Role of Energy Efficiency Programs in Buildings in Addressing Air Quality and Greenhouse Gas Reduction Goals

OVERVIEW

In 2004, the U.S. Department of Energy (DOE) launched the Clean Energy/Air Quality Integration Initiative. A major objective of this Initiative is to promote increased collaboration among energy and air quality agencies at the state and local levels, thereby encouraging increased energy efficiency and reduced air emissions. This background paper is designed to further this objective by providing air and energy officials with basic information on the role of building energy efficiency programs in addressing air quality and greenhouse gas (GHG) reduction goals. It includes information about: (1) the impact of different types of building energy savings measures on air emissions, (2) electricity regulatory reforms that encourage energy savings, (3) examples demonstrating the integration of energy efficiency and air quality strategies, and (4) background resources.

Although energy efficiency in buildings provides a wide range of societal benefits, including significant consumer cost savings[1] and improved electric system reliability, the focus of this fact sheet is limited to air emission reduction benefits from decreasing electric energy use.

IMPACT OF DIFFERENT TYPES OF BUILDING ENERGY SAVINGS MEASURES ON AIR EMISSION REDUCTIONS

Measures to reduce energy use in buildings have a wide range, including products as diverse as high-efficiency lighting and high-efficiency appliances, such as air conditioners, as well as improved controls to reduce energy waste. Each type of energy savings measure differs in its hourly and seasonal pattern of energy savings. In analyzing air emission reduction benefits and developing strategies to improve air quality, it is important to understand these hourly and seasonal patterns.

A few examples are illustrative. High-efficiency refrigerators and dishwashers provide year-round energy savings. In comparison, the energy savings and air emission reduction benefits of high-efficiency residential air conditioners are concentrated in the summer months. The daily and seasonal timing of the energy savings will determine the specific type of fossil fuel-fired electric generating unit (EGU) that will be backed down. This timing, in turn, affects the level of emissions avoided at individual EGUs. For example, in the PJM Interconnection power market, the fossil fuel-fired units that are backed down during the days of highest summer electrical demand are often natural gas turbines or diesel generators with relatively high emissions of nitrogen oxides (NO_X) but relatively low carbon dioxide (CO_2) emissions. In comparison, the fossil fuel units backed down in PJM in the winter are more often coal-fired units with high CO_2 and NO_X emissions.

Furthermore, the design and implementation of applicable emissions trading (cap-and-trade) programs governing GHGs (e.g., CO_2) or other pollutants (e.g., NO_X) will determine whether total emissions in the cap-and-trade region will be reduced below the level of the emissions cap.[2] However, all

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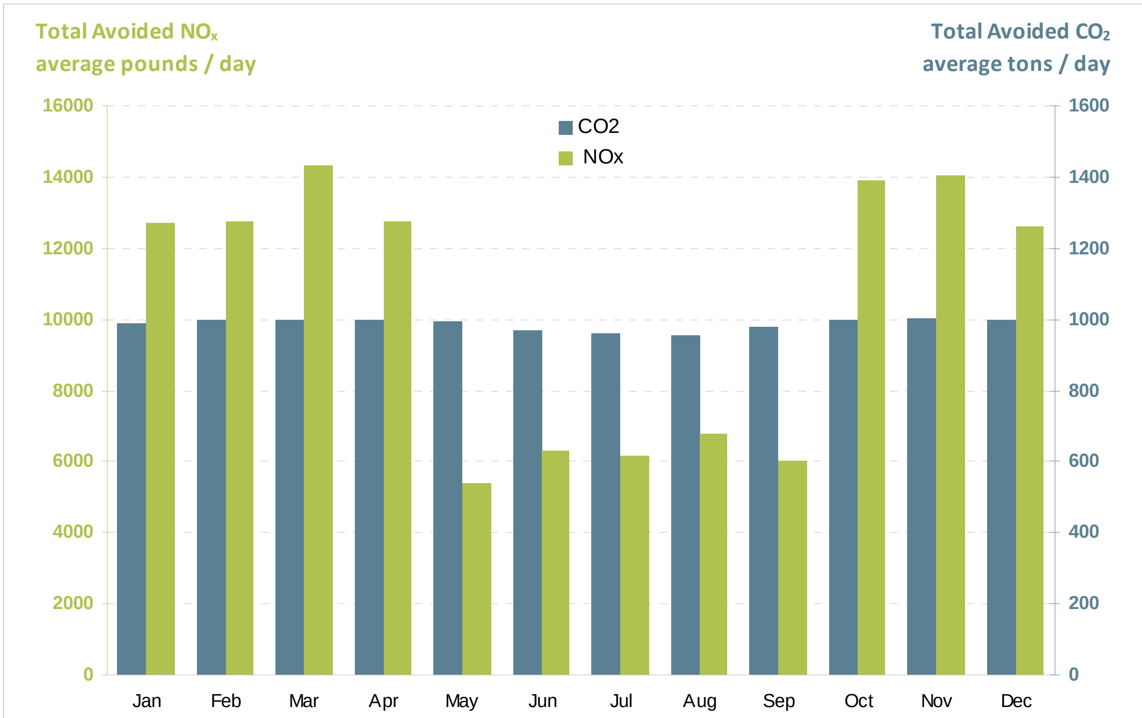
[1] According to the National Action Plan for Energy Efficiency, "[e]nergy efficiency on the order needed to meet 50 percent or more of expected growth for natural gas and electricity is available at a cost of less than half of new generation in many parts of the country."

[2] See Schiller, S., National Action Plan for Energy Efficiency: Model Energy Efficiency Program Impact Evaluation Guide, November 2007, p. 3-17 to 3-18 for a fuller discussion of this issue. See http://www.epa.gov/cleanenergy/actionplan/resources.htm#resources

cost-effective energy savings measures will contribute to the achievement of air quality and climate goals by reducing the overall cost of compliance for polluters seeking to meet the emission cap.
Thus, the actual pattern of avoided emissions reflects the combined effect of the hourly and seasonal patterns of energy efficiency savings, the hourly and seasonal dispatch of EGUs on the grid, and the effect of the cap-and-trade rules. An example of the **seasonal** differences in energy efficiency savings is shown in Figure 1 below.

Figure 1. Avoided Emissions of NO_X and CO_2 for 10,000 MWh per Month of High-Efficiency Lighting Programs in the PJM Power Market (2005)



This example for the PJM power market shows the profile of monthly avoided emissions of NO_X and CO_2 that would have resulted in 2005 if an additional 10,000 MWh per month of energy efficiency savings was provided by high-efficiency lighting fixtures. Although high-efficiency lighting programs save energy throughout the year, the avoided emissions are greater in the winter months for three reasons. First, the energy savings are greater because of shorter daylight hours. Second, in the fall, winter, and spring, the fossil fuel-fired units backed down in PJM are more often coal-fired units with high NO_X and CO_2 emissions as compared with the summer months. Third, the cap-and-trade program in effect for NO_X in the Eastern States has a lower limit on total emissions during the summer ozone season (May 1 through September 30).

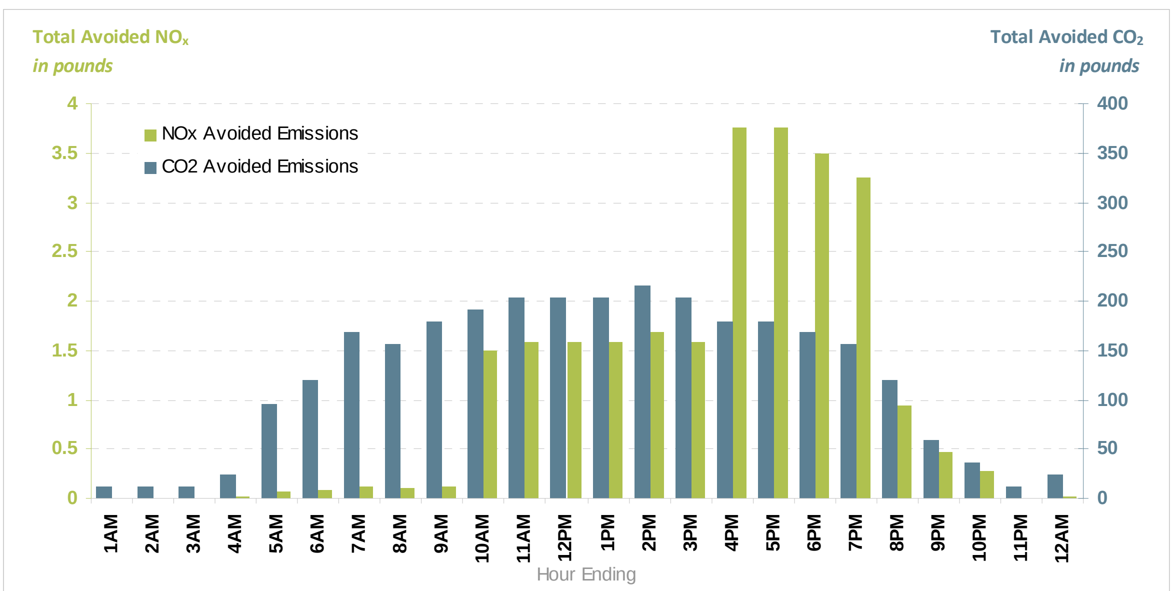
Energy savings measures that reduce summer electric use during the **days and hours with the highest electrical demand**, such as high-efficiency air conditioning and commercial lighting, are particularly valuable in reducing emissions of NO_X—a precursor of ground-level ozone that causes adverse respiratory effects in adults and children. Ozone is formed on hot summer days, and the hottest summer days also are typically the days of highest electrical demand—the so-called "high electric demand days."

Research has demonstrated that daily NO_X emissions on high electric demand days from fossil fuel-fired electric generating units in certain regions of the country (e.g., the Northeast and Mid-Atlantic regions) substantially exceed emissions on more typical summer days. For example, NO_X emissions in Connecticut on high ozone days can be more than twice the level of emissions on low ozone days (e.g., 260 tons on August 14, 2002, compared with 130 tons on August 8, 2002).[3] This result occurs because the peakload generating units used on these limited number of days each year (generally fewer than a dozen days) are typically older units with limited pollution controls. Many oil-fired or natural gas-fired plants that run on these days have NO_X emission levels that can equal or even exceed those of more modern coal-fired units.

Emissions from certain on-site standby generators also contribute to ozone nonattainment on high electric demand days. On these days, regional grid operators and utilities often use a variety of programs to meet high electric demand, including payments to customers to use on-site standby generators. These units—often referred to as behind-the-meter generators—are typically diesel internal combustion engines with very high emission rates for NO_X and fine particulate matter.

Figures 2a and 2b show the effect of energy efficiency in reducing demand and avoided emissions, particularly during peakload hours, on a very high electric demand day. Avoided NO_X and CO_2 emissions are higher in the middle of the day because energy efficiency savings, especially from high-efficiency commercial air conditioning, are greatest at the hours of the day with the highest temperatures and the highest electricity demand in offices and other commercial buildings. These efficiency savings reduce the use of both peakload electric generating units with high NO_X and CO_2 emissions operating on the grid as well as the use of standby on-site diesel generators. The spike in avoided NO_X emissions during the 4:00 PM to 8:00 PM period reflected in Figure 2a highlights the value of energy efficiency measures in reducing NO_X from the use of these standby diesel generators.

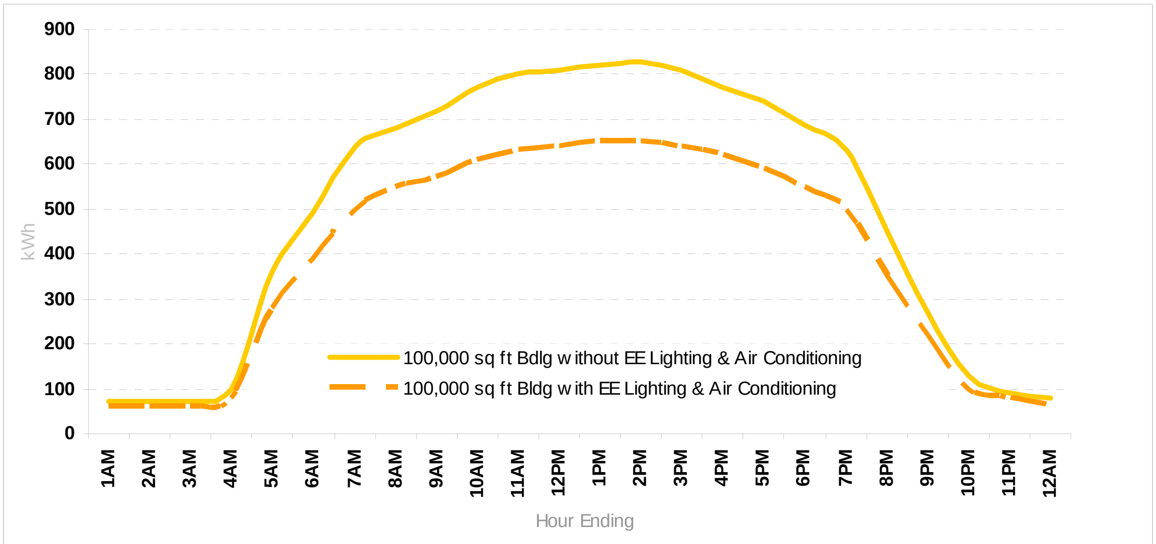
Figure 2a. Reductions in NO_X and CO_2 Emissions on a High Electric Demand Day from Energy Efficiency Savings from Commercial Air Conditioning and Lighting in 100,000-ft^2 of Office Space in Southwest Connecticut[4]



3 Northeast States for Coordinated Air Use Management, *Final White Paper: High Electric Demand Day and Air Quality in the Northeast,* June 5, 2006.

4 The NO_X and CO_2 avoided emissions are based on 2005 emissions data.

Figure 2b. The Hourly Electric Power Use With and Without Energy Efficiency Savings from Commercial Air Conditioning and Lighting in 100,000-ft² of Office Space in Southwest Connecticut[5]



Electricity Regulatory Reforms to Encourage Energy Efficiency

As a result of the acceleration of efforts by public utility commissions and regional grid operators to reform regulatory policies to encourage energy efficiency, it is important for energy and air regulators to understand these market reforms. In addition, greater collaboration among air and energy agencies and utility commissions is essential to ensure that the electricity regulatory reforms are consistent with air quality, climate, and energy policy goals.

One of the most important recent initiatives has been the National Action Plan for Energy Efficiency—a plan developed by more than 50 leading organizations and facilitated by the DOE and the U.S. Environmental Protection Agency (EPA). The purpose of the Action Plan is to overcome barriers that have led to an underinvestment in energy efficiency. The National Action Plan and its related "Vision for 2025" set forth a roadmap of policies and programs with demonstrated success in substantially reducing annual energy consumption as well as peakload energy demand. This roadmap is based on "best practices" of innovative states around the country.

One of the most important policy recommendations of the National Action Plan calls for the modification of rate-making policies in most states that only reward utilities for selling energy and building new infrastructure (e.g., power plants, transmission lines) and fail to provide commensurate incentives for energy efficiency measures (even when the energy saving measures result in significant cost savings). Other major recommendations include rate-making reforms that would encourage energy consumers to reduce energy use at times of peak demand.

In recent years, regional grid operators[6] in several regions also have undertaken actions that have placed energy savings on a more level playing field with electric generation. For example, the regional

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5 Energy efficiency savings are based on a conservative assumption of a 20% reduction in energy use compared to existing buildings. The hourly demand profile is for a high electric demand day in SW Connecticut.

6 The technical name for these regional groups is "regional transmission organization" or RTO.

grid operators for New England[7] and the Mid-Atlantic States[8] have expanded the energy resources that can participate in the electricity markets to include demand reduction generally and/or demand reduction at peakload periods. In other words, these regional grid operators have discontinued their historic policy of restricting participation in the electricity markets to only electric generating plants.

However, in some cases, the electricity reforms have conflicted with air quality policies or have failed to deliver results necessary to meet state energy policy goals. For example, new rules in the PJM power market, which allow the broad participation of diesel generators in electricity markets, are likely to exacerbate ozone nonattainment problems on peak demand days. Most state air regulations have not been amended to take account of this new market reality nor have the market rules been fashioned to take cognizance of these serious ozone nonattainment problems. Similarly, states may face major barriers in meeting the energy efficiency and CO_2 reduction goals stated in their state energy and climate plans if the regional market rules and state energy policies are not well coordinated.

INTEGRATION OF ENERGY EFFICIENCY INTO AIR QUALITY AND CLIMATE STRATEGIES

In recent years, EPA has taken various actions to integrate energy efficiency into air quality and climate strategies. Under EPA guidance, states are authorized to receive recognition in their air quality plans for energy efficiency measures if certain conditions are met, and several states have included energy efficiency actions as a component of their plans. For example, in 2003, the Shreveport-Bossier City, Louisiana, Metropolitan Area entered an Early Action Compact with the EPA relating to the 8-hour ozone standard that included energy efficiency retrofits in 33 municipal buildings as a local control measure to reduce NO_X emissions. This compact was incorporated into the Louisiana State Implementation Plan (SIP).

The Connecticut Department of Environmental Protection (DEP) also cited state energy efficiency initiatives, including actions to reduce peak electric demand, as a key component of its "weight-of-evidence" analysis in its proposed revisions to its SIP to meet the 8-hour ozone standard. DEP received technical support from both the DOE and EPA in this effort.

In addition, actions to reduce energy use in buildings are included in numerous climate action plans developed by States to meet greenhouse gas reduction goals. For example, New York included a variety of actions in this area since the building sector is responsible for more than half of the State's CO_2 emissions after factoring in electric use by commercial and residential buildings.

CONCLUSION

Energy efficiency measures can contribute to substantial reductions in air emissions of nitrogen oxides and carbon dioxide from electric power generation. Well-designed reforms in electric power regulation and complementary environmental policies can further promote such energy savings and emission reductions.

[7] The New England Independent System Operator (ISO New England).

[8] The PJM Interconnection (PJM).

RESOURCES

- U.S. DOE, Clean Energy/Air Quality Integration Initiative web site. See http://www.eere.energy.gov/wip/air_quality_projects.cfm
- National Action Plan for Energy Efficiency. http://www.epa.gov/eeactionplan/
- U.S. EPA, Guidance Documents on Clean Energy/Air Quality Integration. See http://www.epa.gov/cleanenergy/stateandlocal/guidance.htm
- Louisiana Department of Environmental Quality, Shreveport-Bossier City Early Action Compact and Progress Reports. See http://www.dep.louisiana.gov/portal/tabid/2311/Default.aspx
- Connecticut Department of Environmental Protection, Revision to State Implementation Plan, 8-Hour Ozone Attainment Demonstration, pp. 8-30 to 8-33 and Appendix 8P. See http://www.ct.gov/dep/cwp/view.asp?a=2684&q=385866
- American Society of Heating, Refrigeration and Air Conditioning Engineers, Measurement of Energy and Demand Savings, ASHRAE Guideline 14-2002. 2002. See http://www.ashrae.org
- Northeast Energy Efficiency Partnerships (NEEP). See http://www.neep.org/
- IPMVP, International Performance Measurement and Verification Protocol. See http://www.ipmvp.org
- The Climate Registry. See http://www.theclimateregistry.org/

ADDITIONAL INFORMATION

This background paper was prepared by Debra Jacobson of DJ Consulting LLC and Colin High of Resource Systems Group Inc. with funding support from the Clean Energy/Air Quality Integration Initiative of the U.S. DOE's Office of Energy Efficiency and Renewable Energy. Ms. Jacobson and Dr. High can be contacted at djconsultingllc@earthlink.net and chigh@rsginc.com, respectively.