Biomass Plant, and 3 MW Battery Storage

5.1 Overview

This scenario has all five buildings connected to the same grid, and relies on. It would require a significant investment of land and capital for an 8 MW solar array that would cover 10 acres of solid solar panels, and realistically 15 plus acres to address shading and access paths. The 1 MW wind farm would consist of 10 100 kW Northern Wind Turbines. The 1 MW GE Waukesha biomass generator would run continuously while consuming roughly 2.5 lbs. of bone dry wood fuel per kWh of production, and roughly 8,000 bone-dry tons of wood chips annually. An entire year's storage would take 48,000 cubic feet, or a half acre building with dry wood chips piled 20 feet high inside.

5.1.1 Eight MW Solar Array

An 8 MW solar array will ensure the Tribe is a net producer of solar power every month. Since an array of this size would cover approximately 10 acres and the Tribe has many competing land use interests an array of this size wouldn't be feasible without a land purchase. An array of this size would produce about **7000 MWh annually** (60% of the Tribe's annual usage).

5.1.2 One MW Wind Farm

The graph above shows the anticipated annual production from 10 Northern 100kW wind turbines. At $500,000 each these turbines are a significant investment and can produce complaints about noise if not cited far from housing or the hotel where people need quiet sleeping environments. Based on onsite data we anticipate a wind farm of this size would produce about **2000 MWh annually** (17% of the Tribe's annual usage).

5.1.3 One MW Biomass Generator

To compensate for the intermittency of wind and solar we decided to incorporate a 1 MW biomass generator that would continuously run to meet the casino's baseload. In Madera, California there is a bioenergy project using a 1 MW GE Waukesha Biomass Gasifier to increase the resiliency of the local power grid. We are assuming similar capital costs for the casino's proposed 1 MW biomass generator. Based on similar projects we assume the operation of this generator would require roughly 8,000 bone-dry tons of woody biomass annually and have a lifespan of about 15 years. This generator would provide about **8000 MWh annually** (70%)

5.1.4 Three MW Battery Storage

Since the 1 MW biomass generator would be used almost exclusively to meet the casino's baseload, batteries would be needed to store wind and solar energy for the other four buildings to use when the solar and resources aren't producing energy. This scenario would require over 3 MW of battery storage, and at $100/kWh this amount of battery storage is unlikely to be economically feasible. The batteries would also need to be replaced every 10 years.

5.2 Conclusions

This scenario would meet all the energy needs of the Tribe, with an additional **5,000 MWH of energy annually** that could either go unused, sold to the grid, used to power electric cars or assist a seasonal, energy-intensive business or community resource like heated swimming pools., but would cost the Tribe roughly **$33 million to install and maintain**. Because this scenario would require an extreme amount of land and capital we recommend against this integrated approach.

Integrated Approach	Annual Cost
Solar	$ 21,600,000.00
Wind	$ 6,360,000.00
Casino Biomass 1 MW	$ 4,875,000.00
Batteries	$ 400,000.00
Total	**$ 33,602,542.00**

Table 2: Cost Analysis for Installation and Maintenance for **Scenario 2**

6.0 SCENARIO 3: 1.6 MW BIOMASS AND 0.3 MW WIND FARM

6.1 Overview

After reviewing the first two scenarios with the Tribe their biggest concerns were the size of the solar array and wind farm—the land base does not exist within the Tribe's current boundaries to support large energy developments. This scenario eliminates batteries and solar power from the microgrid, and instead relies on a biomass generators to produce 1-1.2 MW for the Casino and another 400kW biomass generator to meet most of the needs of the remaining buildings, with a .3MW (300kW) wind farm using three 100kW Northern wind turbines. This way that way the Tribe could consistently meet the baseload without having to rely on batteries being charged by large solar and wind farms.

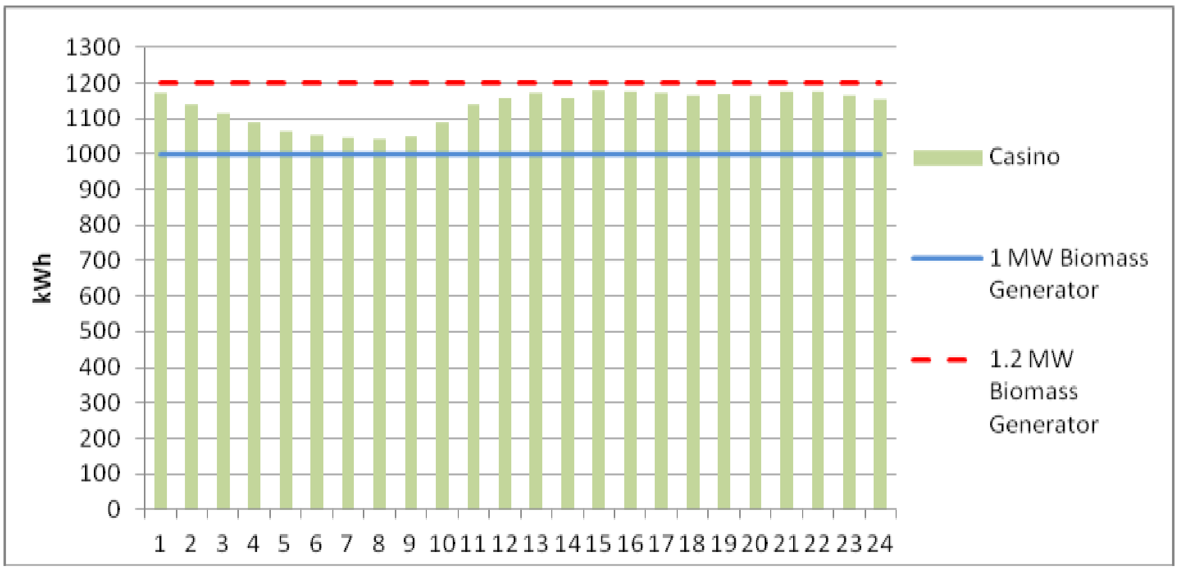


Figure 11: An illustration of how biomass can meet the Casino's hourly energy loads

In November, December and January there is a peak energy demand for space heating that is best met with additional wind turbines—this is when the three 100kW Northern Wind Turbines will be most useful towards the goal of continual energy supply without the use or expense of batteries.

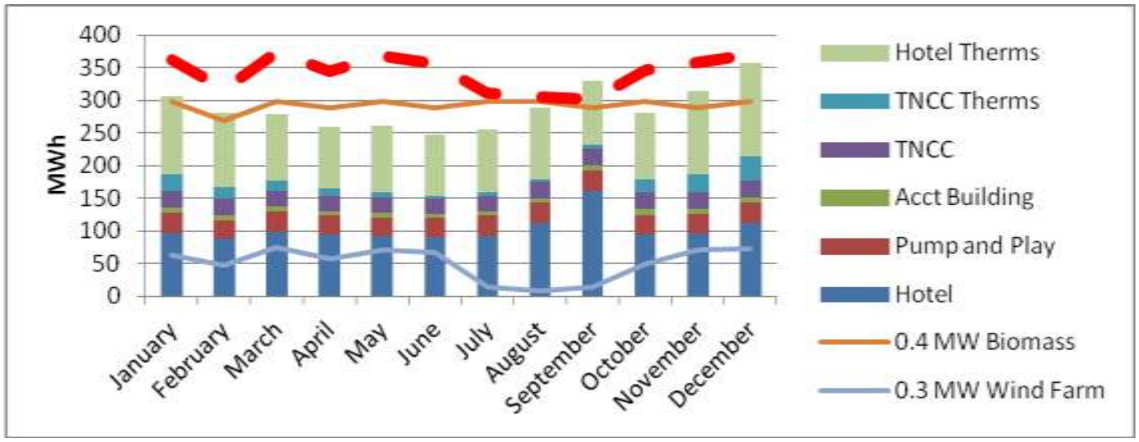


Figure 12: Annual Energy Profile for Non-Casino Buildings with a 0.4 MW Biomass Generator, and a 0.3 MW Wind Farm

6.1.2 0.4 MW Biomass Generator

Fengyu is a Chinese company that has developed multiple 400kW biomass plants for grid level energy production in China, India, and Kenya. These biomass plants generate energy by burning woodchips and require about 2.5 lbs. of bone dry fuel per kWh produced. Continuously running a 400kW biomass generator would generate **3504 MWh** (over 100% of annual usage) and require **4380 bone dry tons** annually. Generators of this size usually cost around $120,000 and have an expected lifespan of 15 years.

6.1.3 0.3 MW Wind Farm

The graph above shows the anticipated annual production from 3 Northern 100kW wind turbines. Based on onsite data we anticipate a wind farm of this size would produce about **608 MWh annually** (17% annual usage). This energy is most available in the winter months when energy usage rises.

6.2 Hourly Energy Profile

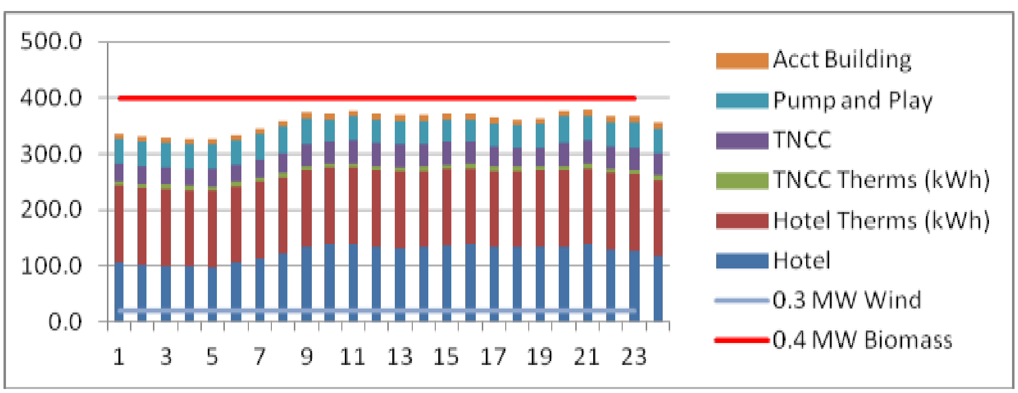


Figure 13: Hourly Energy Profile for average September day

In the previous scenario September was the month that required the greatest amount of battery storage. In this scenario the 0.4 MW biomass generator will be able to meet over 100% of hourly demand without batteries.

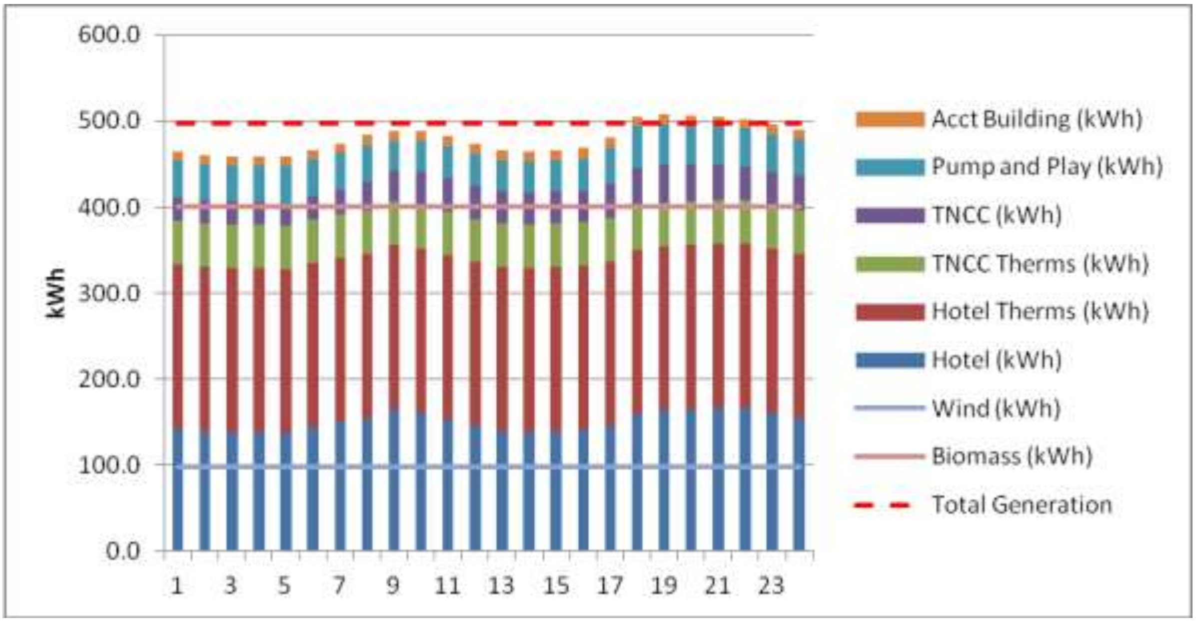


Figure 14: Hourly Energy Profile for an average December Day

In the previous scenario almost 1 MW of battery would have been required to meet the energy demands of the microgrid. As shown above, a 0.4 MW biomass generator can consistently meet the Tribe's energy demand.

6.3 Conclusion

Scenario 3 is the simplest and lowest cost micro-grid design, while also fitting within the limited land base of the Bear River Band. The biomass and wind scenario would allow the Tribe to sell back ~**652 MWh** to the local utility company, Pacific Gas & Electric (PG&E). Credits earned could be used to cover the **28 MWh** deficit that appears to happen in September, or efficiency investments and/or small, quickly deployable biomass generators could meet this peak month of Hotel energy use. The previous scenarios investigated used large solar arrays to generate electricity, but solar arrays take up large amounts of space and must be paired with large battery storage units to store energy for nighttime use. Biomass plants on the other hand have a small footprint and the biomass itself is a type of stored energy, a "wood battery" of sorts, and since the Tribe is located close to forests, woody biomass fuel can be delivered for about $50/ bone dry ton and stored in the forest for use, rather than requiring onsite batteries.

Biomass and Wind	Cost	
Casino 1 MW Biomass	$	4,875,000.00
Other Buildings 0.4 MW	$	2,739,000.00
3 Wind Turbines	$	1,520,400.00
Total	**$**	**9,134,400.00**

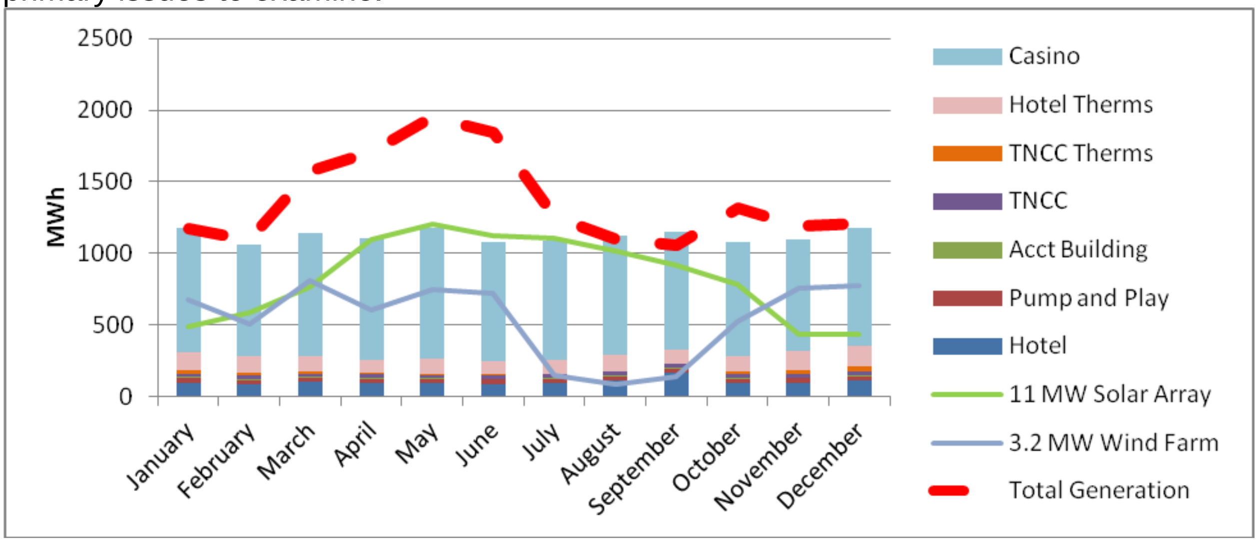
Table 3: Cost Analysis for Installation and Maintenance for **Scenario 3**

7.0 SCENARIO 4: NO BIOMASS

7.1 Overview

Biomass generators create power by burning organic material like woodchips, but maintaining a reliable source of fuel can be difficult due to regulatory hurdles and cost of the wood resource can be constricted when market forces push wood prices up.

As shown below it is possible to consistently meet the Nation's anticipated energy demands with only solar, wind, and electro-chemical battery storage. The larger land and capital investments required to generate on-site energy with wind turbines and solar fields, and the cost of store electricity in electro-chemical batteries are the primary issues to examine.



<u>Figure 14:</u> 2013-2014 Energy Profile with 11 MW Solar Array and 3.2 MW Wind Farm

7.1.2 11.6 MW Solar Array

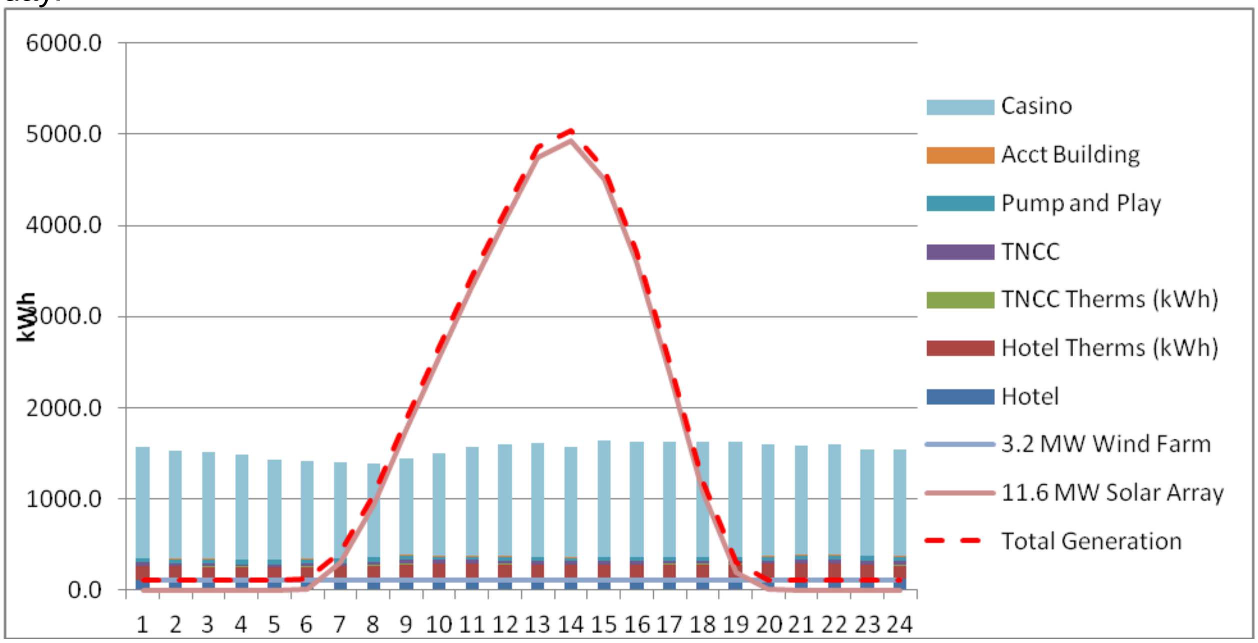
A ground mounted, 11.6 MW solar array would require approximately 14 acres which is roughly 9% of the Nation's total land. Based on data gathered from an existing residential solar array in nearby Fortuna, an array of this size would produce approximately **10,000 MWh** annually.

7.1.3 3.2 MW Wind Farm

Scenario 4 assumes the installation of the same Northern 100 kW wind turbines proposed in previous scenarios. The only difference is scale; in previous scenarios biomass generators were proposed, especially in the winter time when energy usage goes up and solar availability significantly decreases. The winter is when wind is most available so it appears that 32 Northern turbines would be needed to maintain energy sovereignty. A wind farm of this size on this site would generate roughly **6,500 MWh** annually.

7.2 Battery Storage

Since solar and wind both suffer from intermittency issues, it is necessary to have large scale battery storage to ensure a steady flow on consistent electricity. August is the month that, on average, gets the least amount of combined wind and solar. This is important because it means that the average day in August will require more battery storage capacity than any other month of the year. Figure 15 shows that scenario 4 would require about **18 MW** of battery storage for the average August day.



<u>Figure 15:</u> Hourly Energy Breakdown for an Average August Day

7.3 Conclusion

The Nation has many completing land use interests which could make it difficult to secure space for 32 large wind turbines and the 14 acres to install an 11.6 MW solar array. A benefit of this scenario would be that the Nation wouldn't have to rely on outside sources for fuel, they would be generating over 100% of their energy demand exclusively with onsite renewables. This scenario would net the Nation **3,500 MWh** annually.

Solar and Wind	Annual Cost
Solar	$ 31,185,000.00
Wind	$ 20,352,000.00
Batteries	$ 2,000,000.00
Total	**$ 53,537,000.00**

Table 4: Cost Analysis for Installation and Maintenance for **Scenario 4**

APPENDIX F

ENERGY SOVEREIGNTY OWNERSHIP AND FINANCING OPTIONS

Energy Sovereignty Ownership and Financing Options

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TABLE OF CONTENTS

1.0 FINANCIAL RESOURCES FOR MICRO-GRID DEVELOPMENT

There are a variety of sources for funding the Bear River Band's new housing, housing retrofits and non-residential buildings' general energy efficiency and large-scale on-site renewables. Within the Federal Government there are many resources scattered through the USDA, Bureau of Indian Affairs, EPA, Department of Energy and HUD, as well as a limited number of California State resources.

1.1 Residential Development Funding

- *Low Income Housing Tax Credits* distributed by the California Tax Credit Allocation Committee and HUD's *Indian Housing Block Grant Program* (authorized under NAHASDA) are the primary funding vehicles of new and retrofitted Native Nation housing.
- The USDA's *American Indian and Alaska Native Programs* provide financial support through housing grants, low-interest loans (usually 1-3%) and loan guarantees that ensure the USDA repays 90% of the loan should the recipient default. Loan guarantees empower the recipient to negotiate more favorable terms for their conventional bank loan, usually .5%-1% less interest.
- The State of California's Low Income Weatherization Program has been heavily funded for the foreseeable future with Cap and Trade revenue, and will pay for most or all of the efficiency measures and solar for retrofitted low income housing.
- The IRS provides 30% tax credits, which are sellable to investors with tax burdens, for both renewable energy and solar efficiency measures.
- Indian Community Development Block Grant (ICDBG) can provide partial financial support to residential projects for planning and infrastructure.
- PG&E and the State of California additionally offer rebates for solar arrays, with usually equal 1/3rd of the cost of the residential array. When coupled with IRS Renewable Energy 30% tax credits, the final system cost is less than half the billed cost.

1.2 Community Scale Micro-Grid Funding

- *The USDA's main funding program for community-scale energy systems is called the Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans & Grants. The support up to $500,000 in grants and $25,000,000 in subsidized loans, as well as loan guarantees, for large scale renewable energy systems and large-scale energy efficiency retrofits.*
- *The County of Humboldt has taken on the role of providing renewable energy to former PG&E customers via the Community Choice Energy business structure, and will take its first steps in the fall of 2016 to deliver renewably sourced energy purchased on the open market while developing local renewable energy capacity. While the Tribe is transitioning to cutting ties with the PG&E grid, it may be able to partner with the County and gain financing for solar, wind and biomass generation, should the excess be shared with Humboldt energy customers.*
- The Department of Energy's *Indian Energy Program* provides partial grant funding for large-scale renewable energy development, as well as loan guarantees to

support the balance of expense. The below image is from the DOE's website, illustrating their financial participation in community scale wind turbine projects.

Seneca Nation of Indians Breaks Ground on Community-Scale Wind Turbine

Office of Indian Energy Chris Deschene (third from the right) was among those in attendance at a groundbreaking ceremony the Seneca Nation of Indians held for its 1.5-MW wind turbine on April 27. Photo by Ken Parker, Food Is Our Medicine.

- HUD's *Indian Community Development Block Grant* (ICDBG) is again an important source of grant funding for technical planning of the micro-grid, wind turbines or solar field.
- The Department of the Interior *Division of Energy and Mineral Development* has an annual funding program that tribes can apply to for wind energy pre-development studies.
- Private funding in the form of Power Purchase Agreements are also widely available—private investors develop large scale wind and solar energy projects that function as small private solar utilities for an apartment complex or community. The Power Purchase Agreement allows the system Owner to recoup their investment by selling the purchaser electricity at a rate less than PG&E's. Well known companies willing to invest their own funds to develop energy supplies for customers include the SunPower and Solar City. It is not "free" energy—the cost of development is repaid through ongoing utility bills to the actual Owners of the array or wind turbines, usually 1/3rd less than the PG&E utility rates.
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