



National Renewable Energy Laboratory
Innovation for Our Energy Future

Jean Avenue Monitoring Plan February 2010



Sacramento Municipal Utility District (SMUD)
Deep Energy Retrofit (DER)

Home Location:
1110 Jean Ave
Sacramento, CA

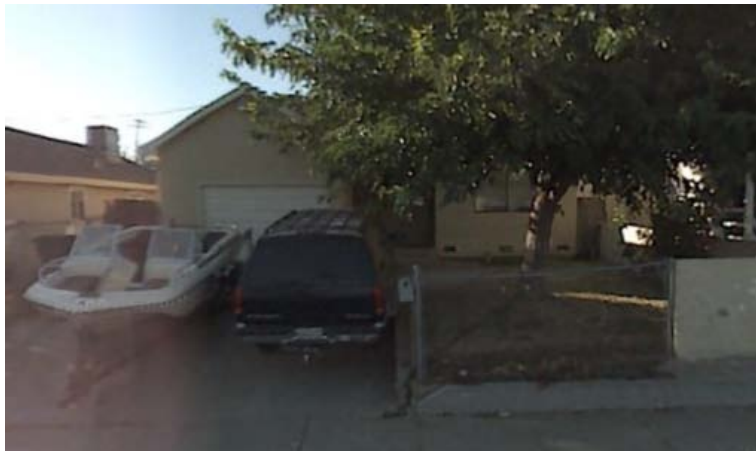


Figure 1: Home Before Deep Energy Retrofit

Proposed Technical Approach:

The goal of this monitoring plan is to develop a protocol for monitoring the SMUD DER Jean Ave project and answer the following major questions:

1. Is heat pump water heater performing as expected?
2. Is the whole house energy as expected?
3. Based on monitored results, how can performance be improved in future retrofit projects?

Domestic Hot Water

The Domestic Hot Water (DHW) system includes Geysler heat pump hot water heater and a storage tank located in the garage. The DHW system will be evaluated with storm-term testing and long term measurements to determine its effectiveness at reducing electric energy use and demand.

Energy Demand

NREL monitoring activities will focus on evaluation of the energy demand for the hot water and total electric energy use and demand.

Comparison of Monitored Performance to Expected Performance

This monitoring plan will compare measured performance to the expected performance of the heat pump domestic water heating system. BEopt will be used to provide estimates of the expected energy performance for the monitored home. The retrofit solution will be evaluated to determine energy savings with respect to SMUD baseline standards. Recommendations for improvements in the performance of future projects will be made based on monitored results.

Research Questions:

1. Domestic Hot Water System
 - a. What is the measured COP of the heat pump water heater? Does intake water temperature to the hot water heater impact the COP? How does this compare to the published COP?
 - b. What is the temperature variation in the output water temperature? How does maximum output temperature compare to HPWH setpoint?
 - c. What is the impact of indoor air temperature on the HPWH performance? Could ventilation to the outdoors increase HPWH performance?
 - d. Does HP placement impact air flow through unit (center of room vs. against wall)? Does air flow rate impact performance?
 - e. What is the predicted annual electrical load? What is the measured annual electrical load? What is the predicted annual reduction in electrical load? What are instantaneous power measurements for each accessible components (pump/fan/compressor) within the heat pump?
 - f. How does the performance of the Geysler HPWH compare with the AirTap? Is there a difference in annual energy use and peak demand loads? Are there notable differences in ease of installation, operation and/or maintenance?
2. Electrical Energy Use
 - a. What was the simulated annual energy use and demand of this home prior to DER? How does this compare to past utility data? What is the simulated annual energy use and peak demand after DER? How does this compare to the measured annual energy use and peak demand?

Instrumentation:

Summary of Jean Ave Measurement Points

The main datalogger will be located in the Utility room adjacent to the hot water heater. Data is collected and stored at 1 minute, 15 minute, 1 hour and 24 hour data intervals. Data is retrieved by NREL from the datalogger via a cellular data modem on a regular basis. All monitoring equipment will be maintained by NREL. The purpose and location of installed sensors are described below.

Summary of Sensors

Sensor	Location	Purpose
WattNode	Electrical Panel	Whole house power
WattNode	HPWH outlet	Heat Pump Water Heater (HPWH) power
WattNode	Electrical Panel	DHW Tank heating element (TBD)
Flow Meter	HW tank in	hot water volume to tank
Flow Meter	HW HP in	hot water volume to HP
Thermocouple	HW tank in	water temperature, cold to tank
Thermocouple	HW tank out	water temperature, hot to house
Thermocouple	HW HP in	water temperature, cold tank to HP
Thermocouple	HW HP out	water temperature, hot HP to tank
Thermocouple	Utility, HP intake	HPWH intake air temperature (dry-bulb)
Thermocouple	Utility, HP exhaust	HPWH exhaust air temperature (dry-bulb)
Temp/humidity	Utility, center of wall	Indoor relative humidity/dry-bulb temperature
Temp/humidity	Outside	Outdoor relative humidity/dry-bulb temperature

Local Weather Data

A temperature and humidity sensor located in an aspirated enclosure is utilized to measure dry-bulb temperature and relative humidity. The temperature and humidity sensor will be located on the exterior of the house, close to the utility room entrance.

Electrical Energy Demand

Power measurements for the total electrical use of the home and are taken with a WattNode located in a dedicated enclosure adjacent to the main electrical panel with current and voltage measurement device located within the main electrical panel.

Domestic Hot Water

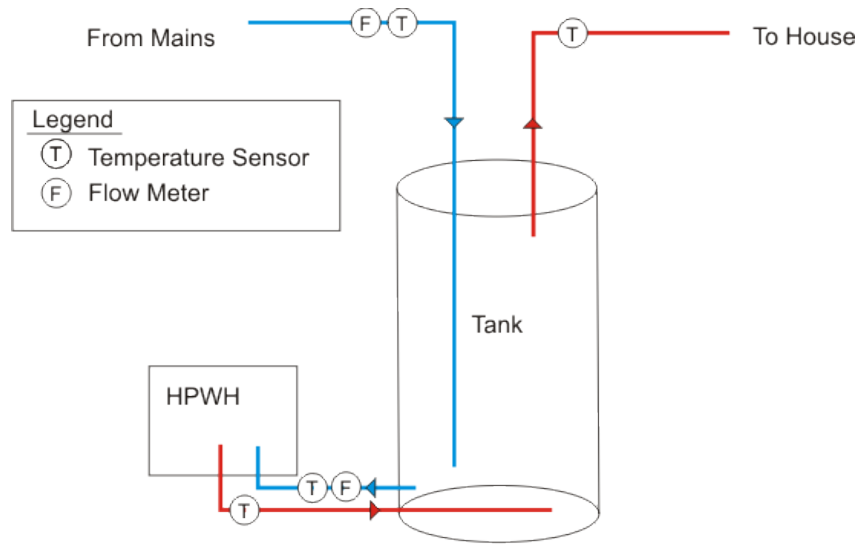
The Domestic Hot Water (DHW) system consists of a Geysler heat pump water heater (HPWH) and a standard storage tank located in the utility room. Flow measurements are taken when water enters the storage tank and when water enters the HPWH. Four submersed thermocouple probes are planned to measure temperatures at key locations in the DHW system. These locations include the temperature of water entering the storage tank, entering the HPWH from the tank, returning to the tank from the HPWH and leaving the tank. Power measurements for the HPWH will be taken with a WattNode. It is currently unclear if the tank has active heating elements. If the presence of an active heating element is confirmed in the field, the electrical draw of this element will also be monitored.



Figure 2: Electrical Panel



Figure 3: HPWH and Tank



Domestic Hot Water Schematic

Long-term Monitoring Supervision:

Long-term monitoring will focus on seasonal and occupant dependant variations in energy consumption and equipment performance. NREL will supervise monitoring equipment (sensors and dataloggers) to ensure proper operation and provide maintenance as required.

Reporting Plan:

Field Test Summary

A field test summary report will be provided for the on-site field test. Summary will include brief descriptions of tests performed and preliminary results.

Quarterly Status Reports

Monitored data will be provided to SMUD quarterly, along with a short summary of key observations.

Case Study Report

A Case Study Report will be provided upon completion of long-term monitoring and analysis effort. The Case Study will include a detailed discussion of monitored data results and computer simulation comparisons to include actual measured energy vs. estimated energy use for the homes. The report will also include a monthly summary of the total energy use and energy demand measured. Recommendations for improving the performance of future projects will be provided.

Contacts:

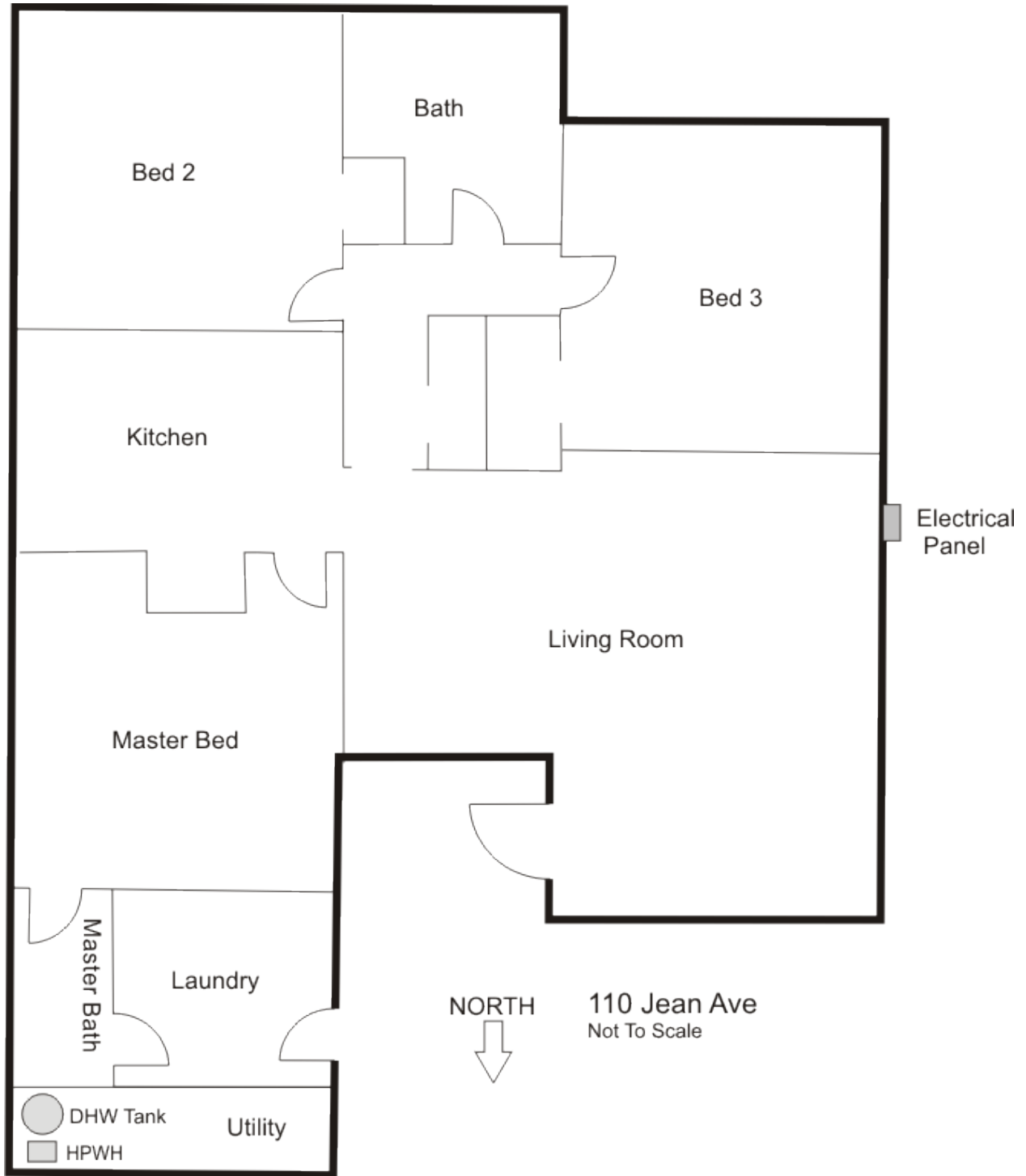
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Appendix A: Home Characteristics (Not Verified)

Refer to Appendix B for Floor Plan.

Measure	Pre-Retrofit	SMUD DER Measure
Thermal Envelope		
Flat Ceilings	No Insulation or existing	15" blown in cellulose R-40
Walls	No Insulation or existing	2x6, 16" O.C, R-20
Air Sealing	None	Air Sealing to comply with Energy Star Thermal Bypass Checklist primarily using ZeroDraft materials and methods
Windows		
Above Grade Windows & Sliding Glass Door	Single Pane Wood with Aluminum Frames U-value = 1.07 est SHGC = 0.70 est	Vinyl low e U-value = 0.32 SHGC = 0.25
Mechanical Systems		
Central Air Source Heat Pump	Existing HSPF/SEER	3 zone, Ductless SEER 15/HSPF 9.2 Mini Split Heat Pump with Jumper Ducts w/ Fans on switch
Thermostat	Manual	"Smart" Thermostat
Water Heating	electric (all electric home only)	Heat Pump Water Heater COP = 3.0
Ventilation		
Spot Ventilation	None	Bathroom low sone fans with Timer Controls
Lighting & Appliances		
Lighting (units)	Incandescent	100% hardwired Energy Star Compact Fluorescent or solid state (LED) Fixtures
Dishwasher	Existing	Level 2 Energy Star EF = 0.68
Inspections	None	HERS Rating
Controls (Optional)	none	Wireless green switch, Tstat, "dashboards"

Appendix B: Equipment Locations



Equipment and sensor locations TBD.