Pinoleville-Pomo Nation Prototype Home
Final Design Report

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Table of Contents

Introduction

The design of the house and engineered systems were decided upon after repeated discussion with various Tribal Members, as well as the professional engineers at LACO. The design was meant to optimize the three objectives of Tribal Sovereignty, Environmental Sustainability, and Financial Security. Tribal members interested in the home floor plan should look at the posters provided, included in the final materials provided by Cares4pomo.

This Design Report will provide information on the engineered systems and materials used in the construction, as a quantitative reference for interested Tribal members. Comparisons will be made among various systems, to highlight why various systems were chosen, and a description of the engineered designs will be provided.

In addition, the Appendix will include technical descriptions of the functioning of the various engineered subsystems, so that interested Tribal members can learn about the inner workings of the new Prototype Home.

Section 1: Sustainable Home Design

1.1: Material Comparisons

At the June 10 workshop, Cares4Pomo presented several material options to be used in the home construction; the advantages and disadvantages of the various materials are shown below.

Type of Material	Advantages	Disadvantages
Conventional Construction (Fiberglass, blankets and batts)	Low upfront costs Common installation	High operating costs Low durability
Earthen Construction	Fire resistant Can be made round easily High thermal mass Reduced cost of material transportation Can be built by unskilled volunteers	Long lead time before construction Must be built in dry season Labor intensive Depends on type of soil at site Requires maintenance Requires specialized professionals
SIPS	Do not require structural framing Energy efficient	Not locally produced Rounded architectural details difficult
Strawbale	Fire resistant Earthquake resistant Non-toxic Energy Efficient Easy to be built with non-professional labor Uses well known wooden framing for structure	Bulky and uneven construction Susceptible to moisture and rot Rodents and insects

Table 1. 1: Advantages and disadvantages of considered materials.

Straw-bale construction was selected as the material of choice, for its high level of energy efficiency, non-toxic properties, and ability to be curved easily. A description of typical straw bale construction can be found in the Appendix.

<u>**Section 2: Sustainable Energy System**</u>

2.1: System Summary

There are three non-conventional aspects of the Prototype Home's energy system which result in dramatic energy and carbon savings; (1) a geothermal heat pump system, which provides space heating and cooling, (2) a solar water heating system, which provides hot water, and (3) a solar photovoltaic system, which provides electricity.

Interested Tribal members can find out more about geothermal heat pumps, solar water heating, and solar photovoltaics, in Appendix 2.

2.2: Geothermal Heat Pump (GHP)

Geothermal (or ground-source) heat pumps are not a new technology, but their extremely high energy efficiency means they can heat and cool a home for a negligible cost. Details on the working of geothermal heat pumps, along with schematic diagrams, can be found in the Appendix.

The GHP system to be installed at Prototype Home is a "slinky" type system, where pipes are piled on top of each other in loops; while this requires more piping, it requires less excavation and ground area than other types of GHP systems.

Figure 1: Photo and schematic diagram of a slinky-type system.

The GHP was chosen to provide heating and cooling for the home due to its very low energy consumption, roughly ¼ or ⅓ that of a conventional heating and cooling system. Estimated cost comparisons are made below for GHP and conventional heating and cooling systems.

	Geothermal Heat Pump	**Conventional (Electric Furnace + A/C)**	**Conventional (Propane Furnace + A/C)**
Equipment	Horizontal closed-loop heat pump system **Water Furnace V024**	Electric furnace Air conditioner	Propane furnace Air conditioner
Size	18,600 Btu/Hr (heating) 26,000 cooling	18,600 Btu/Hr (heating) 26,000 cooling	18,600 Btu/Hr (heating) 26,000 cooling
Additional Equipment	None	None	1,000 gal propane tank
Annual Energy Consumption Heating/Cooling	900 kWh	4,900 kWh	5,200 kWh
Annual Greenhouse Gas Emissions Heating/Cooling	900 lbs. CO_2	5,000 lbs. CO_2	4,000 lbs. CO_2
Estimated Annual Energy Expenditures Heating/Cooling (Comparative Only)	$150	$800	$450
Estimated Upfront Price	$8,300	$3,000	$7,200

Table 2. 1: Comparisons of heating and cooling systems. Annual energy expenditures should be taken as comparative; it is difficult to estimate precisely how much the energy bill will be.

As is a common trade-off, the GHP system is the most expensive upfront, and the least expensive (and most environmentally friendly) over time, requiring much less in annual energy expenditures.

In addition, a “desuperheater” unit will be connected to the GHP; during the summertime, the desuperheater essentially “dumps” excess heat from the home into the water tank, providing nearly free hot water.

2.3: Solar Water Heating

The Prototype Home will incorporate two systems for heating water, to displace energy consumption required; a solar water heating system, and a “desuperheater.” Descriptions, schematics, and images of the solar hot water system can be found in the Appendix.

The SHW system to be installed at Prototype Home is a closed-loop system with two panel collectors; combined with the desuperheater unit, this system is expected to provide 85% of the water heating needs of the household. Comparison with a conventional water heating system is provided in the table below.

	Solar Water Heating + Desuperheater	Conventional Propane
Equipment	2 Heliodyne Gobi 410 collectors Closed-loop system Desuperheater 46.5-gal electric water backup water heating Tankless water heater	80-gal propane water heating Tankless water heater
Annual Energy Consumption Water Heating	520 kWh	5,000 kWh
Annual Greenhouse Gas Emissions Water Heating	530 lbs. CO_2	3,000 lbs. CO_2
Estimated Annual Energy Expenditures Water Heating (Comparative Only)	$85	$430
Estimated Upfront Price	$8,000	$3,700

Table 2. 2: Comparisons of Prototype Home's water heating system, versus a conventional water heating system. Annual energy expenditures should be taken as comparative; it is difficult to estimate precisely how much the energy bill will be.

In addition to the SHW and backup water heating tank, a small tankless water heater will be installed in the master bathroom. This will provide backup heating for episodes of peak load during the wintertime months, to avoid lapses in hot water supply.

2.4: Solar Photovoltaics

A full solar array will be installed to provide all of the electrical needs for the home. Cares4Pomo projects that a 5kW system will supply roughly 100% of the home's electrical consumption over the course of a year, which is estimated to be roughly 9,000 kWh.

A summary of the proposed PV system is given in the table below.

Installer	Size	Panel Type	Estimated Price	Other Equipment
Real Goods	5 kW 420 ft^2	Sharp 216W	$50,000 ($25,000 with rebates)	Inverter: Fronius IG 5100 4-6.3 kW Load Controller <6 kW Safety Disconnect

Table 2. 3: Summary of solar photovoltaic system.

The system is designed to be "grid-tied" due to the high price and environmental disadvantages of batteries; during daylight hours, the solar panels will produce electricity, powering the home and earning credit from the grid utility (PG&E); during nighttime hours, electricity will drawn from the grid.

Battery-powered, “off-grid” systems typically cost more than twice as much, require more maintenance and construction, and can not provide the full electrical needs of a household of this type. Therefore they were not chosen.

2.5: Comparisons of Energy Consumption

The systems to be implemented in Prototype Home will result in large energy savings compared to conventional construction, and to average homes in California. The chart below summarizes energy consumption of the Prototype Home, an average California home, and the existing Lakeport homes.

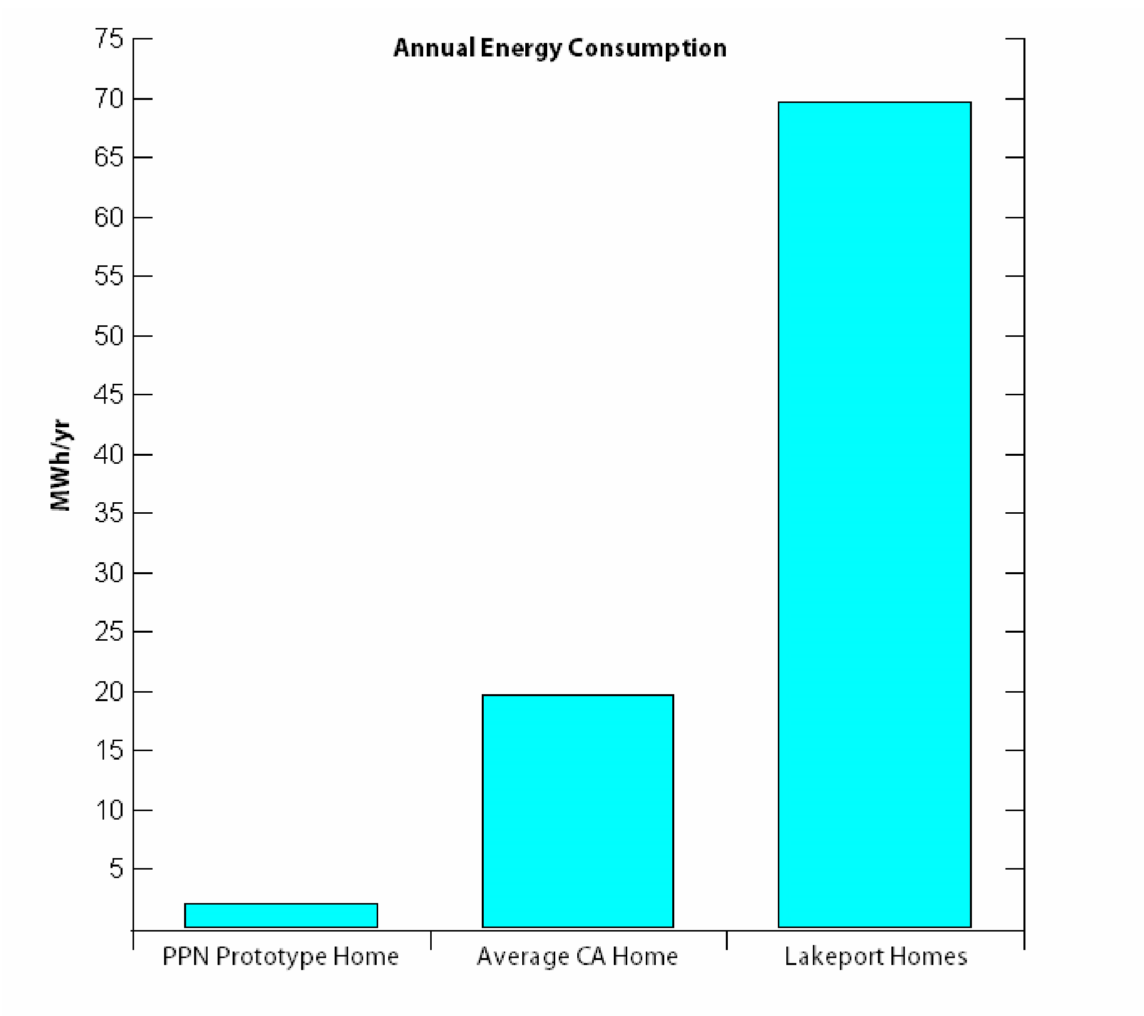

Figure 2 1: Energy consumption comparison chart.

With the 5kW system installed, it is expected that the home will consume less than 1,000 kWh each year; this is less than the *monthly* consumption of an average California home.

The table below contains comparison information for energy consumption, energy expenditures, and greenhouse gas emissions, for the Prototype Home versus conventional construction.

	PPN Prototype Home	**New Home – Conventional Construction**
Annual Energy Consumption (from grid)	250 kWh	18,000 kWh
Annual Greenhouse Gas Emissions	7,600 lbs. CO_2	21,000 lbs. CO_2
Estimated Annual Energy Net Expenditures (Comparative Only)	$40	$2,100

Table 2. 4: Comparison of PPN Prototype Home construction with conventional construction. Annual energy expenditures should be taken as comparative; it is difficult to estimate precisely how much the energy bill will be.

Over the lifetime of the home, the sustainable design of this house will prevent 150 tons of CO_2 from entering the atmosphere.

Section 3: Sustainable Water System

3.1: Water Supply

The home will be supplied by two sources of water. A well on the lower part of the property will supply most of the water; a fraction (roughly 30%) will be supplied by a rain catchment system on the roof of the home. The rain catchment system includes rain gutters around the periphery of the roof of the house and garage.

The collection potential of the home, with a roof envelope of 2,500 ft^2, is given in the table below for both a drought and median year.

	Drought Year (20 inches)	Median Year (36 inches)
Total Rain Catchment	27,500 gal	50,000 gal

Table 3. 1: Rain catchment potential for the PPN Prototype Home.

Rain catchment systems are very simple in essence; a description of how they work can be found in the Appendix.

Both rain catchment and wellwater will feed into a 20,000-gal storage tank, located north of the homes (see Site Plan). Wellwater will be pumped in to the tank; rain will be gravity-fed, as the tank is far enough below the roof level. The size of the storage tank limits the amount of rain that can actually be used to roughly 25,000 gal annually.

A 1.5 HP "booster" pump will move water to the home, to sustain 50 PSI in the home during peak demand.

3.2: Water Filtration

Rainwater is not considered potable without filtration; as there have also been problems with well contamination in the past, the home will have a two-phase filtration system. Water will be filtered through an activated carbon filter and "ozoner" upon entrance to the large storage tank; water intended for drinking will be filtered again through a reverse osmosis unit, before leaving a home faucet made specifically for drinking water.

At the site of the storage tank, the primary advantage of ozone filtration over the other suggested system (ultraviolet disinfection, or UV) is its breadth of protection; whereas UV removes only micro-organisms, ozone removes micro-organisms and also filters out non-biological contaminants, such as iron, arsenic, hydrogen sulfide, nitrites, petroleum products, phenols and cyanide. As contamination of well water with non-biological substances was the primary concern to the tribe, this is the recommended system, despite the higher upfront costs and maintenance requirements.

It is recommended that the ozoner be installed in series with an activated carbon filter. This will provide added filtration against bad tastes, chlorine, sediments, and VOCs.

A reverse osmosis system will be installed in the home, beneath the kitchen sink; this system will provide drinking water through a special tap built into the sink counter. A small 14-gallon tank will be located in a cabinet overhead; this will provide for enough drinking water during peak demand, and also provide potable water during power outages, when the booster pump system will not be functioning. This water will be at low pressure during these periods.

The table below summarizes the filtration capabilities of the systems.

Technology	Activated Carbon	UV	Ozone	Reverse Osmosis
Bacteria and Viruses	0	2	2	2
Petroleum Products	1	0	1.5	2
Arsenic	0	0	1.5	2
Bad Tastes & Odors	2	0	0	2
Chlorine	2	0	0	2
Fluoride	0	0	0	2
Hydrogen Sulfide	1	0	1.5	1
Heavy Metals	1	0	0	2
Nitrates/Nitrites	0	0	1.5	2
Radon	2	0	0	0
Sediment	1.5	0	0	2
Iron	0	0	1.5	2
VOCs	2	0	0	1
Cyanide	?	0	1.5	2

Table 3. 2: Filtration efficacy of various systems. 0 = No Treatment, 1 = Significant Reductions, 2 = Effective Removal.

The filtration system will require maintenance of three components at regular intervals; the carbon filter, ozone cartridges, and the RO membrane. The RO system has its own sediment and carbon filters which must be maintained, as well.

3.3: Composting Toilet

Conventional septic systems include installation of a septic tank and leach field. Conventional toilets consume roughly 2 gallons of water per flush, accounting for 20%

of the average American household's water consumption. The water produced is sewage or "black water", which requires extensive treatment and other precautionary measures for storage.

Composting toilets consume much less water than conventional flush toilets, and do not require installation of a septic tank. Waste is collected in an electric-powered unit; fluids evaporate away, and solids are converted to compost by natural micro-organisms. This compost can be used in gardens, for flower beds and lawns.

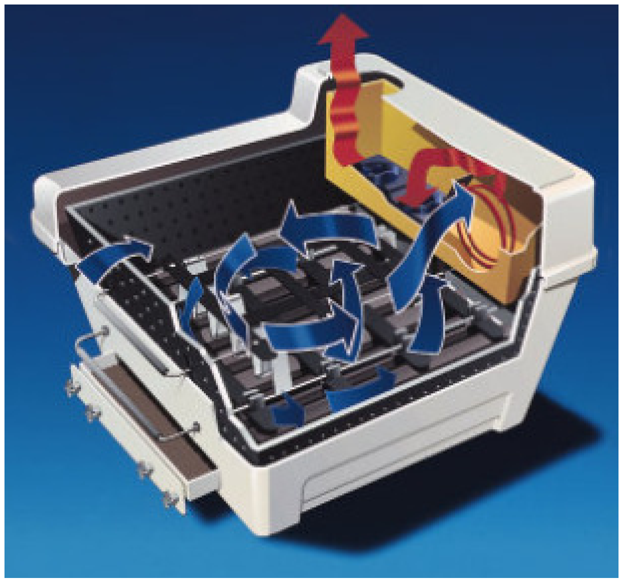

Figure 3 1: Internal image of compost collector. Air flow aids natural micro-organisms in the decomposition of the waste.

The toilets do not smell, require minimal overall maintenance, and consume 1/20 the water of conventional toilets.

The home will have a vacuum-flush system (Envirolet VF 750, with two toilets); each flush will require 0.2L (0.05 gal), compared to 6.4L (1.6 gal) for conventional toilets. The compost collector will be located outside, and situated for easy access, so that removal of solid waste will be easy.

Figure 3 2: Composting toilet, unit and exterior collector. (There will be two toilets and two collectors.)

More information on composting toilets:

- There is no odor from a composting toilet which is properly maintained.
- Compost tray needs to be emptied 2-3 times yearly.
- For health considerations, the compost can not be used on edible plants.
- ~1 cup of peat moss must be added daily
- The following materials can be used instead of peat moss (or as an addition to peat moss): black soil, wood shavings (non-cedar), sawdust, coffee grounds
- Fans and heater consume roughly 190W = 140 kWh/month
- Compost from food waste can be added to the unit, provided the unit is not overfilled.
- Can provide for up to 12 people in the home for 1-2 days, and up to 8 permanent residents.

During peak loads (such as during times with many visitors), overflow from the collector will be diverted from the collector to the drain pit by a gravity-fed pipe.

3.4: Grey Water Garden

The rest of the home's water consumption, since it will not include black water, will be used for irrigation, to create a grey water garden. Water from sinks, showers, dishwasher, and etc., will all drain into the underground grey water irrigation system, creating a garden roughly 800 ft^2 in size. Edible plants and vegetables can be grown in this garden.

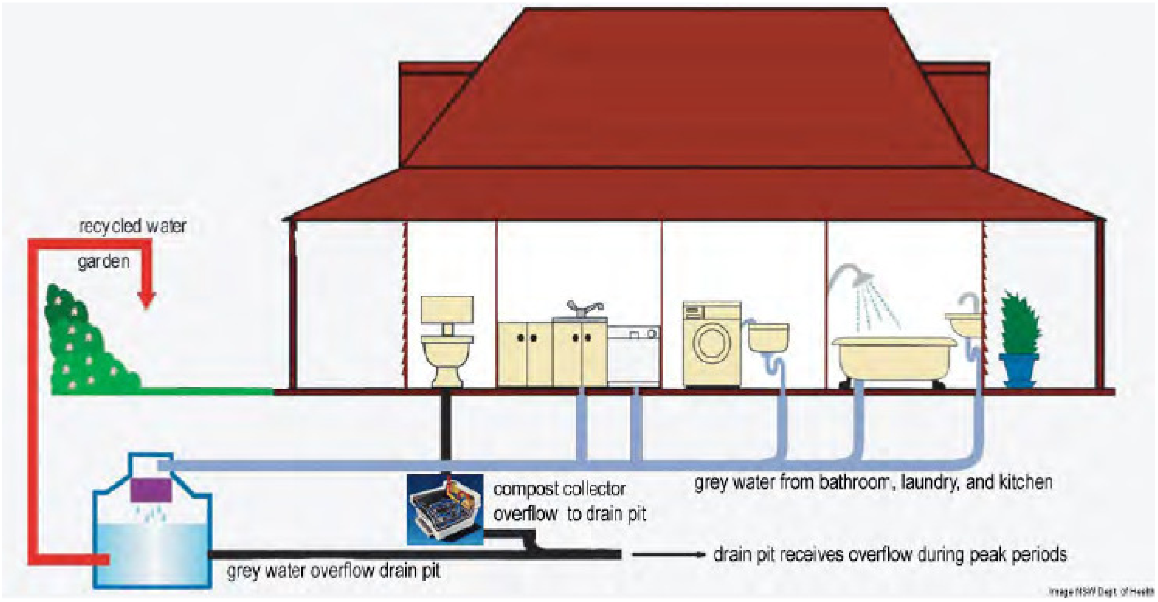

Figure 3 3: Schematic diagram of the grey water garden. A small "settling" tank will be connected to the leach field.

A small settling tank will filter hairs, grease, and other solids; the fluids will drain into a grey water system which is very similar to a conventional leach field. During periods of peak use, overflow will go from the grey water garden into the drain pit.

3.5: Comparisons with Conventional Systems

The low-water toilet coupled with grey water system will provide intensive irrigation while consuming much less water than a conventional home. Coupled with the rain catchment system, groundwater extraction will be roughly 50% less than a conventional home. This information is summarized in the table below.

	Conventional Water System	**Prototype Home Sustainable Water System**
Annual Consumption	99,000 gal	68,000 gal
Annual Rainwater Collection	0 gal	25,000 gal
Annual Groundwater Withdrawals	99,000 gal	43,000 gal

Table 3. 3: Summary of water consumption and collection.

Section 4: Overall Cost Estimate

A rough estimate of the total cost of the home is provided below. Equipment details (manufacturer, model, components, and etc., can be found in the Appendix).

Component	Estimated Upfront Cost
Construction $150/ft^2 x 1,400 ft^2	$210,000
Solar PV Array 5 kW system installed by Real Goods	$25,000 (with rebates)
Geothermal Heat Pump System Excavation, installation, and equipment	$8,250
Solar Water Heating System Equipment	$4,275
Direct Water Heating Equipment	$1,500
Appliances	$2,500
PG&E Tie-In	$4,000
Water System Equipment & Installation	$32,500
Other Equipment	$2,300
TOTAL	$290,000

Table 4. 1: Cost estimate of the Prototype Home.

Appendix

Appendix 1

A1: Straw Bale Construction

Straw bale construction is a building method using straw as structural or non-structural element in a building. The first straw bale structures were built in the 1800's in Nebraska by European settlers to shelter themselves using what was available. The basic method consists of bundling grasses together into bales and stacking the bales together to form walls, then applying plaster inside and out.

Why Straw Bale Building?

- Uses waste products.
- Environmentally friendly by minimizing the use of wood.
- Performs effectively in terms of insulation and thermal mass.
- Involves community effort.
- Flexible and adaptable to a variety of architectural styles/ forms.

Types of Straw Bale Construction

- Non-structure: bales are used as infill panels between or around a structure frame.
- Load-bearing or Nebraska-style: the bale wall carries vertical or lateral load.

The construction type used in the Prototype Home Prototype Home is non-structural; wooden posts provide the strength of the home, while straw bales fill the walls, providing insulation. The good insulation properties of straw bale will make the Prototype Home very energy efficient by minimizing energy losses; this will result in the home staying cool in the summer, and warm in the winter.

Sources and Further Reading

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- Strawbale Building Registry http://sbregistry.greenbuilder.com
- Surfin' Strawbale http://mha-net.org/html/sblinks.htm
- Natural Building Network www.naturalbuildingnetwork.org
- PROFESSIONAL ORGANIZATIONS
- Architects, Designers, and Planners for Social Responsibility (ADPSR) www.adpsr.org
- Northern California Chapter of ADPSR www.adpsr-norcal.org
- American Institute of Architects- San Francisco Chapter www.aiasf.org

- U.S. Green Building Council (LEED) www.usgbc.org

Appendix 2

A2.1: Geothermal (or Ground-Source) Heat Pumps

Geothermal heat pumps (GHPs) use the ground as their heat reservoir; they are highly efficient, in part because underground, the temperature stays close to the same year-round. In the summertime, the GHP "pumps" heat from the home into the ground, providing cooling; in wintertime, heat is pumped from the ground to the home, providing heating.

Heat pumps work much like a car radiator, or an air conditioner, circulating a refrigerant that is compressed and expanded so that the intermediate product is exposed to an environment to be heated or cooled. The "radiator" of the GHP is a system of underground pipes, usually installed 6-8 feet underground in what is called a "horizontal closed-loop system."

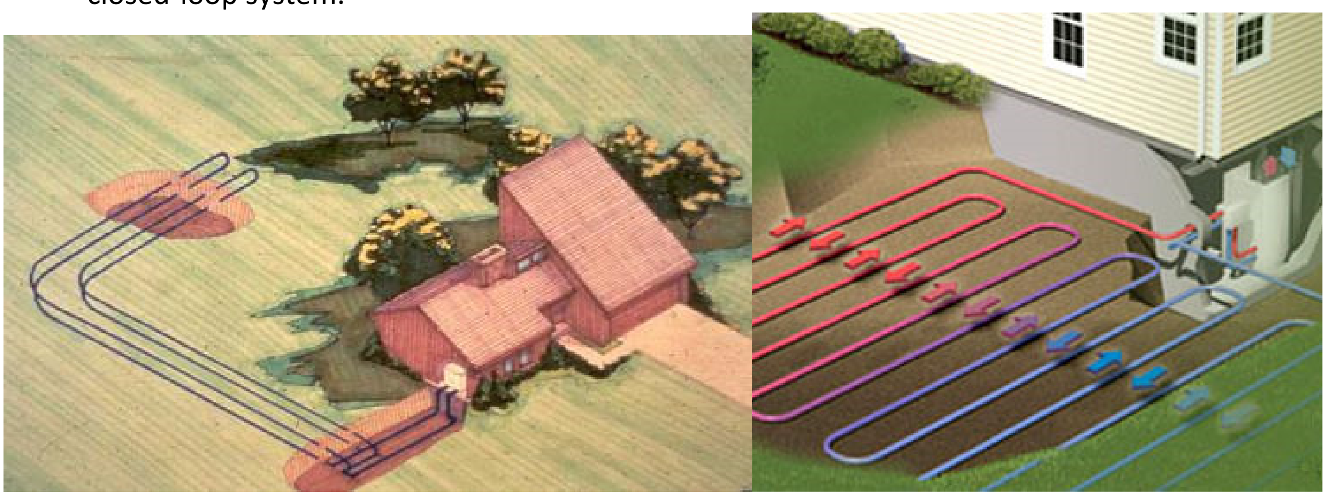

Figure A 1: Schematic diagrams of a geothermal heat pump. Piping connects to heat pump located in the home.

In essence, GHP *transfer* heat from the ground to the home, and vice versa; this is in contrast to conventional furnaces, which *generate* heat, either by burning propane or heating an electrical coil. While the initial cost of installation for a GHP is usually significantly higher than conventional systems, it should be noted that it can both heat and cool a home. GHP systems require a qualified installer for the piping and equipment, as the system's performance directly depends on the quality of the installation.

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A2.2: Solar Water Heating

Solar hot water (SHW) heating is a very old concept, and is very simple; a roof-mounted collector has water flow through it; the sun heats the water, which is connected to a backup hot water tank, to provide hot water at night and during periods of low sun exposure.

Figure A 2: Solar hot water collectors.

In climates with frequent freezing episodes and “hard” water, collectors are set up in a “closed-loop” configuration. A water/glycol mixture (which will not freeze) is circulated through the collectors, and heat collected by this fluid is then transferred to the water in the tank. The glycol mixture used in this setup is the same chemical that is often found in food products; the closed loop system will have a long lifetime, typically more than 25 years.

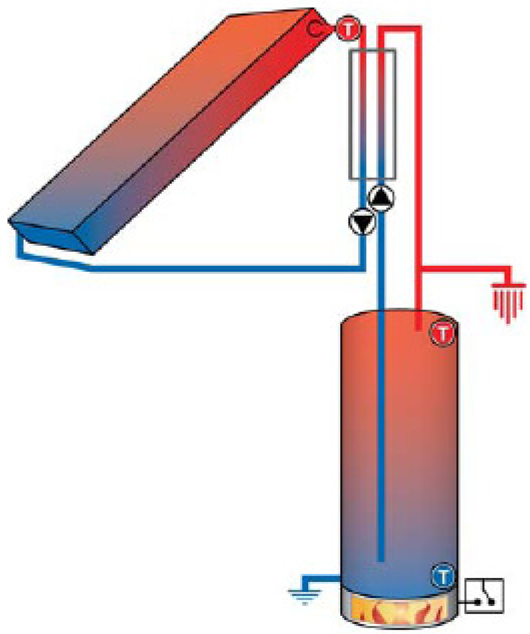

Figure A 3: Schematic diagram of a closed-loop SHW system. The collector has its own independent fluid mixture, usually ethylene glycol and water, which will not freeze; heat is transferred to water in the backup heating tank, which provides heat during cold episodes.

SHW collectors are about 70% efficient at converting sunlight to heat; in contrast, solar photovoltaics are only 15% efficient in converting sunlight to electricity. SHW is the most cost-effective form of renewable energy on the market.

Heliodyne, the system manufacturer, is located in Richmond. Real Goods, located in Hopland, sells and installs their systems.

<u>Appendix 3</u>

A3.1: Rain Catchment

Rain catchment systems are an increasingly utilized technology. These systems are designed to collect rainfall for domestic use. This water can be used directly a non-potable source, supplying water for irrigation, showers, toilets, and other similar uses.

The first step in implementing a rain catchment system is to investigate the feasibility of the system given the rainfall of the area. The Pinoleville Pomo Nation is located in Ukiah, CA where the average rainfall per year is approximately 36.9 in. The amount of water collected in a rain catchment system is dependent on both the rainfall, the roofing material, and the surface area of the collector.

A typical rainwater collection system consists of the following equipment:

- A collection area (usually the roof)

It is recommended that the roofing material used in a rain catchment system be made from non-toxic material, impervious, and not contain lead, wood, or asphalt.

- A method of conveying the water (gutters, downspouts, and piping)

Some approximate price estimates for gutters are $5-$8 per linear foot (galv.steel). Estimates for piping are $4-$7 per linear foot.

- A filtering device

It is recommended that the filtering device be a coarse filter/foul flush device. An estimated price by Rain Harvest Systems is $50.

- A storage tank or cistern

The storage tank is the most expensive component of the rain catchment system; in a climate like Ukiah, which has an extended dry season, it is suggested that tanks should be sized to catch a year's rainfall.

Contamination concerns:

Contamination of the water collected in the rain catchment system is a concern. The most significant sources of contamination are:

- dirt and feces (roof surface)
- leaf debris
- animals, insects, or birds drowning
- roof material or paint made with lead

In addition, there is some contamination due to air pollution; these sources are minimal, especially in rural areas.

Recommendations to prevent these sources of contamination:

1. Sweep the roof before the first rain in a significant amount of time
2. Use rain water 2 or 3 days after it has been collected. Contradictory to popular opinion, water does not become stale with time but actually improves in quality as the bacteria and pathogens die during the first few days of storage.
3. Remove all hanging branches over the collection surface as they will contribute to leaf debris and provide an access point for animals.

4. Prevent light from entering the storage tank as it will contribute to the growth of algae and micro-organisms.
5. Place wire/nylon mesh over all inlets

Generally, a roof catchment system produces water that is relatively clean and requires minimal filtration before storage.

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- http://www.greywaterguerrillas.com/greywater.html

Appendix 4: Equipment Schedule and Design Notes

System	**Equipment Details**	**Estimated Upfront Cost**
Solar PV Array	*System to produce 8,800 kWh/yr *Roughly 5 kW	$52,000 (no rebates) ~$25,000 (with rebates)
Geothermal Heat Pump System	*Water Furnace V024 18,600/26,000 Btu/hr *With factory-installed desuperheater coil *"Slinky" type installation; horizontal closed-loop	$8,250
Heat Distribution	*Sheet-metal ductwork, through ceiling	$500
Solar Water Heating System	*Heliodyne 2-collector closed loop system *2x Gobi 410 Collectors *53.9 ft^2 collector area *Helio-Pak Heat exchanger (HPAK 016 000) *Delta-T Controller (DLTA 000 000) *Expansion Tank (EXPT 002 000) *DOS Discs & Air Vent *Glycol (3 gal) *Rack-Mounted Kit	$4,274
Solar Water Heating System	*119-gal water tank (HSTG 119 000)	$2,273

Direct Water Heating	*Whirlpool "Lowboy" 46.5-gal electric water heater (Model # E2F50LD045V)	$358
Direct Water Heating	*Stiebel Elton Tempra 24 Tankless water heater 3.3 GPM @ 55F	$659
Appliances		$2,500
PG&E Tie-In		$4,000
Water System	*20,000-gal storage tank	$20,000
Water System	*Apec RO-45 Ultra Reverse Osmosis System (36-45 GPD), with 14-gallon "big" tank addition	$500
Water System	*Pump: Flint & Walling 1.5 HP 16-state booster pump (Model #PB1016A151) *1.5" PVC will connect home to storage tank; different piping will require different pump size, due to head losses	$817
Water System	*Envirolet Flushsmart VF 750 system composting toilet *Extra toilet kit	*$6,199 *$1,950 ($8,149)
Water System	*Greywater reuse kit with settling basin, filter housing, director valve, and leach field fittings (thenaturalhome.com) *Leach field excavation and installation	*$695 *$1,800 ($2,495)
Water System	*Rain catchment gutters and filters *Ozoner and activated carbon filter, situated in storage tank	?
TOTAL		$290,000

<u>Design Notes</u>

HVAC Sizing

It is estimated that the home will consume 9,000 kWh/yr of electricity (there is no gas or propane system for the home). Peak heating load is estimated at 18,000 Btu/hr: peak cooling roughly around 25,000 Btu/hr. *A professional HVAC technician should re-assess these loads using the final floor plan.*

Drain Pit

The size and character of the drain pit has not been designed by Cares4Pomo. The pit must be able to handle peak loads of 10 guests in the home for 1-2 days. Overflow will come from both the composting toilet collector and grey water system during these peak periods.

Plumbing and Ductwork

The final details of plumbing and ductwork have not been precisely solved. There is room for plumbing to go through the walls, though laying pipes in the slab would work, as well.

Solar PV Array

It is estimated that the home will consume 9,000 kWh/yr, and the system should be sized appropriately. Cares4Pomo estimates that a 5kW system will provide ample energy, but *it is emphasized that a professional solar installer should assess the appropriate size for the array.* It is noted that 9,000 kWh/yr is only an estimate, and the actual household consumption will likely be different; this is an experimental home, and it is difficult to make a precise assessment. The solar installer should take this uncertainty into account when sizing the PV array.

We did not precisely solve the array placement; two options are presented in the posters, on the roof, or on the ground by the water tank. Placing the panels on the roof is an eyesore for this home, and may block the clerestory window, so it is not recommended; instead, panels should be located above ground elsewhere on the site. This would make for ease of maintenance and installation, as well.

Water Heater/Tank Storage

The “Lowboy” model will provide backup water heating for the SHW system; it will likely only be drawn on significantly in wintertime.

The Stiebel tankless heater will be installed in the Master Bathroom, as a backup. It should only be needed on peak demand days, when there are more than 5 people staying at the home in the wintertime (or more than 10+ guests during the summer, when the SHW is at full capacity).

Solar Hot Water System and Geothermal Heat Pump Desuperheater

The desuperheater, installed with the geothermal heat pump, will provide ample hot water in the summertime, but it is difficult to foresee how these systems will interact with the solar hot water collectors, especially in the wintertime. Space should be left for the additional expansion of a single SHW collector, if necessary. There is ample room on the garage roof, and this is the placement in the design; unlike the solar photovoltaics, this placement does not mar the appearance of the building, as the SHW collector area is much smaller.

Composting Toilet
The large distance between toilets required the more expensive (and sophisticated) vacuum-flush composting toilet system. This type of system was chosen for two reasons; the large distance between toilets, and also the at-grade level of the home (non vacuum composting toilet collectors must be located 30" below the toilet unit, which would have required the collector to be placed below-ground).

Water consumption is still extremely low; the system flushes with the aid of a vacuum pump. During periods of peak use, overflow will go to a drain pit. The piping from the toilet in the master bedroom must go underneath (or inside) the slab.

Pump and Piping Info
Water connection from storage tank to home will be made up of 1.5" PVC. Different materials or pipe size will require a different pump than specified below.

The Flint and Walling pump here assumes that an above-ground pump will be installed; a submerged pump could also be a good option. *A more detailed assessment should be performed of household water consumption and total flow rate, to validate that this pump size will be appropriate for the final design.*

Given a peak load of 15 GPM and a requirement that the pump create 65 PSI, the following pump is recommended.

PSI vs. Flow Rate for PB1016A151									
PSI	40	60	80	100	120	140	160	180	
GPM	14.7	13.8	12.9	11.9	10.8	9.7	8.2	6.6	

Pump info catalog source:
http://www.deanbennett.com/pump-page10a.pdf