Sustainable Design and Energy-Efficient Building Techniques for Existing Housing

PATH Energy Retrofit Project Henderson, Nevada
NREL Research Site, Lebanon NJ

Energy Retrofit Goals

PROJECT GOALS

- Identify, model, implement and evaluate energy saving technologies.
- Compare before and after energy consumption to determine energy savings.
- Determine cost effectiveness of energy retrofit and individual technologies as possible.
- Reduce energy consumption

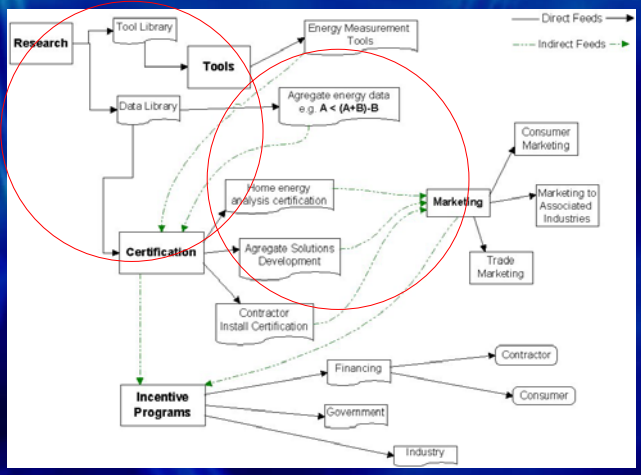
Drivers for change

- Consumer - Cost of homes
  - Acquisition = debt service
  - Property taxes
  - Operation and Maintenance
- Business Opportunities
- National Policy – energy efficiency

Constraints on design and implementation

- Existing topography
- Existing orientation
- Existing zoning constraints
- Lack of engineering modeling
- Little building systems coordination
- Little political will

PATH Energy Efficiency – Existing Homes Roadmap
Where this work fits….

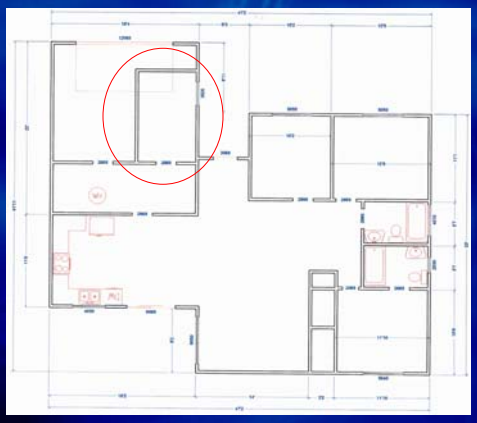


Subject House in Henderson, Nevada

- Built in 1986
- 1,270 square feet
- Slab on grade
- 3 bedroom
- 2 bath

Initial Assessment- Floor Layout

- Original Floor Area: 1,070ft^2
- Finished Garage Area:200ft^2
- Total Finished Area: 1,270ft^2
- Standard 8ft ceilings
- House faces West



Initial Assessment- Site Evaluation

- Duct Blower - 6.6% of floor area (10% avg)
- Blower Door - .44 ACH natural (0.5-0.6 avg for region)
- Energy Audit by Nevada Power
- Major Appliance Assessment
- Materials of Construction
  - R-13 walls / R-19 attic
  - Uninsulated slab on grade foundation
  - Double Glazed Aluminum framed windows

Initial Assessment- Site Evaluation

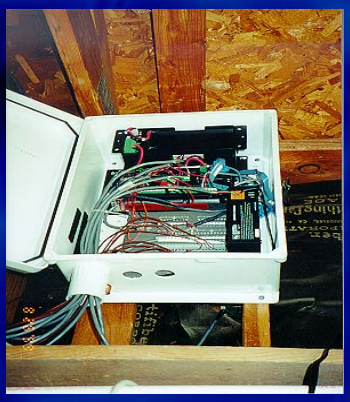
- HVAC Performance - 9.5 SEER - Furnace 75% AFUE
  14 years old
- Previous Energy Consumption
  - $87 per month electric
  - $29 per month gas
  - $1,429 total energy bill for calendar year 1999

Energy Modeling Software

- Energy Modeling can be fairly accurate with little effort using default values.
- A no-cost on-line energy modeling program, Home Energy Saver, is available
  - Web address HTTP://hes.lbl.gov
  - Relatively accurate results (+/-10%), as compared to actual energy bills, can be obtained in less than 10 minutes.
  - Provides suggestions for upgrades
  - Upgrades can be re-entered into model to estimate post upgrade results.

Monitoring-
Campbell Scientific Datalogger

- Directly monitor selected household loads (refrigerator, freezer, HVAC).

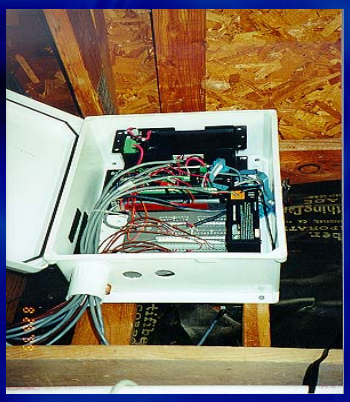


Monitoring-
Campbell Scientific Datalogger

- Record environmental conditions
  - Temp- indoor, outdoor, attic, hot/cold water
  - Mean Radiant Temperature- attic
  - Humidity- indoor, outdoor
  - Solar radiation- outdoor

Monitoring- Campbell Scientific Datalogger

- 15 Minute Data
- Data downloaded weekly via modem



Monitoring- Enetics Data logger

- NIALMS (Non-Intrusive Appliance Load Monitoring System)
- Monitors all large household loads (>150W)
- Identifies loads by consumption “signature”

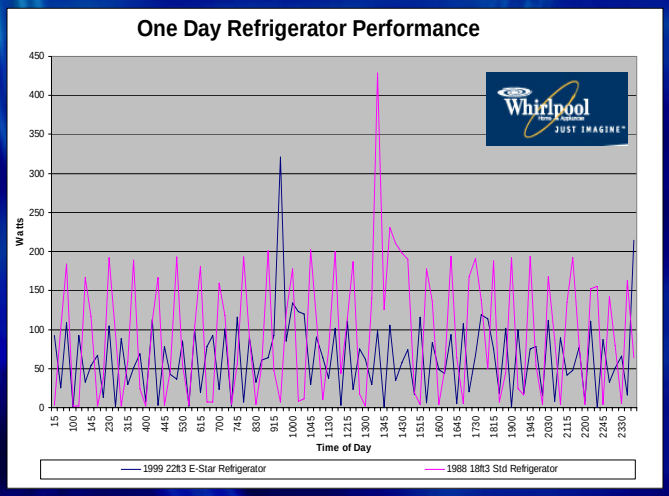
Monitoring- Enetics Data logger

- Accurate for most major loads between 95-99% of actual.
- 15 Minute Data
- Data downloaded weekly via modem

Selected Innovative Technologies

- PATH Technologies
  - Radiant Barrier System
  - CFC Free HVAC System
  - Programmable Thermostat
  - Super Efficient Refrigerator
  - White LED Light
  - Efficient Clothes Washer
- Costs
  - Total $ 6,550
  - Cost Premium For Efficiency Upgrade $ 1,988
- Estimated Energy Savings $ 332 per Year = 16.7% R.O.I.

Super Efficient Refrigerator



Super Efficient Refrigerator

- EnergyStar rated appliance
- Monthly Energy Consumption
  Before: 80kWh/month
  After: 50kWh/month
- New refrigerator has 20% more volume than old refrigerator. (18 ft3 vs. 22 ft3)

- Cost: $900
- Energy Efficient Cost: $100
- Projected Annual Savings: $32
- Simple Payback: 3.1 years

High Efficiency
Air Conditioners without CFCs

- Replace existing unit with Puron (R410a) unit
- Cooling- Before 9.5 SEER
  After 12.0 SEER
- Heating- Before 75% AFUE
  After 81% AFUE
- Typical operating pressures

(PSI)	R-22	Puron
Low	78	140
High	250	400

Puron

High Efficiency
Air Conditioners without CFCs

- EnergyStar rated HVAC system
- Due to load cooling reduction of about 8,000 btu/h, the new system can be reduced in size by 1/2 ton (6,000 btu/h) to 2 1/2 tons.
- Resulting capital equipment cost reduction of $200
- Installed Cost : $3,688
- Energy Savings Cost : $700
- Estimated Annual Savings: $120
- Simple Payback: 5.8 years

Selected - Conventional Technologies

- Technologies
  - Compact Fluorescent Lights
  - Replacement Windows with Lo-E coating
  - Attic Insulation-Duct Insulation
  - Air Infiltration Reduction
  - Humidity Sensor Gas Clothes Dryer
- Costs
  - Total $ 4,288
  - Cost Premium for Efficiency Upgrade $ 1,151
- Estimated Energy Savings $ 307

CONVENTIONAL TECHNOLOGIES
Attic and Duct Insulation

- Attic Insulation initially had R-19
- Modeling determined R-38 to be most cost effective
- Estimated Installed Cost: $350
- Estimated Annual Savings: $65
- Simple Payback: 5.3 years
- Retrofitted supply duct was installed without insulation
- Estimated Installed Cost: $100
- Estimated Annual Savings: $40
- Simple Payback: 2.5 years

CONVENTIONAL TECHNOLOGIES

Air Infiltration Reduction

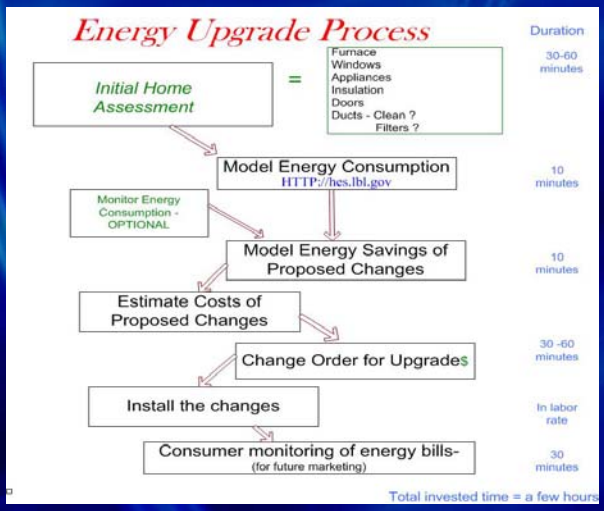
- Reduced air infiltration by 35%
- Caulked leaks
- Foam sealant on large openings
- Installed weather-stripping on 2 doors
- Installed outlet gaskets on all exterior outlets.
- Installed Cost: $250
- Estimated Annual Savings: $20
- Simple Payback: 12.5 years

CONVENTIONAL TECHNOLOGIES

Replacement Windows

- Replaced existing aluminum framed windows with vinyl windows and sliding glass door
- All glass has Lo-E coating to partially reflect radiant energy
- Changed the effective R-value from 1.17 to 3.13
- Installed Cost: $3,528
- Estimated Annual Savings: $157
- Energy Savings Cost: $400
- Simple Payback: 2.5 years

Energy Retrofit Strategy



Project Summary

- **Total Estimated Cost of retrofit- $10,838**
- **Cost premium for Efficiency Upgrade - $3,139**
- **Estimated Potential savings of $639 per Year**
- **Savings are projected to be 44% of previous bills. -PATH target of 30%**
- **Monitoring yielded definitive results.**
- **Results will are on-line:**
  - **www.pathnet.org**
  - **Go to “Results in the Field”, Asdal Builders**

SEER –Systems Engineering for Energy Retrofits

Project Goal

The Systems Engineering for Energy Retrofits (SEER) project seeks to develop innovative approaches to housing retrofits that are designed to improve energy efficiency while maintaining profitability and competitiveness in the industry.

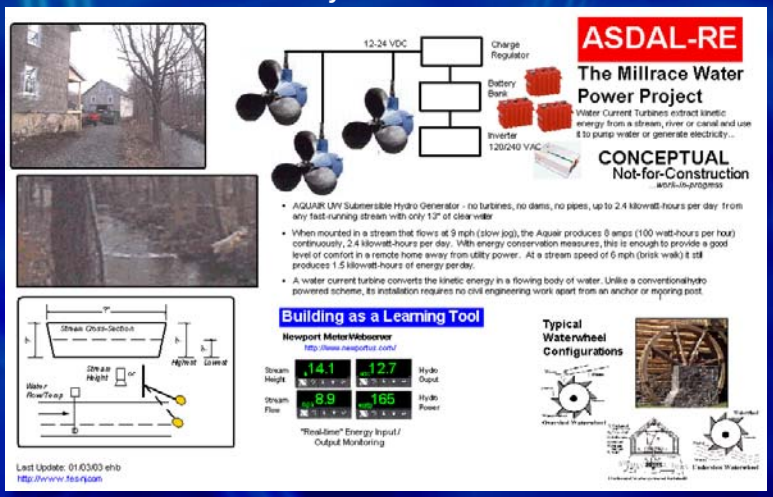
The Site – Lebanon, NJ
www.raritaninn.com

at purchase

current

Renewable energy in existing housing

Hydroelectric



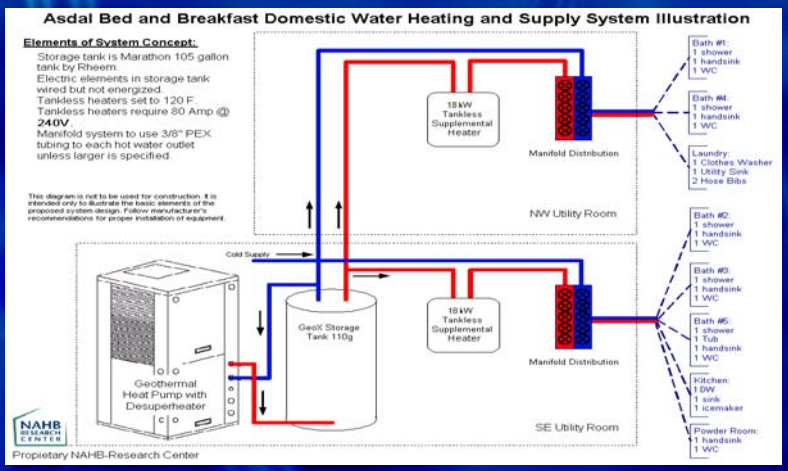
Renewable energy in existing housing

Hot Water System with 80 Gallon Tank (IPV 80)

- **2KW solar water heating system**
- **Complete 80-gallon solar water heater**
- **Side arm heat exchanger used for converting any electric water heaters to solar**
- **Single tank electric or two storage only for gas and LPG back-up**

Renewable energy in existing housing

Geothermal Heating and Cooling – Domestic Hot water

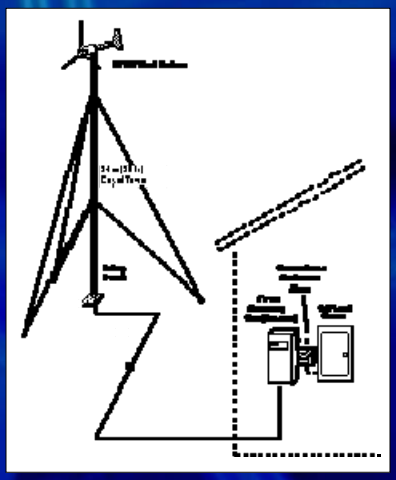


Renewable energy in existing housing

Wind: Grid-Intertie System

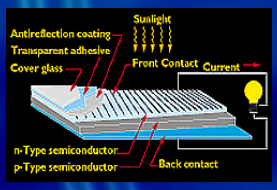
Bergey wind turbines operate at variable speed to optimize performance and reduce structural loads. Power is generated in a direct drive, low speed, permanent magnet alternator. The output is a 3-phase power that varies in both voltage and frequency with wind speed. This variable power (wild AC) is not compatible with the utility grid.

Renewable energy in existing housing



To make it compatible, the wind power is converted into grid-quality 240 VAC, single phase, 60 hertz power in an IGBT-type synchronous inverter, the GridTek Power Processor. The output from the GridTek can be directly connected to the home or business circuit breaker panel. Operation of the system is fully automatic.

Renewable energy in existing housing



14.2 Kw proposed

Photovoltaic

A typical solar cell consists of a cover glass or other encapsulant, an anti-reflective layer, a front contact to allow the electrons to enter a circuit and a back contact to allow them to complete the circuit, and the semiconductor layers where the electrons begin and complete their voyages.

Energy Saving / Conservation technologies

Energy Upgrade/Process Analysis