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Review Draft

White Paper for July 2007 ACI Summit:

Moving Existing Homes Toward Carbon Neutrality

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ABSTRACT

This white paper addresses the potential of reducing energy use in existing homes by 70–90%. It discusses how the emerging 'deep energy reduction' paradigm contrasts with conventional efforts to reduce residential energy use. It explores the opportunities, challenges, and recommendations that are the result of the ACI (Affordable Comfort, Inc.) Summit "Moving Existing Homes Toward Carbon Neutrality," July 11 – 13, 2007. The following key points emerged from the Summit: (1) Deep energy reductions (70–90%) are achievable now, but full scale implementation will benefit from technical innovations and institutional partnerships(2) Achieving deep energy reductions requires re-evaluating current assumptions about the potential for reducing energy use in existing homes. While some experience gained from housing, energy, and utility programs, supports implementation of the deep energy reduction paradigm, other residential energy-efficiency 'traditions' make it more difficult to obtain deep energy reductions; (3) Occupant behavior can either help to make deep energy reductions possible or unachievable; and (4) 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 comfort, indoor air quality, and durability.

EXECUTIVE SUMMARY

In July 2007, Affordable Comfort, Inc. (ACI) convened the summit, "Moving Existing Homes Toward Carbon Neutrality" in San Francisco. The goal of the summit was to create and clarify the vision of deep energy savings—70% to 90% reduction in total energy use—in existing single-family and multifamily dwellings. These levels of reductions are achievable now through a combination of technical interventions and behavioral choices. While not all homes will be good candidates for deep energy reductions, we 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 increased awareness of climate change's likely impacts makes it compelling to adopt deep energy reductions as the new anchor by which we develop policy and invest resources. Properly implemented, the deep energy reduction paradigm offers the potential for reduced energy vulnerability and environmental impact both at a national level and at the level of an individual dwelling, while enhancing a building's comfort, indoor air quality, and durability.

The technology for achieving ambitious reductions largely exists, but the essential knowledge is fragmented. Different retrofit strategies will be needed to address the variability in climate, housing types, and lifestyles. We need to identify the remaining information gaps and fill them quickly. Given the success of the ACI summit, there is great hope that this next step can be quickly and effectively taken. Technical innovations and institutional partnerships will likely be necessary for full-scale implementation of these retrofits. Transforming the physical and institutional infrastructure to support rather than to threaten global, community, and household sustainability is a challenging and urgent task.

Residential Sector: Huge Infrastructure, Large Opportunity

The residential sector accounts for 21% of U.S. energy use and carbon emissions. There are 124 million dwellings in the U.S. and 13 million in Canada. Existing homes simultaneously 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. The majority of these homes are wasting energy. In 2006, $228 billion were 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 deep energy 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 there are major efforts to stimulate renewable energy technology, there have not been comparable efforts in North America to address deep reductions through efficiency improvements in existing homes. Yet, efficiency investments often have a lower cost per kWh saved or produced than investing in photovoltaics does. We recommend a substantial immediate effort to develop comprehensive strategies that:

- Start by assuming that zero net energy and carbon neutrality is achievable in existing homes;
- Optimize the investment in conservation, efficiency, and renewable energy sources;
- Accurately value the energy and non-energy 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 residential energy-efficiency 'traditions' make it more difficult to obtain deep energy reductions. As there is increased activity right now in government and utility energy programs, it is urgent that program managers consider how best to realign their programs. The failure to do so can make deep reductions less obtainable or out of reach altogether. For example, rather than addressing the many problems of 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.

Energy reductions are limited when you address the efficiency of each end use independently and fail to ask the fundamental question "*What do we really need to live well?*" We need to go back to the principles of creating comfortable living spaces and find ways to satisfy these requirements as simply and effectively as possible, with a goal of achieving net zero energy and carbon neutrality.

Costs and Non-Energy Benefits

Achieving deep energy reductions in existing homes is more challenging and often more expensive than in new construction. To make deep energy reductions more practical and less costly, it is critical to, as Amory Lovins suggests, "tunnel through" the cost barrier. He cites two key ways to do this: an integrative design approach that produces multiple benefits from single expenditures, and coordination with retrofits being done anyway.

While this approach will bring down the costs for individual homeowners, the multiple benefits that result from investments in efficiency retrofits need to be viewed from a broader perspective than just energy reductions for the occupant. These investments also benefit the utility, the community, and the larger 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.

In addition to dramatically smaller utility costs and greenhouse gas emissions, deep energy reductions provide the following benefits:

1. Buffer and protect occupants from outdoor temperature extremes that occur during power outages and/or severe weather events and from potential future spikes in energy prices.
2. Maintain and build on embodied energy and resources already invested in homes.
3. Improve housing quality by increasing building durability, improving indoor air quality, increasing comfort, correcting health and safety problems, and reducing noise and pests.
4. Increase the impact of investment in renewables by making it easier to satisfy a home's remaining reduced energy demands.
5. Shift investment and / or spending to products and services with greater local economic benefit.
6. Reinforce voluntary lifestyle choices through the aggregation of benefits and occupant feedback.
7. Reduce the cost of home ownership and increase home affordability.
8. Stimulate product development and deployment that can benefit the remainder of the residential and small commercial sectors.
9. Enable occupants to enhance their reliance and reduce their personal energy use and carbon footprint.
10. Ease strain on energy supplies and distribution networks and help to make the US and Canada more energy-independent with reduced energy-related pressures.

Recommended Next Steps

Recommendations to lay the foundation and accelerate implementation of deep energy reductions include:

- 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 intercity competition—to publicly demonstrate the feasibility and methods of achieving deep energy reductions in a variety of climates.
- Support a consensus process to establish key metrics for quantifying 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, as well as 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.
- Stimulate and support the research, development, and deployment of products and systems that are an integral part of deep energy reductions.
- Support efforts to convey the potential for occupant behavior and consumer choices to impact residential energy use and environmental impact with comprehensive campaigns, as well as local efforts that provide positive and concrete messages, initiatives, feedback systems, and case studies.
- Develop tools that make it possible to quantify the benefits of deep energy reductions from a 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, marshalling the courage, commitment, and creativity needed to meet and exceed 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 an occupant's comfort, indoor air quality, and financial health.

We have the means; we must summon the will.

BACKGROUND

Existing homes simultaneously represent a tremendous investment of resources and a commitment to maintenance and operating costs for years to come. (Community Solutions, 2007) It is estimated that between 50 and 60% of today's homes will be present in 2050. (NREL, 2006) In 2006, $228 billion were invested in US home improvements; in 2005, $38 billion was invested in siding, windows, roofing, insulation, and HVAC systems alone. (JCHS, 2007) The recent confluence of political, social, environmental, economic, and technical awareness of global climate change make a compelling case to re-examine our assumptions regarding the degree to which energy use can be reduced in existing homes. Transforming our existing housing stock in such a way that it supports rather than threatens global, community, and household sustainability is a daunting task.

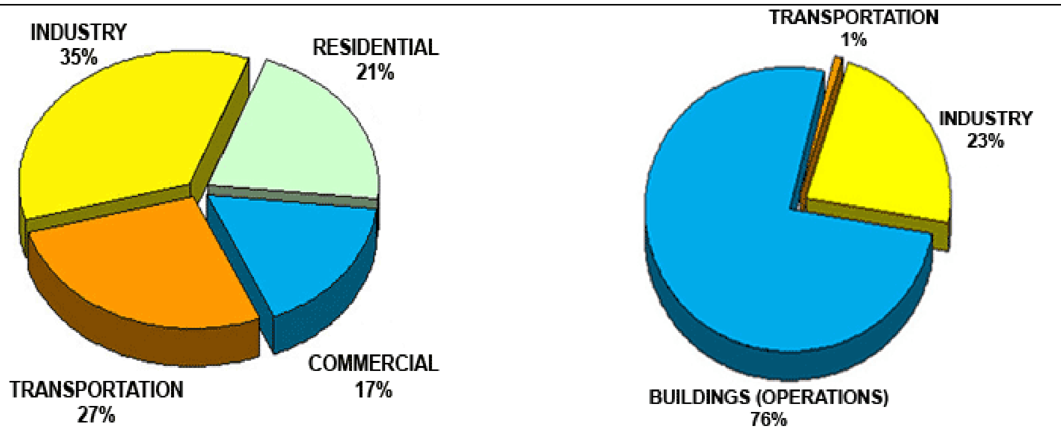

***Figure 1. US Energy Consumption (left) and Electricity Consumption** (right)*

Source: http://www.architecture2030.org/home.html

The amount of energy used and greenhouse gases emitted by the US and Canada is badly out of proportion to our population. The US accounts for 5% of the world's population but consumes 25% of fossil fuels produced each year. (Bartlett, 2006) In his keynote address to the 2007 annual ACI Conference, Dr. Bernd Steinmueller explained the ‘Factor 10’ concept as a recognition that developed countries in general, and the US in particular, need to reduce per capita energy consumption by at least a factor of 10 (a factor of 20 is more accurate for the US overall) to bring it into line with the global limit for CO_2 emissions of about ten billion tons / year. Human population is expected to reach ten billion by 2050. Therefore, we need to strive for a maximum emission rate of one ton of carbon dioxide per person per year. On average, the US and Canada exceed this amount by a factor of twenty, and Europeans exceed it by a factor of ten. “Thus, in order to become sustainable, it will be necessary to reduce energy-related CO_2 emissions by at least a factor of ten in the western world.” (Steinmueller, 2007)

Even if we achieved a twenty, thirty, or fifty percent reduction in residential energy usage in North America, using conventional approaches to conservation and efficiency, most households would still be using drastically more energy per capita than the world’s population average. Deep energy reductions in existing buildings that could approach the factor of 10 are possible through a combination of system-level efficiency improvements and behavioral choices. The issue is, therefore, not whether deep energy reductions are necessary, but rather how to define and support this vision.

According to the 2004 US Census Bureau statistics there are over 124 million dwellings in the United States; and an additional 13 million in Canada. The residential sector represents 21% of US energy consumption and an equal percentage of greenhouse gas production. By comparison, US automobiles contribute 20% (the entire transportation sector contributes 33%, 60% of which is from gasoline powered autos). Existing homes have a large impact on energy use and our carbon footprint; 21.1 quads of energy and 1254 million metric tons of CO_2 (E.I.A., 2006). Seventy percent of the CO_2 emissions from the residential sector are from electricity; thirty percent are from the direct use of fossil fuels. Of the worldwide CO2 emissions that result from building operation, the contribution from US buildings (with only 5% of the world’s population) is 42%. In 2001, the average US household annual energy use was $1680 per house totaling $191 billion annually.

Our energy using buildings, habits, equipment, and systems reflect our long-standing perception of the apparently infinite abundance of low cost energy. This usage cannot continue.

SUMMIT METHODS

The July 2007 ACI Summit on “Moving Existing Homes Toward Carbon Neutrality” focused on developing strategies for achieving deep energy reductions in existing single and multifamily homes throughout the US and Canada. The term “deep energy reduction” was initially defined as reducing the energy consumption of a home by 70–90% from its current consumption.

The Summit focused on reducing housing energy consumption regardless of its source. Though greenhouse gas emissions can be best reduced by reducing the use of fossil fuels, reducing any utility-provided energy (including hydro, geothermal, nuclear, and renewables) has the potential to offset the consumption of carbon-based fuels elsewhere.

Summit objectives were to:

- Explore the opportunities, challenges, barriers, costs, and benefits of achieving deep energy savings in selected house types and diverse climatic regions of the United States and Canada by employing a combination of technical interventions and behavioral choices;
- Propose simple, transparent energy performance metrics that help to define and communicate residential energy use and its impact on the environment;
- Begin to identify the technical systems (products, applications, etc.) that can accelerate and lower the cost of deep energy savings;
- Explore strategies for achieving deep energy reductions by incorporating both custom approaches and mass-produced systems;
- Explore the potential for alignment of current programs, initiatives, incentives, markets, and policies with the longer-term goal of deep energy reduction;
- Identify and catalyze the key steps needed to move forward individually and collaboratively.

To make progress on this identified scope, the Summit specifically avoided discussion of the following important and related issues:

- carbon offsets and trading;
- onsite power generation (renewable energy);
- transportation energy used in commuting and delivering goods and services to homes;
- energy used in water supply and wastewater treatment systems;
- energy embodied in building materials;
- energy used in solid waste management, and
- energy used in food production.

Because all of the above are also important, and may impact the way energy is used within the housing unit, their significance should be investigated in future work on the deep energy reduction issue, at least to the point of determining that some may not have significant impacts.

THE SYSTEMS APPROACH TO DEEP ENERGY REDUCTIONS

In housing we have discovered that moisture and mold problems, combustion spillage and indoor air pollution can only be addressed by the systems approach, whereas the component by component approach of old did not work. With all of these problems, the interactions between components of the house were very important, but were not always obvious when we looked at one component or area at a time. For example, while the moisture problem may have seemed worse in the bedroom of a sick child, it often started either outside or in the basement/crawl space. Combustion spillage problems in the utility room were sometimes caused by the powerful new kitchen range hood. Changing a natural draft furnace to a high-efficiency one, without introducing controlled, low-rate ventilation, often resulted in the build-up of pollution indoors that was worse than the occasional spillage problem from that furnace. All these were system problems and they were much more easily identified when the systems approach was used.

To produce deep energy reductions we have to do what Hunter and Amory Lovins did when they built their first ultra-low energy use building in Snowmass, Colorado. They took the mental leap to a view of a building that would use very little energy, by processes that they had not yet determined, and then went from that visualized endpoint to determining what individual components would have to be like and how they would have to perform. This produced a whole new paradigm to address the problem, one that would never have occurred if only incremental changes were envisioned. There would be no huge heating or cooling system; it would not be needed. Therefore, of course, there could not be large heat losses through the envelope nor heat gains through windows. With a little effort, they found that those performance goals could be achieved. Air could not be permitted to leak readily through the envelope, so airtightness was mandatory. They found ways to make walls and ceilings airtight. Ventilation was needed, but passive approaches were developed that could do the job (Since then we have developed low-energy-use mechanical systems that can also do the job, although passive ventilation works well in some climates and buildings. We can even do better, if we learn more about small-motor system performance issues.). Interactions between components were important to the successful operation of the building as a whole; they were found and addressed. They ended up with a successful building that used very little energy but was a joy to live and work in; quite an accomplishment.

To dramatically reduce the energy use in our existing housing we must make a similar leap of imagination, make similar evaluations of whole building performance, and then do the renovation to suit the building in question. This will be challenging at first, but will produce great rewards in both energy use reduction and in building performance and occupant satisfaction. The important point here is that the approach to the energy use reductions improves the overall house performance; it does not degrade it as incremental changes have done in the past.

The renovated, deep energy reduction house will have to meet all real needs of the occupants, and address all interactions between components, environments and processes. The renovation must ensure that heat losses and air leakage are low, but that moisture that gets into the structure can quickly get out again before damage is done. When heat flows are large we can sometimes move lots of moisture with little damage; that is not possible in low-energy-use buildings. Techniques that do not meet these requirements will not be used, even if they have been used before and met historical code and standard requirements. The heating and cooling systems will be small, if not miniscule. These systems will be efficient and they will not significantly pollute the indoor or outdoor air. In damp regions or local areas, moisture in outdoor air will be addressed before it can cause structural damage or indoor air comfort and quality problems. If soils are prone to wetness, waterproofing will be used, not just damp-proofing. Surface water will be dealt with properly, not ignored. The existing construction, climate, use and other factors will make significant demands on what can and should be done in any renovation.

Obviously some of the above actions are not practiced in conventional housing, not even in some of our present low-energy-use new housing, but the systems approach defines what must be done for a renovated housing unit to meet all needs, and then defines ways that those needs can be met.

The Summit brought out many of these special needs and interactions, both by defining problems and by posing good questions; often identifying existing answers to those questions. This was such an important outcome that it will be summarized later in Appendix D.

If the systems approach is properly developed for deep energy use reductions, it can succeed. An important task will be to determine which existing or evolving techniques and products can be used and which cannot, if the renovation is to be successful. Renovated houses that fail to meet real needs could give the whole movement a black eye.

Note that it will likely be necessary to measure how well we have performed new and critical tasks; perhaps even tried and true ones. Some techniques for inspection and performance determination already exist. Others may be needed. Proper inspection should never be a major cost of building or renovating, but, nevertheless, will be necessary. A few percent of the value of the renovation, spent as insurance of proper performance, is well worth spending.

ENERGY EFFICIENCY IN EXISTING HOMES

We need immediate action to demonstrate the practicality of significant reductions in energy use, to evaluate and refine the systems, to accelerate product development, and to build the human capacity to make the improvements. Some energy using products, such as appliances and home electronics, are relatively simple to replace with more efficient models. On the other hand, homes operate as complex systems and comprehensive solutions are needed. Well-intentioned singular efforts, such as replacing the heating system without properly sizing and delivering conditioned air to the living space, ignore house interactions that can negatively impact durability, combustion safety, and/or indoor air quality. Isolated improvements also miss the opportunity to achieve positive synergy. When replacing a central air conditioner, a smaller one can be installed if the insulation and air tightness is improved and solar gain through windows addressed. It may be possible to eliminate a conventional central system altogether.

Since short-term improvements can make it more difficult or expensive to achieve long-lasting deep reductions in energy use, it becomes critical that programs and policies include metrics and methodology sufficient to express the true cost (by true cost we mean the total societal cost of producing, transporting, and consuming energy resources).

Energy reduction renovations can be variously expensive and also variously effective in reducing electrical and heating use. Danny Parker's Summit address (Parker, 2007) included the following example:

Retrofit Type	Cost per home	Savings kWh/yr	Savings Therms
Low-hanging fruit	$ 1,500	1,000	100
Extensive Retrofit	$10,000	4,000	400
Deep Retrofit	$50,000	7,000	600
Deep Retrofit + 3 kW PV	$75,000	7,000 + 4,300	600

The question, "Can we afford to invest in measures that could be obsolete in one or five years…or that are already obsolete depending on one's assumptions?" surfaced as a key challenge.

Existing homes represent a challenging sector but have a simultaneously huge potential for energy efficiency. The traditional approach to energy savings opportunities has been viewed from a short-term economic perspective. Given finite resources to invest, logically a home owner or program would examine the opportunities, assess their cost and energy savings, and select those with either the best payback or the highest return on investment. With this traditional paradigm, the higher the investment, the lower the returns, with a decreasing cost-effectiveness. To make a case for deep energy reductions it is critical to break through the cost barrier. To do this the synergy between actions must be considered. The solutions and benefits need to be viewed from a broader perspective rather than the limited context of direct and immediate energy reductions for the occupant or utility. Amory Lovins cites two key ways to "tunnel through" the cost barrier: 1) an integrative design approach that produces multiple benefits from single expenditures, and 2) coordination with retrofits being done anyway (Lovins, 2007)

Efficiency efforts focus on meeting household loads with more efficient building materials (e.g., insulation), components (e.g., windows), and equipment (e.g., appliances). Conservation efforts focus on reducing loads, or the amount of energy needed to live in the house, and depend largely on occupant behavior, preferences, and lifestyle choices. However, any and all energy reduction strategies are directly tied to human behavior in that any self-driven reduction in energy use is dependent upon occupant action -- be it a one-time decision to replace an inefficient appliance or a decision to consistently change daily behaviors. Nothing short of a worldview change among energy consumers would lead to the 70–90% levels of deep reduction being proposed.

The potential for drastically reducing energy use of existing homes is huge, but so are the challenges. Reducing total energy consumption by an order of magnitude requires nothing short of a paradigm shift in our commitment to and understanding of what reductions are achievable and how they can be achieved.

To properly understand the deep energy reduction paradigm, one needs to understand the characteristics, status, and limitations of all of the paradigms that represent current influences and practice:

- The Widget Paradigm;
- The Whole House or Home Performance Paradigm;
- The Sustainable Renovation Paradigm; and then,
- The Deep Energy Reduction Paradigm.

The Widget Paradigm

- Often focuses on a product or technology;
- Assumes or defines efficiency by the presence of key products;
- Has potential to bring selected product costs down and increase saturation and adoption;
- Extensive experience in rebate programs, standards development, and in addressing the supply chain;
- Evaluation usually based on indirect energy impact (number of units times adjusted energy reduction) (survey with demographic or climate data);
- Programs or incentives are short-term, ramp up quickly, and are easy to deploy;
- Program assumptions change over time as adoption increases; life cycle curve to innovation adoption in response to codes, standards, product availability, and cost;
- Efficiency programs that are characterized by relatively low savings per unit, very high number of units, and low transaction cost can yield significant and cost-effective energy reductions, particularly if the market is transformed after the removal of the incentive;
- Does not address site-specific application, installation, measure interaction, or side effects;
- Widespread concern that measure-specific programs designed to reduce heating and cooling loads lead to lost opportunities and have the potential to create negative side effects.

The Whole House or Home Performance Paradigm

- Focuses on building system performance with energy reduction as one part of greater whole;
- Two primary conduits: low-income program delivery and market driven home performance (occupied homes);
- Typical cost of low-income and home performance projects ranges from $3,000 to $35,000 (including non-energy costs and administrative costs assuming professional, not DIY installation) per house; energy reduction ranges from 5–35%. In many cases evaluations have only focused on the heating energy portion of the bill. A savings of 50% is rare but obtainable in a high use home or with a very comprehensive project addressing all loads;
- Within many low-income usage reduction programs, including the low-income weatherization program and utility-sponsored programs, there is increased recognition that the changes to a home through weatherization have the potential to create or exacerbate moisture, indoor air quality and / or combustion safety problems. Efforts to address and prevent these problems have included increased training and use of diagnostic equipment, verifying combustion safety after work is completed, and development and use of standards for installation and auditing. There are protocols to identify and document the presence of pre-existing hazards. Program guidelines address liability and walk away policies;
- Focuses on infrastructure development so that the capacity for delivering comprehensive services becomes the basis for perpetuation;
- Not mature in terms of industry and stakeholder consensus on specific standards, protocols certification; more mature within low-income program delivery;
- Involves longer lead time to develop contractor capacity than the widget paradigm;

- It is not clear that a contractor / professional infrastructure can be created and maintained without significant public investment in supportive resources over a period of years;
- Though it is conceptually easy to convey the key principles, when we consider interactions or want to be comprehensive to minimize lost opportunities and verify performance, actual implementation varies significantly. It can be driven elsewhere by a home owner – "I just want new windows," or by a contractor "We only install what we sell" or by more systems-based program incentives to drive comprehensiveness if a breadth of measures are installed;
- An excellent opportunity to incorporate durability, healthy housing, comfort, renewables and sustainability, and provide a constellation of benefits not limited to energy reductions. Homeowner investment is typically driven by non-energy benefits;
- The transaction cost per house is high; the larger the job the easier it is to justify the investment in site specific visual, diagnostic, and energy use analysis, occupant interview, financing, and work scope development;
- In homes with average or below average energy use for heating and cooling, the complexity and cost of ensuring "doing no harm" can swamp the benefits, if energy reduction is the only goal, and current perception of recommended energy measures are embraced.

The Sustainable Renovation Paradigm

- Focuses on a building and its impact on the community and larger environment;
- Embraces life cycle of building components as well as products consumed in house operation, land use, water use and site environmental impact, as well as building durability, and energy use;
- Significant variation in emphasis may be placed on different components of sustainability;
- Rapid growth of interest and investment from both professionals and the general public;
- Emerging national standards for residential new construction (NAHB, LEED for Homes) can be applied to existing homes;
- "Green" building is perceived as energy efficient, though it doesn't necessarily incorporate a whole building performance-based approach to energy efficiency;
- Energy performance is not based on measured performance.

The Deep Energy Reduction Paradigm:

- Builds on strengths of each previous paradigm;
- Vision and imagination are bigger challenges than cost and technology;
- A reduction goal of 70–90% is arbitrary and needs to be replaced with a combination of indices of performance that address: energy use per square foot of house; energy use per house; peak load per house; and energy use per person. Until we have those indices, "70–90% reduction of total energy" will be used to convey "substantially better than business as usual";
- Fits well within a sustainable paradigm that incorporates broad benefits beyond the site and is driven by occupant values and investment;
- Needs to incorporate verification of system and household performance through diagnostics and a process for tracking and measuring impact;
- Mechanisms to support occupant behavior and provide feedback on building performance are part of long-term process of maintaining deep energy reductions;
- Strategies must be customized to address dominant energy loads and will vary by household, climate, region and housing type;
- Past assumptions regarding value of energy reductions and measures of cost effectiveness must be re-assessed;
- Two of the primary approaches are: 1) "Whole Enchilada" one shot renovation (unoccupied) / comprehensive retrofit (occupied); and 2) "Phased" process over several years with the end point already defined. Other approaches can and should be defined;
- Though in its infancy, many opportunities to glean experience exist. Several hundred super insulation projects in existing homes exist from 1980's; the focus was on heating loads in northern climates; US Zero Energy Home experience in new construction has great lessons for renovation projects; "Passiv

Haus" experience in new and existing buildings in Europe has important implications (http://www.passiv.de/index_PHI.html);

- While phased improvements over time are one strategy, incremental improvements can make it more difficult and expensive to achieve deep energy reductions. Sealing ductwork in unconditioned spaces, upgrading a central HVAC system and installing new windows are measures that may have to be redone or eliminated to achieve deep energy reductions. The vision for deep energy reductions is needed early to optimize investment;
- Has potential for simpler technical solutions to combustion safety, distribution systems, durability, and indoor air quality problems because solutions may be an integral part of the work scope. A deep energy retrofit work scope could eliminate the conventional chimney, eliminate attic ductwork and include a small mechanical ventilation system to address air quality and radon. As a result, the need to diagnose and address the existing systems is minimized. The work scope may have more in common with new construction than retrofit.

Non-Energy Benefits

Achieving deep energy reductions in existing homes is more challenging than in new construction. Efforts to achieve deep energy reductions should be viewed within the constellation of benefits at the societal, community, and household levels so greater investment is justified. 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. In addition to dramatically smaller utility costs and greenhouse gas emissions, deep energy reductions provide the following benefits:

1. Buffer and protect occupants from outdoor temperature extremes that occur during power outages and/or severe weather events and from potential future spikes in energy prices.
2. Maintain and build on embodied energy and resources already invested in homes.
3. Improve housing quality by increasing building durability, improving indoor air quality, increasing comfort, correcting health and safety problems, and reducing noise and pests.
4. Increase the impact of investment in renewables by making it easier to satisfy a home’s remaining reduced energy demands.
5. Shift investment and / or spending to products and services with greater local economic benefit.
6. Reinforce voluntary lifestyle choices through the aggregation of benefits and occupant feedback.
7. Reduce the cost of home ownership and increase home affordability.
8. Stimulate product development and deployment that can benefit the remainder of the residential and small commercial sectors.
9. Enable occupants to enhance their reliance and reduce their personal energy use and carbon footprint.
10. Ease strain on energy supplies and distribution networks and help to make the US and Canada more energy-independent with reduced energy-related pressures.

From the consumer and market perspective, efforts to achieve deep energy reductions fall into at least two very different implementation paths. The first involves a one shot comprehensive project, logically building on a remodel, renovation, or home improvement (referred to as “Whole Enchilada”, until a better label emerges). The key question for this path is: “How do we develop the systems and infrastructure to achieve and encourage deep efficiency as the opportunities present themselves through a major renovation or remodeling project?”

The second path is characterized by a deep energy reduction project being deployed in stages over a period of years (referred to as “Phased” until a better label emerges). Two key questions for this path are: “How do we develop the methods to engage and support homeowners and occupants in a process that can lead to deep energy reductions and to make it possible to achieve those reductions over a period of time through a series of investments?" and, "How do energy, housing, and environmental programs and initiatives align themselves with, rather than challenge or ignore, the vision of deep energy reductions?"

A cornerstone of the whole-house systems approach is that optimizing thermal characteristics of the enclosure (the home's outside walls, doors, attic or roof, floor and foundation) allows significant downsizing of space conditioning equipment. It is more cost-effective to make substantial improvements at the time of replacement or home renovation. However, these major components, such as roofing, siding, and windows, have longer lifetimes and are not replaced as often as HVAC equipment and appliances. The challenge in existing homes is to maximize improvements as opportunities present themselves, while maintaining a focus on long-term enhancements, so the potential for deep energy reductions is not compromised by short-term incremental improvements.

Neither our understanding of systems needed to achieve deep energy reductions nor the technical systems that will achieve them are static. The process for both the "whole enchilada" and a "phased" approach need a strong emphasis on rapid feedback and verification in order to accelerate the learning curve, fine tune the climate-specific applications, and to verify that the intended results are being achieved and maintained. It is envisioned that as new innovations and technical systems are developed the potential for broader applications at lower costs emerge. It is also likely that new strategies for achieving deep energy reductions will occur as we further develop our understanding.

PROCESS FOR ACHIEVING DEEP ENERGY REDUCTIONS

While many strategies can be used to achieve deep energy reductions, universal principles are emerging. To summarize, they are:

1. A systems approach is necessary to optimize site and off-site benefits and interactions;
2. Good indoor air quality and building durability are integral elements;
3. Performance must be verified with a combination of diagnostic equipment and actual measurement (both energy use and other benefits);
4. Occupant behavior and lifestyle are an integral part of a deep reduction strategy;
5. Even if the investment of resources is made at a single point in time ("Whole Enchilada"), deep energy reductions should be viewed as an ongoing process, as building systems need to be properly maintained and operated; and,
6. In some cases, the trigger event that makes it possible to achieve optimum results may only appear every 20 or 50 years as major systems are replaced or renovations made. Processes need to be in place that enable us to intervene and optimize energy reduction and cost savings during these opportunities.

The systems approach considers and optimizes the interactions between home energy use, combustion safety, physical durability, indoor air quality, and occupant safety and health. It also emphasizes the importance of quality installation of building materials and systems, and performance measurement and verification. The systems approach is necessary to prevent adverse side effects, such as creating combustion safety hazards or other indoor air quality problems as a result of air sealing, while capturing multiple benefits, such as solving existing problems related to infiltration, moisture, lead, or radon.

Another cornerstone of a systems approach to home performance is the use of diagnostic tools and techniques, which include measuring building enclosure leakage area, duct leakage and delivered fan flows. In existing homes, diagnostic testing is used not only to verify post-retrofit conditions and performance, but also to help identify existing problems that need to be fixed during the retrofit.

However, it may be easier to eliminate (rather than fix) many problems typically found in existing homes by specifying several fundamental building changes that are consistent with high performance homes. For example, replacing open combustion with a combination of sealed combustion appliances and balanced heat recovery mechanical ventilation, or moving ductwork into the conditioned space, eliminate many of the potential problems that are addressed, and can complicate a home performance job. Whole house deep efficiency strategies have the potential to simplify and remove the uncertainty from the retrofit process.

Site Assessment Process - Nine Steps to Deep Reductions

The following steps, listed in order of priority, provide a framework for assessing and implementing a deep energy reduction for a specific dwelling. 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

This step is centered on the occupants, their use of space, and the house. This step provides the opportunity to rethink assumptions in light of a paradigm that was not considered when the dwelling was built. What are the occupants' goals, needs, and priorities? These could include affordability, allergen reduction, sustainability, carbon neutrality, security, adaptability, passive survivability, safety, comfort, and more. What challenges and opportunities does the house and community provide? Does the dwelling have solar access or other renewable options? Energy loads should be minimized prior to investing in renewables so the investment in renewables can provide a greater portion of the homes' energy needs at a lower total investment. The cost of renewables and the cost of improvements vary significantly. An integrated approach can optimize the investment to achieve the greatest impact. Are radon, asbestos, vermiculite, or lead based paint risks that need to be considered? Is there an opportunity to integrate rental space or a safe room as part of the planned renovations? What are the opportunities to incorporate water reuse, rainwater capture, and to minimize the impact of basement flooding in the event of a deluge?

A key challenge at Step 1 is balancing the goal of maximizing the efficiency of the house (independent of the occupants) vs. providing systems that assume some level of occupant involvement or maintenance. A homeowner who is self financing may drive the project differently than if there is a government or utility subsidy with a goal of long-term energy or carbon emission reductions.

Step 1 provides an opportunity to clarify energy benefits beyond site boundaries. Air pollution, energy supply, utility rate structures, electrical capacity, supply, and transmission constraints can influence decisions regarding energy using systems. Incentives and rates may influence decisions at the local level. Two homes in similar climates may have different technical solutions as a result of differing regional and local priorities. The option of combined heat and power or centrally produced heat at the community level may influence decisions. 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 Enclosure to Reduce Heating and Cooling Loads

The goal of Step 2 is to use a combination of window type and placement, shading, air-sealing, insulation, and window treatments to reduce the heating and cooling loads. The higher the level of insulation, the more critical it is to address thermal bridging. Thermal bridging refers to the heat loss from a thermal short circuit through the structure or framing of windows and doors, etc. In a wood frame building the heat loss through the studs (framing) can contribute as much to heat loss as the rest of the insulated wall area. In addition to heat loss, thermal bridging contributes to cold interior surfaces in the wintertime that may be sources of condensation. 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 window areas to maximize passive heating, minimize summertime solar gain, and optimize daylighting or natural ventilation. Keeping thermal distribution systems within the thermal boundaries is important. If the forced air distribution is outside a home's thermal boundaries it is difficult or impossible to achieve extremely high levels of air tightness, because of duct leakage, pressure differences resulting from return / supply duct leak imbalances, and duct penetrations of the building enclosure. Duct work in an unconditioned attic also contributes to conductive and radiant heat loss and gain that lower the efficiency of the HVAC system.

Step 3 - Minimize Internal Loads (Lighting, Appliances, Electronics)

Although these improvements usually have shorter life expectancies than the building enclosure or mechanical equipment, they have a significant effect on the remaining energy usage, peak electric demand, and heating and cooling loads. Load reduction is achieved by more efficient new technology, combined with information regarding operation and real-time feedback to consumers. Energy use is a function of the device's size and efficiency, the manner in which it is operated, and how long it is used.

Shifts in occupant preferences and patterns of consumption represent an unknown. Much of the savings resulting from refrigerator efficiency standards and use of compact fluorescent lighting has been offset by an increase in consumer electronics and lifestyle changes.

Step 4 - Provide Fresh Air

Even in mild climates, an intentional, distributed, efficient supply of outdoor air for ventilation is essential because there will be times when occupants do not open windows. Ventilation strategies vary depending on the climate. Control of indoor moisture and exclusion of soil gasses should be considered during ventilation system design.

Step 5 - Control Humidity

Summertime humidity is often a primary source of discomfort. High humidity also contributes to mold, poor indoor air quality, 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 relative humidity. A residential dehumidifier can use tens of KWH per day so it is important to use the most efficient system possible. Development of more efficient dehumidification equipment needs to be a priority.

Step 6 – Determine Cooling Needs

Greatly reduced cooling loads provide the opportunity for non-conventional cooling strategies, and in many climates mechanical cooling can be eliminated. However, climate change may create more summer days with high humidity and higher nighttime temperatures. Providing cooling with minimal impact on peak loads increases a home's adaptability over time. Humidity control can eliminate or minimize the need for cooling. Ironically, with a very efficient building enclosure, the effect of internal gains from lighting, appliances, and plug loads is greater. Internal gains can make a significant contribution to the cooling load.

Step 7 - Determine Heating Needs

With greatly reduced heating loads, it may be possible to eliminate a central heating system. Heating loads may be largely met with a dehumidifier, internal loads, and/or a solar thermal system. If the ventilation system is ducted, it may double as the distribution system for a home since the loads are drastically reduced. A point source of heat, such as an efficient direct vented gas or wood stove or ductless heat pump, is an option. The lower the load, the harder it is to justify a $10,000 - $20,000 investment in an extremely efficient heating system. Electric resistance heat is the most flexible and least expensive to install, but is often associated with high carbon generation source, high peak load contributions, and low source efficiency (33%) unless it is from an onsite source.

Step 8 - Integrate Hot Water with Other Loads

In energy efficient homes, water heating may be the dominant load. Minimize hot water loads by addressing distribution losses and more efficient end uses. Significant energy use is embodied in the entire water supply and treatment cycle, so reducing hot water use also reduces energy used to treat and pump water. Examine using the same equipment to provide both space heating and water heating. By combining two small loads it is possible to justify a higher investment and obtain higher efficiency. Consider heat pump technology, combined hydronic, solar, and heat recovery from other processes.

Step 9 - Incorporate Verification, Feedback, and Evaluation

Careful design, best intentions, and good modeling results do not alleviate global climate change. Deep home energy reductions must be verified through monitoring and utility bill analysis in order to verify that expected savings result. Such verification may identify problems early so corrections can bring performance up to expectations.

Measurement and verification are also a crucial aspect of learning from experiences, modifying our assumptions, and improving systems for achieving deep reductions. Monitoring systems can provide feedback regarding temperature, humidity, and indoor air quality as well as energy use so that the building systems and their operation can be optimized.

WORKING GROUP DISCUSSION and INSIGHTS

Throughout the Summit some consistent messages developed and some differences of opinion, approach and concern also occurred. To better explain why this White Paper recommends what it does, and to allow development of an understanding of the scope of work to be done, the following subsections present summaries of those discussions.

Feedback, Monitoring, and Verification

Feedback does not exist at a sufficient level for occupants, building owners, contractors, program implementers, designers, and policy makers. Evaluation efforts have tended to focus on counting installed units rather than measuring impact. There is a lack of data on installed performance of individual measures or technologies, as well as systems. Greater use of utility bill data is an important first step. Bill disaggregation can help determine patterns of use and be used to target households or buildings with the highest opportunity for reductions. Websites that use utility data and other basic household information as inputs have the potential to provide more useful feedback to consumers regarding their energy use.

Stakeholder collaboration is needed to overcome barriers including privacy concerns and the use of common indices of performance. This is important in multifamily buildings (tenants, maintenance staff, building owners). Access to consumption information can help measure impact on a community or aggregate basis. If manufacturers are going to install sensors or communication devices, there should be standards that address interface issues.

A variety of “dashboard” systems for consumers are emerging. These provide occupants with energy feedback and benchmarking. Criteria include: 1) They must be simple; 2) They are not for everyone; 3) Levels of complexity can vary as required by occupant; 4) Real time results are best; 5) Mass production and good marketing are needed to get costs down; 6) They should include all metered energy; 7) Occupant education is necessary; 8) Monitor ventilation, CO, furnace filter condition, humidity, water use, and the desirability of opening windows for ventilation; 9) Could be wireless; 10) Break out heating, cooling, water heat, and base loads separately. Devices that provide feedback to occupants can also inform professionals and programs.

Metrics

The lack of clear, quantifiable targets or performance indicators is a critical barrier to deep energy reductions and repeatedly surfaced as an issue throughout the Summit. The easier our metrics are to understand and use, the more effective our efforts will be. Metrics serve different purposes; the purpose helps to define the approach. Energy ratings have been developed to evaluate the performance of a building, independent of its occupants. The goal has been to develop instruments that qualify homes for the purpose of financing, incentives, tax credits, or labeling. This current tool is in the process of revision and is designed to include new and existing homes. The Metrics Issue Group recommended that deficiencies in the current tools be addressed. The rating number is the easiest understood metric across a large number of users. Software used to create numbers needs to be improved; the primary shortcomings identified were lack of accuracy and the bias toward larger homes.

In addition to a rating tool, there is a benefit to having performance indicators that provide the opportunity to benchmark a dwelling to compare it to others, compare it to itself over time, or to measure field performance against a goal such as zero energy. It was agreed that no single metric is complete and that several, in combination provide a more accurate understanding of past, current, and potential performance. The combination of energy use per square foot, energy use per house, energy use per occupant, carbon footprint and cost provide a more complete picture of performance than any one of them on their own. Both site energy (reflected by utility bills) and source energy (primary energy consumed at the power plant) were viewed as useful. The indices should be useful to any occupant who is interested in evaluating his or her household’s performance. There is the possibility of integrating these indices with EPA’s web-based “Energy Yardstick.”

The challenge of identifying targets for what would qualify a home to achieve the status of deep reductions is elusive. The weakness of percent reduction or Factor 10 is that the quantity is relative to the starting point. A very efficient home may achieve a 50% reduction and end up at a much lower absolute energy use (per square foot, per person or per building) than a home that is an energy hog and reduces its energy use reduced by 90%.

There was disagreement on the value and use of carbon footprint as a metric. An area of surprising consensus was that KWH is preferable over BTUs as a measure of energy use.

We recommend the development of a universal one-page base report for dwellings that incorporates both performance-based and rated information. This report needs to be recognized in the marketplace and could be incorporated into the home sales and improvement process. The city of Portland, Oregon is starting this reporting with an Energy Performance Certificate and information from this report is included in the multi-list service.

Alignment and Synergies

Alignment refers to consistency between programs, policies, and initiatives to the long-term goals of deep energy reductions. For example, a program that promotes insulating attics before they are air sealed is not in alignment, because it makes it harder to achieve a tight building enclosure (something that may also be very important in that building). Also, rebating medium performance windows in a northern climate is not in alignment because it precludes higher performance windows that can be justified in many ways other than just energy use reduction.

Some important questions here are: a) How can the existing programs and efforts that have a single measure focus, i.e., compact fluorescent light (CFL) bulbs, sealing ducts, or replacing HVAC equipment, across a broad population be leveraged?; b) How can we build on the comprehensive focus and infrastructure development provided by Home Performance with ENERGY STAR and the Weatherization Assistance Program to go further and deeper?

Alignment is potentially the most politically-challenging issue of the deep energy reduction paradigm. Programs and policies call for immediate reductions in energy use and carbon emissions. Some have annual time tables; others have intermediate goals that are relatively short-term. As of June 2007, over 600 US municipalities have signed onto meeting the Kyoto Accord which calls for reductions by 2012. The tendency has been to accelerate efforts to capture cost-effective energy savings through single-measure programs that are relatively easy to ramp up and evaluate. How do you integrate additional choices and options in a program without making it more costly, more complicated, and more confusing?

We need creative approaches that provide greater consumer, contractor, and program incentives for deep reductions without compromising immediate goals. For example, sealing ducts that are located in unconditioned attics is a key opportunity for energy savings. However, as part of a long-term strategy for deep energy reductions there are other options. Either move the ducts inside of the conditioned space (by moving the boundary from the attic floor to the roof or by moving them to the inside of the house) or eliminate the need for the forced air system altogether. Both of the latter approaches offer five advantages: 1) decreased heat loss through the ceiling; 2) increased air tightness of the home; 3) increased distribution efficiency; 4) reduced potential for pressure effects caused by duct leakage; and 5) elimination of the need to seal and test the attic ductwork. If the goal is to achieve the greatest reductions of energy use and energy load, efficiency programs need to drive the decisions to the optimum solutions. For a homeowner, sealing the ducts becomes a deterrent to making the other changes in the future. Realistically, not sealing the ducts could mean that the immediate opportunity for reductions in energy use and load is missed because the homeowner never gets around to implementing the more comprehensive solution.

Increased efficiency incentives are needed for technologies that offer to transform the market that are on par with the incentives for renewables. Once field research clearly documents their performance, incentives could be offered to the most highly efficient technological systems to stimulate manufacture, distribution, and customer adoption. This model is not new; the Golden Carrot Refrigerator Initiative was a collaborative effort. Comprehensive programs can increase adoption of new technologies by building on incentives. Ideally, the collaboration of spurring efficiency would be done at both the national and international levels; there are examples in place already. A clear signal to manufacturers, that is independent of any single country's political process, could provide for sustained investment in research, development, and deployment with a greater emphasis placed on the latter. We have many great technologies that never get out of R&D because they are cost prohibitive (as perceived in isolation) or there are infrastructure issues with proper installation and maintenance. These need increased focus to achieve deep energy reductions.

There is a need to change the utility evaluation mechanism (broaden the criteria for energy program selection) for determining cost effectiveness. Cost effectiveness tests developed to protect rate payer investments by providing accountability are a barrier to comprehensive programs that leverage significant home owner investments and embrace measures that offer non-energy benefits. The Total Resources Cost (TRC) Test was cited as a significant impediment to the deployment of whole house programs. (Knight, 2006) The utility cost-recovery equation needs to exclude the cost of non-energy benefits so more deep energy savings in the residential sector can be realized, quantified, and be deemed cost-recoverable.

Financing and Incentives

Financing sources and mechanisms that could be used to support deep energy strategies are within reach. They include things like white tags and green tags, mortgage financing, green initiatives backed by banks, and legal settlements.

These financing mechanisms are not without substantial challenges. While the energy reductions obtainable in the residential market are huge, they are also scattered among 100 million dwellings and even more decision makers. The high transaction cost is a huge impediment. A deep energy reduction strategy offers the potential of increasing the comprehensiveness of energy savings in a house and a lower transaction cost per dollar invested.

Aggregation of savings is needed in order to qualify for some of the financing opportunities. The development and deployment of comprehensive deep energy reduction packages could overcome many challenges by minimizing transaction costs, alignment with aggregators, reducing risk, and incorporating feedback systems to monitor and maintain performance.

Affordable housing is a sector whose occupants are more vulnerable to rising costs of energy and who have less access to financing for improvements. Comprehensive cost and value analysis is needed to incorporate the societal cost of inaction and to justify private and government investment. Accurate assessment of non-energy benefits is essential to justify the expenditure needed. Priority for investment should be placed on areas of greatest vulnerability and highest energy intensity.

Limiting investment in affordable housing to an engineering-only cost analysis is risky. How is the death of an elderly person due to excessive heat valued? We need decision-making strategies that reflect a value of life as well.

Strategic Alliances and Initiatives

The group reached three fundamental conclusions:

- When high-percent energy improvements are the goal, the distinctions between remodeling or renovation projects vs. new homebuilding become less of an issue. Some of the same basic strategies, design measures, etc., are in play, including renewables. We can look to high-performing new custom homes for models that might be adapted for use in existing homes.
- To be able to "tunnel through" (i.e., bypass the incremental, cost-additive approach to energy improvements), we need model projects that have done just that. These model projects would form the basis for a massive outreach/education effort. In order to get model projects, however, we need to seed a process, for example, a very engaging international competition. The group felt this could be a very high-profile initiative and could engage the vast and varying array of players.
- We need measures for a phased approach. Many of the traditional incremental measures may not work because they don't lead to tunneling through and therefore aren't economical enough to achieve the improvement needed.

Occupant Behavior

Occupant behavior is a rich opportunity precisely because of its inherent challenges. It was simultaneously viewed as the biggest opportunity to reduce energy use and also the biggest obstacle to achieving deep energy reductions. Huge reductions in energy use are possible with a combination of the following:

- Recognition of the need or opportunity on the part of the household;
- Recognition that their actions can make an impact;
- Accurate, consistent information on which to base decisions and avoid unexpected negative consequences;
- Resources to make investments (including time, personal energy, as well as financial resources);
- Feedback on the effectiveness of their actions (should be almost real-time);
- Incentives (not limited to financial) that reinforce progress.
- A way to measure progress against a goal; and,
- Access to technical expertise.

Californians' response to the ENRON debacle provides an excellent case study of the potential for consumers to act en masse with a peak load reduction of over 10%.

Traditional vs. emerging deep energy reduction paradigm implications for occupant behavior include:

- From “we use energy” to “we buy energy”;
- From “consumptive” to “sustainable”;
- From “unaware” to “aware” at the moment of choice;
- From “everyone else’s actions matter” (not mine), to “personal responsibility” (my actions do matter);
- From “disconnect” to “feedback at the point of purchase and use”;
- From “behavior” to “lifestyle”; and,
- From “reactive” (when it breaks I will fix), to “proactive” (I maintain it so it will last).

The linkage is not at all clear between energy *use* and energy *behaviors* in consumers’ minds.

- Using energy is not clearly perceived as making a purchasing decision.
- The *true costs* of energy are largely unknown by North American consumers, and are often intentionally obfuscated at a societal level.
- Energy consumers often feel they are at the mercy of energy providers, energy systems, and energy-consuming devices, versus being *in control* of their energy use.

Recommendations include increasing the point-of-use feedback and communicating a sense of urgency, while emphasizing the positive.

From Consumerism to Sufficiency

Lifestyle change has been branded by some as the “Un-American Way”. Alternatively, efforts to achieve deep energy reductions could be viewed as contributing to “The New American Way”, supporting energy independence, and blazing a vision that demonstrates the strategic combination of choice, efficiency, and renewables. Redefining quality of life and the concept of sufficiency, as opposed to consumption, tend to be seen as political suicide and are therefore relegated to the fringe. Change is therefore more likely to happen at the local and occupant level until the political levels “get it”. Strategies for deep energy reduction need to recognize voluntary lifestyle change as one option, and support that option with accurate information regarding the potential impact. This is critical to discouragement of well intended actions that could contribute to poor health, reduced durability, or to introduction of new indoor air quality problems. The systems approach should help solve even existing indoor air quality problems.

For the past quarter century, the energy efficiency community has worked hard to focus on energy efficiency or productivity (more services per unit of energy) and to sharply distinguish its goals from energy conservation (using less). The latter implied "doing without" the energy services presumed to be essential for modern life. To achieve deep cuts in energy use, we need to look at both energy efficiency and a larger view of energy conservation. Reducing house size, or choosing not to increase house size, is one of the most effective energy conservation strategies available. A small house with only moderate energy performance standards might use substantially less energy for heating and cooling than a large house with very high energy performance standards, once the larger house is filled with goodies. Despite gains in the energy efficiency of building envelopes, lighting, HVAC, and plug loads, total primary energy use has increased more than 30% in US residential buildings since 1978 as a result of ever increasing house size and the number of appliances within our homes. Smaller homes, which emphasize good design and quality over quantity, reduce both initial construction costs and operating costs thereby freeing up funds for efficiency measures to achieve deep energy cuts.

However, the idea that bigger is better in house size is a leading driver of the real estate industry; the North American "McMansion" has become a status symbol for consumers. Participants at the house size working group suggested the need for an aggressive marketing campaign to counteract the prevalent consumer perception that bigger is better, to point out the excesses of current housing, and to promote design techniques for optimum use of space. Since our existing older housing is more appropriately sized than typical new construction (living area per family member has increased by a factor of 3 since the 1950's) it is particularly beneficial to maintain and upgrade this stock in a way that incorporates the features important to consumers without creating excess space and to provide flexibility to adapt to changing family structures.

There are few champions for campaigns that have the ability to convey the trend toward increasing house size as being excessive. Our current financial systems do not provide deterrents for excessively large homes, nor do they offer rewards for smaller dwellings with higher occupancy per square foot. LEED for Homes is to be commended for incorporating this item.

National Rating System

Developing a standard for a national rating is a response to the need for accurate consumer information. Providing accurate occupant information on energy reduction options is much more challenging than recognized by either consumers or policy makers. Important questions here include: A) What is the context (occupant investment or public investment/incentive)?; B) How accurate is good enough?; C) What is the purpose of the information?; and, D) How is it going to be used? Present energy ratings have the potential to reinforce the perception that energy decisions are independent of health, safety, durability, adaptability, and community development. They also have the potential to convey that deep energy savings are not practical or obtainable "Your energy use is really good for a home this age." The challenge of aligning the proposed rating system to include the paradigm of deep energy use reductions is not to be underestimated. Simultaneously, a protocol for a rating system also has the potential for a more consistent message and the incorporation of this vision in a way that could serve to accelerate the comprehension that deep energy reductions are a possibility. In addition, a coordinated rating system could serve to collect data that would inform program designers and policy makers and to help target deep energy reduction strategies, as well as identify candidates for deep energy reductions.

Workforce Development

This is one of the most severe limitations to implementation of deep energy reductions. We lack the entry-level, skilled, and professional workforce needed to implement residential energy and housing initiatives under the business-as-usual paradigm, let alone a more aggressive strategy. Implementation of deep energy reductions requires a level of teamwork that is not customary for the existing home market. The Whole Enchilada approach integrates teamwork or expertise encompassing residential sustainable design, remodeling, contracting, home performance, renewables, healthy house, and energy education.

The lack of appeal of building trades as a vocation for those entering the job market is a major barrier to developing and maintaining a skilled workforce. One solution is to demonstrate an important and exciting career path. Another is to clarify the vision of deep energy reduction so that participation is compelling, and seen as "deep green" and critical to addressing larger energy supply and environmental problems. This builds on the radical, bold nature of a deep energy reduction paradigm and turns it into an asset.

A recommendation by Alex Wilson for a voluntary "Environmental Service Corps" (Environmental Building News, 2007) is an intriguing idea that could serve as a point of entry to the skilled and professional workforce. It could also provide a labor force that could be used in tandem with professionals to catalyze self-help community-based initiatives. Another suggestion made by Bill Parlapiano is to create the Green Collar Workforce Development Initiative (GCWDI). A new service industry will be created that is neither white collar nor blue collar; rather it is "green collar". At the same time we must continue evolving the existing workforce into new areas of growth and opportunity, to support the green collar economy that is growing rapidly in the country. This is truly the American way in terms of providing opportunity here at home, but there needs to be much more synergy, as too many efforts are presently occurring in a vacuum; they do not compliment one another.

It is difficult for consumers to differentiate conventional contractors from home performance contractors. Remodelers and most insulation, window, siding, HVAC and home performance contractors offer improved comfort and energy savings. Energy savings claims vary widely; every homeowner has been propositioned by window salesmen promising 50% savings. Deep energy savings offers a niche that is uniquely different from business as usual. That difference needs to be marketed, not just to attract customers, but also to attract and retain employees who recognize the vital importance of this new field.

One strategy to maximize impact and lower the labor cost lies in the development of implementation systems that are in sharp contrast to our current house-by-house customized approach. For example, the development and refinement of a package that is appropriate for a common house vintage could have components that are mass produced. Deployment could integrate installation, financing, packaging, and marketing. Key technical details and code issues would be resolved for the package, minimizing potential costs and barriers. Ironically, it is the comprehensiveness of deep energy retrofits that make it possible to simplify the package; systems that can pose challenges and require customized solutions are being replaced or eliminated rather than upgraded. Solutions for indoor air quality, moisture, durability and the provision of mechanical ventilation are essential components. Many communities have housing stock that is the same vintage, same construction, and house type. The package concept could be tied to local manufacturing, or it could be implemented with off the shelf components by a do-it-yourselfer or self-help group with skilled professionals engaged only as needed.

One manufactured option could be the development of a SIPS-type wall panel that minimizes piecework and labor, while addressing vital structural, air leakage and water management issues. Costs would be lowered if multiple homes with nearly identical measurements in the same community were packaged as a single project.

Technical and Market Innovation

Technical and market innovation have the potential to accelerate deep energy reductions. While many products would make it easier to achieve deep reductions in use, it is important to recognize that the majority of Summit participants were confident that we have the technology needed to achieve deep reductions now, assuming a motivated occupant, access to financing, and the expertise needed.

Products and systems are divided into three categories: 1) acceleration needed - already exists in North American market (A); 2) products exist, but not in the North American market (A-NA); and 3) innovation needed (I). In some cases, a product could fall into all three categories. Not all products are appropriate for all climates. The products and systems are:

a.	Better windows – U.15 with high solar gain	(A-NA)
b.	Window systems with permanent frames and removable sashes to prevent obsolescence	(I)
c.	Exterior automatic shutters	(I)
d.	Dynamic windows	(I)
e.	High performance storm windows to integrate with exterior wall insulation upgrade when window replacement cannot be justified	(A)
f.	Better doors (insulation, durability, tightness)	(A-NA)
g.	Exterior insulation systems for walls and roof	(A, A-NA)
h.	Small heating, cooling, ventilation, and dehumidification systems	(A- NA, I)
i.	Prefab exterior wall systems for high R walls – SIPS, LEGOs	(A-NA)
j.	Prefab interior wall insulation system – laminated with finished surface	(A-NA)
k.	Home automation systems (to address temperature, humidity, IAQ, plug loads)	(I, A)
l.	Alternatives to conventional dehumidification	(I)
m.	Systems to integrate with renewables	(I)
n.	Control and monitoring systems for IAQ, mechanical, natural ventilation	(I)
o.	Passive ventilation systems	(I)
p.	Efficient utility core for retrofit that provides plumbing, refrigeration, dehumidification, cooking, and DHW with heat recovery	(I)
q.	Variety of dashboard systems (energy, water, carbon, and maybe RH, IAQ)	(A,I)
r.	Super-efficient small appliances for motivated consumers	(A-NA)
s.	More efficient distributed ventilation systems	(A-NA)
t.	Phase change materials to add thermal mass	(A/I)
u.	Systems and strategies to enhance material reuse / deconstruction	(A,I)
v.	Super insulated cooking systems to minimize heat input	(A-NA)
w.	Efficient cooking, kitchen options for outdoor living (reduce summer heat gain)	(I, A)
x.	Appliances and mechanical systems with built-in energy performance tracking	(I,A)

Recommended strategies to accelerate technical systems and product innovation are:

1. More funding of research and field testing with recognition of the unique needs of existing homes;
2. Improved metrics, indices of performance, benchmarking, and wireless monitoring systems;
3. Demonstration projects in common house types across climate zones;
4. 1000 house demonstration program / competition;
5. Guidebooks on best practices;
6. Increased funding for deployment efforts including training programs;
7. Better modeling tools designed to address deep reductions and integration with renewables;
8. Government funding of dashboard development;
9. Diagnostic tools for commissioning and monitoring performance;
10. Access to product information and field performance data;
11. Industry challenges such as Golden Carrot Refrigerator (North American and international);
12. Investigate ways to reduce trade / code / product spec barriers for efficient technologies; and,
13. Website or other sources with the most efficient consumer products, appliances, and equipment.

CHALLENGES to DEEP ENERGY REDUCTIONS

1. Energy efficiency is viewed predominantly by consumers and policy makers as a function of widgets rather than systems;
2. Solutions will be limited if our assumptions are not accurate. Consensus of policy and clear signals for consumers is very difficult to achieve when assumptions are changing;
3. Action may be delayed by vested interests and widely divergent views of the urgency of movement;
4. One strategy does not fit all; customized solutions in response to climate and housing stock pose barriers to conveying the concept;
5. We lack consensus on a set of metrics that serve as indices of performance particularly in terms of push goals, but even in terms of specific indices;
6. Data regarding baseline residential energy use needs to be improved, using the indices of performance, to clarify similarities and differences with existing housing stock by climate, age, operation, construction, type;
7. We lack the data needed to verify modeling and rating assumptions;
8. Reliance on HVAC equipment standards and the failure to understand true system performance is a barrier to system innovations that minimize parasitic losses. Financial incentives should be tied to system performance. It is critical that the intermediate indicators of performance such as SEER, EER, and AFUE deliver the savings as assumed;
9. We lack the green collar workforce needed for deployment;
10. Lifestyle change has been branded as the “Un-American Way”. Redefining quality of life and the concept of sufficiency as opposed to consumption tend to be seen as political suicide and are relegated to the fringe. Change is more likely to happen at the local and occupant level until the new paradigm is seen as a winner at the political level. Strategies for deep energy reduction need to recognize voluntary lifestyle change as one option, and support that option with accurate information regarding the potential impact; and,
11. There are few champions for campaigns that have the ability to convey the trend toward increasing house size as excessive. Our current financial systems do not provide a deterrent for excessively large homes or rewards for smaller dwellings with higher occupancy per square foot. LEED for Homes is to be commended for incorporating this.

RESEARCH NEEDED

While experience from efforts to achieve very high performance new homes offer important lessons for deep reductions in existing homes, it is important to recognize that there are many differences between new and existing homes. Suggestions for research emerged from many of the working groups during the Summit. They include the following research needs:

1. Field verification of deep reduction renovation systems (range of climates, lifestyles, and starting points) to develop database and recommendations for optimization;
2. Alternatives to conventional residential dehumidification;
3. Investigate and improve our ability to model the impact of ground coupling;
4. Verification of comfort and impact of nontraditional HVAC systems;
5. Research into utility peak impacts of deep energy reductions;
6. Research into peak and energy impact of extreme house tightness (<.2 CFM/per square foot) in different climates, humidity, cooling heating loads and ventilation strategies;
7. Investigate integrated radon, soil gas, moisture control, and mechanical ventilation strategies;
8. Investigate interaction of basement wall and floor insulation with moisture flows, humidity, summer cooling, and soil gas entry;

9. Research performance of different safe room / comfort zone strategies (energy, IAQ and moisture);
10. Evaluate whole house lighting retrofits from a redesign approach, rather than a bulb replacement perspective; and,
11. Evaluate field performance of retrofit systems designed to achieve deep energy reductions, while simultaneously increasing passive survival and responsiveness to climate change and increase in severity of weather events and natural disasters (wind, rain, fire, and drought).

CONCLUSIONS

Because of our appetite for and dependency on energy in general and fossil fuels in particular, North Americans are vulnerable to changes in energy supply and energy costs. The need for immediate and deep energy reductions in existing homes provides an opportunity for people and communities to become engaged in making significant or even profound differences in the amount of energy we use, which in turn will enable us to both mitigate and adapt to changes in global climate.

Under the right circumstances – including a suitable home, motivated occupants, access to technical expertise, and at least $50,000 – deep energy reductions are achievable now. Lacking one of these, it is still possible to significantly reduce total energy use. What we do not have – and what is needed to accomplish this on a national scale – are the collective will, policies, organization, financial incentives, and technical infrastructure to make deep energy reductions in existing homes the standard, rather than the exception.

It will not be easy or cheap. The first wave of implementation will be by daring, committed 'early adopters. However, the necessity, possibility, and vision of achieving much higher energy performance in existing homes has already changed the work of many Summit participants.

We need to re-evaluate how our actions and habits, our work, our assumptions, our programs and policies fit into an energy-constrained future. What processes and systems can we adapt, what patterns and paradigms need to be discarded, what programs need to be invented or made new? How do we redefine our roles in the rapidly emerging future so we and our descendants can not only survive but thrive?

Join us in laying a foundation for deep energy reductions, so our homes will be healthy, low energy, comfortable, durable, resilient, and sustainable 50 years from now.

RECOMMENDATIONS and NEXT STEPS

ACI recommends the following actions to lay the foundation for and accelerate the implementation of deep energy reductions:

1. 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.
2. Embark on a 1,000 house demonstration project - possibly a challenge or competition - to publicly demonstrate the feasibility and methods of achieving deep energy reductions in a variety of climates.
3. Support a consensus process to establish key metrics for quantifying the energy use, energy cost, and energy-related environmental impact of existing homes based on actual performance.
4. Support research and monitoring to assess the field performance of technologies, systems, and projects, as well as to increase our ability to model deep energy reductions in existing homes.
5. Support contractors, remodelers, designers, and homeowners by developing regional guides and protocols for deep energy reductions.
6. Create and support workforce development initiatives.

7. Stimulate and support the research, development, and deployment of products and systems that are an integral part of deep energy reductions.
8. Support efforts to convey the potential for occupant behavior and consumer choices to effect residential energy use and environmental impact with comprehensive campaigns, as well as local efforts that provide positive and concrete messages, initiatives, feedback systems, and case studies.
9. Develop tools that make it possible to quantify the benefits of deep energy reductions on a societal, community, and household level.
10. Support the development of new organizational systems needed to deliver, package, aggregate, and track the performance of deep energy reductions.
11. Influence energy efficiency, green, and carbon emission reduction initiatives and policies so that they support rather than conflict with the deep energy paradigm.

Federal Government

a) Begin planning a large scale demonstration project, including development of metrics and guidelines for documentation, measurement and verification of pre- and post-retrofit energy use.
b) Increase funding for development and consensus building, and information sharing.
c) Accelerate research to support deep reductions in existing homes (see research section).
d) Launch a 'Green Collar Workforce Development' and volunteer Environmental Corps. Consider a Deep Energy Reduction contest / demonstration equivalent to the Solar Decathlon project.
e) Revisit assumptions regarding benchmarking and metrics to address accuracy and generate the equivalence of MPG (miles per gallon) rating that is independent of house size.
f) Stimulate development and deployment of the ultra high efficiency products and systems that are needed to accelerate deep energy reductions.

Private Sector and Foundations

a) Fund or implement social marketing campaigns to demonstrate the environmental, economic, and lifestyle benefits of smaller homes (Less is More), and convey the potential for consumer lifestyle choices to impact energy and environmental use while maintaining or improving quality of life.
b) Fund national, regional, and local ecumenical efforts to collaborate on supporting and stimulating education and exploration on "Reducing the Environmental Impact of our Lives."
c) Fund efforts to convey accurate customer-specific information about lifestyle choices that impact energy and environmental impact.
d) Stimulate and reward development of ultra-low energy appliances, products and technical systems.
e) Fund demonstration and pilot projects.
f) Serve as a catalyst to encourage verified performance and high levels of energy performance within existing initiatives.
g) Support local and regional efforts to stimulate the infrastructure needed to obtain deep energy reductions within carbon action plans.
h) Support higher energy efficiency standards for new construction; encourage verification of whole house energy performance.

Energy Efficiency Stakeholders (program implementers and administrators, utilities)

a) Evaluate ways that current programs and policies serve as barriers to deep energy reductions and explore opportunities to increase alignment.
b) Evaluate analysis tools that impact investment in energy efficiency to determine how non energy benefits can be monetized.
c) Evaluate the housing stock at a local level to identify characteristics of those most suitable for deep energy reduction from a technical and cost perspective.
d) Partner with other organizations to develop demonstration projects.
e) Identify research and product needs that can help to stimulate deep energy reductions. Pursue partnerships to address them.

f) Consider opportunities for collaboration and joint specification to stimulate the development of ultra low energy use products.

Local Government

a) Convene a local summit to explore carbon neutrality in existing homes. Use this as a catalyst to form a local task force to continue the effort.
b) Explore financial, regulatory and educational mechanisms to minimize lost opportunities for energy efficiency during remodeling and renovation.
c) Investigate ways that current and proposed energy efficiency initiatives support or conflict with the deep energy reduction paradigm.
d) Move to 'life-cycle plus' modeling for energy efficiency improvements (health, externalities, beyond) to stimulate deeper energy reductions in affordable housing projects.
e) Form partnerships to ensure technical support for do-it-yourselfers or self-help projects.
f) Consider local policy for overcoming disincentives for smaller homes including financing, taxes, prototype designs for renovation and zoning, and local codes.
g) Support partnerships (industry, energy providers, trade, educational, environmental, and housing) to create deep energy reduction demonstrations to develop regional specific recommendations for typical housing types.
h) Collect house-specific data that could be used to identify and understand the potential for energy reductions in local housing stock.
i) Verify the accuracy and assumptions related to energy efficiency and conservation for educational materials, programs, and initiatives using measured utility data.
j) Stimulate education and training efforts that support deep energy reductions.
k) Investigate ways to integrate improved disaster resistance and passive survivability with local strategies for deep energy reductions.

APPENDIX A: THE SUMMIT PROCESS

The ACI Summit focused on developing strategies for achieving deep energy reductions in existing single and multifamily homes throughout the US and Canada. The term “deep energy reduction” was initially defined as reducing the energy consumption of a home by 70–90% from its current consumption.

The Summit focused on reducing energy consumption regardless of its source. Though greenhouse gas emissions can be best reduced by reducing the use of fossil fuels, reducing any utility-provided energy (including hydro, geothermal, nuclear, and renewables) has the potential to offset the consumption of carbon-based fuels elsewhere.

Summit objectives were to:

- Explore the opportunities, challenges, barriers, costs, and benefits of achieving deep energy savings in selected house types and diverse climatic regions of the United States and Canada by employing a combination of technical interventions and behavioral choices.
- Propose simple, transparent energy performance metrics that help to define and communicate residential energy use and its impact on the environment.
- Begin to identify the technical systems (products, applications, etc.) that can accelerate deployment and lower the cost of deep energy savings.
- Explore strategies for achieving deep energy reductions by incorporating both custom approaches and mass-produced systems.
- Explore the potential for alignment of current programs, initiatives, incentives, markets, and policies with the longer-term goal of deep energy reduction.
- Identify and catalyze the key steps needed to move forward individually and collaboratively.

The Summit specifically avoided discussion of these important and related issues in order to focus on reducing the energy loads attributable to the building and occupant activity within the building:

- carbon offsets and trading,
- onsite power generation (renewable energy),
- transportation energy used in commuting and delivering goods and services to homes,
- energy used in water supply and wastewater treatment systems,
- energy embodied in building materials,
- energy used in solid waste management,
- energy used in food production.

The Summit agenda consisted of whole group sessions, Working Group sessions, and informal networking sessions that included food and poster presentations. Whole group sessions provided a consistent context for all participants. John Krigger of Saturn Resources Management, Inc. and Danny Parker of the Florida Solar Energy Center made official key-note presentations during whole group sessions. After being recognized for their pioneering contribution to deep home energy reductions, Harold Orr, retired from Canada’s NRC, and Amory Lovins of Rocky Mountain Institute provided brief remarks.

The primary work of the Summit was conducted through Working Groups, which consisted of twenty Issue Groups and nine Scenario Groups. Issue Groups focused on specific topics (listed below in Appendix C) and Scenario Groups focused on how to achieve deep energy reductions in a specific house type in a given geographic location. Poster Sessions were designed to give participants an opportunity to informally share deep home energy reduction case studies, key concepts, and strategic initiatives.

Whole group sessions and additional interviews were videotaped by Dave Robinson. John Krigger’s and Danny Parker’s presentations and some poster sessions are available at: www.affordablecomfort.org.

Below is a list of the Working Groups (both Issue and Scenario Groups) formed during the Summit:

Issue Group	Facilitator
Affordable Housing	Elizabeth Chant
Alignment with Current Initiatives, Programs, Markets	Charles Segerstrom
Audits & Related Consumer Information	Charles Segerstrom
Carbon	Rick Diamond
Consumer Behavior	Kindle Perry
Financing & Incentives	Elizabeth Chant
House Size per Person	Jane Thompson
HVAC & Water Heating	Keith Aldridge
Implementation & Infrastructure	Dennis Creech
Lighting, Appliances, & Plug Loads	Rana Belshe
Mechanical Ventilation & House Tightness	Courtney Moriarta
Metrics & Semantics	Keith Aldridge
Multifamily Issues	Kindle Perry
Passive Survivability	Rana Belshe
Product & Technical System Innovations	John Brooks Smith
Regulatory Issues, Insurance, & Codes	David Weitz
Verification, Monitoring, & Feedback Systems	Danny Parker
Wall & Roof Systems	Chris Dorsi
Windows, Doors, & Daylighting	Bill Burke
Workforce Development	Dennis Creech
Foundations: Basements, Crawl Spaces, & Slabs	Pat Heulman

Scenario Group	Facilitator
1980 Ranch on slab, Atlanta GA	Dennis Creech
1980 Ranch on slab, Phoenix AZ	Keith Aldridge
1980 Townhouse, Denver CO	John Krigger
1970 Ranch with crawlspace, Portland OR	Ann Edminster
1970 Ranch with basement, Minneapolis MN	Rana Belshe
1970 Ranch with garage, Albany NY	Charles Segerstrom
1950 One and a half story, Pittsburgh PA	Chris Dorsi
1920 Two story foursquare, Burlington VT	Kindle Perry
1900 Multifamily, New York City NY	Elizabeth Chant

APPENDIX B: SUMMIT PARTICIPANTS

Ninety-nine people from the United States, Canada and Germany participated in the ACI Summit. They represented various local, regional, and national nonprofit organizations; municipal, state, and federal governments; national laboratories; utility companies; residential architects, contractors and remodelers; building scientists, consultants, and educators; and product inventors, manufacturers, and distributors.

Linda Wigington of ACI initiated the Summit, served as whole group leader, and led the planning effort. Rick Diamond of Lawrence Berkeley National Laboratory (LBNL) facilitated all 'whole group' discussions. Working groups were led by a team of facilitators who also provided input to the agenda and working group activities. Summit sponsors, partners, group facilitators and participants are listed below.

Sponsor organizations contributed financial and in-kind support to the Summit. Pacific Gas & Electric (PG&E) provided financial support as well as the Pacific Energy Center, where the Summit was held.

Partner organizations expressed commitment to the goal and objectives of the Summit and supported it though their attendance, contribution to planning efforts, and feedback to the white paper.

Sponsors

Name	Organization	Representation
Dave Hepinstall	Association for Energy Affordability	Implementation - Programs
Mary James	Home Energy Magazine	Print, online media
John Krigger	Saturn Resource Management Inc	Print, online media
David Lee*	U.S. Environmental Protection Agency	Federal Government
Li-Ling Young	Vermont Energy Investment Corp	Implementation - Programs
Richard Morgan	Austin Energy	Utility and Local Government
Charles Segerstrom	Pacific Gas & Electric	Utility
Brian Simmons	Fluid Market Strategies Inc	Implementation - Programs
Bradley Steele	Energy Federation Inc	Distributor
Dan Taddei	Natl Assoc. of the Remodeling Industry	Trade Organization - Remodelers
David Weitz	Conservation Services Group	Implementation - Programs

*Not in attendance

Partners

Name	Organization	Representation
Keith Aldridge	Advanced Energy	Implementation
Katherine Austin	AIA Housing & Residential Knowledge	Trade Organization - AIA
Steve Baden	Residential Energy Services Network	Trade Organization - HERS providers
Rana Belshe	Conservation Connection Consulting	Implementation
Cal Broomhead	San Francisco Dept of the Environment	Local Government
Rich Brown	Efficient Window Collaborative	Deployment
Dennis Creech	Southface Energy Institute	Implementation - Programs
Laverne Dalgleish	Building Performance Institute	Trade Group
Rick Diamond	Lawrence Berkeley National Laboratory	Energy Research
Ann Edminster	Design AVEnues	Implementation - Design
Katrin Klingenberg	Ecological Construction Laboratory	Implementation – Design
Paul Knight	City of Chicago, Dept of Environment	Local Government
Michael Little	City of Portland – Sustainability	Local Government
Courtney Moriarta	Steven Winter Associates	Research / Implementation
Eugene (Pat) Murphy	Community Solutions	Advocacy
Greg Nahn	Wisconsin Energy Conservation Corp	Implementation - Program
Danny Parker	Florida Solar Energy Center	Building Research
Bill Parlapiano	BP Consulting	Implementation - Consultant
Sean Penrith	Earth Advantage	Implementation - Programs
Patricia Plympton	DOE / Natl Renewable Energy Lab	Building Research / Deployment
Bill Rose	Building Research Council, Univ of IL	Building Research
Chris Scruton	California Energy Commission	State Government
Bill Semple	Canada Mortgage and Housing Corp	Federal Government - Research
John Brooks Smith	Johns Manville	Manufacturer
Marko Spiegel	Conservation Technology International	Implementation - Design
Aaron Townsend	Building Science Corporation	Building Research
Alecia Ward	Midwest Energy Efficiency Alliance	Advocacy
Partners not in attendance:		
Terry Brennan	Camroden Associates	Building Research
Nils Petermann	Alliance to Save Energy	Research and Advocacy

Attendees (in addition to those listed above)

Name	Organization	State / Province
Dave Backen	Ecos Consulting	Oregon
Chris Benedict	Chris Benedict, R.A.	New York
Bill Burke	Pacific Gas & Electric	California
Dave Canny	Pacific Gas & Electric	California
Peter Chandler	Living Space	Colorado

Elizabeth Chant	CVOEO Weatherization	Vermont
Rick Cherry	Community Environmental Center	New York
Glenn Chinery	U.S. Environmental Protection Agency	Washington, DC
Rick Chitwood	Chitwood Energy Management	California
Larry Crowson	Bay Systems North America	Oregon
Chris Donatelli	Donatelli Castillo Builders	California
Chris Dorsi	Saturn Resource Management Inc	Montana
Eric Doub	Ecofutures Building	Colorado
Fred Ellis	Pacific Gas & Electric	California
Yael Gichon	City of Boulder – Office of Environment	Colorado
Henry Gifford	Architecture and Energy Affordability	New York
Charlie Gohman	Arizona Energy Office	Arizona
Matt Golden	Sustainable Spaces	California
Jeffrey Gordon	Building Research Council	Illinois
William Haas	Illinois Dept of Commerce	Illinois
Sharon Hanrahan	Energy Center of Wisconsin	Wisconsin
Bob Hendron,	NREL / Building America	Colorado
Nancy Hoeffer	Community Energy Services Corp	California
Robert Housh	Metropolitan Energy Center	Missouri
Pat Huelman	Cold Climate Housing, U. Minnesota	Minnesota
Peter Hurley	Portland Office of Sustainable Development	Oregon
Steve Kaloustian	Masco Corporation	Michigan
Michael Kamon	City of Aurora	Illinois
Rick Karg	R.J. Karg Associates	Maine
Mike Kernagis	Ecological Construction Laboratory	Illinois
Larry Kinney	Synetech Systems	Colorado
Robert Knight	Bevilacqua-Knight Inc	California
Paul Knight	Domus PLUS	Illinois
Steve Kromer	Efficiency Evaluation Organization	California
Jim Larsen	Cardinal Glass Industries	Minnesota
James Lambach	Bayer Material Science	Pennsylvania
Mike LeBeau	Conservation Technologies	Minnesota
Keith Levenson	Vermont Energy Investment Corp	Vermont
Michael Little	Seattle City Light	Washington
Erin McCollum	(ACI) Affordable Comfort Inc	Pennsylvania
Joel Morrison	Penn State U. West Penn Power Sust Fund	Pennsylvania
David Murphy	The Community Solution	California
Harold Orr	Retired	Saskatchewan
Helen Perrine	(ACI) Affordable Comfort Inc	Pennsylvania
Kindle Perry	Energy Education Consultant	New York
Paul Raymer	Heyoka Systems	Massachusetts
Mike Rogers	GreenHomes	Vermont
Judy Roberson	Building Wise	California
Dave Robinson	Renaissance Total Comfort Systems	California
Carl Seville	Seville Consulting	Georgia
Richard Smith-Overman	Housing Finance Agency	North Carolina
Bernd Steinmueller	Sustainability Management Consulting	Germany
Don Stevens	Panasonic Home & Environment Co	Washington
Greg Thomas	Performance Systems Development	New York
Jane Thompson	Jane Thompson Architect	Ontario
Michael Thompson	Sierra Center for Sustainable Living	California
Dan Varvais	BaySystems North America	California
Larry Weingarten	Water heater expert	California
Linda Wigington	ACI (Affordable Comfort, Inc.)	Pennsylvania
David Wooley	Energy Foundation	California
Peter Yost	Building Green Inc	Vermont

APPENDIX C: CHALLENGES and OPPORTUNITIES

The existing home market presents the following unique challenges and opportunities:

Market Fragmentation

There are over 120 million homes in the US alone. Collectively they represent a huge energy reduction potential, but the challenge is that each home must be dealt with on an individual basis. Even homes of the same type (e.g., in a subdivision or multifamily complex) have unique owners. Also, unlike the new home market, which is dominated by large production building companies, the home remodeling market consists of thousands of individual contractors and small businesses.

Fortunately, many home owners are now highly motivated to reduce the environmental impact of their homes, so the market is ripe for innovative policies, incentives, and technical approaches. We can and should optimize available resources by developing strategies for achieving deep energy reductions in a large number of similar homes at the same time by leveraging economies of scale and mass deployment of retrofit measures.

Market Diversity

Because the existing housing stock varies significantly in age, construction type, climate, level of maintenance, occupant lifestyle, and energy loads, there is no simple or easy way to prescribe deep energy savings, and different strategies will be needed depending on individual circumstances. We can and should, however, develop guiding or universal principles that save time and resources by steering people in the right direction and building upon lessons already learned by others. For example, local or regional organizations could maintain online resources with information about local home performance contractors and HERS raters, utility information, financial resources, and case studies. We also need to develop tools for assessing trade-offs to make it easier to combine or integrate options for efficiency, lifestyle, structural, HVAC, plug loads, renewables, and local power generation such as micro generation.

Occupant Lifestyle

Occupant behavior is a very strategic part of deep energy reductions. Discretionary energy uses are increasing and vary significantly. The more efficient a home becomes, the more significant lifestyle becomes as a determinant of total use.

In the classic study addressing lifestyle on energy use, it was found that energy use varied two to one in the same house type and general location. This impact is enormous and can either contribute to energy consumption or to energy reductions.

Feedback devices (bills and / or smart meters) are needed, and should be coupled with other interventions to support lifestyle change. We also need to develop systems (rating, benchmarking) to provide accurate site-specific information to occupants and professionals regarding the potential to achieve moderate or deep energy reductions.

Market Infrastructure

The home improvement and remodeling industry is huge, but not very responsive to regulatory strategies. A confounding challenge is that many home improvement and remodeling transactions, including do-it-yourselfers (DIY), are likely not reported for tax purposes. In this market, voluntary programs may be more effective than regulatory approaches at stimulating deep energy reductions.

Some aspects of deep energy reductions can be done by DIY, and there is also an opportunity for applying a “train the trainer and peer to peer” model using demonstration projects / house parties for renovations such as superinsulation of walls. With online resources, highly motivated do-it-yourselfers can learn the details of, for example, flashing and drainage planes.

Consumers with accurate information and municipalities armed with incentives have the potential to stimulate demand for home performance contractors and energy professionals. A bold initiative that goes well beyond “business as usual” has the potential to attract remodelers, designers, and trade contractors who want to differentiate themselves from their competition. We need to find ways to train, certify and promote residential contractors who specialize in the systems approach to deep energy reductions.

We also need to identify other essential skills and services needed as part of an effective deep energy reduction team, including designers, auditors / raters, contractors, performance analysts or technicians, financiers, real estate agents, and appraisers.

The Low Load Conundrum

The smaller the end uses, the harder it is to justify the cost of efficient technologies. With an improved building enclosure, it might cost $200 per year to heat a home with electric baseboard units. Adding a high efficiency furnace and gas lines with gas service would cost $4000, plus $120 per year for gas service. Installing a geothermal heat pump could cost $10,000. Optimistically, both could save a maximum of $100 per year. Some technologies are only possible if you get the loads below a certain threshold. Tunneling through the cost and performance barrier to deep energy efficiency can dramatically save energy cost and first costs. For example, with a highly efficient building enclosure the heating / cooling system can be downsized or eliminated. An ERV or HRV can provide ventilation, indoor air distribution and humidity control. We need to stimulate development of efficient packaged (plug and play) systems for low load homes.

Opportunities for Intervention

As stated earlier, there are at least two different styles of achieving deep energy reductions, “Whole Enchilada” and Phased Improvements. The key challenge to the “Whole Enchilada” approach is cost; the key challenge to Phased Improvements is sustaining the focus over time. Opportunities for intervention serve to create awareness of the deep energy reduction paradigm, recruit Whole Enchilada candidates, and engage and reinforce the Phased Improvements approach.

Key opportunities for intervention include:

- homeowner seeking to reduce carbon footprint;
- replacement of major components (roofing, siding, mechanical systems);
- renovation (addition or remodel);
- community-based global warming campaigns.
- home sale;
- homeowner seeking to resolve problems (comfort / IAQ);
- actions taken to address non-energy activities such as lead / noise abatement, radon mitigation;
- annual maintenance;
- energy efficiency, environmental, or green program intervention.

APPENDIX D: QUESTIONS of INTEREST

General

1. What do we call this endeavor?
2. What can we learn from the tremendous range in energy use in existing homes that can help support an effort to achieve deep energy reductions?
3. What are the triggers needed to get action at all levels that must start, approve, or require change?
4. What changes will be essential to deep energy use reductions and which will be less vital? Under what conditions do less-important items become crucial? How do we tell before the consequences are too huge to carry?
5. Does the deep energy paradigm provide a vision that is captivating enough to spur consumer investment and provide a framework for environmentally conscious consumer decision making?
6. What location and historical factors change a not-salvageable house to a must-renovate status?
7. What portion of existing housing justifies a deep energy use reduction and who decides that?
8. How will purchase price plus renovation value be rewarded by the marketplace?
9. Will new homes be held to a higher environmental standard if existing homes improve?
10. Are demonstrations (case studies) most needed in single homes, small groups of homes, whole neighborhoods, communities, or all of the above?
11. What will the frequency of unique renovation opportunities be, which make trying this approach an easy sell? How good is the data on this and where do we get it?
12. What indoor environmental conditions are most comfortable / acceptable, across ethnic types, ages of occupants, and regional climate conditions?
13. Are combustion systems compatible with deep energy reductions if they can be made insensitive to over-sizing and totally resistant to spillage? Were should they not be used?
14. What packages of strategies have the potential to impact a large number of homes?
15. What strategies can take deep energy reductions from a customized craft to mass deployment?
16. What mix of energy prices, climate, local regulatory activity, energy supply, transmission and distribution, housing types and age create the best opportunity for community-based reductions?
17. What are the guiding or universal principles that guide development of deep energy reduction strategies?
18. What types of feedback devices (bills, smart meters) are needed, and how can they be coupled with other interventions to support lifestyle change?
19. Can or (how can) this new paradigm accelerate and enhance existing efforts (Home Performance with Energy Star, 2030 Challenge)?
20. What embodied energy must be invested to get to deep energy – does it make sense from a net energy perspective?

Process

21. If we do not use deep energy reductions in our existing housing, where else can we get the energy?
22. How do we introduce solar thermal and PV and other renewable site power and when? The low-load house begs their use, but at what point is even further house efficiency no longer competitive?
23. How can we define a deep-reduction job when it will be staged over time?
24. How do we convince various actors to apply final use targets when the project will be staged?
25. How do we successfully communicate all the non-energy benefits of the deep-reduction approach? (Some of the best input will come from users at the house or the utility or the city, etc.)
26. Who sets the metrics? Total energy per house is the only metric that is fair; wealthy people can retrofit large houses to low use, while occupants of small homers look worse on a ‘per area’ basis.
27. What existing projects can provide early data and lessons on what does and doesn’t work, and why?
28. Who will be best able to help us sell consumers that deep energy reductions are the way to go?

29. Why has it taken so long to properly insulate stove and microwaves, etc.? Why are some refrigerators and freezers still poorly insulated?
30. How do we get nay-sayers to share their objections, so we can change problems into opportunities?
31. How do we ensure that systems, sub-systems and components perform to occupant expectations when most standard associations only look at safety, not performance issues?
32. Do we need building codes and code changes for deep energy retrofits?
33. Will local building officials be supportive? If they are in opposition, how do we change that?
34. How are the benefits assessed, by whom and with what training, provided by whom?
35. Do we need minimum performance requirements? Will that discourage interested participants?
36. What external benefits are there and how do we give value to them?
37. Whose value program will count and who will use which, if there is not a centrally-accepted one?
38. What parts of the process will stimulate the marketplace to help? What parts will be problems?
39. How will we manage ‘failures’ during the demonstration phase? How can we minimize them?
40. Can we collaborate with existing programs like Habitat for Humanity to demonstrate this approach?
41. How do we get the support of new home builders and the residential new construction industry?
42. Why are some energy groups and standards still endorsing systems that do not properly control indoor relative humidity?
43. Are conditions that cause degradation of the structure acceptable under any circumstance? Can’t we define a high cost for this scenario?
44. Can we sell the idea that houses that do not meet all occupant needs are acceptable? Can we maintain any standard that doesn’t meet many occupants’ wants and not suffer irreparable backlash?
45. Can we ever separate the need to produce a joint minimum in effective long-term cost that includes all of the components: capital cost; cost of money; cost of insurance; cost of energy; cost of maintenance; cost of replacement or repair? Do we then not have to go the final step to accounting for improved value (resale value +), level of satisfaction, etc.?
46. Why can’t standards require that large houses meet smaller total energy use requirements than smaller houses? Those who want larger houses likely have the capital to meet higher standards.
47. Don’t we have to implement a waste tax that is totally transparent, making energy reduction a self-serving process and massive energy reductions a really good idea? The costs of waste are real at the planet level, just not obvious to most. The US and Canada have some of the highest percentages of truly caring people anywhere; others may need a big stick because they do not believe in truth as a valued reality (reference Dr. David Hawkins).
48. By what mechanism do communities, states and feds help determine the revise rebuild, replace decisions that are so social value sensitive?
49. Should we ramp up penalties for poor construction (“I’ve always done it that way…)?
50. What is the opportunity and role of local community-based initiatives that can stimulate action and use benchmarking so usage can be compared and potential improvements recognized?
51. How do we create and implement an approach that maximizes the use of packaged components, i.e. “plug and play” -- so deep energy reduction implementation is as simple as possible?
52. How do we stimulate and support initiatives to develop the systems that are needed?
53. Can we afford to invest in measures that could be obsolete in one to five years … or are already obsolete depending on one’s assumptions?
54. What changes are needed in residential mortgage lending and home insurance to provide an incentive for annual maintenance?

Equipment

55. Are there enough high turn-down appliances out there to allow good efficiency even after many reductions in load have been accomplished?
56. What pre-packaged units make sense and in what markets?
57. How can we stimulate the development of efficient packaged (plug and play) systems that are ideal for low load homes?

Research Needs

58. What research into deep energy reductions, if any, is needed before we conduct demonstrations?
59. How high can compressor-driven cooling efficiency go, for loads like freezers, refrigerators, dehumidifiers and air conditioners? Does any group in the industry even know how to do the improvements and how much they would cost?
60. Will we get funding to rapidly study and define the expected end limits to efficiencies of 'widgets,' sub-systems and systems, so that we do not try to achieve the presently-impossible.

Documentation and Training

61. How will we train a work force to do complex tasks well when that is not part of our tradition?
62. What supporting documents are needed? Who should write them and who should review them?
63. How many systems people are out there and how quickly can we get them together to develop appropriate training programs?
64. What are the essential skills needed within a deep energy reduction custom team and how can various models be supported to deliver the requisite mix of services (designer, auditor / rater, re-modeler, contractor, performance tester, financier, and educator)?
65. What present protocols are good enough, which need changing and what new ones need to be developed to support deep energy reductions?

Testing / Evaluation

66. What testing / evaluation / measurement is really needed and what is just more paperwork?
67. What tools are needed to assess trade-offs to make it easier to combine or integrate options for efficiency, lifestyle, structural integrity, HVAC, plug loads, renewables, and local power generation?
68. How can we develop systems (rating, benchmarking) to provide accurate site specific information to occupants and professionals regarding the potential to achieve energy reductions?
69. How can those who specialize in deep energy reductions be recognized, trained, certified?

APPENDIX E: ABBREVIATIONS and DEFINITIONS

Carbon footprint	The amount of carbon dioxide or other GHG equivalent emitted into the atmosphere from any given source (building, event, person, etc)
Carbon neutrality	Having completely and effectively lowered, offset, and / or sequestered the greenhouse gas emissions attributable to any given source
CFA	Conditioned floor area
Conservation	Reducing the amount of energy used to produce a given good or service without reducing the consumption of that good or service.
Curtailment	Reducing the amount of energy used through reducing the amount of goods or services consumed.
Deep energy reduction	Reducing home energy consumption by at least 70% of original usage.
Energy conservation	Reduction or elimination of unnecessary energy use and waste (Source: www.natsource.com/markets/index.asp) Note: This has also been used to mean reducing energy use, even if the use was real and its reduction might have unfortunate consequences. It is this latter use and implementation that has resulted in a sometimes negative connotation of the term.
Energy efficiency	Reducing energy or demand requirements without reducing the end-use benefits. (Source: www.liheap.ncat.org/iutil2.htm) This assumes that the requirements that are inferred by that use are adequately known and maybe even quantified. In this context, energy efficiency is very important in the systems approach to deep energy use reduction.
Factor 10	The concept that energy consumption among European and North American homes must be reduced to 10% of current levels if we are to reduce GHG emissions so that human populations are sustainable – in reality it must be reduced to about 5% in North America, because of our higher use (a 20 times reduction factor)
GHG, greenhouse gas	Gas–particularly carbon dioxide and methane–that contributes to global climate change. (Derived from: www.epa.gov/ocepaterms)
MMTCE	Million metric tons carbon equivalent

APPENDIX F: HOME ENERGY DATA and DEMOGRAPHICS

This section contains US energy consumption and housing demographic data excerpted from the US Department of Energy (DOE) 2006 Buildings Energy Databook: http://buildingsdatabook.eren.doe.gov

Table A. Share of Households by Census Region and Vintage, as of 2001

Region	**Before 1970**	**1970-1979**	**1980-1989**	**1990-2001**	**Total**
Northeast	13.3%	2.0%	2.2%	1.4%	18.9%
Midwest	13.5%	3.4%	3.4%	2.6%	22.9%
South	13.8%	7.2%	7.2%	7.1%	36.3%
West	10.3%	5.0%	5.0%	3.4%	21.8%

Table B. 2001 Delivered End-Uses for an Average Household, by Region (million Btu/household)

End Use	**Northeast**	**Midwest**	**South**	**West**	**National**
space heating	63.1%	66.8%	27.7%	29.7%	43.9%
space cooling	3.3%	5.1%	11.5%	5.4%	7.7%
water heating	18.0%	17.4%	13.9%	15.1%	15.8%
refrigerator	4.2%	4.9%	6.0%	4.0%	5.0%
other appliances and lighting	20.1%	23.7%	24.3%	20.2%	22.5%

Table C. 2001 Residential *Delivered* Energy Consumption Intensities, by Housing Type

Housing Type	**per square foot (1000 Btu)**	**per household (million Btu)**	**per person (million Btu)**	**percent of total consumption**
Single-Family	**44.8**	**107.3**	**39.8**	**80.1%**
Detached	44.7	108.5	39.6	69.4%
Attached	45.6	100.4	37.5	10.7%
Multi-Family	**52.1**	**54.3**	**25.8**	**14.6%**
2-4 units	56.1	78.1	34.3	7.5%
≥ 5 units	48.5	41.0	20.5	7.1%
Mobile Homes	**72.0**	**75.9**	**293.4**	**5.3%**

Table D. 2001 End-Use CO_2 Emissions for an Average Household, by Region (pounds CO_2)

End Use	**Northeast**	**Midwest**	**South**	**West**	**National**
space heating	9,083	8,690	4,890	4,467	6,475
space cooling	1,467	2,063	4,742	2,170	3,197
water heating	2,936	2,625	3,135	2,530	2,914
refrigerator	1,444	2,041	2,463	1,796	2,068
other appliances and lighting	6,957	8,694	9,224	7,125	8,177
Total	21,888	24,113	24,455	18,089	22,830

Table E. 2005 US Electricity Generation by Fuel Source (billion kWh)

coal	1956	50.2%
nuclear	780	20.0%
natural gas	546	14.0%
renewable - hydro	269	6.9%
combined heat/power (CHP)	178	4.6%
petroleum	111	2.9%
renewable - other	54	1.4%

Table F. 2005 Residential End-Use CO2 Emissions, by Fuel Type (MMTCE)

End Use	Natural Gas	Petroleum	Electricity	Total	Percent
space heating	50.7	22.5	25.7	99.1	28.9%
water heating	16.4	3.1	21.7	41.2	12.0%
space cooling			43.6	43.6	12.7%
lighting			39.2	39.2	11.4%
refrigeration			26.7	26.7	7.8%
electronics			26.2	26.2	7.6%
clothes washers and dryers, dishwashers	1.0		15.9	16.9	4.9%
cooking	3.1	0.5	12.1	15.6	4.6%
computers			4.0	4.0	1.2%
other	0.6	2.9	26.6	30.2	8.9%
Total	71.8	29.0	241.7	342.8	100.0%

Table G. Total Primary Energy Consumption and Population, by Country/Region

	Energy Consumption (Quad)				Population (million)			
Region/Country	1990	2004	2004	2010	1990	2004	2004	2010
United States	84.7	100.7	22.5%	106.5	254	294	4.6%	310
OECD Europe	69.9	81.1	18.2%	84.1	497	532	8.3%	543
China	27.0	59.6	13.3%	82.6	1,155	1,307	20.5%	1,355
Russia	39.0	30.1	6.7%	32.9	148	144	2.3%	140
Other Non-OECD Asia	12.5	24.9	5.6%	30.3	743	962	15.1%	1,054
Japan	18.4	22.6	5.1%	23.5	124	128	2.0%	128
Central, S America	14.5	22.5	5.0%	27.7	360	448	7.0%	486
Middle East	11.3	21.1	4.7%	26.3	137	191	3.0%	216
Other Non-OECD Europe	28.3	19.6	4.4%	21.9	200	198	3.1%	198
India	8.0	15.4	3.4%	18.2	849	1,087	17.0%	1,183
Africa	9.5	13.7	3.1%	16.9	636	887	13.9%	1,007
Canada	11.1	13.6	3.0%	15.5	28	32	0.5%	34
South Korea	3.8	9.0	2.0%	9.6	43	48	0.8%	49
Mexico	5	6.6	1.5%	8.3	84	106	1.7%	113
Australia, N. Zealand	4.4	6.2	1.4%	6.8	20	24	0.4%	25
Total	347.3	446.7	100%	511.1	5,278	6,388	100%	6,841

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