



Home Energy Efficiency Report



Property Address: [REDACTED]

City, State, ZIP: [REDACTED]

Date of Site Visit to Property: **August 20, 2009**

Site Visit and Report by: **Rick Meyer**, CHEERS® Certified Existing Home Analyst and
[REDACTED], Certified GreenPoint Rater

CHEERS® is a registered trademark and servicemark of California Home Energy Efficiency Rating Services, Inc. This report copyright © 2009 by Home Energy Saving Analysts. All rights reserved. Some photos and diagrams courtesy of The Energy Conservatory, Inc. – used with permission. Although every effort has been made to insure the accuracy of this report, estimated energy usage and financial savings projected in the report do not constitute a warranty, either expressed or implied, as to the energy efficiency or operating costs of the house that was analyzed. See our contract for details.

Introduction and Methodology

This report is based on questionnaire information, detailed measurements and an inspection of the property identified on the cover page by our analyst(s) during a site visit. The methods we use to conduct the energy survey are recommended by California Home Energy Efficiency Rating Services ([CHEERS®](#)), a public benefit, non-profit organization established in cooperation with the state and utility companies. CHEERS also are responsible for quality control over our work. Some of our methods are recommended by the California Building Performance Contractor's Association. Our work was performed under a contract that contains important warranties and limitations on liability that you may wish to refer to in connection with your review of this report.

Information that extends and explains elements of this report are available by following links to web pages. To learn more about the typical tests we perform and how to interpret test results that appear in this report, [Ctrl-click here \(www.energysavinganalysts.com/tests.html\)](#) if you are reading this report on your computer. If you're reading a paper version, you will have to type the web address into a web browser on a computer. If you do not have web access, you can call us to request a printed copy of these "appendices."

Background

The home is 2350 square feet, with three stories. It is occupied by two people with frequent family visitors. It is in a mild but often foggy microclimate only a few hundred yards from the ocean in the [REDACTED]. It was originally smaller, built around 1950, and heated with a Williams gravity fed wall furnace, which remains in service. A large addition was made around 1976, but there was no provision for central heating. However, a gas fireplace in the master bedroom suite and a wood burning stove on the first floor were added. The old wall furnace remains, but heats probably less than half the house and overall, heating is inadequate. Crystal's downstairs office, the kitchen, breezeway/den, and living room are all under heated. There is a conventional fireplace in the living room, which is used for atmosphere rather than heating, and the wood burning stove is not relied on regularly. There is no air conditioning and none is contemplated.

The owners plan to install a central 90+% AFUE central heating system on the first floor, with distribution limited to the first floor, removing the old wall furnace and retaining the gas fireplace in the master bedroom. The tentative plan is for the second and third stories to be heated with heat rising from the first floor through open stairwells as well as the gas fireplace. Windows are primarily double pane clear with wide spacing between the panes. No replacement windows are under consideration.

An objective of the audit was to insure that gas usage for heating does not rise precipitously once the home is effectively and centrally heated, so the audit placed special focus on insulation levels and infiltration/ventilation. Although a new system will be more efficient than the wall furnace, the wall furnace is small and does not keep the house warm, so energy usage could rise. The homeowner has not ordered energy modeling from us that could result in cost effectiveness calculations and heating sizing calculations but will consider it during the audit. No building plans are available.

A forced air system is under consideration, but other options may also be considered. There are several less than optimal locations for the central furnace or boiler, some requiring long duct or pipe runs. A boiler with baseboard or wall mounted hydronic radiators would solve the duct space problem, but placement of wall or

baseboard radiators might present aesthetic or practical problems. Since the current water heater is a low efficiency storage type, it might make sense to choose a combined hydronic heating/water heating boiler, thus avoiding some of the added cost of upgrading to a separate on-demand water heater when the old water heater fails.

The owners have a strong commitment to reduce energy consumption in their home and are willing to undertake a number of measures to achieve it. There are no plans to move and Christian suggested that 15 years is perhaps a good planning period for recapturing investments in efficiency. However, improvements may take place over two or more years for budgetary reason, so a tentative strategy and timeline for improvements is included that spreads out costs, while achieving some immediate improvement in comfort and durability.

Your Energy Usage

We analyzed the PG&E usage data you provided us with and our analysis appears at the end of this report. We estimated how much of your gas bill was spent on space heating, by determining the gas usage in the summer months when the furnace is usually off, and set this as a baseline usage associated with year-round water heating, cooking, clothes drying and similar loads. By deducting the baseline load from all months of usage we arrived at the estimated heating cost of about \$420.90 per year. We then calculated your home heating index, which estimates how efficient your home is, given its size and local climate conditions. Your home heating index is 4.7. Normally, a home with this index number would be efficient, but since the old wall furnace is incapable of heating the entire house, and the house is often uncomfortably cold, we cannot draw such a conclusion. For example, if you were only “half heating” the house, your index would jump to 9.4, indicating large opportunities for improvement. By conducting a similar analysis a year or two after your efficiency upgrades and new central heating system are in place, we could determine your index to gauge how well your improved house is performing.

Summary of Principal Recommended Improvements

- Order termite inspection, treatment and repairs
- Repair leaks and water damage
- Reduce envelope leakage by sealing
- Upgrade insulation in older walls and both attics
- Test for radioactive radon gas
- Conduct additional humidity tests, then reduce humidity
- Upgrade heating systems
- Service or replace water heater
- Perform other smaller improvements as time permits.

Recommended Improvements in Detail

We urge you to make all improvements that are likely to be cost effective. You will earn tax free savings on your energy bills, like owning a bond or certificate of deposit with a high interest rate, but tax free. A penny saved is actually better than a penny earned, when taxes are considered. You also will help our earth deal with global warming and our trend-setting state of California meet its aggressive energy efficiency goals. In effect, you'll be paid to "go green," especially when you consider that a major part of the cost of some improvements can often be recovered through federal and state tax credits and rebates. See our Resource Directory for resources to implement the recommendations and to find credits or rebates to help pay for them. Our firm receives no compensation connected with your making improvements – we sell nothing but our inspection and analysis services. We do make ourselves available to help you guide through the implementation phase, under a new contract, or you may choose a performance contractor to fulfill this role.

Recommended Improvements in Detail

Termite Inspection

We noted termite frass (excrement) across the bottom of the front wall to the office on the third story, and also on the outside of the north side mud sill to Crystal's office in the converted garage. We did not note subterranean termite tubes on those areas of the foundation wall that we inspected from the crawl space but recommend a more complete inspection by a licensed company.

The infestation appears to be well established, and is slowly destroying the home. Most damage is typically hidden, but required repairs can be extensive and expensive even when no damage is visible from the outside. We recommend an immediate inspection by a licensed termite inspection company. A termite inspection report will specify necessary repairs. You are not obligated to have the repairs done by the company that did the inspection. Please contact us to see if we can help make sure the repairs are done in an environmentally sensitive way and to see how their recommended repairs might impact plans to make the home more efficient. You may prefer to have a performance contractor perform necessary repairs, to coordinate those repairs with the efficiency projects. For example, we are also recommending the construction of access to the attic over the kitchen – if this is done first, then the termite inspector will be able to inspect that attic.

Repair water leaks and damage

You pointed out an area where water was damaging the ceiling, and we noted a corresponding area of possible water intrusion on the roof deck. It is important to stop the water leakage before the next rainy season because, like termites, water damages the interior of hidden building areas and can require expensive repairs. Insulation materials in walls can absorb water, greatly reducing its effectiveness. It is often is very hard to find all the wet areas without a thermographic inspection. A more thorough search for other areas of water intrusion, particularly in the areas where we plan to install more insulation is recommended.

Reduce Envelope Leakage

Our tests revealed that your home's envelope is quite "leaky". Your home's envelope consists of the exterior walls, floors and ceiling that hold air inside. Total envelope leakage was 4955 cubic feet per minute, measured at a pressure of 50 Pascals, which is much more than the minimum leakage needed for healthy ventilation of 113.89 CFM_{nat} which would read 2250 CFM₅₀ in our blower door test. In other words air you are paying to heat

is escaping at a higher rate than is needed to provide healthy ventilation, wasting money. If we added together all the leaks in your house, most of which are hidden, they would equal having a window open all the time, with an area equivalent to 7 sheets of copy paper (661 square inches). Our ventilation calculations, attached to the end of this report, will be useful to performance and HVAC contractors.

Many people assume that they should not seal up their house tightly because fresh air is healthy. It is true the fresh air dilutes any indoor air pollution, and is healthy, but above the minimum requirement, more fresh air is not better, as in many health matters. It is better to eliminate sources of indoor pollution rather than just rely on the hit or miss strategy of diluting them. Also, natural ventilation without mechanical assistance cannot be relied upon. On still warm days when the outdoor and indoor temperatures are both near 70 degrees, very little natural ventilation occurs without opening doors and windows. Conversely on cold, windy mornings there will be greatly excessive ventilation just when you are paying the most to heat the escaping air. For this reason the next version of the California Energy Code will require a fan for fresh air ventilation.

We recommend that you hire a home performance contractor to identify and eliminate sources of the leakage. While the tools and materials to do this job are low tech, the work is very specialized and tricky, and a contractor with the necessary skill and experience is essential. We recommend the work be done using a blower door to track the effectiveness of sealing work and determine when the target has been reached or when further sealing would not be cost effective.

As part of this work, the specialist may seal attic and floor areas with foam or caulk. We recommend that particular attention be paid to sealing the floors to prevent moisture intrusion from the wet crawl space. The specialist may install or adjust weather-stripping on all doors and hatches to unconditioned space, among other projects.

Many people assume that the worst leaks that need sealing are around doors and windows, but energy auditors have found they are more likely to be found in walls, unconditioned attics, electrical outlets, recessed lighting fixtures, holes where pipes or wires pass through walls, basements and hidden areas like baseboards.

Your goal may be to reduce leakage down towards the minimum ventilation guidelines of .35 air changes per hour (ACH). Since your home's volume is about 19,505 cubic feet, .35 ACH is about, or 113.8 CFM, which would bring a whole house full of fresh air in about once every three hours.

CAUTION

Air sealing must be done while insuring that there is no potential for backdrafting of gas burning "gravity" appliances that mix combustion gas with room air. Backdrafting occurs when toxic flue gas comes into the home rather than going up the flue. Since the water heater is almost completely outside the air barrier, and the Williams furnace will be replaced, we did not conduct a backdraft test. If you do the air sealing prior to removing the old furnace, you must conduct a backdraft test to make sure that the furnace will not backdraft. Also you should make sure that any sources of poor indoor air quality are addressed at the same time as sealing work.

The current measured leakage rate of 4955 CFM at the pressure of 50 pascals, is approximately equal to 252.8 CFM of natural airflow when dividing the by the correction factor of 19.6. The correction factor is from a table developed from research at Lawrence Berkeley National Laboratory. This means that the rate of natural

ventilation is more than twice the target rate. The minimum rate of 113.78 CFM, which equates to 22230 CFM₅₀ on a blower door test, may or may not be cost effective given the location and number of leaks.

Rather than relying on leakage, a more efficient but more expensive goal is to make the house nearly airtight and use a small efficient continuous fan or central system to distribute fresh air to every room. The next version of the California Energy Code will require the use of this method. Fresh air from leaks may go to the wrong places in the house and may be drawn from sources of polluted air. Leakage is usually either much higher or much lower than optimal. A well sealed house has no drafts and retards entry of noise and pollutants as well as using less energy.

After you have sealed leaks, we can return, if you like, to retest and confirm the effectiveness of sealing work.

Upgrade Insulation

Insulation in walls, ceilings and floors is material that retards the escape of costly indoor warmth or coolness to the outdoors. Fiberglass batts are the most popular insulation, but some homes have cellulose, foam, or other types of insulation. From an efficiency and environmental standpoint, adding insulation prevents the burning of fossil fuels. It is usually quite cost effective to add insulation in accessible areas. Unlike a furnace, insulation almost always lasts as long as the building it is in.

We checked the walls of the house for insulation by probing behind electrical outlets and looking for signs that insulation had been blown in following construction. It appears that the old portion of the house, including Crystal's office, has no insulation. This should be confirmed by an insulation or performance contractor. Empty walls are typical of construction in the 1950s in our area. We recommend that high density cellulose insulation be blown into all empty walls by an insulation contractor. We recommend high density cellulose because it does the best job of sealing air leaks in the walls as well as insulating. Cellulose easily absorbs water, however, so the areas where it will be blown in should be carefully inspected for signs of moisture intrusion and any leaks fixed and wet areas repaired prior to the insulation work.

There is an attic area above the old portion of the house that is accessible from a hatch in the ceiling in front of the old wall furnace. We noted some dislodged insulation and recommend that the insulation in this attic be repaired and upgraded to R38. The insulation contractor must make sure that the attic will still be well ventilated after the insulation job. This may involve adding baffles near roof vents in the eaves/soffits prior to "blowing" the insulation to prevent vents from being blocked by the added insulation. Any old knob and tube wiring must be replaced or worked around.

There is another attic area over the kitchen, with no access. It is likely that this area is insulated because we found fiberglass in the walls of the same new addition, and R19 ceiling insulation was typically installed in new construction starting around 1975. We recommend installing access into this area, to facilitate termite, roof and insulation inspections, and to provide access for repairs to electrical or plumbing runs in the area. If you eventually find that you want to install an exhaust hood over the range, access to this attic area would be needed. If this attic hatch is installed first, then termite inspector can inspect there and the insulation contractor would have the opportunity to increase the insulation level in the attic to R38, if it is not already at this level.

The insulation or performance contractor should insulate the hatches to the attic and crawl space areas with foam board and seal them with weather-stripping or other gasket material.

Test for Radon

Of 262 tests for radioactive radon gas in Aptos homes, 9 have tested higher than the EPA guidelines, a ratio over 3%. Testing is fairly inexpensive and you can organize it yourself. Learn more about radon and testing companies at <http://epa.gov/radon/>. An inexpensive test kit is available from www.drhomeair.com. We suggest you test because of the incidence in our area and because your home will very likely to need a ground moisture retardant barrier and if you have a radon problem, the construction of the barrier would be different.

Reduce Humidity

To prepare for our humidity measurement you closed all doors and windows at 4 AM the day of the test, which was at 10 AM, and refrained from activities that would have increased humidity. It had been a night of heavy dew and water was still on the ground. We measured 76% relative humidity indoors at 65 degrees, and 73% humidity outdoors at 63%. Compensating for the temperature difference with a psychrometry chart, we find the indoor air had 70 grains/lb. of moisture compared with 64 grains/lb. outside or almost 10% more. Since indoor sources of moisture were eliminated for our test, much of the extra moisture almost certainly came from the crawl space. The high level of dew may have impacted our measurements, and we recommend that additional humidity testing be done, to include the crawl space. Measurements made on a warm afternoon might be more conclusive.

We found the soil damp in both crawl spaces, and you reported that a sump pump runs intermittently to drain the area, even during the summer. The foundation wall appeared to have no large cracks and no efflorescence. The foundation under the original portion of the house showed a considerable amount of voids, but no cracks. Clearances from the soil to the bottom of joists or beams ranged from about 14 to 16". There is no floor insulation. We saw no subterranean termite tubes on the inner foundation walls but recommend a more thorough termite inspection.

The sump pump is not keeping the soil dry enough, although it may be somewhat effective. We did not have time to examine it during our inspection. We recommend checking for proper operation and then testing effectiveness by testing soil moisture at different distances from the pump. It may be that ground water is uniformly high in your neighborhood and that, depending on the geology, you are, in effect, attempting to drain the entire neighborhood.

You reported prior humidity problems indoors, and these were partially addressed by laying down thin unreinforced polyethylene sheet. However, inspection of both crawl spaces showed that the sheet only partially covers the soil and it is not sealed anywhere to the foundation wall. We noted an area of mold growth on a pier block in the crawl space, indicating the moisture is beginning to degrade building materials. We recommend a more thorough examination of the crawl space to examine the condition of wood there by a performance contractor or the contractor chosen to install a moisture retardant barrier.

Relative humidity above 50%-60% is considered unhealthy as it encourages the growth of viruses, bacteria, dust mites and other organic threats, and can worsen any respiratory problems. Your humidity was considerably higher. Humidity will fluctuate of course. It will of course be drier on days with less fog or dew and even higher during the rainy season. The humidity is likely to be even higher in the crawl space, where the moisture appears to be starting to lead to the deterioration of wood. If you installed air ducts for a forced air system in the crawl space, moisture could possibly deteriorate them.

If you follow our recommendation to better seal the envelope, and it is not practical to fully seal the floor, the moisture coming from the crawl space could increase the humidity indoors, and a better moisture barrier can help prevent this.

For these reasons we recommend, after confirmation through further humidity testing, the application of a better moisture retardant barrier on the ground in both crawl spaces, from 6 mil or thicker reinforced polyethylene. The edges should be sealed to the foundation wall and pier blocks with mastic or construction adhesive. Prior to installing the barrier, we recommend removing cellulose debris on the ground that can attract termites and any sharp objects that could puncture the barrier. Some building officials require that several inches of concrete remain exposed on the foundation and piers to facilitate inspection for subterranean termite tubes and that is our recommendation. We recommend monitoring the humidity in the home for a while after the vapor retardant barrier has been applied and the envelope has been sealed.

We inspected the outside areas adjoining your foundation and found little or no slope in many areas. We recommend regrading these areas wherever practical to have a 5 degree slope away from the foundation for several feet, so that rainwater is carried away from the foundation. This will reduce the wetness in the crawlspaces during the rainy season. Try to avoid watering heavily next to the foundation. Another similar measure is to put extensions on downspouts so that their outlets drain two to three feet away from the foundation.

Upgrade HVAC System

Your wall furnace has a low efficiency of about 65% AFUE efficiency and is obsolete and inadequate. We recommend that it be replaced with an Energy Star rated condensing central furnace or boiler with 90% AFUE or higher efficiency. Efficiency for the equipment is given as AFUE, the annual fuel utilization efficiency. If you follow our recommendations related to insulation and reducing building leakage first, you may be able to install a less expensive furnace with a lower heating capacity. It has been very common that HVAC contractors install oversized equipment and you should guard against this as such equipment is more expensive and runs less efficiently.

We suggest you explore hydronic as well as the more common forced air systems. In a hydronic system, a boiler heats hot water, which circulates through insulated water pipes to radiators each in area. The radiators can be baseboard types that are long and placed on the floor next to walls, or rectangular panels that mount low on the walls. Hydronic systems are usually zoned with separate circulation pumps for each zone, and separate thermostats in each zone. Your home lends itself to a zone system, since you both have offices that could be heated on schedules separate from the central areas of the house. Heating zones only when heating is required can add substantially to efficiency. Zoning a forced air system is more difficult due to the need to install separate return ducts and registers for each zone.

In the north-most crawl space, the clearance between the ground and the beams was only about 14" and a little more in the south-most crawl space. If ducts for a forced air system were installed there, they would block access making it difficult or impossible to conduct termite inspections, repair the sump pump or other systems in the crawl spaces. It would be possible but maybe awkward to place air ducts in other areas of the house.

While the AFUE combustion efficiency of modern boilers and hot air furnaces is similar, there are lower distribution losses in hydronic pipes than in hot air ducts. Also, you can buy a boiler combined with a domestic

hot water storage tank, so that your hot water is also produced with 90+% efficiency. Hydronic systems are quieter than forced air, since there is no noisy blower.

A new furnace or boiler would likely qualify for a federal tax credit of 30% of the cost of the furnace, not to exceed \$1500, but the credit is scheduled to expire at the end of next year. It would also be likely to qualify for a PG&E rebate. The greatly higher efficiency will generate significant savings for an equal output, but this will be offset because you will be heating your home to a comfortable level for the first time.

New furnaces and installation services are available from HVAC contractors – see our Resource Directory for suggestions or you may use a performance contractor to oversee all your upgrades and subcontract the HVAC work and make sure it is sized and installed properly and efficiently, which is often not the case.

The work done by typical HVAC contractors has been driven by the need to be the low cost bidder rather than to meet efficiency goals. This has caused many to cut corners in sizing analysis, duct system design, duct and plenum sealing, and in insulation, areas the typical homeowner is unaware of. We believe that the incremental cost of paying for accurate sizing, sealing, insulation and testing probably has a rapid payback. To insure that you do not get an oversized furnace or boiler, insist that formal sizing analysis be done and independently verified.

If you select a forced air system:

1. Insist that the contractor seal and test the duct system so that it has a leakage of 6% or less. We can do an independent test of duct leakage when you are at that stage.
2. Insist on R-6 or higher insulation on all ducts and plenums.
3. Where possible, insure that any ducts in attics are surrounded by or buried in insulation.
4. Insure that there is a return path for all rooms that have a supply register. This can involve undercutting doors with an inch or more gap between the bottom of the door and the floor or carpet, or install jump ducts or registers between rooms.
5. Balance and verify airflow to each register and verify total external static pressure.

The breezeway/den has an open stairwell that goes up to the second and third floors. Heat from the first floor will rise to the upper floors and possibly overheat them unless you undertake appropriate measures. You may find yourselves futilely trying to open and close doors to regulate temperature. In the worst case, you will open windows on the upper floors to remain cool enough, negating the new efficiency you have worked hard to attain.

Placement of registers or radiators in the breezeway/den, so that their natural convection flow is not upstairs can help, but it may also be necessary to use an air barrier to block rising heat. Doors to the rooms on the upper floors can perform this function, but it is a poor way to regulate heat in these rooms. Vents in normally closed doors or in walls adjoining the stairwell could regulate heat entry. A ceiling fan in the breezeway den could push rising heat downwards. The conventional option and it is a good one, is to leave doors closed and provide registers or radiators in the upstairs rooms, perhaps putting the master bedroom suite on a separate zone. It would be easier to find a place to run hot water pipes from a hydronic system than larger hot air ducts from a hot air furnace to this area.

Service or Replace Water Heater

Your water heater is an A.O. Smith, model FGR 40 224 with two inches of R16 foam insulation and a glass lined tank. It was originally sold as an energy efficient model. It does not require an added fiberglass blanket, but blankets are inexpensive and would result in a little extra energy savings. We noted rust around the vent where it joins the draft diverter.

If you have not had the water heater serviced in the last few years we strongly recommend that it be serviced by a qualified plumber equipped with a "Muck Vac". Sediment and/or scale build up on the bottom of the tank acting as an insulation that causes overheating and premature failure of the tank and a loss of efficiency. The technician can remove the material with a "Muck Vac". The technician will also check whether the sacrificial anode needs replacement. This kind of servicing can extend the life of the water heater by several years.

On the other hand, if you plan to replace it in the next couple years, for example because you chose a combined boiler/water heater system for your home heating needs, then you could forgo servicing. We also noted that many of the hot water pipes lack insulation, and suggest that you, your handyman, or a performance contractor add pipe insulation to cover all hot water pipes.

Refrigerator Replacement Analysis.

We noted that your use of electricity is relatively high. We recommend using the Kill-A-Watt product that we showed you to track down the various electrical loads. Your refrigerator probably contributes to a lot of the load. It is an Amana model TX25R4W, S/N 9412254397. It was built in 1994 or 1995, has a capacity of 24.6 cubic feet, and uses 772 kWh per year. If you purchase an Energy Star model with approximately the same size, for example the Kenmore 7759*80* with 24.78 cubic feet, a bottom freezer and no icemaker, it would use about 474 kWh per year, for a savings of $772 - 474 = 298$ kWh / year. At the average price you paid for electricity over the last two years, 19.3 cents/kWh, your annual savings would be $298 * .193 = \$57.51$ per year, or \$575.10 over 10 years. If the electricity price rises, your savings will rise proportionately. Consumption on similar models is often very similar as it is driven by federal efficiency standards.

Priority and Timing of Main Recommendations

We have not done energy modeling of your home, which is the best way to predict the energy and cost savings for particular recommendations, and we remain available to conduct such an analysis. Our recommendations are based solely on our experience and that of the auditors and researchers that trained us.

Because you indicated that you need a plan that may stretch out over a few years, and because some of recommendations interact with others, we offer suggestions for a timeline below. Contractors may have additional insights about the sequence of work:

1. Install access into the attic above the kitchen to facilitate termite inspection and probable upgrading of insulation and other work.
2. Do the termite on an urgent basis. The longer you wait the more expensive and disruptive the necessary repairs will become. Because the cost of repairs is unknown, you need to determine them so you know the remaining budget that you have for other recommended improvements.

3. Fix water leaks and repair damage. Like termite damage, repairs become more expensive the longer you wait. Again, since the cost of repairs is unknown, you need do them to determine your remaining budget.
4. Seal the envelope. This will immediately reduce energy costs and increase comfort.
5. Next, upgrade insulation. Sealing work in the attic should be completed before insulation is upgraded because insulation covers up the areas needing sealing. When you have more insulation, your energy use will immediately decline or at least the wall furnace will be capable of heating more of the home until it is replaced.
6. We recommend sealing and insulation before the installation of a new heating system, because success of these projects can reduce the size system you need. If you cannot install a central heating system before the winter season, you may consider temporarily installing a powerful 220 VAC electric heater in the breezeway/den, or a free-standing gas furnace ("space heater") in place of the wood-burning stove. The wood-burning stove could return after the new central system is installed.
7. Test for radon gas prior to getting bids on the installation of a ground moisture retardant barrier as the presence of radon may affect the design of the barrier.
8. Have us or a performance contractor take additional humidity measurements. It will probably be necessary to install a ground moisture retardant barrier, hopefully before the next rainy season when humidity will rise. If your budget allows it, applying a tough barrier before the sealing work and the installation of a central heating system will make it much more comfortable and clean for workers who need to work in the tight crawl spaces. Technicians understandably are reluctant to work in mud. Sealing work might raise the humidity levels even higher and you might find that you want to install the barrier sooner for that reason.
9. Install a new right-sized central heating system. However, to claim the \$1500 federal tax credit, the system must be installed before the end of 2010.
10. Replace the refrigerator last since savings are not dramatic and it may have useful remaining lifetime. Be sure to research available rebates when you do purchase a new one.

Because our recommended improvements involve a number of different trades, you may find it convenient to hire a general contractor, in particular a performance contractor certified in green retrofits, to oversee all the work rather than hiring a variety of different contractors yourself.

Other Recommendations

These further recommendations can be done as time and money permit.

1. We noted rodent droppings in the crawl space, and over the slab that is accessible from a hole in the floor in Christian's office. You worked to exterminate them but they are likely to return unless all possible points of entry are sealed up with foam or other materials. Mice tend to make nests from fiberglass insulation. They can chew through electrical wires, creating a fire hazard. They can also carry parasites and spread disease. We also measured high leakage in your home. During leakage much air is typically drawn from the crawl space into the house and that air has been in contact with the mouse

droppings and possible pesticide residues from old termite treatments. To keep mice and other pests from the crawl space, search for all openings into the area and block them. Urethane foam in an aerosol can is a good tool for filling gaps up to 3 inches across. Ventilation openings should be entirely covered with wire screens. It makes sense to combine this work with the envelope sealing recommended above as the same skills, tools and materials are needed.

2. Repair the hole in the floor of the closet in Christian's office. The hole is a point of major air leakage and can provide entry into the living area for pests.
3. Crystal's office on the top floor gets hot in the summer. A lot of the heat gain is through the roof, and there is no easy access to add roof insulation, until the roof needs replacing. This would be an area where you might be able to experiment with adding a cool roof coating, as the roof has a low slope and is not visible from most vantage points. These coatings are relatively new and have not been tested for long periods of time, but accelerated independent aging tests have been conducted. The state of California has approved certain available cool roof coating products. We did not inspect this roof and do not know what material was used or whether coatings are compatible with the material.

There are cool roof elastomeric coatings that are designed for application over existing asphalt shingles and over other types of roofs. If such a coating were practical, it would significantly improve the reflectance of solar heat and the re-radiation of the heat that is absorbed. Coatings also may extend the lifetime of the underlying roofing materials. However, representatives from a knowledgeable roofing company tell us that there may be possible longevity problems, meaning that if you research this further, you should be very careful, and see if installers and manufacturers are able to give a warranty of several years.

Acryshield A550 from National Coatings is a typical product. Data compiled from testing by the Cool Roof Rating Council, shows a solar reflectance of 81% after 3 years of weathering (the test period), and an emissivity of 93% after the same 3 years of weathering. We are not specifically recommending this product, just using it as an example of the potential benefits of using a product with similar reflectance and emissivity characteristics. Some inferior products rapidly lose their reflectance with weathering. If you do research this further, you would want to look for a product that maintains reflectance over many years. We suggest using the Cool Roof Rating Council database at www.coolroofs.org/products/search.php to look at products whose reflectivity decreases only slightly and whose emittance improves after 3 year of weathering. Other properties important in selecting a coating include:

- Good adhesion to your current roofing material with low bleed through
- Protection of underlying roofing material
- Longevity
- Aesthetic acceptability
- Cost
- Availability of local contractor who has experience with the material.

We have not yet located a local roofing contractor specializing in cool roof coatings.

4. The hot tub cover is getting near the end of its useful life. It may be possible to get a replacement cover with a higher level of insulation, e.g. 5" thick at the center and 3.5 – 4" thick at the sides. We recommend installing an electrical timer to turn off the heat during periods when you do not expect to use it, if feasible.
5. Search for and reduce phantom electrical loads with the Kill-A-Watt or similar product. For your computer equipment, you can purchase a "smart strip" that turns off all the computer-related equipment, when the computer is turned off. Make sure to use the power management features of your computers during the day. When you replace computers, consider energy saving models.
6. There is a dryer duct partially blocking the access to the crawl space in the breezeway/den. To facilitate work in the crawlspace we recommend rerouting the duct. The duct run is very long, causing the dryer to run less efficiently. If it is feasible to run it to a nearer outside wall, the dryer would run more efficiently.
7. We noticed signs of aging on your roof, and several areas where drainage is not routed properly. For example, water drains near the water heater vent. Repairing some of these areas now could avoid more expensive roof and ceiling repairs in the future.
8. Unless you plan to replace the old Williams furnace very shortly, we recommend installing a carbon monoxide sensor in an electrical outlet near the furnace in compliance with the manufacturer's directions. The typical mode of failure for this type of furnace is that holes corrode through the heat exchanger, releasing flue gas containing carbon monoxide into the home. Purchase an alarm that plugs into the wall and emits a loud alarm tone. These units cost about \$25- \$40 and are available at hardware and home improvement stores as well as online. Do not use an outlet protected with a ground fault interrupter (GFI). You can identify such an outlet by its two push buttons between the two outlets, usually marked Reset and Test.

CAUTION

We did not perform safety inspections of your gas fired appliances. These can release poisonous gas or cause fires when not in good repair. PG&E can conduct free safety inspections – see our Resource Directory-- or you can contact a heating, ventilation and air conditioning contractor. Gas fired furnaces need regular maintenance; many heating contractors offer a low cost furnace annual "tune-up."

9. We noted that you have replaced some incandescent light bulbs with compact florescent lamps (CFLs). Some bulbs are enclosed in recessed cans. If these fail to last a few years, you may need to use special CFLs rated for high temperature use. Models rated for use with dimmers are also available for any cans on dimmers. Hardware and home improvement stores may not have suitable specialized bulbs, but they can be obtained from commercial lighting supply stores. See our Resource Directory for these stores.

The best commercial quality compact fluorescent bulbs have improved greatly in recent years. They have better color rendition and are available in "warm white" color that approximates that of incandescent bulbs, and in cooler color tones. They turn on at full brilliance immediately, and have a lifetime several times that of incandescent bulbs. Although CFLs cost more than incandescent bulbs,

since they last several times as long, over the long term the cost of replacement bulbs may result in savings too.

LED lighting is the most efficient available for indoor use. It is becoming cost effective on a long term lifecycle basis, and currently is excellent for replacing bulbs with an output equivalent of 50 watts incandescent or less. It is particularly effective to illuminate counters, and for accent lighting and small spotlights such as those in MR16 track lights. Local companies stock very few of the available LED lamp types, but there are many sources available on the Internet. Predicted lifetime is very long, for example 30,000 hours. If used 3 hours per day, such a lamp would last 10,000 days or 27 years. Efficiencies are often two to four times higher than CFLs.

Conclusion

Our inspection and analysis was limited in scope so as to limit costs to you. Do not be surprised if contractors need to conduct additional inspection and tests before they begin work. We remain available to you to help guide you through implementing our recommendations or conduct further recommended tests.

Besides the recommendations in this report, there are many other smaller things you can do to reduce your carbon footprint and lower your PG&E bill. We do not cover all of these, because they are well documented in some excellent books that are listed in the Resource Directory at the end of this report. As a sustainability consultant, you are probably aware of many.

We appreciate your business and are constantly looking for ways to improve our services. We like to hear both positive and negative feedback, which you can send to the email address on the cover of this report, or you can call us. We sometimes post testimonial letters or brief statements on our website.

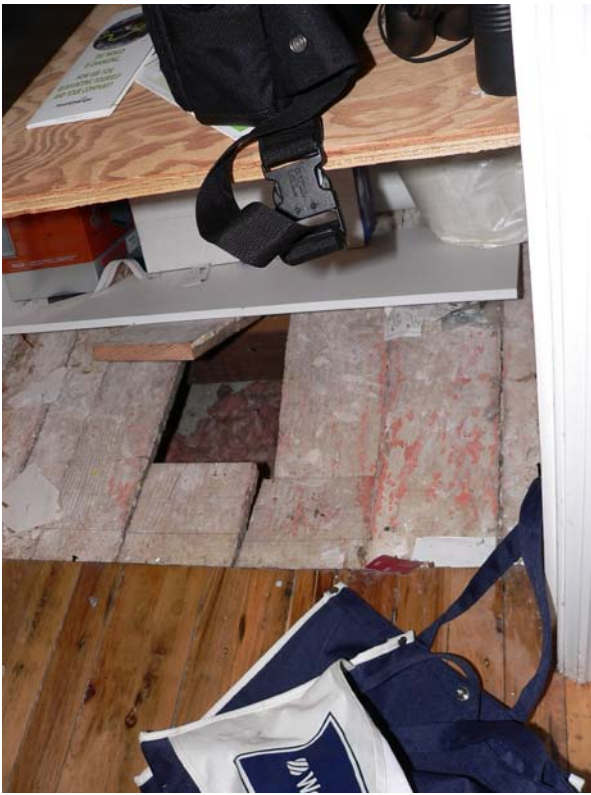
Inspection Photos



Blower door test underway



Williams wall furnace to be replaced.



Hole in floor in Christian's office needs repair.



Polyethylene sheet in crawl space does not cover ground fully, is not sealed to foundation and will not withstand technicians working on it.



Foundation wall in old portion of house has voids, but no large cracks.



This example (not a photo of your house) has a ground vapor retardant barrier made from thick reinforced polyethylene. All joints are taped. The edges of the polyethylene are glued to the foundation wall and taped around pier blocks. There is also closed cell polyurethane foam insulation sprayed underneath the subfloor. This not only insulates the floor but creates a moisture and air barrier seal between your living space and the crawlspace, reducing infiltration. We are not recommending insulating your floor at this time because of your mild climate and the high cost of foam (about \$4.00 per square foot at 3" thickness.)

Resource Directory

This report contained a 5 page directory of local resources.

[Redacted]

[Redacted]

[Redacted]

[Redacted]

[Redacted]

[Redacted]

[Redacted]

[Redacted]

[Redacted]

[Redacted]

[Redacted]

[Redacted]

Home Heating Index and Ventilation Calculations

Christian Forthomme, [REDACTED] 8/19/09
 Analyst: Rick Meyer

Input data:

Conditioned Floor Area in sq.ft. (CFA)	2350	sq.ft.
Average Ceiling Height in feet	8.3	ft.
Heating Degree Days from www.huduser.org	2900	degree days
Current Number of Occupants	2	people
Number of Bedrooms	3	
Blower Door Measurement	4955	CFM50
Windiness of Location (choose from pull down menu)	Normal	
Number of Stories (choose from pull down menu)	2.0	stories
Duct Blaster Total Leakage Measurement	0	CFM25
Furnace Input BTU	0	BTU
Furnace annual fuel utilization efficiency	0.0	%
Air Conditioner Tons	0.0	Tons

Gas data imported from PG&E download and sorted low to high therms:

Account Number	Bill Date	Gas Usage (Therms)	Gas Charges (\$)	Total Charges (\$)
8090535509	10/13/2008	34	\$48.56	\$152.37
8090535509	8/13/2008	38	\$74.63	\$175.97
8090535509	9/15/2008	39	\$64.98	\$184.74
8090535509	9/18/2007	40	\$53.04	\$138.99
8090535509	7/15/2009	43	\$49.22	\$175.53
8090535509	10/16/2007	47	\$64.95	\$170.34
8090535509	6/13/2008	48	\$81.73	\$153.46
8090535509	6/15/2009	49	\$52.56	\$187.05
8090535509	11/12/2008	49	\$62.88	\$188.51
8090535509	7/15/2008	49	\$94.63	\$174.45
8090535509	5/15/2009	52	\$56.16	\$202.26
8090535509	8/17/2007	53	\$75.74	\$164.83
8090535509	11/14/2007	58	\$78.15	\$183.70
8090535509	5/14/2008	60	\$97.53	\$174.68
8090535509	4/15/2009	62	\$66.88	\$189.04
8090535509	12/12/2008	68	\$75.43	\$231.93
8090535509	4/15/2008	80	\$117.67	\$282.82
8090535509	2/15/2009	81	\$98.62	\$246.85
8090535509	3/17/2009	88	\$57.00	\$261.31
8090535509	3/14/2008	89	\$120.64	\$209.57
8090535509	12/14/2007	96	\$129.66	\$275.29
8090535509	1/13/2009	120	\$140.55	\$380.65
8090535509	1/15/2008	128	\$173.77	\$352.72
8090535509	2/13/2008	132	\$176.79	\$320.51
TOTALS		1603	\$2,111.77	\$5,177.57

Avg. Monthly Baseline in Therms / Mo.

40.2

Ann. Avg. Heat Therms = (total - baseline)/2 319.5
 Average Price per Therm = Total Gas Cost / Total Therms \$1.32
 Average Annual Total Gas Cost = Total Cost / 2 \$1,055.89
Avg. Ann. Estimated Heating Cost = Ann. Heat Therms * Avg. \$ per Therm \$420.90
 Average Annual Baseline Gas Cost (non heating) \$634.98

Annual Heating Degree Days 2900.00
 Square Feet of Conditioned Floor Area of House 2350.00
Home Heating Index = BTUs/square feet/HDDs 4.7

NOTE: Homes with HDD > 8 probably have cost effective energy improvements
 Homes with HDD < 4 probably are energy efficient already.

Energy Conservatory Equiv. Orifice Leakage Area (EOLA) = CFM50 / 7.495 661 sq.in.
Estimated Leakage Area sq.ft. = EOLA / 144 sq.in. per sq.ft. 4.59 sq.ft.
Estimated Leakage Area, sheets of copier paper = EOLA / (8.5 * 11) 7.07 sheets
 CA Estimated Leakage Area (ELA) = CFM50 * .055 273 sq.in.
 California Specific Leakage Area (SLA) = CFM50 * 3.812 / CFA 8.0 sq.in./sq.ft CFA

Min. Ventilation Requirement per ASHRAE 62 - 1989 & CA 2005 Energy Code

Approx. Volume of Home = CFA * avg. ceiling ht., or from model 19,505 cubic feet
 Required .35 Air Changes Per Hour (ACH) in CFM= Volume * .35 / 60 min. 113.78 CFM
 Effective occupants = greater of actual occupants or (bedrooms + 1) 4
 Effective occupants x 15 CFM 60.00 CFM
Min. Ventilation (greater of .35 ACH or effective occupants * 15) 113.78 CFM

Equivalent Natural Ventilation Rate

Lawrence Berkeley Labs "n-factor" Look up table, Zone 4 only				
Stories:	1	1.5	2.00	3
Well-shielded	29.4	26.5	23.5	20.6
Normal	24.5	22.1	19.6	17.2
Exposed	22.1	19.8	17.6	15.4

N-factor for the property from table above, given # Stories, Windiness 19.60
Natural Ventilation Rate = CFM50 / n-factor 252.8 CFM(nat)
Natural Ventilation Rate in ACH = CFM(nat) * 60 min. per hr. / Volume 0.78 ACH
Natural Ventilation Above Minimum Required? TRUE
Add'l Mech. Ventilation Req'd = Min. Ventilation - Natural Ventilation 0.0 CFM
Blower Door Reading at Minimum Required Ventilation would be 2230 CFM50

Duct Leakage

Furnace CFM Output = Input BTU/1000 * AFUE * 21.7 N/A CFM
 A/C CFM Output = Tons * 400 CFM 0.00 CFM
 Effective CFM = greater of Furnace CFM Output or A/C CFM Output N/A CFM
 Duct Leakage Percentage = Duct Blaster CFM / Effective CFM N/A %

END