Don't Supersize Me!
Toward a Policy of Consumption-Based Energy Efficiency

Jeffrey Harris, Rick Diamond, Maithili Iyer, and Christopher Payne,
Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division
Carl Blumstein, University of California Energy Institute

ABSTRACT

Building on prior discussions at ACEEE Summer Studies and elsewhere, we argue that today's primary focus on energy efficiency may not be sufficient to slow (and ultimately reverse) the growth in total energy consumption and carbon emissions. Instead, policy makers need to return to an earlier emphasis on "conservation," with energy efficiency seen as a *means* rather than an end in itself. We briefly review the concept of "intensive" *vs* "extensive" variables (i.e., energy efficiency *vs* energy consumption), and why attention to both consumption and efficiency is essential for effective policy in a carbon- and oil-constrained world with increasingly brittle energy markets. To start, energy indicators and policy evaluation metrics need to reflect energy consumption as well as efficiency.

We introduce the concept of "variable" (consumption-sensitive) efficiency,[1] where the level of efficiency varies as a function of size (for a home), capacity (for an appliance), or scale of energy consumption. We propose introducing variable efficiency criteria first in consumer information programs (appliance test methods, categories for appliance labeling) and then in voluntary rating and recognition programs (LEED and ENERGY STAR for homes). As acceptance grows, the concept could be extended to utility rebates, tax incentives, and ultimately to mandatory codes and standards.

For these and other programs, incorporating both consumption and efficiency criteria offers a path for energy experts, policy-makers, and the public to join debate and build consensus on energy policies that recognize finite resources and global carrying-capacity, perhaps helping to shift our shared expectations from perpetual growth toward sufficiency and sustainability.

An Overview of Energy Efficiency and Energy Consumption

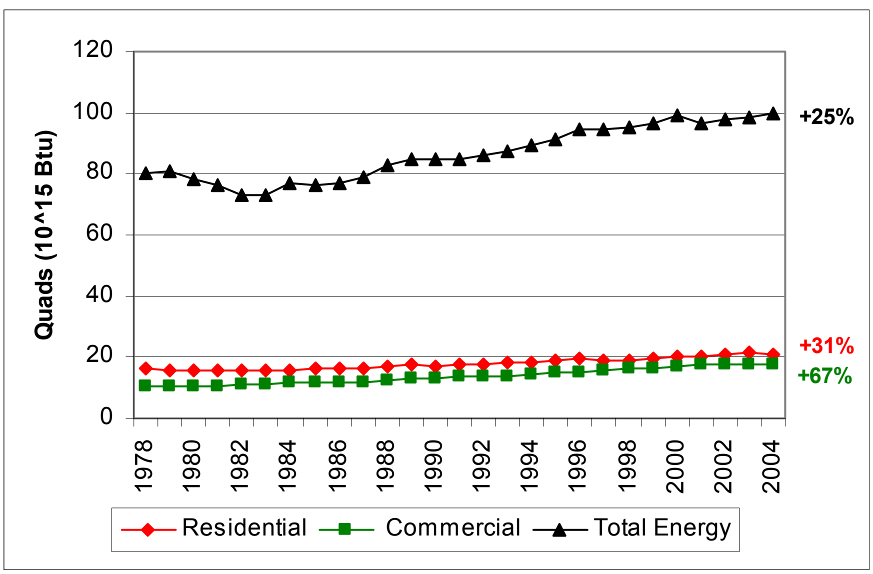
For the past quarter century, the energy efficiency community has worked hard to focus on energy efficiency or productivity (more services per unit of energy) and to sharply distinguish its goals from energy conservation (using less). The latter implied "doing without" the energy services presumed to be essential for modern life – or at least our inalienable right. A few voices at past Summer Studies and elsewhere have challenged this assumption, arguing that energy consumption does matter and that energy efficiency is one way, perhaps not the only way, to reduce energy use (Rudin 2000; Wilhite et al. 2000; Moezzi and Diamond 2005). Meanwhile, recent headlines about peak oil, event-triggered fuel or electricity shortages and price spikes, climate change, and air pollution all send the message that energy consumption matters, and begin to call into question our unconstrained appetite for energy services and future ability to afford them. The very title of this ACEEE conference, "Toward Zero-Energy Buildings,"

[1] A previous formulation of the concept of "variable efficiency" is in Moezzi and Meier 2001.

underscores this point: zero energy use is the goal, with efficiency (and renewable energy sources) as the means. Thirty years ago President Carter called for sweaters and sacrifice; today one might instead ask whether a sweater (or in summer a short-sleeve shirt to replace coat and tie) might not be part of how we satisfy our needs for comfort. Sacrifice – or common sense?

Energy efficiency has made significant contributions to reduce the growth in energy demand below what it otherwise might have been. But this has not been enough, in the US and other industrial countries and even more strikingly in rapidly developing economies like China and India, to offset the drivers of increased energy consumption: population growth, increased wealth and income, and our collective preferences for ever larger, more energy-intensive products and services. Despite notable gains in the energy efficiency of building envelopes, lighting, HVAC, and plug loads, total primary energy use has increased over 30% in US residential buildings since 1978 (Figure 1), and more than 65% in commercial buildings. The growth in buildings sector energy has been significantly faster than for all US energy (25%). Of course, there are many ways to disaggregate or "explain" this growth in energy use: floorspace additions, increasing penetration of central air conditioning along with population shifts to cooling-intensive southern regions, growing saturation of appliances and miscellaneous plug loads (especially consumer and office electronics with their 24/7 standby loads), consumers' desire and ability to pay for thermal comfort and (conditioned) fresh air. Since most of these growing loads use electricity, accounting for energy in primary (resource) terms rather than site energy (including electricity system losses) further highlights these trends – and properly so if our energy concerns include resource depletion, carbon emissions, and economic costs.

Figure 1. Primary Energy Use in US Buildings, 1978-2004



Source: EIA 2004a

An energy policy that seeks to mitigate climate change, avoid pollution, and/or reduce oil dependency must measure its success in terms of lower energy consumption – or at least slower growth. At present, there is ambiguity about the main thrust of energy-saving policies at both national and state levels. In some cases the focus is clearly on efficiency without regard to consumption; in others consumption-management ("conservation") is creeping in, especially where the policy drivers include oil dependence, electric grid capacity and reliability, or climate change and pollution. And in many cases policy-makers seem confused (or deliberately vague) about efficiency *vs* conservation, perhaps in the hope that efficiency improvements will be powerful enough to reduce absolute energy use and carbon without any constraint on consumers or consumption.

Some observers have suggested that energy efficiency itself leads to increased consumption by lowering the cost of energy services. Others maintain that a pre-occupation with hardware technology causes us to overlook behavioral changes that include both efficient operation of buildings and equipment and reduced demand for energy services (Herring 2006). The purpose of this paper is not to further debate the "snapback" effect of efficiency on consumption nor the merits of technology *vs* behavior change. Nor do we anticipate or advocate an imminent mass movement toward "voluntary simplicity" (welcome though that might be). Rather than discard energy efficiency we seek to enhance it, by (re-)introducing energy *conservation* as a legitimate and desirable policy goal and drawing attention to trends in energy consumption as well as energy efficiency. Framing our policy goals in terms of energy consumption can tell us how much efficiency is needed to manage that consumption, in the face of growing population, income, and consumer desires.

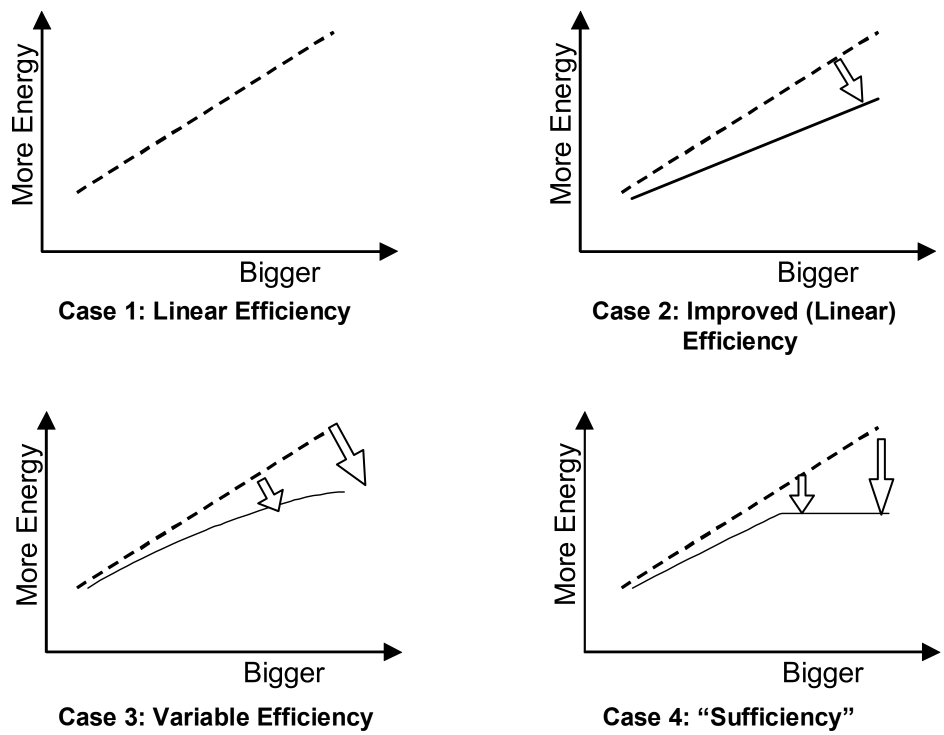
We recognize that it is impractical today to propose a quantum leap from a policy of energy efficiency to a policy based on energy services *sufficiency* (although easier, in principle, for a wealthy industrial economy). Instead, this paper offers some initial steps toward the goal of managing total energy consumption with efficiency as a means to that goal. The central idea is that the level of energy efficiency, rather than remain constant, should increase as the scale of energy use or energy service increases (i.e., larger appliances, homes, or vehicles). In some cases, physics alone would dictate increased efficiency at a larger scale: the surface-to-volume ratio suggests that a larger building envelope, refrigerator, or water heater tank should have proportionately lower thermal losses or gains. In practice, though, efficiency criteria for large units are sometimes less stringent rather than equally or more so. The four sketches in Figure 2 illustrate schematically our current approach to energy efficiency, and an alternative formulation.

Case 1 shows energy efficiency remaining constant with increased scale of energy or service consumption; energy use is a linear function of size. When policy-makers want to improve energy efficiency (Case 2), they tend to change the slope of that line (and perhaps the intercept) while keeping the linear relationship. A real-world example is shown in Figure 3 (below) for US refrigerator efficiency standards adopted in 1993 (upper dashed lines) and then tightened significantly in 2001 (lower solid lines).

Case 3 in Figure 2 shows an alternative formulation, with efficiency (i.e., the slope of the line) rather than just energy use, varying as a function of scale. For example, a criterion based on variable efficiency would expect or demand a higher level of efficiency for a larger home or appliance. Energy consumption could still increase with size, but at a slower rate. A final variant is shown in Case 4: Above a certain size, a very large home or appliance, in order to be considered "energy-efficient" (or more accurately, energy-conserving) would have to offset all of its upsizing with increased efficiency.

The next sections of this paper explore some practical steps toward a policy of variable, or "consumption-sensitive," efficiency beginning with voluntary information and incentive programs but potentially also including mandatory standards. We offer three short case studies of how to incorporate energy consumption along with energy efficiency: first in the choice of energy indicators, next in setting criteria for recognizing energy-efficient homes under ENERGY STAR and LEED, and finally in defining categories for appliance labels (and perhaps standards) in ways that discourage rather than reward upsizing. For these programs and others, combining consumption criteria with energy efficiency can also help energy experts, policy-makers, and the public begin to acknowledge a world of finite resources and carrying capacity, and perhaps move beyond assumptions of indefinite growth toward some vision of sustainable sufficiency (Princen 2005).

Figure 2. Efficiency Varying with Scale



Case 1: What You Measure Is What You Get (WYMIWYG)

Intensive and Extensive Variables

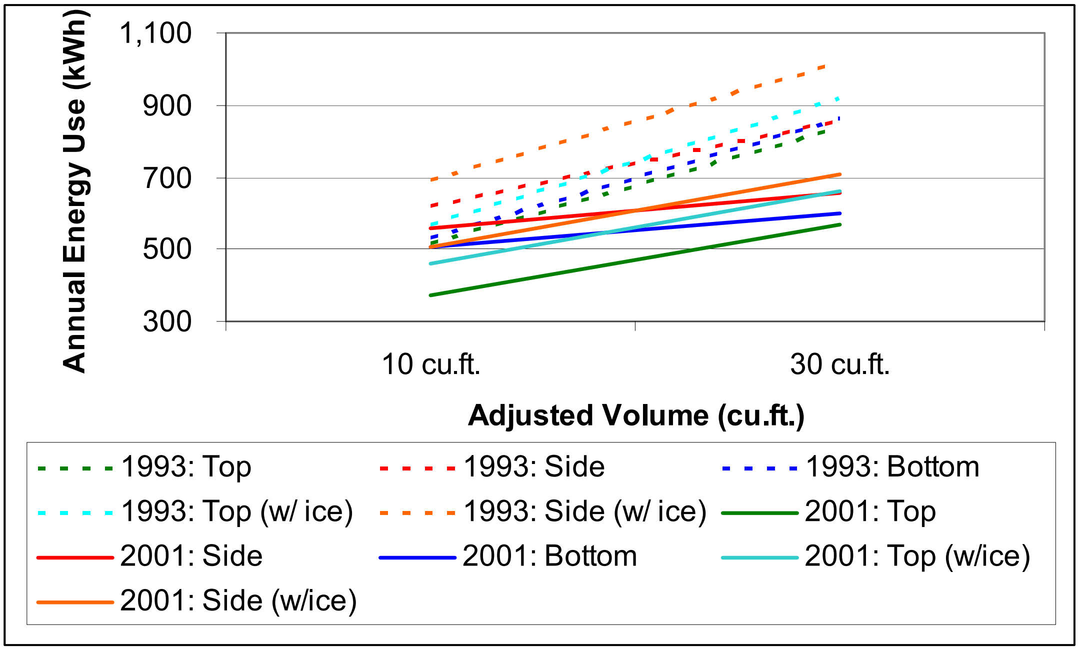
The debate between energy efficiency and energy conservation can be framed in terms of intensive *vs* extensive variables.[2] Extensive variables are scale-dependent; intensive variables are not. For example, the size of the economy, as measured by gross domestic product (GDP), is an extensive variable; the energy *intensity* of the economy, measured by energy use per unit of GDP, is an intensive variable.

For years, energy efficiency advocates have taken pains to distinguish efficiency from conservation, asserting that efficiency means providing the same service with less energy (e.g., using a more efficient furnace to warm the air in a house to 72° F) while conservation means using less of a service (warming the air only to 70° F). The politics of increasing efficiency has generally been preferred – especially in the US – to the politics of advocating energy

[2] The phrases "intensive variable" and "extensive variable" are more commonly used in the physical sciences than in the social sciences. For example, many thermodynamics texts discuss the distinction in an introductory chapter.

conservation. Thus, objectives are usually defined in terms of intensive variables—miles/gallon, energy per square foot of floorspace, electricity per ton of steel, or Btu per dollar of GDP.

Figure 3. Linear Efficiency for Refrigerators



Source: 10CFR430 - PART 430--Energy Conservation Program for Consumer Products. http://www.access.gpo.gov/nara/cfr/waisidx_02/10cfr430_02.html

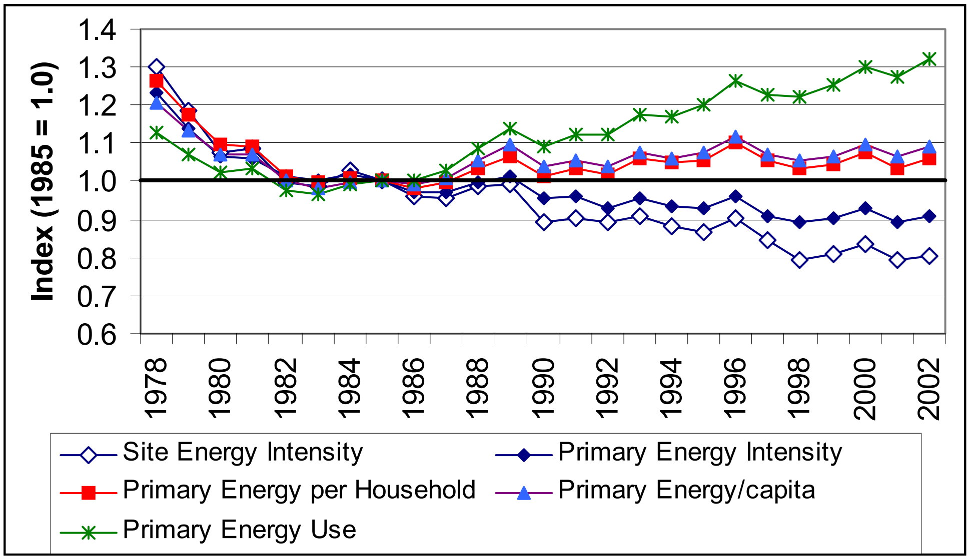
The current Administration frames US goals for greenhouse gas mitigation in term of an intensive variable: tons of CO_2 per dollar of GDP (White House 2002). But increasingly it is the extensive variables – carbon emissions, fossil fuel consumption, or oil imports – that are the ultimate objectives. There is no *a priori* reason to prefer efficiency over conservation as the means to reduce energy consumption or slow its growth; the two could be combined in any proportion. Only by shifting the focus of energy policy and public debate from efficiency (intensive variable) to consumption (extensive variable), can we establish the gains needed in energy efficiency to achieve our aspirations for both economic well-being (per capita GDP) and energy services (housing, health care, leisure activities, travel) and for climate change mitigation, air quality improvement, and reduced oil dependency.

Analysts may reach different conclusions about the effectiveness of energy policies depending on their choice of intensive or extensive indicators. Consider some simple examples for trends in US residential and commercial buildings. Figure 4 shows several indicators of residential energy use, all indexed to 1985. The indicator most often cited for homes is site energy intensity (energy per square foot of floorspace), which declined 20% since 1985 after an even sharper drop from 1978-85 (open diamonds, in the Figure). In primary energy units, however (including electricity system losses), energy intensity declined only half this fast, or 10%, from 1985 to 2002 (solid diamonds). However, we use energy in homes not for the benefit of "floorspace" but to provide services to the people in those buildings. Introducing "households" and occupants to the equation tells a different story (still in primary energy units).

Average household size has been shrinking: 3% from 1978 to 1985 then another 6% from 1985 to 2002. At the same time, the physical size of houses has grown: 17% from 1985 to

2002 as a stock average (thus even faster for new homes). The net effect is an increase – not a decrease – in per household energy use from 1985 to 2002 (up 6%, squares) and in energy use per residential occupant (up 9%, triangles). Combining this with a 21% population growth from 1985 to 2002, the final (extensive) indicator of total residential site energy increased 32% since 1985 – after initially declining from 1978 to 1985 (crosses). So, over this period did we gain ground by 20% (reduction in site energy per square foot) or fall behind by 32 % (increase in total primary energy)? Or was it something in between? The answer depends on whether we're talking about energy consumption or energy efficiency, and which specific indicators of each.

Figure 4. Indices of US Residential Energy



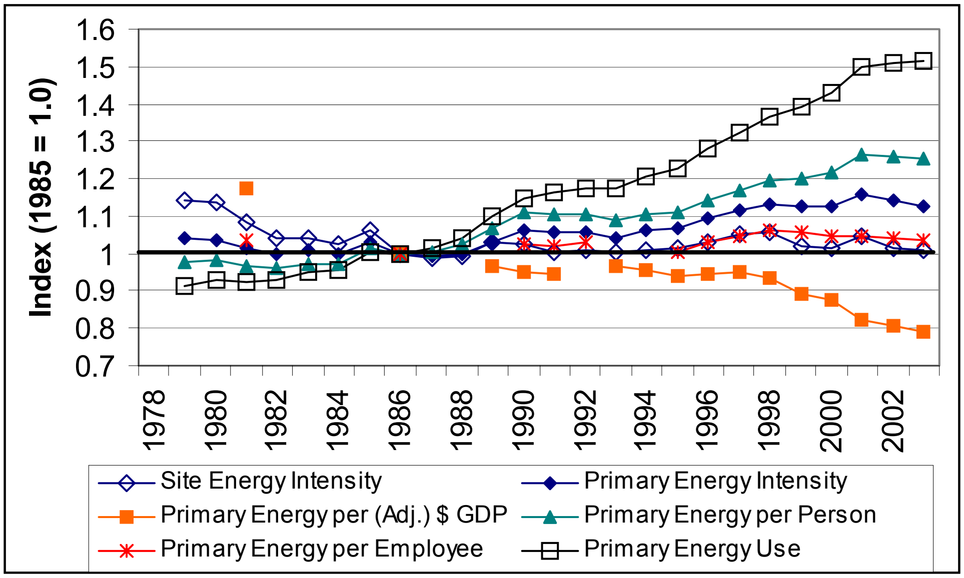
Source: PNNL 2005

Figure 5 shows similar indicators of energy use in US commercial buildings, again in both site and primary energy. The most common indicator is once again site energy intensity (site energy/sq.ft.) which actually declined about 12% from 1978 to 1985, then stayed roughly constant for the next 17 years (open diamonds in the Figure). Primary energy intensity, however, grew by 13% over the same period (solid diamonds). And on a per capita basis, commercial sector primary energy use per person (triangles) first increased modestly from 1978-85, then more rapidly: up 25% from 1985 to 2002. From one perspective it makes sense to normalize commercial energy use by the total population ultimately served by the commercial activity in offices, retail shops, health care and educational buildings, and hotels and restaurants. Another viewpoint, however, emphasizes the "energy productivity" of commercial buildings, arguing that we are finding more efficient ways to use commercial buildings to increase GDP and to provide workspaces. Thus, the next two indicators in Figure 5 show primary energy use per dollar of "adjusted" GDP (solid squares) and primary energy per employee (crosses).[3] Energy per dollar

[3] Figure 5 is based on GDP in constant (2002) dollars. The data exclude GDP and employment related to manufacturing, construction, mining, and agriculture. Energy use per employee is obviously a more meaningful metric for some types of commercial buildings (offices, and perhaps retail and schools) than for warehouse or public assembly buildings with intermittent or highly varying occupancy, but a breakdown by building type was beyond the scope of this paper. Finally, a comparison of 1992 and 2003 CBECS data shows that floorspace per worker has declined in most types of commercial buildings, averaging -7% for the sector as a whole, so the roughly constant trend in primate energy per employee is even more noteworthy.

of constant-dollar GDP declined dramatically, by more than 20% from 1985 to 2002 (solid squares) while energy per employee remained roughly the same. Last, after factoring in the growth in both GDP and commercial floorspace, total primary energy use in commercial buildings (our extensive indicator, open squares) first increased about 10% in the 7 years from 1978 to 1985, and then shot up by more than 50% in the next 17 years.

Figure 5. Indices of US Commercial Buildings Energy



Source: PNNL 2005; Stat Abstract 1992-2006

From these simple examples we would conclude that:

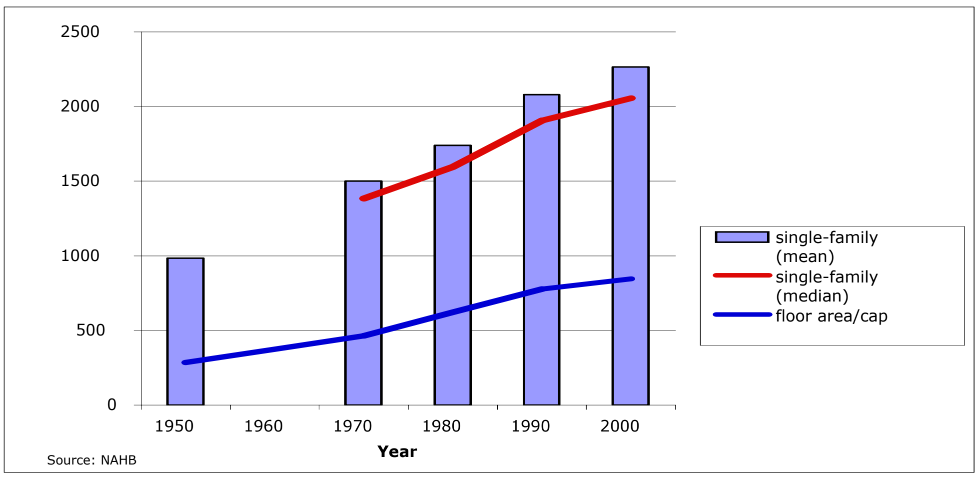
- Both policy targets and tracking of progress need to reflect energy consumption indicators (extensive) as well as energy efficiency (intensive); and
- While normalizing energy use often adds useful information, the ultimate value of energy use is in services to people. Thus, energy per person should always be one of the metrics considered, in addition to indicators that divide energy use by building floor area, dollar of GDP, ton of industrial output, etc.

Case 2: Homes or Castles?

In recent years, numerous articles and news stories in the popular press have highlighted, and often decried, the growth in average size of new US homes. Increasing house size is a major factor in the growth in total residential energy (and in energy per household or per capita) along with the growing saturation of major appliances (>100% in some cases), convenience appliances, home electronics, and amenities like pools, spas, and home saunas/steam rooms. Among these trends, let us consider upsizing in more detail.

In 1950, the average floor area for a new house was 1,000 ft^2. By the year 2000, the average floor area for new homes had more than doubled to 2,200 ft^2 (Figure 6). Combined with fewer people per household, the result was a three-fold increase in average floor area per capita, from 286 to 847 ft^2/person over those five decades. In theory, bigger houses are more efficient in enclosing space (and thus reducing heat loss and gain) because of their lower surface-to-volume ratios. In practice, though, today's large houses often have complex perimeters (more bay windows, dormers, and other features) that add to surface area and often complicate construction detailing for insulation and air-sealing. Consequently, regardless of the code-prescribed insulation levels and air barriers, these new homes may be less efficient in terms of actual surface-to-volume ratios, effective u-values, and envelope infiltration, compared with a smaller, simpler design.[4] Bigger houses also tend to have room for more stuff – more appliances, more entertainment and convenience devices, more everything. Finally, the higher ceilings and two-story entries and other dramatic spaces in today's new homes also increase the volume of space to be heated and cooled. Even though stratification could theoretically be used as a strategy to reduce cooling requirements in summer (while increasing them in winter), the placement of air supply ducts and occupant ignorance about proper use of ceiling fans for summer comfort cooling *vs* winter de-stratification tend to make high ceilings a net energy penalty rather than an advantage, even in cooling-dominated climates.

Figure 6. US House Size (floor area) Mean and Median 1950–2000



Source: NAHB 2003

So why this increase in US house size? The short answer may relate to our cultural assumptions that more (or bigger) is better. But there are other forces at work: mortgage and tax structures, complex zoning requirements, real estate practices, and other factors that tend to drive up house size – none of which can be separated from what people seemingly "want." The high turnover in single-family homes also contributes to a preference for larger houses, as expected resale value becomes more important in deciding the number of bedrooms and bathrooms than the actual needs (or even desires) of the current resident. Mortgage banks may encourage upsizing by requiring the value of the home to be three times the value of the land, according to Art Castle, Executive Vice President of the Home Builders Association of Kitsap County, Washington: "If you put a house outside of these perimeters, you create a market aberration… A lot of lenders are unwilling to support smaller houses" (California Energy Circuit 2004).

A study by Prahl (2000) suggests that the Home Energy Rating System (HERS) used by ENERGY STAR Homes and a number of utility-sponsored programs requires smaller houses to have higher levels of energy efficiency, component by component, in order to achieve the same

[4] Larger homes also tend to have longer runs of air ducts and domestic hot water pipes, with corresponding increases in distribution losses for both HVAC and DHW systems; this loss of system efficiency is directly related to scale.

HERS score as a larger house. Holding constant domestic water heating efficiency, the study found that in Pittsburgh, Pennsylvania, a typical 1,537 ft^2 home would need to install a furnace rated at 96% Annual Fuel Use Efficiency (AFUE) to achieve a HERS score of 86, whereas a 5,564 ft^2 house would require only an 80% AFUE furnace.[5] Building a bigger house efficiently will typically "save" more energy than building a smaller house at the same efficiency level, but the larger house will still consume more energy. Further, since smaller houses tend to be designed for the lower end of the market and sited on less expensive lots, the added energy efficiency investment becomes a larger proportion of the total purchase price.

Acknowledging the fact that bigger houses imply more energy consumption per household, some green-building rating programs have started to incorporate a factor to reflect house size. Like many green building programs, the Portland [Oregon] Gas and Electric Earth Advantage certification program combines required measures and additional points that can be earned for a home's green features. In 2003, Earth Advantage created four advanced certification levels, two of which include a matrix based on house size. For example, under the new Earth Advantage Gold package for environmental and water efficiency, a 2,500 ft^2 home needs to earn 50 more points for environmental responsibility or resource efficiency than a 1,999 ft^2 home in order to earn the same overall ranking (Baker 2004).

The Vermont Built Green (VBG) program, started in 2003 and often considered as the most comprehensive program in the country, takes this idea one step further. To earn VBG certification, a home must meet 54 separate requirements and earn at least 100 points. Under this system, the easiest way to earn certification is to meet the minimum requirements and build a very small house. For example, a two-bedroom house earns 100 points if it has a floor area of 1,000 ft^2, but only 25 points with a floor area of 1,500 ft^2. By contrast, a four-bedroom house at 5,200 ft^2 starts with a negative (-)100 points, meaning that other features will have to earn 200 points – twice as many – for VBG certification (Baker 2004).

The new Leadership in Energy and Environmental Design (LEED) rating for homes is currently in the pilot phase with roll-out by the US Green Building Council (USGBC) expected in 2007. The LEED credit for Home Size under "Materials and Resources" is designed to "promote the construction of homes that are smaller than the national average." Houses are penalized if they are larger than the national average for their category (based on the number of bedrooms) and get up to 10 points out of 108 possible points if they are smaller than average. As an example, the national average floorspace is 1900 ft^2 for a new three-bedroom house. A house that is 2900 ft^2or larger loses 10 points, while a house 900 ft^2 or smaller would gain 10 points, with a proportional number of points added or subtracted between these two extremes. The rationale for the large number of points associated with this credit was the realization that as house size increases, so does the home's consumption of materials and energy. So the USGBC doubled the original maximum of 5 points to reflect the "intimate linkage between home size and its dual consumption profiles: materials and energy" (USGBC 2005, p.75).

In addition to a recognition by some home rating systems of the issue of size and total energy use (or "ecological footprint"), a small but growing number of communities are adopting local policies to discourage home super-sizing. In Colorado, Pitkin County and the town of Aspen charge new homeowners a fee if their homes exceed 5,000 ft^2 and another fee up to $100,000 if they exceed the "energy budget" allotted to their property by the local building code.

---

[5] Other parameters were varied as well, all pointing to lower efficiency levels required in the larger house. There are a number of degrees of freedom by which a given score can be achieved, so the heating AFUE comparison, in that sense, is an example.

In Marin County, north of San Francisco, new homes over 3,500 ft^2 must be 25 percent more efficient than the state energy code, and homes over 7,500 ft^2 must install a solar energy system that supplies at least 25 percent of their energy.

While these are promising developments, the country's largest energy efficiency program for new homes, ENERGY STAR for Homes,[6] still allows a house of any size to qualify for the ENERGY STAR label based on a HERS rating. Starting in July 2006, there are additional requirements for efficient appliances and lighting. An ENERGY STAR home must include "Five or more ENERGY STAR qualified appliances, light fixtures, ceiling fans equipped with lighting fixtures, and/or ventilation fans." On the one hand, it is laudable that the program will now consider the efficiency of these other energy uses, in addition to the envelope, space conditioning, and hot water systems that have defined an ENERGY STAR home until now. At the same time, this new criterion may be in fact *easier to meet* in a larger home which may feature two or more central air conditioners, two or more furnaces, multiple refrigerators and dishwashers, and many more ceiling fans and installed light fixtures – of which only 5, rather than a fixed percent of the total, must be ENERGY STAR qualified. Clearly, this approach is not even "linear efficiency" as described in Figure 2, above. Instead, it uses a criterion for "energy-efficient" that becomes more lax as house size and energy consumption increase!

As we have noted, even linear definitions of efficiency fail to account for the thermodynamic (and marketing) opportunities to push for greater-than-proportional energy savings in larger houses. Instead, using the variable-efficiency approach outlined above and shown schematically in Figure 2, maximum energy consumption for an ENERGY STAR home might be a simple linear function of floor area for small-to-mid size houses, while for bigger houses there would be a steadily increasing requirement to deliver high efficiency. Perhaps at some point on the floorspace scale, a home could only qualify as ENERGY STAR if it uses no more energy than a home of a specified maximum size – say 3750 ft^2 (or 50% larger than the median new US home). A variable efficiency specification for new homes could be further adjusted for the number of bedrooms, as some of our example programs already do, although this might also lead to gaming (such as relabeling rooms) thus further complicating compliance.

This is just one example of how the concept of variable efficiency might be applied to an important and popular program, to take advantage of the thermodynamic (and often fiscal) opportunities for expecting increased energy efficiency in larger houses. If policy specifications were to take such a form, efficiency efforts could be directed where they would achieve the most savings in energy consumption and – not incidentally from the viewpoint of ENERGY STAR – the greatest net reductions in energy-related greenhouse gas emissions.

Case 3: Categorical Illusions

US appliance energy labeling offers still more examples of how to incorporate energy consumption along with energy efficiency as a matter of policy and practice. This includes both the Federal Trade Commission's "EnergyGuide" comparison label and the ENERGY STAR endorsement label, since both are in turn based on the same appliance test methods adopted by DOE and the same sets of categories used to group models for comparison purposes – and for setting mandatory national standards.

[6] According to an Energy Star press release (10/05), "Currently there are more than 2,500 home builders who have constructed more than 400,000 Energy Star qualified homes, including close to 10 percent of the new housing starts in 2004."

Appliance energy testing, labeling, and standards were originally authorized in the 1975 Energy Policy and Conservation Act (42USC77, Sec. 6201). The Congressional statement of purpose in that law, drafted at a time of intense concern over oil imports, electricity supply, and sharply higher prices for all forms of energy, clearly encompasses both energy efficiency *and* energy conservation (reduced consumption). The labels and standards were designed:

> ... (4) to conserve energy supplies through energy conservation programs, and, where necessary, the regulation of certain energy uses;
> (5) to provide for improved energy efficiency of motor vehicles, major appliances, and certain other consumer products...

While the efficiency of many consumer appliances has increased notably over the years, total appliance energy use has remained constant or has risen due to rapid growth in stocks, saturation, size, and functionality, as well as entirely new categories of appliances and new combinations of them (e.g., not only do refrigerator-freezers offer thru-the-door-ice, but some models feature on-the-door LCD monitors connected to an internet-linked PC).

To return to the basic issue with some appliance labels: Both the Federal Trade Commission (FTC) yellow EnergyGuide and the ENERGY STAR label, as currently implemented, compare energy *efficiency* only among a narrowly-defined set of models with very similar size and features. As a result, the labels may be shortchanging the legislative objective of helping consumers make energy-*conserving* decisions – which sometimes requires a broader set of comparisons. Consider the example of refrigerator-freezers: the problem with the current labeling scheme is that the product categories fail to offer the consumer a full comparison of energy consumption among models that provide similar levels of functionality (i.e., all 3 styles of freezer location as well as capacities across a range broader than 2 cubic feet). Thus, the impact of refrigerator size and freezer configuration on energy consumption remains largely invisible to all but the most attentive buyers. This issue was highlighted in recent comments by Consumers Union, as part of an FTC Advance Notice of Proposed Rulemaking on possible revisions to the EnergyGuide label:

> Consumers trying to select a refrigerator based on energy efficiency must be able to compare across categories, instead of within the current very narrowly defined subclasses. ... The ratings of energy efficiency of refrigerators published in *Consumer Reports* allow consumers to directly compare refrigerators across types... (CU 2006).

Figures 7a and 7b display the range in FTC labeled energy use for 16 of the most common refrigerator-freezer groupings used for comparison labeling (four capacity ranges in 2-cu.ft. bins and four freezer configurations). Fig. 7a shows the large range of energy consumption values among refrigerators delivering roughly the same level of service (i.e., storage capacity), and differing only by freezer configuration. These same data, regrouped in Fig. 7b, show that there is a great deal of overlap in the range of energy consumption for models with the same freezer configuration, but capacities that differ by up to 40%. Note that neither the minimum nor the maximum energy consumption level (for the same freezer configuration) is clearly correlated with capacity.

For example, the range of annual energy consumption for refrigerators with top-mount freezers, from 24.5 to 26.4 cubic feet (and without through-the-door ice), is 445 to 520 kWh. For a bottom-mount freezer of the same size, the range is 465-594 kWh. For a side-by-side model, the range is 561-661, and for a side-by-side model with through the door ice, the range is 578-732. In other words, the most energy-consumptive top-mount model uses <u>less</u> energy than the most "efficient" side-by-side model! Consumers, though, will never see this range of energy use (and corresponding costs) based on the information currently offered on the EnergyGuide label. The energy consumption impact of choosing a side-by-side model is simply not communicated. In fact, the current label may imply to some – perversely – that a side-by-side model using 578 kWh is "efficient" in some absolute sense, even though it consumes 10-30% more energy than a top-freezer model of the same capacity. All this argues for broader categories for comparing models, making it easier for consumers to see the full range of energy use and operating costs.

Figure 7a. Range of Refrigerator Energy Use by Capacity (Adjusted Volume)

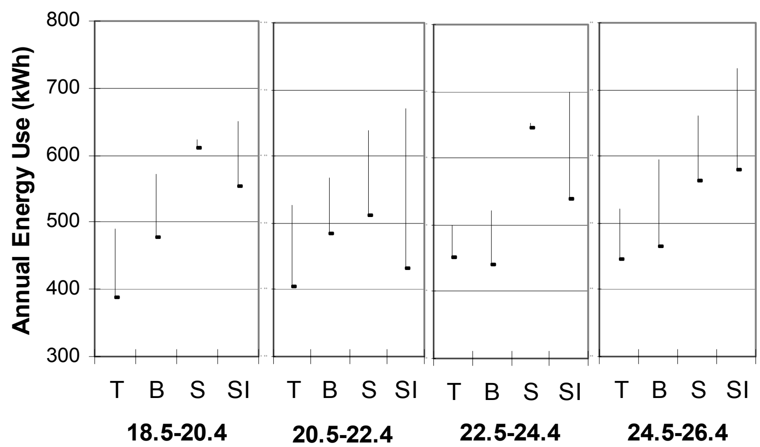
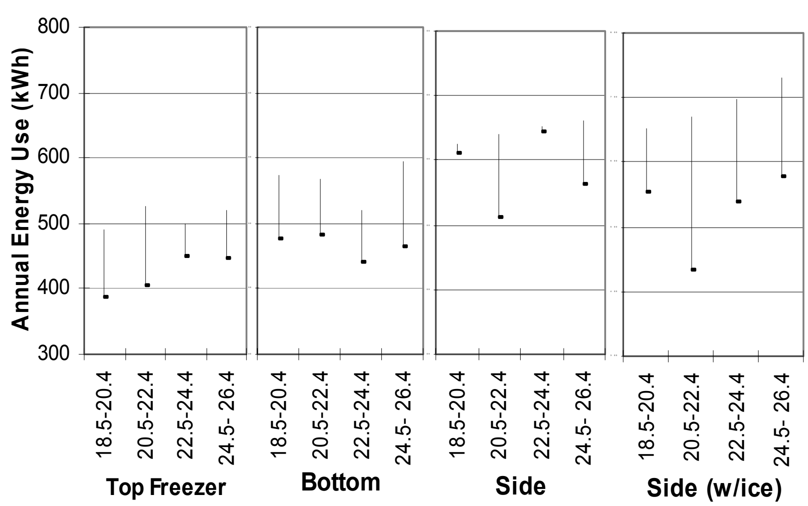


Figure 7b. Range of Refrigerator Energy Use by Freezer Location



Source: FTC 2006.

In contrast, the EnergyGuide label for clothes washers was changed a few years ago to include within the same comparison group both the newer horizontal-axis models and the conventional vertical-axis models. Prior to that change, horizontal-axis washers had been labeled separately even though there was relatively little difference between the most efficient and least efficient h-axis model – but large differences in both energy and water consumption between any h-axis washer and any vertical-axis model. With this change, the label now provides consumers with a true comparison of the full range of clothes washer energy consumption; the current range is about 6 to 1. Even after normalizing for clothes washer tub capacity, the energy "efficiency" range is more than 5 to 1.[7]

Many of the same issues with appliance categories that are too narrowly defined for the EnergyGuide comparison label also apply to the ENERGY STAR endorsement label. This is because both ENERGY STAR and the FTC, when labeling white goods, use the same size and type categories developed by DOE for efficiency standards. Once again, Consumers Union has critiqued these narrow categories, which emphasize energy efficiency more than energy consumption:

> ...[W]e believe that the current method of determining EnergyStar designations is deeply flawed. A specific example of this flawed application in the labeling of EnergyStar refrigerators is highlighted in the following example:
> Assume that the consumer is going to buy a refrigerator with 8 cubic feet of freezer space, and 14 cubic feet of fresh food space.
> - Under regulations effective July 1, 2001 a refrigerator/freezer with the above specifications configured with the freezer on top would be allowed to use 541 kWh/yr;
> - A refrigerator configured as a side-by-side model with ice- and water-dispensers would be allowed to use 679 kWh/yr and still retain an EnergyStar designation.
> - A top freezer that actually used 466 kWh/yr (14% less than allowed) would not be labeled as an EnergyStar model;
> - A side-by-side model that used 578 kWh/yr (15% less than that allowed for side-by-sides) would be labeled as an EnergyStar model.
>
> Thus, a model using 112 kWh/yr (24%) more than another would be labeled EnergyStar while the model with greater actual energy efficiency would not. (CU 2006).

For labels to be effective at helping consumers reduce energy consumption, the energy information provided should cover a broader range of energy consumption for comparable products, not just nearly-identical ones. Consumers will then be able to make truly informed trade-offs between energy consumption and product characteristics. And for appliances as well as for houses, endorsement labels like ENERGY STAR should consider the use of variable-efficiency criteria, requiring larger models to perform proportionately better than smaller ones.

[7] The actual range of FTC-reported data is even larger; the ratios cited here are based on eliminating a few outliers which may represent reporting or recording errors.

Toward a Policy of Variable Efficiency

In the preceding pages we discussed the reasons why energy consumption, not just energy efficiency, must be a focus of energy policy in a resource-constrained and carbon-burdened world. The choice is not between pursuing energy efficiency and advocating conservation; both can play a legitimate role in managing energy consumption and its consequences. Energy efficiency is often the most attractive way to slow and possibly reverse growth in energy demand. Energy conservation does not always involve sacrifice, as President Carter's sweater implied, but in some cases it may – just as other important personal and collective goals sometimes call for sacrifice: sending kids to college, caring for an aging parent, reducing roadside litter, or countering terrorism. The question is how much sacrifice is necessary, and how much we are willing to accept. Slower growth in energy consumption can mean real sacrifice for many in the developing world who still await access to electricity or clean water, but for most of us fortunate enough to live in the US it may mean a modest shift in our aspirations, deciding to be satisfied with sufficiency rather than pursuing excess.

There are many difficulties – conceptual, practical, and ethical – in proposing a transition from unbounded consumption to comfortable sufficiency, and many will disagree on the necessity or merits of doing so. Rather than press the point, we suggest one useful and politically feasible first step that will help us manage energy consumption in response to oil, climate, and grid constraints: incorporate variable efficiency as a conceptual basis for energy policy and program design. Considerations of both thermodynamics and equity argue for size- or consumption-based efficiency specifications. Starting with information and endorsement programs like home energy rating and appliance energy labeling, we can begin to educate people that when it comes to energy, size does matter. This is easier to envision for appliances and homes; it is admittedly more challenging in the case of offices, retail space, health care, or other services provided by the built environment. Once the principle of variable efficiency is embedded in voluntary programs, policymakers and program planners can consider how to extend the concept to rebates, incentives, and mandatory standards. Finally, energy indicators should include both extensive variables (consumption) as well as intensive ones (efficiency or productivity). Consumption-based indicators can be used to calibrate policy goals, helping us decide how much to increase efficiency and when we may need to move beyond it to assure a sustainable energy future.

References

Baker, Linda. 2004. "Great Big Green Monster Mansions." *Salon.com* July 7, 2004.http://archive.salon.com/tech/feature/2004/07/07/green_big_houses/index.html.

California Energy Circuit. 2004. "Livin' Large Causes Demand to Surge in Inland Empire." August 13. http://www.californiaenergycircuit.net/

City of Aspen, Colorado. 2002. Adoption of the 1999 Aspen/Pitkin Energy Conservation Code, as Amendments to the City Building Code, Section 8.20.020. http://www.bpcnet.com/codes/aspen/_DATA/Title_8/20/020.html

Consumers Union (CU). 2006. Comments of Consumers Union of the US, Inc. to the Federal Trade Commission "Energy Labeling, Project No. R511994" 16 C.F.R. Part 305. Washington DC. http://www.ftc.gov/os/comments/energylabeling/519870-00017.pdf

Energy Design Update. March 2003. “Grappling With National Green Standards.” *Energy Design Update* 23 (3).

Herring, Horace. 2006. “Energy Efficiency–A Critical View.” *Energy* 31 (1): 10–20.

Moezzi, Mithra and Rick Diamond. 2005. “Is Efficiency Enough? Towards a New Framework for Carbon Savings in the California Residential Sector.” California Energy Commission PIER report, Sacramento, California. LBNL Report-58580.

Moezzi, Mithra and Alan Meier. 2001. “Recasting Energy Efficiency to Restrain Carbon Emissions.” Unpublished draft. Lawrence Berkeley National Laboratory.

National Association of Home Builders (NAHB). 2003. “Housing Facts: Figures and Trends 2003.” Washington, DC.

Prahl, Duncan. 2000. “Analysis of Energy Consumption, Rating Score, and House Size.” Washington D.C.: U.S. Green Building Council.

Pacific Northwest National Laboratories (PNNL). 2005. “Indicators of Energy Intensity in the United States.” http://intensityindicators.pnl.gov/

Princen, Thomas. 2005. *The Logic of Sufficiency*. Cambridge, MIT Press.

Rudin, Andrew. 2000. “Why We Should Change Our Message from ‘Use Energy Efficiently’ to ‘Use Less Energy’.” *Proceedings* of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings. Washington DC: ACEEE.

US Department of Commerce, Bureau of the Census (Stat Abstract). 1992-2006. “US Statistical Abstract.” http://www.census.gov/statab/www/

US Department of Energy, Energy Information Administration (DOE/EIA). 2004a. Annual Energy Review. “Table 2.1a Energy Consumption by Sector, Selected Years, 1949-2004.” http://www.eia.doe.gov/emeu/aer/pdf/pages/sec2_4.pdf

US Department of Energy, Energy Information Administration (EIA). 2004b. “Annual Energy Outlook 2004 with Projections to 2025. U.S. Department of Energy.” DOE/EIA-0383(2004). www.eia.doe.gov/emeu/aer.

US Federal Trade Commission (FTC). 2006. Appliance Energy Data. Listings for refrigerators and freezers as of May 1, 1006. http://www.ftc.gov/appliancedata

US Green Building Council (USGBC). 2005. “Rating System for Pilot Demonstration of LEED for Homes Program. Version 1.72. http://www.usgbc.org/DisplayPage.aspx?CMSPageID=147

White House. 2002. “Global Change Policy Book.” Washington, DC. February. http://www.whitehouse.gov/news/releases/2002/02/climatechange.html

Wilhite, H., L. Lutzenhiser, E. Shove and W. Kempton. 2000. “Twenty Years of Energy Demand Management: We Know More About Behavior but How Much Do We Know About Demand?” *Proceedings* of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings. Washington DC: ACEEE.