U.S. Department of Housing and Urban Development
Office of Policy Development and Research

# Field Evaluation of PATH Technologies

## Energy Retrofitting Advanced Technologies in a Hot Climate: Henderson, Nevada

Field Evaluation

PATH (Partnership for Advanced Technology in Housing) is a new private/public effort to develop, demonstrate, and gain widespread market acceptance for the "Next Generation" of American housing. Through the use of new or innovative technologies the goal of PATH is to improve the quality, durability, environmental efficiency, and affordability of tomorrow's homes.

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# Energy Retrofitting of Advanced Technologies in a Hot Climate: Henderson, Nevada

***Prepared for***
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## About the NAHB Research Center, Inc.

The NAHB Research Center is a not-for-profit subsidiary of the National Association of Home Builders (NAHB). The NAHB has over 205,000 members, who build more than 80 percent of new American homes. NAHB Research Center, Inc. conducts research, analysis, and demonstration programs in all areas related to home building and carries out extensive programs of information dissemination and interchange among members of the industry and between the industry and the public.

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## 1.0 Introduction

Energy retrofitting of existing homes has received much attention since the energy crisis of the mid-1970's. Traditional energy saving upgrades have consisted of such measures as caulking, adding insulation and installing double pane replacement windows. In addition, there have been a number of technologies developed that are not yet widely accepted or understood. Many of these technologies have been identified by the PATH program and were considered for the energy retrofit as appropriate with respect to climate and site. Establishing a methodology and understanding technologies used in field evaluation is an important step in accomplishing one of the primary PATH visions to reduce energy use by 30% or more in existing homes.

This study documents a cost-effective approach to existing home energy conservation through technology, rather than sacrificing comfort or convenience. The methodology includes analysis of traditional energy saving techniques in addition to lesser-known PATH technologies. A pre-retrofit analysis was done by characterizing the home, modeling the technologies and evaluating the potential cost effectiveness of the upgrades. After the retrofit was completed, the home was re-characterized and evaluated to assess the actual energy savings and cost-effectiveness of the retrofit.

**Figure 4**
**Subject House**

The NAHB Research Center worked with Bill Asdal, the property owner, to perform this warm climate energy retrofit on existing home in Henderson, Nevada, a southeastern suburb of Las Vegas.

Objectives of the project were to:

- Identify, model, implement and evaluate energy saving technologies,
- Compare before and after energy consumption to determine energy savings,
- Determine overall cost effectiveness of energy retrofit, and of individual technologies.
- Reduce energy consumption while minimizing the impact to the occupants.

## 2.0 Methodology

There are many ways to perform an energy retrofit of existing homes. However, a standardized method can be used in taking on an energy upgrade to an existing house. The approach taken at the Henderson, Nevada location included the following steps:

### 2.1 Initial Assessment

#### 2.1.1 General

The first step was to perform an initial assessment on the subject house. Information such as square footage, house volume, window data (area, type, orientation, shielding), insulation levels, appliance types and age, HVAC information, previous energy bills and materials of construction were necessary to understand the performance of the house.

House Characteristics:

- Year Built: 1986
- Conditioned Space: 1,270 square feet
- Ceiling Height: 8 feet
- House Volume: 10,160 cubic feet
- Bedrooms: 3

- Bathrooms: 2
- Foundation: Slab on grade, uninsulated
- Orientation: West Facing
- Major Appliance Assessment- Refrigerator, Washer, Dryer, Dishwasher, Freezer
- Materials of Construction – 2x4 Wood Frame, 16” on center studs and exterior stucco finish
- Insulation: R-11 walls- fiberglass batts/ R-19 attic- blown in cellulose
- Windows: Double Glazed Aluminum framed - 14% of wall area
- Lighting- Entirely incandescent
- HVAC: Rating – A/C 9.5 SEER - Furnace 75% AFUE – manufactured in 1986
- Previous Energy Consumption
  - Average $90 per month electric- 1,251 kWh / month
  - Average $29 per month natural gas- 39 therms / month
  - $1,429 total energy bill for calendar year 1999

### 2.1.2 Energy Audit

The Research Center, with help from Nevada Power, performed a comprehensive energy audit on the subject house. As part of the energy audit, Nevada Power also tested the house and ducts for air tightness using Blower Door and Duct Blaster test equipment.

- Duct Tightness: Duct Blaster – 7.75% of flow (10-15% avg.)
- House Tightness: Blower Door - 0.44 ACH natural (0.5-0.6 avg. for region)

Nevada Power’s Energy Audit recommendations included the following:

- Radiant Barrier stapled to the underside of the roof trusses
- Solar screens with a shading coefficient of 0.21 on the south and west windows
- Weather stripping on doorjamb.
- Replace some interior lights with compact fluorescent lights.
- Programmable thermostat
- Refrigerator and freezer coils should be cleaned
- Ceiling fans should be added to the bedrooms
- Water heater lines should be insulated
- Duct in attic requires additional insulation

**Figure 5**
**Blower Door Test Setup**

### 2.1.3 Occupants

In an interview with the occupants of the house, a number of items were discussed in order to understand the household makeup and energy usage habits. The occupants consisted of two adults, and one teenage male, who recently graduated from high school. Comfort and convenience were very important to them. They were up-front about not wanting to change their daily habits or sacrifice comfort in order to reduce their utility bills. This matched our objective of reducing energy through technology rather than personal sacrifice.

## 2.2 Energy Modeling

Once the initial assessment was completed, energy modeling was done to simulate the existing house. Energy modeling can be a relatively quick and accurate method used to simulate the effects of changes to the building envelope, lighting and appliances within the home.

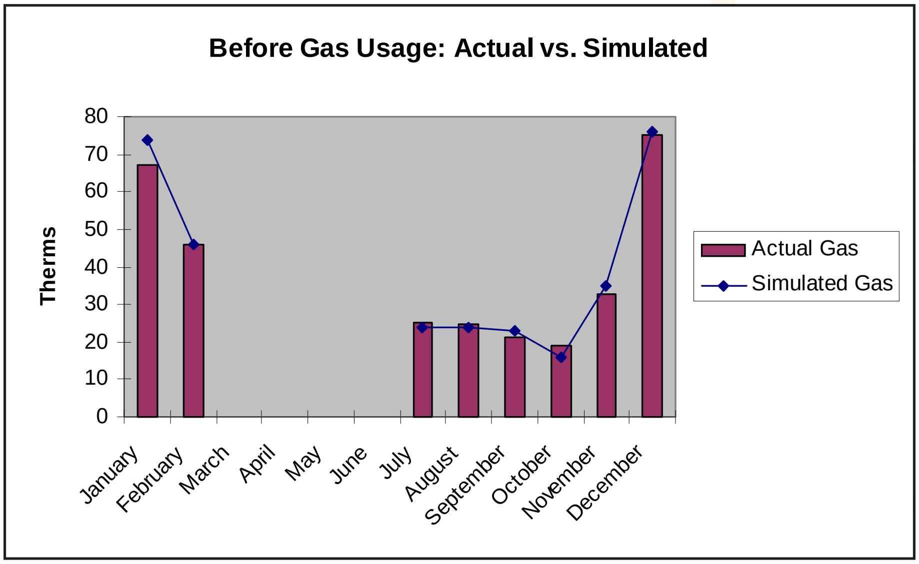


**Figure 6**
**Gas Usage Calibration Model**

The Research Center chose to use Energy-10 version 1.3 to model the subject house. However, a number of the technologies were modeled outside the Energy-10 simulation. When possible, the technology specific calculations modeled outside Energy-10 were then plugged back into the simulations.

Modeling software was used in combination with actual energy use. This made it possible to calibrate the simulated house using actual weather data. The calibrated model was able to get the eight month total simulated usage within 2% of actual. Simulated monthly energy usage correlated to actual with a correlation coefficient of greater than .99 (1 is perfect correlation). Figures 6 and 7 represent the comparison between the actual and simulated energy consumption of the calibrated model.

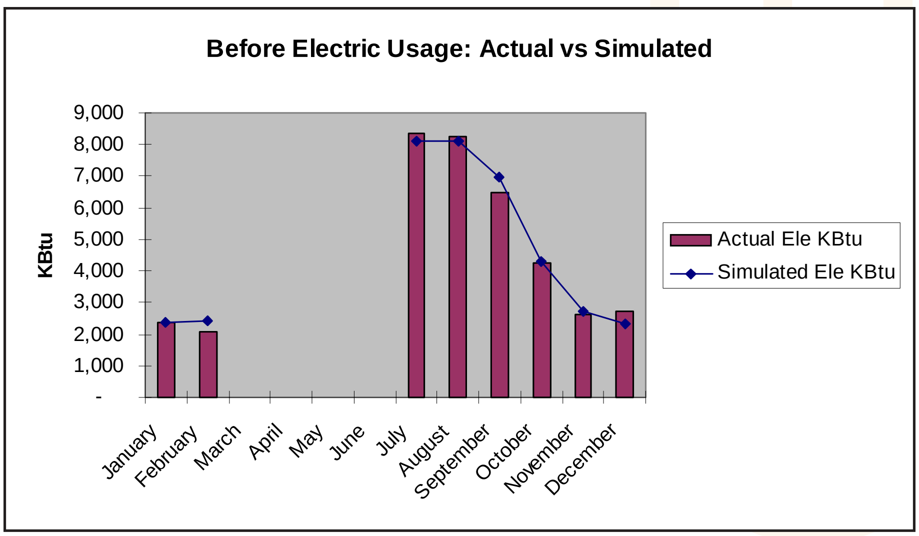


**Figure 7**
**Electric Usage Calibration Model**

## 2.3 Monitoring

When performing a residential energy retrofit, it is typically not necessary to directly monitor the energy consumption of individual loads as well as indoor and outdoor conditions. Monitoring was chosen for this project to estimate, as closely as possible, the benefit of each modification performed.

Two monitoring systems were installed in the test house. The first was a conventional datalogger to directly monitor energy consumption and environmental conditions of specific points. The second system is referred to as a non-intrusive appliance load monitoring system (NIALMS), which monitors various electric loads from a single point near the utility electric meter.

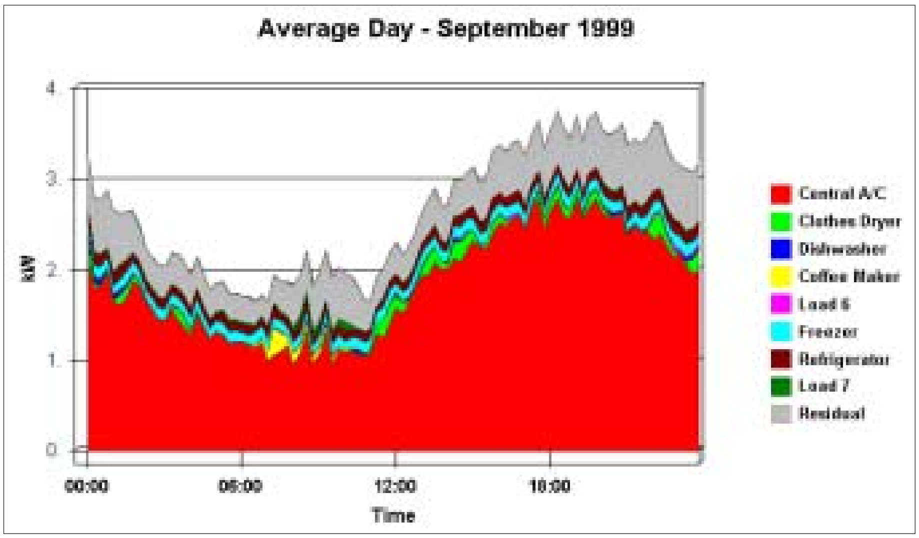


**Figure 8**
**Energy Usage Profile for an Average Day- September 1999**
Courtesy of Enetics Inc.

The NIALMS device identifies specific loads through an appliance's unique consumption "signature". The magnitude and frequency of both the inductive and resistive components of each appliance is compared to a databank of known loads to identify the source. It is able to measure not only the electricity used, but also the frequency and duration of use. Enetics, Inc. supplied us with the NIALMS unit. The system was set to identify individual loads in excess of about 200 watts.

The conventional datalogger has the flexibility to perform many data acquisition functions and is capable of downloading data or reprogramming the system via modem. It was used to gather data on the operating parameters of the house. Several types of measurement devices were used in conjunction with the datalogger and positioned throughout the house as shown in Table 3.

Data was measured every five seconds, averaged (or summed) and stored to a data file on a 15 minute basis. Data was then downloaded weekly via modem to the Research Center. A full four months of baseline monitoring, along with four additional months of natural gas and electric utility bills were accumulated prior to beginning the upgrade process.

**Table 3**
**Datalogger Monitoring Points**

| Monitoring Point | Thermocouple | T & H Sensor | Pyrometer | kWh Meter | Flow Meter |
|---|---|---|---|---|---|
| Attic | 2 | | | | |
| Attic (Radiant) | 2 | | | | |
| Attic (Insulation) | 1 | | | | |
| Attic (Sheathing) | 2 | | | | |
| Attic (Ceiling) | 1 | | | | |
| Ambient | 1 | 1 | 1 | | |
| West Bedroom | 1 | | | | |
| Thermostat | | 1 | | | |
| Whole House | | | | 1 | |
| Refrigerator | | | | 1 | |
| Freezer | | | | 1 | |
| HVAC | 1 | | | 1 | |
| Hot Water | 2 | | | | 1 |

## 2.4 Prospective Upgrade Evaluation

A list of prospective energy retrofit measures was compiled through suggestions made from the energy audit performed by Nevada Power and a careful look through the list of PATH Technologies for energy reduction measures applicable to a retrofit.

Once the list of potential upgrades was determined and modeled to estimate their benefit, savings were compared to the installed cost to calculate a simple payback in years. For this case study, simple payback was the chosen criteria for evaluation. Simple payback was determined by dividing the extra cost of upgrading to high efficiency by the annual savings. The additional cost for upgrading to high efficiency was used rather than the entire cost; this was done to not penalize equipment that required replacement. This method gave a general idea of what changes would be most effective in easily understood terms.

The upgrade analysis did not explicitly consider costs of maintenance, other costs and/or benefits that might be used in a comprehensive life cycle cost analysis. Expected lifetime was only considered if the lifetime were less than the simple payback. Life cycle costing analysis requires many assumptions and often reaches the same conclusion as a simple payback calculation.

Utility costs in the Las Vegas area are some of the lowest in the country. As of October 1999, Nevada Power's residential electric rates were (after all taxes) $0.067/kWh (national avg. $0.086/kWh, from EIA[1] + 5% tax); this does not include the monthly service charge. Southwest Gas charged $0.59/therm for natural gas (national avg. $0.75/therm from EIA+ 5% tax), again including all applicable taxes and excluding the monthly service charge.

[1]EIA is the Energy Information Administration, a branch of the U.S. Department of Energy.

## 2.5 Pre-Retrofit Analysis

Estimated annual savings is based on each energy reduction measure being the only retrofit. This is necessary in the pre-retrofit analysis, because it is not yet determined what changes will be included in the retrofit.

**Table 4**
**Pre-Retrofit Cost-Effective Analysis**

| Energy Retrofit Measure | Selected Measure | Estimated Installed Cost | Estimated Annual Savings | Estimated Additional Cost for High Efficiency | Simple Payback on High Efficiency (Years) |
|---|---|---|---|---|---|
| Programmable Thermostat* | X | $80 | $64 | $80 | 1.3 |
| Compact Fluorescent Lights (8) | X | $60 | $25 | $56 | 2.2 |
| Bare Duct Insulation | X | $100 | $40 | $100 | 2.5 |
| Super Efficient Refrigerator* | X | $900 | $32 | $100 | 3.1 |
| Gas Clothes Dryer w/Moisture Sensor | X | $450 | $30 | $100 | 3.3 |
| Super Efficient Large Refrigerator* | | $1,100 | $80 | $300 | 3.8 |
| Replacement Windows - Low-E Glass | X | $3,500 | $110 | $450 | 4.1 |
| White LED Lighting- Entryway* | X | $65 | $10 | $63 | 6.5 |
| HVAC- 12 SEER- Packaged Unit | | $3,665 | $126 | $745 | 5.9 |
| HVAC- 12 SEER- Packaged w/no CFC's* | X | $3,755 | $126 | $745 | 5.9 |
| Additional Attic Insulation - from R19 to R38 | X | $450 | $65 | $450 | 6.2 |
| Additional Attic Insulation - from R19 to R49 | | $590 | $77 | $590 | 7.0 |
| Infiltration Sealing | X | $150 | $20 | $150 | 7.5 |
| Resource Efficient Top Loading Washer* | X | $600 | $25 | $200 | 8.0 |
| Radiant Barrier* | X | $500 | $35 | $500 | 14.3 |
| HVAC- 16 SEER- Split System** | | $6,450 | $196 | $3,530 | 18.0 |
| HVAC- 15 SEER- Split System** | | $6,080 | $173 | $3,160 | 18.3 |
| Solar Water Heater* | | $1,670 | $65 | $1,370 | 21.1 |
| HVAC- 18 SEER- Split System** | | $8,035 | $230 | $5,115 | 22.2 |
| Tankless gas water heater* | | $1,118 | $31 | $818 | 26.4 |
| Aerosol Duct Sealing* | | $800 | $12 | $800 | 66.7 |

* PATH Technology
** Includes cost to modify house for split air conditioning system

An important point to remember when evaluating the savings of multiple technologies is that benefits may not be additive. For example, if a higher efficiency air conditioner is installed along with higher efficiency windows, the resulting savings will be less than the sum of the two if calculated separately. This is because, not only is the amount of energy being lost through the windows reduced, but at the same time the cost to remove heat by the more efficient air conditioner has also been reduced. This interaction lowers the overall benefit of the combined modifications and means the energy savings of the air conditioner and windows can only be accurately determined as a package.

## 2.6 Selecting Energy Retrofit Measures

The selection of energy retrofit measures was based upon a simple payback calculation. Simple payback is an economic calculation comparing the cost of an energy retrofit to the time required to pay back the investment. Simple payback does not take into account time value of money or useful life of the components. The simple payback cutoff point selected for this study was eight years. Shorter paybacks are better for the investor, other things being equal.

The eight-year cutoff rule was followed with the exception of the radiant barrier system. This was done because Southern Nevada is an excellent location for a radiant barrier system, and there is disagreement as to the effectiveness of radiant barriers.

## 2.7 Installing Upgrades

The first modifications began in mid-January 2000 with the final retrofit being performed on August 1, 2000. Some of the installations were intentionally staggered in an attempt to segregate the savings of the individual technologies.

**Table 5**
**Installation Schedule and Cost**

| Retrofit | Installation Date | Material Cost | Labor Cost | Energy Eff. Cost |
|---|---|---|---|---|
| Refrigerator | 01-12-00 | $900 | $0 | $100 |
| Washer | 01-12-00 | $600 | $0 | $200 |
| Dryer* | 01-12-00 | N/A | N/A | N/A |
| Low-E Windows | 02-16-00 | $2928 | $1980 | $450 |
| Infiltration Sealing | 02-22-00 | $40 | $110 | $150 |
| Radiant Barrier | 02-23-00 | $300 | $350 | $650 |
| Compact Fluorescent | 02-23-00 | $65 | $0 | $54 |
| HVAC System | 03-31-00 | $1941 | $1564 | $745 |
| Thermostat | 03-31-00 | $50 | $30 | $80 |
| Attic Insulation | 07-14-00 | $250 | $200 | $450 |
| White LED Light | 07-14-00 | $65 | $0 | $63 |
| Duct Insulation | 08-01-00 | $20 | $55 | $75 |
| HVAC Reduced Size | | $212 | | -$212 |
| Totals | | $7,397 | $4,289 | $2,805 |

*Dryer energy saving feature was not used and was therefore eliminated from the study.

Some costs were higher than originally estimated. This was primarily due to the labor component of the window, insulation and radiant barrier installations. The total price over the estimate amounted to $1,338.

## 2.8 Evaluated Savings

Based upon a weather normalized eight-month before and eight-month after comparison, the annualized reduction in electric usage was calculated to be 32%. The results are slightly lower than the predicted savings of 36% (Figure 9). The actual gas savings of 27% also fell short of the 33% predicted savings (Figure 10). The difference is attributed to under-utilization of the thermostat and dryer as well as over estimated savings on the washer and radiant barrier.

The actual energy consumption had to be weather normalized to allow a meaningful comparison between the measured before and after usage. The winter Heating Degree Days (HDD) for 1999 was 23% below average (HDD is a common method for determining the severity of a season). This compares to the "after" HDD measuring 1.2% higher than normal. The dramatic difference between the two heating seasons illustrates the need to normalize for weather conditions. The same type of approach was taken for summer.

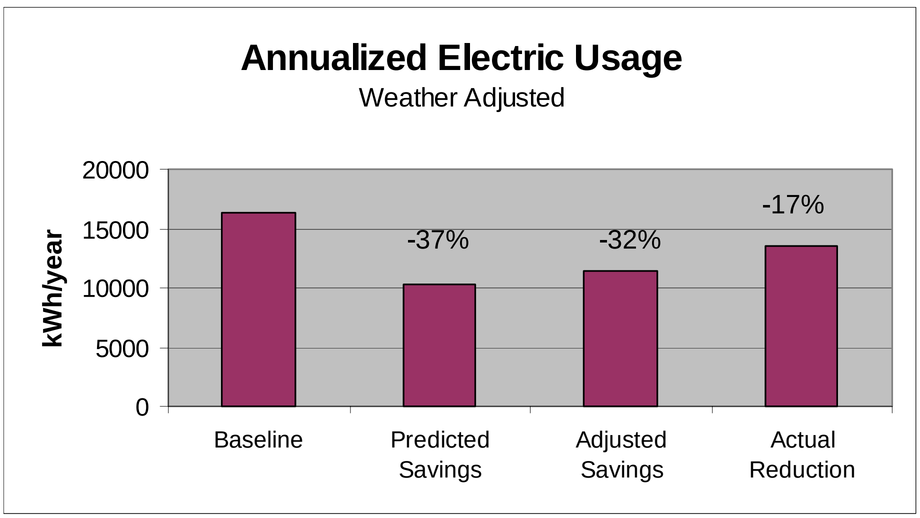


**Figure 9**
**Annualized Electric Usage**

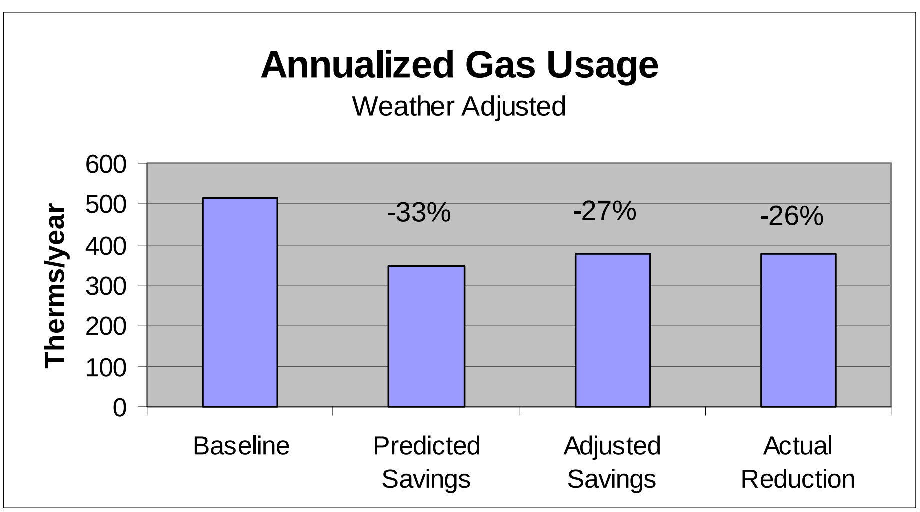


**Figure 10**
**Annualized Gas Usage**

Typical Meteorological Year (TMY) data was used to replace the actual weather in arriving at the normalized before and after energy use. The results of the retrofit were not as straightforward as expected. A variety of dynamics occurred that affected the savings. Figures 9 and 10 reflect the complications that can occur when determining savings associated with an energy retrofit.

All energy use numbers are based on simulated results using a calibrated model normalized to an average weather year. The "Predicted Savings" are modeled results that were calculated using the full savings potential of all installed energy retrofit measures. The savings incorporated assumed changes with the temperature settings and appliance usage. With a 37% electric and 33% gas savings predicted, the net energy reduction is in excess of the 30% PATH goal.

"Adjusted Savings" are based on the actual performance of the energy retrofit measures. This takes into account the shortcomings of the "Predicted Savings", but does not account for lifestyle changes and usage habits. Discounting the lifestyle changes, the after modeling and data combine to show savings of 32% electric and 27% gas.

The "Actual Reduction" reflects a significant decrease in the electric savings (from 37% to 17%), and a decrease in the gas savings (from 33% to 26%). There were a number of factors that are believed to be major contributors to these discrepancies. First, in the post retrofit monitoring there were four occasions when the thermostat was set to the "fan on" position, rather than the "auto" position, accounting for at least 160 days of constant blower operation. Second, the new, more easily opened bathroom window was partly open, for moisture control, the majority of the post retrofit period. Also, two highly used electric loads were introduced into the house around the end of 1999, a computer and a large screen television.

# 3.0 PATH Technologies

## 3.1 Radiant Barrier System

### 3.1.1 Description

Attics with daytime temperatures in excess of the surrounding conditions are usually caused by heat from the sun, also known as solar or radiant heat. Radiant heat is the heat we feel from distant objects like the sun or a fire and is unique because it does not require a medium to travel through. Radiant barriers are designed to block the effects of radiant heat gain in homes by reflecting the sun's radiant heat rather than absorbing it. They may provide substantial energy savings in warm climates. Manufacturers claim that radiant barriers can lower the air conditioning component of the utility bill by between 10 and 30 percent when used in conjunction with thermal insulation. Studies from other independent sources show savings in the 0 to 20 percent range, depending on location.

An attic exposed to the sun for a prolonged period will absorb a great deal of heat, sometimes reaching temperatures in excess of 150°F. The effects of attic radiant heat gains can be reduced with the aid of highly reflective surfaces. Unlike traditional forms of insulation, which absorb radiant heat energy, radiant barriers reflect it. Alternatively, radiant barriers can also retain heat in the winter months.

Radiant barriers are made from materials that are excellent at reflecting heat, but are poor at emitting it, such as reflective foil, reflective paint coatings, and reflective chips. To be considered a radiant barrier, at least 90% (per ASTM C1158-01) of all radiant energy must be reflected from the barrier. Radiant barriers, which do not provide a significant amount of thermal insulation, can be combined with thermal insulation for increased energy efficiency. They reduce heat gains without taking up significant space.

### 3.1.2 Energy Modeling

Energy-10 does not have the ability to evaluate the performance of radiant barriers. However, information gathered from an Oak Ridge National Laboratory (ORNL) publication gave us a yearly payback of $22 for the subject house. Also taken into consideration was a study published by ASHRAE that realized up to a 14% reduction in cooling load (Moujaes, Brinkman) that equates to $48/year for the subject house. Given the large disparity in the two estimates, the average result of $35/year savings was used in the evaluation.

### 3.1.3 Pre-Upgrade Evaluation

With an predicted $35/year energy savings and a $500 estimated installed cost; the simple payback came out to 14.3 years. The eight-year or less simple payback rule-of-thumb was disregarded in this example. This is because the energy savings attributed to radiant barriers are not well defined, and it was believed that this hot, sunny climate would be an excellent evaluation site for a Radiant Barrier System.

### 3.1.4 Installation

There are two possible retrofit installation methods, the barrier can either be laid down flat on top of the insulation, or can be stapled to the underside of the top truss chord. For this project, attaching the barrier to the underside of the truss chord was chosen (Figure 11). This configuration minimized the potential performance degradation of the system by minimizing the dust accumulation on the barrier, which was an issue in the Las Vegas area. It also protected the attic ducts from radiant gains.

**Figure 11**
**Installation of Radiant Barrier**

The downside of the mounting method was the increased cost of installation (roughly $150), and additional material consisting of staples and staple guns ($50), and a slightly lower initial savings (about 5%) (ORNL).

An experienced installation supervisor indicated that sufficient ventilation (soffit and gable) already existed to remove the heat retained between the barrier and the sheathing. This agreed with ORNL’s recommended practices.

### 3.1.5 Monitoring

Attic temperature sensors were put in place prior to the installation of the radiant barrier. Monitoring consisted of thermocouples in a variety of locations to obtain sheathing temperature, ambient temperature, mean-radiant temperature and insulation temperature.

### 3.1.6 Measured Savings

Measured savings were determined by establishing a relationship between solar radiation , outdoor temperature and attic temperature. Because of multiple changes to the building envelope (e.g. additional insulation in the attic, insulating a bare supply duct in attic), long-term tested results may be slightly skewed. The week before and after installation of the barrier data was not affected by other changes that occurred in the house.

Data acquired from the house indicates that a radiant barrier functions in a manner that reduces peak loads in both summer (late afternoon) and winter heating loads (early morning). Figure 13 shows that during two weeks (one week before retrofit, one week after) in February at night, the barrier retained the heat from the house and stored in the attic. Also in February, even though the brief daily peak was reduced by 6 degrees, the average nighttime attic temperature was increased by four degrees. Decreasing the temperature difference between the attic and house consequently reduced the heat loss from the house. Comparing the summer conditions of September 1999 with September 2000 (Figure 12), the average peak attic temperatures were reduced by eight degrees.

As the R-value of attic insulation increases, there is a diminishing return on the investment in the radiant barrier. Temperature simulations were run using actual data for summer and winter conditions. The heat flow calculations determined the net savings would be $29 per year as the only retrofit and $12 per year as the last retrofit. Decreased radiant barrier savings were due primarily to addition of R-19 batt insulation and also to the increased efficiency of the air conditioner.

After extensive investigation, it appears that the ORNL studies on radiant barriers are the most comprehensive, quantifiable effectiveness research available. The data available from the retrofit reinforces the ORNL research by showing similar savings, but not as large as some other studies or manufacturers have claimed.

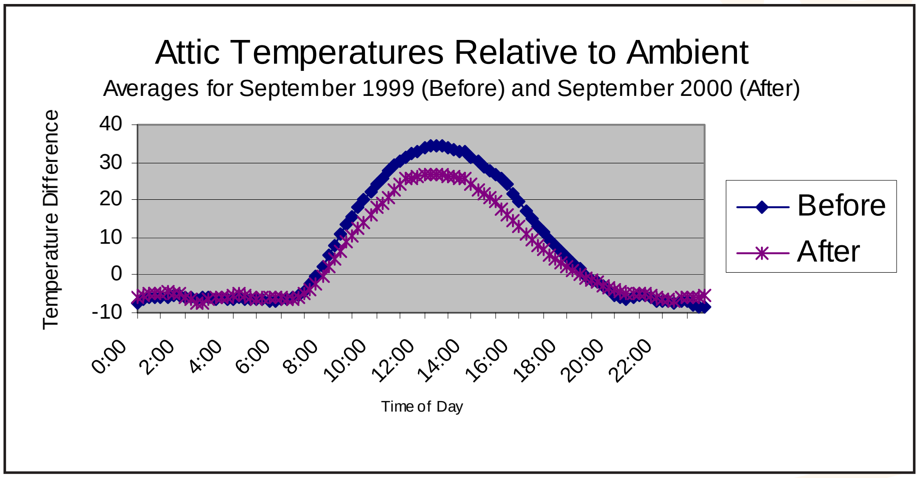


**Figure 12**
**Summer Differences with Radiant Barrier**

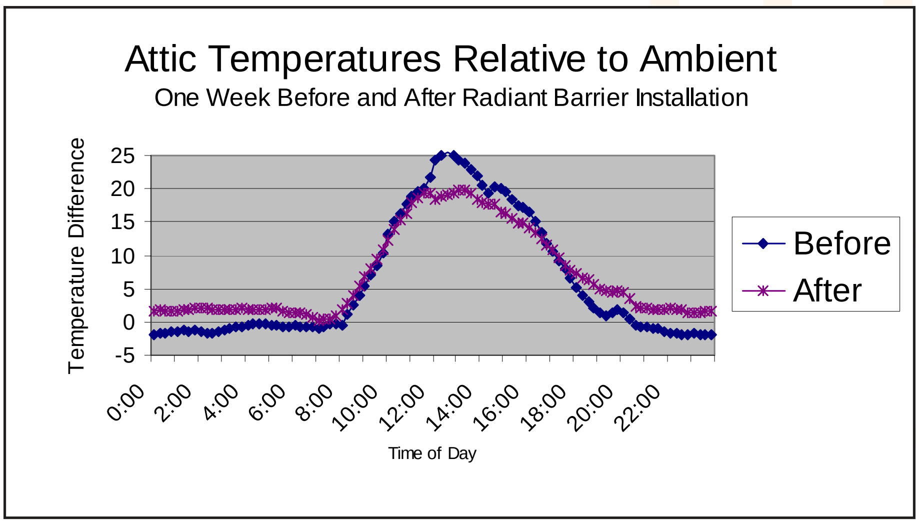


**Figure 13**
**Winter Differences with Radiant Barrier**

**Table 6**
**Radiant Barrier Savings**

| | Annual Radiant Barrier Savings* |
|---|---|
| Before with R-19 Attic | $29 |
| After with R-38 Attic | $12 |

* Using 2001 utility rates

### 3.1.7 Observations

The occupants of the house were not aware of the radiant barrier being installed in the attic, nor did they observe any obvious changes in comfort.

## 3.2 Programmable Thermostat

### 3.2.1 Description

Programmable thermostats can be set to adjust the temperature according to a user's schedule. For example, newer electronic thermostats for use in most HVAC systems have a digital interface that allows consistent temperature control and a wide range of options or features, such as:

- Daily programming that allows one schedule to be used each day,
- Weekday/Weekend (5/2) programming that allows adjustment of timing for setbacks with different settings for weekdays and weekends, or 5/1/1 programming that permits separate schedules for Saturday and Sunday, or
- Full seven-day programming that permits a different setback schedule for each day of the week.

During an average season in Las Vegas, a winter nighttime setback of 2°F can amount to savings of 5% in heating costs. Likewise, in the summer, a daytime setup of 5°F could save as much as 8% in cooling costs.

### 3.2.2 Energy Modeling

In our modeling, it was assumed that the house would be vacant during the Monday through Friday daytime hours in both summer and winter months. This was based on the previous habits of the tenants. Also, during the winter, a nighttime setback would be used.

**Table 7**
**Modeled Programmable Thermostat Settings**

| | 5-7 AM | 7AM – 4PM | 4-10PM | 10PM - 5AM |
|---|---|---|---|---|
| Winter Schedule (M-F) | 72 | 67 | 72 | 67 |
| Winter Schedule (S-S) | 72 | 72 | 72 | 67 |
| Summer Schedule (M-F) | 72 | 77 | 72 | 72 |
| Summer Schedule (S-S) | 72 | 72 | 72 | 72 |

### 3.2.3 Pre-Upgrade Evaluation

With an installed cost of $80 and a projected annual savings of $66 this proves to be a simple, low cost and extremely cost effective upgrade. With the programmable thermostat being the only energy upgrade, the following savings would be expected (See Table 8).

**Table 8**
**Modeled Programmable Thermostat Savings**

| | Annual Energy Savings** | Annual Savings* |
|---|---|---|
| Heating Savings | 61 therms | $36 |
| Cooling Savings | 246 kWh | $16 |
| Blower Savings | 194 kWh | $14 |
| Total Annual Savings | | $67 |

* Using 1999 Utility Rates
** First Retrofit Savings

### 3.2.4 Installation

The programmable thermostat was installed at the same time as the new HVAC system, in March 2000. The change out of the existing thermostat took about 15 minutes and consisted of hooking up four wires and mounting the new unit.

### 3.2.5 Monitoring

The monitoring consisted of the temperature sensor inside, a watt-hour meter on the HVAC system, and system runtime for gas usage.

### 3.2.6 Measured Savings

The programmable thermostat was only used to alter the temperature in the winter due to summer daytime occupancy. The setback is reflected in the average indoor temperature reduction of 2°F throughout the winter months. This equated to natural gas savings of 56 therms and associated blower savings of 142 kWh. Using 2001 utility prices, the annual savings amount to $67. While considerably less than the originally estimated savings, this still amounted to a 1.2 year payback.

### 3.2.7 Observations

The schedule of the tenants changed shortly after the initial evaluation, preventing them from using both the daily summer set-up and the daily winter setback. They were pleased with the thermostat, finding it easy to set and convenient to use. The night setback in the winter made it easier to sleep. Prior to the programmable thermostat, they would occasionally set the thermostat back, but they were happier with the consistency of the programmable thermostat. They also felt that there was no comfort sacrifice in using the setback function.

## 3.3 White LED Lighting

### 3.3.1 Description

Fluorescent lights have long been known as the energy-efficient form of lighting. LED (light emitting diode) lamps consume around one third of the electricity that fluorescent lighting does, and the lamps last about ten times as long. Until recently though, White LED lighting systems were difficult to manufacture. With sales rising and prices slowly decreasing, white LED lights could become a popular way to provide lighting in the home.

Each diode is about ¼” and consumes about ten milliamps (a tenth of a watt) of DC power. Lamps come in various arrangements of diodes on a circuit board. Standard arrays are 3, 6, 12, 18 or 36 diodes, or custom sizes. Factories can incorporate these into custom-built downlights, sconces and surface-mounted fixtures. With an inexpensive transformer, they run on standard 120-volt alternating current (AC), albeit with a slight (about 15% to 20%) power loss. They are also available as screw-in lamps to replace incandescent. A 3.6 watt white LED light cluster of 36 diodes is as bright as a 40-watt incandescent lamp (bright enough to read by).

The lighting quality is comparable to that of cool white compact fluorescent lamps, with color rendering indices near 85. LED lights don't flicker. The light is very directional in small arrays. LED strip lights can be installed under counters, in hallways, and in staircases. Concentrated arrays can be used for room lighting. Waterproof, outdoor fixtures are available, and they operate in temperatures from –20°C to 80°C (the efficacy of fluorescent lights drops dramatically below 0°C). Manufacturers consider applications such as gardens, walkways, and decorative fixtures outside garage doors to be the most cost-efficient, especially when combined with solar/battery systems.

### 3.3.2 Pre-Upgrade Evaluation

Based upon usage, only one good location for the LED light was apparent. This was on the entryway to the front door. It was a good candidate because of the many hours of operation, estimated by the tenants to be seven hours a day, that included frequent times when the light was left on overnight. Using a simple wattage calculation, the annual savings were determined to be 143 kWh equating to $9.59. The original bulb was 60 watts and was replaced by a 36 diode white LED light that consume 4 watts of power.

The cost of the LED light was $65.00 at the time of the initial evaluation. With similar usage, the simple payback using the initial LED price will be less than 8 years, satisfying our criteria for an upgrade. Shortly after we purchased the lights, however, the price for the light rose to $190.80.

**Figure 14**
**White LED Light**

### 3.3.3 Installation

The installation process could not be any simpler, it was a direct screw-in replacement of the existing bulb. Unfortunately, the entryway fixture was not ideal for the LED light. LED lights are directional and, even with a diffuser, most of the light is directed up, so it did not illuminate the entryway very well.

### 3.3.4 Monitoring

No direct monitoring was conducted on the entryway light. The previously assumed usage was used in energy calculations.

### 3.3.5 Measured Savings

The savings realized by the white LED light would be reflected in the reduction of the residual energy consumption. The energy was believed to be in line with the predicted amount, but the savings is accompanied by some sacrifice in light luminance. There was a lower lumen rating on the LED light (approximately 550 lumens) than the incandescent it replaced (860 lumens). In addition, the directional light emitted from the fixture was directed away from the desired area, making it a less than ideal application. With no direct monitoring, the calculated savings of 143 kWh was used. After adjusting for the increase in energy prices, this came to savings of $13.50.

### 3.3.6 Observation

The tenants were not pleased with the white LED light. They did not feel that it provided sufficient light in the entryway, and planned on replacing it after the monitoring was over. Because the original fixture was not well suited for the LED light, the perception of the occupants might not apply to other applications of the technology.

## 3.4 Super-Efficient Refrigerator

### 3.4.1 Description

Today's generation of high-efficiency refrigerators include more insulation, high-efficiency compressors, better door seals, and more accurate control of temperature. Depending on refrigerator volume and level of efficiency, they will use from about 450 kWh per year (for a 15 cubic foot top-freezer model) to about 850 kWh per year (for a 26.7 cubic foot side-by-side model). This compares with a typical 1973 model that used nearly three times the electrical energy of a typical current refrigerator. Furthermore, refrigerators certified by the EPA/DOE Energy Star® program must yield at least a 20 percent improvement over the Federal standard. Factors such as size, configuration (side-by-side or top-mounted freezer), and optional features influence the amount of energy that a refrigerator consumes.

### 3.4.2 Pre-Upgrade Evaluation

The modeled benefit of $35/year was weighed against the additional cost of the high efficiency refrigerator that was determined to be $100 by Whirlpool. This amounted to a simple payback of less than 3 years.

To determine the potential energy savings from the refrigerator, Energy Guide ™ ratings from the existing refrigerator were compared to the potential new unit. In addition, the reduced energy usage would result in decreased internal heat gains, thus reducing the A/C load in the summer, and slightly increasing the heating load in the winter.

There was also hope that the tenants would eliminate their need for a separate freezer due to the larger refrigerator. However, they did not feel the top freezer in their new refrigerator was large enough to consolidate all their frozen goods. Consequently, the 984 kWh/year consumed by the stand alone freezer would continue.

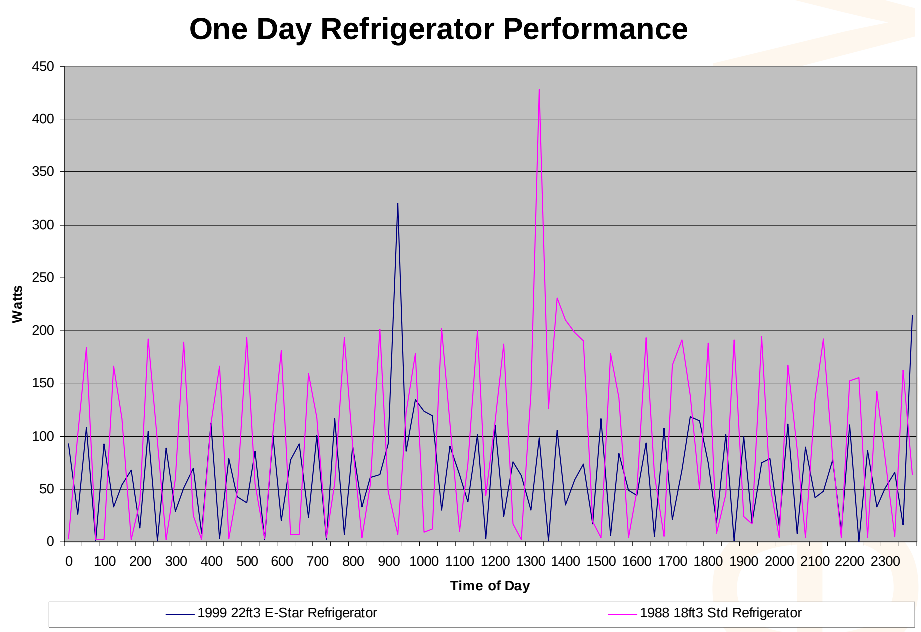


**Figure 15**
**One Day Refrigerator Performance**

### 3.4.3 Installation

There was a direct swap from the existing unit to the new unit. Although slightly larger than the original refrigerator, it still fit easily into its location.

### 3.4.4 Energy Monitoring

Direct energy monitoring was used to determine how much energy was saved. Figure 15 illustrates that the EnergyStar refrigerator consistently uses less energy than the original older and smaller refrigerator.

### 3.4.5 Measured Savings

Using September through December data for 1999 (before) and 2000 (after), and extrapolating out over a year, the before 18 cubic feet refrigerator would use 931 kWh/year. The replacement 21.6 cubic feet (20% larger) EnergyStar refrigerator used 574 kWh. This results in direct savings of 368 kWh. In addition, 81 fewer kWh of air conditioning energy would be required, due to reduced internal heat gains. The heating load in the winter months would be increased by 6 therms. The net annual savings for the refrigerator become $36.50, making the simple payback 2.7 years.

### 3.4.6 Observation

The tenant noticed some functional differences related to the allocation of space inside the unit, but the performance of the refrigerator was comparable to or better than the previous unit.

## 3.5 Vertical Axis Energy Saving Clothes Washer

### 3.5.1 Description

In the past, a resource efficient clothes washing machine was only available in a front loading (horizontal axis) version. The front loading washer can cost twice as much as a typical top-loading washer. Top-loading energy-saving washers generally use much less water, due to a rinse cycle that sprays the rinse water rather than having a deep fill soak. They also conserve hot water by using temperature-regulated warm (not hot) water during the wash cycle.

Top-loading, energy-saving washers use two innovative methods to reduce the resources required for a load of laundry. To reduce water consumption, there is a spray rinse cycle that consists of repeated high-pressure rinses to remove soap residues, rather than a soaking cycle with a full tub of rinse water. These spray rinse models average around 25 gallons per wash compared to 40 gallons per wash for traditional soaking models.

To reduce energy consumption, sensor technology is used to closely control the incoming water temperature. Incoming wash water is monitored and adjusted to maintain an optimal temperature. Optimum temperatures are determined for water to be hot enough to dissolve the detergent and provide high performance cleaning, but low enough to save energy and minimize any hot water damage to fabrics. A 100° F setting is used for color-safe loads, and loads for sensitive fabrics are controlled to 75° F. The end result is fewer gallons of hot water and reduced water heating energy use.

### 3.5.2 Pre-Upgrade Evaluation

The choice to include the Resource Saver washer in the retrofit was done prior to a full evaluation of the loads per week done by the occupants and the gallons of hot water used per load. The initial assumption was that 7.5 loads per week were being done, and 3.6 gallons of water would be saved per load. With this data, the estimated water heating savings was calculated at $25/year.

Note: For the purposes of this energy retrofit study, we have only considered energy savings, not water or sewer savings. This is not meant to suggest that conservation of water is unimportant, but only that this report focuses on energy.

### 3.5.3 Installation

The process of installing the Resource Saver washing machine was identical to that of most other clothes washers.

### 3.5.4 Monitoring

The Enetics datalogger was able to determine the number of uses per week of the clothes washing machine (5.2 loads/week). Only whole house hot water usage was directly measured. However, hot water consumption coincident with washer use can be segregated to determine washer hot water usage. From this, the total gallons of hot water over a given period of time were calculated.

### 3.5.5 Measured Savings

When analyzing the data, the amount of hot water consumed by the household actually increased by over four gallons per day. Although small, the increase is contrary to the two-plus gallons per day decrease that was initially expected.

When isolating the hot water usage used by the washing machine, it was estimated that an average load saved only 1.5 gallons of hot water, 58% less than was originally estimated. This in turn reduced the calculated savings from $25 to $12. This is partially validated by the observation that the tenants have historically washed a majority of their clothes in warm or cold water, thus reducing the potential savings. The reduced hot water usage also slightly reduced the air conditioning load.

### 3.5.6 Observation

Initially there were some minor cleaning problems (soap residue) with the washer. The manufacturer suggested decreasing the amount of soap. The tenant chose to dissolve the soap in the water prior to adding the clothes. According to the tenant, this solved the problem.

## 3.6 High Efficiency Air Conditioner Without CFCs

### 3.6.1 Description

As ozone-depleting chlorofluorocarbon (CFC) refrigerants are phased-out (no air conditioning systems manufactured after 2010 can contain any refrigerants containing CFCs), manufacturers are charged with developing air conditioners that do not use CFCs. One residential product currently on the market employs a refrigerant called R-410a. Unlike CFC based refrigerants, R-410a is not an ozone depleting substance and, therefore, does not pose a risk to the ozone layer. Non-CFC air conditioners are available in the same range of efficiencies as traditional CFC refrigerants (R-22) up to about 18 SEER (Seasonal Energy Efficiency Ratio).

### 3.6.2 Energy Modeling

Energy-10 modeling software was used to calculate the energy savings for the replacement HVAC system, and “Right-J” was used to size the HVAC unit. From the “before” calculations using Right-J, it appeared that the 3 ton (36,000 Btuh) A/C unit was properly sized with a total equipment load at the ASHRAE 1% design point of 32,239 Btuh. After the retrofit, Right-J determined the design load to be 24,057 Btuh. The only changes incorporated into the simulation included the attic insulation, replacement windows and infiltration reduction. Other changes that could affect the internal loads were not addressed in a straightforward manner in Right-J, and therefore were not considered in the calculation.

The Right-J simulation showed that after the retrofit, a 2½-ton unit would be adequate, and even a 2-ton unit would be marginal at an outdoor design temperature of 106° F (1% ASHRAE design point in Las Vegas).

From the simulated savings standpoint, the majority of modifications proposed would have some impact on the HVAC load. The only true exception to that would be the LED light installed outside. Also, the washer and dryer should have very little impact on the heating and cooling load.

When considering a replacement of an HVAC system, there are a wide variety of options related to configuration, proper sizing and efficiency. For this project, installed cost and overall efficiency were the main drivers.

**Figure 16**
**New 12 SEER Puron HVAC System**

### 3.6.3 Pre-Upgrade Evaluation

A number of solutions were available to change out the existing packaged, roof mounted HVAC system, ranging from a standard efficiency (10 SEER) packaged unit to a very high efficiency (18 SEER) split system. A SEER of 12 was necessary to meet EnergyStar standards. In the spring of 2000, the maximum efficiency available in a packaged R-410a unit was 12 SEER.

The existing unit had an air conditioning SEER of 9.5 and a heating AFUE rating of 75%. Although slightly below today's minimum standards, this was among the highest efficiencies available back in 1986. The unit was working fine until March of 2000 when the blower motor failed.

The calculated savings for upgrading the HVAC system was $205, this was assuming that the existing unit was performing at rated efficiencies. There was a $212 cost savings in the equipment as a result of downsizing the equipment from the original 3-ton unit down to a 2½-ton unit. This savings was credited as a reduction in the energy efficiency upgrade cost. The reason for this is that the reduced load is a direct result of the improved thermal envelope (e.g. more insulation, low-E windows, radiant barrier etc.).

The evaluation for the HVAC systems was the most complicated of the prospective upgrades. This is because nearly all of the other modifications are affected by the change in efficiency of the heating and cooling systems.

### 3.6.4 Installation

The installers had very few problems retrofitting the new 2½ ton CFC-free packaged HVAC system. The only special consideration required was the transition piece between the old duct and the new system. Because this was a pre-charged packaged system with no need to add any refrigerant to the loop, the installation was no different than a standard retrofit of a 14 year-old roof mounted system. Had refrigerant charging been required, the only additional materials would be Puron (R-410a) and a pressure gauge capable of handling higher operating pressures required by the Puron (400 psig vs. 210 psig which is standard).

### 3.6.5 Monitoring

A watt-hour meter directly measured the energy consumed by the HVAC system. Also from the watt-hour meter measurement, a winter blower runtime was measured. The runtime can be multiplied by a furnace calibration factor to determine the amount of natural gas used by the furnace.

### 3.6.6 Measured Savings

It becomes difficult to make a definitive comparison when multiple modifications are made and monitoring is done under different weather conditions. To minimize these differences it is necessary to model the results. When monitoring and modeling are used together, actual monitored results can be used to calibrate the model under actual weather conditions.

Actual savings of 2,865 kWh and 22 therms were associated with the improved efficiency of the HVAC system. This amounted to $290, making the simple payback of the high efficiency unit 2.6 years.

#### 3.6.7 Occupancy

The tenants felt that the supply air in the summer came out a "little cooler" than before. No other differences were noted related to the performance of the HVAC system. This was a good indicator that the system was properly sized.

## 4.0 Conventional Technologies

Conventional energy retrofit technologies are well proven, but they are necessary for a comprehensive energy retrofit. A variety of standard technologies were chosen for the Henderson energy retrofit:

### 4.1 Additional Attic Insulation

Attic insulation is probably the most often thought of modification when considering household energy conservation. Most single-family residential houses have easy access to the attic making the addition of attic insulation a practical energy retrofit measure.

The subject house initially had R-19 blown-in cellulose insulation. An insulation level of R-19 was the standard for attic insulation in southern Nevada in the mid-80's. Since then, the Model Energy Code (1993) had been adopted, and required a minimum R-value of 26 for new construction. For the retrofit, an additional R-19 fiberglass batt was added to the attic, coupled with the radiant barrier installed four months earlier.

Modeling indicated that 25 therms of natural gas and 485 kWh of electricity would be saved, amounting to $69/year in utility savings. With a $450 installed cost, the payback is 6.5 years.

### 4.2 Insulating Bare Duct in Attic

The most obvious energy related deficiency found during the initial audit was a 25-foot long 7-inch diameter bare metal supply duct located in the attic that supplied air to the converted living space in the garage. During the inspection, supply air was measured at the supply register as being 92°F. This was with the outdoor temperature at 106°F and an attic temperature over 130°F, indicating that the very hot attic air heated supply air in the bare duct.

Energy losses were modeled to be 197 kWh of cooling and 28 therms of heating, resulting in savings of $45 and a simple payback of 1.7 years. Since the duct was elevated from the attic floor, the R-19 batt insulation added to the attic floor did not help. Adding insulation required wrapping and taping the duct directly with R-11 insulation.

### 4.3 Compact Fluorescent Lights

The criteria for deciding which light to replace was the average daily usage, compatibility with the fixture (both physically and aesthetically), and absence of a dimmer switch connected to the light (standard CFLs are not compatible with dimmer switches). Two hours of operation per day, or more, was determined to be sufficient to provide a reasonable payback. Eight lights fit this criteria.

**Table 9**
**Fixtures Selected for Compact Fluorescent Lights**

| Room | #Lights | Incandescent Watts/Light | CFL Watts/Light | Hours/Day* |
|---|---|---|---|---|
| Utility | 1 | 60 | 13 | 8 |
| MBR | 1 | 60 | 22 | 2 |
| Hall | 1 | 60 | 15 | 3 |
| LR Lamp | 2 | 75 | 22 | 3 |
| Foyer | 3 | 60 | 15 | 2 |

The direct savings related to the energy required to operate the lights was 1,175 watt-hours per day. In addition, the reduced energy usage reduced internal gains to the house that in turn reduced the cooling load and increased the heating load. Calculated annual savings was 569 kWh electric (including A/C savings), and due to reduced internal gains, the winter heating load was increased by 10 therms, amounting to a net savings of $40 versus a cost of $56 (1.4 year payback).

The occupants were not completely satisfied with the performance of the CFLs. They felt that less light was being emitted from the CFLs than the equivalent rated incandescent light.

## 4.4 Air Infiltration Sealing

Air infiltration testing was performed for the energy audit. The blower door test indicated a natural air infiltration rate of 0.44 air changes per hour ($ACH_{nat}$). Although better than average for the area, there was still room for improvement.

Initial predictions were that new windows would reduce the infiltration rate by 15% and air sealing around cracks and other penetrations would also reduce the infiltration rate by 15%. The actual reduced air infiltration rate as a result of replacement windows, was 17% bringing the $ACH_{nat}$ to 0.36. This savings was credited to the replacement windows rather than the air infiltration sealing.

**Figure 17**
**Installation of Weatherstripping between the Garage and Conditioned Utility Area**

The air infiltration sealing was done with the assistance of a blower door, which depressurized the house to exaggerate leakage and make the leaks more identifiable. The major infiltration points included, around exterior doors, partition walls added in the garage, and around outlets and the attic hatch. Gasketing, weather-stripping and expanding foam sealant was applied to the identified points, reducing the infiltration to 0.28 $ACH_{nat}$. Modeling indicated gas reduction of 14 therms and electric reduction of 42 kWh, totaling $23 in annual savings at a cost of $150 resulting in a 6.5 year payback.

## 4.5 Low-E Vinyl Replacement Windows

The original windows were double glazed with an aluminum frame. The estimated U value for these windows was 0.85 BTU/hr/°F/ft$^2$. The 14 year-old windows were installed when the house was built and were still within their useful life.

Windows are generally not replaced for energy efficiency reasons alone. Reasons, such as comfort, functionality, appearance, maintenance and house value will usually be the primary drivers in the decision to replace windows. However, when replacing windows, energy efficiency should be strongly considered. For the purposes of the retrofit study, it was assumed that the decision to replace the windows had already been made, so the remaining life of the existing windows was disregarded.

The new windows all had low-e coating, a U value of 0.35, and a solar heat gain coefficient of 0.36. Replacement windows (eight sliders and one sliding glass door) were the single most expensive retrofit done on the project. Cost of windows amounted to $4,908, of which $450 was charged to the energy efficient component, reflecting up-charges for low-e coating and vinyl frames. The calibrated saving for both the reduced energy loss through construction and the reduced infiltration from the tighter windows amounted to 36 therms and 716 kWh. This totals $101.50/year, making the payback 4.4 years.

### 4.6 Humidity Sensor Gas Clothes Dryer

The existing electric clothes dryer, even though still working, was past its prime (circa 1987) and a candidate for replacement. Because a natural gas connection already existed, a natural gas model with a humidity sensor was selected. The humidity sensor was believed to save energy due to the elimination of over drying clothes.

The tenant liked the gas model, in that it dried clothes more quickly. But the tenant did not find the humidity sensor feature convenient, and believed it took longer to dry using the feature (the manufacturer does not believe that this is possible). Without using the sensor feature, the only savings realized would be the reduced cost per BTU by switching from electric to natural gas using prevailing local utility rates. Since the idea was to evaluate the humidity sensor, and the sensor feature was not used, the dryer energy consumption was not used for this report.

## 5.0 Summary of Results

The calibrated energy modeling predicted after installation of all twelve energy saving modifications, an overall energy cost savings of 30% (31% electricity, 27% gas), would result. The normalized results indicated a combined gas and electric dollar savings of $600.

Between 1999 and 2001, many residents of the West saw a dramatic increase in cost of electricity and natural gas. Nevada Power, which serves Henderson, Nevada, increased the price of electricity from 6.7 cents per kilowatt-hour in 1999 to 9.4 cents per kilowatt-hour in April 2001. Natural gas from Southwest Gas cost $0.59 per therm in 1999 and $0.95 per therm in June 2001.

**Table 10**
**Predicted vs. Actual Cost and Savings**

| | Total Retrofit Cost | Cost of Energy Efficient Component $ | Electric Savings | Gas Savings | Annual Utility Savings* | Simple Payback** |
|---|---|---|---|---|---|---|
| Predicted | $10,560 | $ 2,894 | 39% | 28% | $530 | 5.5 years |
| Actual | $11,398 | $ 2,805 | 31% | 27% | $600 | 4.7 years |

* Annual Utility Savings for Predicted use 1999 energy costs, Actual uses 2001 energy costs.
** Simple payback relates the additional cost for energy efficiency to the annual utility savings.

**Table 11**
**Energy Retrofit Measure Savings and Cost**

| Energy Retrofit Measure | kWh Saved | Therms Saved | $ Saved | Installed Cost | Energy Efficiency Cost | Simple Payback (years) |
|---|---|---|---|---|---|---|
| **Programmable Thermostat** | 142 - 81 | 56 - 32 | $ 67 - 38 | $ 80 | $ 80 | 1.2 - 2.1 |
| Compact Fluorescent Lights | 569 - 455 | (10) - (8) | $ 40 - 35 | $ 60 | $ 54 | 1.4 - 1.5 |
| Duct Insulation | 247 - 179 | 28 - 24 | $ 50 - 40 | $ 75 | $ 75 | 1.5 - 1.9 |
| **CFC Free HVAC** | 2865 - 2258 | 22 - 9 | $290 - 221 | $ 3,675 | $ 745 | 2.6 - 3.4 |
| **Efficient Refrigerator** | 449 - 436 | (6) - (5) | $ 37 - 36 | $ 900 | $ 100 | 2.7 - 2.8 |
| Low-e Replacement Windows | 716 - 619 | 36 - 30 | $105 - 97 | $ 4,908 | $ 450 | 4.3 - 4.6 |
| **White LED Light** | 143 - 143 | 0 - 0 | $ 13 - 13 | $ 65 | $ 63 | 4.8 - 4.8 |
| Attic Insulation | 485 - 313 | 25 - 16 | $ 69 - 45 | $ 450 | $ 450 | 6.5 - 0.10 |
| Infiltration Sealing | 20 - 17 | 22 - 20 | $ 23 - 21 | $ 150 | $ 150 | 6.5 - 7.1 |
| **Efficient Clothes Washer** | 20 - 16 | 11 - 11 | $ 12 - 12 | $ 600 | $ 200 | 16.7 - 16.7 |
| **Radiant Barrier System** | 214 - 81 | 9 - 4 | $ 29 - 12 | $ 650 | $ 650 | 22.4 - 54.2 |
| Gas Clothes Dryer | N/A | N/A | N/A | N/A | N/A | N/A |

PATH Technologies are in BOLD

Note: Columns with two entries represent the range of the benefit based on the order implemented. The first entry being the first modification, the second representing the last.

From Table 11, it can be seen that some technologies did not meet the original criteria of an eight-year payback. By eliminating the technologies with paybacks in excess of the eight year target, (radiant barrier, vertical axis washing machine), the retrofit package could have reduced the payback from 4.7 years to 3.6 years, and the energy efficient upgrade cost to $2,269.

## 6.0 Conclusions

This energy retrofit project is a successful example of a retrofit that realizes significant savings without having to sacrifice comfort or lifestyle. Energy retrofit measures need to be utilized properly to realize the full energy savings potential and education may be necessary to make it happen. Additional electronic equipment such as computers and larger televisions are part of a trend in American households that tends to increase consumption, making it even more important to pursue energy retrofits in existing homes.

A well thought out energy retrofit can produce dramatic savings. The PATH target of 30% energy savings is achievable, but does require major overhauling of the energy systems in a house. Houses of earlier vintages (containing less efficient appliances, HVAC equipment and insufficient insulation levels) will tend to reach the 30% threshold more easily in a comprehensive energy retrofit.

Simple, low-cost, energy saving measures can be installed to make a difference in most homes. The programmable thermostat and compact fluorescent lights alone could save as much as $9/month. Just choosing this “low fruit” will not get a 30% savings, but combined with attrition of appliances and mechanical systems, an older home can cost effectively reduce its energy consumption.

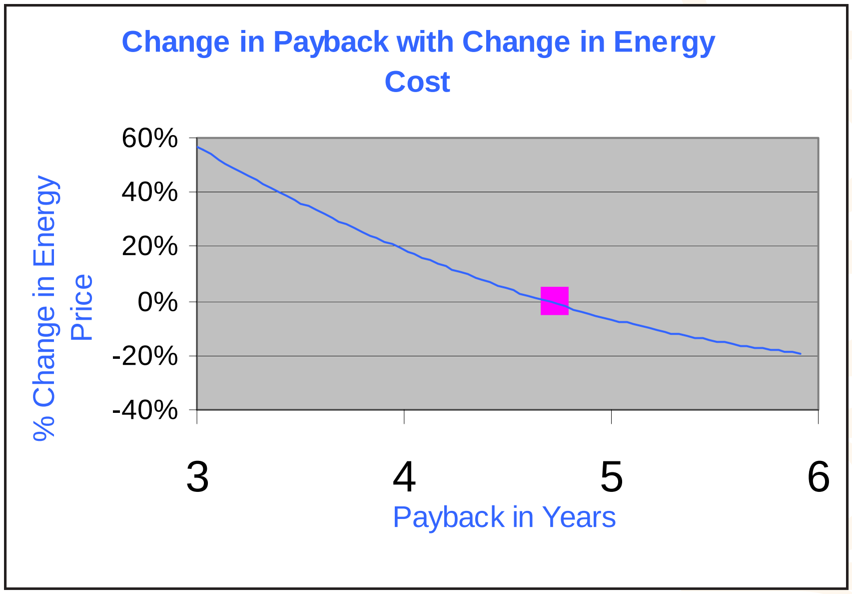


**Figure 18**
**Energy Prices vs. Payback**

As electricity and natural gas prices increase, so does the cost effectiveness of energy retrofits. Just during this energy retrofit project, the price of electricity increased 40% and natural gas 61%. Granted, this may not be a typical scenario, but with deregulation and instability in oil prices, reducing energy consumption through technology can reduce the impact of these uncertainties. Figure 18 shows how the price of energy can affect the payback of an energy retrofit.

Education of end-users on the cost effectiveness of energy retrofit measures and the proper operation of installed measures incorporated into a home will help facilitate the reduction in energy consumption. This is a necessary first step in accomplishing the PATH vision of a 30% reduction in energy consumption in existing homes.

Some states and the federal government have either enacted or introduced bills to provide tax incentives for the purchase of energy efficient appliances and other energy related equipment such as photovoltaic and solar hot water systems. These incentives can go a long way in getting the consumer's attention and justifying the costs of energy retrofits.

## 7.0 Information Sources

### 7.1 Energy Modeling Software

Energy Efficiency and Renewable Energy Network (EREN)
http://www.eren.doe.gov/buildings/tools_directory/

Energy-10
Sustainable Buildings Industry Council
Suite 1000
1331 H Street, NW
Washington, D.C. 20004
(202) 628-7400 ext 210
facsimile (202) 393-5043
http://www.sbicouncil.org/

Right Suite
Wrightsoft Corporation
394 Lowell Street
Lexington, Massachusetts 02420
(781) 862-8719 sales: (800) 225-8697
facsimile (781) 861-2058
http://www.wrightsoft.com

Rem/Design
Architectural Energy Corporation
2540 Frontier Avenue, Suite 201
Boulder, Colorado 80301
(303) 444-4149
facsimile (303) 444-4304
http://www.archenergy.com

## 7.2 Radiant Barriers

Oak Ridge National Laboratories
P.O. Box 62
Oak Ridge, TN 37830
http://www.ornl.gov/ORNL/Energy_Eff/build_tech.htm

Innovative Insulation Inc.
6200 W. Pioneer Parkway
Arlington, TX 76013
800/825-0123
http://www.radiantbarrier.com

Reflective Insulation Manufacturers Association (R.I.M.A.)
4840 West 15th Street
Suite 1000
Lawrence, KS, 66049-3876
800/279-4123
http://www.rima.net

Solar Energy Corporation
129 Walters Avenue
Ewing, NJ 08638-1829
609/883-7700
http://www.solec.org

## 7.3 Programmable Thermostat

Honeywell
101 Columbia Road
Morristown, NJ 07962
973/455-2000
http://www.honeywell.com

White Rogers
9797 Reavis Road
St. Louis, MO 63123
314/577-1300
http://www.white-rodgers.com

## 7.4 White LED Lighting

Holly Solar Products
P.O. Box 864
1340 Industrial Ave.
Petaluma CA 94952
800-622-6716
http://www.hollysolar.com

LEDtronics
4009 Pacific Coast Highway
Torrance CA 90505
310-534-1505
http://www.ledtronics.com

## 7.5 High Efficiency Refrigerators

Association of Home Appliance Manufacturers (AHAM)
Suite 202
1111 19th Street NW
Washington, DC
202/872-5955
http://www.aham.org

California Energy Commission
(916) 654-4058
http://www.energy.ca.gov/efficiency/appliances/

Energy Efficiency and Renewable Energy Clearinghouse (EREC)
U.S. Department of Energy (DOE)
(800) DOE-EREC (363-3732)
http://www.eren.doe.gov/consumerinfo/energy_savers/

EPA ENERGY STAR® Appliance Program
Mailbox 6202 J
Washington, DC, 20460
888/STAR-YES
http://www.energystar.gov/products/refrigerators/index.html

## 7.6 Clothes Washers

EPA ENERGY STAR® Appliance Program
Mailbox 6202 J
Washington, DC, 20460
888/STAR-YES
http://www.energystar.gov/products/clotheswashers/

Whirlpool Corporation
200M 63
Benton Harbor, MI 49022
1-800-253-1301
http://www.whirlpool.com

## 7.7 CFC Free Air Conditioning Systems

Air Conditioning and Refrigeration Institute
4301 North Fairfax Drive
Suite 425
Arlington VA 22203
703-524-8800
http://www.ari.org

Energy Efficiency and Renewable Energy Network
United States Department of Energy
Philadelphia Regional Office
1880 John F. Kennedy Blvd. Suite 501 Philadelphia, PA 19103-7483
Phone: 800-DOE-EREC or (363-3732)
http://www.eren.doe.gov/consumerinfo

Sustainable Building Sourcebook
503-484-9353
http://www.greenbuilder.com/sourcebook

Carrier Corporation
Attn: Customer Relations
PO Box 4808
Syracuse, NY 13221
800-227-7437
http://www.carrier.com

# 8.0 References

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