United States Environmental Protection Agency

Roadmap for Incorporating Energy Efficiency/Renewable Energy Policies and Programs into State and Tribal Implementation Plans

Appendix I: Methods for Quantifying Energy Efficiency and Renewable Energy Emission Reductions

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By:
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Outreach and Information Division
Research Triangle Park, North Carolina

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SECTION I.1: PURPOSE

The purpose of this appendix is to help jurisdictions determine the best emissions quantification approach when accounting for energy efficiency/renewable energy (EE/RE) policies and programs in state implementation plans/tribal implementation plans (SIPs/TIPs). This appendix starts with an overview of the important factors to consider prior to quantifying emission of EE/RE policies and programs. Then, the emission quantification process is described with links to resources, tools and key information to help state, tribal and local agencies select an appropriate emissions quantification approach. After reviewing this appendix, jurisdictions should understand the methods and options for quantifying EE/RE policies and programs in their SIP/TIP.

SECTION I.2: GETTING STARTED: IMPORTANT FACTORS

Important factors to consider before quantifying emissions of EE/RE policies and programs include:

- Availability of staff, budgetary resources, and energy data;
- Energy data availability and air agency's relationship with state, tribal and local energy experts;
- Potential magnitude of emission reductions for the electric generating unit (EGU) sector associated with EE/RE policies and programs; and
- Whether to engage in multi-jurisdictional collaboration.

Understanding these factors upfront will aid the decision making process for how to account for emission reductions in a SIP/TIP.

Availability of Staff and Budgetary Resources

Understanding the range and capability of the emission quantification approaches will help a jurisdiction judge the level of resources needed to address analytical questions on the emissions impact of EE/RE policies and programs. It is possible to estimate the emission impacts of EE/RE policies and programs with low staff resources. Basic approaches are easy to employ and are often useful in justifying more effort if there is a significant emission reduction potential. Methods that are more sophisticated could mean increased staff time, air-energy trainings and monetary resources devoted to paying for fees associated with proprietary energy models. Reviewing the existing tools and resources that complement each emission quantification approach described in this appendix is a good first step to determining the level of effort needed to quantify the emission impacts of EE/RE policies and programs

Energy Data Availability and Relationship between Air and Energy Agencies

A significant piece of information necessary for quantifying the emissions impact of EE/RE policies and programs is data on energy impacts from state energy offices, utility commissions, or other data sources. The strength of relationship between a state's air agency and its energy agencies may influence whether the appropriate type of data is available for a SIP/TIP emissions analysis. For example, some approaches will require hourly energy impacts information, while others only need annual or season energy impact information. It is possible that, even in cases where relationships between air and energy agencies are strong, the types of data needed for specific emissions analysis may not be available at the level of detail compatible with the desired emissions quantification approach. In these cases, air agencies may need to rearrange the data to use it with a specific approach or choose the emissions quantification approach that is compatible with the available energy impacts information. Reviewing this appendix will help determine what energy impacts information will be needed depending upon the state, tribal or local air agency's policy objectives and analytical questions.

Potential Magnitude of Emission Reductions

One of the most important objectives in understanding the potential magnitude of emission reductions of EE/RE policies and programs is comparing the potential emission reductions for a particular pollutant resulting from an EE/RE policy or program to existing emissions for that pollutant:

1) From the EGU sector in the state,
2) From all sources in that state, and
3) In a nonattainment area for which the SIP/TIP is intended.

This comparative analysis will help illuminate how large an impact the EE/RE policies and program may potentially have in an area relative to other contributors. Generally, state, tribal and local air agencies inventory emissions on an annual basis to review the emission reduction potential of different control strategies. However, EE/RE policies affect EGUs that operate marginally at shorter time scales. Therefore, a typical annual emissions profile of the EGU sector will not be completely indicative of the emission reduction potential of EE/RE policies and programs within a jurisdiction. Some emissions quantification approaches provided in this appendix, such as the capacity factor and hourly emissions approaches, can be used at the same time as the emissions inventory development process to help determine the emission reduction potential of EE/RE policies and programs over shorter time periods without expending large resources.

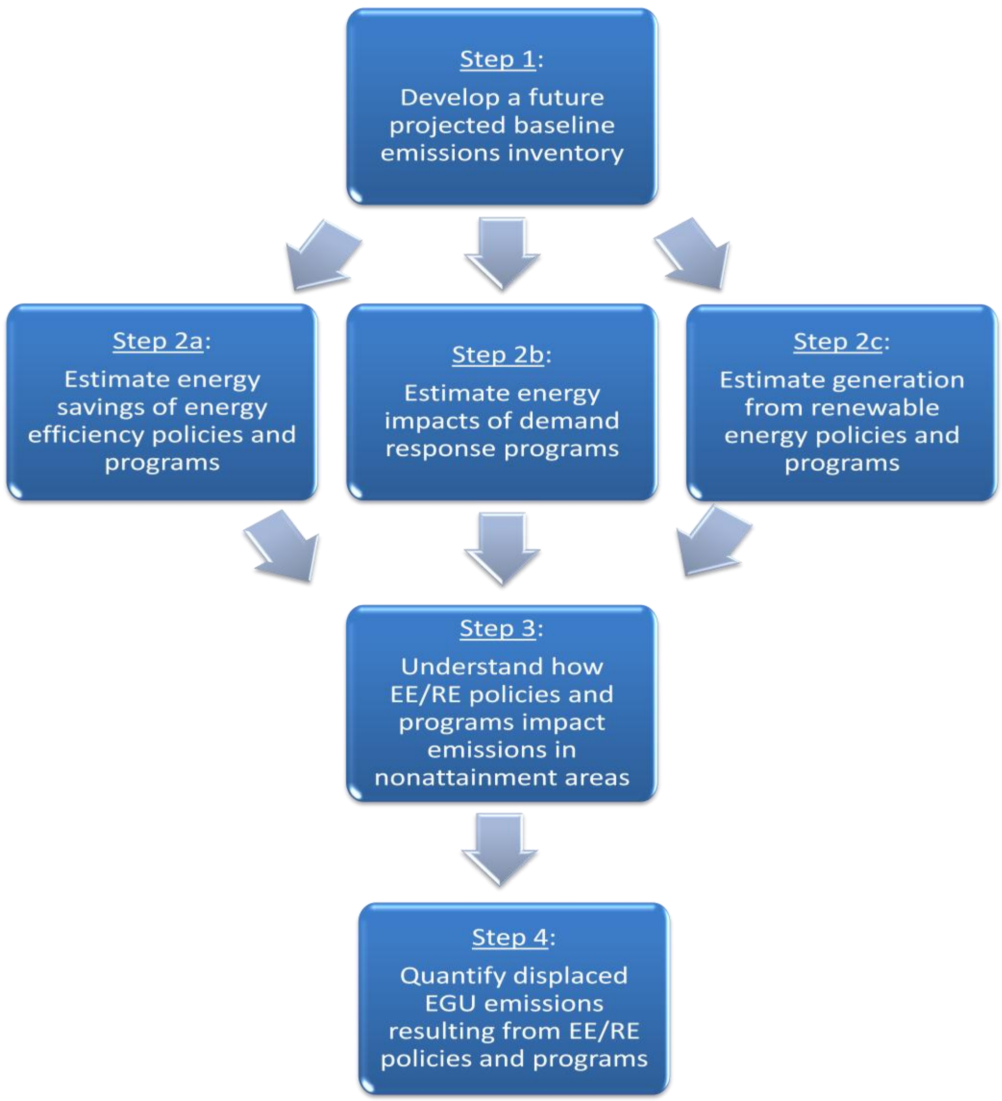
Multi-Jurisdictional Collaboration

Since power plants are interconnected through the larger electric power system, to fully understand the emissions impact of an EE/RE policy, it is often important to consider collaborating with neighboring states to develop joint EGU analyses. Understanding the goals and intentions of neighboring state, tribal and local air agencies could be an important factor in deciding the most appropriate emissions quantification approach. For example, a highly resource intensive approach for one state may make sense if multiple states are contributing resources. Including collective EE/RE policy goals may also increase the emissions reduction potential within the region. In many cases, a collective quantification effort would enhance efficiencies in costs and would better capture cross state benefits in the air quality planning process.

SECTION I.3: STEPS FOR QUANTIFYING EMISSIONS OF ENERGY EFFICIENCY AND RENEWABLE ENERGY POLICIES AND PROGRAMS

There are four general steps state, tribal and local agencies should consider when quantifying emission reductions of new EE/RE policies and programs (see Figure 1). (If all of the EE/RE policies and programs sought for inclusion in the SIP/TIP process are included in baseline emission projections, then steps 2,3 and 4 are not needed.)

Figure 1: Steps for Quantifying Emissions of Energy Efficiency and Renewable Energy Policies and Programs



Step 1: Develop a Future Projected Baseline Emissions Inventory

As a part of the SIP/TIP process, a jurisdiction must prepare an emissions inventory that documents the emissions in a selected base year for the EGUs within the area of analysis (e.g., state-level or multi-state level emission inventories). The information necessary to develop an emission inventory for the EGU sector includes electricity generation data, and emission factors to convert estimates of energy use into emissions or measured reports from continuous emissions monitoring (CEMS) equipment. For both SIPs/TIPs and developing a future projected baseline emission inventory, a bottom-up emissions inventory is the most appropriate and involves collecting activity data, emissions profiles and pollution control device information for each EGU in the state, tribal area, locality, or region. Developing a future projected baseline emissions inventory provides a comprehensive assessment of emissions and details regarding spatial and temporal attributes that are required for air quality modeling. (See Figure 2 for resources on emissions inventory development.)

Emissions relevant to SIPs/TIPs include all six criteria air pollutants, including precursors to ozone (nitrogen oxides (NO_x) and volatile organic compounds (VOC)), as well as carbon monoxide (CO), sulfur dioxide (SO_2), lead (Pb), and coarse and fine particulate matter (PM).

Figure 2: Resources for Emissions Inventory Development

Emissions Collection and Monitoring Plan System (ECMPS)

- The EPA system for reporting of emissions data, monitoring plans, and certification data.
- It replaces the *Emission Tracking System* that previously served as a repository of SO_2, NO_x, and cabon dioxide (CO_2) emissions data from the utility industry.
- The EPA collects data annually in five-minute, hourly, daily, monthly and annual intervals from continuous emissions monitors at all large U.S. power plants.
- Available at: http://camddataandmaps.epa.gov/gdm/

Emissions & Generation Resource Integrated Database (eGRID)

- This free, publicly available software from EPA has data on annual SO_2, NO_x, and CO_2, and mercury (Hg) emissions for most power plants in the United States.
- It also provides annual average non-base load emission rates, which may better characterize the emissions of load-following resources.
- Available at: http://www.epa.gov/egrid

A baseline emissions projection forecasts what emissions will occur in the future, in the absence of additional policies. This baseline projection is a reference case that includes “on the books” EE/RE policies or programs, against which the impacts of new policies and programs are measured. When state, tribal or local agencies take into account certain EE/RE policies and programs in developing a baseline emissions projection, then such activities are considered already included in the SIP/TIP, as part of the SIP/TIP baseline pathway, and additional emission reductions cannot be granted through another SIP/TIP pathway. Only those policies and programs not included in the future baseline may be included in the subsequent steps. In other words, if a state, tribal or local agency incorporates the EE/RE policies and programs in the SIP baseline emissions projections, then any emission reductions from those EE/RE policies and programs are already counted and cannot be "double counted" in other parts of the SIP/TIP. (Refer to Figure 3 for resources for emissions projections and Appendix E for more information on the SIP/TIP baseline emission projections pathway.)

State, tribal and local agencies can project future emissions based on historic trends and expectations about the impact of numerous factors, including projections of population growth and migration, economic growth, fuel availability and prices, and technological progress. Some of these factors will rely on data about electricity imports and exports, power plant construction or retirement, transmission constraints and environmental regulations.

Figure 3: Resource for Emissions Projections

EPA *Emissions Inventory Improvement Program Technical Report Series, Volume X: Emissions Projections*.

- This is guidance that provides information and procedures to state and local agencies for projecting future air pollution emissions for the point, area, and mobile source sectors.
- It describes data sources and tools states can use for emissions projections.
- Available at: http://www.epa.gov/ttn/chief/eiip/techreport/volume10/x01.pdf

The underlying assumptions for the baseline emissions projection include an electricity demand forecast. The forecast documents the historical, current, and projected pattern of energy demand in the state or region, as well as how future generation projections will meet forecasted demand.

Step 2a: Estimate the Energy Savings of Energy Efficiency and Combined Heat and Power Policies and Programs

Energy Efficiency

The purpose of this step is to determine the energy savings from the specific EE policy/program, which can then be used to estimate any associated emission reductions from the power sector.[1] Energy savings refer to the expected reduction in energy demand that are the result of a specific EE policy and/or program. For SIP/TIP purposes, energy savings can be a reduction in the base year energy demand, and/or a reduction in the projection of future energy demand. The impacts of EE policies or programs are typically measured in kilowatt-hours (kwh) or gigawatt-hours (GWhs) and are generally reported on an annual basis, but some EE programs may be available in smaller time intervals, such as a seasonal or hourly scale.

A general approach for determining the amount of energy saved for EE policies and programs, although each EE policy and/or program will have individual factors to be considered. The general approach is:

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[1] Estimated savings from EE policies and programs can be calculated in many different ways. State energy regulators typically have methods for estimating energy savings in your jurisdiction. Methods may vary in precision and rigor. Energy regulators can provide the estimates of the energy savings in your jurisdiction from the EE policies and programs they oversee.

- Step A: Determine the baseline energy usage subject to the EE policy and/or program.[2]
- Step B: Determine the projected energy use after implementation of the EE policy and/or program.
- Step C: Subtract the result of Step A from the result from Step B. The result yields the projected energy savings due to the EE policy and/or program.

For later verification purposes, state, tribal and local agencies may need to collect and compare the evaluated (e.g., ex-post)[3] estimate of energy savings to initial forecast impacts. This added step can result in more accurate estimates of energy savings and associated emission reductions. The appropriate level of energy savings verification depends primarily on the SIP pathway selected. Other factors to consider are the magnitude of projected energy impact and the nature and type of efficiency program under consideration (for more information, consult the appendices on each SIP pathway).

Combined Heat and Power

Combined heat and power (CHP) is an efficient method of providing energy services (electricity and thermal energy, including cooling) to the end user. Instead of purchasing electricity from the grid and simultaneously burning fuel in an on-site boiler or furnace to produce needed thermal energy, an industrial or commercial user can use a CHP plant on site to provide both services in one energy efficient step. CHP's inherent efficiency and the elimination of demand for electricity from the power system with associated transmission and distribution losses can provide significant energy savings and lower emissions that can be accounted for in a SIP/TIP. Calculating the net energy savings from CHP requires estimating the expected reduction in the amount of electricity generated by an existing utility system as a result of the specific CHP policy and/or program and subtracting from that the incremental fuel used by CHP systems over and above the existing boilers and/or furnaces that were replaced. The resultant savings can reduce current energy demand, future demand, or both. The purpose of this step is to determine the energy saving impacts of a specific CHP policy/program.

For determining the amount of energy saved for CHP policies and programs, although each policy and/or program will have individual factors to be taken into account, the general approach is as follows:

- Step A: Determine the baseline forecast of energy use for the activity subject to the CHP policy and/or program.
- Step B: Determine the projected energy use after implementation of the CHP policy and/or program. The projected energy use must reflect:
    - The reduction in energy use at the utility power plant due to the reduction in demand caused by the generation of power on-site.

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[2] EPA (2010c), Chapter 2.

[3] Evaluations of ratepayer funded energy-efficiency programs – sometimes referred to as evaluation, measurement, and verification (EM&V) – provide retrospective estimates of energy savings. They are typically conducted on an annual basis by state Public Utility Commissions (PUCs). It is important to note that energy-efficiency forecast data – not ex-post EM&V data – are used to calculate avoided-emissions for SIP purposes.

- The incremental increase in fuel use at the industrial or commercial facilities that the CHP system uses over and above the boilers and/or furnaces that CHP replaced.

- Step C: Subtract the result of Step A from the result from Step B. The result yields the projected energy savings due to the CHP policy and/or program.

For later verification purposes, state, tribal and local agencies may need to collect and compare the evaluated (e.g., ex-post) estimate of energy and fuel savings to initial forecast impacts. This added step can result in more accurate estimates of energy and fuel savings as well as associated emission reductions. The appropriate level of verification depends primarily on the SIP pathway selected. Other factors to consider are the magnitude of projected energy impact and the nature and type of CHP program under consideration. (See the SIP Pathway appendices for more information.)

Operational and performance data for CHP technologies are also important factors in this analysis. This information is available from the EPA Combined Heat and Power Partnership,[4] National Renewable Energy Laboratory (NREL), the Department of Energy's (DOE) eight Regional Clean Energy Application Centers[5] and universities and other energy associations that promote or conduct research on the applications of CHP.

Sources of Information for Energy Efficiency and Combined Heat and Power Policies and Programs

Energy experts within a jurisdiction can help state, tribal and local air agencies understand current and future policy opportunities, as well as obtain estimates of the kilowatt-hour (KWh) impacts (projected and historical) from the EE/CHP policy/program of interest. The EPA recommends starting with the public utility commission staff and energy offices. These agencies are typically responsible for the evaluation, measurement and verification (EM&V) of EE programs, and the tracking of RE generation. If jurisdictions need further information, the Energy Information Administration (EIA) and electric grid operators can also be good sources. For example, a large utility that controls the dispatch of resources within the area of analysis could be an electric grid operator and could provide electricity demand and supply forecasts. If a state, tribal or local jurisdiction is located within a regional transmission organization (RTO) or an independent system operator (ISO), these entities can also be helpful resources. These organizations can help develop the energy impacts information or serve as a resource for assistance in developing

Sources of Information on Energy Impacts of EE/CHP Policies

- State Public Utility Commissions
- State or Local Energy Offices
- Energy Information Administration
- Electric Grid Operators
- Regional Transmission Organizations
- Independent Service Organizations
- Utilities

[4] For more information, go to: http://www.epa.gov/chp/.

[5] For more information, go to: http://www1.eere.energy.gov/industry/distributedenergy/racs.html.

the energy savings or generation estimates for particular EE/CHP policies or programs. Refer to Appendix B, for more information on the roles and responsibilities of these organizations.

When gathering information from energy organizations in a state or region, air agencies will want to ask specific questions about the policy or program design characteristics. .[6] The questions below are intended to help air agencies ask questions up front to avoid confusion and ensure the energy savings information is provided in the proper SIP/TIP context.

- *Program period:* What year does the policy/program producing the energy savings start and end?
- *Anticipated compliance or penetration rate:* How many utilities will achieve the target or standard called for? How many consumers will invest in new EE/CHP equipment based on the initiative? How will this rate change over the time period?
- *Compliance assurances:* Are there compliance penalties, monetary incentives or other assurances included in the policy or program design?
- *Annual degradation factor:* How quickly will the performance of the EE measure installed become less efficient?
- *Transmission and distribution loss (T&D):* Is there an increase or decrease in T&D losses that would require adjustment of the energy savings estimate?
- *Past Performance:* What is the success rate of existing or past EE/RE policies and programs?
- *Evaluation, Measurement and Verification (EM&V):* Which programs have EM&V procedures in place, and how will energy savings be measured and verified over time?

Step 2b: Estimate the Energy Impacts of Demand Response Policies and Programs

"Demand response" is a broad term encompassing a range of programs designed to reduce electricity demand during peak periods of electricity use. Demand response initiatives range from programs that provide customer incentives for voluntary or mandatory load curtailment based on contractual arrangements, to dynamic pricing structures that charge higher rates for energy consumed during peak periods.

Demand response policies and programs can effectively reduce emissions during "high electric demand days."[7] For example, hot summer days are conducive to ground-level ozone formation, and air conditioning loads on such days are often major contributors to electricity demand spikes. At the same time, some EGUs called "peaking units" only operate during periods of peak demand when the electric grid requires maximum generating capacity, and could be high-emitting sources. Peaking units may lack NO_x controls because they have low

[6] EPA (2010c), p. 42.

[7] On the hot, hazy days of summer, higher demand for electricity can result in a dramatic increase in ozone-forming air pollution. These are called "high electric demand days" or HEDD.

emissions on a seasonal basis, even if hourly emissions are high during periods when they are in use.

Since demand response programs target peak demand hours, air agencies will want to collect hourly energy savings data, during peak hours, to translate the energy savings from these programs into emission reductions. Demand response programs may not always provide emission reduction benefits. For instance, some demand response programs relieve demand from the electric grid by replacing that generation with back-up generators that emit emissions. (e.g., diesel generators) To properly account for the emission impact of demand response programs in a SIP/TIP, emission calculations should account for the net emissions (e.g., emission reductions from the electricity grid and any emission increases from back-up generation).

To avoid a net emissions increase that can result from the use of emissions-intensive sources of backup power generation, state, tribal and local agencies should combine demand response efforts that focus on passive approaches, such as cycling down equipment to curtail electricity demand, with efforts to promote clean backup power that can be an effective strategy for achieving this objective. Some program administrators have addressed this issue by including requirements for the types of load reductions that are eligible for demand response incentives.

Step 2c: Estimate the Renewable Energy Generated from Policies

This step determines how much energy would be displaced by the RE policy and/or program, including less polluting sources of new energy, such as cogeneration and fuel cells. In general, for renewable sources, state, tribal and local agencies will need data showing the total amount of energy provided to the grid by the RE source. Keep in mind, for later verification purposes, data on the amount of renewable energy generated may need to be collected and compared to original estimates.

Operational and performance data for renewable technologies are also important factors in this analysis. This information is available from National Renewable Energy Lab (NREL), as well as universities and other RE associations that promote or conduct research on the applications of RE. In addition, generation-related data and RE potential information can be obtained from many sources, including:

- State energy offices
- Utility Integrated Resource Planning filings
- Public utility commissions
- ISOs
- North American Electric Reliability Corporation (NERC)
- EPA’s Emissions & Generation Resource Integrated Database (eGRID) [8]
- DOE’s EIA
- DOE’s NREL

[8] For more information, go to: www.epa.gov/egrid.

Important Considerations

The jurisdiction's analysis of RE policy and program impacts needs to account for how various RE resources generate energy at different times of the day and year. For example, wind power facilities may be unable to provide energy during high ozone episodes due to stagnation conditions, as compared to solar power facilities. Land-based wind energy facilities have to be sited in locations where winds speeds are sufficiently strong to produce power on as many days as possible, which can be in locations outside of the urban corridor where air quality tends to be the poorest. Nevertheless, these remote RE facilities may affect emissions levels at fossil-fired EGUs that are positioned upwind of jurisdictions with poor air quality. Any air-quality analysis of RE policy impacts should account for these emissions impacts. Off-shore wind generation – which may be closer to coastal load centers and areas of poor air quality – should likewise be analyzed to determine how generation and emissions from surrounding EGUs are affected, including the magnitude of such impacts.

Step 3: Understand How EE/RE Policies and Programs Impact Emissions in a Nonattainment Area

Air quality planners need to determine the displaced emissions attributable to each applicable EGU in order to understand how those emission reductions will improve the air quality in the nonattainment area.[9] Emission reductions cannot be assigned to the nonattainment area based on where the EE/RE policy is implemented. Rather, a jurisdiction should assign emission reductions based on where the displacement of electrical generation will likely occur. All emission quantification approaches described below, except for the eGRID non-baseload emissions rate approach, can allocate emission reductions to an individual EGU or power plant. To determine if an EE/RE policy affects a nonattainment area, air agencies should (1) estimate which EGUs and EE/RE policy or program will likely affect generation and (2) use the emission rates at those EGUs.

For example, if the nonattainment area imports a significant amount of electricity from locations outside and downwind of the area, reduced demand from EE could result in less electricity being imported, rather than reduced production (and consequently reduced emissions) within the nonattainment area, or in areas affecting its air quality. Conversely, if the energy savings reduce emissions at upwind sources, then the measure may produce some air quality benefits to the area. (For more details, see the section below on determining the geographical area where emissions occur.)

After state, tribal and local agencies quantify the emission reductions of EE/RE policies/program, as described in step four of this appendix, the state should use the appropriate air quality model to evaluate the extent to which reductions will improve air quality

[9] The current policy with respect to taking credit for emission reductions outside nonattainment areas for purposes of Reasonable Further Progress in ozone SIPs is as follows: RFP credit can be taken for VOC and NO_x emission reductions within 100 kilometers (km) and 200 km, respectively, outside the nonattainment area under certain circumstances. This policy is currently under reconsideration. See "Reasonable Further Progress Requirements for the 1997 8-Hour Ozone National Ambient Air Quality," 75 Federal Register 80420-80425, 80421, http://www.gpo.gov/fdsys/pkg/FR-2010-12-22/pdf/2010-32139.pdf,.

in the nonattainment area from the selected EE/RE policy and/or program. The EPA has separate modeling guidance documents to help state, tribal and local agencies choose the best air quality model for SIPs/TIPs.[10]

Determining the Geographic Boundary of Emissions Analysis

Determining the appropriate geographical boundaries for an emissions quantification analysis requires an understanding of the electric power grid relative to the nonattainment area and EE/RE policy of interest. (Refer to Appendix B for more information on the electric grid.) A state, tribal or local agency will need to choose the most appropriate boundary for their analysis based on key factors:

- Whether adjacent states are analyzing EE/RE policies within the same NERC region[11]
- The location of the area in which the EE and/or RE policy is being implemented
- Whether there are any transmission constraints where the EE/RE policy is being implemented
- How energy is transferred within the state and across state boundaries

Determining the location of the emission reductions that occur at fossil fuel fired generation units is challenging because electricity from numerous generators is fed into an electrical grid from which many different consumers at various locations will draw power. There typically is no direct connection between a specific facility generating electricity and the end user of that electricity. Understanding how the electric grid operates within a jurisdiction is the first important step in making an approximation as to which units would be affected by a certain EE/RE policy and program.

In areas of the country where several states in close proximity to one another implement EE and/or RE policies and programs, it may be advantageous for these states to work together in conjunction with their electric grid operation, ISO/RTO and EPA regional office to identify the overall impact of the EE/RE policy and programs on the electrical grid in the future. Ideally, such a process will yield a technically valid solution that attributes the emission reductions from decreased reliance on fossil fuel fired EGUs in an equitable manner between the states, and also ensures that double counting of emission reductions does not occur.

The EPA understands that conducting this type of analysis may be beyond the means of the jurisdictions that implement these EE/RE policies and programs. Accordingly, EPA encourages any state, tribal and local agencies that need assistance with this to contact the relevant EPA regional office for assistance.

Steps to Analyze Energy Efficiency/Renewable Energy Policy and Program Impacts

Determining the location of the fossil fuel fired units that can operate less as EE or RE becomes available can be a complex task, particularly when the efficiency or renewable resources are located outside the nonattainment area that seeks to use the emissions reduction from that

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[10] For more information, go to: http://www.epa.gov/ttn/scram/aqmindex.htm.
[11] For more information, go to: http://www.eia.gov/cneaf/electricity/page/prim2/figure7.html.

reduced generation for SIP/TIP purposes. The following three steps can be used to analyze EE/RE policies and programs:

- Step 1: Review historical analysis to determine the location of the fossil fuel fired EGUs that could reduce their output as EE or RE resources were made available. This information should already exist at the balancing authority or reliability organization such as an, ISO or RTO that oversees the electrical grid for the area or the utility that is complying with the EE or RE policy.
- Step 2: Understand how the grid has responded in the past as efficiency or renewable resources have come on-line in order to develop planning assumptions for how the grid will respond in the future.
- Step 3: Obtain and review the results from existing dispatch modeling conducted by the grid operator of the balancing authority, ISO or RTO. The grid operators have the most pressing need to accurately determine the impact that EE or RE resources will have on the future operation of the electrical network.

The next section will describe four different emission quantification approaches that state, tribal and local agencies can consider.

Step 4: Choose an Approach to Quantify Avoided or Displaced Electric Generating Unit Emissions

State, tribal and local agencies will need to choose the most appropriate emission quantification approach based on the agency's policy objectives. Each approach answers different analytical questions, has varying levels of rigor, assumptions, resource requirements, data needs, and varied temporal and spatial scales of emission outputs. They all are intended to quantify the avoided or displaced emissions from fossil fuel generation as a result of EE/RE policy/program implementation.[12]

The level of sophistication of each emission quantification approach is inversely related to the degree of uncertainty inherent in each approach. Basic approaches apply simple assumptions and tend to have a higher degree of imprecision compared to more sophisticated approaches. Figure 4 shows how the level of sophistication of those approaches increases as you go from straightforward emissions calculations to complex modeling.

Basic approaches, such as eGRID emission rates, are generally more appropriate for preliminary screening analyses or to be used for analyzing the incorporating of emission reductions in specific SIP/TIP pathways, such as the weight of evidence (WOE) or emerging/voluntary measures SIP pathway (Refer to Appendix H for the WOE pathway and Appendix G for the emerging/voluntary measures pathway). More sophisticated approaches, such as energy modeling can simulate how the system of EGUs will change generation and emissions given specific assumed conditions and capture multiple assumptions for multiple factors such as:

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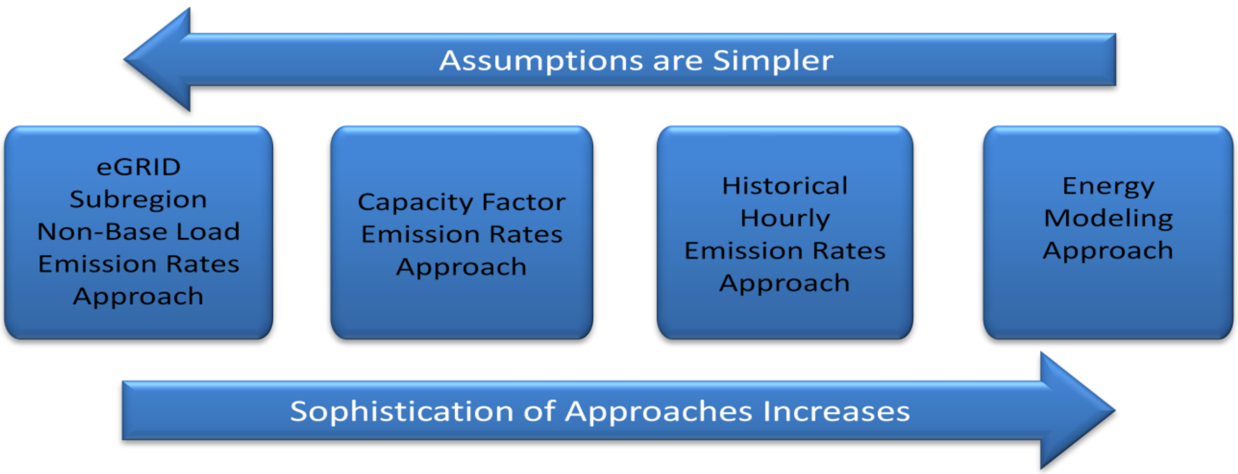
[12] Lifecycle emissions are not addressed in this appendix and do not apply to quantifying emissions for SIP/TIP purposes.

electricity imports, exports, fuel prices, unit availability, and technology performance. (Refer to Appendix B for more information on how the electric grid operates) Therefore, more sophisticated approaches are most appropriate for quantifying emissions for the baseline emissions projection and control strategy pathways. (Refer to Appendix E for information on the baseline emissions projection pathway and Appendix F for information on the control strategy pathway.)

Figure 4: Emissions Quantification Approaches



Four Emission Quantification Approaches

This section explains four emission quantification approaches, including how each approach works, when to use it, the advantages and limitations, available tools to support each, and an emission quantification example[13]. The approaches are:

- Basic approach: eGRID sub region "non-base load" emission rates
- Basic approach: capacity factor emission rates
- Midrange approach: historical hourly emission rates
- Sophisticated approach: energy models

Agencies will have different policy objectives and associated analytical questions associated with incorporating EE/RE policies and programs in their SIPs/TIPs. Some of the policy objectives and analytical questions state, tribal and local agencies may want to address can be satisfied by one or more of the quantification approaches. Table 1 provides analytical questions commonly asked during the SIP/TIP process and the corresponding emissions quantification approach.

[13] Emission quantification examples are currently under development. For more information on specific SIP/TIP examples, go to Appendix K.

Table 1: How to Choose an Emissions Quantification Approach

Analytical Questions	Emission Quantification Approaches	Energy Data Needs	Emissions Outputs	Pathways
• What is the relative magnitude of SO_2 or NOx emission reductions of an EE/RE policy or program in my jurisdiction?	eGRID region non-baseload emission rates approach	Annual or season energy impacts (megawatt hours (MWh))	eGRID regional average non-base load emissions	WOE
• Which EGUs in my state are on the margin and how much will emissions be displaced on a seasonal or annual basis?	Capacity factor emission rates approach	Annual or seasonal energy impacts (MWh)	EGU emissions of marginal units on an ozone season or annual basis	WOE, Emerging/ Voluntary Measures, or Control Strategy Pathways
• How can I quantify hourly emission reductions? • How much are emissions reduced during peak electricity demand?	Historical hourly emission rates approach	Hourly energy impacts, peak and/or base load effects (MW or MWh)	Quantify EGU hourly emission rates and hourly emission reductions	Baseline, WOE, or Control Strategy Pathways
• How will EGU emissions change in future years? • How can I compare baseline emissions forecasts and emissions of new EE/RE policies? • How can I simulate emission changes of EE/RE policies when also subject to cap and trade program(s)?	Energy models approach	Hourly, seasonal or annual energy impacts depending upon model capabilities (MW or MWh)	Average emissions based on dispatch order, hourly emissions or seasonal emissions	WOE, Emerging/ Voluntary Measures, or Control Strategy Pathways

Basic Approach: eGRID Sub region "Non-Base Load" Emission Rates

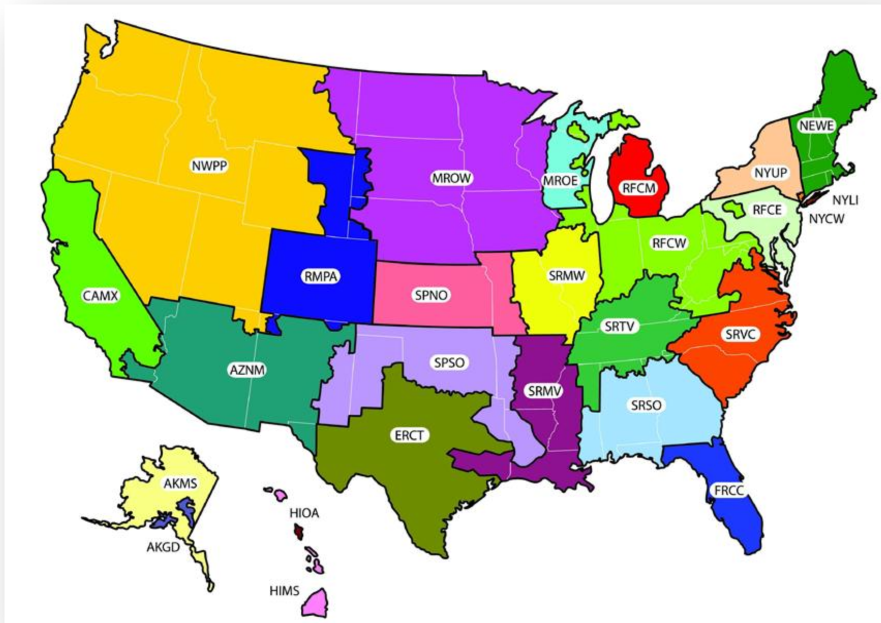
This approach entails a simple calculation. An agency would multiply the amount of generation or electricity consumption displaced by the EE/RE policy/program by the "non-base load" emission rate indicated for a specific pollutant in an eGRID subregion. The non-base load emission rate for an eGRID subregion represents an average emission rate for the EGUs that are likely to be displaced by an EE/RE policy and program.

What is eGRID?

The EPA's eGRID is a data source that provides information on the environmental characteristics of almost all electric power generated in the U.S. The eGRID includes operational data such as total annual emissions, emission rates, generation, resource mix, capacity factors, and heat input.[14]

The eGRID includes emissions of GHGs , NO_x, and SO_2, and Hg. The eGRID emissions data are associated with the generation of electricity, not with the consumption of electricity; therefore, the values do not account for transmission and distribution losses, imports and exports across eGRID subregions (or any other geographic area), transmission constraints within any geographic area, or life cycle emissions at EGUs (e.g., emissions from the extraction, processing, and transportation of fuels).

Figure 5: eGRID2010 Subregion Representational Map



Source: http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2010V1_1_year07_SummaryTables.pdf>

The eGRID subregions are identified and defined by EPA, using the NERC regions and power control areas as a guide. An eGRID subregion is often, but not always, equivalent to an Integrated Planning Model (IPM)[15] sub region. The 26 eGRID subregions in eGRID2010 are subsets of the NERC regions as shown in Figure 5.

When to use the eGRID approach

The EPA recommends that state, tribal and local agencies use this approach as a method for estimating potential emission reductions for the WOE SIP pathway. Alternatively, the approach can be used as a preliminary, screening analysis before carrying out a more sophisticated analysis that could be used under another SIP/TIP pathway submission or to justify a more sophisticated analysis under the WOE pathway.

[14] For more information, go to: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

[15] The IPM is a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. It provides forecasts of least cost capacity expansion, electricity dispatch, and emission control strategies while meeting energy demand and environmental, transmission, dispatch, and reliability constraints.

Jurisdictions can estimate the emissions reduction potential for SO_2 emissions, ozone season or annual NO_x emissions in their region by applying eGRID subregion emission factors to the EE/RE policy energy impacts. This method requires minimal resources, simple assumptions, and provides a rough estimate of average emissions at a regional scale. This approach is most appropriate when EGUs within the eGRID subregion contribute to air quality in the nonattainment area, either by being in or upwind to the nonattainment area.)

How does this approach work?

State, tribal and local agencies can use the eGRID subregion non-base load output emission rates to estimate emission reductions of EE/RE policies and programs that reduce consumption of grid-supplied electricity. In particular, eGRID will help planners figure out the non-baseload output emission rates. This type of rate is useful to understand because it is associated with emissions from the EGUs most likely to be displaced when EE/RE policies and programs are implemented. These emissions data are derived from plant level data and are aggregated up to the eGRID subregion level.[16]

This basic eGRID method entails a simple calculation where a jurisdiction would multiply the amount of generation or electricity sales displaced by the EE/RE policy/program by the "non-base load" emission rate indicated for a specific pollutant in an eGRID subregion.[17] The non-base load emission rate for an eGRID subregion represents an average emission rate for the EGUs that are likely to be displaced by an EE/RE policy and program. This method is recommended to help state, tribal and local agencies estimate the relative magnitude of emission impacts from a potential EE/RE policy or program by using the equation in Figure 6.

Figure 6: Emissions Quantification using an eGRID Approach

Non-base load emission rate (lb/MWh)
x
(1/1-grid loss factor)
x
Reduced consumption or supply in energy of EE policy and program (MWh)
x
(2,000lbs/1 short ton conversion for criteria pollutants)
=
Tons of emissions reduced from EE/RE policy and program

What are the advantages and limitations of the eGRID approach?

Advantages:

- Easy "back of the envelope" calculation
- Non-baseload output emission rates gives a basic understanding of how much EGU emissions could likely be avoided or displaced

[16] EPA (2010a).

[17] Grid loss factors should be included in this calculation. EPA (2010c).

- eGRID data is derived from reported data submitted to EPA and the Energy Information Administration

Limitations:

- Future looking EGU capacity is not represented
  - Some EGUs in base year may have already or will shut down in future years.
- The eGRID approach does not show which EGUs could have its emissions displaced
- Information is from 2007 and is generally on a three year time lag
- The eGRID only accounts for generation within a specific area and does not include information about imports/exports of electricity (except for state level net imports)
  - Approach assumes EE/RE policies will affect all non-baseload plants proportionally to each plant's non-base load generation.

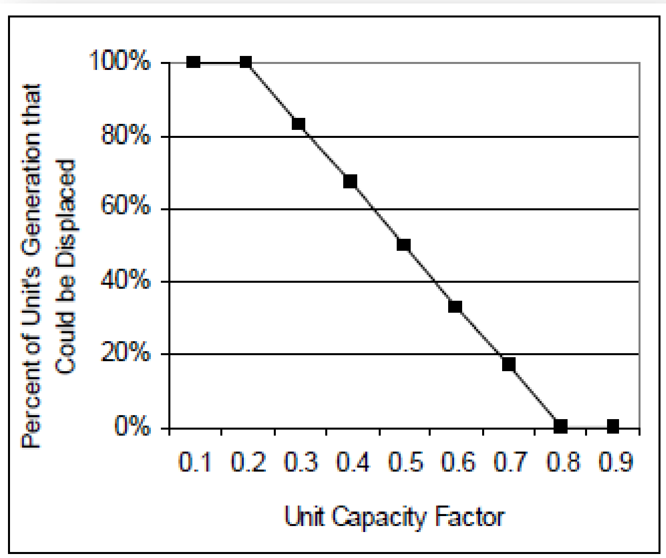
What tools and resources are available for this approach?

The eGRID contains information in several formats, including spreadsheets, and summary tables in Portable Document Format (PDF) format.[18]

Basic Approach: Capacity Factor Emission Rates

This approach is based on the assumption that a power plant's capacity factor is an indicator for the amount of generation subject to displacement. This approach makes general assumptions based on the capacity factor of a power plant to show, which power plants may reduce generation with additional EE/RE policies or programs. Capacity factor information can be found n the eGRID or a state, tribal or local agency can use their own capacity factors from other sources. This approach does not account for the complex nature of the electrical grid such as electricity imports, exports, and transmission constraints.

Figure 7: Sample Curve for Relating Displacement to Capacity Factors



Source: http://www.synapse-energy.com/Downloads/SynapseReport.2005-07.PQA-EPA.Displaced-Emissions-Renewables-and-Efficiency-EPA.04-55.pdf

What is a capacity factor?

A power plant's capacity factor is a ratio in a given period of time: "the actual electricity produced by a generating unit" to "the electricity that could have been produced at continuous full-power operation."[19]

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[18] For more information on eGRID, go to: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

[19] For more information, go to: http://www.eia.doe.gov/electricity/page/prim2/charts.html.

The capacity factor of a power plant can be used as a proxy for how likely the power plant is to be displaced by an EE/RE policy or program. Figure 7 shows an example of a displacement curve, or a “rule of thumb,” that relates the likelihood that a power plant or unit’s output would be displaced to its capacity factor. Baseload plants, such as nuclear units or large coal-fired plants, have capacity factors close to 1, so they are represented on the lower right hand side of Figure 7. The capacity factor approach assumes that these plants will displace zero percent of their generation from the addition of EE/RE policies and programs. As a power plant’s capacity factor gets closer to zero, the likelihood that a plant will displace generation increases. For example, the capacity factor approach assumes that peak load plants with low capacity factors, such as combustion turbines are represented on the upper left hand side of Figure 7, and therefore, are much more likely to be displaced.

<u>When to use the capacity factor approach</u>

State, tribal and local agencies could use a capacity factor approach to incorporate EE/RE policies and programs in their SIP/TIP as a control measure, as long as future generation characteristics, exports, and imports are included in the analysis. The approach could also be used in an analysis of the benefits of EE/RE policies and programs in support of a WOE demonstration or voluntary/emerging measure pathway. This approach is most appropriate to answer the questions such as:

- What is the relative dispatch order of the power plants within a state or region?
- Which power plants are on the margin and what are the emission rates of those plants?

Estimating the emission impacts of energy efficiency policies or policies or solar policies or programs that generally affect non-baseload power plants more so than baseload power plants would be the appropriate type of EE/RE policy or program to apply for this approach (e.g., using this approach for specific RE technologies, such as on-shore wind, that displace baseload EGUs would not produce satisfactory results).

<u>How does this approach work?</u>

This approach is based on the assumption that a power plant’s capacity factor is an indicator for the amount of generation and emissions subject to displacement by an EE/RE policy/program. This approach makes general assumptions about power plant generation and displacement based on an power plant’s historical annual or seasonal generation. By using a general rule of thumb shown in Figure 7, the impacts of EE/RE policies and programs are allocated to each power plant’s or unit’s annual or seasonal emission rate.

For example, the approach assumes that power plants with low capacity factors (operating at equal to or less than 20 percent of capacity) are most likely to be displaced by the EE/RE policy/program and power plants with high capacity factors (operating at equal to or greater than 80 percent of maximum capacity) would not be displaced by the EE/RE policy/program. The power plants with capacity factors between 20-80 percent are displaceable using a linear relationship shown in Figure 7.

Seasonal Variation Considerations
While the annual capacity factors described above are helpful in determining which power plants are likely to displace generation by EE/RE programs/policies, EPA recommends using seasonable capacity factors when possible for summer-time ozone because annual capacity factors ignore seasonal weather variations. For example, many combustion turbines only operate during summer daytime hours in a typical year. Using an annual capacity factor would incorrectly allocate displaced emissions to these units during seasons when they are not operating. If you are assessing the impact of EE/RE programs on ground-level ozone, the EPA's eGRID has ozone season capacity factors available for this type of analysis.

Table 2 illustrates how an example could work in practice for an efficiency program projected to save 1,000 MWhs pear year. There are seven generating units in this hypothetical power system, labeled A through G in the first column. The second column shows the percentage of each unit's production that could be displaced by the efficiency program, based on the rule of thumb from Figure 7. The third column shows each unit's actual generation in the historical year being used. The fourth column shows the amount of energy that could be displaced at each unit, which is the second column multiplied by the first column. The fifth column shows the percentage of the saved energy that is allocated to each unit. This is done by dividing the displaceable energy for each unit by the total available displaced energy (e.g., Unit A's displaced energy is 50,000 MWhs, which is 6.5 percent of the total 768,100 MWhs displaceable energy) and the sixth column shows the MWhs displaced at each generating unit (column five multiplied by 1,000 MWhs). The final step would be to multiply the MWhs displaced in Column 6 with the appropriate emission rates for each unit.

Table 2: Allocating Displaced Energy Using the Capacity Factor Approach

Unit (1)	Percentage Displaceable (2)	Historical Generation (MWh) (3)	MWhs Displaceable (4)	Percentage of Energy Saved Allocated to Unit (5)	MWhs Displaced (6)
A	100%	50,000	50,000	6.5%	65
B	82%	65,000	53,000	6.9%	69
C	79%	120,000	94,800	12%	123
D	48%	500,000	240,000	31%	312
E	22%	1,500,000	330,000	43%	430
F	0%	1,800,000	0	0%	0
G	0%	2,000,000	0	0%	0
Totals		**6.035,000**	**768,100**	**100%**	**1,000**

Source: http://www.synapse-energy.com/Downloads/SynapseReport.2005-07.PQA-EPA.Displaced-Emissions-Renewables-and-Efficiency-EPA.04-55.pdf

<u>What are the advantages and limitations of this approach?</u>
Advantages:

- Emissions can be assigned to each power plant or generating unit
- Relatively easy calculation if infrastructure is set up

- Simple way to get a relative sense of the marginal unit in area of analysis

Limitations:

- This is a simplified approach assuming power plants are operating the same throughout the year or ozone season
- Emissions estimates are approximate, based on annual or seasonal capacity factors
    - Does not account for maintenance and outages
- Imported and exported power is not considered
- Assumes power plant generation characteristics are the same in the base year and future year.
- Assumes a general rule of thumb where all energy savings or generation affect all peaking units first, which is not always true with some EE programs or RE technologies (e.g., street lighting programs, wind power)

What tools and resources are available for this approach?

The EPA is providing a Capacity Factor Emissions Calculator (CFEC) for state, tribal and local agencies to use for this approach. The CFEC uses eGRID annual and ozone season capacity factors for the power plants represented in this database. Jurisdictions can follow the instructions in this appendix and the CFEC when using this emission quantification approach.[20]

Midrange Approach: Historical Hourly Emission Rates

This approach requires technical manipulation of data about historical generation, including load and emission rates to determine EGU dispatch order and marginal emissions rates. By applying this approach, state, tribal and local agencies will understand where EGUs lie within the dispatch order for each hour, day, and month of a historical year. Depending upon where geographical boundaries are set, this approach may not account for electricity imports, exports, and transmission constraints. And understanding these things will be useful in quantifying emissions in a SIP/TIP because the electricity grid is a large interconnected system that crosses nonattainment area and state boundaries. For example, if an EGU in a nonattainment area is exporting it's generation outside of the nonattainment area, then EE/RE policies implemented within the nonattainment area will have little effect on the EGU's emissions.

The EPA has information state, tribal and local agencies can use for this approach. The EPA collects generation, emissions and heat input data in hourly intervals from CEMS for all large EGUs subject to EPA's trading programs.[21] State, tribal and local agencies can use reported hourly generation and emissions data for each EGU to derive hourly emission rates for one hour or group of hours. For example, 2 p.m. to 6 p.m. in the Electric Reliability Council of Texas (ERCOT) NERC region[22] is a typical group of hours that represents times of peak demand.

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[20] Capacity factors are located in the eGRID excel file called: eGRID2010V1_1_year07_PLANT.xls. EPA (2010b).

[21] For more information, go to: http://camddataandmaps.epa.gov/gdm/index.cfm?fuseaction=emissions.prepackaged_select

[22] The Electric Reliability Council of Texas manages the flow of electricity in Texas. For more information, go to: http://www.ercot.com/about/.

Taking into account the emission rates from the EGUs that typically operate during these hours would represent the potential emission reduction during peak hours within ERCOT.

When to use historical hourly emission rate approach

By applying this approach state, tribal and local agencies will understand (for every hour or segment of hours of an historical year) which EGUs are base load (operating all hours of the day), which EGUs are load following (EGUs that ramp up or down depending upon demand), and which EGUs are peaking units (EGUs that only operate at high demand periods). This approach is most appropriate to answer the questions such as:

- How much emissions are reduced in blocks of hours, or during periods of peak electricity demand?
- How much emissions are reduced for demand response policies or programs?

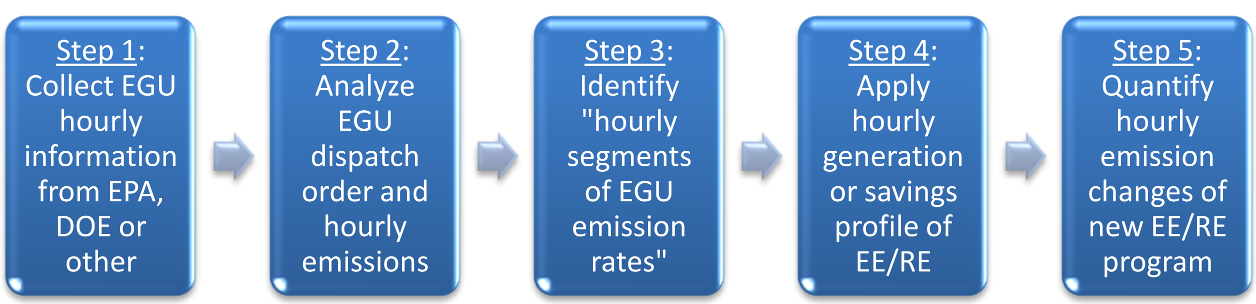
Agencies can use an historical hourly emissions rate approach to incorporate EE/RE policies and programs in their SIP/TIP as a control measure, as long as future generation characteristics, exports, and imports are included in the analysis. The approach could also be used in an analysis of the benefits of EE/RE policies and programs in support of a WOE demonstration or baseline analysis.

How does this approach work?

The state, tribal or local agency first needs to evaluate how the EE/RE policy reduces load or displaces generation in the area of analysis. Most importantly, the agency needs to identify if the EE/RE policy impacts peak hours and/or base load energy use. From this, air quality planners will be able to determine which EGUs within the dispatch order will be affected by the policies.

It is possible for multiple EE/RE policies/programs to affect both the base load and peak hours of a day. In that case, the agency should add the programs "bottom up" to obtain an aggregate level of energy savings and generation on an hourly basis and then apply their impacts to the

Figure 8: Steps for Historical Hourly Emissions Rate Approach



predicted displaced EGUs.[23] Refer to Figure 8 for steps associated with this approach.

[23] Synapse (2005).

What are the advantages and limitations to the approach?

Advantages:

- Reported data is easy to find on EPA's website on an hourly, daily, and quarterly basis
- EGU emission rates from any group of hours can be derived from the hourly data
- Emission impacts of different RE technologies can be compared against other RE technologies (e.g., wind vs. solar) and EE policies and programs

Limitations:

- Setting up hourly emissions database can be resource intensive if infrastructure is not in place
- Future EGU capacity changes are not represented.
- Only EGUs subject to EPA's national reporting requirements are represented in EPA's hourly EGU database[24]
- Energy import and export exchanges and transmission constraints are not captured

What tools and resources are available?

The EPA has available hourly emissions and generation data.[25] EGUs greater than 25 megawatts (MW) must report hourly emissions data to EPA on quarterly basis to comply with EPA's National Acid Rain Program.[26]

The Mid-Atlantic Regional Air Management Association (MARAMA) completed an hourly emissions analysis of the states in the Northeast and Mid-Atlantic region.[27] The purpose of the analyses was to assist states in the Northeast and mid-Atlantic regions with addressing policy relevant questions concerning emissions during periods of peak electricity demand.

The Washington Council of Governments used a time-matched marginal emissions approach that matches certain EE or RE technologies or measures with historical hourly emissions information from the EPA hourly database. The emissions tool is applicable for the Virginia/Maryland/ Washington, DC area.[28]

[24] For more information, go to: http://www.epa.gov/airmarkets/.
[25] For more information, go to: http://www.epa.gov/airmarkets/.
[26] For more information on the hourly emissions and generation information, go to: http://camddataandmaps.epa.gov/gdm/index.cfm?fuseaction=iss.progressresults
[27] For more information, go to: http://www.marama.org/RegionalEmissionsInventory/2007hourlypoint/FinalDoc_mar2011_Analysis_of_Hrly_CAMD_Emissions_Data.pdf.
[28] For more information, go to: http://www.mwcog.org/environment/air/EERE/default.asp.

Sophisticated Approach: Energy Models

This approach employs dynamic simulation models that forecast which EGUs will be displaced in the future based on inputs and assumptions in the model. Energy models can produce emissions output information at various levels and account for the complex interactions of the grid such as, transmission constraints, import/export dynamics, fuel prices, air pollution control equipment and wide range of energy policies, and environmental regulations.

What is an energy model?

Energy models require extensive underlying data and complex formulation that represents the engineering and economic decisions made by the energy system. They capture the complex interactions within the electricity market and simulate what might happen given a set of assumptions. These models are equipped to:

- Simulate energy transfers among different regions
- Optimize system dispatch from EGUs
- Incorporate transmission constraints, forced outages, environmental regulations, plant retirements, new generation, and limitations on specific power plants (e.g., ramp rates, start-up constraints minimum down time)

Dispatch models

Dispatch models specifically replicate least-cost system dispatch, with the lowest cost resources dispatched first and the highest cost last. Dispatch models determine which generating units are displaced and when they are displaced based on economic and operating constraints.

Capacity expansion models

Capacity expansion models (also called system-planning models) can examine the potential long-term impacts on the electric sector or upon the entire energy system of an EE/RE policy and program. These models predict how the electric system will evolve over time; including what capacity will be added through the construction of new generating units and what units will be retired, in response to changes in new regulations, demand, and prices.

When to use an energy model approach

If a jurisdiction wants to incorporate EE/RE policies and programs in their SIP/TIP in the baseline emissions projection pathway or as a control strategy, using an energy model, dispatch model, capacity expansion model, or comparable model, is recommended. Either energy model or an alternative emission projection tool can handle multiple iterations of different EE/RE policy/program scenarios, therefore, state, tribal and local agencies can use a single emission quantification method to compare emissions of a baseline emissions projections and varying policy cases with new EE/RE policies.

Dispatch models are generally good to use for analysis of one to five years into the future especially when the future EGU fleet is not changing substantially. An hourly dispatch model can be used to determine hourly emission rates, which can then be aggregated by time period and applied to a range of EE/RE policies and programs according to their production characteristics.

Capacity expansion models forecast future generation and retirements, as well as the dynamic fluctuation within the electric grid and are generally useful to use for analysis five to 30 years into the future. This approach is most appropriate to use when an EE/RE policy or program is at a large enough scale to completely change electric system operations (e.g., EE/RE policy transforms the electric sector market or future EGU operational characteristics)

How does this approach work?

Dispatch models

Energy modeling experts or consultants normally operate dispatch models. These models determine which EGUs operate on the "margin" in the electrical power system (typically the most expensive unit needed to meet demand is the "marginal EGU" in a given time period). States can use hourly dispatch or energy models to determine hourly marginal emission rates (pounds/kWh), which can then be aggregated by time period and applied to a portfolio of programs used to achieve the EE/RE policy requirement. [29]

There are important considerations when using dynamic simulation models such as dispatch models. Since this method can be less transparent than other methods, jurisdictions should inform the EPA regional office of important input assumptions for any dispatch or energy model used to measure displaced emissions.

The following information should accompany a state, tribal or local agency's SIP/TIP submittal under this pathway for any quantification of emission reductions using a dispatch or similar type of model:

- Type and amount of energy savings/generation information used
    - Specify if peak (MW), annual (MWh), seasonal, and/or hourly load information was applied for EE/RE policy
- Fuel prices assumed for all fuels and technologies
- Emission rates for each applicable EGU

What are the advantages and limitations of *dispatch models*?

Advantages:

- Electricity transfers are well represented
- Can provide very detailed estimations about specific plant and plant type effects
- Highly detailed, geographically specific hourly emissions data at the EGU level
- Can simulate emission changes for jurisdictions subject to cap and trade programs

Limitations:

- The model is only as good as the assumptions

[29] EPA (2010c), pp. 69-70.

- All dispatch models are proprietary and require more resources than other approaches
- Expertise in energy modeling is normally recommended
- Future changes in electric system are not factored into model

Capacity expansion models

Energy modeling experts or consultants normally operate capacity expansion models. These models are typically used for longer-term studies (e.g., five to 20 years), where the impacts are dominated by long-term investment and retirement decisions. They are also typically used to evaluate large geographic areas. This method involves allowing the model to predict what will likely happen to the electric energy resource mix based on costs of new technology, growth, existing fleet of generating assets, environmental regulations (current and planned), and considering dispatch both with and without the new clean energy resource.[30]

The following documentation should accompany a state, tribal or local agency's SIP/TIP submittal under this pathway for any quantification of emission reductions using a capacity expansion model or similar type of model:

- Fuel price forecasts, EGU retirements, and EE/RE regulatory requirements (e.g., renewable portfolio standards)
- Plant type and emission rates of assumed new generation for all applicable future years
- Information on whether model outputs were validated or calibrated against actual data or another projection model

<u>What are the advantages and limitations of *capacity expansion models*?</u>

Advantages:

- This is the most sophisticated way to capture how the electrical grid will react to EE/RE policies
- Future EGU generation and retirements are represented
- Provides very detailed estimations about specific plant and plant type effects
- Highly detailed geographically data at EGU or emission unit level
- Can simulate emission changes for jurisdictions subject to cap and trade programs.

Limitations:

- The outputs of energy models are only as good as the assumptions
- Energy models are proprietary, require significant resources to run than other approaches, and can be data intensive
- Input assumptions for capacity expansion models can be difficult to discern due to the proprietary nature of the models
- Expertise in energy modeling is normally recommended
- Hourly emissions information is not always available

[30] EPA (2010c), p. 71-72.

What tools and resources are available?

There are many different energy models available. Dispatch models include: PROSYM, PROMOD, and Ventyx Market Analytics. Capacity expansion or planning models include: NEMS, IPM, and ENERGY 2020.

Suggested Quantification Approaches for Each State and Tribal Implementation Plan Pathway

The EPA is providing suggested emission quantification approaches state, tribal and local agencies can use as guidelines when accounting for emission impacts of EE/RE policies and programs within a certain SIP/TIP pathway (see Table 3). These approaches are suggestions only, so a jurisdiction can choose to use an alternative approach, not listed here, that has comparable rigor and emission results. Before getting too deep into any EE/RE emissions analysis, contact the air program in an EPA regional office[31] to discuss options for the emission quantification approach that is appropriate for the EE/RE policies and programs at hand.

Table 3: Suggested Emissions Quantification Approaches for Each Pathway

Pathway	Suggested Quantification Methods[32]
Baseline Emissions Projection Pathway	• Energy models approach • Historical hourly emission rate approach • Alternative emissions projection tools or analysis
Control Strategy Pathway	• Energy models approach • Historical hourly emission rate approach • Capacity factor approach
Emerging/ Voluntary Measures Pathway	• Capacity factor approach
WOE Pathway	• Energy models approach • Historical hourly emission rate approach • Capacity factor approach • eGRID subregion non-base load emission rates

Important Considerations for Emission Quantification Approaches

All emission quantification approaches should address the following key information:

- Defining geographic boundaries at the appropriate regional level (see section below)
- Identifying EGU dispatch order
- Accounting for electricity imports/exports
- Transparency of data sources and analytical steps
- Recognition of any transmission constraints
- Environmental regulations affecting EGUs

If a state, tribal or local agency is not using an energy modeling approach, the following information should be specifically addressed in any SIP/TIP submission:

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[31] For more information, go to: http://www.epa.gov/aboutepa/where.html.

[32] The quantification methods are only suggestions. Please note that the capacity factor and historical hourly emissions approach are under a third-party peer review process as of June 2012.

Future Generation

If the projections for EE/RE policies and programs extend out more than five years, then, for more sophisticated analyses, a state, tribal or local agency should develop assumptions for how future generation will change over time. The jurisdiction should examine each nonattainment area[33] and assign emission rates to new units expected to come online or exclude planned retired plants in the jurisdiction's future emission rates. There are multiple organizations that project how EGUs will meet future demand and react to new environmental regulations. The EPA recommends obtaining projections of future EGU growth from EPA, EIA, electric grid operators, RTOs, ISOs, or NERC.

It is also important to consider which new resources may be entering an area and whether there are plans for transmission upgrades. Energy efficiency resources can help an area avoid the need for new or upgraded transmission lines. Depending upon the region, upgrades could encourage further development of RE, or may permit greater access by older, high-emitting sources that may be more likely to run if the new transmission is built.

Energy Exports and Imports

The EGUs located in the area of analysis may import or export significant amounts of energy. The first step in addressing electricity transfers is to determine whether there has been significant movement in recent years between the area of analysis and other areas. The following data sources are available for electricity import/export information:

- Data on total generation and export/import percentages will indicate whether the area is a net importer or exporter, as well as the magnitude of transfers relative to total generation[34]
- Most system operators (balancing authorities, RTOs /ISOs) release information annually about generation, loads, and interchange on their system
- Long-term power purchase agreements that underlie exports and import transfer information

If EGUs collectively in an area of analysis are net exporters or importers, then the next step is to determine if the transfer level follows a daily load pattern, a seasonal load pattern or is a consistent source of energy to an outside importer throughout the year. Once typical energy transfers are characterized, the dispatch order in the area of analysis should be adjusted to account for these transfers within the relevant time frames.[35]

Managing Uncertainty

All SIP/TIP emission reduction measures have some level of uncertainty, whether it comes from the uncertainty associated with the emissions factors for certain sources, the level of

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[33] For more information on areas not meeting the National Ambient Air Quality Standards, go to: http://www.epa.gov/oar/oaqps/greenbook/.

[34] For more information, go to: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

[35] Synapse (2005).

compliance with existing SIP/TIP measures, or air quality modeling for an attainment demonstration. By using conservative assumptions, appropriate discount factors or verification techniques, emission reductions from EE/RE policies and programs can be applied for SIP/TIP purposes. The EPA recognizes that there will likely always be some level of uncertainty regarding the exact quantity and location of emission reductions resulting from EE or RE measures. However, in many cases EPA also believe that you can apply existing tools with sufficient rigor to be able to quantify estimated emission reductions with acceptable certainty to allow the reductions to be credited.

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