# Energy Efficiency as a Climate Change Mitigation Strategy

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**ABSTRACT**

This paper provides an overview of the opportunities and challenges associated with incorporating energy efficiency into greenhouse gas emission reduction programs. It is intended as an introduction to the 2006 ACEEE summer study roundtable on this topic. Background is provided on GHG issues associated with energy efficiency and example programs that utilize efficiency as an emissions reduction strategy. In addition, the paper points out some barriers and provides options and recommendations for reducing these barriers.

## Introduction

Energy efficiency (EE) reduces emissions by lowering the demand for fossil fuels used in the production of electricity and/or thermal energy. Historically, emissions reductions from EE projects have been described only subjectively as a non-quantified benefit. However, with the development of emission trading programs and other environmental market mechanisms, there is now an opportunity to (a) utilize EE projects as part of effective emission control strategies and (b) monetize the emission reduction benefits associated with energy efficiency. While criteria pollutants such as Carbon Monoxide (CO), Nitrogen Dioxide ($NO_2$), particulate matter ($PM_{10}$ and $PM_{2.5}$), and Sulfur Dioxide ($SO_2$) as well as toxic pollutants such as Mercury (Hg) can also be reduced by energy efficiency, this paper focuses on greenhouse gas emissions, principally $CO_2$. Energy efficiency is particularly important for the energy industry because approximately 61% of all human induced (anthropogenic) GHG emissions (and about 75% of all $CO_2$ emissions) come from energy related activities (the breakout of energy related GHG emissions is estimated at: electricity and heat 40%, transport 22%, industry 17%, other fuel combustion 15% and fugitive emissions 6%) (Baumert, Herzog & Pershing 2005).

The principal components of greenhouse gases (GHG) are indicated in Table 1. GHG emissions are generally reported in terms of carbon dioxide equivalent $CO_2$(e). When calculating the tons of $CO_2$(e) from non-$CO_2$ GHG emssions, the values in Table 1 are used as multipliers.

**Table 1. Greenhouse Gas Emissions, Global Warming Potential and Common Sources**

| Greenhouse Gas | 100-Year Global Warming Potential (GWP) | Sources |
|---|---|---|
| Carbon dioxide ($CO_2$) | 1 | Combustion |
| Methane ($CH_4$) | 21 | Landfills, coal mines, oil/gas production, agriculture |
| Nitrous Oxide ($N_2O$) | 310 | Combustion, fertilizers |
| Hydrofluorocarbons (HFCs) | 140-11,700 | Semiconductors, refrigeration, fire protection |
| Perfluorocarbons (PFCs)/($C_xF_x$) | 6,500-9,200 | Semiconductor, refrigeration, fire protection |
| Sulfur Hexaflouride ($SF_6$) | 23,900 | Electrical power circuit breakers, switchgear |

Source: EPA 2006a

There is new and stronger evidence that most of the climate warming over the last 50 years is attributable to human activities (EPA 2006b). Furthermore, there is clear scientific justification for stronger climate change mitigation action now and for many years into the future (Pew 2005). Consensus on this perspective was indicated in a recent joint statement by the science academies of the G8 countries, Brazil, China and India: "The scientific understanding of climate change is now sufficiently clear to justify nations taking prompt action…[A] lack of full certainty about some aspects of climate change is not a reason for delaying an immediate response that will, at a reasonable cost, prevent dangerous anthropogenic interference with the climate system." (Joint Science Academies 2005). However, greenhouse gases are not a criteria pollutant in the United States, thus not regulated by the US EPA, and are only beginning to be regulated in some other countries.

While EE can be an important part of climate change mitigation and adaptation strategies, neither the best mechanism(s) for incorporating EE into these strategies nor the economic value of GHG reductions associated with EE is clear at this time. This situation is in part due to the nature of energy efficiency, which has an indirect effect on reducing emissions at a power plant. In addition there are, what are known as "secondary effects". Secondary effects are the "unintended consequences" of a project or program such as life cycle impacts (e.g., increasing energy use as it becomes more efficient and less costly), activity shifting (e.g., manufacturing moving to another location), and market leakage (e.g., emission changes due to changes in supply and/or demand profiles), as well as benefits such as reductions in other pollutants and water savings that are also common considerations in demand side management program evaluations.

For developers of emission reduction programs and EE project investors the emission reduction value associated with EE projects depends on the alternatives available – which in the case of $CO_2$ are limited – and the value attributed to GHG reduction as determined by the market place and/or regulation. For any particular EE project or program the specific economic value equals the amount of energy displaced through EE, the emission rate of gases, in $CO_2$(e) per unit of energy displaced, and the value given to each ton of $CO_2$(e) reduced. As will be discussed later in this paper, determining the actual GHG reduction resulting from efficiency efforts is not necessarily straightforward.

To get a sense of the range of values associated with electricity energy efficiency projects, one could make some fairly simple calculations. Using California as an example, the range of $CO_2$(e) utility power generation emission factors varies from an average emission rate for California on the order of 0.4 metric tons of $CO_2$(e) per MWh to a marginal emissions rate of 0.8[1] for one major utility (Marnay et al. 2002). Using these values, a couple of basic points can be made. First of all, it takes, in California, on the order of one to three MWh of electricity generation reduction to obtain 1 ton of $CO_2$(e) reduction[2]. That one to three MWh of electricity might have an average retail value in California in the range of $80 to $750 (using 8 cent to 25 cent per kWh rates). At 2006 prices, that reduced ton of $CO_2$(e) has zero market value in California. However, the market rates, as of 27 April 2006, on the voluntary Chicago Climate Exchange (www.chicagoclimatex.com/) or the European Union Emission Trading System – EU

[1] These values are lower than the average for other parts of the United States, which have higher reliance on coal power

[2] And to begin the complexity, the emissions rate depends at least on the power plant whose output is displaced (e.g., a coal plant or hydro plant), whether one is displacing baseload or peak output, and whether the displaced power is from existing plants (termed operating margin) or potential future plant marginal power (termed built margin).

ETS - (www.pointcarbon.com) were approximately \$3.50 and \$21 per ton of $CO_2$(e), respectively[3]. Thus, the above calculations indicate that relative to the value of energy cost savings, GHG reductions can add well less than 1% to about 25% to the value of energy efficiency activities.

This rather large range of results indicates several points:

- One needs very large energy efficiency projects to obtain a meaningful amount of economic value from GHG reductions,
- GHG economic benefits from individual EE projects are trivial today in the United States, and
- The potential value of GHG as compared to energy savings will depend heavily on the regulatory and market mechanisms that are put in place- and the stability of the mechanisms.

In addition, though, it should be noted that the total economic value of a portfolio of energy efficiency programs can be very large. For example, if one takes the California 2013 energy efficiency cumulative savings goal of about 23,000 GWh saved per year (CPUC 2004a), it appears that the efficiency goals represent, by 2013, a reduction in annual $CO_2$(e) emissions in the range of 9 to 18 million tons per year. Using the CPUC's "Final E3 Avoided Cost Report" estimate for the value of $CO_2$ in 2013, \$17.50 per ton (CPUC 2004b), indicates an approximate value of \$150 to \$300 million per year.

Actually realizing these values requires a regulatory mandate to reduce GHG and most likely a market mechanism for valuing GHG reductions. Even with a regulatory and market structure, energy efficiency will face its old foe of the transaction costs associated with documenting the energy, and now emission, reductions. Transaction costs can be a significant barrier particularly considering that the emission reduction from individual EE/RE projects tends to be fairly small. On the other hand, as noted above, the advantages of aggregating large numbers of projects can result in significant total economic value. Thus, an efficient mechanism and process for monetizing and documenting emission reductions from EE projects would most likely include both aggregation and reduced transaction costs.

## Carbon Emission Control Through Efficiency

The conventional approach to emission control, often termed "command and control" involves a regulatory agency setting emission limits for certain industries or processes and/or requiring the use of certain control technologies. For carbon emission reductions, the classic command and control approach has serious limitations for the power industry, since there are no commercially viable post-combustion control technologies for $CO_2$. To reduce carbon emissions, generators must reduce the carbon content of generating fuels (e.g., renewables), reduce energy generation (through demand or supply efficiency projects), utilize sequestration (e.g., planting forests or injecting $CO_2$ into underground wells), or some combination of all three.

[3] Note that under the EU ETS if participants do not meet their obligations they have to pay a penalty of 40 Euro per ton $CO_2$ for the period 2005-2007, for the next periods the penalty will be 100 Euro per ton $CO_2$. It should also be noted that EU ETS carbon prices have been very volatile during the Spring of 2006 ranging from €32/ton early in 2006 to a mid-May price closer to €12/ton.

In this context, the primary carbon management policy mechanisms, for the energy industry, other than command and control, are:

- Carbon tax – this approach was explored by the Clinton Administration and was quickly shown to not be politically viable, at least for now
- Emissions performance standard or "intensity goals" (popular with some industry groups and the Bush administration) – this involves setting a goal of so many tons of carbon per unit of energy (e.g., MWh) production; however, this approach does not assure overall carbon emission reductions, since increases in energy consumption increase carbon emissions
- Voluntary programs and technology development incentives (also popular with the Bush administration and some industry groups) – for example, organizations wishing to reduce their GHG emissions can report their reductions on a voluntary basis to a centralized clearinghouse (e.g., US Department of Energy 1605b Program) and state registries (e.g., California Climate Action Registry).
- Cap and trade (basis for the EU ETS, the UNFCCC CDM and JI programs[4], and proposed in California and the Northeast United States)

Since Cap and Trade is one of the most popular mechanisms being considered for controlling GHG emissions, the basics of cap and trade are explained below:

- A regulating authority sets a cap on total mass emissions for a group of sources for a fixed compliance period (e.g., 1 year)
- The regulating authority divides the cap into allowances, each representing an authorization to emit a specific quantity of pollutant (e.g., 1 ton of $CO_2$)
- The regulating authority distributes allowances
- For the compliance period, each recipient of allowances measures and reports all of its emissions
- At the end of the compliance period, each recipient of allowances must surrender allowances to cover the quantity of the pollutant it emitted
    - If it is has excess (credits) it can sell them or possibly "bank" them
    - If it does not have enough allowances, it can try to buy them
- If a source does not hold sufficient allowances to cover its emissions, the regulating authority imposes penalties and/or sanctions.

How EE projects are incorporated into a cap and trade system depends significantly on the allocation method for allowances. With a cap and trade program, there are three primary approaches for distributing or allocating allowances. Using the electricity generation sector as an example, these approaches are:

- Generator-based (upstream) allocation – allowances are directly allocated to the electricity generators, typically based on historical fuel input, output, or emissions. This is the most common approach and has been used almost exclusively for other emission cap and trade programs, e.g., the Acid Rain Program.

[4] United Nations Framework Convention on Climate Change Clean Development Mechanism and Joint Implementation strategies (from the Kyoto Protocol) – see www.unfcc.int

- Load-based (downstream) allocation – allowances are allocated to load serving entities (LSEs, or electricity distribution utilities) or other service providers; these entities then have incentives to buy less electricity and/or buy electricity with less of a carbon "footprint."
- Auctioning some or all allowances – allowances are sold in an auction and the proceeds are utilized for any number of purposes, including EE development; this approach can be used in conjunction with either of the two other approaches.

Generator-based allocations address direct emission sources (and reductions) while load-based allocations can address both direct and indirect emission sources (and reductions). As mentioned above, energy efficiency is a form of indirect reduction. Thus, for a load-based allocation, there is no need for an explicit consideration of EE, since EE projects will directly reduce the number of allowances required by a LSE. One of the difficulties with a load based allocation though, is that the LSEs would need a complex and not easy to verify accounting system for their power suppliers.

Alternatively, with a cap-and-trade system utilizing generator allocations, because the power plant level emission reductions from efficiency investments are indirect, EE projects and programs must be accounted for explicitly. If they are not, the potential exists for mis-counting allowances. For example, a manufacturer that reduces end-use electricity consumption could seek to claim an emissions reduction, but because the cap is on emissions at the power plant, the manufacturer's reduction in electricity use could be offset by increased electricity use elsewhere and thus, result in no net reduction in emissions at the power plant. If, however, the efficiency-based emission reductions were assigned allowances, there would not be the accounting problem described above. Thus, including EE in a power sector cap-and-trade requires an "add on" (e.g., a "set-aside", an "opt-in" or an auction for EE allowances) mechanism for assigning allowances to account specifically for EE emission reductions - if generator allocations are used.

It should be noted that some cap-and-trade programs, notably the European Union's carbon system and the proposed RGGI process, pursue EE through parallel policies (such as a renewable portfolio standard or an efficiency incentive program) and do not try to "force" these resources to be advanced within the cap. The overall intent is to enable compliance with an aggressive cap and to lower the total cost of the policy. This can be a workable approach, but only if the parallel policies are rigorous, designed to reap a significant fraction of the potential that EE offers, and there is not competition or conflicts between the parallel policies.

In summary, load-based allocation approach, assuming a cap and trade program, may be the most conducive to EE, with an auction system as the second most appropriate for generating funds to support EE programs. However, if a generator allocation system is used, then the set-aside approach might be effective, although this approach can be complex with high transaction costs. Alternatively, a strong parallel program of EE programs could be supported as a greenhouse mitigation strategy that is companion to a generator based allocation program. Many of these approaches are being attempted, and in the near future, the results from each approach will hopefully be available for comparison.

## Emission Reduction Programs Incorporating Efficiency and Renewables

Many economic studies have recognized that EE investments provide broad societal benefits, both economic and environmental, that are not all rewarded in the revenue streams derived by investors in these projects. A major study by the U.S. Department of Energy (Interlaboratory Working Group 2000) also shows that accelerated adoption of the energy efficiency is an essential, economically sound means to reduce emissions while developing the U.S. economy. However, historically, the emission reductions from EE projects have not been formally recognized in air quality planning processes (Vine 2003). While beyond the scope of this paper to describe all of the existing emission reduction programs that are attempting to incorporate EE as an emission reduction option, the following is a brief list of some of the programs:

- U.S. Acid Rain Program.
- U.S. EPA NOx SIP Call. A multi-state program to reduce NOx that includes a voluntary provision for states to set aside emission allowances for renewable energy and efficiency projects and programs
- Regional Greenhouse Gas Initiative (RGGI). An agreement between the governors of seven Northeast states to address the challenge of climate change while increasing energy efficiency investments and stimulating emerging clean energy technology markets. Key provisions of the RGGI memo of understanding are: (a) an agreement to stabilize carbon dioxide emissions from the region's power plants at current levels from 2009 to the start of 2015 followed by a 10% reduction in emissions by 2019 and (b) each state may allocate allowances from its CO2 emissions budget as it determines appropriate, except that all states agree that at least 25% of their allowances will be allocated for consumer benefit or strategic energy purposes, such as energy efficiency. (RGGI 2005)
- California Public Utilities Commission initiatives. These initiatives include the addition of $CO_2$ costs and risk to energy procurement decisions and a carbon cap for investor owed utilities. (CPUC 2004b, CPUC 2006)
- Pacific Gas and Electric Company Voluntary Climate Protection Program (PG&E 2006).
- State GHG Registries. Examples include the California and Eastern States registries that establish baseline emission values for individual companies and other entities, such as utilities (www.climateregistry.org and www.easternclimateregistry.org).
- West Coast Governors' Global Warming Initiative-www.climatechange.ca.gov/westcoast
- The Climate Trust. An Oregon entity that provides greenhouse gas offset projects for industry, utilities, and individuals (www.climatetrust.org)
- Texas "state implementation plan" (SIP). This plan includes a credit of 0.5 tons/day NOx emissions reductions for enacting a building code that includes specific energy efficiency requirements for new construction.
- UNFCCC Clean Development Mechanism (CDM). This is a program that allows GHG emitters in developed countries to "take credit" for GHG reduction projects (or programs) they implement in developing countries. This provides dual benefits of low cost emission reduction programs and expertise and technology export opportunities for developed countries and sustainable development, infrastructure improvements for developing countries. This is a particularly important mechanism for least developed countries (LDCs) as they may be most impacted by climate change (which generally speaking they did not cause) and are least able to afford mitigation and adaptation measures.

There are also a number of protocol efforts specifically associated with documenting GHG baselines, and to a lesser degree reductions. The most well know of these are the World

Resources Institute Corporate Accounting and Reporting Standard (WRI 2004) and Project Protocol (WRI 2005), the California Climate Action Registry Power Protocol (CCAR 2004), and the CDM methodologies (UNFCC CDM Board 2006). Generally speaking these protocols all attempt to utilize a "common language" for defining what constitutes a ton of $CO_2$(e) reduction.

## Issues for Incorporating Efficiency Into GHG Emissions Programs

As mentioned above, several entities, such as the European Union (Bertoldi and Rezessy 2006), the Regional Greenhouse Gas Initiative (RGGI 2005), EPA (Schiller 2004) and the California PUC (CPUC 2006) are looking to implement emission cap and trade systems with EE components[5]. In doing so, they are discovering a number of structural issues that need to be addressed (in addition to the transaction costs and mechanisms for incorporating EE into a Cap and Trade systems as discussed above). The structural issues include:

- Ownership – Different policies would indicate whether the owner of any credits is the end-use customer or project owner, the contractor, or for example, a utility or state agency that provided incentives for a project. Of course related to this issue of ownership is who will conduct and pay for measurement and verification.
- Relationship of existing programs (e.g., efficiency portfolio standards, building codes, and public goods charge programs) to a cap and trade program. Many states have existing programs that promote EE projects, in part due to their environmental benefits, and therefore, emission reduction programs that include EE projects as mitigation measures must augment and not displace these existing programs.
- Tracking and evaluation – Sophisticated evaluation and tracking systems are required for trading programs, and these systems would need to include consideration of EE projects and their unique characteristics. Related to this issue are the jurisdictional conflicts between air and energy regulators as well as questions of where reductions will be registered and who will have authority over these registries.

### Evaluation

Key to the credibility of any market mechanism system is the evaluation process for documenting and verifying emission reductions. When designing and implementing an emissions trading program, the challenges associated with creating a credible documentation and verification process involve balancing the cost, effort and rigor of various approaches with the value of the information generated by the efforts. Ideally, the evaluation process for calculating emission allowances will be consistent, accurate and transparent. These three criteria are particularly important for GHG emissions trading as ultimately, GHG emission reduction programs will involve national and international markets. These markets will require a standardized approach to estimating, trading and reporting reductions in order for both allowances and credits from different allocation and mitigation strategies, such a efficiency, to be fungible.

[5] In the case of the California PUC cap on GHG emissions for investor owed utilities, no decision has been made on compliance mechanisms, such as whether or not to allow trading.

Emission reductions from EE projects are most commonly associated with reduced electricity production at an electric generating unit (EGU)[6]. For electricity efficiency projects, actual emission reductions depend on which EGU(s) the electricity is displaced from and the emissions rate from these power plants. Which EGUs provide the displaced electricity can vary from day to day and even hour to hour. In addition, the emissions profile of the supplying power plants can vary on a daily or even hourly basis as the operating modes and fuel sources, possibly, change. However, as a typical simplification for most trading programs, the power plant source and emission factors are reduced to a single value. The source of such factors is typically a grid model that establishes which EGUs serve various locations at various times of the year. Several grid models are available through the EPA (Biewald and Keith 2004).

To add complexity, but perhaps more accuracy, one could use emissions factors for the marginal generating plant (multiplied by the energy saved) for each hour of the year, rather than the average emission rate for the entire system (i.e., total emissions divided by total sales). Alternatively, one could also consider the emissions rate of EGUs that were not built because of the EE projects. One would have to determine if the EE projects would reduce peak demand and energy sufficiently and with enough reliability to defer or obviate planned capacity expansion. For the CDM process, the UNFCCC has developed a methodology for considering EGU operating margins and build margins in the calculation of displaced electricity emission factors (UNFCCC 2006). The UNFCCC CDM program has also addressed the issue of acceptable crediting periods (measure lives) for reductions programs by allowing two options, a maximum ten-year life crediting option or an option allowing renewals, but with further justification.

## Evaluation Issues and Recommendations

When quantifying energy savings and verifying emissions reductions from EE projects, the following are recommendations for improving credibility and managing analysis costs.

**Program versus project evaluation (project bundling).** The techniques for determining savings from a single project or group of projects with similar characteristics (a program) are quite similar, with one exception. That exception is that with projects, each project is evaluated, but with programs, a sample of projects is selected for evaluation, and the results are applied to the entire program "population". The result is that program evaluation, on a per project or ton of pollutant basis, tends to be much more cost-effective than project-by-project analyses. Thus, the author recommends that with respect to documentation and verification, it is more cost-effective to encourage programs, or large aggregations of similar projects, to participate in allowance trading programs.

**Additionality.** Having consistent and simple baseline standards is an important part of a successful emissions trading program. Baseline definitions will consist of either: (a) existing conditions (e.g., the electricity consumption of the system being replaced), (b) minimum government standards (e.g. buildings codes and appliance standards) , or (c) baseline levels of activity included in planning scenarios or mandates (e.g., a pre-existing statewide energy

[6] Although of course, there are also benefits from thermal energy efficiency activities, such as those that reduce natural gas and fuel oil use with resulting $CO_2$ and $CH_4$ emission reductions. Much of the focus for energy efficiency climate programs has been on electricity and, to a lesser degree, natural gas with little consideration for non-regulated fuels.

efficiency portfolio mandate). The author recommends that the appropriate approach is to use the baseline levels assumptions that were used to define the amount of allowances to be allocated.

**Using quality assurance guidelines versus project specific m&v requirements.** Instead of defining requirements for M&V documentation, the author recommends that evaluation protocols include Quality Assurance Guidelines (QAG). Adherence to such quality assurance guidelines allows the M&V methods employed to be shaped by the specific circumstances of the projects/programs, the uncertainty of the savings estimates, and the value of the allowances. A QAG covers key issues associated with different data collection and analysis methods and requires applicants for allowances to describe how certain key issues were addressed rather than defining prescriptive requirements. In some cases, a QAG can also refer to standardized M&V approaches for guidance and issues that must be addressed.

Once the M&V documentation is reviewed, the indicated emission reductions can be:

- Used "as is" for determining the emission reductions that will be credited to the subject project or program
- Revised to provide a new emissions reduction value that will be credited to the project or program
- Discounted based on general or specific concerns about the accuracy of the emission reductions values provided.[7]
- Rejected.

Since some form of energy savings documentation will often be prepared as part of a project or program implementation, it can be more cost effective for all involved to evaluate this documentation using QAG versus requiring a totally new documentation and verification effort for the sole purpose of defining reductions.

## Conclusions

Allowance trading programs provide an opportunity to both utilize and recognize EE projects and programs for their emission reduction benefits. Evaluating and utilizing emission reductions from EE projects enhances the cost effectiveness of emission control programs and adds to the direct economic and indirect sales "sizzle" value of EE projects. These benefits help justify the increased implementation of EE projects. When designing and implementing an emissions trading program that incorporates efficiency, the challenge associated with evaluation is balancing the cost, effort and rigor of various approaches to measurement and verification with the value of the information generated by the efforts. Most of the value of information is tied to the value of allowances and overall program integrity, i.e. gaining the confidence of regulators and traders that the risks and the capital intensive expenses associated with energy efficiency and emission reductions are relatively conservative and cost-effective, respectively.

Thus, the documentation and verification processes are about reducing barriers and risk management. How much risk is acceptable is largely dependent on the number and value of the allowances, other benefits of promoting EE activities, and the resources available to trading

[7] For more information on discounting approaches, see Vine et al. (2003).

system sponsors and project promoters. Simply put, low-risk projects require less effort to document and verify; high-risk projects require more effort.

In summary, some mechanisms for aligning risks and benefits as well as reducing the effort and barriers associated with including efficiency in GHG mitigation programs are: (1) serious consideration of enforceable energy efficiency parallel policies, (2) use of load based allocations or auctions of emission allocations, (3) program level aggregation of individual project emission credits, (4) use of Quality Assurance Guidelines that are used in conjunction with standardized documentation and verification approaches, and (5) evaluation mechanisms that balance risks with benefits such as infrastructure development (e.g., CDM) as well as immediate emission reductions.

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