

Driving Energy Efficiency: Applying a Mobile Source Analogy to Quantify Avoided Emissions

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ver the past 40 years, energy efficiency (EE) has helped the United States to cost-effectively avoid emissions that cause air pollution. Studies show that the costs per ton of reducing emissions through EE are lower than traditional control measures implemented by air regulators.² Further, the energy, environmental, and other benefits of EE start as soon as the first devices are installed, and they continue to accumulate over time.³

As a result, one would expect EE to be a highly regarded and widely used regulatory strategy for improving and maintaining air quality. It is only recently, however, that state and local air regulators and the US Environmental Protection Agency (EPA) given serious consideration to EE as a viable emissions reduction option.⁴ The slow pace of

Through quantification approaches approved by EPA and adopted by states in compliance with the Clean **Power Plan**, energy efficiency can establish its efficacy as a cost-effective, enforceable, multi-pollutant emissions reductions strategy that provides numerous important societal co-benefits. integrating EE into air quality planning is primarily due to the challenge of accurately quantifying the air pollution emissions reductions that EE measures provide. There

are two complex steps in this process: (1) characterizing the energy savings that result from EE measures, and (2) translating those energy savings into pounds or tons of avoided emissions.

Air regulators initially sought to quantify EE-related emissions reductions in a manner similar to

traditional stationary source controls; they tried to tie the electricity saved by EE to a specific power plant based on the notion that the power plant's output was reduced due to the EE measure(s). This approach, however, reflected an inadequate appreciation of how the electricity grid actually works. Because electrons are extremely difficult to

- The authors are indebted to Leah Weiss for her assistance in the *editing and organization of this paper.*
- The Mobile Source Analogy posits that dispersed energy effi-1 ciency is sufficiently analogous to dispersed mobile and area sources that mobile and area source methods to determine emissions reductions can also be applied to energy efficiency, encouraging the use of energy efficiency as an air quality strategy.
- 2 Examples from China, the EU, and the US, respectively, include: Mao, X. Q., et al. (2013). Co-Control of Local Air Pollutants from the Chinese Coal-Fired Power Industry, Journal of Cleaner Production, article in press. Amann, M. (2013). Experience on Air Pollution Prevention and Control of Europe. Presentation at Restoring Blue Skies: Air Quality

International Forum, Energy Foundation, Beijing, China. McKinsey and Company. (2009). Unlocking Energy Efficiency in the US Economy. Retrieved from http://www.mckinsey.com/ client_service/electric_power_and_natural_gas/latest_thinking/unlocking_energy_efficiency_in_the_us_economy

- Lazar, J., and Colburn, K. (2013). Recognizing the Full Value 3 of Energy Efficiency: What's Under the Feel-Good Frosting of the World's Most Valuable Layer Cake of Benefits. Montpelier, VT: The Regulatory Assistance Project. Retrieved from www. raponline.org/document/download/id/6739
- Although the term "energy efficiency" properly applies to 4 numerous forms of energy (e.g., electricity, natural gas, oil, propane, and gasoline), unless otherwise noted, references to EE in this paper refer to electrical EE.

track,⁵ it is impractical to try to link EE-related emissions reductions to specific electric generating units (EGUs). Two key issues impede regulatory acceptance of EE by air regulators: (1) how can EE-related emissions reductions be effectively quantified for air quality planning purposes, and (2) can the quantification process be made simple enough to encourage EE while maintaining the rigor and accountability necessary for air regulatory purposes.⁶

This paper suggests a new way of assessing EE programs that is analogous to the manner in which mobile and area source control measures are treated in State Implementation Plans (SIPs) under Section 110 of the Clean Air Act. States and EPA are very familiar with characterizing emissions from non-point sources like cars, trucks, and buses. Emissions reductions from these sources are quantified based on manufacturers' data, laboratory testing, field audits, vehicle registration data indicating the number purchased and in use, and other factors and assumptions. Similarly long experience in EE performance evaluation suggests that emissions reductions attributable to EE can be quantified in the same manner. In both cases, it's not the performance of an individual vehicle or EE device that is important to air quality, but the accumulation of thousands or millions of vehicles or devices in a given area. Having identified a close analogy between the nature of mobile sources and the nature of energy efficiency devices, this paper suggests that the quantification of emissions reductions from mobile source measures and EE measures should be treated analogously in air quality planning.

This paper also offers other quantification approaches that function similarly to the manner in which nonpoint sources are currently quantified and credited in air quality programs. These new approaches are intended to streamline the complex two-step quantification process for EE. They may provide less granularity than some EGU-based methods, particularly regarding locational and temporal aspects of EE, but are as equally robust as commonly accepted SIP-creditable quantification methods

- 5 Attributes of energy can be tracked. The New England Generation Information System (GIS), for example, tracks renewable energy attributes from production to use by a customer, allowing RPS compliance to be assessed. This is different from the impractical task of tracking electricity operationally from where it is produced to where it is consumed (or not consumed due to energy efficiency).
- 6 As used in this paper, "regulatory purposes" for criteria air pollutants means being able to incorporate into SIPs, and for GHGs means being able to incorporate into Clean Air Act

for mobile and area sources. While these new techniques remain in their infancy, they could be expeditiously refined with adequate attention and resources. Once developed and approved by EPA, these methods would make it far easier for air regulators to use EE to meet air quality planning goals and requirements.

Background

This section describes current practices concerning quantification of energy savings and emissions reductions attributable to EE. The reader may skip directly to detailed discussion of the mobile source analogy by going to page 4.

Measuring Energy Savings from EE

Energy efficiency programs are typically mandated by state policy, through specific legislative requirements and regulations, and through public utility commission (PUC) orders. Annual expenditures for electricity programs nationwide are over \$6 billion.^{7,8} Resources to fund these programs often come from "system benefit charges"small charges paid by all electricity consumers on a per-kilowatt-hour (kWh) basis. States' commitments to EE vary markedly, from 0.02 percent to over 2 percent of retail electricity sales per year.9 State energy offices, utility employees, or third parties act as EE program administrators, responsible for implementing and overseeing EE measures and programs and verifying the resulting energy savings. Program administrators typically use metrics such as kWh savings for electricity, and therms (British thermal units or BTUs) for natural gas.

As electricity moves from the power plant, where it is generated, through transmission lines to the local electrical distribution network and end user, electric energy losses occur. During periods of peak electricity demand, these "line losses" rise exponentially, from 6 to 7 percent

Section 111(d) state compliance plans.

- 7 Consortium for Energy Efficiency (CEE). (2014, March 24). 2013 State of the Efficiency Program Industry, p. 24. Retrieved from http://library.cee1.org/content/2013-state-efficiencyprogram-industry-report
- 8 American Council for an Energy Efficient Economy (ACEEE).
 (2014). The 2014 State Energy Efficiency Scorecard. Report No. U1408.
- 9 Ibid.



normally to as high as 20 percent.¹⁰ In the latter case, which might occur during a peak load hour, the generating output of five power plants would be needed in order to meet the electricity demand satisfied in an unstressed grid by that of four power plants. The emissions impacts of line losses during peak demand periods may be especially significant because older, higher-emitting EGUs are called into service during these times, and because peak electricity demand is typically driven by weather conditions (e.g., heat waves) that create greater health risks from air pollution. EE measures work right at the end user's site, so they require no transmission or distribution and thus avoid line losses.

In both utility-run and private EE programs, recovery of costs and payment for services provided is typically based on accurate quantification of the energy savings achieved. Accordingly, EE program administrators spend considerable effort and resources characterizing energy savings outcomes. As a result, thorough and credible best practices have evolved for evaluating, measuring, and verifying energy savings. These best practices can provide the information necessary for regulators to address the first step in quantifying EE-related emissions reductions for air quality purposes: how much energy is saved or avoided.

Measuring Emissions Reductions from EE

Air regulators focus on reducing public exposure to harmful air pollutants, which they accomplish primarily through requirements that reduce the amount of pollution emitted into the atmosphere.¹¹ The federal Clean Air Act mandates that states attain and maintain National Ambient Air Quality Standards as expeditiously as possible. Notwithstanding the public health progress made through traditional end-of-pipe air pollution controls over the last several decades, their limitations have become increasingly evident (e.g., parasitic energy loads or control technology incompatibilities). Air regulators have therefore started exploring EE and renewable energy (RE) options as ways to improve air quality. EE programs can reduce multiple pollutants (including greenhouse gas (GHG) emissions such as carbon dioxide (CO₂)) simultaneously, provide numerous additional benefits (e.g., water savings), and often represent least-cost solutions compared to other pollution control options.

Air regulators must be able to quantify avoided emissions associated with the energy savings created by EE measures in order to include them in air quality and climate plans. Emissions reductions associated with EE measures must be quantifiable, surplus, enforceable, and permanent to be approved in a SIP.¹² They must also be quantified using EPA-accepted methods; this ensures consistency and accountability across the country when EPA's regional offices review and approve state and local air quality plans. Requirements for state GHG emission reduction plans under Section 111 of the Clean Air Act are likely to be similar, but not identical, to those for SIPs; EPA is expected to finalize these requirements in mid-2015.¹³

Incorporating EE in air quality plans is consistent with the Clean Air Act and explicitly recognized in EPA guidance.¹⁴ In July 2012, EPA released its *Roadmap for Incorporating Energy Efficiency/Renewable Energy Policies and Programs into State and Tribal Implementation Plans*.¹⁵ This document supplemented earlier guidance on how states could account for EE and renewable energy programs in

- 10 Lazar, J., & Baldwin, X. (2011). Valuing the Contribution of Energy Efficiency to Avoided Marginal Line Losses and Reserve Requirements. Prepared for the Regulatory Assistance Project.
- 11 While most traditional air quality measures require specific controls on emitting sources, some programs—such as the vehicle inspection and maintenance program—provide requirements and incentives for maintaining sources so that emissions are avoided. This is similar to avoided emissions due to energy savings.
- 12 US Environmental Protection Agency (EPA), Office of Air Quality Planning and Standards. (2012, July). *Roadmap for Incorporating Energy Efficiency/Renewable Energy Policies and Programs into State and Tribal Implementation Plans*, Appendix F. Retrieved from http://epa.gov/airquality/eere/ pdfs/appendixF.pdf
- 13 James, C., and Colburn, K. (2015). It's Not a SIP: Opportunities and Implications for State 111(d) Compliance Plans. Montpelier, VT: The Regulatory Assistance Project. Retrieved from http:// www.raponline.org/document/download/id/7491
- 14 Ganley, S. & Welton, S. (September 2013). Legal Issues in Integrated Multi-pollutant Planning for Energy and Air Quality (IMPEAQ). Retrieved from https://web.law.columbia.edu/ sites/default/files/microsites/climate-change/files/Publications/ Collaborations-Visiting-Scholars/IMPEAQ%20Final_ Sept%202013.pdf
- 15 US EPA. (2012, July). Roadmap for Incorporating Energy Efficiency/Renewable Energy Policies and Programs into State and Tribal Implementation Plans. Retrieved from http://epa.gov/ airquality/eere/pdfs/EEREmanual.pdf



their SIPs.¹⁶ In addition to allowing some EE to be credited as innovative or emerging control measures,¹⁷ the Roadmap identified three related pathways: (1) incorporating EE measures as part of a SIP's baseline emissions forecast, (2) adopting EE measures in a manner similar to traditional air quality control requirements, and (3) including EE measures as part of a weight-of-evidence analysis. Although the Roadmap represents only a modest step forward in crediting EE-based emissions reductions in air quality plans, its issuance marked an important watershed for EE-air quality (EE-AQ) integration. Several states began exploring EE and RE as control strategies in partnership with EPA, the Northeast States for Coordinated Air Use Management (NESCAUM),¹⁸ and the Regulatory Assistance Project (RAP) as a prelude to future SIP work.

Air quality programs have always had a significant advantage over other environmental programs (such as water quality programs) with respect to metrics that identify and measure problems and improvements. When traditional stationary source control measures—such as selective catalytic reduction for nitrogen oxides (NO_x) emissions or flue gas desulfurization (i.e., "scrubbers") for sulfur dioxide (SO₂) emissions—are evaluated for SIP purposes, quantifying the tons of pollution removed is a straightforward exercise based upon the effectiveness of the control technology. Air regulators are assured of the emissions reductions achieved because the equipment is warranted to perform, and because continuous emissions monitoring systems (CEMS) reliably verify pollutant concentrations being emitted from the stack several times per minute. The accuracy of CEMS performance is ensured through quarterly and annual relative accuracy tests and audits.¹⁹ Given this experience, EPA and air regulators expect stationary source emissions metrics to have a relatively high level of accuracy, and it is understandable that they may carry similar expectations over to EE programs.

Due to the prescriptive requirements of the Clean Air Act, air regulators considering the use of EE measures in air quality and climate plans have raised questions about the location and timing of the measures' emissions reductions, even when the quantity of energy savings was accurately known. These concerns reflect key parameters regarding how precise the second step of the EE emissions quantification process—the translation of avoided energy into avoided emissions—must be for regulatory purposes. Too much rigor is likely to discourage the pursuit of EE as a compliance strategy; too little rigor may jeopardize confidence that emissions reductions will be achieved when and where needed. Observing how non-stationary source emissions are treated within SIPs may help in developing guidance and quantification methods for EE-related emissions reductions.

The Mobile Source Analogy

In 2013, three states conducted hypothetical exercises to secure SIP credit for EE measures, with the assistance of NESCAUM, EPA, and RAP, using the EPA's Roadmap. As part of that effort, they discussed the appropriateness of attributing energy savings and resulting emissions reductions to specific EGUs. They found that, while such an approach may be appropriate in some cases, it could only be achieved through a resource-intensive, comprehensive analysis based on sophisticated dispatch modeling. And even that would yield a modeled estimation rather than a measured outcome. The states suggested that an EGU-specific quantification approach should not be necessary when a state is considering multiple EE programs (i.e., a portfolio of measures), or when multiple states are jointly undertaking broader regional EE/RE programs. The states also recommended that EPA "adopt an approach for addressing the location of EE/RE program emissions reductions that is similar to how area and mobile source

- 16 US EPA. (2004, August 5). Guidance on SIP Credits for Emission Reductions from Electric-Sector Energy Efficiency and Renewable Energy Measures [Memorandum from Brian McLean to Steve Page]. Retrieved from http:// www.epa.gov/airquality/eere/ pdfs/ereseerem_gd.pdf
- 17 Whereby a state may assign up to 6 percent of the emissions reductions needed for a SIP to emerging and voluntary measures. See: US EPA, Office of Air and Radiation. (2004). *Incorporating Emerging and Voluntary Measures in a State Implementation Plan (SIP)*. Retrieved from http://www.epa.gov/ ttn/caaa/t1/memoranda/evm_ievm_g.pdf
- 18 Northeast States for Coordinated Air Use Management. (2013, December 31; revised 2014, May 2014). States' Perspectives on EPA's Roadmap to Incorporate Energy Efficiency/ Renewable Energy in NAAQS State Implementation Plans: Three Case Studies. Retrieved from http://www.nescaum.org/ initiatives/ee-re-in-sips
- 19 Note, however, that CEMS typically operate with an accuracy of plus or minus 10 to 15 percent. See US EPA. (n.d.). Overview: Accuracy, Precision, and Bias in Continuous Emissions Monitoring Systems. (undated EPA document, post 1993). Retrieved from http://www.epa.gov/airmarkets/emissions/docs/bias1.pdf



programs are treated within SIPs."²⁰ A framework for this approach, the "Mobile Source Analogy," follows.

The characteristics of regulated mobile and area sources

are quite similar to those of energy-using devices subject to EE improvements. Mobile and area source programs regulate thousands of small emissions sources (e.g., cars,

Table 1

Similarities Betwe	en Mobile Source and	d Energy Efficiend	v Programs
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Attribute	Commonality	Mobile Sources	Energy Efficiency
Source Characteristics	Sources are numerous, dispersed, and decentralized	Thousands or millions of vehicles operate in major metropolitan areas and statewide	Thousands or millions of light bulbs, appliances, and motors are installed in metropolitan areas and statewide
Program Characteristics	Programs may be concentrated or dispersed	Programs may be concentrated or dispersed (e.g., requirements for the entire vehicle fleet, corporate vehicle fleet requirements, or individual buyer choices)	Installations may be concentrated or dispersed (e.g., statewide building codes, multiple property or whole building retrofits, or single family home retrofits)
Program Benefits	Aggregation of improvements over numerous small sources can yield large emissions reductions	Improvements in vehicle operation (through lower evaporative, combustion, and tailpipe emissions) and fewer vehicle miles traveled result in reduced emissions	Reduced electricity demand on the grid results in less power production and reduced EGU emissions
Emissions Reductions Quantification	Algorithms are based on statistical sampling and performance data	Emissions reductions are determined using EPA-approved modeling and guidance, based on field-test data and state-specific inputs	Energy savings are determined by field tests for devices and aggregated using technical reference manuals (TRMs) and Evaluation, Measurement, and Verification (EM&V) protocols
			Emissions reductions can be derived from energy savings, given EPA-approved methods and guidance
Performance Assessment Data	Key variables include manufacturing parameters, vintage, persistence (the estimated lifetime of the units), and operating characteristics	Vehicle tailpipe and other field-testing occurs at approved laboratories (e.g., EPA Ann Arbor, California Air Resources Board, and South Coast); models and guidance are developed by EPA	Device-specific analytical and field-test data are provided by EPA- and state-approved sources (e.g., the Northwest Power & Conservation Council's Regional Technical Forum)
Compliance Assurance	Compliance is state- based (or shared within a regional, multi-state program)	State regulatory programs assure compliance	Routine, independent third-party EM&V and field audits assess installation rates, performance, and persistence against benchmarks from approved sources
Tools, Models, and Methods Used	Simplifying quantification to be workable requires readily available, approved (or readily approvable) tools	EPA-developed or approved mobile source models are used by federal, state, and local agencies for air quality planning purposes and assessing emissions benefits	For energy savings: best-practice EM&V utility planning models; Independent System Operator/ Regional Transmission Operator models For avoided emissions calculations: EPA calculators and tools; EPA-approved estimation protocols; ISO- New England's evaluation of marginal emissions rates
Limitations	Locational and temporal uncertainty is associated with sources and uses	Regulators don't know where, how, or how much each vehicle is driven or at what time of day	Regulators don't know where each device is installed, how it is used, or its precise hours of operation

20 Northeast States for Coordinated Air Use Management. (2013, March 27). Issues Arising from Case Studies Applying and Evaluating EPA's Roadmap to Incorporate Energy Efficiency/ *Renewable Energy in State Implementation Plans* [Memorandum from Leah Weiss to Julie Rosenberg, US EPA/OAP/CPPD].



lawn mowers, and gasoline cans) that are operated by individuals over widely varying times, places, and conditions. Similarly, EE programs typically install thousands of EE devices in any given area in any given year; each device has a very small effect on reducing generation at EGUs and is used under widely varied conditions.

In current practice, this similarity breaks down when it comes to the manner in which emissions reductions from mobile and area sources are treated versus those from energy efficiency. Well-established, EPA-approved protocols for SIP-creditable quantification for the former exist, whereas the latter faces arduous case-by-case assessments, limitations, or both. Figures 1 and 2 illustrate this difference graphically, showing current practice and the application of the mobile source analogy.

Table 1 lists numerous characteristics shared by mobile sources and energy efficiency. The breadth and depth of these characteristics substantiate the analogous nature of mobile sources and energy efficiency.

In air quality planning, emissions reductions calculation methods for mobile source controls (e.g., tailpipe emissions standards for cars, trucks, boats, and locomotives) and area source controls (such as volatility standards for paints and consumer products) appear much less accurate and precise than stationary source methods. This is due to the number and disparate nature of the individual sources, the variability in their operation, and the impracticability of expending resources to track and monitor each individual source.

Much like mobile and area sources, it is also impractical to directly quantify the emissions reductions attributable to site-specific EE measures.²¹ It is more appropriate to aggregate emissions reductions from numerous installed EE measures and apply a process similar to how EPA aggregates and quantifies emissions reductions from mobile or area source control measures. It is not critical to know, for example, whether any particular building has installed more efficient lighting. Although the energy-and moneysaved by a specific EE measure in a specific building certainly matters to its owner or occupant, the amount of emissions saved by that single installation is small (e.g., fractions of a pound per day). The sum of such installations across many measures in many buildings, however, can aggregate into avoided emissions of hundreds of tons of pollutants per year.

EPA and air regulators use assumptions, tests, projections, and statistics to quantify the emissions reductions of motor vehicle control measures. Energy efficiency measures should be afforded similar treatment. To assess mobile source programs for SIPs, EPA has developed guidance, methods, and models that incorporate manufacturer test data, laboratory-based performance testing, and assumptions about the extent of penetration and the nature of operation of vehicle emissions control technologies in the field. Air regulators may provide state-

specific inputs that include current and future fleet size and characteristics, travel variables (e.g., average distance and speed), modes of operation, meteorological factors, control technology characteristics, and regulatory program parameters. EPA determines percentages or quantities of emissions reductions achievable through each control measure. These calculated or modeled emissions reductions can be used by state regulators to select or configure specific control programs as they develop their state air quality plans. While issues have arisen over the years between state and local air regulators and EPA about the performance of these methods and models, there is general agreement that the overall approach for quantifying emissions from mobile sources is appropriate and acceptable for SIP purposes.

The concerns with EE quantification do not differ qualitatively from the uncertainties associated with emissions reductions from many mobile and area source measures, yet mobile source quantification methods are routinely and effectively employed in air quality planning. Air regulators are comfortable incorporating the expected impacts of more stringent fuel specifications and engine emission standards in SIPs, for example, even though they don't know precisely when, where, or how individual vehicles will be driven. Assumptions, commonly accepted values and formulas, and statistical methods are used to estimate the emissions reductions impacts of control measures for motor vehicles. EE measures can and should be afforded similar treatment by air regulators and EPA.

Mobile source emissions reductions are sometimes allocated spatially (through statistical means) for purposes of "hot spot" analyses and SIP attainment demonstrations, but there is no critical policy need for mobile source emissions reductions to be attributed to specific locations when quantifying their overall program benefits. A similar approach could be adopted and applied to EE programs. This approach, the Mobile Source Analogy, could help



²¹ For simplicity, this paper focuses on mobile source programs.

Driving Energy Efficiency: Applying a Mobile Source Analogy to Quantify Avoided Emissions



Figure 2

Illustration Applying the Mobile Source Analogy

Power plant emissions (a.) would still be measured for SIP credit, while EE (b.) and mobile source emissions (c.) would derive from statistical assessments.





overcome the initial tendency to try to tie EE-related emissions reductions to specific EGUs while maintaining adequate analytical rigor for SIPs and other air quality plans.²²

New Approaches for Quantifying Energy Efficiency in Air Quality Plans

Given the numerous benefits of integrating EE into air quality planning, air regulators, EPA, and the public interest would be well served by adopting simple, streamlined approaches to quantifying EE program emissions reductions that invoke the Mobile Source Analogy and do not endeavor to link EE energy savings and emissions reductions to specific EGUs.

To assess the emissions avoided through EE programs, air regulators should consider: (1) the energy saved per EE device, (2) the number of devices installed, (3) the persistence of the devices' energy savings over time (i.e., their performance and degradation over time), and (4) the "load shape" of the measure (i.e., how energy savings from the installed devices affect electrical demand or "load" over the course of a day). For example, air conditioning load generally coincides with peak electricity demand, so EE measures directed at heating, ventilation, and air conditioning (HVAC) can be quite valuable in reducing peak electricity demand. In contrast, lighting demand occurs mostly at night, typically affecting electricity demand after peak times. Refrigeration load occurs in a fairly consistent pattern throughout the day, so EE measures targeting improved refrigeration are more apt to reduce baseline electrical load or "baseload" demand.23 "Load shape" curves for EE measures are available, but they can be time-consuming for air regulators to locate and learn

how to assess.

As a component of—or complement to—the Mobile Source Analogy, it seems logical to consider additional quantification methods for EE that are similar to triedand-true methods routinely used by air regulators to quantify emissions reductions from stationary, area, and mobile source control measures. These approaches may help streamline and facilitate the incorporation of EE as a compliance option into state air quality plans. Three approaches are described below: deemed emissions reductions, emissions factors, and modeling.

Deemed Emissions Reductions

The costs of state-mandated EE programs implemented by utilities are usually recovered from ratepayers. Such arrangements are reviewed and approved by state PUCs. To ensure that ratepayers get their money's worth, PUCs often require that state EE programs conduct independent assessments, called evaluation, measurement, and verification (EM&V) assessments, to evaluate the energy savings that they achieve. Many states require EM&V assessments to be performed by third-party contractors who report directly to the PUC, and not the utility, to ensure unbiased, legitimate results. For several decades EM&V assessments have been conducted in nearly every state and municipality that has made significant ratepayerfunded investments in EE. The Consortium for Energy Efficiency has found that, on average, about 3 percent of electricity EE program budgets go to EM&V activities. Based on electricity EE spending of \$6.1 billion in 2012, annual expenditures for EM&V in the US may approach or exceed \$200 million.24

To reduce the overhead burden imposed by EM&V, energy regulators often approve the use of "deemed

- 22 The Mobile Source Analogy is a conceptual extension of accepted quantification practices from the mobile and area source sectors to EE measures. RAP recommends that the emissions performance of EE measures be quantified like mobile source programs, but not quantified as mobile source measures.
- 23 Two energy effects may be of interest to air regulators: rebound and spillover. Rebound relates to situations where consumers increase their energy consumption after installing EE devices, essentially "spending" some of the savings achieved by taking actions such as buying an additional appliance. Spillover refers to additional, unexpected energy savings that may occur, such as when a participant in an EE program becomes more aware of EE opportunities and purchases unrelated EE devices, or

when a neighbor of a participant becomes aware of an EE opportunity and echoes it. Another example is when consumers in areas not served by an EE program purchase EE devices, even though they are not eligible for the incentive. Rebound effects are typically minor. Spillover effects can be hard to document, but can result in additional energy savings (and emissions reductions). Both rebound and spillover have been concerns in mobile source programs; air regulators have been aware of these effects, but have rarely if ever characterized or accounted for them in SIPs.

24 Consortium for Energy Efficiency. (2014, March). 2013 State of the Efficiency Program Industry, pp. 24, 39. Retrieved from http://library.ceel.org/sites/default/files/library/11350/ CEE_2013_Annual_Industry_Report.pdf



energy savings" to quantify the energy savings provided by wellestablished EE measures with well-documented outcomes that don't vary significantly from project to project. Deemed energy savings values are based on prior experience, field data, and data from reliable, traceable, documented sources, using

"Deemed emissions reductions" is a logical extrapolation of the deemed energy savings approach. Where deemed energy savings pragmatically meet the needs of PUCs and utilities regarding cost recovery, deemed emissions reductions would meet the corresponding needs of air regulators.

approved formulas and statistical methods. Periodically, performance may continue to be verified through on-site visits or third-party audits. Energy regulators in several states have also developed technical reference manuals (TRMs) to provide values or formulas for estimating the energy savings provided by specific EE measures. TRMs usually identify thousands of discrete measures, listing the equipment manufacturer, model, purchase location (where applicable, such as for appliances), energy savings, and costs for each. Other important variables, such as water usage or water heating methods (e.g., electricity or natural gas) are also often provided. Utilities seeking cost recovery for EE programs that have deemed energy savings can simply multiply the number of devices installed by their deemed energy savings, thereby reducing burdensome EM&V expenditures.

"Deemed emissions reductions" is a logical extrapolation of the deemed energy savings approach. Where deemed energy savings pragmatically meet the needs of PUCs and utilities regarding cost recovery, deemed emissions reductions would meet the corresponding needs of air regulators. EPA should develop and standardize the deemed emissions reductions approach, just as PUCs have done for deemed energy savings, as a simple, low cost, effective quantification approach. Air quality regulators could then simply multiply the amount of energy savings produced by an EE program (in MWh) by a standard amount of emissions reductions corresponding to an avoided MWh of electricity in that state or region.

A deemed emissions reductions approach could streamline the emissions quantification process for EE, eliminating obstacles that otherwise threaten the use of EE as a cost-effective, multi-pollutant air quality compliance option. Air quality regulators would calculate the avoided emissions from existing and future EE programs based on standardized emissions-per-MWh factors determined by EPA to be appropriate to the generation mix serving the area. Before avoided emissions could be determined, the quantities of energy saved would be established through an approved EM&V or deemed energy savings process. For each EE device, a defined quantity of energy savings would be provided based on its characteristics, use, and bestpractice assessments or audits of

energy savings performance in the field. Energy savings data could also be grounded on past dispatch modeling and load shape studies to help assess when energy savings occur (e.g., peak or off-peak), and whether this timing would affect the amount of emissions reduced. Where load shape data are not yet available, reasonable estimates about the time differentiation of energy savings could be developed based on the types of EE measures built into an EE portfolio. The accuracy of available methods for time-differentiating energy savings is arguably comparable or in some cases better than the accuracy of similar methods for time differentiating mobile and area source control measures.²⁵

The Northeast Energy Efficiency Partnership and the Pacific Northwest Regional Technical Forum, among others, have established deemed energy savings for some EE measures. Tables 2 and 3 present examples of deemed energy savings and avoided emissions based on measure- or device-specific information from EE programs in Wisconsin and the Pacific Northwest, respectively. These are small but representative examples of the types of measures that EE program administrators are responsible for implementing and overseeing.

The sample data shown in Table 3 illustrate only one clothes washer model from one manufacturer. The energy savings would be slightly different for other models or manufacturers, and would vary if natural gas rather than electricity was used to heat the water. The difference between customer site savings and bus bar savings illustrates the impact of line losses. One MWh saved through EE translates into approximately 1.10 MWh of generation avoided because EE avoids generation of

²⁵ See Stern. F. (2013, April). The Uniform Methods Project, Chapter 10: Peak Demand and Time-Differentiated Energy Savings Cross-Cutting Protocols. Prepared by Navigant Consulting for the National Renewable Energy Laboratory (NREL). Retrieved from http://www1.eere.energy.gov/wip/ pdfs/53827-10.pdf



Table 2

Sample EE Energy Savings Quantification from Wisconsin²⁶

Measure	Deemed Annual Net Energy Savings (MWh)	Units Needed to Save 1 MWh per Year
CFL ²⁷ lighting— new construction	0.027	37.04
Mobile home duct sealing	1.080	0.93
SEER-15 ²⁸ air conditioner with electronically commutated motor	0.101	9.90

both the end-use MWh that was saved and the roughly 10 percent attributable to losses incurred in moving that electricity to the customer. As the table shows, it may be necessary to install several thousand efficient devices to remove one ton of pollution, but the expectation of selling and installing that quantity of devices in large metropolitan areas is realistic and commonly occurs.

The deemed emissions reductions approach is a critical starting point for quickly and easily quantifying the air quality benefits of EE measures on an individual or a portfolio basis. With proper assumptions, this approach can simplify the emissions reduction quantification process for air quality regulators while yielding appropriately conservative results that are supported by robust data.

- 26 Wisconsin Focus on Energy Program. (2010). *Program Evaluation Report*. Retrieved from https://focusonenergy.com/ sites/default/files/annualreport2010_evaluationreport.pdf
- 27 CFL stands for Compact Fluorescent Light.
- 28 SEER stands for Seasonal Energy Efficiency Ratio. A higher SEER-number rating means greater energy efficiency.
- 29 Pacific Northwest Regional Technical Forum. (2012). Workbook data for single-family home clothes washers. Retrieved from http://rtf.nwcouncil.org/measures/measure.asp?id=118. Derivation done 13 January 2015 (future revisions to this workbook may change the location of these data): At this website, click on the link to latest version under "Measure workbook" to download entire workbook (v 4.3). When the workbook opens, click on the "MeasureTable" tab. The example in Table 3 uses an Energy Star clothes washer with electric domestic water heating and a gas dryer (see row 9).

Table 3

EE Emissions Reduction Quantification Example from the Pacific Northwest Regional Technical Forum²⁹

Number of Units Needed to Reduce One Ton of Emissions

Clothes Washer Example	NO _X	SO ₂	CO ₂
Number needed to reduce emissions by 1 ton using customer site savings	38,339	55,031	43
Number needed to reduce emissions by 1 ton using bus bar savings	35,520	50,985	40

Emissions Factors (AP-42) Approach

Another way to help streamline the quantification of EE-related emissions reductions is for EPA to offer a standardized emissions calculation approach akin to its AP-42, Compilation of Air Pollutant Emission Factors (AP-42).³⁰ This method employs emissions factors that "facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (i.e., a population average)."³¹ This approach could offer graduated or partial credit, based on the rigor of the data used and the quantification protocols employed. It could

Deemed savings are 49 kWh/year per unit at the customer site, and 53 kWh/year per unit at the bus bar (see cells X9 and Y9 respectively). To convert energy savings to emissions reductions, EPA eGrid 2010 default regional emissions data for the Western Electric Coordinating Council (WECC) was used. Default emissions for WECC are 1.0642 lbs NO_X/ MWh, 0.7414 lbs SO₂/MWh, and 952.16 lbs CO₂/MWh. Units calculation for NO_X: at 49 kWh/year per unit savings at the customer site, 20.4 units are required to save 1 MWh/yr (1 MWh = 1000 kWh; 1000/49 = 20.4). At 20.4 units/MWh x 1 MWh/1.0642 lbs NO_X x 2000 lbs/ton = 38,339 units to reduce one ton of NO_x emissions.

- 30 US EPA. (1995). AP-42, *Compilation of Air Pollutant Emission Factors*. Retrieved from http://www.epa.gov/ttnchie1/ap42
- 31 Ibid.



also discount the amount of credit allowed where EM&V programs lack adequate rigor.

As noted above, TRMs based on robust EM&V programs can provide energy savings data for thousands of specific devices and appliances, thereby simplifying the quantification of EE savings. EE program administrators, utilities, and PUCs routinely use these manuals to design, implement, and audit EE programs. TRMs are used as the basis to measure the performance of installed energy saving devices (whether done by a utility, ESCO or third-party), and to inform decisions made by the PUC to allow recovery of costs, in full or in part, for their installation. TRMs are arguably analogous to EPA's AP-42 document; they provide "energy savings factors" much like AP-42 provides emissions factors. It seems logical to combine energy savings factors with emissions factors to calculate emissions reductions that air regulators could use in state air quality planning.

To implement an AP-42 emissions factors approach for quantifying EE programs, EPA could reference existing sources³² or develop its own list of EM&V methods and protocols (perhaps based on the work done by Northeast Energy Efficiency Partnership, the Pacific Northwest Regional Technical Forum, and others) that the Agency finds acceptable for assessing energy savings. EPA could similarly develop or reference acceptable protocols for calculating avoided emissions based on the energy saved. This would provide a suite of acceptable emissions factors and algorithms for different types of devices that could be supplemented by state-specific and program-specific data from air quality and utility regulators (e.g., number and type of EE devices installed or measures adopted, their generic locational and temporal characteristics concerning load, and the system mix of local generation sources). This methodology could make also use of the deemed energy savings and deemed emissions reductions approaches described above in developing emissions factors.

Modeling

Air regulators must often address air pollution problems over specific geographic areas (e.g., counties), particularly in circumstances where high ambient concentrations of criteria pollutants violate of one or more of the National Ambient Air Quality Standards. In these cases, the Clean Air Act requires that reductions occur within the nonattainment area,³³ so state air regulators may need to know where energy savings (and their accompanying emissions reductions) occur. Specifying a precise location is less of an issue with CO_2 emissions, as their climate impacts are global in nature. Moreover, EPA has proposed to regulate GHGs from EGUs under Section 111 of the Clean Air Act rather than the more prescriptive SIP process under Section 110.

When air regulators face location-specific criteria pollutant problems, both the location and timing of energy savings from EE programs may be important considerations. In such cases, EM&V professionals and air regulators could consider apportioning energy savings (and emissions reductions) among the geographic locations involved. A strong case can be made that the apportionment could be done with as much precision and confidence as occurs when quantifying the emissions impacts of geographically uncertain mobile and area source control measures.

Over the years, EPA has developed and refined airshed models that help air regulators assess possible improvements in ambient air quality under various control measure scenarios. Such models generally enable emissions—and emissions reductions—to be temporally and spatially allocated. The EPA has also developed companion models that estimate emissions from area and mobile source program scenarios, the output of which can be used as input into the airshed models. Mobile source models have allowed analyses to be conducted based on a broad range of variables such as vehicle miles traveled, vehicle hours traveled, fleet size and characteristics, modes of operation, meteorological factors, existing and future technologies, and regulations. The EPA's latest mobile model, Motor Vehicle Emission Simulator (MOVES), is designed for use in hot spot analyses, air quality conformity determinations, SIPs, and climate plans. Air regulators would be well served if EPA (with the assistance of the US Department of Energy (DOE), if necessary) developed a model similar to MOVES for assessing the emissions impacts of EE and RE programs, the results of which could also be input into airshed models.

- 32 For example, State and Local Energy Efficiency (SEE) Action Network, US Department of Energy's Uniform Methods Project, and state-of-the-art TRMs.
- 33 The Clean Air Act was adopted before the role of transported pollution was fully appreciated. It is now possible, through modeling, to establish with reasonable certainty the magnitude and location of emissions reductions outside a designated nonattainment area that may be necessary to improve air quality within that nonattainment area.



Experience among air regulators in using models to assess emissions avoided by EE is limited. Some knowledge is being gained through use of the Northeast version of the Market Allocation model (NE-MARKAL), which can calculate least-cost combinations of energy technology deployment. It characterizes electricity generation, transportation, and the industrial, residential and commercial building sectors to assess potential emissions reductions for pollutants such as NO_x, SO₂, and CO₂ in the Northeast over a 30-year time horizon.³⁴ The MARKAL model is widely used in Europe, and EPA's Office of Research and Development employs a nine-region national version of MARKAL called "US9r." To date, none of the states that have conducted NE-MARKAL analyses have submitted a SIP that includes NE-MARKAL emissions reduction estimates. While EPA has acknowledged NE-MARKAL as a currently available energy model,³⁵ it is unclear how EPA will consider its results for SIP crediting purposes.36

The EPA has released the Avoided Emissions and Generation Tool (AVERT)³⁷ to help quantify emissions reductions attributable to EE/RE. AVERT produces EGUspecific results that are more accurate than average emissions factors, and it could provide an essential first step in the agency's development of deemed emissions reductions for individual states or counties, the AP-42 approach described above, or a full-scale model for EE/RE analogous to the MOVES mobile source model.

Sophisticated dispatch models are used by electric utilities and transmission operators to manage and plan their system's operation and needs. These models are labor intensive, very expensive, and often proprietary because they project scenario results down to the level of individual EGUs. As such, they can also be used to assess avoided emissions under various EE/RE scenarios. These models are comparable to MOVES or other complex models for assessing emissions from mobile and area source control strategies. Their use as a primary planning tool for state air and utility regulators would be prohibitively expensive. Their results, however, could inform EPA's development of the emissions quantification methodologies discussed

34 More information on NE-MARKAL is available at http://www.nescaum.org/topics/ne-markal-model/ne-markal-model.

35 US EPA. (August 2013). Roadmap for Incorporating EE/ RE Policies and Programs into SIPs/TIPs - Frequently Asked Questions. Retrieved from http://epa.gov/airquality/eere/pdfs/ eerefaqAug2013.pdf above, and could provide the basis for developing a robust EE emissions reduction model.

Next Steps

EPA has endeavored to promote EE as an air quality strategy through its Roadmap and accompanying resources, but much more effort is needed to make genuine integration of EE and air quality a reality. More streamlined tools, in the form of statistically-based, vetted, and approved quantification methods, are needed, along with clear guidance and policies about the acceptable use of these tools. Guidance based on the Mobile Source Analogy would help explain how and why EE emissions reductions for most SIP and climate planning purposes need not be explicitly linked to specific EGUs. Guidance that introduces new quantification methods—such as those proposed above—for states to develop acceptable EE-based emissions reductions estimates would also be useful.

If energy efficiency is to be fully recognized and valued as a strategy to mitigate air pollution and comply with air quality regulations, then EPA and DOE should also conduct or augment existing statistical sampling, testing, and analysis of EE in order to develop standardized emissions reductions performance algorithms. These algorithms would enable states to readily apply deemed emissions reductions in their air quality planning efforts. Embarking on such work would do much to enhance EE-AQ integration by rendering the quantification of EE-based emissions reductions far more simple and effective. In partnership with DOE, EPA should also explore promoting an emissions factors approach, launching regional EE emissions reduction pilot projects with the US9r model, and assessing the viability of a MOVES-like model for assessing EE programs for air quality planning purposes.

Efforts outside of EPA and DOE to develop estimation methods could also be enlisted in developing more streamlined EE emissions reductions quantification tools. For example, ISO-New England and the states it serves have developed marginal emissions rate estimation methods that use actual dispatch records to identify which EGU(s)

- 36 While the Clean Air Act requires air quality modeling for SIP attainment demonstrations, it is silent on the use of energy models.
- 37 US EPA, State and Local Climate and Energy Program. *AVoided Emissions and GeneRation Tool (AVERT)*. Retrieved from http://www.epa.gov/avert/



set the clearing price for each 5-minute period. It then develops a marginal emissions rate based on the emissions rate(s) of those EGU(s).³⁸ Other examples include the NE-MARKAL and US9r modeling noted above, and the Energy Systems Laboratory at Texas A&M University, which has assessed avoided emissions from EE and renewable energy programs in the ERCOT³⁹ region using statistical methods.⁴⁰ Additionally, Energy Strategies LLC's work with the state of Utah and PacifiCorp to assess the emissions reductions benefits of EE/RE through dispatch modeling also offers useful underpinnings for developing generalized tools to incorporate EE-based emissions reductions in air quality planning.

Conclusion

Integrating EE-based emissions reductions into air quality planning can be daunting, but several states and regions have taken constructive steps to do so. They have found such efforts useful for addressing multipollutant challenges (such as ozone, particulate matter, and climate planning) simultaneously, and they appreciate the economic and non-energy benefits this cost-effective approach can provide.

Resources for similarly interested states are slowly emerging. EPA has created some resources to help states that wish to pursue EE in their air quality planning, including its Roadmap, the AVERT model, and other guidance and resource documents on some quantification techniques.⁴¹ A variety of avoided emissions estimation tools that have been developed by respected power sector and academic experts are also available.⁴² In addition, RAP's publication *Quantifying the Air Quality Impacts of Energy Efficiency Policies and Programs* describes state EM&V programs and provides details on how air regulators can assess the air quality benefits of EE programs.⁴³

At bottom, dispersed energy efficiency is sufficiently like dispersed mobile sources that mobile source methods to determine emissions reductions can also be applied to make the most of energy efficiency as an air quality strategy. EE-based emissions reductions can be readily and reliably quantified, but must be made sufficiently simple and efficient for air regulators to routinely and consistently apply them in state air quality planning processes. The methodologies discussed in this paper should be explored and developed by EPA toward that end. EPA's proposed Clean Power Plan under Section 111(d) of the Clean Air Act offers a special window of opportunity due to the uncommon regulatory flexibility it provides. Through quantification approaches sanctioned by EPA and adopted by states in compliance with Section 111(d), EE measures can establish their efficacy as cost-effective, enforceable, multi-pollutant emissions reductions strategies that provide numerous important societal co-benefits. Given its costeffectiveness and breadth and depth of opportunity, EE has vast potential to become a primary air quality control strategy. America will benefit by making it so.

- 38 For a complete description of the methodology, see ISO New England. (2014). 2013 ISO New England Electric Generator Air Emissions Report. Retrieved from http://www.iso-ne.com/ static-assets/documents/2014/12/2013_emissions_report_ final.pdf
- 39 ERCOT (Electric Reliability Council of Texas) is one of three grid interconnections in the North American Electric Reliability Corporation (NERC) region.
- 40 See, for example, Haberl, J. (August 2012). Quantification of Energy and Emissions Saved in Energy Efficiency/Renewable Energy (EE/RE) Programs in Texas. Retrieved from http:// esl.tamu.edu/docs/publications/presentations/ESL-TR-12-04-01(2).pdf
- 41 US EPA. (2012, July). Incorporating Energy Efficiency/Renewable Energy in State and Tribal Implementation Plans: Quantification. Retrieved from http://www.epa.gov/airquality/eere/quantify. html
- 42 A chapter on methods for estimating avoided emissions in the State and Local Energy Efficiency Action (SEE Action) Energy Efficiency Program Impact Evaluation Guide (2012) is a good example. See: http://www1.eere.energy.gov/ seeaction/pdfs/emv_ee_program_impact_guide.pdf
- Shenot, J. (2013, August). *Quantifying the Air Quality Impacts of Energy Efficiency Policies and Programs*. Montpelier, VT: The Regulatory Assistance Project. Retrieved from www. raponline.org/document/download/id/6680



Related RAP Publications

Calculating Avoided Emissions Should be a Standard Part of EM&V and Potential Studies

http://www.raponline.org/document/download/id/7270

Thanks in large part to some recent guidance and proposed federal regulations by the U.S. Environmental Protection Agency (EPA), state and local air pollution regulators have a growing interest in using energy efficiency (EE) as a strategy to improve air quality. The largest challenge for air pollution regulators is to quantify the impacts of EE in a way that is suitable for regulatory purposes. To measure the air quality impacts of EE, one has to begin with an assessment of energy savings. However, assessing the timing and location of energy savings is also critically important for estimating avoided emissions. EE professionals are better suited to this task of quantifying current or potential future avoided emissions than the air pollution regulators themselves. This paper explains the enormous hurdles that air pollution regulators face in this area, and why the methods are more suitable for use by EE professionals. This paper also suggests how EE professionals might collaborate with air pollution regulators to better understand the data needed for regulatory purposes, and modify their standard practices accordingly. Further, it explains how EE professionals and the other audiences they serve (utilities, public utility commissions, and consumer advocates) will all benefit from a greater emphasis on the air quality benefits of EE. Finally, encouraging examples where these ideas are already being put into practice are discussed briefly.

It's Not a SIP: Opportunities and Implications for State 111(d) Compliance Plans

http://www.raponline.org/document/download/id/7491

EPAs proposed Clean Power Plan, under Section 111(d) of the Clean Air Act, affords flexibility to states as they craft their compliance plans. But 111(d) is different from Section 110, the section of the Act with which states are most familiar. To help manage risk and create certainty, RAP clarifies the key differences between 111(d) compliance plans and the air-quality State Implementation Plans (SIPs) developed under Section 110. The paper also suggests actions states can take now and notes that 111(d) plans are a unique opportunity for states to innovate.

Quantifying the Air Quality Impacts of Energy Efficiency Policies and Programs

http://www.raponline.org/document/download/id/6680

In recent years, more and more regulators view energy efficiency as a viable air quality improvement strategy. While no regulator should expect to solve all air quality challenges through one strategy alone, efficiency has distinct advantages over pollution control methods. This report is premised on the belief that regulators should employ energy efficiency as a first step toward air quality improvement rather than as a last resort. The report provides an introduction for air quality regulators to the rationale and opportunities for using energy efficiency as an air quality improvement strategy, identifies useful data sources, and outlines four basic steps for quantifying the air quality impacts of energy efficiency policies and programs. In addition, the paper explores opportunities to work with energy agencies to communicate air regulators' energy efficiency data priorities, including ways to improve the data.

Recognizing the Full Value of Energy Efficiency

http://www.raponline.org/document/download/id/6739

Energy efficiency provides numerous benefits to utilities, to participants (including rate payers), and to society as a whole. However, many of these benefits are frequently undervalued or not valued at all when energy efficiency measures are assessed. This paper seeks to comprehensively identify, characterize, and provide guidance regarding the quantification of the benefits provided by energy efficiency investments that save electricity. It focuses on the benefits of electric energy efficiency, but many of the same concepts are equally applicable to demand response, renewable energy, and water conservation measures. Similarly, they may also apply to efficiency investments associated with natural gas, fuel oil, or other end-user fuels. This report is meant to provide a comprehensive guide to consideration and valuation (where possible) of energy efficiency benefits. It provides a realworld example that has accounted for many, but not all, of the energy efficiency benefits analyzed herein. We also provide a list of recommendations for regulators to consider when evaluating energy efficiency programs.





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