Energy Efficiency's Role in Climate Change Policy

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The Need for CO_2 Emission Reductions and Efficiency's Potential Contribution

The Intergovernmental Panel on Climate Change (IPCC) has estimated that it will be necessary to level off GHG emissions rates by 2015 and then reduce overall emissions by 50% to 85% by 2050 to keep the global mean temperature increase to 2 to 2.4°C above pre-industrial levels. Many climate scientists view this level of temperature rise as an upper limit to avoid catastrophic effects (IPCC 2007). Most analysts also agree that achieving these reductions is a massive challenge. Fortunately, the IPCC and others have documented large potential sources of cost-effective GHG emission reductions. In Figure 1 the IPCC summarizes its studies of cost-effective mitigation potential by sector. These potential GHG reductions account for the majority of global emissions, indicating that achieving climate stabilization is possible. Figure 1 suggests that the largest single source of GHG emission reduction potential occurs in the buildings sector, and that the bulk of these opportunities are available at low cost. Another recent study (McKinsey 2007) found that by 2050, energy efficiency could reduce U.S. carbon dioxide emissions by 40%: 16% from buildings, 13% from transportation and smart growth, and 11% from industrial efficiency. The McKinsey study results are shown graphically in Figure 2.

Figure 1. GHG Emission Reduction Potential by Sector (IPCC 2007)

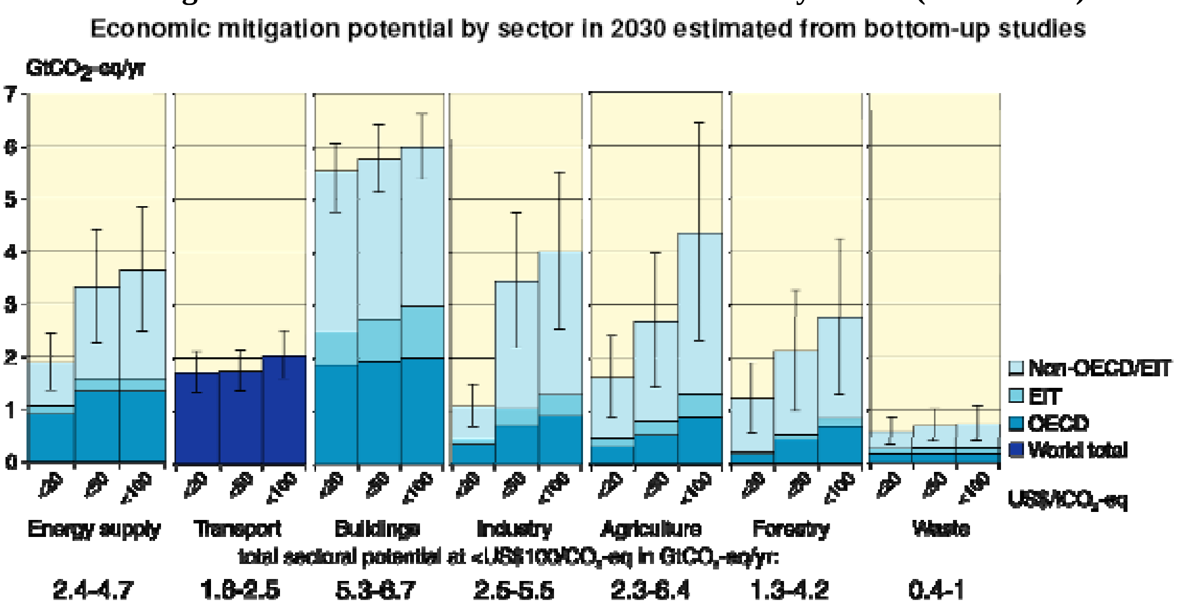
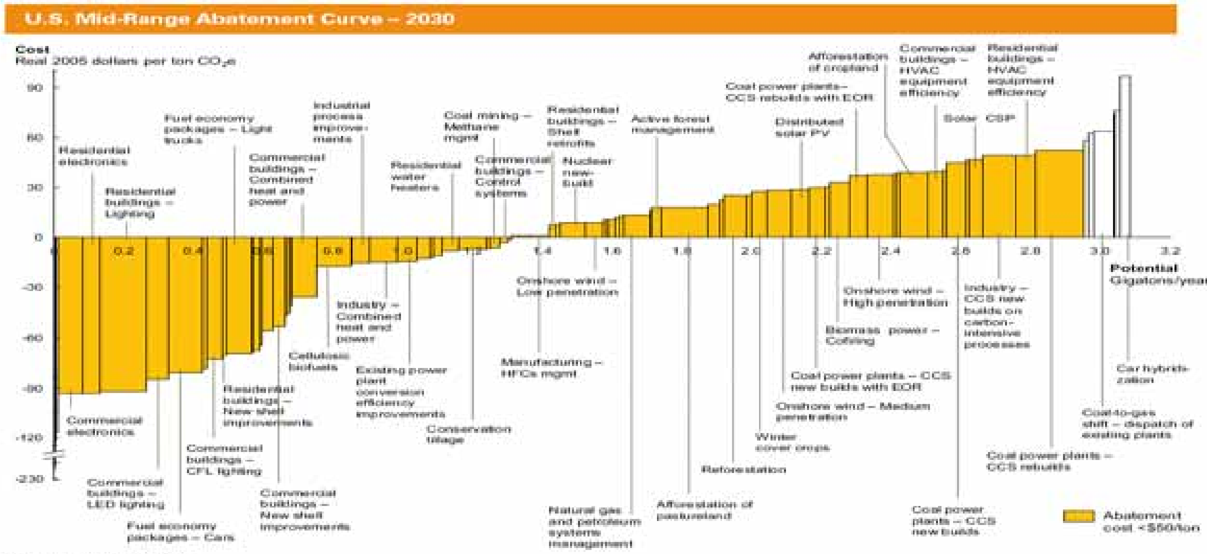


Figure 2. Carbon Dioxide Abatement Cost Curve (McKinsey 2008)



Source: McKinsey analysis
Note: The McKinsey report only examines a scenario through 2030. NRDC recommends a goal of 80 percent emissions reductions by 2050.

In Figure 2 the carbon reduction options on the left end of the graph are almost all energy efficiency technologies. These efficiency options show a negative net cost of CO_2 abatement, meaning that they cost less on a levelized life cycle basis than reference-cast costs of energy supply. They also account for a major portion of the total emission reductions on the graph. More importantly, the net savings from the efficiency options offset much of the costs of the emission reductions on the right side of the graph – those with net positive costs. These efficiency technologies are thus essential to achieving an entire package of emissions reductions at low net costs to the economy.

Energy efficiency is widely available as a resource that costs less than conventional energy in U.S. markets. In electricity markets, efficiency savings potential has been shown to be on the order of 25% of total electricity usage, at a levelized cost of about 3 cents per kilowatt-hour (Kushler 2004). This is much less than the average national retail price of electricity, currently at more than 8 cents per kWh (EIA 2007) or the marginal generation cost of new power plants, estimated, depending on the technology, to cost 5 cents per kWh and higher.

In the U.S., as in most countries, analyses have shown that the efficiency potential has been tapped only in small measure (UN Foundation 2007, Nadel 2004). These analyses, along with the recent IPCC and McKinsey analyses consistently show that efficiency is not only a large energy resource but also offers major opportunities for addressing the climate challenge. They generally show that aggressive efficiency investment, driven by policy commitments and policies focused on addressing market barriers, can meet most or all of the projected growth in energy demand in the U.S., especially in the electricity sector. Similarly, these studies tend to show that the growth in GHG emissions can be arrested through accelerated energy efficiency technology deployment. However, realizing these opportunities will take policy action as subsequent sections of this paper discuss.

The Economics of Efficiency and Carbon Dioxide Emission Reduction

There are at least two ways to think about the relationship between end-use efficiency and GHG reductions: (a) assume that efficiency is an important societal goal and ask whether CO2 reduction programs can lend value to its attainment; or (b) focus on CO2 emission reduction as the goal and ask whether accelerated efficiency is a central element in attaining those essential reductions. While the answer to the second question is that efficiency is essential to GHG attainment, it does not follow that simply monetizing the cost of CO2 emissions will realize the full level of efficiency resource potential through market forces alone.

The efficiency community's interest in monetizing the value of efficiency's GHG reduction benefits (as well as other environmental benefits) has been based on a hope of improving the calculated cost-effectiveness of efficiency. However, CO2 emission reduction benefits may only marginally improve efficiency economics (Schiller 2006). This rather large range of results suggests several points for efficiency project sponsors:

- Only very large energy efficiency projects can obtain a meaningful amount of economic (total dollar) value from CO2 reductions.
- The potential economic value of energy efficiency as a GHG mitigation strategy will depend heavily on the regulatory and market mechanisms that are put in place.

On the other hand, as the McKinsey carbon abatement cost curve indicates, large amounts of efficiency are available at lower cost than reference-case energy prices. This curve also shows that aggregate economic benefits from efficiency resources appear to be roughly equal in magnitude to the aggregate costs of low-carbon technologies. This suggests that aggressive pursuit of efficiency can offset much if not all of the total economic costs of more expensive low-carbon technologies. For example, research conducted for the Regional Greenhouse Gas Initiative (RGGI) showed that doubling efficiency resource investments reduced, by year 2021, average residential, commercial and industrial customer energy bills by about 12%, 8% and 5%, respectively; but perhaps more importantly, cut the price of carbon allowances by about one-third, while increasing gross regional product, employment, and personal income (Prindle 2006).

A key challenge for policy-makers is how to resolve this asymmetry between efficiency's very large societal economic value potential and the relatively low economic value for individual projects. This asymmetry is due to market barriers, and to the diffuse nature of efficiency—it occurs through millions of relatively small transactions, rather than a few large projects as typifies the energy supply sectors. This has the effect of making transaction costs for individual efficiency investments high relative to those for larger energy projects which in turn results in chronic under-investment in efficiency.

This asymmetry leads to a paradox: despite its manifold benefits in reducing CO2 and other emissions, and in containing the economic costs of climate policy, small projects are simply not attractive to investors, and monetizing the value of individual efficiency action's GHG reduction benefits is difficult. Therefore, from this paradox we posit that "climate change mitigation needs efficiency more than efficiency needs climate change mitigation". This phrasing means that while efficiency by most accounts is the logical choice as a first-priority, no-regrets resource in policies aimed at reducing CO_2 emissions, it will require support to overcome the obstacles to individual project investment.

Why Efficiency Requires Specific Policy Support

There are numerous mechanisms for controlling greenhouse gas emissions, including carbon taxes, direct controls on sources (command and control) and "cap and trade" mechanisms. Cap and trade appears to be the preferred mechanism among many policy makers, industry leaders, economists, and environmentalists. Unfortunately, the emissions cap and trade policy designs most often proposed to reduce GHG emissions do not, in and of themselves, provide sufficient impetus for the level of efficiency investment needed. This limitation stems from two principal factors: (a) the indirect nature of emissions reductions associated with energy efficiency and the complexity of addressing these indirect reductions in conventional cap and trade systems and (b) the market barriers to efficiency and the resulting reduction in price elasticity of energy consumption[1].

The most commonly identified efficiency market barriers are front-end capital investment requirements, the principal agent problem (wherein homebuilders, landlords and other agents fail to make efficiency investments on behalf of the ultimate energy bill payers), and information/transaction costs (wherein most efficiency-purchase decisions are too small to support the economic analysis needed to make the optimal choice). A new International Energy Agency study shows that up to 50% of residential energy use in the U.S. is affected by such barriers (Prindle 2007).

Market barriers and price inelasticity (which are interrelated) suggest that "carbon taxes" alone will not fully realize the potential of energy efficiency. Given that price increases alone do not significantly motivate either short term conservation or efficiency investments in most end-use markets, taxes would have to be very high to motivate energy users to invest the necessary funds and the taxes raised would be many times higher than the costs of effective programs. Such taxation levels are also not politically viable in the foreseeable future, even if the tax revenues were invested in energy and non-energy activities (e.g. reducing income taxes). The other mitigation mechanism mentioned above, targeted regulation, has limited application for CO_2 because of the lack of established CO_2 "smokestack" controls; although as are discussed below, there are opportunities for efficiency targeted regulation, e.g. building energy codes and appliance efficiency standards.

Cap and trade policies' impacts on energy efficiency are complex; the following section discusses cap and trade regulations in relation to end-use, non-transportation, efficiency. The paper then discusses mechanisms for addressing efficiency within a cap and trade system. Following the cap and trade section is a discussion addressing efficiency policies that can complement cap and trade programs (such as codes and standards) and can reduce the economic impacts of a cap and trade policy.

[1] Price elasticity of demand is defined as the response of demand to price changes. It is generally negative, indicating that demand will decrease if price rises and increases if price drops. However, analyses of the North American electricity and natural gas markets generally indicate that energy is not an elastic commodity and demand is not very sensitive to prices. The degree of inelasticity varies based on the data used and the analysis period.

Cap and Trade Policies for CO2 Emission Reductions

Under a cap and trade program, an overall emissions tonnage cap is set for defined sectors or emission sources. A government entity creates allowances representing the temporary right to emit one unit (e.g., one ton) within the total cap. Initial allowance allocations can be sold (auctioned) by the government or distributed for free to affected emitters or to other entities. As the climate policy bill that passed the House of Representatives in June 2009 indicates, allowance allocations can become quite complex and politically contentious. The primary compliance requirement is that each regulated entity must hold and retire allowances equal to its actual emissions at the end of each compliance period (typically a year). However, there is no fixed emission limit on any individual source and each source's emissions are not limited to the allowances that it may have initially received. Sources may purchase additional allowances from other entities if needed or sell allowances if they have a surplus.

One of the counter-intuitive aspects of an allowance cap is that while emissions cannot exceed the cap they also are unlikely to fall below the cap. The reason for this is that a source that emits less than the allowances that it has available in a given compliance period may sell those allowances to another source, which can use them rather than reduce its emissions. Under many trading schemes sources may also "bank" unused allowances to use in a future year. Thus, the overall regulated sector will tend to emit approximately at the cap level.

The fact that capped emissions tend to remain at the cap level for the entire pool of covered sources, in each compliance period, is relevant to the effects of energy efficiency on total emissions. Efficiency reduces, for example, the output of electricity generators or the burning of natural gas in boilers, and thus reduces emissions in the immediate timeframe in which the energy is consumed. However, under a cap and trade program, reductions in some covered entities' emissions simply makes extra allowances available for use or sale over the full timeframe of the compliance period. During the course of a compliance year, if energy use and emissions are trending lower than expected because of end-use efficiency, the covered emitters will tend to use this "windfall" to run higher-emitting sources, up to the limit their allowances permit, or can also sell allowances not needed to cover their reduced emissions. These "efficiency windfall" allowances can be sold in the market and used elsewhere or banked for use in a later year. Thus, even if allowances are freed up by increased efficiency within the compliance period, total emissions for the sector in the overall compliance period will remain roughly equal to the cap level. However, efficiency can reduce the cost of compliance with the cap, by reducing allowance prices, and enabling lower-cost, higher-emitting sources to run.

These effects create what is called the "indirect emission reduction problem" for efficiency. Because it does not directly reduce emissions, it is not viewed as a valid source for tradable credits, and typically cannot participate in carbon trading markets. Efficiency can only be directly credited with reducing emission if either (a) the "efficiency" allowances are retired (removed from the market) or (b) mechanisms are put in place to ensure that the emissions trading cap and the amount of allowances initially allocated are reduced commensurate with the amount of energy efficiency.

The cap and trade mechanisms that most significantly impact energy efficiency are:

- Placement of GHG caps, including the use of set-asides

- Allowance allocation and auction mechanisms
- Use of allowance and auction revenues
- Definitions of additionality[2]

Cap Placement

Most cap and trade policies in place or under discussion place emissions caps "upstream" at the sources of emissions – such as power plants. However, end-use efficiency potential is realized "downstream" in individual facilities or buildings[3]. Efficiency is thus an indirect emission reduction strategy, compared to direct reduction strategies such as power plant efficiency improvements or carbon capture and sequestration (CCS). Placement of the cap on upstream emission sources makes it more difficult for covered entities to invest in downstream energy use reductions unless they are a totally vertically integrated utility.

Alternatively, placing caps on distribution utilities is known as a "load-side" cap. Distribution utilities, because they would have to hold allowances on behalf of the loads they serve, could directly benefit (i.e., need fewer allowances) from helping customers reduce energy usage. This load-side cap approach has garnered some attention in part because with CO_2, the lowest-cost emission reductions are typically not at the point of emission, or the "smokestack", as is the case with Clean Air Act pollutants that can be controlled by combustion or scrubbing technologies relatively cost-effectively. Thus, since it is more appropriate to consider cap and trade designs that effectively capture the lowest-cost emission reduction technology opportunities, a load-based cap is perhaps more effective for CO_2 control. In the natural gas sector, however, the 2009 House climate bill places the cap on local distribution gas utilities, creating inconsistency among sectors.

Some jurisdictions have recognized that downstream caps, at least in the power sector, can offer advantages in terms of encouraging energy efficiency investment. However, this approach is not gaining much traction – primarily because of the difficulty of tracking emissions from the variety of sources from which distribution utilities buy power. California was one state that was very seriously considering load side caps for its electricity sector in order to comply with AB32 requirements. However, the California Public Utilities Commission and the California Energy Commission have now recommended a cap and trade system that, while not-exactly a generator cap based system, closely mimics the characteristics of such a cap with respect to energy efficiency participation (CPUC 2008).

One way for energy-efficiency programs to create direct reductions under a generator cap and trade program is to assign allowances to the efficiency activities and retire them or "set them aside". For example, some states have created special "set-aside" allocations of allowances in their NO_x trading programs for efficiency projects (EPA 2008).

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[2] "Additionality" is the term used in the emission mitigation industry for addressing the question of whether a project will produce reductions additional to those that would have occurred in the absence of the program or policy. While the basic concept of additionality may be easy to understand, there is no common agreement on the procedures for defining whether individual projects or whole programs are truly additional. As such, there is no generally-accepted level of stringency for additionality rules. Policy makers need to decide what tests and level of scrutiny should be applied in additionality rules..

[3] Upstream and downstream are relative terms. In much of the air regulation literature, upstream is considered to be at the level of primary fuel producers, such as coal mines. For the purposes of this paper we define upstream as the power plants for electricity markets and downstream as the distribution utilities or end-use consumers.

Qualified project sponsors (such as energy services companies) that obtain these set-aside allowances can choose to retire them to make emissions reduction claims and avoid the expense of an allowance purchase that would otherwise be necessary to make such claims. The National Action Plan for Energy Efficiency has published a guide on calculating avoided emissions from efficiency programs (Schiller 2007b). Sponsors may also sell the allowances to subsidize the project economics, in which case the project sponsor may not claim that their actions resulted in a GHG emission reduction. However, the set-aside mechanism has not been used to any large degree because of its complexity, the relatively low value of CO_2 allowances as compared to value of energy savings, and high transaction costs. Thus, it appears that even if a cap and trade design were modified such that a generator could directly claim emission reductions from customer end-use efficiency gains, other conventional barriers would serve to discourage the use of this option.

For the electric and gas utility sectors placing emissions caps “downstream” at the level of distribution utilities encourages the greatest investment in energy efficiency because these entities can claim direct emission reduction credit from energy savings their direct customers achieve. However, the broader policy consensus appears to be that while electric generator caps are not directly advantageous for efficiency they have other positive attributes and are “winning out” over load based caps. Given the 2009 House climate bill’s placement of downstream caps in the natural gas sector, the U.S currently has a mixed approach on this key policy issue.

Allowance Allocation and Auction Policies

A key aspect of any cap and trade system is how the allowances are initially distributed into the marketplace. The allowance certificates have value and who gets them and how much they pay for them creates markets and market value. Climate policies under serious discussion today all include provisions to auction significant fractions of GHG (carbon) allowances, rather than giving allowances to emitters for free. The free-allocation approach, whose roots come from the Title IV SO_2 provisions of the Clean Air Act Amendments of 1990, was also based in part on the assumption that the point of regulation—i.e. the smokestack—would be the focus of the lowest-cost emission reductions. However, the SO_2 precedent for free allowance allocation is not fully applicable to CO2, because much of the lowest-cost carbon dioxide emission reductions are not found at the smokestack level. End-use efficiency, renewable energy, and offsets are typically less expensive than direct CO2 controls. Additionally, in the era when SO2 allowances were first allocated, virtually all power generation was subject to retail rate regulation under vertically integrated utilities. Today, much of the U.S generation fleet operates in unregulated wholesale power markets, where marginal price bidding determines prices for all generators. In such markets, free allocations do not reduce electricity prices, and in fact tend to increase net revenues to generators. There is less justification for free allowance allocations in such markets. But because the U.S. generation fleet is partly unregulated and partly subject to retail price regulation, there is no national consensus on this point.

States, however, have begun to act on these issues. In the Regional Greenhouse Gas Initiative (RGGI), covered the 10 northeast states from Maryland to Maine, the model rule requires that states auction at least 25% of all allowances, and use the funds for energy efficiency and other low-carbon technologies. This policy was set for all of the reasons listed above. It should also be noted that allowance auctions can encourage early actions for climate mitigation, prior to the actual regulation date. To date, all of the states that have issued draft rules under RGGI have elected to auction all or nearly all of their allowances[4], and most are spending substantial portions of their revenues on efficiency.

In the European Union Trading (GHG) System, allowances were freely distributed during the first allocation period, however, now the European Union is seriously considering auctioning of the allowances and using some of the funds for efficiency activities. The 2009 House climate bill auctions some allowances, and allocates other shares to states and utilities in ways that can be used for energy efficiency. These auction proceeds and allocations could become larger than current U.S. publicly funded federal spending on efficiency, which is around $1 billion and state/utility spending on efficiency, which is currently about $3.1 billion (CEE 2007).

This discussion leads to the suggestion that a significant fraction of auction proceeds and/or allocation revenues be spent on energy efficiency programs, because end-use efficiency provides the greatest combination of emission-reduction and cost-containment benefits. Since the principal objective of cap and trade policy is to attain reductions at the lowest cost to society, the evidence suggests that explicit efficiency policies are an essential element of national climate and energy policy.

Use of Allowance and Auction Revenues

Under any meaningful national climate policy, the economic value associated with carbon allowances will be enormous, ranging into the hundreds of billions of dollars annually, whether the allocations are given away or auctioned. If allowances are auctioned it is crucial to determine who gets the allowance revenue, what will it be spent on, and what criteria will guide the spending. We posit that an arguable basis for such decisions to ask "what results in the maximum amount of cost-effective energy efficiency?" The generic term for such activities is "parallel policies and programs."

The 2009 House climate bills, for example, allows distribution utilities to use allowance proceeds to be used for compensating consumers for the electricity rate impacts of allowance prices. While this sounds like a fair and logical policy, investing the same allowance proceeds in energy efficiency results in much greater electric bill reductions, albeit for all consumers as a whole than simply rebating a portion of the money. Thus, when investing allowance proceeds in efficiency programs, individual bills may still go up for consumers who do not actually implement energy efficiency actions. However, for the RGGI states, analysis showed that investing in efficiency would reduce average consumer bills by 3 to 12 times as much as simply rebating allowance auction proceeds. (Prindle 2006). It is thus important to specify that allowance proceeds be used in ways that will provide maximum cost containment benefits, which means channeling at least a significant portion of the money toward energy efficiency.

If the cap is placed on generators, program experience suggests that allowances not be allocated to individual efficiency project sponsors but to the administrators of public-interest

[4] Vermont was the first state to enact a 100% auction requirement, with a statute that placed auction revenues under the jurisdiction of the independent utility regulator, the Public Service Board, and dedicated those revenues to end-use energy efficiency in the electricity sector. In 2008, the statute was amended to authorize the use of RGGI revenues to promote efficiency in buildings generally, adding also reductions in direct use of oil, propane, natural gas, and kerosene. As another example, 2008 Maryland legislation creates a Strategic Energy Fund which is to spend 46% of auction revenues on efficinecy. However, in 2009 Maryland legislator redirected part of the Fund for electric rate reductions.

efficiency programs, which are usually distribution utilities and/or state agencies. These administrators can aggregate projects through cost-effective programs needed to support achieving the full potential of efficiency. This aggregation and the inherent leveraging of funds addresses the barriers to efficiency summarized earlier in this paper.

Parallel Policies and Programs

Because conventional cap and trade policy designs do not address the principal barriers to efficiency, they will not harvest the majority of cost-effective energy efficiency potential available in end-use markets. However, auction and allocation policies fund complementary programs that do address these barriers. In addition, energy efficiency regulations can get at the most persistent market barriers even more cost-effectively. Five types of complementary policies programs have been proven to be effective in using funds and regulatory mechanisms to realize both cost-effective efficiency and CO2 reductions:

- Public benefits funds (PBFs)
- Energy efficiency resource standards (EERS)
- Appliance efficiency standards
- Building energy codes
- Research, development and demonstration

Public Benefits Energy Efficiency Funds

Public benefits programs in the U.S. have used ratepayer funds to pay for a wide range of energy efficiency resource acquisition and market transformation programs. The Consortium for Energy Efficiency has recently estimated (CEE 2007):

- U.S. administrators of broadly defined energy efficiency programs spent $US 3.1 billion in 2007. An increase of over 30% in three years.
- U.S. Consortium for Energy Efficiency members, who account for most of the above figures, in 2006 saved 55,500 GWh of electricity, 158.4 million therms of gas, and abated more than 33 million metric tonnes of CO_2. And energy consumers saved about $5 billion from these programs.

These programs have used public funds to leverage energy efficiency investments. As an established channel for successful efficiency activities the authors recommend that allowance auction funds be used to augment successful programs at the state level.

Energy Efficiency Resource Standards (EERS)

Some 19 states and three European Union nations have instituted these policies, which set numerical energy savings targets for utilities to meet through customer efficiency investments, combined heat and power, and other efficiency measures. ACEEE has documented these policies in multiple reports and white papers (Nadel 2006). ACEEE's analysis of these EERS (in combination with renewable energy standard – RES) policies showed that they can reduce electricity prices significantly. A 15%-15% EERS-RES policy can reduce wholesale prices by about 18% in 2025 in a climate framework, versus about 10% in a business-as-usual framework. These price reductions, plus reductions in consumer electricity bills from efficiency investments and other net economic effects, would provide up to $600 billion in net benefits to consumers by 2030. This analysis shows in the clearest terms that EERS, in combination with RES or alone, can provide very effective cost-containment benefits for federal climate policy.

Therefore, the authors recommend the implementation of an EERS on a national level, and that as needed auction funds be used to offset portions of implementation costs, perhaps in conjunction with public benefits programs. Note that the EERS does not require a trading system, such as the use of energy efficiency certificates, and the authors feel that the "jury is out" as to whether such certificates would be beneficial.

Appliance Efficiency Standards and Building Energy Codes

Appliance standards, enabled by the National Appliance Energy Conservation Act of 1987, and updated in the Energy Independence and Security Act of 2007, have been very effective at overcoming the market barriers described earlier, and have also provided major energy, economic, and emission reduction benefits at low cost. ACEEE analysis estimates that standards enacted through 2005 will reduce U.S. electricity use almost 10% below forecast in 2020, avoiding some 300 500-MW power plants, preventing the emission of 86 million metric tons of carbon, and providing customers over $230 billion in net cumulative savings (Nadel 2006). Pending and proposed standards could increase these benefits by up to 50%.

Building energy codes mandate minimum energy efficiency requirements for new construction and when major building renovations take place. New construction markets are among the most severely affected by market barriers, notably the principal-agent barrier, as builders are not motivated to invest the extra design time and capital to optimize energy efficiency for the building's life cycle. New buildings are also the largest source of new energy consumption and associated carbon emissions in most electricity systems, making it all the more imperative that this market be addressed by public policy.

Building energy codes have been adopted by most states, using the International Energy Conservation Code (IECC) and other model codes. States like California have frequently driven building codes and appliance standards well beyond federal levels. California's Title 24 building codes are the most stringent in the U.S. if not the world, and are proposed to evolve into zero-energy-performance regulations in the coming decades. The state's Title 20 appliance standards continue to regulate products not pre-empted by federal law, and in many cases have lead to the adoption of federal standards.

Therefore, the authors strongly recommend a broad range of aggressive and continually improving energy codes and standards be adopted to greatly accelerate the widespread deployment of highly efficient buildings and equipment. To this end we recommend using a portion of the allowance auction funds for:

- Developing codes and standards that are more stringent and more comprehensively cover energy-consuming applications.
- Improving code compliance and enforcement.
- Improving code research and analysis.

Research, Development and Demonstration (RD&D)

Technology advancement and understanding and building on human behavior are fundamental to achieving efficiency's long-term, full potential. While technology breakthroughs do occur, the timing requirements of climate mitigation goals demand a targeted focus on moving more technologies into the marketplace. Since most demand-side technologies involve a human interface, increased knowledge of human behavior and social science is also necessary—as is the infusion of that knowledge into technology development and deployment.

Another area where research is required is basic energy markets policy. Structural changes are probably required in the energy industry if we are to achieve the necessary levels of efficiency. This is because of a shift in spending by utilities to provide energy to consumers to increased investment by consumers (and utilities) to reduce their consumption. Reaching goals such as California's zero-energy building goals implies that what used to be invested in power plants and natural gas and electricity distribution systems will in the future need to be spent to build highly efficient buildings and self-generation systems. How this will influence utility system economics, rate design, investments, etc. needs need to be analyzed. Therefore, the authors recommend that a portion of the allowance auction funds be used for RD&D.

Conclusions

The evidence and analysis provided in this paper suggest the following observations:

- Energy efficiency holds large potential to reduce carbon dioxide emissions at low cost and to reduce the total economic cost of a national climate policy.
- Market and regulatory barriers and related price effects reduce the market's ability to respond to carbon price signals and realize appropriate efficiency improvements.
- Conventional approaches to climate cap and trade regulatory policy will not tap more than a small fraction of efficiency's potential. Since cap and trade policies typically place the cap "upstream" for economic efficiency purposes, "downstream, indirect" reductions such as end-use efficiency cannot participate effectively in carbon trading markets.
- Explicit policy treatment and funding, designed to be complementary to cap and trade regulation are needed to ensure that efficiency contributes maximum value to climate mitigation, and minimizes the overall cost of mitigation.

These observations suggest that in the broader climate policy context, efficiency should be addressed outside of the cap and trade system. Options for achieving this objective include:

- Devoting a substantial share of allowance auction proceeds to efficiency programs
- Allocating allowances to entities that are most capable of implementing efficiency programs and policies, with stipulations that such objectives guide the use of allowance revenues
- Pursuit of complementary end-use efficiency policies and programs, including
    i. Public benefits funds (PBFs)
    ii. Energy efficiency resource standards for energy providers (EERS)

iii. Appliance efficiency standards and labeling
iv. Building energy codes
v. Technology, behavior, and policy research, development and demonstration (RD&D) activities

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