

Moving Toward Carbon Neutrality

by Linda Wigington

In July 2007, Affordable Comfort, Incorporated, (ACI) convened a summit in San Francisco, which was called “Moving Existing Homes Toward Carbon Neutrality.” The goal of the summit was to create and clarify a vision of deep energy savings—a 70% to 90% reduction in total energy use—in existing single-family and multifamily dwellings. This level of reduction is achievable now through a combination of technical interventions and behavioral choices. While not all homes will be good candidates for deep energy reductions, we at ACI propose that the deep energy reduction paradigm can and should provide the framework for viewing energy and carbon reductions at a household, program, and policy level. Indeed, the growing awareness of the probable impacts of climate change makes it compelling to adopt deep energy reductions as the basis for developing energy and housing-related policy and investing resources. Properly implemented, the deep energy reduction paradigm has the potential to reduce energy vulnerability and climate change’s environmental impact, both at the national level and at the level of the individual home, while enhancing the comfort, indoor air quality (IAQ), and durability of that home.

The technology for achieving ambitious reductions exists—or most of it exists—but the knowledge essential to doing so is fragmented. We need different retrofit strategies to address different climates, lifestyles, and types of housing. We need to identify the remaining information gaps and fill them quickly. Given the success of the ACI summit, we hope that these gaps can be filled quickly and

effectively. Full-scale implementation of these retrofits calls for technical innovations and institutional partnerships. Transforming the physical and institutional infrastructure to support, rather than to threaten, global, community, and household sustainability is a challenging and urgent task.

The Residential Sector: Huge Infrastructure, Huge Opportunity

The residential sector accounts for 21% of U.S. energy use, and 21% of U.S. carbon emissions. There are 124 million dwellings in the United States and 13 million in Canada—and most of them are wasting energy. Existing homes represent a tremendous investment of resources, and a commitment to maintenance and operating costs for years to come. The median age of U.S. housing is 34 years, and roughly 60% of these homes will still be occupied in 2050. In 2006, \$228 billion was invested in U.S. home improvements—improvements that often could have included deep energy reductions. This level of investment indicates that both the resources and the opportunities exist for achieving such reductions. However, significant improvements in residential building codes, code enforcement, commissioning, education, and incentives are needed before the majority of remodeled—and even new—homes will no longer be immediate candidates for additional energy improvements.

Deep energy reductions are achieved by a combination of energy

efficiency, energy conservation—which depends on occupants’ behavior—and renewables. While many states and even the federal government have made efforts to stimulate renewable energy technology, no comparable efforts have been made to stimulate achieving deep reductions through efficiency improvements in existing homes. Yet efficiency investments often cost less per kilowatt-hour saved or produced than investing in photovoltaics does. ACI recommends that federal and state governments, utilities, and other industries make a substantial and immediate effort to develop comprehensive strategies that

- start by assuming that net zero energy and carbon neutrality are achievable in existing homes;
- maximize investments in conservation, efficiency, and renewable energy sources;
- accurately value the energy and nonenergy benefits of deep energy reductions; and
- identify opportunities to reduce the costs of a deep energy reduction package.

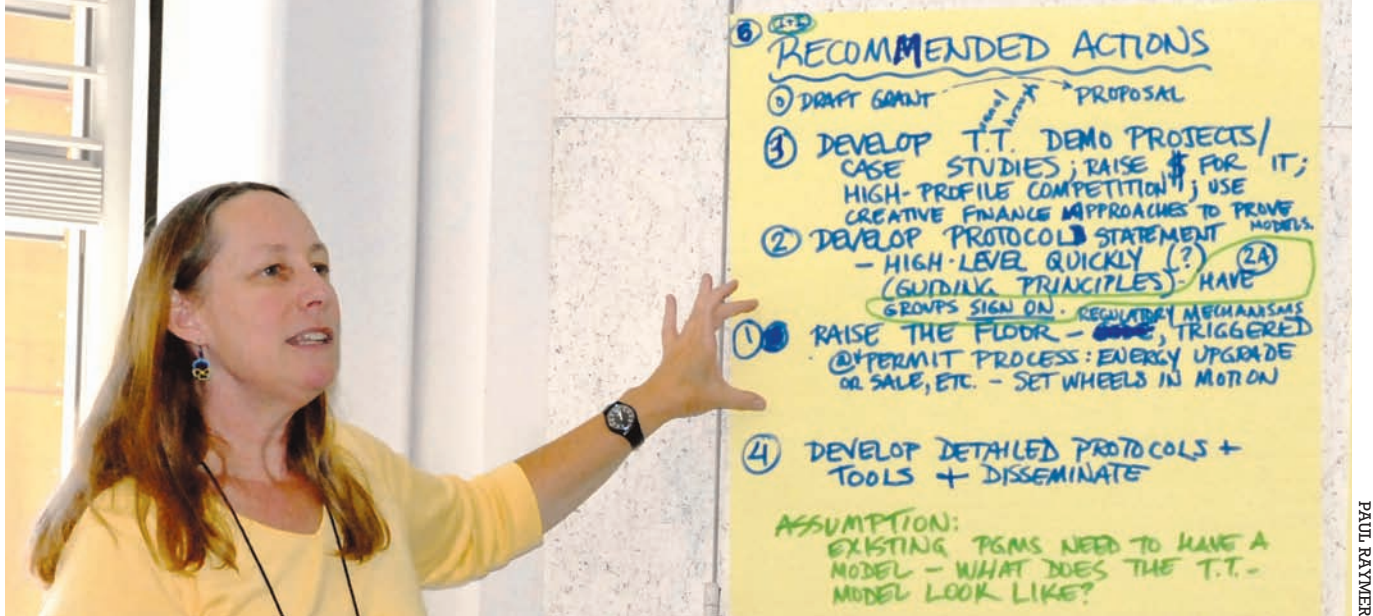
New Paradigm

To many summit participants, the realignment of current residential energy initiatives to support the paradigm of deep reductions is a bigger issue than the technical challenges. While some experience gained from housing, energy, and utility programs supports implementation of the deep energy reduction paradigm, other traditional residential energy efficiency approaches make implementation more



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Charles Segerstrom of Pacific Gas & Electric Company leads a small group.



Ann Edminster of Design AVENues presents a small group report.

difficult. Right now, many government and utility energy programs are getting new or increased sources of funding or new mandates—and sometimes both. Program managers must consider how best to realign their programs to achieve deep reductions. Failure to do so can make it difficult or impossible to achieve these reductions. For example, rather than trying to correct the many problems posed by forced-air distribution systems, we should strive to eliminate the need for a conventional central heating or cooling system. In most climates, the best low-energy homes have small, integrated space-and-water-heating systems, and are equipped with heat recovery ventilation.

We achieve only limited energy reductions when we address the efficiency of each individual end use separately. Instead, we need to ask the fundamental question, What do we really need to live well? We need to go back to the principle of creating comfortable living spaces and find ways to do so as simply and effectively as possible, with the goal of achieving net zero energy and carbon neutrality.

Costs and Nonenergy Benefits

Achieving deep energy reductions in existing homes is more challenging and often more expensive than

achieving them in new construction. To make deep energy reductions more practical and less costly, it is critical, as Amory Lovins suggests, to “tunnel through” the cost barrier. Lovins, Rocky Mountain Institute cofounder, cites two key ways to do this. The first is to take an integrative design approach to deep energy retrofits—an approach that realizes many benefits from a single expenditure. The second is to coordinate energy efficiency efforts with retrofits that are being done anyway.

While this approach will bring down the costs for individual homeowners, the many benefits that result from investing in efficiency retrofits need to be viewed from a broader perspective (see “Ten Nonenergy Benefits of Deep Energy Reductions”). Investing in efficiency retrofits also benefits the utility, the community, and the greater society. Because the cost of deep energy reductions is a major barrier to implementation, we need new mechanisms to quantify site and societal costs and benefits.

Recommended Next Steps

To lay the foundation for, and accelerate implementation of, deep energy reductions, ACI sees the necessity for the following steps:

- Convene a follow-up event to continue the work of the summit and to begin the process of developing a guidance document for deep energy reduction in North America.
- Embark on a North American 1,000-house demonstration project—possibly a challenge or an intercity competition—to publicly demonstrate the feasibility of achieving deep energy reductions in various climates, and the methods of doing so.
- Support a consensus process to establish standards for measuring the energy use, energy cost, and energy-related environmental impact of existing homes based on actual performance.
- Support research and monitoring to assess the field performance of technologies, systems, and projects, and to increase our ability to model deep energy reductions in existing homes.
- Support contractors, remodelers, designers, and homeowners by developing regional guides and protocols for deep energy reductions.
- Create a Green-Collar Workforce Development initiative to develop skilled labor to implement deep energy reductions.

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Nine Steps to Deep Reductions

by Linda Wigington

The following steps, listed in order of priority, provide a framework for assessing and implementing a deep energy reduction for a specific house. This process can be used to help define priorities or clarify whether interim measures support or make it more difficult to achieve deep reductions.

Step 1. Assess Needs, Site, Goals, and Use of Space

Step 1 is centered on the occupants, their use of space, and the house. This step gives the homeowners or occupants an opportunity to evaluate how their home could meet both deep energy reduction goals and their other goals, needs, and priorities. These could include affordability, allergen reduction, sustainability, carbon neutrality, security, adaptability, survivability during extreme weather events, safety, comfort, and more. What challenges and opportunities do the house and the neighboring community provide? Does the house have solar access or other renewable options? Energy loads should be minimized before a homeowner invests in renewables, so that any investment in renewables can meet more of a home's energy needs at a lower total cost. Do radon, asbestos, vermiculite, or lead-based paint pose risks that need to be considered? Does the client want to integrate rental space or a safe room as part of the planned renovations? Are there opportunities to incorporate water reuse and rainwater capture, and to prevent the basement from flooding in the event of a deluge?

Step 1 offers the opportunity to implement a range of efficiency improvements. Some, such as added insulation and air sealing, will reduce a home's energy use, irregardless of any action on the homeowner's or occupant's part. Other improvements, such as programmable thermostats, depend for their effect on some level of occupant involvement. Another consideration at this stage is financial

incentives. A homeowner who is paying for all of the improvements may drive the project differently than a homeowner who is taking advantage of a government or utility subsidy to reduce energy use or carbon emissions.

Step 1 also gives the homeowner the opportunity to weigh the larger implications of any efficiency improvements being considered. Air pollution, energy supply, utility rate structures, electrical capacity, supply and transmission constraints—all these considerations can influence decisions regarding energy-using systems. Local incentives and local rates may also influence a consultant's decisions. Two homes located in similar climates but in areas with different regional attributes or priorities may call for different technical solutions to the same problem. For example, if the community in which a home is located offers the option of combined heat and power, or centrally produced heat, this fact may influence the choice of heating system improvements. Wood fuel may be a cost-effective option in some places, and pose an unacceptable air pollution hazard in others. In any case, only clean-burning technologies should be employed.

Step 2. Optimize Building Enclosure to Reduce Heating and Cooling Loads

The goal of Step 2 is to reduce heating and cooling loads through a combination of airsealing, insulation, shading, and type and placement of windows. The higher the R-value of the insulation, the more critical it is to address thermal bridging, or heat loss through the framing of walls, windows, and doors. In a woodframe building, heat loss through the studs can equal heat loss through all the rest of the insulated wall area. In the wintertime, thermal bridging can also produce cold spots on interior surfaces that may be a source of condensation.



ANN HUTCHESON-WILCOX

Minimizing solar heat gain during summer is a priority in nearly all climates, to limit electrical peak loads driven by air conditioning. If windows are being replaced, there is an opportunity to change how windows and their shading options can maximize passive heating, minimize summertime solar gain, and optimize daylighting or natural ventilation.

This step also offers the opportunity to move any forced-air distribution system within the thermal boundaries. If the forced-air distribution system is outside the thermal boundaries, it is difficult or impossible to minimize leaks from the distribution system to the outside. Duct leakage, pressure differences resulting from return and supply duct leak imbalances, and duct penetrations of the building enclosure waste more energy when the conditioned air is leaking to outside of a home's thermal boundary rather than inside. Ductwork in an unconditioned attic also contributes to conductive and radiant heat loss and gain. This in turn lowers the efficiency of the heating, ventilating, and air conditioning (HVAC) system.

Step 3. Minimize Internal Loads

Internal loads are the electrical loads caused by lighting, appliances, and electronics. Although upgrading or replacing these types of loads usually has a shorter life span than does making improvements to the building envelope or to the mechanical equipment, these loads contribute significantly to energy usage, peak electric demand, and heating and cooling loads. Load reduction can be achieved by replacing older equipment with newer, more efficient technology, and by teaching the homeowner how to best use appliances

and other devices so as to minimize overall household energy use. An extremely efficient appliance can still consume large amounts of energy, depending on the manner in which it is used, and how long it is used. Real-time energy monitors, combined with education, can help homeowners to better manage overall household use. Indeed, shifts in occupant preferences and patterns of consumption can strongly impact overall energy use. For example, higher efficiency standards for refrigerators and the increased use of compact fluorescent lighting (CFLs) have produced significant energy savings. But much of these savings has been offset by an increase in consumer electronics, and by lifestyle changes that entail the use of more energy.

Step 4. Provide Fresh Air

Even in mild climates, it is essential that each house have a distributed, efficient supply of outdoor air for ventilation, because there will be times when occupants do not open windows. Recommended ventilation strategies vary depending on the climate. In designing the ventilation system, an energy consultant or HVAC professional should consider how best to control indoor moisture and how to keep soil gases out of the house

Step 5. Control Humidity

Summertime humidity often makes a house uncomfortable to live in. High humidity also contributes to mold growth, poor indoor air quality (IAQ), and structural deterioration. Tightening the home and using a mechanical ventilation system to control outdoor air exchange is one way to minimize indoor humidity during the summer. It is also important to control indoor sources of moisture. Efficient residential dehumidifiers may be necessary to maintain acceptable indoor humidity. These units can be energy hogs, so it is important to install the most efficient system possible. Development of more efficient dehumidification equipment would greatly help insure control of a home's moisture levels without wasting energy.

Step 6. Determine Cooling Needs

Greatly reduced cooling loads should be the goal of any energy efficiency retrofit. The use of unconventional cooling strategies should be considered, as well as eliminating mechanical cooling altogether, whenever possible. Humidity control can minimize or even eliminate the need for cooling. However, climate change may create more summer days with high humidity and higher nighttime temperatures. Anyone who is redesigning a cooling system must keep in mind that, with a very efficient building envelope, internal gains from lighting, appliances, and plug loads will affect the cooling load more strongly than they do in a poorly built home. Finally, providing cooling with a minimal impact on peak loads increases a home's adaptability over time.

Step 7. Determine Heating Needs

With a greatly reduced heating load, it may be possible to eliminate a central heating system, and instead meet the heating load with a solar thermal system, internal loads, or using some other novel approach. If a home has a ducted ventilation system, it may double as the heating distribution system, once the heating load is drastically reduced. A point source of heat, such as an efficient direct-vented gas or wood stove or a ductless heat pump, is also an option. The lower the load, the harder it is to justify a \$10,000 to \$20,000 investment in an extremely efficient heating system. Electric-resistance heat is the most flexible option and the least expensive to install, but the fuel mix used to generate that electricity may come from high carbon sources. In addition, using electricity for heating contributes to high peak demand. Finally, although 100% of the electricity that arrives at a house is usefully converted to heat, usually only about 33% of the energy used to generate that electricity gets to a house, due to generation and transmission losses, unless the electricity is generated onsite.

Step 8. Integrate Hot Water with Other Loads

In energy-efficient homes, water heating may be the dominant load. Hot water loads can be minimized by addressing distribution losses—that is, the loss of heat in the piping system that delivers the hot water to where it is used—and by installing more efficient end uses, such as dishwashers and clothes washers. The entire water supply and treatment cycle uses a lot of energy, so reducing hot water use also reduces energy used to treat and pump water. Using the same equipment to provide both space heating and water heating can reduce the energy needed to individually supply both loads. Also, by combining two small loads, it is possible to justify a higher investment and obtain higher efficiency. Heat pump technology, combined hydronic, solar, and heat recovery from ventilation systems are examples of more efficient technologies whose higher costs might be justifiable for a homeowner if used to meet both water-heating and space-heating needs.

Step 9. Verify, Provide Feedback, and Evaluate

Careful design, the best intentions, and good modeling results do not alleviate global climate change. Deep home energy reductions must be verified by monitoring a home's performance and by analyzing utility bills, to verify that any changes have produced the expected savings. Monitoring systems can provide feedback regarding temperature, humidity, and IAQ, as well as energy use. Monitoring also provides a way to identify any problems early, so that they can be corrected promptly. Measurement and verification are crucial aspects of learning from experience. Only with such feedback will we, individually and collectively, be able to modify our assumptions and improve systems for achieving deep reductions.

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- Stimulate and support the research, development, and deployment of products and systems that are an integral part of deep energy reductions.
- Support comprehensive campaigns that convey the impact of occupant behavior and consumer choices on residential energy use and on the environment. These campaigns can be national, as well as local, and should feature positive and concrete messages and case studies. Feedback systems, such as energy monitors, can help educate consumers about their energy usage.
- Develop tools that make it possible to quantify the benefits of deep energy reductions on the societal, community, and household level.
- Support the development of new organizational systems needed to deliver, package, aggregate, and track the performance of deep energy reductions.
- Influence energy efficiency, green, and carbon emission reduction initiatives and policies so that they support, rather than conflict with, the deep energy reduction paradigm.

Our nations have met great challenges before, marshaling the courage, commitment, and creativity needed to meet seemingly impossible goals. We now need to confront the challenge of achieving deep energy reductions in our existing homes. Properly implemented, the deep energy reduction paradigm offers the potential for reduced energy vulnerability and environmental impact over the life of a dwelling, while enhancing the occupants' comfort, IAQ, and financial health. We have the means; we must summon the will.

Ten Nonenergy Benefits of Deep Energy Reductions

In addition to dramatically smaller utility costs and greenhouse gas emissions, retrofits to achieve



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Ann Edminster of Design AVENues, Dennis Creech of Southface Energy Institute, Brad Steele of Energy Federation, Incorporated, Peter Yost of BuildingGreen Incorporated, Keith Aldridge of Advanced Energy, and David Weiss of Conservation Services Group take a break during the summit.

deep energy reductions provide the following benefits:

1. They buffer homeowners and occupants from future spikes in energy prices. This reduces the cost of homeownership, making homeownership an affordable option for more people.
2. They protect the occupants of a home from outdoor temperature extremes that occur during power outages or severe weather.
3. They maintain and build on the embodied energy and resources already invested in the housing stock.
4. They improve the quality of housing by increasing the durability of the building, improving IAQ, increasing comfort, correcting health and safety problems, and reducing noise and pests.
5. They increase the impact of investment in renewables, because once a home's energy usage has been drastically reduced, a renewable resource can more easily meet a home's remaining energy demands.
6. They shift investment and spending to products and services that benefit the local economy.

7. They reinforce voluntary lifestyle choices by increasing the benefits that accrue from those choices.
8. They stimulate product development and deployment that can benefit the remainder of the residential and small commercial sectors.
9. They enable occupants to reduce their energy use and their carbon footprint.
10. They ease the strain on energy supplies and distribution networks and help to make the United States and Canada more energy independent.

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For more information:

The white paper, *Moving Existing Homes Toward Carbon Neutrality*, is a product of the ACI summit. To read the full white paper, go to www.affordablecomfort.org/event/aci_summit_moving_existing_homes_toward_carbon_neutrality/resources/29