Residential Energy Efficiency Measures

Introduction

There are a number of cost-effective energy saving technologies, design strategies, construction methods and operational techniques to optimize the energy efficiency of residential buildings. For new construction in particular, there is a unique opportunity to incorporate *integrated* design strategies among multiple building systems for maximum overall building efficiency and operating cost reductions.

One of the most important reasons for lower energy use in California buildings over the last 25 years is a result of the *Energy Efficiency Standards* for Residential and Nonresidential Buildings that were established in 1978 in response to a legislative mandate to reduce California's energy consumption. California's Building and Appliance Efficiency Standards have saved more than $20 billion in electricity and natural gas costs over this period. Moreover, it is estimated that the Standards will save $57 billion by the year 2011[i]. New California homes that meet the Standards use approximately 52% less energy than before the Standards were established.[ii] This does not count the potential for those homes that exceed the Standards…

A typical residential building in California has a number of distinct end-use energy loads. For example, the top 3 *electricity* consuming end-uses in a typical California home are: lighting and miscellaneous electrical loads at 33%, followed by refrigeration at 23%, and major appliances at 12%. Likewise, the top 3 *natural gas* consuming end-uses in these residences are: space heating at 45%, water heating at 38%, and cooking at 6%.[iii]

Energy Solutions for Residences

There are several building systems and components common to most residences that can be investigated for energy efficiency potential:

Building Envelope

The building envelope includes everything that separates the interior of a building from the outdoor environment, including the windows, walls, foundation, ceiling, roof, and insulation. Some specific envelope measures include:

[i] http://www.energy.ca.gov/title24/
[ii] http://www.energy.ca.gov/efficiency/home_energy_guide/CHARTS_AND_GLOSSARY.PDF
[iii] http://www.energy.ca.gov/reports/98_baseline_outlook.html, Figures 8 and 9

1. Insulation: Envelope insulation should have a thermal value optimized for the microclimate zone of the home and encapsulates the entire occupied space that is air-conditioned – either by entirely filling the cavity between the structural system or through the use of an *exterior-applied insulation system* that also reduces air leakage. Stud framing can be omitted entirely with *Structural Insulated Panels* comprised of a foam-core sandwich panel, and have been shown to save 10-15% more in the winter than conventional wood framing assemblies[iv], and have as much as 15 times less air leakage[v]. Doors should have *weather stripping* and windows should be *caulked*.

2. Radiant Barrier: The addition of a *radiant barrier* under the roof can lower the heat gain another 10-15% by blocking 95-97% of the radiated energy from the roof[vi].

3. House Wraps: These are membranes that wrap around the entire envelope of the living space like a "wind breaker" for the home, and they reduce air infiltration to preserve the R-value of the wall, floor and/or ceiling insulation while also acting as a secondary protection to the primary siding material from water penetration.

4. Fenestration: *High performance* windows, glazed doors and skylights reduce heating and cooling energy costs; improve occupant comfort and enable greater utilization of floor areas on perimeter zones; improve noise control and condensation resistance; minimize fading of interior furnishings; and increase the resale value of a property. *Spectrally-selective glazings* use a low-emissivity coating to minimize ultraviolet transmission, maximize the visible light admitted, and reduce solar heat gain in the summer and heat loss in the winter. This type of glazing typically lowers solar gain and heat loss by 25-45% with only a 10-15% reduction in visible light transmission – while tinted glass or reflective coatings can also be used for additional solar control [vii].

5. Shading: *Exterior shading systems* such as fixed overhangs, fins, awnings and operable, louvers, shutters, awnings or weave screens block the solar gain before it enters the fenestration assembly, while *integral and interior shading systems* are secondary options for solar gain, glare and heat loss control. Solar screens resemble standard window screens and can block up to 85% of the sun's heat from entering the home.[viii] Such shading control can lower the space temperature in spaces adjacent to windows by as much as 20 degrees Fahrenheit on a hot day[ix].

Landscaping

By strategically placing *vegetation and trees* immediately adjacent to the building envelope, incoming solar heat gain and glare through fenestration is reduced and cold

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[iv] http://www.eren.doe.gov/consumerinfo/refbriefs/bd1.html

[v] http://www.sipweb.com/about/benefits.asp and "New Oak Ridge Tests Verify SIP Performance Advantage" at http://www.sips.org/

[vi] http://www.eren.doe.gov/consumerinfo/refbriefs/bc7.html

[vii] Performance values calculated per representative comparison of 1" nominal Guardian Dual-Pane Clear with 1" nominal Cardinal LoE2-172 Clear

[viii] http://www.energy.ca.gov/efficiency/home_energy_guide/WINDOWS.PDF

[ix] http://www.energyloans.org/EnergyReference/body_awnings.html

prevailing winds are obstructed, thereby lowering cooling and heating costs while improving occupant comfort. Deciduous trees offer one of the best year-round ways to save energy by blocking the summer sun for solar control and dropping their leaves in the winter to admit more solar gain through fenestration[x]. This practice in conjunction with *light colored hardscape* elements and reflective Cool Roof materials also reduces the "Urban Heat Island Effect" that raises the overall average air temperature of the region.

Lighting

Lighting accounts for about 25% of all electricity used in a California home. Indoor and outdoor lighting fixtures need to be designed in a manner appropriate to the task to prevent illumination levels higher than necessary at any time throughout the day. Efficient indoor lighting systems also reduce heat gain to the space that in turn lowers air conditioning costs. Some specific areas include:

1. Skylights: These provide additional *daylight* and can be either fixed or operable for square and rectangular shaped skylights, and in static or mechanically ventilated configurations for tubular shaped skylights. They can also be augmented with electrical lighting assemblies below or inside the skylight for nighttime illumination.

2. Lamps: *High efficacy lamps* offer the highest lumens per watt efficiency possible. One easy way to reduce your electric bill without sacrificing the quality of your home lighting is to replace your incandescent light bulbs with *compact fluorescent* lights. Compact fluorescents come in a variety of sizes, shapes, and wattages to fit most lamps and light fixtures. The light they provide is a soft, warm color, similar to incandescents, but they use up to 75% less energy, and last approximately 10,000 hours. That is about ten times longer than a regular incandescent light bulb.

   Halogen lights were once considered the lighting of the future. Although some halogens use up to 20 percent less energy than incandescent lights, they are far less efficient than compact fluorescents. Popular halogen torchieres use bulbs in the 300-watt range. New compact fluorescent torchieres use two 36-watt lamps that provide 25 percent more light – yet use one-fourth the energy of the halogen lamp. The new compact fluorescent torchieres are also far safer than the halogen ones because they do not operate at the same high temperatures.[xi]

3. Controls: Interior *automated lighting controls* typically save 20-40% through the use of *occupancy sensors* to turn off the lights when spaces are unoccupied. Exterior lights should be controlled by *motion sensors, photocells or timeclocks* to reduce unnecessary hours of lighting electricity use.

Mechanical

Low energy-consuming mechanical heating and cooling systems are possible through the use of thoughtful building envelope design, siting and orientation, followed by: high

[x] http://www.energy.ca.gov/efficiency/home_energy_guide/LANDSCAPING.PDF
[xi] http://www.energy.ca.gov/efficiency/home_energy_guide/LIGHTING.PDF

efficiency equipment, automated controls, improved duct systems, and various advanced technologies. In addition, energy-efficient domestic water heating combined with water-efficient appliances and fixtures will save water, energy, and money.

1. Space Heating Systems: Should be properly zoned, sized and installed. Furnaces, heaters and air-source heat pumps should meet or exceed California's *Appliance Efficiency Standards.*[xii] *Variable speed* furnace and heat pump fan motors reduce energy usage by matching their speed to the *actual* building space heating and cooling loads, and often operate at low heating capacity 90% of the time – thereby saving energy, extending equipment life, improving occupant comfort, lowering fan noise, and improving indoor air quality.[xiii] Consider reclaiming furnace exhaust flue waste heat with *heat recovery systems* to preheat the furnace combustion air or domestic hot water. *Ceiling fans* reduce stratification and increase task-level space temperatures, allowing occupants to lower the thermostat setpoint.

2. Space Cooling Systems: Should be properly zoned, sized and installed. Air conditioners and air-source heat pumps should meet or exceed California's *Appliance Efficiency Standards*, while packaged terminal heat pumps should meet or exceed California's *Building Energy Efficiency Standards*. *Variable speed* furnace and heat pump fan motors that provide airflow for the indoor cooling coil reduce energy usage by matching their speed to the *actual* building space cooling loads – thereby saving energy, improving humidity control and occupant comfort, extending equipment life, and improving indoor air quality.[xiv] Also, utilize *evaporative cooling systems* in lieu of compressor-based refrigerant air conditioning systems wherever possible. Consider reclaiming waste heat off the condenser with a *heat recovery system* to preheat domestic hot water loads. *Ceiling fans* reduce stratification and decrease task-level space temperatures, allowing occupants to raise the thermostat setpoint. *Use ceiling as well as portable fans* in lieu of mechanical cooling whenever possible.

3. Ductwork: Ensure that ducts are insulated adequately, unobstructed, and the joints are held together with mastic or mechanical hose clamps instead of duct tape that can fail over time. Also ensure that *air cleaners are cleaned or replaced regularly* – as excess loading on the filter increasing fan energy and decreases their filtration effectiveness.

4. Ventilation & Exhaust: Ventilation provides fresh, outside air to a conditioned space; while exhaust removes unwanted air from a space to the outside.

    - Strategically open *operable windows and skylights* to optimize natural cross-ventilation and stack-effect airflows by opening them "offset" from each other.

    - Attic temperatures can rise to 150ºF in some cases, and even with a well-insulated ceiling – this heat can seep from your attic into your home.[xv] A *whole house fan*, however, can help keep your home much more comfortable. They

[xii] http://www.energy.ca.gov/efficiency/appliances/index.html
[xiii] http://www.indoorweather.com/tech/set_comfheat.htm
[xiv] http://www.indoorweather.com/tech/set_comfheat.htm
[xv] http://www.energy.ca.gov/efficiency/home_energy_guide/FANS.PDF

draw cooler outside air in through your open windows during the evening and early morning hours while forcing the residual hot air in the attic out through the roof vents. This reduces or defers the need to mechanically air condition the space the following afternoon.

- Use *energy recovery ventilation* through the use of air-to-air heat exchangers. These systems preheat the colder incoming winter ventilation air with the warmer stale exhaust air – lowering heating costs while recovering up to 85% of the exhausted heat;[xvi] likewise, they pre-cool the warmer incoming summer air with the outgoing cooler air – lowering cooling costs. They also improve indoor air quality and humidity levels. [xvii]

- Bathroom fans should use *timer-switches* for automatic shut-off after occupants leave the room for ideal odor and moisture control and energy savings.

5. Programmable Setback Thermostats: These thermostats typically save 15-75% on your heating and cooling costs while maintaining your home's comfort. Programmable thermostats allow you to enter at least one "at home" and "away from home" schedule for the weekdays and one for the weekend. Others feature full seven-day programming, enabling you to customize your heating and cooling system for any day of the week. Some models will start your furnace or air conditioner at the time you specify, some can be controlled by an incoming signal from your utility to respond to peak electrical emergencies, while others reach the temperature you want at the time you want.[xviii]

6. Water Heating: Use *high-efficiency* water heaters, *low-flow* fixtures and appliances, *sufficient insulation* on storage tanks and pipe runs, *hot water recovery systems* for end uses that are at extended distances from the water heater, or *instantaneous ("tankless") water heaters* at the point of use to avoid piping and storage tank thermal losses.

7. Pool and Spa Pumping: Pool and spa pumps are typically the largest pumping systems for a home. *Premium efficiency motors* can cut this energy use by at least 12%[xix]. Energy-efficient motors offer other benefits as well. Because they are constructed with improved manufacturing techniques and superior materials, energy-efficient motors usually have longer insulation and bearing lives, lower waste heat output, and less vibration – all of which increase reliability[xx]. *DC motors* are well suited to pool filtration pumping because they can also be powered directly by photovoltaic systems, which provide their greatest direct current output at the same time the need for filtration is greatest: during sunny weather when usage and algae growth are highest.[xxi]

[xvi] http://www.otpco.com/home/products_heat_comftHtex.asp
[xvii] http://www.aprilaire.com/category.asp?id=9CC6090D12294A40B6DBF3B28DADEFC1
[xviii] http://www.energy.ca.gov/efficiency/home_energy_guide/SETBACK_THERMOSTATS.PDF
[xix] http://www.eren.doe.gov/EE/industry.html
[xx] http://www.oit.doe.gov/bestpractices/motors/factsheets/mc-0382.pdf
[xxi] http://dankoffsolar.com/Solar_Water_Pumps/Surface_Pumps/Dankoff_Solar_Pool_Pump/index.html

Appliances

Look for the federal *EnergyGuide* labels for rated efficiency comparisons as well as *ENERGY STAR* rated products that offer additional energy savings potential. For example, refrigerators are the largest electricity-consuming appliances, averaging almost one-quarter of all electricity used in a California home. *Top-freezer* models use about 13% less than side-by-side models. Meanwhile, *halogen or induction electric cook tops* are 60% more efficient than solid-disk and radiant models, and *front-loading tumble-action washers* can cut energy use by up to 70 percent.[xxii]

Almost all growth in residential electricity consumption over the next two decades will come from the often neglected small appliances in U.S. residences (the so-called "miscellaneous" end uses), if current trends continue, so also pay attention to these devices.[xxiii]

Operation & Maintenance Optimization

Conduct *routine maintenance* of all building systems. This includes regular filter changes; verifying that all belts, compressors, and dampers are operational; cleaning of cooling and condenser coils, fans, drains, and flues; calibrating controls; and adjusting the fuel to air ratio of any gas burning equipment[xxiv]. Finally, conduct regular *onsite performance measurements* and *utility bill analysis* of energy consumption for pro-active energy management.

Conclusion

With thoughtful consideration regarding the energy impacts of design and equipment decisions, many benefits are possible. Enhanced automation technologies and efficient systems reduce operating costs, lower environmental impacts, increase occupant comfort and well-being, provide additional information on building conditions for better control and decision-making and enhance property values.

Next Steps

To learn more about how to ensure that the highest efficiency goals for your home is met, tap into the numerous resources available to you from the *San Diego Regional Energy Office*. Don't let these opportunities pass you by, act today!

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[xxii] http://www.energy.ca.gov/efficiency/home_energy_guide/APPLIANCES.PDF
[xxiii] http://www.lbl.gov/Science-Articles/Archive/res-energy-growth.html
[xxiv] Guide to Energy-Efficient Commercial Equipment, ACEEE, page 3-34