Energy Efficiency and Climate Change Mitigation Policy

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ABSTRACT

This paper presents the need for energy efficiency to provide a significant share of the reductions in greenhouse gas (GHG) emissions that science indicates are required for climate stabilization. It discusses policy options for deploying energy efficiency resources in electricity (non-transportation) end-use markets to meet needed GHG emission reduction levels. This discussion includes a description of barriers inherent to climate policy design, as well as energy markets, that inhibit efficiency investment as an emissions reduction strategy. The paper also provides recommendations for effective mechanisms that incorporate end-use electricity energy efficiency into climate change mitigation efforts. Assuming that generator based cap and trade mechanisms will be favored over energy taxes, the authors recommend complementary actions outside of, but directly linked to and integral to the success of, the trading systems. We suggest using cap and trade allowance auction proceeds to invest in four categories of complementary programs: (a) energy efficiency, public benefit program activities, (b) energy efficiency resource standards, (c) technology, behavior, and policy research, development and demonstration, and (d) codes and standards development and enforcement.

Need for CO_2 Emission Reductions and Potential Reductions from Efficiency

The Intergovernmental Panel on Climate Change (IPCC) has estimated ranges for GHG emission reductions required to stabilize global temperatures. IPCC's models conclude 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 global mean temperature increases to 2.0 to 2.4^{o}C above pre-industrial levels; which many climate scientists view as the upper limit on temperature rise that avoids catastrophic effects (IPCC 2007). Fortunately, the IPCC and others have documented large potential sources of economical GHG emission reductions, especially reductions due to increased investments in end-use energy efficiency. Figure 1 summarizes IPCC's studies of economical mitigation potential by sector. These potential GHG reductions account for the majority of global emissions, indicating that achieving climate stabilization is possible. As Figure 1 shows, the largest single source of emission reduction potential occurs in the buildings sector and that low cost opportunities dominate in the building sector unlike any other sector.

Another recent study (McKinsey 2007) found that by 2050, energy efficiency could reduce United States (U.S.) carbon dioxide emissions by 40%: 16% from buildings, 13% from transportation and smart growth, and 11% from industrial efficiency (Figure 2)[1].

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

[1] The data and analyses done by McKinsey have not been made available for public or independent review.

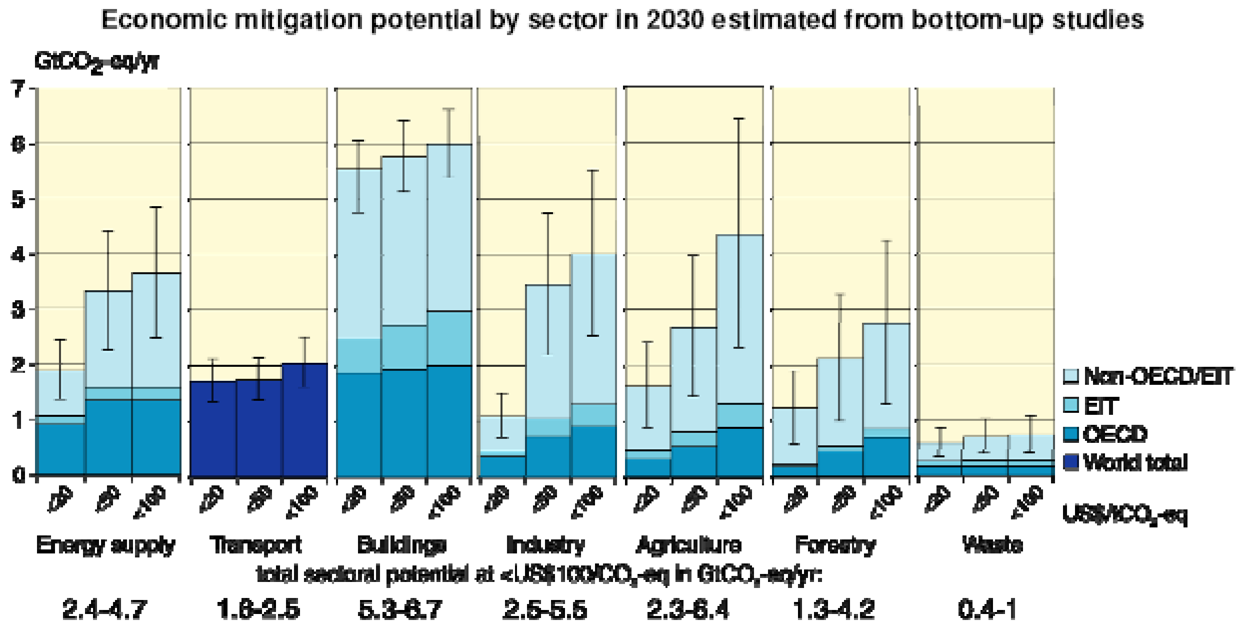
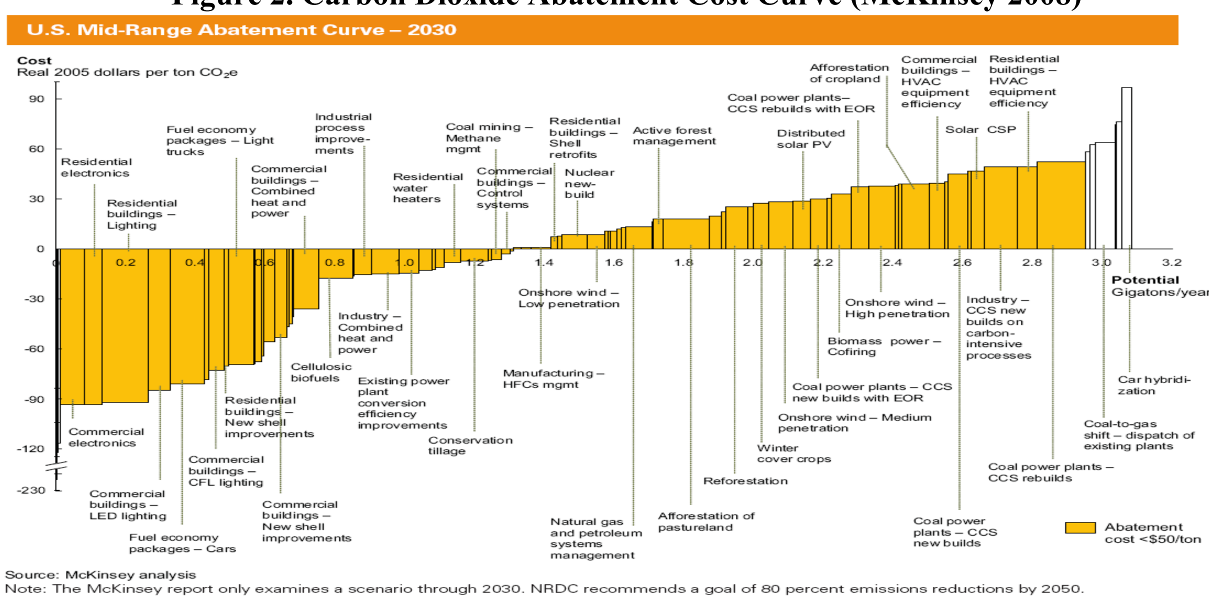


Figure 2. Carbon Dioxide Abatement Cost Curve (McKinsey 2008)



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, and 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.

Furthermore, 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 and modeling assumptions, to cost 5 to 15 cents per kWh.

In the U.S., as in most countries, analyses have shown that the efficiency potential has been tapped only in small measure (United Nations 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 global warming problem. They also indicate that aggressive and well-designed efficiency programs, 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.

Economics of Efficiency and Climate Mitigation

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 GHG reduction programs can lend value to its attainment; or (b) focus on GHG reduction as the goal and ask whether accelerated efficiency is a central element in attaining those essential reductions. While both goals, economic efficiency and climate mitigation, are important, we focus here on the role of efficiency as a crucial tool in meeting climate goals. In this context, even though *efficiency is essential to GHG attainment, it does not follow that simply monetizing GHG emissions will actually call forth the full level of efficiency that is both attainable and cost-effective*.

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, GHG reduction benefits may only improve efficiency economics on the order of 1-25% (Schiller 2006). This rather large range of results indicates several points *for individual project sponsor*s:

- Only very large energy efficiency projects can obtain a meaningful amount of economic (total dollar) value from GHG reductions.
- Many of the positive economic attributes of individual efficiency projects, such as lowering the marginal cost of power and adding to grid reliability, are externalized and not captured in project economics.
- 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—and the stability of those mechanisms.

At the same time the McKinsey carbon abatement cost curve above indicates there are large amounts of efficiency available at costs lower than current energy prices and, as noted before, the total economic benefits from efficiency resources may be roughly equal in magnitude to the low-carbon technologies that bear net economic costs. This suggests that aggressive pursuit of efficiency can offset much if not all of the societal 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).

How can we 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 various market barriers, as mentioned in the next section, and the diffuse nature of efficiency—it occurs through millions of relatively small actions 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 – one of the reasons for chronic under investment in efficiency.

This asymmetry leads to a paradox: despite its manifold benefits in reducing GHG, 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 conclude that *climate change mitigation needs efficiency more than efficiency needs climate change mitigation* and thus while efficiency should be the first-priority, no-regrets, resource in policies aimed at reducing CO_2 emissions, it will require support to overcome barriers to individual project investment.

Why Efficiency Requires Specific Policy Support to Realize Its Full Potential

There are numerous mechanisms for controlling greenhouse gas emissions and other pollutants 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, although not all, policy makers and industry leaders throughout the world as well as some economists, regulators, 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 conservation and efficiency and resulting inelasticity of the energy consumption response to price increases[2].

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) are the reasons why the authors realize that "carbon taxes" alone would not fully realize the potential of energy

[2] Price elasticity 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. In the power sector, the long-run price-elasticity of demand has been estimated at between -0.15 to about -0.35. (EPRI 1989).

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 in order 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 levels of taxes 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, command and control regulation, has limited application for CO_2 because of the lack of established CO_2 "smokestack" controls; although as discussed below, there are opportunities for efficiency command and control, such as codes and standards.

What are more likely than GHG taxes or command and control regulations are GHG cap and trade policies. Cap and trade's impact on energy efficiency is complex and therefore the following section discusses cap and trade regulations and the relationship to end-use, non-transportation, efficiency. We then discuss 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 and *can reduce the cost of implementing a cap and trade mechanism*; which is the reason why the complementary, or parallel, mechanisms are considered integral to the success of GHG cap and trade programs and thus recommended in this paper.

Cap and Trade

Under a cap and trade program, an overall emission tonnage cap is set for an affected sector or set of emission sources. Governments create allowances representing the temporary right to emit one unit (e.g., one ton) within the total cap amount. Initial allowance allocations can be sold (auctioned) by the government or distributed for free to affected sources or to others. 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 at auction or 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 can 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 always 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. Efficiency reduces, for example, the output of electricity generators or the burning of natural gas in boilers, and thus reduces emissions. In the *absence* of a cap and trade program, energy consumption reductions due to efficiency in one location do not lead, in themselves, to increased emissions in another location. However, under a cap and trade program, reductions in capped-source (e.g., large generators or boilers) emissions due to end-use efficiency will make extra allowances available to others. Those "efficiency windfall" allowances can be sold in the market and used elsewhere or banked for use in a later year. Thus, if allowances are freed up by increased efficiency, total emissions for the sector in the overall compliance period will remain roughly equal to the cap level. Of course since the goal of trading is typically not to go below the cap but to achieve the cap at the lowest possible cost to society, *by helping to minimize the compliance cost, efficiency contributes to the primary goal of the cap and trade program while at the same time reducing the total cost of providing energy*.

Thus, within a capped sector[3], under a cap and trade program, an efficiency program may not be able to claim avoided emissions unless 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 allocated are reduced commensurate with the amount of energy efficiency projected or achieved. The cap and trade mechanisms that impact energy efficiency are:

- The "point of regulation" for placement of GHG caps (which sources are capped), including the use of set-asides (which are defined below)
- Allowance allocation and auction mechanisms
- "Who gets the money"
- Definitions of additionality[4]

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[5]. 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 emission sources, typically referred to as generator caps, makes it 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 (Cowart 2004). 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. CCS, for example, is complex, expensive,

[3] This paper discusses efficiency within developed countries that are most likely to be subject to a GHG cap. However, for developing countries that are not (currently) subject to a cap the rules are different. For example, the Clean Development Mechanism under the Kyoto Treaty allows for project offsets, i.e. developed countries can obtain GHG offsets by investing in energy efficiency projects in developing countries (Schiller 2007a).

[4] "Additionality" is the term used in the emission mitigation industry for addressing the key question of whether a project will produce reductions in emissions that are additional to reductions that would have occurred in the absence of the program activity. This is directly related to the efficiency evaluation issue of defining proper "baseline" conditions and free ridership. 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 technically correct level of stringency for additionality rules. Policy makers need to decide based on their policy objectives, what tests and level of scrutiny should be applied in additionality testing. Generally speaking, given the severity of the climate issue, the authors suggest rigorous definitions of additionality.

[5] 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.

and unproven. 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.

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. The Oregon Carbon Allocation Task Force recommended a load-side cap for its energy utilities and the California Public Utilities Commission (CPUC) very seriously considered load side caps for California's electricity sector. However, the CPUC 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 actual reductions under a generator cap and trade program is to assign allowances to the efficiency activities and retire them. For example, some states have created special "set-aside" allocations of allowances in their NO_x trading programs for efficiency projects (EPA 2008). 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.

The authors believe that for the power and perhaps the natural gas sectors, caps at the level of distribution utilities encourages the greatest investment in energy efficiency and thus reduces the cost of compliance. However, the broader policy consensus appears to be that while generator caps are not directly advantageous for efficiency they have other positive attributes and are "winning out" over load based caps. Thus, realizing that, like carbon taxes, load based caps are not the direction policy makers are headed, the rest of this paper provides background and recommendations for policies that maximize efficiency potential in the context of generator based (or even further upstream in the case of natural gas markets) cap and trade systems.

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, rooted in 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 does not hold true for GHG for three main reasons (Cowart 2006):

- Much of the lowest-cost carbon dioxide emission reductions are not expected to be found at the smokestack level, as discussed above.
- Free allocations do not reduce consumer costs of electricity, and in fact increase net revenues to generators, in unregulated wholesale markets. Since a large fraction of U.S. power sales go through unregulated wholesale markets, it does not make economic sense to give all generators free allocations.
- By using auction proceeds to support energy efficiency programs, the total economic impacts of the cap can be reduced to a degree not possible with SO_2.

For some analysts, the discussion ends here – they view an auction, like a carbon tax, simply as a means of monetizing the cost of carbon emissions and including that cost in the stream of commerce. In this view, *the use of auction revenues* is not relevant to GHG reductions; they could be used as general tax receipts, for example to supplement Social Security. Unfortunately, this approach to cap and trade design would prove to be a very expensive way to attain needed GHG reductions. In the power sector, this is also true for three reasons:

- Since market barriers are high and demand elasticity is low, it takes very high power prices to reduce energy use and thus emissions significantly.
- Power dispatch is based on marginal costs, and it takes a very high carbon price to significantly reorder the dispatch.
- Since fossil generation sets the clearing prices in those parts of the U.S. with centrally organized electricity markets, an increase in the cost of coal or natural gas generation also increases the cost of nuclear and renewable generation with no additional reductions in emissions.

In RGGI, 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, versus simply giving away allowances. To date, all of the states that have issued draft rules under RGGI have elected to auction all or nearly all of their allowances[6].

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. U.S. federal legislation,

[6] 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, Maryland legislation introduced by the Governor in 2008 proposes to create a Strategic Energy Fund, which would receive RGGI allowance auction proceeds and use the funds for efficiency and other strategic carbon reduction purposes. However, there has been pushback from legislators concerned about rate increases from carbon goals and thus wanting a large portion of the funds to be used for rebates to ratepayers versus going for efficiency programs. We argue in this paper that efficiency investments would be more beneficial than direct rebates, both for the economy as a whole and for consumers participating in efficiency programs.

S. 2191, America's Climate Security Act, was voted out of the Environment and Public Works Committee in 2007 with an auction policy that begins at 26.5% in 2010 and rises to 69.5% in 2049. Of this auction fraction, more than half would go to energy technology deployment. The technology deployment funds would be about $16 billion in 2012 (assuming $16/ton carbon prices), rising to about $64 billion in 2049 (assuming $96/ton) (Center for Clean Air Policy 2008). If efficiency were to receive one third of deployment funds, that amount would exceed $5 billion in 2012 and $20 billion in 2049. Current U.S. federal spending on efficiency is under $1 billion and state/utility spending on efficiency is currently about $3.1 billion (CEE 2007) so these auction funds could more than double public efficiency investment in 2012.

Because end-use efficiency provides the greatest combination of emission-reduction and cost-containment benefits the authors recommend that a significant fraction – the actual amount determined by further analysis - of auction proceeds be spent on energy efficiency attainment. Since the principal objective of cap and trade policy is to attain reductions at the lowest cost to society, we conclude that explicit pro-efficiency policies are an essential, complementary design element of a national cap and trade system.

"Who Gets The Money?"

It is widely understood that under any meaningful national GHG program, the economic value associated with carbon allowances will be enormous, whether the allocations are given away or auctioned. If allowances are auctioned it is crucial to determine who gets the allowance revenue, what it is spent on, and what criteria will guide the spending. We conclude that the basis for answering all of these questions is "what results in the maximum amount of cost-effective energy efficiency?" The authors' term the activities paid for by the allowance money as *complementary policies and programs* – i.e. programs that while running parallel to cap and trade programs are still integral to the success of cap and trade and GHG mitigation policies.

S. 2191, for example, allows distribution utilities to use allowance proceeds 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 (i.e. at the macro economic level), 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 a significant portion of the money toward energy efficiency[7].

If the cap is placed on generators, it is recommended that a large fraction of allowance auction revenues not be allocated to individual efficiency project sponsors but to the administrators of public-interest efficiency programs, which are usually distribution utilities and/or state agencies. These administrators can aggregate projects and the parallel programs the authors recommend as needed to support achieving the full potential of efficiency. This aggregation and the inherent leveraging of funds addresses the barriers to efficiency summarized

[7] A proposal to create a national Efficiency Allocation as part of federal cap-and-trade legislation has been presented in congressional testimony. (Cowart 2008)

earlier in this paper. However, an important condition for these programs should be, in order to address the unbalanced relative impact of higher energy prices due to GHG mitigation, is making sure the programs impact as many consumers as possible - particularly those sensitive to higher bills.

Complementary Policies and Programs

As discussed above generator-based allocation cap and trade programs do not address the principle barriers to efficiency and thus in themselves will not deliver the maximum amount of cost-effective energy efficiency being achieved. However, auctioning cap and trade allowances can raise, in aggregate, large amounts of funds that can be used in complementary programs that do address these barriers. The authors suggest five types of complementary, complementary, programs that can utilize these funds and support both cost-effective efficiency and GHG reductions:

- Public benefit programs
- Energy efficiency resource standards
- Appliance efficiency standards
- Building energy codes
- Research, development and demonstration

Public Benefit Energy Efficiency Programs

Public benefits programs in the U.S. have decades of experience using 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 $3.1 billion in 2007. This is an increase of over 30% in three years.
- U.S. Consortium for Energy Efficiency members, who are a subset 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 15 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. Analysis of these EERS (in combination with renewable energy standard – RES) policies showed that they can reduce electricity prices significantly (Nadel 2006). A national 15%-15% EERS and RES policy can reduce wholesale prices by about 18% in 2025 in a climate mitigation 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 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. They have also provided major energy, economic, and emission reduction benefits at low cost. It has been estimated 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 energy consumers with 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 that a broad range of aggressive and continually improving energy codes and standards be adopted to greatly accelerate the wide-spread 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 quickly 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. After 100 years of utility investments and a regulatory system based on increasing fossil generation, a new business model is needed – one that will support an energy sector that meets stringent climate goals and inherently promotes end-use efficiency. Reaching goals such as California's zero-energy building goals implies that the capital sums that were formerly 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 to be analyzed. Therefore, the authors recommend that a portion of the allowance auction funds be used for RD&D.

Conclusions

In this paper the authors offer five main observations:

- Energy efficiency has a large potential to reduce GHG emissions at low cost and to reduce the economy's cost of a national carbon policy.
- Market and regulatory barriers and price inelasticity reduce the market's ability to respond to carbon price signals and realize appropriate efficiency improvements. Thus, low to even moderate "carbon" taxes would not be effective in calling forth the full potential of efficiency resources and high carbon taxes are neither economically efficient nor politically viable, at least at this time.
- The economics of power plant dispatch, the magnitude of the existing fossil power fleet, and the pricing rules of wholesale power markets combine to make reducing carbon emissions via carbon taxes or auction prices alone a very difficult proposition.
- Conventional approaches to climate cap and trade regulatory policy will also not induce efficiency's full 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. While the authors note that load side caps are the most effective for maximizing efficiency, they understand that is not the trend on a national or worldwide basis.
- Explicit policy treatment and funding for efficiency in parallel with cap and trade regulation are necessary to ensure that efficiency contributes maximum value to climate mitigation, minimizes the overall cost of mitigation, and makes greater emission reduction attainment possible.

The authors' recommendations for climate policy under the assumptions of cap and trade system with generator caps are thus that efficiency should be addressed as part of climate mitigation policy on a complementary and integrated basis with cap and trade programs. Thus:

- In a generator-based allocation system, carbon allowances should be auctioned rather than given to generators.
- The largest fraction possible of auction proceeds should be used for energy efficiency investment to support parallel, complementary end-use efficiency programs.
- The complementary programs should include:

    i. Augmenting public benefits programs
    ii. Energy efficiency resource standards
    iii. Enhanced appliance efficiency standards
    iv. Enhanced building energy codes
    v. Advanced technology, behavior, and policy research, development and demonstration (RD&D) activities

- A large fraction of overall allowance value should be allocated to administrators of these complementary programs in proportion to their attainment of measured end-use efficiency, providing both financial support and performance-based incentives for greater attainment.

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