Efficiency in a Climate-Constrained World: Are We Aiming High Enough?

Chris Calwell and Laura Moorefield, Ecos Consulting

ABSTRACT

Climate scientists have determined that a proportional U.S. contribution to stabilizing atmospheric concentrations of greenhouse gases requires absolute greenhouse gas emissions reductions of 60 to 80% by mid-century, with additional reductions needed thereafter. The American Solar Energy Society (ASES) and other organizations have found that half or more of those savings should come from efficiency to minimize cost.

Yet utility-funded efficiency programs and mandatory efficiency standards are not currently on course to deliver those needed savings. Most utilities' financial health is still tied directly to increases in sales of electricity, and their efficiency efforts attest as much. Although many utilities are now including carbon costs in resource planning, the practice is far from routine when assessing the cost effectiveness of efficiency programs. Some utilities are still pursuing efficiency programs as a supplement to their proposals to build new coal-fired generation, rather than a substitute for them. Even California's much-touted efficiency successes have only stabilized per-capita consumption; absolute consumption is continuing to rise.

This paper examines the level of U.S. efficiency achievement needed to stabilize the climate and the expected budget levels for such an effort. It considers the national utility efficiency program budgets that would result from the whole country running today's best-in-class programs (>$12 billion/year), and whether the savings from such programs would be sufficient to meet climate targets.

It considers three examples of consumer products – light bulbs, refrigerators, and televisions – to illustrate the level of absolute reduction in energy consumption needed to achieve climate targets vs. the recent pace of efficiency improvement for each.

Lastly, it proposes guiding principles for future efficiency programs and policies to ensure that climate targets can, in fact, be met.

Historical Context

Electric utilities have historically been motivated by a variety of factors to fund and implement energy efficiency programs on behalf of their customers. Many utilities do so out of a desire to minimize the cost of operations, especially when the price of purchased power continues to rise each year. A few investor-owned utilities do so to maximize profits, because their regulators have removed their disincentive to sell less electricity and established a financial incentive mechanism allowing them to earn additional revenues for their shareholders by cost-effectively reducing their customers' usage. Some utilities invest in efficiency because it generates positive public relations, creating good will they hope to employ with their regulators when they next propose to build a contentious coal plant or power line extension. Other utilities pursue energy efficiency programs because of mandates to do so by their public utilities commission or their legislature. Still others would chalk it up to simple common sense – help your customers lower their bills and, over the long term, you will have more satisfied customers.

Some utilities have never offered such programs at all, of course, believing that their mission is to sell the greatest number of kWh at the lowest unit cost.

But rarely have utilities pursued energy efficiency programs principally out of a motivation to minimize environmental impact. This is not for lack of financial opportunity or need to make such investments. The Office of Technology Assessment attempted a comprehensive estimate of the total annual expenditures by utilities on air pollution control and concluded that the real cost was about $6.4 billion in 1991 alone (OTA 1994). Using a different methodology, the U.S. Census Bureau's 1999 Pollution Abatement and Control Expenditures survey estimated $1.14 billion of capital costs and another $1.16 billion of operating costs for utilities, yielding a total of $2.3 billion in that year alone (US Census 2002).

If anything, these costs appear to have risen in recent years, primarily resulting from litigation to compel overdue Clean Air Act compliance. Between 1988 and 2001, the U.S. EPA sued 11 utility companies to force installation of air pollution controls at a total of 49 power plants (Seelye 2001). Court orders and out-of-court settlements with government agencies and environmental organizations have recently forced numerous *individual* utilities to make investments of $1 billion or more in pollution control equipment or natural gas repowering for aging coal-fired power plants. Seven utilities alone (Table 1) account for nearly $11 billion of such committed investment between 2000 and 2007 (Rugaber 2007, Wald 2000, *Electricity Forum* 2008, Shogren and Chadwick 2007, Citizens Utility Board 2008). This is an amount roughly similar to the total committed investment by *all* U.S. electric utilities in cost-effective energy efficiency programs during the same period.[1] TVA, facing similar litigation from the state of North Carolina, estimates it will invest $1.3 billion in pollution control equipment for its 59 coal-fired units between 2006 and 2010, but still does not plan to retire any of them for another 15 years (Flessner 2008; Ferrar 2006).

Utilities' electric revenues are now about $343 billion per year (and rising about 4% per year on a nominal basis), so the air pollution control investments and litigation costs still represent a modest fraction of utility expenditures today (DOE 2008). But that fraction will rise sharply as utilities confront the need for further air quality improvements, mercury control, and CO_2 capture and sequestration.

Table 1: Utility Air Pollution Control Investment Requirements

Utility	Air Pollution Control Investment Required	Year Announced
Cinergy Corporation	$1.4 billion	2000
Tampa Electric	$1.0 billion	2000
Dominion Virginia Power	$1.2 billion	2003
First Energy	$1.1 billion	2005
Public Service Company of New Mexico	$0.5 billion	2005-2006
American Electric Power	$4.6 billion	2007
WEPCO	$0.8 billion	2007

[1] These totals do not include additional costs to those utilities in attorneys' fees, fines and penalties, negative publicity, increases in future power plant operating costs, local offset payments, and interest paid on the money borrowed to make the equipment retrofits. ACEEE and CEE estimates of U.S. electric utility investments in efficiency programs were consistently below $2 billion per year prior to 2006, suggesting that a total for the years 2000-2007 of about $11 billion would be reasonable.

Each one of these investments exceeds those same utilities' expected investments in cost effective energy efficiency programs over the multi-year periods needed to complete the air quality retrofits. This invites the question of whether a targeted effort to greatly accelerate DSM in those service territories might hasten the day when older coal-fired power plants could be retired. This would avoid the pollution control investment entirely, while reducing the average bills paid by customers instead of increasing them. The Mohave coal-fired power plant serves as a compelling example; its owners elected to retire the plant in 2006 rather than invest more than $1 billion in retrofitting it with air pollution controls to comply with a consent decree.

Indeed, recent legal battles in Wisconsin, Kansas and Colorado over proposed coal plant retrofits and expansions both explicitly raised the fungibility of efficiency investments instead. In Colorado, this resulted in Xcel committing to make expanded investments in efficiency as a condition of environmental advocates dropping their opposition to a new coal plant proposal. Kansas City Power & Light reached a similar agreement with the Sierra Club in 2007 to offset the CO_2 emissions from a new 850 MW coal plant by quadrupling their investment in wind power, greatly expanding energy efficiency programs, and offsetting other criteria pollutant emissions at existing facilities (Mufson 2007).

How Climate Changes Investment Priorities

With regulations on greenhouse gas emissions increasingly likely between now and 2009, the question of whether to increase investments in energy efficiency becomes even more urgent. Indeed, a 2003 analysis by Repetto and Henderson (2003) found that a group of 47 large investor-owned utilities may face compliance costs equal to 2 to 55% of their 2000 revenues if cap and trade regulations are established simultaneously for NO_X, SO_X and mercury. (The range of estimates varied widely depending on each utility's percentage of coal-fired power and whether or not the permits are grandfathered or auctioned).

What happens when a fourth pollutant, carbon dioxide, is added to the cap and trade requirements? If the permits are entirely auctioned, Repetto and Henderson found that the greenest utilities face financial exposure of about 3% of year 2000 revenues, but the most coal-dependent utilities' exposure is roughly 100% of their year 2000 revenues (2003). To an industry in which a few percentage points of change in net revenues makes the difference between a good and bad year, this level of financial exposure could be catastrophic. Even utilities whose regulators allow them to continue building conventional coal plants now and still pass through all of the cost of retrofitting or retiring them in the future would face a set of very angry customers if rates doubled to pay for the cleanup. The strategy that minimizes utilities' risk is clear: begin making decisive changes to their generation mix and reduce their total exposure to financial risk by dramatically increasing the energy efficiency of buildings and installed equipment in their service territories.

Our Current Course with Efficiency Programs

Given the recent growth in energy efficiency investments by utilities, would present levels of efficiency investment be sufficient to mitigate that climate risk? Recent annual savings from utility efficiency programs have averaged about 55 to 70 billion kwh per year nationwide, according to a 2005 analysis by ACEEE (2005).[2] The same study estimated cumulative impacts by the most efficient states at 6 to 8% of annual electricity sales. In other words, total annual electricity sales in those states are 6 to 8% lower than they would have been without the efficiency programs. This demonstrates that a concerted effort by utilities over a period of many years can definitely reduce the need for new generation. Many utilities are also now trying to save 1% of more of annual electricity consumption by their customers.

How many new power plants have been avoided from these savings? Dr. Jonathan Koomey recently proposed standardizing a metric for power plants avoided, and scaled it to the average annual electrical output of a coal-fired power plant in the U.S., correcting for associated transmission and distribution losses: 3 billion kWh/year (2008). The proposed name for this metric is the *Rosenfeld*, in keeping with the tradition among physicists for naming the unit in honor of the person most responsible for the discovery and widespread adoption of the underlying scientific principle in question – Dr. Arthur Rosenfeld. We can therefore estimate that U.S. electric utility efficiency programs run between 1993 and 2003 have saved 18 to 23 *Rosenfelds* – offsetting the need in any one year for approximately 18 to 23 new coal plants or their equivalent from other generation sources. (Measure lifetimes for efficiency programs are often shorter than operational lifetimes for coal plants, so cumulative energy production and savings comparisons must be made with some care).

However, another 151 new coal plants were proposed for construction between 2000 and 2006. By the end of 2007, 10 of those had been completed, 25 were under construction, and another 59 had been canceled or indefinitely deferred, leaving the fate of another 57 proposed plants undecided (Sourcewatch 2008). Even if the great majority of these 151 plants are never built, new conventional coal plants are still being added to the generation mix more rapidly than existing ones are being retired, pushing utility greenhouse gas emissions and financial exposure to carbon risk ever higher.

As renowned architect Ed Mazria has pointed out, each new conventional coal plant built emits enough carbon dioxide to negate the climate benefits of many other high profile efforts to reduce it. Desert Rock, the proposed 1,500 MW merchant coal plant on the Navajo Nation, would emit more carbon dioxide each year than has typically been saved by all of California's electric utility-funded efficiency programs in a given year (Calwell, Neugebauer and Sheldon, 2008).

Expanding Efficiency to Address Climate

Is there sufficient capital to radically expand investments in utility efficiency programs? Yes, if utilities consider those investments fungible with investments in new power plants, repowering old ones, building new transmission lines, and paying for pollutant control equipment retrofits on existing power plants. Citigroup estimates that U.S. electric utilities will make more than $125 billion of coal and nuclear generation and air pollution control investments between 2005 and 2015 (Citigroup 2007).[3] This works out to an average of more than $11

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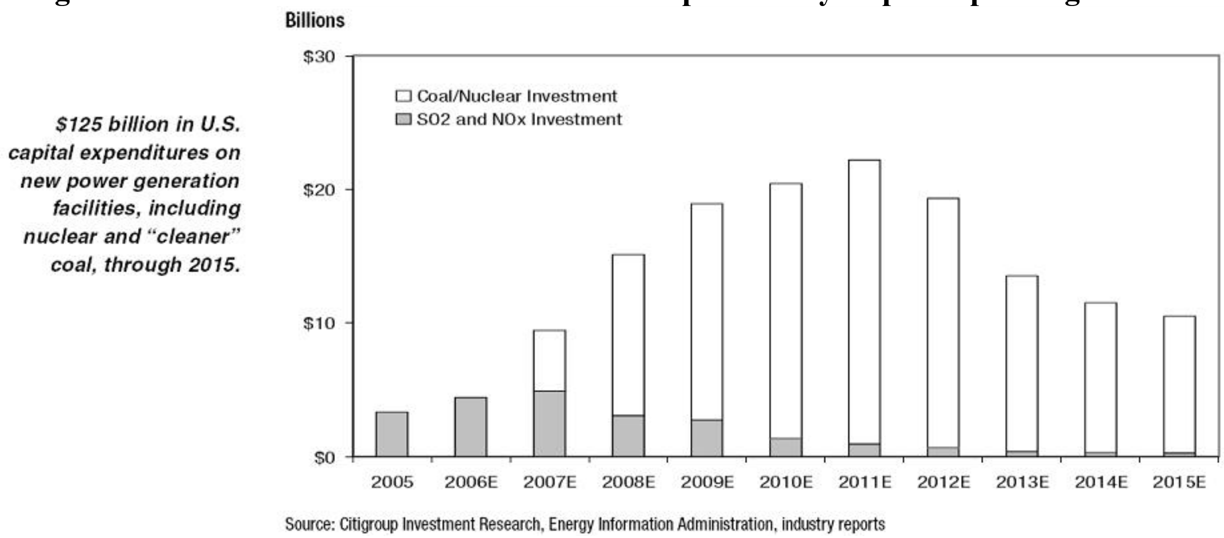
[2] This estimate aligns closely with CEE's estimate of 59.8 Twh/year of savings in the U.S. and Canada from utility efficiency programs in 2006, since both sets of estimates rely heavily on EIA data from utilities.

[3] Utilities' total capital requirements over that period will be much greater, of course – $500 to $700 billion in aggregate – but much of this is for maintenance of existing equipment or for new transmission capacity. Citigroup's optimistic forecast of future investments in coal may not be surprising, given its interest in lending the capital for

billion per year – about five times current annual utility investments in cost-effective energy efficiency programs (CEE 2008).[4]

Figure 1: US Generation and Environmental Expansionary Capital Spending Outlook



Source: Citigroup 2006

What if utilities invested $11 billion per year into energy efficiency instead? It is difficult to precisely project energy savings from that level of investment, but some clues can be gleaned from recent publications on the topic. CEE estimates that U.S. and Canadian utilities' electric and natural gas efficiency programs yielded 59.8 TWh of electricity savings, 162.6 million therms of natural gas savings, and 36 million metric tons of CO_2 reductions in 2006 -- the same year they invested perhaps $2 to $2.3 billion in energy efficiency programs (CEE 2008). Those CO_2 savings represent about 0.6% of current U.S. emissions. On a constant dollars basis, utility efficiency investments rose appreciably in only 21 U.S. states between 2006 and 2007, according to CEE's summary reports (2008).

Simple extrapolation might suggest that a five-fold increase in investment would yield correspondingly larger energy and CO_2 benefits – perhaps 300 TWh of electricity savings, 800 million therms of natural gas savings, and 180 million metric tons of CO_2 reductions. This would translate to about 3% of U.S. CO_2 emissions in 2006 or 9% of utility sector emissions, but an even smaller share of forecasted total emissions in future years due to expected growth (*Science Daily* 2007).

Recognizing the many disparities between national estimates of current investment levels and current savings results (which are largely the result of past investments in efficiency programs), we can also consider the potential for savings by estimating typical cost effectiveness of current programs and scaling up from there. On average, today's utility programs are saving electricity for approximately $0.02/kwh (Calwell & Gordon 2004; and Rogers, Messenger, and Bender 2005), with market transformation initiatives from the Northwest Energy Efficiency

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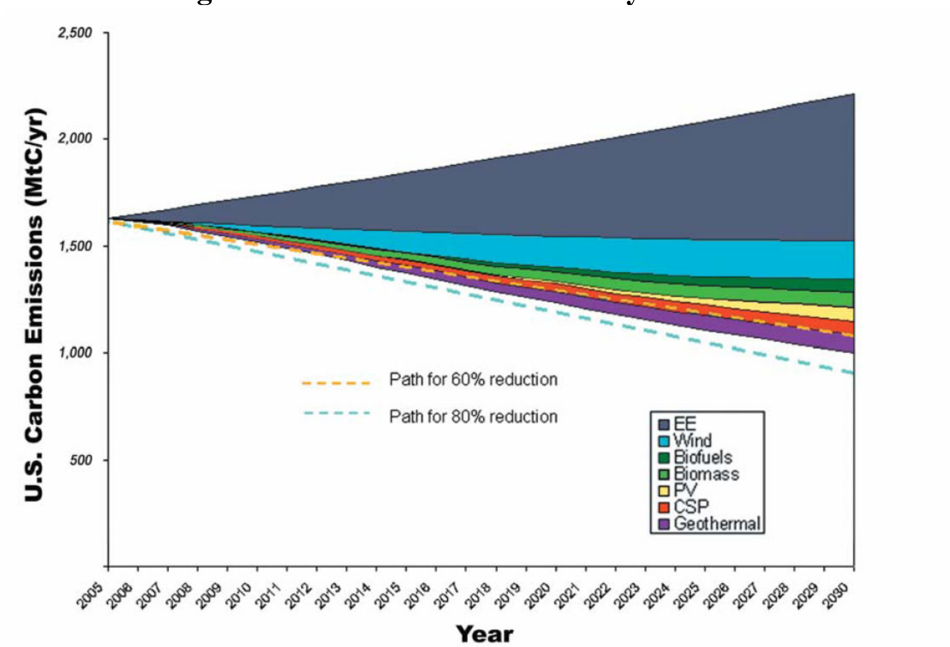
those investments. The Sierra Club notes that nearly 50 recently proposed coal plants involved possible financing from Citigroup. See http://www.sierraclub.org/environmentallaw/coal/plantlist.asp.

[4] The Consortium for Energy Efficiency estimates that total electric DSM investments in the U.S. were $2.72 billion in 2007, of which $536 million went to load management and $2.19 billion went to residential, low income, commercial, industrial, and other energy efficiency programs.

Alliance and other regions averaging more like $0.013/kwh (Eckman 2008). As an upper bound, we could forecast that efficiency budgets grow rapidly enough to exhaust all of the least costly efficiency options, leading to a doubling of the average cost of such programs. Under that scenario, $125 billion over an 11 year period would be enough to offset roughly half of the electricity the U.S. currently consumes in any one year, though the savings would of course be spread out across the lifetimes of the efficient measures installed during that period.[5] The resulting CO_2 savings in any one year would still be about 3% of current total emissions and 10% of utility sector emissions – significant, but not nearly large enough to achieve that sector's share of U.S. climate stabilization targets calling for absolute reductions of 60 to 80% from current levels. Even greater investments and emissions reductions will be needed.

The American Solar Energy Society projects that about 60% of overall reductions below the 2030 forecast would need to come from energy efficiency improvements, with about 5% of the building sector's share resulting from utility efficiency programs (Kutcher 2007).[6]

Figure 2: US Carbon Emissions by Year



Source: Kutcher 2007

McKinsey & Company asked the question a different way in its 2007 climate study (McKinsey & Company 2007), ranking options for reducing emissions on a $/ton basis. Its central finding was that the U.S. could achieve absolute reductions of emissions of about 38%

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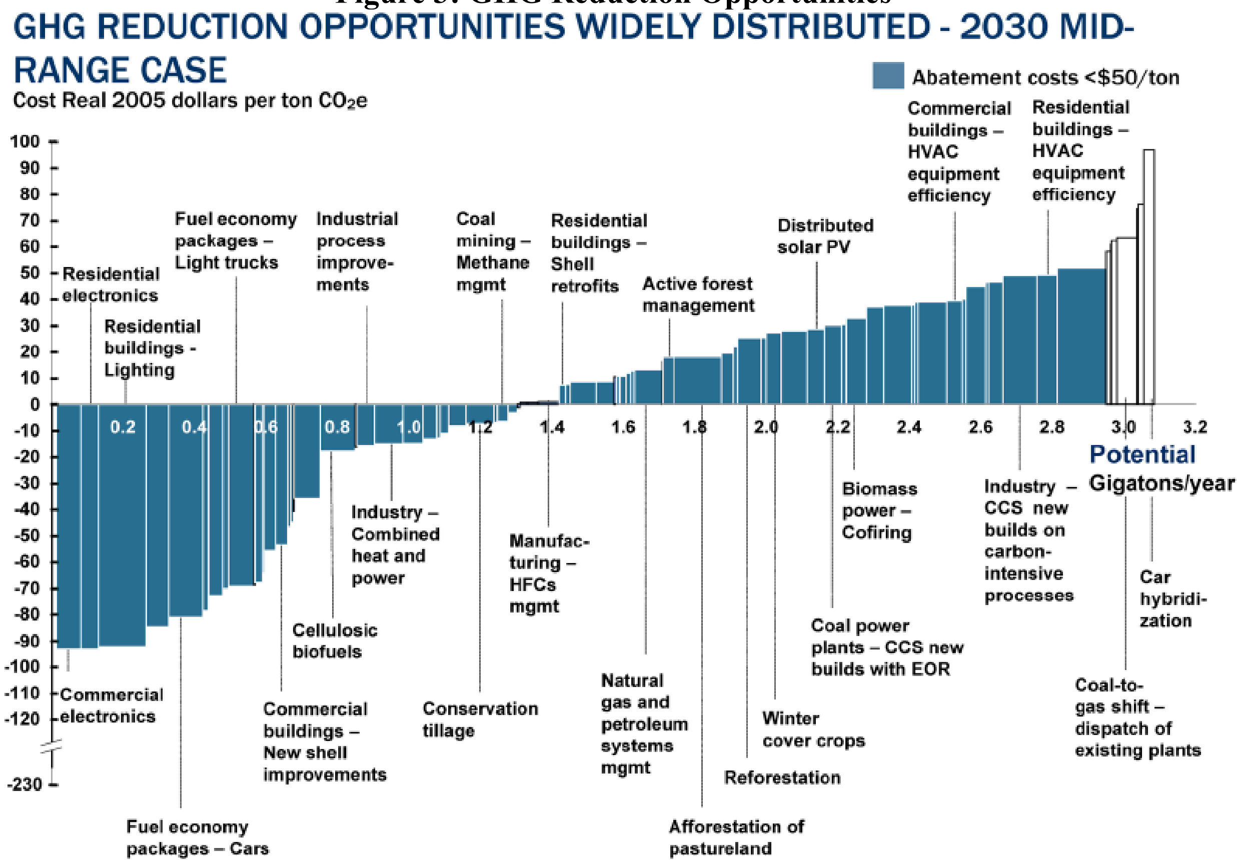
[5] For example, investments in energy efficient refrigerator programs would save kwh over a period of 20 years or more. Investments in efficient compact fluorescent lamp programs might save energy over a period of only a few years, depending on the lifetime of the lamps and the likelihood that purchasers would replace them with CFLs after the first set of lamps burn out.

[6] Table 1 in the document estimates that utility energy efficiency programs could save 0.63 quads and 10.2 million tons of carbon per year by 2020, out of 11.6 quads and 198 million tons of carbon delivered by energy efficiency in total.

from 2005 levels at zero net cost, because the energy savings resulting from the first 1.3 gigatons of CO_2e per year (mostly energy efficiency technologies, policies, and programs) would offset the cost of the next 1.7 gigatons of CO_2e per year (mostly supply-side energy measures and land use changes). Figures 3 and 4 illustrate the central McKinsey findings.

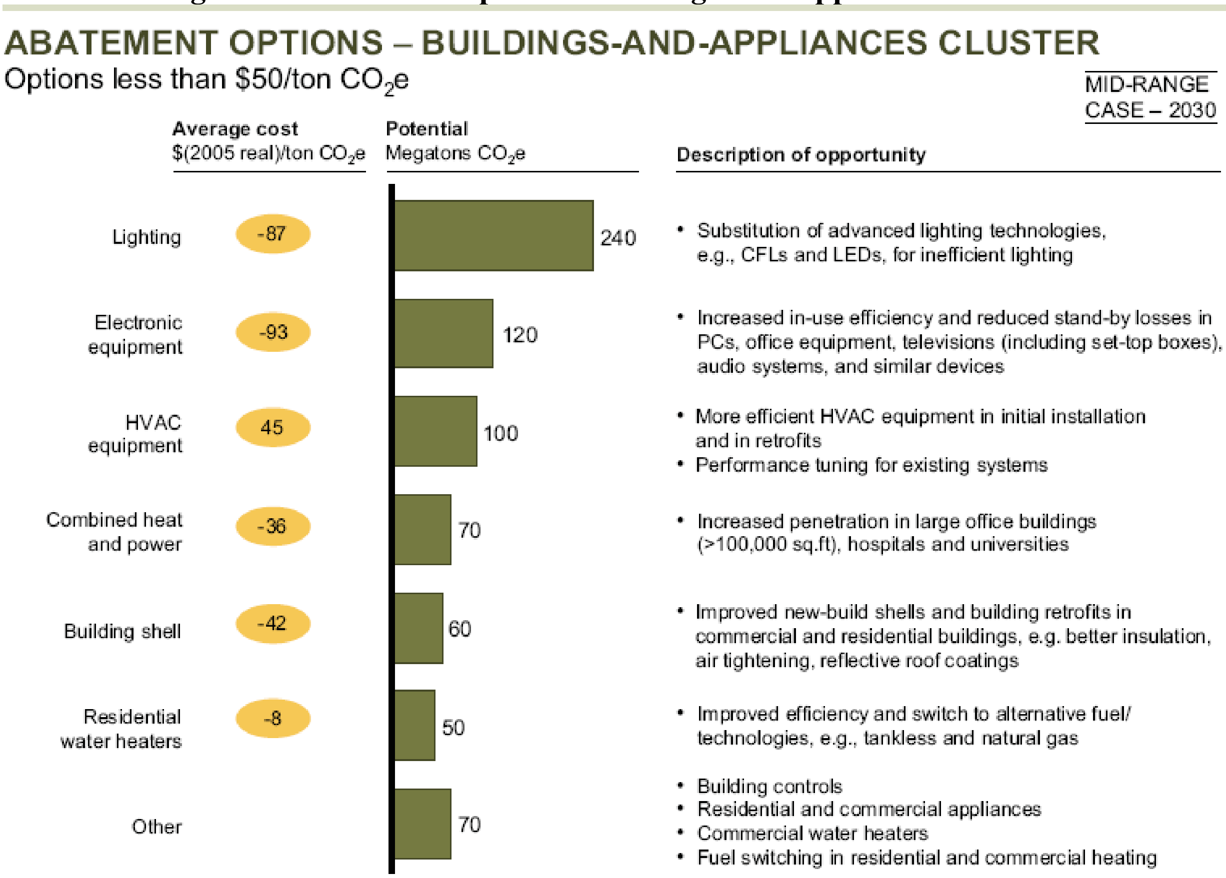
Figure 3: GHG Reduction Opportunities



Source: McKinsey and Company 2007

Many of the lowest cost measures with the largest savings look exactly like the kinds of programs utilities now run or are poised to run to reduce the energy use of residential and commercial electronics, residential lighting, commercial buildings, and industrial processes. Even those measures that eventually might logically end up in codes and standards begin with utility-funded efficiency programs, through efforts such as the California utilities Codes And Standards Enhancement (CASE) process. The 710 megatons of CO_2e per year McKinsey ascribes to cost effective energy efficiency savings suggest that utility efficiency investments could, directly or indirectly, help the U.S. ultimately achieve approximately a 9% reduction in CO_2 emissions – about 15 times present savings levels. A society interested in stabilizing the climate at the lowest cost should fund such energy efficiency measures fully before committing billions of dollars for carbon capture and storage, nuclear power, and other significantly more expensive options.

Figure 4: Abatement Options - Buildings-and-Appliances Cluster



Source: McKinsey and Company 2007

Most Promising End Uses

Much has been made of the energy efficiency community's successes to date with refrigerators and compact fluorescent lamps. Indeed, the most energy efficient versions of both technologies reduce energy use per device by roughly 70 to 80% from the levels consumed by standard refrigerators in the past or incandescent lamps today.[7] But continued growth in the sales and stocks of refrigerators and light bulbs has undercut much of those savings on an absolute energy consumption or CO_2 emissions basis. Globally, it is likely that the total energy consumption of residential refrigerators is greater now than ever before, simply because of the number of new homes in the developing world that now have a refrigerator, and the number in the developed world that now have two, or at least one that is very large (Calwell 2006).

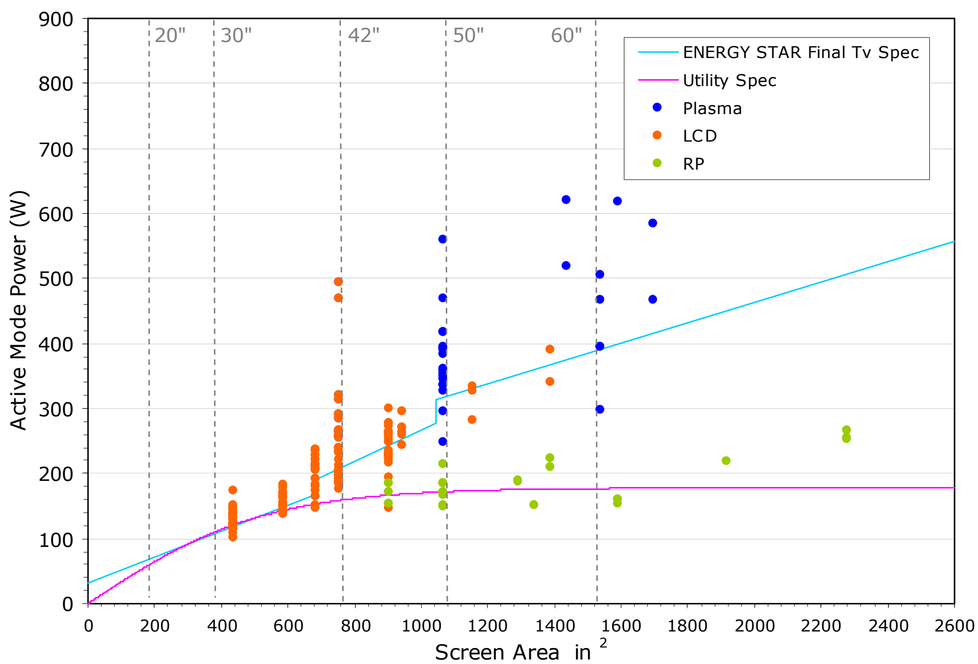
Even when considering only the U.S., it is clear that a number of demographic and product trends are running in the opposite direction of the efficiency improvements that result from utility efficiency programs and mandatory standards. Homes have gotten larger, average household size has declined (increasing the total number of homes and sets of energy-using

[7] For example, many large ENERGY STAR refrigerator models have an annual electricity use of 400 to 450 kWh today, compared to average annual usage of refrigerators in the early 1970s of 1,800 kWh. Similarly, compact fluorescent lamps drawing 13 watts routinely replace 60 watt incandescents today.

products needed for a given population), features and conveniences have expanded, and consumers' ability to pay for greater levels of amenity has increased.

Nowhere is this more evident than in current efforts to improve television efficiency on a watts-per-square-inch of screen area basis. The new ENERGY STAR labeling specification that takes effect in November 2008 allows labeled televisions that have twice the screen area of a 36 inch TV, for example, to consume twice the power and still be labeled as energy efficient (Figure 5). There will be more televisions than people in the United States by 2010 (May-Ostendorp 2006). Average annual hours of television operation per person rose from just over 1,500 in 1984 to nearly 1,900 in 2006. More than half of those hours now involve the operation of multiple pieces of electrical equipment (game console, set top box, VCR, DVD player, multi-channel receiver, etc.), rather than just the television (Calwell 2007). Those factors threaten to drive up absolute energy consumption and resulting CO_2 emissions faster than efficiency programs can reduce them. The largest television sets now consume more energy per year than two refrigerators, and the audio/video equipment connected to them consumes even more.

Figure 5: Two Approaches to Specifying Television Efficiency



Source: Frazer & May-Ostendorp 2008.

The natural increase in television size and number of televisions sold over time will tend to swamp the projected savings from energy efficiency labeling programs. Other specifications being considered by various utilities only increase allowable power slightly with screen area, driving absolute reductions in power use even as consumers switch to bigger screens. This philosophical approach to energy efficiency specifications will increasingly be warranted in other efficiency programs for homes, electronics, vehicles, and other end uses where increases in amenity and product populations are swamping efficiency gains. It will take massive, unprecedented expansions in utility-funded efficiency programs, new funding sources (such as taxes on carbon emissions or on highly consumptive products), and new programmatic approaches (incentives tied to levels of efficiency higher than ENERGY STAR) to turn those growth curves around.

Conclusions

Even our greatest energy efficiency success stories to date like refrigerators and CFLs do not yet point to a way for our nation to achieve absolute reductions in total CO_2 emissions of 60 to 80%. But our community can begin that process by recognizing that existing funding levels and cost effectiveness justifications for utility efficiency programs are not nearly sufficient to stabilize the climate. Radically higher investment levels will be warranted in the years ahead. Budget and savings expansions of 5 to 15 times would result from expanding cost effective program offerings across all sectors and all states, and from including a realistic value for carbon in the resulting cost effectiveness calculations.[8] Even that level of energy savings is not sufficient for fully meeting greenhouse gas reduction targets, but at least gets on the right path.

Building new conventional coal-fired power plants is fundamentally incompatible with climate stabilization, and undercuts the climate gains achieved by even large-scale utility efficiency programs. Efficiency programs can no longer be seen as a strategy for obtaining the public goodwill needed to obtain PUC approval to build coal plants. Efficiency is not the icing on the cake, it's the cake.

The process of establishing an energy efficiency test procedure for a new group of products, measuring those products, proposing voluntary efficiency specifications, incentivizing those products, raising the bar, and removing the least efficient products from the marketplace through mandatory efficiency standards also needs to become much more ambitious, rapid and deliberate. Voluntary programs need to aim higher than the top 25% of the current marketplace, update more rapidly, and be intentionally linked to mandatory labeling schemes tied to automatically updating mandatory standards. Europe and Australia have shown that these approaches can significantly shorten the time required to achieve major increases in efficiency.

Some have argued that addressing climate change is primarily a supply side problem – that we simply need to replace our current generation mix, gaseous fuels, and liquid fuels with renewable alternatives. We do, but there is neither enough money nor enough time to accomplish the needed reductions by focusing solely or even mostly on the supply side. We will only contain climate change at reasonable cost if we extract the maximum possible benefit from energy efficiency first.

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[8] Tom Eckman of NEEA found that CO_2 price adders of \$10 to \$40 per ton would increase the amount of achievable cost effective efficiency savings by 4 to 15% in the Pacific Northwest. In a region with a more carbon intensive generation mix, the proportionate impact would be greater.

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