

1110 Jean Ave., Sacramento, CA 95838

Case Study

SMUD Energy Efficient Remodel Demonstration Program

- Del Paso Solutions
- Sacramento Municipal Utility District
- Sacramento Housing and Redevelopment Agency
Neighborhood Stabilization Program
Vacant Property Program

Project Resources

Heat Pump Water Heater – North Road Technologies

Ductless Mini-Split Heat Pump – Friedrich Air Conditioning

Ventilation Fans – R. Johnson & Association



Before



After

Project Parameters

Location: 1110 Jean Avenue, Sacramento, CA 95838

Structure: 1040 square foot, 3 bedrooms, 2 baths

Areas Remodeled: Total remodel, including new roof, windows, HVAC, bath fans, kitchen appliances, flooring, and counters

Total Project Cost: \$120,000.00

Energy Efficiency Measures: \$40,800

Completion Date: July 2010

Estimated Annual Utility Bill Savings: 65%, approximately \$1,659.00 per year

Estimated Annual Energy Savings: 10,140, kWh (53% reduction)

Project Team

Design-Build Team: Jim Murray-Clark -- Murray-Clark Painting and Construction, Bruce Solorzano -- Zano Heating and Air, and Jan Solorzano -- owner

Project Management: Mike Keesee, Sacramento Municipal Utility District (SMUD)

Energy Analysis: National Renewable Energy Laboratory (NREL)



Project Upgrades

BY SYSTEM	EXISTING	ENERGY EFFICIENT REMODEL
Building Enclosure		
Air Sealing	None	Air sealed the home, caulking, weather-stripping all accessible cracks, joints, and seams
Roofing		Replaced roof adding ridge vents to improve attic ventilation
Attic Insulation	R-19	15" blown in cellulose (R-49) attic insulation
Room Addition	NA	2x6, 16" o.c. framing with blown in cellulose insulation (R-20)
Blower-door Test	1880 cfm @ 50 pa 13.6 ACH	408 cfm @ 50 pa 2.9 ACH
Windows		
	Aluminum Frame Dual pane, clear U-value = .71 est SHGC = 0.73 est	ENERGY STAR®, Vinyl Frame dual pane, low e U-value = 0.32 SHGC = 0.25
Heating, Air Conditioning and Ventilation (HVAC)		
Space Heating	Heat Pump 7.0 HSPF	Tri-Zone Mini-Split Heat Pump 9.0 HSPF
A/C	3 ton Heat Pump SEER 8 EER 7	2 ton Ductless, Mini-Split Heat Pump SEER 15 EER 9.2
Ducts	Leaky R-2.1	Ductless
Water Heating		
	40 gal. Electric Storage Tank, 0.90 Energy Factor	New 40 gal. Electric Storage Tank 0.98 Energy Factor with heat pump water heater booster with 2.50 COP
Lighting & Appliances		
Lighting (units)	Incandescent	100% hardwired ENERGY STAR® Compact Fluorescent Lamps (CFLs)
Ceiling Fans	Incandescent	ENERGY STAR® with pin-based ENERGY STAR® CFLs
Inspections	NA	HERS required inspections and testing
HERS Rating	194.79	85.54, 56.1% improvement

Water Efficiency Measures

- Non-invasive shade and drought tolerant plants.
- Reduced turf area.
- Drip irrigation system.

Green Materials and Resource Efficiency

- Returned paint buckets, pallets, and plant containers for re-use.
- Re-conditioned and re-used salvageable components and materials.
- Sorted demolition and construction waste and recycled aluminum, steel, wood, concrete, beverage containers, cardboard, and green landscape waste.

Project Purpose

SMUD partnered with the Sacramento Housing and Redevelopment Agency (SHRA) to dramatically improve the energy efficiency of foreclosed and abandoned homes in neighborhoods especially hard hit by the current recession. Under SHRA's Vacant Property Program (VPP), qualified single-family developers/builders renovate repossessed, abandoned homes in low income neighborhoods and sell them to low to middle income families. Under the Energy Efficient Remodel Research and Development program, SMUD worked with VPP developer/builders to improve the energy efficiency of their projects.

In particular, SMUD and the National Renewable Energy Laboratory (NREL) want to test whether a simple package of energy efficiency upgrades can achieve a 50% annual energy savings in homes built before 1978 when the current California Title-24 building energy code was enacted. The energy efficiency package includes:

- Sealing the home (sealing all accessible joints and seams and weather-stripping all penetrations, such as electric outlets and plumbing pipes)
- Upgrading the attic insulation and adding a radiant barrier
- Replacing the existing windows, HVAC system and ducts, water heater, incandescent lighting fixtures, and dishwasher
- Adding mechanical ventilation in the form of bathroom exhaust vents and a range hood.

Del Paso Solutions expressed interest in working with SMUD on testing whether this energy efficiency package would achieve the expected savings. They were also interested in increasing their knowledge of energy efficient construction techniques and features with an expressed goal of incorporating the energy efficiency package into future projects.

The 50% Energy Savings Package

As an older, smaller, all electric home, 1110 Jean Avenue provided an excellent opportunity to test whether a simple package of energy efficiency upgrades could cost effectively reduce the home's annual energy use by 50%.

SMUD project manager Mike Keesee developed a "package" of energy efficiency measures that would meet the home's renovation and energy performance requirements. The final list of energy efficient upgrades included:

- Air sealing the building enclosure
- R-40 attic insulation
- Using 2x6 framing and insulating the walls of the room addition to R-21.
- Replacing the existing windows with high performance ENERGY STAR® windows
- Replace the existing Heat Pump with a "ductless, mini-split" Heat Pump
- Replacing the existing electric water heater with a new electric water and adding a innovative heat pump water heater booster

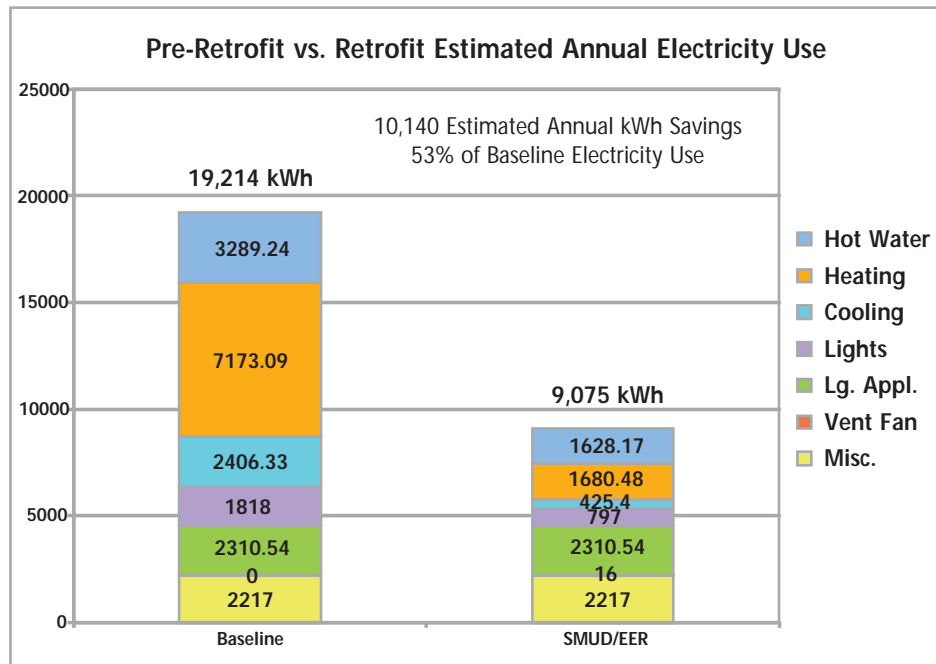
- Replace all incandescent lighting fixtures with ENERGY STAR® compact fluorescent lamp (CFL) fixtures

NREL provided a detailed energy analysis of the home comparing the existing home to the upgraded home's energy use using NREL's BEopt energy simulation tool. BEopt is a computer assisted simulation tool that evaluates a broad range of different to determine the least-cost set of energy efficiency and renewable energy measures to achieve the maximum amount of energy savings. The Jean Avenue BEopt simulation showed upwards of 53% energy savings (*see page 4*).

According to the BEopt analysis, the home was estimated to use 10,140 kWh less than the existing home. Based on current and future approved rate increases, the home's estimated electric bill is less than \$881/year (compared to almost \$2,539/year for the pre retrofit home) a savings of \$1,659 per year, or \$138/month. The home was also inspected and tested by a certified home energy rater who

The 50% Energy Savings Package

completed a home energy rating (HERS) analysis, conducting blower door tests and verifying the attic insulation and HVAC and water heater ratings. The homes' HERS rating showed an impressive 56.1% improvement, going from 194.79 to 85.54 (a HERS score of 100 is equivalent to a new home built to current 2008 Title-24 standards).



Focus on Mini-Splits and Heat Pump Water Heaters

Like many historic Del Paso houses, 1140 Jean Avenue is a 1950s vintage, bungalow style, all-electric, 1040 square foot single story, 2 bedroom, 1 bath home built on a raised foundation with a small crawl space. The home was foreclosed and vacant requiring extensive renovation, including new roof, windows, heat pump, and water heater, when Del Paso Solutions, (Jim Murray-Clark -- Jim Murray-Clark Painting and Construction, Bruce Solorzano -- Zano Heating and Air, and Jan Solorzano -- owner) bought it for \$46,000. Del Paso Solutions applied for and received a rehabilitation loan from the Sacramento Housing and Redevelopment Agency's (SHRA) Vacant Property Program (VPP) to renovate the home.

Work on the home began in August, 2009 and was completed in 2010. In addition to upgrading the building enclosure – air sealing and weatherizing, increasing attic insulation, and installing high performance windows, and converting the storage

area to a bathroom/laundry room, the Jean Avenue project features two advanced energy efficiency features just coming on the market:

- Ductless Mini-Split Heat Pumps
- Heat Pump Water Heater



Mini-Split Indoor Air Handler

Ductless Mini-Split Heat Pumps

The ductless, mini-split heat pump (mini-splits) represents a new heat pump technology that offers low cost, high performance heating and cooling. Although they are common outside of the United States, they have only been recently introduced into the American market by their Japanese and Chinese manufacturers. For more information on mini-splits, visit www.energysavers.gov/your_home/space_heating_cooling/ or www.toolbase.org/Technology-Inventory/HVAC/ductless-mini-split-heat-pumps.

In general, mini-splits make good retrofit add-ons to houses with "non-ducted" heating systems, such as hydronic (hot water heat), radiant panels, and space heaters (wood, kerosene, propane). They can also be a good choice for room additions, where extending or installing distribution ductwork is not feasible. SMUD is also interested in testing whether mini-splits are a good match for small homes and apartments.

In a conventional heat pump, a single indoor unit (refrigerant coil and air handler) and single outdoor unit (condenser and compressor) serve the entire house. Air is cooled at the evaporator coil and distributed around the house via ductwork. In ductless systems, there is (usually only) one outdoor unit serving multiple indoor units (each containing a refrigerant coil and blower). Refrigerant is piped from the outdoor unit through small-diameter insulated refrigerant lines directly to individual rooms or zones. Cooled air is blown into the room by a fan in the individual evaporator units. The term "mini" is used to describe the small indoor units located in each room or zone.

Mini-splits have many advantages. The main advantages of mini splits are their small size and flexibility for zoning or heating and cooling individual rooms. Many models can have as many as eight indoor air handling units (for eight zones or rooms) connected to one outdoor unit. The number depends on how much heating or cooling is required for the building or each zone (which in turn is affected by how well the building is insulated). Since each of the zones will have its own thermostat, you only need to condition that place when someone is there. This will save energy and money.

Ductless mini-split systems are also often easier to install than other types of space conditioning systems. For example, the hook-up between the outdoor and indoor units generally requires only a three-inch hole through a wall for the conduit. Also, most manufacturers of this type of system can provide a variety of lengths of connecting conduits.



**Mini-Split
Condensing
Unit**

Since mini-splits have no ducts, they avoid the energy losses associated with ductwork of central forced air systems. While distribution energy losses in conventional systems have been estimated as high as 30 percent, distribution losses for ductless systems are about one to five percent.

In comparison to other add-on systems, mini-splits offer more flexibility in interior design options. The indoor air handlers can be suspended from a ceiling, mounted flush into a drop ceiling, or hung on a wall. Floor-standing models are also available. Most indoor units have profiles of about seven inches deep and usually come with sleek, high tech-looking jackets. Many also offer a remote control to make it easier to turn the system on and off when it's positioned high on a wall or suspended from a ceiling.

The Jean Avenue home features a Friedrich mini-split with three air handlers located in the living room and two bedrooms. Compared to a standard forced air, ducted heat pump, the mini-split has superior performance ratings with a SEER 15/HSPF 9 versus a SEER 13/HSPF 7.5 (visit <http://www.friedrich.com/> for more information). Energy simulations estimated that the Friedrich mini-split heat pump will reduce the Jean Avenue home's heating and cooling energy use by up to 80%.

For more information on mini-split heat pumps, visit: www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12630
www.toolbase.org/Technology-Inventory/HVAC/ductless-mini-split-heat-pumps

Heat Pump Water Heaters



Heat pump technology can also be applied to water heating. Heat pump water heaters (HPWH) use electricity to move heat from one place to another instead of generating heat directly. Therefore, they can be two to three times more energy efficient than conventional electric resistance water heaters.

To better understand the concept of heat pumps, imagine a refrigerator working in reverse. While a refrigerator removes heat from an enclosed

box and expels that heat to the surrounding air, a HPWH takes the heat from surrounding air and transfers it to water in an enclosed tank.

After heating and cooling, water heating is typically the largest energy user in the home. In particular, homes with a standard electric resistance water heater could see dramatic energy savings by installing a heat pump water heater.

Heat pump water heating systems are available as an integrated unit with a built-in water storage tank and back-up resistance heating element or can be retrofitted to work with an existing convention storage tank water heaters.

The Jean Avenue home features the North Road Technologies Geyser pump water heater. According to the manufacturer, the Geyser heat pump water heater has a COP as high as 3.7 (This means it creates 3.7 units of heat from the air for every 1 unit of electricity required to run the unit) making it one of the most efficient units on the market (*visit <http://www.northrd.com/> for more information*). It is estimated that the Geyser heat pump water heater will reduce the Jean Avenue home' water heating energy use by up to 70%.

Like mini-splits, heat pump water heaters are common in Japan, but they're experiencing a renaissance in the United States. The US Environmental Protection Agency (EPA)'s have begun qualifying heat pump water heaters under its Energy Star® program that cut water heating costs by more than half. For more information on heat pump water heaters visit:

- www.energysavers.gov/your_home/water_heating/
- www.energystar.gov/index.cfm?c=heat_pump_pr_heat_pump
- www.aceee.org/Consumerguide/waterheating.htm

Lessons Learned

The Jean Avenue project shows what a can be accomplished with older, all electric housing stock. When Del Paso Solutions acquired the property they inherited a home with lots of problems – the house required major renovation and it was in a struggling neighborhood. Moreover, for Del Paso Solutions owner Jan Solorzano, this was her first construction project. According to Jan, "Everything was a learning experience. Philosophically, I was happy to do a green renovation, but I knew nothing about construction."

Jean Avenue was also a learning experience for Jan's construction partner, Jim Murray Clark Construction and Painting. Although always interested in energy efficiency, Jim had never taken on the challenge of renovating a home, let alone a home with advanced energy efficiency technologies, such as the mini-split heat pumps and heat pump water heater.

One major lesson from Jean Avenue is that even an older home can be made substantially air-tight. Jim and his crew spent considerable time and effort sealing the home and it showed. Air leakage was reduced about 80% going from 13.6 air changes per hour at 50 pascals (ACH50) of pressure to 2.9 ACH50. As a result, the home is substantial better than current Title-24 new home air leakage levels of 7.5 ACH50.