

# PORTOLA VALLEY HOME ENERGY AUDIT STUDY

by

John Hermannsson, Architect  
Bo Crane, Certified Green Building Professional

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# 1. Introduction

Portola Valley was founded to preserve a community in a rural landscape setting from being consumed by residential sprawl. The residents of Portola Valley did not accept residential sprawl as a sustainable solution for a vibrant and healthy community and took immediate action to incorporate in 1964 to gain control of community open space and natural views and prevent the residential development of what is currently the Windy Hill Open Space Preserve. The founding goals of Portola Valley were to preserve the beauty of the land, to foster low-density housing, to keep government costs low through volunteer service, and to limit commercial enterprises to services necessary for local residents.

In hindsight, the founding of Portola Valley was a bold and responsible act in opposition to the popular belief of the time, which was the existence of a 'fairy tale dreamland' in the country without dust or flies that was called Suburbia. This belief existed at a time when the United States was producing more oil than it could consume, the discovery of world oil reserves was greater each year than the year before, and the United States was in control of the world oil market because it was the leading producer of oil with the greatest known reserves. It was a giddy time that was fueled by gasoline at 15 cents per gallon at the pumps, and 'fairy tale dreamlands' didn't seem so far away. It was also a time when greenhouse gases were believed to exist only in greenhouses. Nevertheless, suburbia never delivered on its promises, and Portola Valley put its land use ordinances in place just in time for the opening of Interstate 280, in 1968, which paved the way for a suburbanite invasion that was managed without getting out of control.

The first alarm sounded in 1973 with the Arab oil embargo. Amid the distractions of Vietnam and Watergate, the United States looked into the rearview mirror to see the year 1970 receding like another highway exit sign on the way to suburbia. However, it became apparent that it was not just another year, but a pivotal year for the United States because it had passed its peak for oil production and could no longer control the world's oil market by simply pumping more oil or even supplying its own energy needs. Instantly, the United States became a desperate oil importer to satisfy its growing energy needs that exceeded its dwindling production.

Fifteen years passed and a second alarm sounded on June 23<sup>rd</sup>, 1988, when Dr. James Hansen gave testimony to Congress that global warming was underway and that greenhouse gases from the burning of fossil fuels was responsible.

Twenty years have passed since the second alarm was put on 'snooze', and a third alarm is about to sound that includes all previous alarms: world oil production has either almost reached or is in the process of passing its peak (Only a distant look in the rearview mirror will tell.); and, Dr. James Hansen once again gave testimony to Congress on June 23<sup>rd</sup>, 2008, to repeat what he said 20 years ago, but with one big difference. *"The difference is that now we have used up all slack in the schedule for actions needed to defuse the global warming time bomb. Otherwise it will become impractical to constrain atmospheric carbon dioxide to a level that prevents the climate system from passing tipping points that lead to disastrous climate changes that spiral dynamically out of humanity's control."* \*

How do greenhouse gases cause global warming? Scientists, who are experts in the field, have known for quite some time that greenhouse gases in the atmosphere envelop the Earth and trap heat similar to the way a blanket traps heat. However, more recent studies have revealed that greenhouse gases play a more complex and vital role in maintaining climate stability than was previously understood. Greenhouse gases are present in the atmosphere at certain naturally occurring levels of concentration and are essential for maintaining an average global temperature of 57 °F. Without the presence of naturally occurring greenhouse gases, scientists have determined that the Sun's energy alone would not be sufficient to raise the average global temperature above 0 °F. The Earth uses greenhouse gases to maintain its temperature similar to the way a thermostat works in a house. As greenhouse gas levels increase from man-made emissions to levels above what is naturally occurring, the 'dial' on the thermostat that controls the temperature of the Earth's atmosphere is being tampered with which may result in unpredictable temperature fluctuations and cause unusual climate instability. This may have profound and far reaching effects for life on Earth.

Why does this residential energy audit, which is a study of energy usage, present results in terms of carbon dioxide (CO<sub>2</sub>) emissions? Greenhouse gases consist of water vapor, CO<sub>2</sub>, smaller amounts of methane (NH<sub>4</sub>), nitrous oxide (NO), and numerous other toxic gases in much smaller quantities. CO<sub>2</sub> is the primary combustion bi-product of fossil fuels, and serves as a convenient measure of greenhouse gases. CO<sub>2</sub> emissions have been accepted worldwide as a standard for gauging global greenhouse gas emissions.

A third alarm will not be necessary for Portola Valley to take immediate action against global warming. In keeping with the town's

goals for maintaining a vibrant and healthy community, Portola Valley residents Linda Yates and Paul Holland have volunteered their time and financial support towards this study that includes energy audits of 5 Portola Valley residences to determine where energy might be saved, and how carbon dioxide emissions may be reduced. In addition, guidelines for improved residential comfort and health have been addressed.

\* On December 16th, 2008, Dr. James Hansen spoke at the Portola Valley Town Center Community Hall and stated, in a question and answer session, that he believed that his previous number of 450 ppm (parts per million) was not accurate, and that he had revised his prediction for the global warming 'tipping point' to be 350 ppm. He confirmed that we are currently at 385 ppm of atmospheric CO<sub>2</sub> concentration, and pointed out that the sooner the CO<sub>2</sub> concentration is reduced the less the environmental destruction that will occur.

## 2. Passive Solar Heating

Sunlight streaming through windows is warm, beautiful, clean, cheap, and available. And, it doesn't leave a carbon footprint. Because this process takes place without the assistance of fans, pumps, motors, or any other energy consuming devices, it is referred to as 'passive solar heating'.

Passive solar heating functions by natural means from energy available in the immediate environment and is most effectively incorporated into a new house or addition through good siting, orientation of windows, and the use of thermal storage materials.

Two elements are required for a passive solar heating system: south facing windows; and, thermal storage materials, which would typically be concrete, brick, or any other dense building materials incorporated into floors or walls. There is a popular belief that too much window and thermal storage area is needed for passive solar heating to be a practical alternative for a traditional residence. This is an unfortunate fallacy. While it is true that each space must have window and thermal storage areas, studies have demonstrated, a well designed passive solar heating system need not have excessive areas of window or thermal storage material to function.

A traditional Portola Valley ranch house can incorporate passive solar heating without compromising design style. An attractive precedence for incorporating design elements that take advantage of passive solar heating in Portola Valley may have been first established in 1954 with the completion of a residence designed by the celebrated Bay Area architect, William Wurster. The residence is well designed to incorporate passive solar heating along with a sweeping panoramic view to the southwest. A concrete slab floor provides a thermal storage area, which works in combination with the roof overhangs that are designed to block sunlight from striking the slab during the summer while letting heat from the sun be absorbed by the slab during the winter months. The residence is located in the Westridge area neighborhood and has been included in this energy audit.

### 3. Insulation

Insulation has been the single most important ingredient for residential energy conservation since California's energy regulations took-off in the early 1980's, with almost three-quarters of the 2 billion dollars spent by Americans for insulation each year going for fiberglass batts. When the U.S. Department of Health and Human Services added it to its list of suspected carcinogens in 1994, consumers were motivated to look for better alternatives that contained no suspected carcinogens, in addition to being environmentally friendly, and utilizing recycled materials. In the meantime, opposition by the fiberglass insulation manufacturers has succeeded in eliminating all previous listings of fiberglass insulation as being a 'suspected carcinogen' from all reputable sources except the U.S. Department of Health and Human Services listing, which continues to stand by its published research and lab results. Nevertheless, fiberglass insulation remains the most common and inexpensive choice for the cost conscious consumer.

Cellulose insulation is one attractive alternative to fiberglass. Manufactured from shredded recycled newspapers with boric acid added (also used as a fire retardant in children's cotton pajamas), cellulose insulation provides a similar insulation value to fiberglass, is more fire resistant, much better for blocking air infiltration, is acoustically superior, and doesn't irritate the skin. Also, a little known anomaly of fiberglass insulation is that it loses its effective insulation value as the temperature difference between the inside heated or cooled space and outside increases, however cellulose does what one would expect an insulation product to do and maintains a constant insulation value regardless of temperature. Although the cost of fiberglass compared with the cellulose material is about the same, the cost of labor to install the cellulose insulation is more than the cost for fiberglass batts. Fortunately, the installation cost has been coming down as the use of cellulose increases.

Cotton insulation is also a common alternative made from shredded denim textile scraps. It has all the good qualities of cellulose, in addition to being available in batt form for ease of installation. Cotton batts are free of formaldehyde-based binders that are often used in fiberglass batts, which can present a health problem when off-gassing occurs. Cotton insulation batts are about twice as expensive as fiberglass batts, but labor costs are similar.

Foam insulation is available, but currently, its use is limited because testing and certification standards do not meet the new limited requirements of the California Building Code 2007. Rigid insulation is another option but is not typically used, because it is more difficult to

handle, except as a substitute for batt insulation in cavities with limited depth.

## 4. Space Heating & Air Conditioning Systems

Most homes are heated with forced air furnaces, consequently furnace efficiency has been a focus for more than two decades as California's energy regulations have evolved to require relatively high efficiency furnaces. Although most old inefficient furnaces have been replaced with higher efficiency types, overall heating system efficiency remains low in existing Portola Valley residences due to duct leakage and system pressure imbalances.

During the period when most of the existing Portola Valley residences were built, it was not uncommon to use building cavities as return air ducts. For example, in the Portola Valley Ranch subdivision, we inspected one residence with a ceiling joist cavity serving as a return air duct, a typical construction practice for the '70's. This caused outside air to be drawn into the unlined return air cavity and introduced moisture into the surrounding wood structure. The excess air in the system creates a positive pressure in the residence that pushes warm air out and results in a significant loss of system efficiency while also creating a potentially unhealthy environment that incubates in the warm moist return air cavity.

Only 1% of residences, built in California since 2005, achieve the current Energy Code requirement for a 5% duct loss. Most new homes lose 30% of their space heating and cooling energy through leaks in the duct system. Aging systems can be much worse with the widespread and inappropriate use of 'Duct Tape', which causes joints to deteriorate and leak over time. We found evidence showing where animals had found their way into the crawl space or under floor areas in the insulation surrounding warm air ducts. This caused the ducts to be stripped of insulation and leak due to the nesting and gnawing activities of rodents and raccoons. The result is a decrease in system efficiency and also a potential health hazard from animal hairs and droppings that may enter the air distribution system through openings in the ducts.

Other areas of significant inefficiency for forced air systems, in Portola Valley residences, include the popular use of recessed can light fixtures that, in the older version, were essentially holes in the ceiling for warm air to pass through to the outside, by way of an attic or airspace. When spiders span recessed ceiling lights with their webs, you can be confident that you're living in a luxurious fly catching apparatus powered by your furnace, which will be reflected on your heating bill.

With the popularity of 'Jacuzzi' style tubs, that include an interior service access panel, a significant air leak may have been unknowingly custom built into many Portola Valley homes. We observed that the

underside of a 'Jacuzzi' tub is typically exposed to a crawl space, and the service panel is usually a custom cabinet style door located on the tub enclosure, which draws in outside air when the furnace calls for heat. A furnace located within a conditioned space or unsealed mechanical room, will also draw in outside air. This was typical of the Portola Valley residences we inspected.

Field measurements have shown that a conventional 80% efficient furnace, with a single speed fan, will typically perform more efficiently than a two-speed furnace rated at 94% efficiency. This is because a furnace's efficiency is determined in a testing laboratory under ideal conditions that rarely exist when a furnace is in use in a residence. The performance of a high efficiency furnace is more sensitive to barometric pressure and humidity, for example, to achieve optimum combustion efficiency than a conventional furnace. The result is that a conventional furnace will typically exceed the performance of a high efficiency furnace installed in a residence.

Since a high efficiency furnace is twice the cost of a conventional furnace, instead of spending money on a high efficiency furnace, the most cost effective approach to improving the performance of a forced air system is to spend money on sealing the ducts, and leaks in the floor and ceiling.

When a residence is properly insulated, and its windows are shaded from receiving too much direct sunlight, air conditioning should not be necessary to maintain comfort in a Portola Valley home. Nevertheless, a forced air system, whether it is cooling or heating, will never be ideally suited to the task of efficiently conditioning a space because the more it is used, the more it will bring in outside air and push out inside air. A forced air system greatly increases air leakage by creating air movement and pressure imbalances throughout a residence. Older homes are especially vulnerable to this type of increased air leakage problem that is magnified by a forced air system, and this applies to most of the residences in Portola Valley.

What is the most cost effective and ecologically sound source of heat for older residence in Portola Valley? The sun is the most cost effective source of heat. Nothing could be better than the ground surrounding each Portola Valley house for the collection and storage of heat from the sun, which provides a natural solar collector and thermal storage system available to a house. Thermal energy stored in the great mass of earth located below the surface is available to heat a residence with the use of a ground source heat pump.

A ground source heat pump transfers heat from the ground during the heating season to heat a residence and reverses the process to transfer heat from a residence to the ground during the cooling season. A ground source heat pump does not burn fuel, such as gas or oil like a furnace or boiler, but uses electricity to operate a compressor and pump which transfers energy between the earth and house. A ground source heat pump is more efficient and will provide more years of service, but is also more expensive to install than other space heating systems. Nevertheless, for an older residence, the pay-back period for the additional investment can be as little as 7 years.

The most efficient means of distributing heat to a residence is through hot water pipes located in the floor, which is also referred to as hydronic heating. Hot water pipes in the floor enhance comfort, improve efficiency, and promote health in a residence. The distinguishing features of hydronic heating over a forced air system are, as follows: unlimited zone controls for saving energy, greater temperature near the floor for efficiency and comfort in heating people, reduced air temperature necessary for comfort, and improved respiratory health without the distribution of dry warm air that may carry dust, pollen, or bacteria. Hydronic heating is quiet and creates a comfortable warm floor for toddlers and people who prefer to remove their shoes and walk in bare feet.

The Environmental Protection Agency performed a study in 1978, applicable to most Portola Valley residences, which determined that the greatest impact on indoor air quality in a residence comes from the soles of shoes which transport toxins into homes and deposit these toxins on carpets. In the study, it was determined that typical carpet cleaning techniques did not adequately remove these toxins. Because hydronic floor heating creates a more comfortable floor for bare feet, it may promote indoor air quality by making it more comfortable for people to remove their shoes when they enter a residence and reduce the physical transfer of environmental toxins from outside to inside the home.

## 5. Windows and Shading

If a house is the embodiment of its people, its windows are akin to the eyes that are the windows to the soul. Portola Valley Ranch Style residences rely on windows to wash walls and flood rooms with natural light and set the tone for living close to nature. Grand sweeping views are framed by large windows that reach for something of beauty in the landscape that is cherished by Portola Valley residents. Windows are the single most important and valued architectural feature on a Portola Valley residential façade, and the greatest of energy consumers.

Most of Portola Valley's residential lots have houses from a period between the 50's to the early 80's, and these houses will probably remain standing for two or three decades to come. Consequently, the primary energy saving challenge is to be able to retro-fit energy saving features on to a typical Portola Valley residence built, mostly, during a time of cheap energy with inefficient single-pane metal framed windows. These residences were also built at a time when the choicest lots were available with the most unobstructed views of the western hills. The late afternoon sun is typically not blocked by overhangs on Portola Valley residences with large windows facing west and are often a source of discomfort from glare and heat gain from solar radiation, consequently, adding to residential cooling costs.

Stopping solar radiation before it passes through window glass, is the only effective means of controlling heat gain. Strategically locating trees or trellis structures, which support deciduous plants, that block solar radiation during the warmest months, and offer less blockage during the winter months, when solar radiation may be desirable, works with nature. Exterior shutter devices provide an effective architectural solution, which may be manually or automatically operated to control heat gain. 'Low-E' window films are also available that may be retro-fitted as sheets. These adhere directly to existing window glass and provide a limited reduction of solar radiation at the lowest possible cost.

Nevertheless, as soon as the opportunity arises, single-pane aluminum windows, which are typical of Portola Valley residences, should be replaced by energy conserving windows with a wood or fiberglass frame. A single-pane window loses twice as much heat through its glass alone as a double-pane window. Moreover, an aluminum framed window has a built-in 'thermal short circuit' that loses more heat through its frame than through the glass. These old windows are also poorly weatherstripped and lose additional heat through air infiltration. Indoor air quality is also compromised by single-pane aluminum windows because the warm moist interior air will condense on the cold surfaces of

the glass and frame and promote mildew and mold growth, which can release spores into the air that may impact immune systems and cause allergic reactions.

In addition to heat loss, there are several other important performance criteria for selecting a window, as follows: daylighting, radiation control, acoustical transmission, maintenance requirements, and durability.

Daylighting and radiation control are probably the most important, yet the least understood performance characteristics of windows by most homeowners and builders. Fortunately, the most esthetically attractive windows on the market today happen to have good attention to detail and are also among those that perform better. In this category, a double-pane window will usually be available as a standard window with a second generation Low-E, or low-emissivity, glass coating. The coating is designed to reduce heatloss by providing a low-emitting surface for heat that inhibits its tendency to radiate to the colder outside air. Also, the second generation Low-E coating is designed to reduce incoming solar radiation, typically, by 50 to 65%. The latter point is an important consideration for those who want to grow indoor plants because plants will not grow behind a second generation Low-E coated window. However, plants will grow behind a first generation Low-E coated window because it does not block daylighting and only reduces heatloss. If this is an important consideration for your window selection, be sure to check if your window manufacturer will provide a first generation Low-E coated glass for your windows. Not all window manufactures provide that option because they believe that most homeowners don't know the difference, but now you do.

## 6. Ecology of Community

Portola Valley has 4462 people living in 1700 households on 10 square miles in a secluded rural setting in a relatively mild climate, but is it a sustainable community? The *Portola Valley Home Energy Study* will take the first step towards answering this question by identifying energy consumption and CO<sub>2</sub> production among a selection of five local residences. The results of the Study are summarized in *Table 1* and *Table 2*, below.

**Table 1: ANNUAL UTILITY BILLS, 2007**

HOUSE	AREA (SF)	ELECTRICITY	GAS	TOTAL	Cost /SF
A	2480	\$739	\$1703	\$2442	\$.98
B	2300	\$919	\$1211	\$2130	\$.93
C	7800	\$6392	\$4812	\$11204	\$1.44
D	2970	\$1025	\$1824	\$2849	\$.96
E	4200	\$1653***	\$1420	\$3073	\$.73
Average US Residence **	2400	\$1200	\$1260	\$2460	\$1.03

**Table 2: ANNUAL CO<sub>2</sub> EMISSIONS, 2007 \***

HOUSE	ELEC. CO <sub>2</sub>	GAS CO <sub>2</sub>	TOTAL CO <sub>2</sub>	CO <sub>2</sub> /SF
A	1.5	7.7	9.2	7.4 pounds
B	1.7	5.6	7.4	6.4 pounds
C	5.8	21.6	27.4	7.0 pounds
D	1.8	8.4	10.3	6.9 pounds
E	2.8***	6.4	9.2	4.4 pounds
Average US Residence **	8.9	5.2	14	11 .7 pounds

\*measured in tons of CO<sub>2</sub> ,unless otherwise noted

\*\*National Association of Home Builders and EPA report.

\*\*\* solar electric assisted (photovoltaic panels on roof)

House A was selected as a representative residence for computer modeling. A computer simulation confirmed that retrofitting insulation into all uninsulated walls of house A would result in a significant savings: 52% for heating and 53% for cooling. If all the existing metal framed windows and skylights were replaced by high performance double-glazed windows and skylights, there would be a 22% savings for heating and a 44% savings for cooling. The model predicts that if both the insulation

and high performance glazing options were combined, a savings of 67% for heating and 80% for cooling would be achieved. This would result in a combined space heating and cooling system energy usage reduction of 56%. The single most significant energy conserving improvement that can be made to an older residence is to retro-fit insulation. Retro-fitting high-performance windows would be the second most significant energy conserving measure.

If a high efficiency furnace were to be installed in house A instead of retro-fitting insulation in the walls, an 11% savings in heating energy would have occurred, only 1/5 of what could be achieved by solving the problem directly.

A 56% reduction in heating and cooling energy usage represents about a 34% annual savings on \$2442, shown in *Table 1* under the column labeled *TOTAL*, the total energy cost for house A, which would result in a savings of \$837. This is also a demonstration of how a benefit is typically evaluated in the market place in the form of dollars saved.

Where *Table 1* measures energy consumption in dollars, *Table 2* measures sustainability in CO<sub>2</sub> emissions produced.

In *Table 1*, the column labeled *TOTAL* is not the grand total. It is only the total in the market place. A hidden cost, which economists refer to as an externalized cost, is accounted for in *Table 2: ANNUAL CO<sub>2</sub> EMISSIONS*. Essentially, *Table 2* represents a deferred cost of using fossil fuels for energy. It has become increasingly evident that this cost cannot be deferred indefinitely but must be paid by unfortunate future generations due to the rapid increase in global warming.

In the final analysis, how can anything be sustainable that has a deferred cost? Isn't it reasonable to expect that eventually someone will need to pay for a deferred cost, plus interest? By definition, a sustainable community cannot have a deferred cost. A lower dollar amount provides a way to make short-term decisions based on cost-effectiveness for energy efficiency and payback compared to other potential investment opportunities. However, the concept of CO<sub>2</sub> emissions provides a means for making long-term decisions towards sustainability. This may be put into perspective with the following question: what is the cost-effectiveness of preserving Portola Valley for future generations? A community with zero net CO<sub>2</sub> emissions can be a sustainable community for future generations, although some people may question the cost-effectiveness of such a decision.

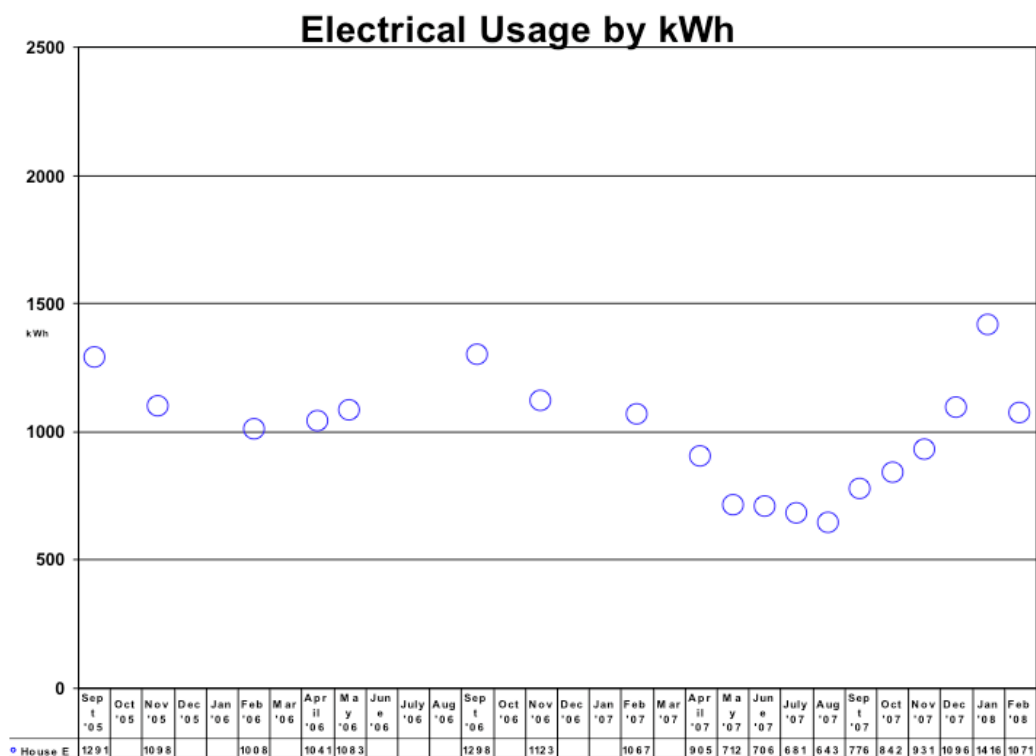
Portola Valley has been fortunate to receive assistance from its utility

district towards reducing CO<sub>2</sub> emissions. The utility, PG&E, has reduced CO<sub>2</sub> emissions, below the national average, by supplying electricity from a mixture of energy sources that make it among the cleanest in the nation, which includes 14% California-based renewables, 17% hydroelectric power, 22% nuclear, 44% natural gas, and only 2% coal, with 1% listed as 'other'.

Consequently, the average emissions of the four Portola Valley houses: *A, B, C, and D*, that do not have the benefit of photovoltaics, is about one-half of the CO<sub>2</sub> emissions per square foot compared to an *Average US Residence*. This means these Portola Valley residences are about twice as sustainable as the nation's average, and it is entirely due to PG&E's policy of using low emission energy sources. With sustainability as a priority, it's not surprising the average *Cost/SF* of energy for houses, *A, B, C, and D*, is 16% higher than the *Average US Residence*. You get what you pay for and clean energy costs more.

Of the five Portola Valley houses shown in *Table 2*, house *E* has the lowest CO<sub>2</sub> emission per square foot. This is not surprising because house *E* is the newest house, and benefits from a photovoltaic system. *Figure 1* shows the monthly electric bills for house *E*. A dramatic drop in PG&E electricity usage occurred after a photovoltaic system was installed in May, 2007, which is shown by the cluster of dots appearing below the 1000 kWh line in *Figure 1*. However, by January, 2008, the PG&E electrical usage is 40% higher than at the same time the previous year. February to April, 2008, showed a 10% increase in PG&E electricity usage and June to August, 2008, showed a 13% increase over the same period in 2007. The available data shows every indication that this is a 'rebound effect'.

**Figure 1: HOUSE 'E' ELECTICITY BILLS, 2005-2008**



The 'rebound effect' is a well documented effect and imposes a limitation on how sustainable a community can become in a market economy, a type of glass ceiling for sustainability. The 'rebound effect' describes consumer behavior that responds to lower energy costs resulting from increased energy efficiency, and may play a more significant role in limiting energy efficiency than technology can play in improving it. For example, solar panels may be purchased and placed on a residence for the purpose of achieving energy efficiency. This will save energy, which saves money. But, what is done with the money saved has an important impact on the environment also. If a homeowner purchases just as much electricity from PG&E after solar panels have been installed as before they were installed, the money saved will have been used to increase consumption. Although the initial investment may have been intended for saving energy, the solar panels will become, in effect, merely another luxury item for consuming more energy.

While energy consumption motivates improved technical efficiency, it's long been known that efficiency also acts as an enticement to consumption. The industrial revolution would not have succeeded if energy consumption and energy efficiency didn't work together, in a

leap-frog fashion, to promote economic growth and prosperity by improving the productivity of labor and capital. Consequently, a sustainable community must ultimately address cultural issues before it can fully benefit from its investment in technical efficiency for energy savings.

As a nation, we see the enticement of improved energy efficiency in residences continue to motivate consumption, which exactly offsets all net energy savings as the average size of a house increases, which requires more heating, cooling, and lighting for the additional square footage, in addition to the demand for more appliances and electronic devices.

What does a sustainable community look like? It will be a community that establishes a sustainable culture through its government and its laws, policies, standards, and energy guidelines; and, incorporates what is moral and what is possible in an underlying message that creates a new cultural perception of efficiency and consumption. The human community should resemble the natural community in which it resides by not only relying on local energy, such as energy from the sun, but also by developing local transportation networks, such as walkways and bike paths, which would not only provide a way for children to walk to school but also support local business activities. The benefits of establishing a sustainable culture go beyond the measureable indicator of energy savings. It will lead to a complete stewardship of the community, which will result in energy efficiency occurring naturally, as it occurs in a natural community. A complete culture of sustainability is the key to a sustainable community, which remains engaging, meaningful, and a delightful place in which to live.

## 7. Portola Valley Home Energy Study

The objective of this Study is to take the first step on the path of sustainability for the Town of Portola Valley by identifying where energy is consumed and how CO<sub>2</sub> is produced in residences. The primary benefit of the Study is to provide a basis for thought and discussion among members of the community for making long-term decisions based on a broader understanding for a sustainable community.

In order to achieve the objective, four areas of investigation were pursued:

- **Energy consumption:** Where is household energy consumed? How much opportunity is there for reducing waste, utilizing energy more efficiently, and saving money? What are the long-term implications for sustainability when energy consumed is related to CO<sub>2</sub> produced?
- **Water consumption:** Why is this an important issue for an energy study? How much opportunity is there for reducing consumption? What role does water play in sustainability?
- **Health:** What impact does saving energy have on health and the quality of life? What are the issues and conflicts? What are the solutions? How does health fit into the context of sustainability?
- **Comfort:** How can energy conservation enhance comfort? What does sustainability mean in this context?

Five Portola Valley homeowners offered to have their residences audited for energy consumption for this Study. An energy audit, taking several hours, was performed on each residence by Emerson Environmental, and the results were compiled into the *Portola Valley Home Energy Study Report*, included as a separate report at the end of this Study.

A key issue for Portola Valley is that most of the residences are decades old and were built during a time of cheap energy with a lack of energy conserving features. Very few new residences are being built in Portola Valley currently, which dictates that almost all of the energy savings must come from addressing problems related to retrofitting existing housing stock with energy conserving features. Related to this is the broader issue of the remote locations of residences in Portola Valley, which places an emphasis on the need for automobile transportation to all locations within and outside of the community.

Another broad issue is the evolution of a community that will continue to nurture health and happiness by enabling sustainability through a culture that embraces improved technical efficiency as an opportunity to reduce a household's carbon footprint, rather than as an

enticement to the pursuit of luxury through unlimited energy consumption.

The *Portola Valley Home Energy Study Report* includes the results of a calibrated blower door test that was conducted on each of the five residences to determine the location and amount of air leakage through the building's envelope. An exterior doorway was sealed with an airtight fabric that incorporated an opening for a fan that exhausted interior air to the outside. When the fan was turned on, a negative pressure was created inside the house similar to a 20 mile per hour wind blowing outside. The results of the measured and calibrated blower door tests produced the air infiltration ratings for the residences, as shown in *Table 3, Residential Air Infiltration*.

A surprising result of the blower door test was that the oldest residence, house *D* built in 1954, had the lowest infiltration rate of the residences tested. Moreover, house *E*, built in 2001, the most recently built residence, had the second highest air infiltration rate.

**Table 3: RESIDENTIAL AIR INFILTRATION**

HOUSE	AIR CHANGES /HR	ENERGY COST, % OF TOTAL \$	ANNUAL ENERGY COST	CO <sub>2</sub> / SF
<b>A</b>	<b>0.73</b>	<b>7%</b>	<b>\$167</b>	<b>0.6 pounds</b>
<b>B</b>	<b>1.19</b>	<b>9%</b>	<b>\$201</b>	<b>0.8 pounds</b>
<b>C</b>	<b>1.58</b>	<b>9%</b>	<b>\$983</b>	<b>1.2 pounds</b>
<b>D</b>	<b>0.62</b>	<b>7%</b>	<b>\$208</b>	<b>0.6 pounds</b>
<b>E</b>	<b>1.21</b>	<b>13%</b>	<b>\$408</b>	<b>0.9 pounds</b>
<b>New House*</b>	<b>0.34</b>	<b>4%</b>	<b>\$90</b>	<b>0.3 pounds</b>

\*Based on theoretical performance prediction using CA Energy Code

As shown in Table 3, house *E* pays substantially more for energy loss through infiltration, as a percentage of its total energy bill, than the other residences. This may indicate that the reduction in infiltration losses for new construction has fallen behind advances in other energy conserving features since the older homes, *A*, *B*, *C*, and *D*, had only 7%-9% of their total energy costs consumed through infiltration losses compared to 13% for house *E*. Nevertheless, the difference between house *E*, at 13%, and the expected performance of a new house, at 4%, may indicate a need for better oversight and verification by permitting agencies to achieve the lower infiltration level.

Studies have shown, air infiltration in buildings is primarily driven by a stack effect, which is a natural result of hot air that rises. Consequently, infiltration is most sensitive to air leaks through floors and ceilings. House *D* was the only

residence with a concrete slab floor, which guarantees that it will never leak air, regardless of age. This may explain why the air infiltration rate for house *D* was lower than the other residences, which stand on raised floors that can leak air through the typical floor penetrations, such as, electrical connections, registers and spa motor access doors.

A computer simulation of house *A* was performed as a standard for comparison. From the simulation, we expected to see a 16% envelope heat loss due to infiltration, however our measurements determined that house *A* was performing much better with only an 11% loss. The discrepancy between the simulation and measurement remains unexplained and may indicate a need for a better understanding of residential infiltration losses and modeling.

The areas that were discovered to contribute the most to infiltration losses, yet may be easily addressed by homeowners with little cost and effort, were as follows:

- Passage doors, both solid wood and French doors, had large gaps between the door and frame and lacked adequate weatherstripping, which let in outside air. This was especially evident with the older homes that had doorframes that warped with age.
- Metal casement windows had latches and cranks that had fallen into disrepair and did not close properly and continuously vented to the outside.
- Dog doors, which consisted of hanging plastic flaps, provided a way for cold air to enter the residence like an open hatch.
- Fireplace dampers were found to be unattended and left in their open positions, even during the summer, which provided an effective exit for warm air, whenever the furnace called for heat.
- Walls had many holes that had been drilled by electricians and plumbers for wires and pipes that had been left uncaulked and allow air to leak through on circuitous pathways through walls.
- Spa motor access doors were found to be a significant source of cold air leakage into two of the residences.
- Attic access was provided through removable ceiling or wall panels that were not weatherstripped or insulated.
- Recessed ceiling lights were the original 'can lights', which were holes in

the ceiling with the insulation removed in the area of each light fixture to prevent overheating. Dust suspended in spiders' webs indicated the passage of warm air through the can lights to the outside.

- Return air chases used the space between structural members, such as exterior stud walls and floor joist cavities which substituted for ducts, and leaked air.
- Furnace and water heater closets were not adequately weatherstripped and insulated from conditioned spaces, which allowed cold air leakage.

The *Portola Valley Home Energy Study Report* in the appendix, presents more information with specific instances of air infiltration areas and what may be done to correct them. Most of the air infiltration problems mentioned here may be easily solved with sealers and weatherstripping, except for correcting the return air chases located within the wall and ceiling structure.

### **Standby Power Consumption**

Portola Valley residents avail themselves of advances in consumer electronics through an assortment of many devices employed in their homes. Many of these electronic devices have standby power consumption losses, however the audit did not find standby losses to be problematically high, averaging between 1%-2% of total electricity consumption. The standby loss measurements were lower than what we would have expected.

According to a study by the Lawrence Berkeley National Laboratories (LBNL) that was conducted on ten Northern California residences, the typical range was found to be between 5% and 26% of total electricity consumption, with an average of 9% for a typical number of 19 appliances with standby power.

Standby power, which is becoming increasingly more common with new appliances, can be elusive to measure when the power to the appliance cannot be completely turned-off without being unplugged. An easy way to check a household's standby power is to turn-off all electrical devices, either at the switch or by unplugging, and observe how much power is consumed over time, as recorded by the residence's utility kilowatt-hour meter. Choose a convenient time period, such as 10 minutes, and observe the motion of the horizontal round dial on the kilowatt-hour meter, which is calibrated in 10's for each mark on the dial. For example, if 2 watts of power is consumed in 10 minutes, it would represent approximately 105 kWh/yr of standby power losses, or 2% of 6000 kWh/year, similar to the kWh usage for houses A and B in *Table 4*.

**Table 4: CO<sub>2</sub> Emissions from Estimated Standby Power Consumption**

House	Annual kWh	Annual kWh CO <sub>2</sub> Emissions	2% Standby Power CO <sub>2</sub> Emissions
<b>A</b>	<b>5662</b>	<b>2968 pounds</b>	<b>59 pounds</b>
<b>B</b>	<b>6660</b>	<b>3490 pounds</b>	<b>70 pounds</b>
<b>C</b>	<b>22187</b>	<b>11626 pounds</b>	<b>233 pounds</b>
<b>D</b>	<b>7019</b>	<b>3679 pounds</b>	<b>74 pounds</b>
<b>E</b>	<b>10779</b>	<b>5642 pounds</b>	<b>113 pounds</b>

The *Portola Valley Home Energy Study Report* lists standby power for electrical devices, such as a computer with a touch screen with 111 watts and a laptop with 7 watts. Some of the more common devices that have standby power losses include the following: phone/fax/copier, computer, cordless phone, microwave oven, answering machine, garage door opener, automatic gate, DVD player, printer, television, internet terminal, cable box, satellite system, VCR, home security system, TiVo, and cell phone charger.

The *Report* recommends that a power strip be used to conveniently turn-off computer peripherals while keeping the computer on a different switch. The sleep mode for a computer will save energy although not as much as turning the computer off, and a blank screen on a monitor will save energy while a screen saver will not.

Appliances are also considered in the *Report*. Although new appliances will almost always be more efficient than older models, additional features are typically an enticement to consumers to upgrade and exchange improved efficiency for a net gain in consumption to power the additional features.

As the number of appliances in households increased over the last three decades, electrical energy consumption and CO<sub>2</sub> emissions from appliances started to rise rapidly. Lists of appliances are shown grouped by household usage, with a listing of associated CO<sub>2</sub> emissions for reference, as follows:

#### **Home Office Equipment Annual CO<sub>2</sub> Emissions**

- Computer with monitor                    121 pounds
- Cathode ray tube (CRT) monitor        91 pounds
- Liquid diode crystal (LCD) monitor    31 pounds
- Fax                                                181 pounds
- Printer                                           23 pounds
- Laptop computer                            23 pounds
- Home copier                                   14 lbs.

Televisions offer a wide spectrum of CO<sub>2</sub> emissions to choose from. Liquid diode crystals (LCD) televisions consume less electricity than plasma screens, and therefore have lower emissions. Some TV's come with backlighting, which may be turned down, and reduce electrical consumption. The following is a comparative list, with associated CO<sub>2</sub> emissions, of some of the more common household TV's and accessories that are in use:

#### **Television and Accessories Annual CO<sub>2</sub> Emissions**

▪ 60" plasma HDTV	755 pounds
▪ 52" LCD HDTV	377 pounds
▪ 42" plasma HDTV	377 pounds
▪ 42" LCD HDTV	252 pounds
▪ 36" rear-projection tube	167 pounds
▪ TiVo	181 pounds
▪ DVD player	45 pounds
▪ Video game	18 pounds
▪ VCR	17 pounds

The kitchen and laundry together account for most of the CO<sub>2</sub> emissions produced by household appliances. The auditor checks the number and volume of refrigerators and freezers, and notes if there are any beverage or wine chillers, and checks the temperature settings. The findings are presented in the Appendix. The following is a list of the typical electrical appliances found in the kitchen and laundry, with associated CO<sub>2</sub> emissions:

#### **Kitchen and Laundry Appliances Annual CO<sub>2</sub> Emissions**

▪ 22-cubic foot refrigerator auto-defrost	1270 pounds
▪ 17-cubic foot freezer	1358 pounds
▪ Dishwasher	226 pounds
▪ Oven with cook-top	157 pounds
▪ Oven self-cleaning	94 pounds
▪ Microwave	94 pounds
▪ Range top	75 pounds
▪ Coffee maker	74 pounds
▪ Toaster oven	60 pounds
▪ Toaster	19 pounds
▪ Clothes dryer	656 pounds
▪ Washer	63 pounds

Miscellaneous electrical devices that are household necessities, which also add to CO<sub>2</sub> emissions, are as follows:

### Miscellaneous Household Devices Annual CO<sub>2</sub> Emissions

▪ Cordless telephone	23 pounds
▪ Answering machine	45 pounds
▪ Cell phone recharger	14 pounds
▪ Small electric clock	14 pounds
▪ Ceiling fan	19 pounds
▪ Vacuum cleaner	72 pounds
▪ Electric blanket	125 pounds

Finally, some specialty household equipment for health and relaxation, listed with CO<sub>2</sub> emissions, are as follows:

### Specialty Household Equipment Annual CO<sub>2</sub> Emissions

▪ Spa tub, air jet	72 pounds
▪ Air Purifier	543 pounds
▪ Hot Tub, insulated	3735 pounds

The easiest way to start saving on the household electric bill and reduce CO<sub>2</sub> emissions is by exchanging incandescent light bulbs for compact fluorescent (CFL) bulbs. For the same amount of illumination, CFL's will reduce a household's lighting electricity consumption by 75%, and the bulbs will last up to ten times longer than incandescent bulbs. Nevertheless, the *Report* notes that only one out of five residences made extensive use of CFL's. Since lighting accounts for about 20% of the electricity consumed by the average residence, the exchange of incandescent lights for CFL's would reduce a household's electric bill by about 15%.

Recessed "can lights" are common in most Portola Valley residences. Each recessed can creates an opening in the ceiling, which should be properly sealed and insulated to reduce air infiltration. However, this energy conserving measure may trap enough heat from an incandescent bulb to cause it to activate a high temperature sensor and turn-off the fixture until it cools down. The problem can be solved by replacing an incandescent bulb with a more efficient and cooler CFL.

For the same light output, replacing an incandescent bulb with a CFL or light emitting diodes (LED) would reduce CO<sub>2</sub> emissions. The following compares the annual (2920 hours of usage) emission results:

- 60 watt light bulb..... 92 pounds of CO<sub>2</sub>
- 13 watt CFL bulb.....20 pounds of CO<sub>2</sub>
- 6.9 watt LED bulb.....11 pounds of CO<sub>2</sub>

## 8. Energy Saving Steps & Carbon Footprints

'Sustainable' is a concept linked with economy in the business community because businesses focus on what is directly measurable in dollars. That has changed recently. Prominent retail and restaurant franchises in the U.S. have come to the realization that the economy is part of a greater system called the ecology. Therein lies the key to business sustainability for restaurants such as McDonald's, which has a prototype in Chicago, with high efficiency appliances, pavement that filters and collects rainwater into cisterns, less toxic cleaners for maintenance, and green roof gardens to reduce cooling loads and extend roof life. Pizza Fusion, a chain in Florida, makes use of waste heat from their ovens to produce hot water. Even a burrito chain, Chipotle, has a wind turbine for generating electricity outside its restaurant in Chicago. Granted, this can be discredited as merely an attempt to curry favor with customers, but businesses are making significant investments in creative ways to save energy and resources that go far beyond the obvious attention grabbers.

Other businesses making similar energy and resource conservation choices, include: Wal-Mart, Subway, Target, Office Depot, Staples, Best Buy, and Kohl's. They claim they save 20% to 45% on energy costs compared to conventional stores. They monitor their bottom line, and report it's just a better way to run a business. So what is everyone waiting for? Does McDonald's have to unveil its green roof organic vegetable garden for an offering of fresh organic vegan burgers to promote good health and longevity for its customers, for households to realize that sustainability is also a better way to run residential communities, not just the business community?

How does a household establish a goal for sustainability? According to a recent M.I.T. study, "Environmental Life Style Analysis", presented at the International Symposium on Electronics and the Environment, held in San Francisco in May, 2008, the U.S. per capita CO<sub>2</sub> emissions is five times the World average. In all fairness, this reveals the magnitude of the problem because it means that, on the average, U.S. residents would need to reduce their CO<sub>2</sub> emissions by 80% to approach sustainability. Weighing in at a colossal 106,000 pounds of annual CO<sub>2</sub> emissions, an average U.S. household would also need to reduce emissions by approximately 80%, or about 84,000 pounds of annual CO<sub>2</sub> emissions to equal the World average. The M.I.T. study believes that "tolerable changes in a life style" could lead to a 30% reduction in CO<sub>2</sub> emissions. Consequently, that is the initial focus of our energy saving steps.

As with many journeys, the long journey to sustainability starts with a single step. However, prior to taking an energy saving step, a household's energy consumption should be established as a datum point for comparison. Consequently, a home energy audit begins with a record of the previous year's PG&E and water bill. Utility bills are available online at <http://www.pge.com/myhome/myaccount/myaccount/> or by calling 1-800-743-5000.

The following is an action list a household may use to reduce CO<sub>2</sub> emissions by saving energy, and resources, and by making environmentally friendly choices while also promoting indoor air quality, comfort, and health. To promote "thinking outside the box" and for making informed decisions within a greater context for comparison, a broad perspective has been applied to a list of energy saving steps, which includes all three major residential categories of housing, transportation, and food. As you scan the energy saving list, a helpful perspective may be to keep in mind that a typical car produces about 1 pound of CO<sub>2</sub> per mile. Water usage will be addressed in the following chapter. Initial steps towards sustainability may be taken with the following list:<sup>1</sup>

- **Clean** with natural cleaners. For more information: [www.housekeeping.about.com/od/environment/f/greenclean.htm](http://www.housekeeping.about.com/od/environment/f/greenclean.htm)
- **Spend** money in environmentally friendly ways<sup>2</sup>
- **Turn-off** standby power for electronic devices  
Eliminate 59 – 233 pounds of CO<sub>2</sub> emissions per year<sup>3</sup>

1

Residential CO<sub>2</sub> emissions are based on computer modeling of house A, unless otherwise noted.

2

"Environmental Life Style Analysis", which is referenced in the text, above, states the following: "Generally, anything that is expensive but does not consume energy and/or material resources leads to a lower environmental profile. This includes a wide range of activities that require skilled individuals, as listed above [e.g., vegetarian diet, increase educational activities, personal trainer, psychoanalysis, law services, repair and maintenance, etc.]. Of course, this does not account for how those who receive these payments might alter their spending habits."

3

This is based on measurements taken at each of the five Portola Valley residences appearing in the *Portola Valley Home Energy Study Report*. Our measurements found standby power to be between 1%-2% of total electricity consumption. Our results do not agree with a study done by the Lawrence Berkeley National Laboratories (LBNL) on ten Northern California residences, that found a range between 5% and 26%, with an average of 9% for a typical number of 19 appliances with standby power: "Whole-House Measurements of Standby Power Consumption", Second International Conference on Energy Efficiency in Household Appliances, Naples (Italy), September 2000. Also published as LBNL-45967, Ross, J.P., Meier, Alan.

- **Do 2 Less Loads** of laundry per week with ENERGY STAR machine  
50 pounds of CO<sub>2</sub> emissions eliminated per year
- **Do 2 Less Loads** of laundry per week with typical washing machine  
100 pounds of CO<sub>2</sub> emissions eliminated per year
- **Increase Ceiling Insulation** from R-19 (6 ½") to R-30 (9 ½")  
228 pounds of CO<sub>2</sub> emissions eliminated per year
- **Take Family Car Camping** : 1 month and 3000 miles in S.U.V.  
369 – 686 pounds of CO<sub>2</sub> emissions eliminated per trip
- **Replace Conventional Washing Machine** with ENERGY STAR rated  
500 pounds of CO<sub>2</sub> emissions eliminated per year
- **Wash laundry in cold water** using cold-water detergent. For more:  
–Go to [www.mge.com/home/appliances/laundry/](http://www.mge.com/home/appliances/laundry/)  
200 – 700 pounds of CO<sub>2</sub> emissions eliminated per year
- **More Efficient Use of Space** instead of adding 200 SF to house  
600 pounds of CO<sub>2</sub> emissions eliminated per year
- **Lower Water Heater Temperature** from 140°F to 120°F.  
600 pounds of CO<sub>2</sub> emissions eliminated per year
- **Install Occupancy Sensors** on Incandescent light fixtures  
600 pounds of CO<sub>2</sub> emissions eliminated per year
- **Take 1 Less Short Flight** on a commercial aircraft  
800 pounds of CO<sub>2</sub> emissions per person eliminated per year
- **Replace Incandescent** with compact fluorescent light bulbs  
900 pounds of CO<sub>2</sub> emissions eliminated per year
- **Stop Junk Mail** from being delivered to residence. For more:  
–Go to [www.GreenDimes.com](http://www.GreenDimes.com) or [www.41pounds.org](http://www.41pounds.org)  
1000 pounds of CO<sub>2</sub> emissions eliminated per year
- **Walk or Bike** two miles per day instead of driving a car.  
350 – 1200 pounds of CO<sub>2</sub> emissions eliminated per year
- **Recycle** glass bottles, aluminum cans, plastic, and paper  
1200 pounds of CO<sub>2</sub> emissions eliminated per year (2 people)

- **Eat local** food. For more information, go to:  
[www.cmu.edu/news/archive/2008/April/april17\\_foodmiles.shtml](http://www.cmu.edu/news/archive/2008/April/april17_foodmiles.shtml)  
1000 – 1500 pounds of CO<sub>2</sub> emissions eliminated per year
- **Eat chicken or fish** instead of meat, one day per week.  
[www.cmu.edu/news/archive/2008/April/april17\\_foodmiles.shtml](http://www.cmu.edu/news/archive/2008/April/april17_foodmiles.shtml)  
1000 – 1500 pounds of CO<sub>2</sub> emissions eliminated per year
- **Eat organic** food.  
1800 pounds of CO<sub>2</sub> emissions eliminated per year (2 people)
- **Maintain Air Filter** for car engine air intake (replace twice per year)  
1800 pounds of CO<sub>2</sub> emissions eliminated per year
- **Weatherstrip** house to CA Energy Code standards.  
2050 pounds of CO<sub>2</sub> emissions eliminated per year<sup>4</sup>
- **Seal Ducts** to meet CA Energy Code standards for heating and A/C  
3850 pounds of CO<sub>2</sub> emissions eliminated per year

Sealing leaky ducts is clearly the most effective action to take around the house to save energy. Nevertheless, there isn't a single solution that will solve the problem of emissions, but rather, many choices that must be made to create a solution. What is also quite evident is that there are many opportunities available to a household for saving energy when a broader perspective is applied to the problem. All of the interdependent categories of housing, transportation, and food need to be included in a household's energy saving choices to effectively reduce emissions.

The M.I.T. study went on to predict that a reduction in CO<sub>2</sub> emissions beyond 30% would require federal, state, and local government involvement because voluntary action by individuals would probably not be reliable. For those of you who would take exception to such a statement and would consider yourselves to be reliable, within the context of energy and resource conservation, additional steps towards sustainability may readily be taken, as follows:

- **Install Solar Powered Attic Fan** to reduce A/C cooling load  
100 pounds of CO<sub>2</sub> emissions eliminated per year

4

This is based on blower door test measurements conducted on each of the five Portola Valley residences appearing in the *Portola Valley Home Energy Study Report*. The highest infiltration rate was approximately ten times the lowest infiltration rate among the five residences measured. The average infiltration rate was calculated for the average house size, which resulted in an average elimination of 2050 pounds of CO<sub>2</sub> emissions per year.

- **Raise Thermostat 2°F** to reduce A/C cooling load  
175 pounds of CO<sub>2</sub> emissions eliminated per year
- **Substitute Solar Powered Attic Fan** for A/C cooling  
580 pounds of CO<sub>2</sub> emissions eliminated per year
- **Compost** food scraps and yard trimmings  
800 pounds of CO<sub>2</sub> emissions eliminated per year
- **Maintain Optimum Tire Pressure** for car  
800 pounds of CO<sub>2</sub> emissions eliminated per year
- **Replace Storage Type Water Heater** with instant water heater  
850 pounds of CO<sub>2</sub> emissions eliminated per year
- **Replace Incandescent bulbs** with LED lights  
1050 pounds of CO<sub>2</sub> emissions eliminated per year
- **Drive 55mph** instead of 65 mph on highway  
1100 pounds of CO<sub>2</sub> emissions eliminated per year
- **More Efficient Use of Space** instead of adding 400 SF to house  
1200 pounds of CO<sub>2</sub> emissions eliminated per year
- **Install Photovoltaic System** panels to supply electricity  
1800 pounds of CO<sub>2</sub> emissions eliminated per year
- **Install Solar Water Heater** panels to supply domestic hot water  
1900 pounds of CO<sub>2</sub> emissions eliminated per year
- **Maintain Clean Air Filter** for car engine air intake (check monthly)  
3000 pounds of CO<sub>2</sub> emissions eliminated per year
- **Take 1 Less Long Flight** on a commercial aircraft  
4400 pounds of CO<sub>2</sub> emissions eliminated per person per year
- **Remove Roof Rack** from car whenever rack is not in use  
4900 pounds of CO<sub>2</sub> emissions eliminated per year
- **Replace Toyota Prius** with Tesla electric car  
6050 pounds of CO<sub>2</sub> emissions eliminated per year
- **Lower Thermostat to 60°F** for heating [and wear sweaters]  
7465 pounds of CO<sub>2</sub> emissions eliminated per year

- **Retro-fit House** to high performance windows and wall insulation  
8000 pounds of CO<sub>2</sub> emissions eliminated per year
- **Install Solar Space Heating** thermal energy transfer system  
8439 pounds of CO<sub>2</sub> emissions eliminated per year
- **Replace Mercedes ML320 SUV** with Toyota Prius hybrid car  
8700 pounds of CO<sub>2</sub> emissions eliminated per year
- **Walk or Bike** twenty miles per day instead of driving a car  
3500 – 12000 pounds of CO<sub>2</sub> emissions eliminated per year
- **Eat chicken or fish** instead of meat or dairy products  
7000 – 10500 pounds of CO<sub>2</sub> emissions eliminated per year
- **Eat vegetables** instead of meat or dairy products  
8000 – 12000 pounds of CO<sub>2</sub> emissions eliminated per year

Perhaps it may come as a surprise to some, that many choices for saving energy and reducing CO<sub>2</sub> emissions are not dependent on a financial investment or technical breakthrough. For example, if a household is going to pay for a photovoltaic system to supply electricity, wouldn't it make sense to also protect one's investment by making sure that the 1800 pounds of CO<sub>2</sub> emission that is saved, at a cost of about \$25,000 for a solar electric system, isn't simply squandered by a household's dirty little air filter in the car, for example, or by not stopping junk mail from being delivered to the mailbox? How about taking the next obvious step and eating chicken or fish instead of meat to eliminate up to 10500 pounds of CO<sub>2</sub> emissions annually? Fortunately, many of the most significant choices a household can make are lifestyle choices that anyone can make today to save money, improve health and comfort, and reduce CO<sub>2</sub> emissions.

Finally, the M.I.T. study demonstrated that government is responsible for 43% of U.S. per capita CO<sub>2</sub> emissions through the amount of infrastructure and subsidies it makes available to U.S. residents. According to the study, a U.S. household cannot reduce its CO<sub>2</sub> emissions by more than 57% without government assistance. The study concludes, unless government takes an active role in energy and resource conservation management, CO<sub>2</sub> emissions by U.S. households cannot possibly be reduced to less than double the World average.

Government clearly has an important role to play. What can local government do for its part in reducing CO<sub>2</sub> emissions? The following is a list of recommendations:

- Adopt a green building ordinance for new construction, which provides an accelerated permit process as a voluntary incentive for greener projects.
- Provide incentives for residents who can demonstrate energy savings on a monthly basis, compared with a previous year's benchmark.
- With the assistance of PG&E, collect utility data from Portola Valley addresses and post it on the town's website each month to keep the community informed of its relative standing with respect to local and national goals.
- Create a comprehensive green household ordinance that considers all of a household's CO<sub>2</sub> emissions, such as emissions from vehicles.
- Coordinate ride sharing through the Town's website.
- Provide a free shuttle service for commuters to the nearest train and light-rail station.
- Create a Community Supported Agriculture (CSA) organic farm.
- Allow salvage sales, associated with construction, to occur on weekends.
- Cut solar panel permit fees to zero.
- Allow solar panels to be placed within property setbacks.
- Convert the Town's fleet of vehicles to electric.
- Allow only electric chainsaws, mowers, and blowers.
- Allow existing adjacent residences to organize into cohousing units.

## 9. Energy Saving Steps & Water Consumption

Why is water consumption an important issue for an energy study? Some renewable energy sources consume large quantities of water while others consume very little water. For the Town of Portola Valley, which is vulnerable to drought, consideration must be given to the impact of energy saving steps on water consumption for sustainability because a community can survive without oil but not without water.

For purposes of our discussion, it would be helpful to think of water as energy in liquid form. Rain may be thought of as “liquid sunshine” because rain is created with energy from the sun through the evaporation of water. Currently, 32% of California’s natural gas and 19% of the state’s electricity is consumed in the processing and distribution of water, and large quantities of water are used in the production of energy and power.

Thermoelectric power plants require large quantities of water to clean equipment, remove excess heat, scrub pollutants, and create steam for turbines that power generators. Unfortunately, some alternative energy sources present a dilemma, such as, hydrogen, ethanol, and biodiesel, which all require much more water than conventional fossil fuel energy sources use.

Thermoelectric power plants in the US, consume 136 billion gallons of water per day. When the conversion is made to power, 25 gallons of fresh water are consumed for each kilowatt-hour (kWh) of electricity that is produced.<sup>5</sup> For California, that translates into billions of gallons of water consumed per day to produce electricity. Moreover, as the demand for energy grows with the California population, which is predicted to grow by 30% by 2030, the demand for water to produce energy will also increase.

Since water uses energy, and energy uses water, it is important to not only consider water conservation at the spigot but the energy sources that are conserving of water. Energy production and generation technologies vary tremendously with respect to water consumption. For example, a nuclear power plant consumes the most water of all means of power generation with approximately 100 to 300 times the water consumption of a hydroelectric plant for the same power

5

“The Intertwined Tale of Energy and Water”, Hill, Rachele, Younos, Dr. Tamim, Virginia Water Resources Center, College of Natural Resources, Virginia Polytechnic Institute and State University, Blacksburg, Va. April, 2008.

output. Even replacing an aging fossil fuel burning power plant with a nuclear power plant, would increase water consumption by 2 to 3 times. In stark contrast, a residential photovoltaic system also generates power but consumes very little water, depending upon how often the panels are cleaned with water.

“By wringing every bit of utility from every drop of water, Californians can stretch water supplies and help ensure continued economic and environmental health in anticipation of droughts and population pressures on limited water resources.” This is California’s plan for providing its growing population with adequate water for the 21st century. However, limiting our attention to drought resistant green plants will not be “wringing every bit of utility from every drop of water”. We also need drought resistant “energy plants”, such as solar collectors, in addition to the collection of rainwater for drought resistant green plants.

For the same light output, replacing an incandescent bulb with a CFL or light emitting diodes (LED) would reduce water consumption for power generation. The following compares the annual (2920 hours) usage with water consumption for three types of light bulbs:

- 60 watt light bulb..... 2000 to 4200 gallons
- 13 watt CFL bulb.....430 to 910 gallons
- 6.9 watt LED bulb.....240 to 500 gallons

Water is not only essential for the functioning of biological systems, it is used for the production of energy and power generation for a community. Because the production of energy consumes water, saving energy will also save water. The following list is similar to the list appearing in the “Energy Savings & Carbon Footprints” chapter and was prepared for the purpose of showing the relationship between CO<sub>2</sub> emissions eliminated, shown on the previous list, with gallons of fresh water saved. It is also an action list a household may use to reduce water consumption by making environmentally friendly choices. Similar to the Energy Saving Steps list, a broad perspective has been applied to the ways to save water, which includes all three major residential categories of housing, transportation, and food. The following household action list shows how many gallons of water are saved, both directly through water conservation and indirectly from energy saved, from least effective to most effective:

- **Replace Toyota Prius** with Tesla electric car  
No gallons of fresh water saved per year

- **Increase Ceiling Insulation** from R-19 (6 ½") to R-30 (9 ½")  
6 gallons of fresh water saved per year
- **Wash laundry in cold water** using cold-water detergent.  
4 – 14 gallons of fresh water saved per year
- **More Efficient Use of Space** instead of adding 200 SF to house  
16 gallons of fresh water saved per year
- **Lower Water Heater Temperature** from 140°F to 120°F.  
16 gallons of fresh water saved per year
- **Replace Storage Type Water Heater** with instant water heater  
22 gallons of fresh water saved per year (plus water)
- **More Efficient Use of Space** instead of adding 400 SF to house  
32 gallons of fresh water saved per year
- **Install Solar Water Heater** panels to supply domestic hot water  
50 gallons of fresh water saved per year
- **Weatherstrip** house to CA Energy Code standards.  
54 gallons of fresh water saved per year
- **Seal Ducts** to meet CA Energy Code standards for heating and A/C  
102 gallons of fresh water saved per year
- **Lower Thermostat to 60°F** for heating [and wear sweaters]  
198 gallons of fresh water saved per year
- **Retro-fit House** to high performance windows and wall insulation  
212 gallons of fresh water saved per year
- **Install Solar Space Heating** thermal energy transfer system  
224 gallons of fresh water saved per year
- **Do 2 Less Loads** of laundry per week with ENERGY STAR machine  
2200 gallons of fresh water saved per year
- **Fix Leaky Faucet**  
2500 gallons of fresh water saved per leaky faucet per year
- **Take Family Car Camping:** 1 month and 3000 miles in S.U.V.  
3000 gallons of fresh water saved per trip

- **Put Aerators On** kitchen and bathroom sink faucets  
3300 gallons of fresh water saved per year
- **Install Solar Powered Attic Fan** to reduce A/C cooling load  
2170 – 4560 gallons of fresh water saved per year
- **Do 2 Less Loads** of laundry per week with typical washing machine  
5000 gallons of fresh water saved per year
- **Replace Conventional Washing Machine** with ENERGY STAR rated  
4700 – 6700 gallons of fresh water saved per year
- **Raise Thermostat 2°F** to reduce A/C cooling load  
3800 – 7990 gallons of fresh water saved per year
- **Compost** food scraps and yard trimmings  
8500 – 17100 gallons of fresh water saved per year
- **Maintain Optimum Tire Pressure** for car  
8500 – 17100 gallons of fresh water saved per year
- **Take 1 Less Short Flight** on a commercial aircraft  
8500 – 17100 gallons of fresh water saved per flight
- **Stop Junk Mail** from being delivered to residence.  
10600 – 21400 gallons of fresh water saved per year
- **Drive 55mph** instead of 65 mph on highway  
11700 – 23500 gallons of fresh water saved per year
- **Walk or Bike** two miles per day instead of driving a car.  
3700 – 25700 gallons of fresh water saved per year
- **Replace Old Toilets** with 1.6 gallons or less low-flush toilets  
14000 – 25000 gallons of fresh water saved per year
- **Substitute Solar Powered Attic Fan** for A/C cooling  
12610 – 26480 gallons of fresh water saved per year
- **Install Occupancy Sensors** on Incandescent light fixtures  
13000 – 27400 gallons of fresh water saved per year
- **Replace Standard Showerheads** with energy efficient showerheads  
28000 gallons of fresh water saved per year

- **Eat local food.**  
10500 – 32000 gallons of fresh water saved per year
- **Harvest “liquid sunshine”** for irrigation from 2000 SF roof  
34800 gallons of fresh water saved per year
- **Eat organic food.**  
19000 – 38500 gallons of fresh water saved per year (2 people)
- **Maintain Air Filter** for car engine air intake, replace twice per year  
19000 – 38500 gallons of fresh water saved per year
- **Replace Incandescent** with compact fluorescent light bulbs  
19550 – 41090 gallons of fresh water saved per year
- **Replace Incandescent bulbs** with LED lights  
22820 – 47930 gallons of fresh water saved per year
- **Maintain Clean Air Filter** for car engine air intake, check monthly  
31800 – 64200 gallons of fresh water saved per year
- **Repair Leaky Toilet**  
73,000 gallons of fresh water saved per toilet per year
- **Install Photovoltaic System** panels to supply electricity  
39130 – 82170 gallons of fresh water saved per year
- **Take 1 Less Long Flight** on a commercial aircraft  
47000 – 94000 gallons of fresh water saved per flight
- **Remove Roof Rack** from car whenever rack is not in use  
51900 – 104700 gallons of fresh water saved per year
- **Eat chicken or fish** instead of meat, one day per week.  
92000 – 113000 gallons of fresh water saved per year
- **Replace Mercedes ML320 SUV** with Toyota Prius hybrid car  
90000 – 186000 gallons of fresh water saved per year
- **Walk or Bike** twenty miles per day instead of driving a car  
37000 – 257000 gallons of fresh water saved per year
- **Eat chicken or fish** instead of meat or dairy products  
600000 – 750000 gallons of fresh water saved per year

- **Eat vegetables** instead of meat or dairy products  
640000 – 800000 gallons of fresh water saved per year

In a community's efforts to save energy and eliminate CO<sub>2</sub> emissions, it is important to understand that water conservation is as important if not more important to the sustainability of a community that is vulnerable to drought. As conventional fossil fuel energy sources are replaced by renewable energy sources, a priority needs to be placed on the use of energy sources that do not consume large quantities of water.

The above action list shows that the most significant water saving steps can be achieved by simply making environmentally friendly choices, many of which fall outside the realm of the house, but under the categories of household transportation and food. Nevertheless, many of these choices may be difficult for a household to make because of an established reliance on existing infrastructure that is based on government or institutional decisions, such as providing safe walking and bicycling paths as an alternative to driving. Government will need to take an active role to enable households to make many environmentally friendly choices to reduce water consumption in a safe and practical manner.

In addition, there is an urgent need for PG&E to implement a more comprehensive energy policy that includes water consumption as a result of energy production and generation, which would incorporate more drought tolerant sources of power. PG&E's current energy mixture includes 22% nuclear, which is not a drought tolerant means of energy generation because the process relies on a very inefficient use of water, as noted in the text above.

The first entry on the list above is: "**Replace Toyota Prius** with Tesla electric car", which resulted in, "No gallons of fresh water saved per year". This is because the calculation for 'water saved' was based on PG&E supplying the electric power to the Tesla. However, if the sun or wind, for example, had generated the electric power for the Tesla, such as with solar panels, instead of through PG&E, the result would have been, 150,000 gallons of fresh water saved per year.

This points to an inefficient use of water through PG&E's current energy mixture. In effect, PG&E is competing for water with the Town of Portola Valley to supply it with energy that has lower CO<sub>2</sub> emissions. This could develop into a growing competition for dwindling water resources between PG&E and the Town of Portola Valley, and the other surrounding communities that are also vulnerable to drought. The question is: can PG&E create an energy mixture that will consume less water? The answer

may be for PG&E to change its current energy policy to allow households to install photovoltaic panels that are large enough to power both a residence and household vehicles. Current PG&E policy limits the size of photovoltaic panels to only meet the power requirements of a residence for the purpose of limiting the utility's investment in infrastructure. But, maybe it's time to "think outside of the box", don't you think?