

Case Study: Cenicerros Whole House Performance Retrofit

Bruce Cenicerros
Home Owner

The home

- Built: 1998
- 2 stories
- 2850 ft²
- Slab on grade
- 30% more efficient than Title 24 (SMUD Advantage Home)



The Problem

(How New Homes are Built)

- 3-6 standard floor plans per subdivision
- Mass-production techniques
- Contractors hired by low-bid, incentive is to do as many homes in a day and pass inspection
- Insulating contractors may insulate 2-3 homes in a single day!
- Plumbers and electricians may punch holes or move insulation without understanding impact on energy performance
- Energy and comfort performance suffers

Our Motivations

- Buying a house: 2,800 ft² tract home in Folsom, CA built in 1998
- Were aware of common home performance problems (uneven temperatures, moisture, poor IAQ, high energy costs)
- Wanted to identify extent of problems to inform purchase decision and allow financing of comfort improvements in mortgage

Flow hood
measures air
flow from
each register



Infrared camera spots
thermal bypasses
(Blue or black areas)



**Knee wall
was poorly
insulated
(gaps,
sagging)**



**Knee wall
was not
insulated**



What the Contractor Found

- Upstairs was 7° F hotter than downstairs in heating mode
- IR camera revealed poorly insulated knee-walls and numerous other thermal bypasses
- Duct leakage 7%
- Envelope leakage 1,900 cfm₅₀
- Insufficient airflow
- Well-sized but inefficient AC
- Over-sized and inefficient furnace
- Ventilation fans used too seldom due to noise
- Furnace fan very loud and draws 1,060 Watts
- 13 out of 37 low-e windows were installed backwards

Improvements

To Improve Comfort:

- Repair thermal bypasses
- Insulate knee-walls properly
- Insulate floor assembly between garage and upstairs bedroom
- Seal envelope to achieve minimum desired natural air changes (to 1200 cfm₅₀)
- Seal ducts to less than 3% leakage
- Install additional return in master bedroom
- Install balancing dampers and perform air balance

Improvements

To Improve Comfort:

- Reconfigure ducts to allow burying in insulation
- Install engineered and re-sized return grills to achieve better mixing and reduce noise
- Provide return air paths from bedrooms
- Install knee wall dams and re-insulate attic to R-38
- Right-size AC and furnace
- Perform test-out to confirm performance (including combustion appliance safety testing)

Improvements

To reduce energy costs further:

- Freus 17 EER evaporatively-cooled condensor
- 95% furnace with high efficiency variable speed fan
- NightBreeze night ventilation system
- Install fluorescent lighting throughout home
- In-home energy monitor

Performance Contract

- Guaranteed that performance targets will be hit:
 - Less than 3% duct leakage
 - Less than 1200 cfm envelope infiltration
 - Proper air flow to all rooms and across coil
 - Less than 3 degree temperature differential between all rooms and floors in the house
 - Quiet noise levels (NC 25-30)
 - At least a 56% reduction in heating and cooling costs
- Total Installed Cost including Lighting and controls:
\$21,400

Would Any Normal Family Pay \$21,000 for Better “Home Performance”?

Our reasons to want a healthy, comfortable house:



How much does a kitchen remodel cost?

Which is more important, a stylish kitchen or a comfortable and healthy indoor living environment?

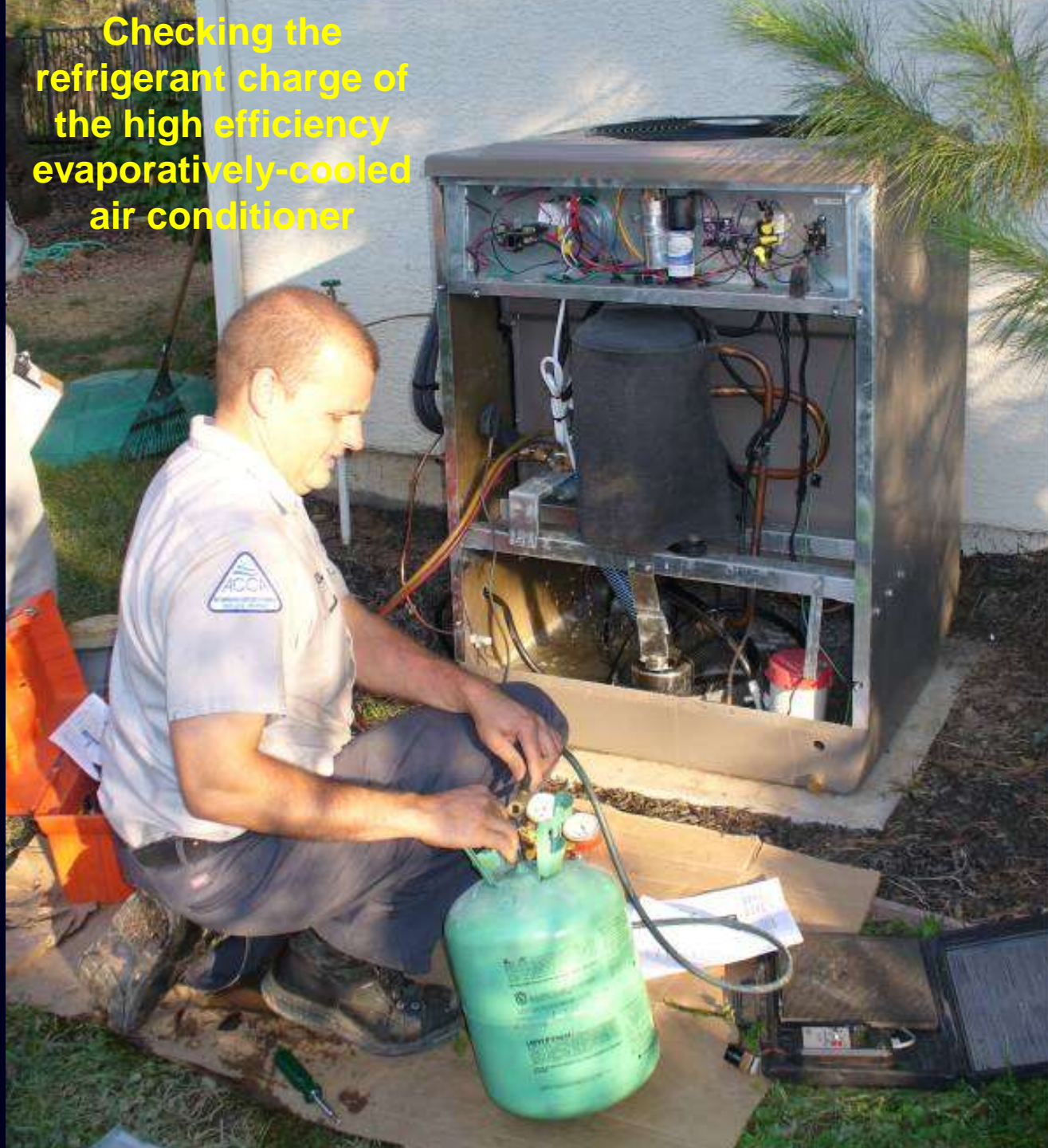
(and the kitchen remodel *doesn't pay for itself*)

Fixing the construction Flaws...



Installing a new
“right-sized”
evaporator coil
and furnace

**Checking the
refrigerant charge of
the high efficiency
evaporatively-cooled
air conditioner**




Re-insulating and
sealing the knee walls





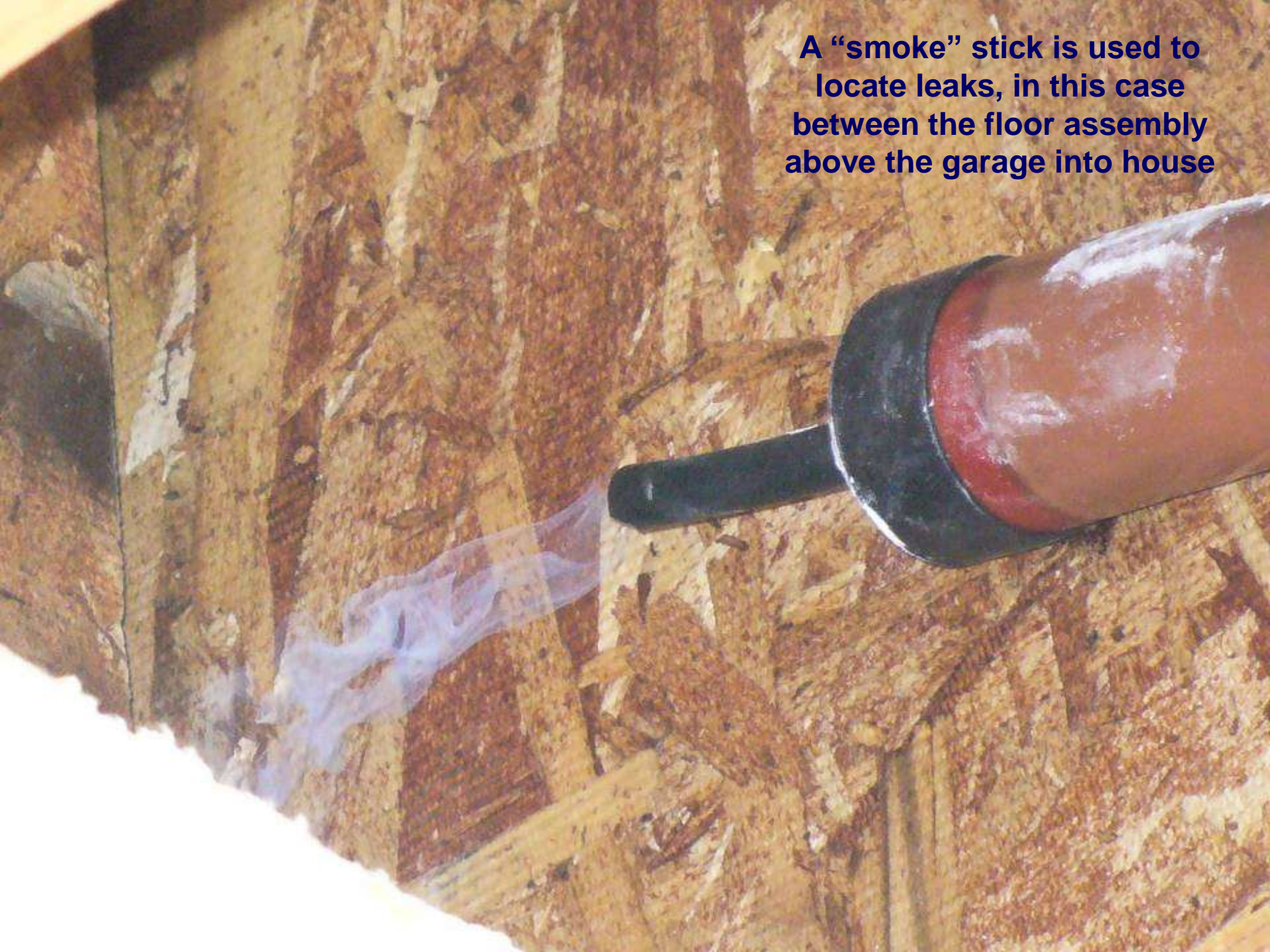
A sealed wall
top plate

The image shows a cross-section of a wall under construction. A horizontal wooden top plate is visible, with a red sealant applied along its length. The wall is filled with white insulation. A white wire runs horizontally across the insulation. The wooden frame of the wall is made of light-colored wood. The text 'A sealed wall top plate' is overlaid in yellow.

A close-up photograph showing a person's hand lifting a beige carpet. The carpet is being pulled back to reveal a wooden floor board underneath. There is a significant gap between the carpet and the wall on the left side. The wooden board has some red paint or staining on it. The overall scene suggests a renovation or inspection of a staircase area.

Large gaps were
present where stairs
abutted the walls

A “smoke” stick is used to locate leaks, in this case between the floor assembly above the garage into house





Engineered supply grilles resized for proper velocity and throw at design air flow

And we kept going...

In-home energy display



Control of “Vampire” Loads

- Smart Strips for computer peripherals & home theater components
- Dedicated charging station



Energy Star Appliances and fans

- Front loading washer and fridge among top ten most efficient models
- High Efficiency ceiling fans with temperature-based controls



CFLs in every fixture but the oven





**LED down lights in
home office (dimmable!)**

Lighting and fan Controls

- Timers
- Occupancy Sensors
- Temperature-based ceiling fan controls



Smart Kitchen Remodel

- Good lighting design
- LED down lights
- LED undercabinet lights
- Fluorescent cove lights
- Multi-switching
- High-efficiency right-sized exhaust fan
- Charging station
- Recycling, compost bins



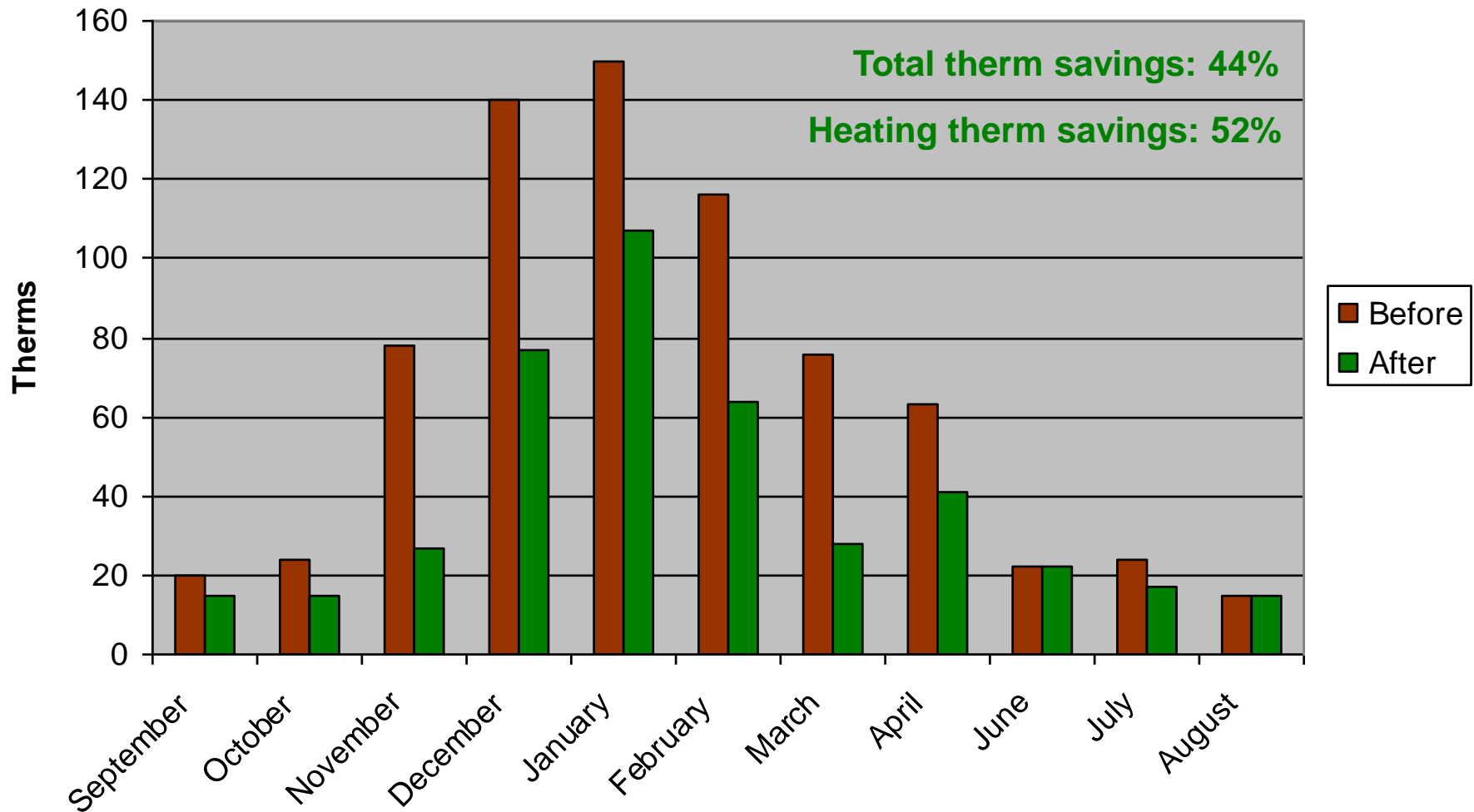
Behavior

- Close shutters on sunny side in summer
- Optimal use of setback thermostat
- Turn off when room is vacant
- Use ceiling fans
- Watch energy monitor, be aware of big loads, and act when unusual things happen

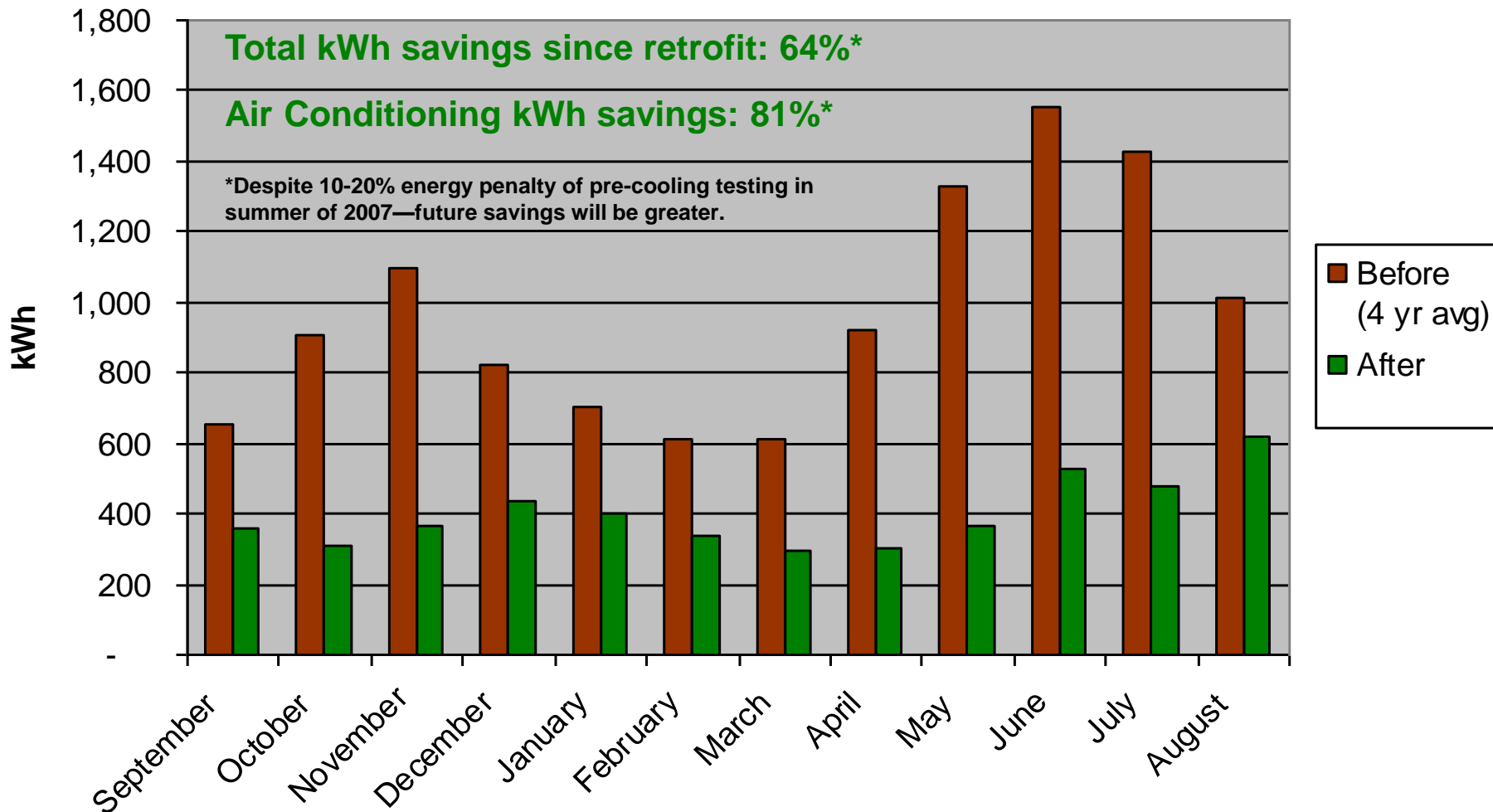


Results of Our Home Performance Retrofit

Natural Gas Savings



Electric Savings



The background of the image is a collage of US one hundred dollar bills, showing the portrait of Benjamin Franklin and the text 'ONE HUNDRED DOLLARS' and 'FEDERAL RESERVE NOTE'.

**Average Monthly Energy
Costs: \$85**

**Total Bill Savings:
52%**

\$1,400/year

The Confidence that our Home is
Comfortable and Healthy:
PRICELESS



- Two months after the retrofit was complete, Kira Sabrina was born via a planned home birth

Results of Home Performance Retrofit

Most importantly, achieved all comfort performance targets:

- Upstairs and downstairs are now the same temperature
- All rooms are comfortable
- No longer can feel or hear the HVAC system
- Musty smell in under-stair closet gone
- Peace of mind that indoor environment is healthy

Next, Heat pump water heater

- 85% of operating cost of a 94% efficient condensing gas WH
- Demand response capable
- Larger storage = more peak shifting capability and excess generation storage
- Zero carbon when powered by PV

Now, time for PV!

BRUCE S CENICEROS
Issue Date: 05/13/13

Total Amount
Bank Will Pay On 06/10/13

No Amount Due
\$12.00

Location:	464 WILLIAMS ST FOLSOM 95630	Usage History	Dates	Days	kWh/Day	\$/Day
Rate:	RSGH: Standard Residential Rate	Billing Period	04/11/13 - 05/09/13	29	7.3	\$0.41
Cycle:	06 Location Number: 1694394	Last Year	04/11/12 - 05/09/12	29	10.8	\$2.30
		Last Month	03/13/13 - 04/10/13	29	9.9	\$1.33

Meter No.	Current Meter Read	Previous Meter Read	Difference	Multiplier	Usage	Usage Type
2015074	14865.0000	14653.0000	212.0000	0	212	kWh from SMUD
2015074	363.0000	0.0000	363.0000	0	363	kWh to SMUD from PV
2066430	448.0000	0.0000	448.0000	0	448	Total PV Generation

ELECTRIC SERVICE CHARGES/CREDITS	USAGE	TYPE	RATE	TOTAL
KWh From SMUD Less kWh To SMUD Equals Billed Kwh Of	-151			
Base Usage	-151	Winter kWh @	0.091100	-13.76
New Cumulative Net Energy Charges/Credits (excluding payments)				13.76
System Infrastructure Fixed Charge*				12.00
A) TOTAL ELECTRIC SERVICE CHARGES/CREDITS				\$12.00
Cumulative Net Energy Charges/Credits (excluding payments)			\$-13.76	

ACCOUNT ACTIVITY SINCE LAST STATEMENT

Beginning balance from last Statement	69.08
Payment-EFT	-38.56
Payment-EFT	-30.52
B) PREVIOUS BALANCE	\$0.00
C) TOTAL DUE (A+B)	\$12.00

Now, time for PV!



What homeowner's want

- It all comes down to **value**
- Bill savings was least important motivator
- Priorities:
 - Healthy living environment
 - Comfort
 - Aesthetics (look, noise reduction)
 - Helping improve the environment

What homeowner's want

- Clean, trustworthy, prompt contractors who do what they say the will do.
- Simple choices, customized packages
- Minimize hassle factor

Saving energy can become addictive

- A utility can build deeper engagement over time and change a customer's values
- One small action leads to another, then another
- Timing is everything. Know key triggers, have resources in place, and engage customer at the right time.
- People care about what their peers do
- People are competitive by nature

Pathway to deeper engagement

Utility benefits:

- Deeper customer engagement
- High customer satisfaction
- Loyalty
- Customer retention
- Reduced infrastructure costs

