Emerging Tools for Assessing Air Pollutant Emission Reductions from Energy Efficiency and Clean Energy

PHASE II

FINAL REPORT

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Air Pollutant Emission Reductions
from Energy Efficiency and Clean Energy

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Background

In 2003 and early 2004, the Global Environment & Technology Foundation (GETF) reviewed existing tools for assessing the impacts of electricity usage on emissions of air pollutants. The goal of this project was to identify a single robust tool that state air quality officials could use to incorporate energy efficiency and renewable energy in State Implementation Plans. The Integrated Planning Model (IPM) is a highly detailed tool that is used by the U.S. Environmental Protection Agency (EPA) to assess the emissions impact of regulations. This tool was seen as prohibitively expensive for states to use. If a less expensive tool were identified and seen to be credible, GETF would have brought the states together to formally request that EPA recognize the validity of this tool for use in State Implementation Plans (SIPs). This would open the door to formal allocation of emission credits to implementers of energy efficiency and renewable energy.

Tools Assessed

One tool that was expected to be available during this process, EPA's Average Displaced Emissions Rate (ADER) methodology, still has not been completed. The two existing tools were the Clean Air and Climate Protection Software (CACPS) tool developed by Torrie Smith Associates for STAPPA/ALAPCO and ICLEI[1] and the Ozone Transport Commission Emission Reduction Workbook (OTC Workbook) developed by Synapse Energy Economics for OTC.

Phase I Conclusions

Although the two tools assessed may be sufficient for uses dependent on "weight of evidence" in determining the effects of actions, they were not designed with the intention of being rigorous enough to demonstrate SIP adequacy. GETF believes that it is not appropriate for these tools to be extended to a highly-rigorous application such as this; state air quality officials agreed with this assessment. Before going to EPA to request support for use of an air pollutant emissions modeling tool, states want to see a tool with established accuracy, widespread applicability, and expanded functionality.

GETF identified the following difficulties associated with using these tools to credit energy efficiency and renewable energy in State Implementation Plans:

- The OTC Workbook was limited to the ISO-NE, NYISO, and PJM regions. As a result, the model is not applicable to some areas with ozone non-attainment status. The geographic limitation also hindered comparisons to CACPS. Where results of the two tools can be compared, they are sometimes similar and sometimes vary substantially (occasionally by more than a factor of two).
- Insufficient historical data existed to check the accuracy of either tool, particularly with regard to marginal emission rates. Projected marginal rates could only be compared to historical rates in one case. In that case, the difference in emissions rates was as much as 40% for sulfur dioxide (SO_2)[2] and 27% for nitrogen oxides (NO_x).
- The tools address cap-and-trade regulations very differently – one raises the possibility that in some cases energy efficiency or clean energy may *not* result in real emission reductions for SO_2 and/or NO_x.
- Although both tools present both grid average and marginal rates, one model recommends using the former and the other recommends using the latter. In fact, the selection of the appropriate approach depends on the circumstances.[3]

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[1] STAPPA/ALAPCO is composed of two organizations, the State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials. ICLEI is the International Council for Local Environmental Initiatives.

[2] SO_2 is the primary type of the broader category of sulfur oxides (SO_x) found in power plant emissions. The terms are used interchangeably to an unfortunate degree.

[3] For example, most efforts to assess an organization's "CO_2 burden" will use the organization's electricity consumption multiplied by the electricity supplier's average CO_2 emissions rate. The WRI Greenhouse Gas

Fundamental uncertainties complicate any form of emissions modeling. Energy efficiency affects both current dispatch and future plant construction. The "duration" of an energy efficiency improvement, and its ability to impact capacity additions, depends on the assumptions made for the "business as usual" case. The nature of the grid even a few years from now is also highly uncertain, particularly as affects marginal generation. While the models agree that it will be much cleaner for some pollutants and moderately cleaner for others, these assumptions are based on a reliable supply of natural gas. Natural gas availability and cost is one of the largest uncertainties affecting the electricity grid in the near-to-medium term. In the medium-to-long term, regulatory or legislative action on carbon dioxide becomes a real possibility for consideration. The accuracy of any assessment tool based on a model depends on the accuracy of the scenarios that were used to create the assessment tool. In any energy scenario, the modeler must make assumptions regarding future environmental regulations and the cost of natural gas. States, communities, and federal agencies will need to decide what level of uncertainty they consider acceptable for various purposes.

Needs for Future Tool Development

GETF presented its findings to state energy and air quality officials in March 2004. Stakeholders felt that the existing tools were not sufficiently robust for a demonstration of SIP adequacy, but agreed that there was merit to using them to provide relative values of the benefits of various actions. A tool suitable for demonstrating SIP adequacy would need to provide resolution at the county scale. Non-attainment status applies to counties, whereas the OTC Workbook and CACPS provide information on emissions changes at the scale of an ISO region or a NERC region. These regions typically cover several states.

Stakeholders expressed interest in working with EPA to ensure that the roles of energy efficiency and clean energy are recognized in the development of regulations to control fine particulate matter ($PM_{2.5}$). Therefore, any future emissions modeling tool would need to account for $PM_{2.5}$ emissions. Many tools base their emissions rates on point source reporting to EPA. Through this requirement, EPA collects data on emissions from individual power plants. Point source reporting for $PM_{2.5}$ began on June 1, 2004, with state reports on emissions from the 2002 inventory year due at that time. This base of information should enable the development of tools to assess $PM_{2.5}$ emission reductions.

Underlying Energy System Models

The relatively inexpensive tools available to states do not involve actual modeling of the energy system. Typically, the tools employ rates for avoided emissions that have been developed through use of more involved energy modeling programs. Models project how the electricity system will respond to changes in demand. In most cases, these modeling tools are too expensive and labor-intensive for states to use to assess the benefits of clean energy and energy efficiency. Modeling tools include the following:

1. The National Energy Modeling System (NEMS) is used by the U.S. Department of Energy in projecting future energy supply and demand. The Annual Energy Outlook is conducted by DOE's Energy Information Administration using NEMS. This report forms the basis for many analyses of the environmental impacts of energy regulation or legislation, such as the analyses conducted by the General Accounting Office (GAO). Torrie Smith Associates based CACPS on emissions rates derived from this tool.

2. PROSYM™ is a production simulation model developed by Henwood Energy Services, Inc. Synapse Energy Economics uses the PROSYM™ model in many of its modeling efforts,

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Protocol uses this approach. Applying the average rate to determine the existing burden and the marginal rate to determine the benefit of energy-saving measures would lead to an inconsistent result.

including the development of the OTC Workbook. PROSYM™ has been used for analyses by Independent System Operators, electricity generators, utilities, and public utility commissions.

3. MARKAL-MACRO was developed by Brookhaven National Laboratory (BNL). MARKAL is an energy engineering model. MACRO is a macroeconomic model, which allows the composite tool to model interactions between energy systems and the economy as a whole. MARKAL-MACRO is used to conduct analysis for the U.S. Global Climate Change Initiative agreed to under the Framework Convention on Climate Change.

4. The Integrating Planning Model (IPM) was developed by ICF Consulting, Inc. EPA uses IPM to analyze the projected impact of policies on the electricity sector. IPM provides the foundation for EPA's new ADER tool.

5. AMIGA, developed by Argonne National Laboratory, is a multi-sector economic model similar to MARKAL. AMIGA employs plant-level resolution for the electricity sector, as do IPM and NEMS, but pollution control technology assumptions are less detailed in AMIGA than in IPM. EPA has recommended studying the comparability of results across AMIGA, IPM, and NEMS.

The term "energy modeling" refers to the process of determining the energy that will be needed by a given facility. A number of sophisticated programs exist to assess the energy demand from homes or other buildings, taking into account building design, energy-efficient components, climate, and occupancy. It is important to properly understand the reductions in energy demand that can be expected from a measure such as improved home insulation, but GETF's project is focused on identifying emission reductions associated with a known reduction in energy demand.

Information Resources

Some emerging tools do not employ an existing energy modeling program. However, all tools require some basis of information on power plant emissions. The eGRID database maintained by EPA is a widely used resource, forming the basis of the ERCOT methodologies developed by Art Diem of the EPA and by the Texas A&M's Energy Systems Laboratory. Other resources include Independent System Operators (ISOs), state air quality offices, and the utilities themselves. The foundation of the information resources is the point source reporting requirement. States are obliged to report to EPA data on the hourly electricity generation and emissions of SO_2, NO_x, and CO_2 from large power plants.

Information resources can also be useful for "back-casting," evaluating the accuracy of emissions modeling tools by comparing previous projections of these tools to actual data. GETF noted that a lack of up-to-date information on both grid average and marginal emissions rates made it difficult to evaluate the accuracy of existing modeling tools. The eGRID database lags a few years behind (the most recent version, released in May 2003, has data through 2000) and does not include marginal emissions factors. ISO-NE provides more up-to-date information and does conduct an analysis of marginal rates, but it is only applicable to the New England region.

Phase II

In Phase I of this project, GETF did not identify an existing emissions reduction assessment tool suitable for demonstrating the emission reductions from energy efficiency and renewable energy to the level of certainty required for SIP adequacy. Because such a tool would be most useful for states, GETF here examines tools that are under development. Where a promising tool is identified, GETF recommends that EPA, state officials, and the model developer should work together to ensure that the finished product is fully suitable to allow crediting of energy efficiency and renewable energy in SIP plans.

Emerging Tools

A number of emissions modeling tools are under development. It is possible that some of these could be modified and enhanced to become suitable for determining emission reductions from clean energy and energy efficiency. A recently-filed SIP revision for the Washington, DC metropolitan area actually incorporates wind power to reduce NOx emissions. The methodology used in this filing is also detailed below along with the emerging tools.

EPA ERCOT Methodology

Art Diem, an Environmental Engineer with EPA's State and Local Capacity Building Branch, has developed an emissions modeling methodology for use in Texas. ERCOT, the NERC region covering the vast majority of Texas, has very limited exchange of power with neighboring NERC regions. This makes the development of Texas-specific tools somewhat less complicated than the development of universally-applicable tools. The ERCOT methodology is specifically discussed in EPA's new guidance document on incorporating energy efficiency and renewable energy in State Implementation Plans, although that discussion does not constitute an endorsement.

Approach

The ERCOT methodology translates energy savings within a power control area into county-specific emission reductions of NO_x, SO_2, and CO_2. The ERCOT methodology is not a forecast model, nor is it precisely a dispatch-based model. Assessed emission reductions are based on eGRID's plant capacity factors and power control area interchange data. Plants with a capacity factor of 80% or greater are assumed to be baseload and unaffected by energy efficiency; those with a capacity factor of 20% or less are assumed to be peaking units for which all generation is potentially displaced by energy efficiency; those with capacity factors between 20% and 80% are assumed to be load-following with some generation possibly displaced. Spreadsheet-based matrix algebra solves simultaneous equations in order to determine where the emission reductions occur. This approach employs actual information such as plant generation, imports and exports between power control areas, capacity factors and emissions data. It can also be adjusted to account for predicted changes to the generation fleet in the future.

Nuclear and hydropower units are considered "baseload" units and are assumed to be unaffected by changes in demand. This assumption is widely viewed as accurate for nuclear power, though hydropower is less consistently a baseload resource than is normally assumed. Since hydropower accounted for only 0.3% of Texas electricity generation in 2002,[4] this issue is not particularly important for Texas. The methodology assumes that the amount of generation at each combustion-based plant that could be affected by energy efficiency or renewable energy is determined by the capacity factor.

Preliminary Assessment

The primary advantages to this approach are that it projects emission reductions at the county level and that it accounts for transmission constraints within a region. State officials emphasized that this is critically important for air quality planning purposes.

The developer of this approach notes that the use of capacity factor as a proxy for dispatch status can tend to over-estimate a facility's role in load following. A facility that is normally baseload but has recurring maintenance outages may have a capacity factor equal to a load-following unit. In that case, the two facilities would be modeled the same even though they are not actually operated the same.

This methodology is subsumed into the eCalc tool, described below.

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[4] Energy Information Administration, *State Electricity Profiles 2002*, at http://www.eia.doe.gov/cneaf/electricity/st_profiles/texas.pdf.

eCalc

Through the Texas Emission Reduction Plan (TERP) that was authorized by the state's Senate Bill 5, Texas is seeking to use energy efficiency to improve air quality. The Energy Systems Lab at Texas A&M University has developed a methodology based on the work conducted by Art Diem and EPA. The Emission Reduction Calculator, known as eCalc, is an online tool that identifies emission reductions from energy efficiency and renewable energy measures.

Approach

The eCalc tool incorporates both energy modeling (assessing the energy saved by a given measure) and emissions modeling (determining the emissions avoided by those energy savings). The energy modeling capability is extremely robust and detailed, accounting for a wide array of load types with weather normalization. It also includes energy production profiles for wind and solar power. Overall, it appears that Texas has undertaken a most rigorous process to identify energy savings.

The emissions modeling component relies on Art Diem's ERCOT methodology, described above.[5] It incorporates data from the Public Utilities Commission to identify transmission constraints and interchanges between different energy suppliers. Energy savings are identified by county. These savings are then associated with specific energy suppliers; in a case where multiple suppliers are active in a county, the changes are pro-rated according to their sales in the county. The methodology then associates the reduction in the energy supplier's load with generation reductions at specific power plants, and thus with emission reductions in counties. The counties where the affected generating units are located may or may not be the same as the counties in which the energy efficiency measures were implemented. The result is a matrix (spreadsheet) calculation showing how the changes in emissions in each country resulting from the implementation of the measure.

Because the state seeks credit not for a set-aside with annual allocations of credits but for a more substantial revision of the SIP, it is necessary to project emission reductions into the future. Based on existing requirements for point-source emission reductions, TCEQ recommended that the emission reductions resulting from energy efficiency and renewable energy in 2007 be discounted by 80% from the levels indicated by the 1999 eGRID data. This enables the revised SIP to properly demonstrate the level of benefit that energy efficiency and renewable energy will be providing in 2007. This analysis in effect assumes that the grid looks and works the same in 2007 as in 1999, except that every plant has emissions that are 80% lower. GETF understands that EPA is providing TCEQ and ESL with a more sophisticated analysis on future emissions.

Components such as the Power Allocation Module are designed as stand-alone pieces of code. In the event that improved information comes along (such as a revised version of eGRID or a new tool altogether), that section of eCalc can be upgraded without needing to revise the rest.

Preliminary Assessment

ESL's eCalc appears to be robust, and it is detailed in its handling of power exchange between service territories. For example, Bexar County includes San Antonio, and effectively all of the load is handled by City Public Service. However, the utility exports some power. Generation and thus emissions are also impacted to some degree by the load of neighboring utilities such as Austin Energy and Lower Colorado River Authority. This is reflected in the spreadsheets showing annual and peak-day emission reductions in Bexar County.

[5] Due to this common origin, we will not discuss EPA's ERCOT methodology independently in our conclusions. Rather, it is considered a component of eCalc.

Because model developers note that the EPA ERCOT methodology is used in assigning load to specific power plants, we assume that eCalc is as accurate as the former tool in identifying the *marginal* plants that would actually be turned down in response to decreased load. As with any tool based on eGRID, the primary limitation is the age of the data. The 2004 version of eCalc used eGRID data from 1999 and attempts to project 2007 emission reductions by applying a flat discount factor to all localities. However, ESL notes that 1999 is the base year for TCEQ's Ozone Episode Day used to model ozone reductions, and so the use of the 1999 eGRID is entirely appropriate.

NE-MARKAL

Northeast States for Coordinated Air Use Management (NESCAUM) is involved in a six-state project to develop SIP planning tools that can incorporate energy efficiency and renewable energy based on an updated energy system optimization model (MARKAL). The model is scalable and flexible – the more rigorous data, the more rigorous the model that emerges. This is a multi-sector model, extending beyond the electricity sector.

Because MARKAL is difficult to set up but fairly straightforward to run, NESCAUM seeks to develop a "toolbox" that will help states in New England (Maine, Vermont, New Hampshire, Massachusetts, Connecticut, and Rhode Island) build their own MARKAL models. A toolbox that includes standardized initial conditions and defined scenarios will facilitate comparisons between MARKAL models conducted by different groups. NESCAUM hopes to add New York and New Jersey, its other member states, in the near future. In the long term, NESCAUM hopes to add four additional states in the PJM Interconnection region, thereby including most of the OTC region.

EPA supports the development of the regional NE-MARKAL tool and is also working to develop a national MARKAL database. In consultation with other government agencies, EPA will assemble the best available information on technologies that produce or consume energy. Modeling of the electricity sector under MARKAL will be based on information from NEMS as well as the Electric Power Research Institute (EPRI). For example, forecasts of electricity demand are taken from the Annual Energy Outlook, which is developed by the Department of Energy using NEMS.

Approach

MARKAL employs linear algebra to solve simultaneous equations. According to its developer, "a typical MARKAL model consists of 4,000 to 6,000 variables and a comparable number of equations."[6]

MARKAL has often been used to model energy systems at a national level, but in recent years the move has been towards regional MARKAL models. Canada has used regional modeling in its national climate change mitigation effort. NESCAUM is seeking to model the New England area as six regions, with each state being one region. NESSCAUM is considering using "pseudo-technologies" to represent transmission constraints around load pockets such as Boston or Southwest Connecticut. It is possible to use MARKAL at a narrower geographic level if the model is constructed with local data. For example, Brookhaven National Laboratory is conducting modeling at the level of a single urban area (lower Manhattan). However, the specificity of the data collected determines the specificity of the model that can be constructed, and NESCAUM is focusing on the state level.

[6] Energy Technology Systems Analysis Programme, "Summary Annex IV, Appendix A: The MARKAL Model," 1993, online at http://www.etsap.org/reports/markal-a4-a1.pdf.

Preliminary Assessment

NESCAUM seeks to use MARKAL for planning over the 20-30 year term. It is not intended for near-term calculations of avoided emissions, but it could be appropriate for calculating the state and regional impacts of long-term measures such as a renewable portfolio standard or building energy code.

ADER

The EPA has been working on an emissions modeling tool known as the Average Displaced Emissions Rate (ADER) methodology.

Approach

ADER uses a methodology similar to the OTC Workbook and to the "marginal rate" calculations within CACPS. ADER differs from those tools in the following ways:

1. ADER uses a series of IPM modeling runs to establish avoided emission rates, rather than PROSYM (used by the OTC Workbook) or NEMS (used by CACPS)
2. ADER divides the contiguous forty-eight states into five regions – it is more extensive than the OTC Workbook (which covers three ISO regions) and uses a different division than CACPS (thirteen regions based on NERC divisions)
3. ADER divides the year into eleven time periods, compared to the six used by OTC Workbook (CACPS does not use time periods)

ADER's documentation suggests that ADER is superior to using "grid average" rates because it more accurately models the near-term actual changes to operation of the electricity system. This is a fair assessment. The documentation also notes that ADER is superior to a "marginal unit" calculation based on identifying a single unit as the highest-cost and thus "marginal" unit. However, this sort of calculation would be unusual. The marginal rates identified the OTC Workbook and CACPS are both based on modeling how the entire electricity system responds to a 1% or 2% change in demand, just as ADER is. They are not based on identifying a single unit or type of unit as marginal.

Preliminary Assessment

ADER is similar to the OTC Workbook or the marginal rates component of CACPS. Its combination of temporal specificity (eleven time periods) and geographic coverage (the contiguous U.S.) is superior to that offered by the other tools. However, ADER will not be able to offer the county-level resolution that states and localities require. For use in determining baseline adjustments, ADER could be as useful as or more useful than OTC Workbook and CACPS.

MIT PV Assessment

Researchers from the Massachusetts Institute of Technology (MIT) have developed a new methodology to assess the emission reduction benefits from solar photovoltaic power systems. This methodology could be applied to other forms of clean energy generation, as well as energy efficiency.

Approach

The MIT methodology assesses the impact on specific generating units. EPA maintains historical data on the hourly emissions from power plants, and NERC regions maintain data on electricity demand (load). MIT used this information to calculate whether or not a given unit is load-following in any given hour. The MIT approach accounts for Automatic Generation Control (AGC), modeling generating units as responding to small changes (such as those produced by a typical PV system) by turning down rather than turning off. Researchers compiled extensive data to classify each unit as full load, spinning reserve, standby, or turning on/off in each hour. Because generation units are most efficient at full load, emission reductions are not directly proportional to demand reductions. That is, a 25% drop in electricity generation at a plant will not result in a 25% reduction in fuel usage and emissions.

The MIT approach has tracked emissions characteristics over five years. This base of information allows for a reasonable projection of avoided emissions in the near future. The cost of this data-intensive approach is mitigated by the fact that much data is already being collected—hourly emissions by EPA and hourly demand by NERC. The cost of re-running the model every year to develop new rates, however, may be significant.

Nuclear and hydroelectric facilities do not have any emissions to report to EPA, and so do not have hourly operating profiles available. MIT's researchers assume that nuclear power operates at full load (>90% of net capability) and that hydropower operates primarily in a "spinning reserve" duty cycle similar to gas turbines (55-90% of net capability). Historical data shows that hydroelectric facilities operated at about 30% of capacity in 2002.[7] Because hydropower is very low-cost, this low utilization is likely due to limited availability of water rather than generation cost. Hydroelectric facilities can respond to non-dispatchable renewables by shifting the limited amount of available power to times when the intermittent resources are not available.

Preliminary Assessment

MIT's methodology represents an intriguing approach. Its recognition of the different efficiencies of the various duty cycles of power plants is important when considering measures that are too small to fully idle a major power plant. On the other hand, one must consider that a hundred small projects – such as ten "Rebuild America" energy efficiency projects in each of ten cities – might indeed make such a difference.

The reporting of emission reductions by hour throughout the year allows for a greater degree of temporal specificity than any other tool evaluated. Because the tool addresses changes at specific facilities, it is also conceivable that this approach *could* be redesigned to provide greater geographical specificity. This resolution would be unmatched by any other. At the moment, the tool only describes emission reductions in a NERC region and so is not suitable for SIP application.

The MIT methodology would require repeated use to be practical. Environmental policy, economic trends, capacity changes, and technological advance all combine to rapidly change the emissions profile of power plants. It would be incorrect to credit energy efficiency improvements in 2007 with emission reduction credits based on 2000 rates. Corrections could be necessary. For example, at the beginning of 2005, a state might allocate 100 tons of NO_x credits to a green power producer for clean power expected to be generated in 2005. The company could then sell or retire these credits as they see fit. In early 2007, or whenever the emissions data for 2005 is in, the state could re-evaluate the 2005 emission reductions and "settle up" with the company to cover the difference. This approach would require emissions data to be reasonably current.

The model developer has suggested that it would be a relatively straightforward practice to expand this model to other regions through the use of an appropriate script. Much of the necessary data is already collected by EPA through the Clean Air Markets program. Additional data on hydroelectric and nuclear facility operation would enhance accuracy.

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[7] According to Energy Information Administration *Electricity Power Annual*, Table ES, hydroelectric net summer generating capacity was 99,727 MW and net generation was 255,586,000 MWh in 2002. This is an average of 2,560 full-capacity hours per unit per year; by comparison, nuclear facilities averaged 90% utilization. See http://www.eia.doe.gov/cneaf/electricity/epa/epates.html.

ENERGY 2020

The ENERGY 2020 modeling tool was developed by George Backus and Jeff Amlin, now of Policy Assessment Corporation and Systematic Solutions, Inc. The latter firm conducts modeling for clients using this tool. Many state energy offices and other stakeholders employ ENERGY 2020 for scenario analysis.

Approach

Descriptions of the ENERGY 2020 tool suggest a model of considerable intricacy that can run on a PC. Similar to MARKAL, the tool integrates energy supply, energy demand, regulatory action, and economic activity. The tool models the entire energy sector and considers the interactions between different fuels and between different applications.

ENERGY 2020 is not an optimization model. Rather, it seeks to characterize how the energy market actually performs, accounting for "market imperfections" and consumer choice. The tool appears to be particularly useful for characterizing markets in varying stages of deregulation. Energy providers are represented as four units: transmission and distribution (both regulated) as well as generation and marketing (which may be deregulated to varying degrees).

Preliminary Assessment

This tool was developed in part to help states conduct energy policy analysis. It appears to fulfill many of the needs of energy modeling. Although some states do use Energy 2020, others have noted that the tool is expensive and/or labor-intensive.

The model developer suggests that one challenge for facing states is this model's incorporation of choice and behavior as opposed to optimization. The size of this multi-sector model may seem daunting to implementers of energy efficiency and renewable energy – although clearly states should consider that such actions impacting the electricity sector will have cascading effects on other energy sectors.

ERT/RSG Methodology

In December 2004, EPA published notice of its intent to accept SIP revisions submitted by Maryland and Virginia for the Washington, DC metropolitan area. This area is in non-attainment status for ground-level ozone under the 1-hour standard. The revised SIP includes NO_x emission reductions of 0.05 tons per day during the summer ozone season due to a regional wind energy purchase led by Montgomery County, MD. The regional buying group will purchase 38,400 MWh of wind power per year. Maryland relied on the Environmental Resources Trust (ERT) and the Resource Systems Group (RSG) to assess the emission reductions from the wind power purchase.

Approach

ERT/RSG contacted load serving entities within the PJM Interconnection region to determine the specific power plants that would be affected by a wind power facility in the Backbone Mountain area of the Allegheny Mountains. In this particular case, ERT and RSG were able to obtain the dispatch ranking order through a voluntary arrangement and confidentiality agreement with Exelon. With this dispatch schedule, ERT/RSG concluded that, in that part of the PJM region relevant to the project, "all of the variable dispatch generation is provided by coal units."[8] ERT/RSG also noted that nuclear power (significant in the region) and hydropower (less significant) would be unaffected by the wind farm.

[8] *Plan To Improve Air Quality In The Washington, DC-MD-VA Region*, State Implementation Plan, Metropolitan Washington Council of Governments, February 19, 2004, Appendix J, p. J-73.

The rate credited to wind power for emissions avoided is 50% of the average NO_x emissions rate for the affected facilities. This discount factor, applied by the Maryland during the SIP revision, reflects uncertainty in the use of this novel methodology as well as uncertainty in the transport of pollutants. The majority of the coal facilities are located near the Backbone Mountain area, over 100 miles from Washington, DC.

As EPA notes in its guidance of August 2004, "Some assurance that the estimated emission reductions will not be swept away by the theoretical cap and trade program mechanics mentioned above can be provided by retiring a commensurate number of allowances that accounts for the emission reductions expected from the measure." Maryland is relying on its renewable energy set-aside to reduce the number of allowances that will be issued to stationary sources commensurate with the projected emission reductions. These allowances will be retired, ensuring that emission reductions will occur.

Preliminary Assessment

In GETF's view, this methodology is highly accurate. It is essentially the approach recommended by EPA in its August 2004 guidance. Emission reductions are based on the actual dispatch schedule, current emission rates, and specific facilities affected. Other PJM wind farms are projected to be located in the same region, so the approach could be generalized to identify their benefits. Furthermore, Maryland will review the methodology in the future, adjusting rates as plants or emission factors change.

This approach requires a large amount of accurate information. Emission rates of plants are available through Clean Air Markets, FERC data, and other sources. However, in the past, many energy providers have been reluctant to provide data on the dispatch schedule because proprietary financial information can be inferred from such data.[9] ERT and RSG have found a cooperative approach with confidentiality agreements to be effective in Maryland, Chicago, and other regions. Additionally, Generation Attribute Tracking (GAT) systems are under development in several regions of the country. EPA should work with state public utility commissions and air quality offices to ensure that such systems are designed to facilitate analysis of emission reductions.

Detailed information on transmission constraints will also be needed to perform a robust analysis, particularly on projects in or near constrained load pockets. An ISO or other grid operator is the best resource for this data.

Because Maryland is relying on a set-aside approach, the emission reductions will be subject to true-up each year. State air quality officials note that this will be important as there have been recent SCR improvements applied to the generating facilities that were identified as affected by the wind farm. A true-up will involve assessing the wind farm operation in ozone season, the dispatch schedule in that season (which could be affected by natural gas prices), and the emissions of the affected facilities.

Common Challenges

Some emissions modeling tools offer better value for states and localities than others do. Still, there are common challenges facing all models. States, localities, and federal agencies should work with model developers to address these issues as best as possible.

Updating Models

Emissions modeling requires a tradeoff between accuracy and cost. In order to make a methodology more accurate, it must be periodically revised to account for new regulations and new market conditions.

[9] This caution was raised, for example, at the July 2003 meeting of the Commission for Environment Cooperation and is included in the meeting summary notes.

A tool that is explicitly based on historical data, such as the MIT methodology, must be continually updated to develop new rates for avoided emissions. As an illustration of how quickly emission rates change, consider that marginal SO_2 rates in ISO-NE decreased by *65%* from 1997 through 2002, and that marginal NO_x rates decreased by 58% over that time period.[10]

Updating models will continue to be a useful and necessary step in any event, as regulations and market conditions continue to change. The process allows stakeholders to evaluate the impact of various actions on the electricity sector. In the long term, the only difference among the various models is the frequency with which they require updating. The MIT, eCalc, and ERT/RSG methodologies could require future updates because they are based on historical data and do not make projections for the future. CACPS, OTC Workbook, NE-MARKAL, and ADER may only require "true-ups" and updates every few years if their projections prove reasonably accurate.

Geographic Resolution

Most existing and emerging tools have a regional level of resolution. Energy efficiency measures are implemented within a NERC region, and the resulting energy savings most often occur within that NERC region (some tools recognize emission changes in neighboring regions). NERC regions are fairly large, generally covering several states. They may have diverse types of generation in different service territories or power control areas within a region, and may have transmission constraints between these areas. These factors may have a significant impact on avoided emissions; energy savings in Boston, MA will not produce the same results as energy savings in Stamford, CT. Some tools, such as eCalc, do account for transmission constraints and location of an energy efficiency measure within a NERC region. Most do not. The ERT/RSG approach incorporates transmission constraints where they are significant to the project at hand. Finally, transport of pollutants will always present an issue in the geographic resolution of emissions modeling tools. This will be most significant when the affected facilities are at some distance from the non-attainment areas. Uncertainties surrounding transport can be addressed through the use of a discount factor.

Geographic resolution is *not* a concern for CO_2 modeling. Should states, localities, business, or organizations wish to undertake measures to reduce CO_2 emissions, we believe that a much broader range of tools should be considered, including CACPS, OTC Workbook, and ADER.[11]

Emissions Trading

The Acid Rain Program emissions trading protocol has proved remarkably successful in reducing emissions of SO_2 and meeting environmental goals at low cost. However, the existence of the cap-and-trade program complicates modeling efforts. The CACPS software demonstrates that in some cases energy efficiency can *increase* local emissions of SO_2, as power plants with lesser demand may choose to buy credits rather than install pollution controls.[12] CACPS developers also note that at no time do national emissions of SO_2 increase or decrease due to electricity demand – as modeled by NEMS, total national emissions remain at the cap. This effect could also be an issue under the NO_x SIP Call credit trading program, which has superseded credit trading under the Ozone Transport Commission. The EPA guidance (see below) provides suggestions for addressing this problem.

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[10] *2002 NEPOOL Marginal Emission Rate Analysis for the NEPOOL Environmental Planning Committee*, ISO New England Inc., December 2003.

[11] These tools identify region-level emission reductions. They differ primarily in the models used to generate the marginal rates. CO_2 emission reduction measures could be modeled up to the point at which the energy system has been changed more than the decrement used in developing the tool – 2% in OTC Workbook and CACPS.

[12] This is a simplified version of one scenario in which reduced energy demand increases local pollutant emissions.

Duration of Credits

It is necessary to consider an appropriate duration for incentives such as emission reduction credits. Energy efficiency improvements and clean energy technologies reduce emissions over a period of years. The federal Renewable Energy Production Incentive (now expired) provided a direct payment to publicly-owned clean energy generation for the first ten years of a facility's operation, subject to annual appropriations. The Production Tax Credit for wind energy likewise lasts for ten years of a facility's operation. Given the relatively slow adoption of clean energy technologies, the allocation of credits for ten years is reasonable. Ten years from now, a wind farm will still be displacing fossil fuel power plants.

Energy efficiency is a more difficult analytical issue than renewable energy, because efficiency is measured against a moving baseline. A product that is among the most efficient models today could be among the "middle of the pack" in ten years. Not only are the new models of many products more energy-efficient due to technological advance, but the existing stock becomes more energy-efficient on the whole due to capital stock turnover.

Establishing the Baseline

When a company replaces a system with a newer and more efficient one, is the baseline taken to be the system that is replaced, the average existing system, or the average new system in the region? EPA's guidance document on incorporating renewable energy and energy efficiency in SIPs suggests the first option, and indeed most companies touting an environmental improvement will cite their electricity savings using such a comparison. ENERGY STAR buildings are designated based on the second option, comparison to existing buildings. The LEED (Leadership in Energy and Environmental Design) Green Building Rating System® for new commercial construction, developed by the U.S. Green Building Council, falls closest to the third option.[13] However, it is important that the building is compared to the average new system built to local codes, in order that only surplus energy savings are considered.

GETF would recommend that, when energy efficiency is considered, states and localities give serious thought to addressing these issues. A company that replaces an old and inefficient chiller with a system that is of average efficiency for a new unit may in fact save a very large amount of emissions (as well as maintenance cost and energy cost). However, providing incentives to this company would disadvantage those that have made continual improvements in energy efficiency over time and so do not have such easy and dramatic opportunities available. ENERGY STAR and LEED provide a reasonably *objective* measure of a facility's energy efficiency that is not skewed by past performance. By establishing incentives based on ENERGY STAR or LEED, states and localities provide an incentive to be actively energy-efficient, not merely "not wasteful."

EPA Guidance Documents

In August 2004, EPA released its *Guidance on State Implementation Plan Credits for Emission Reductions from Electric-Sector Energy Efficiency and Renewable Energy Measures*. This document outlines the necessary steps for states and localities to take, including guidance on quantification. In September 2004, EPA released the policy document *Incorporating Emerging and Voluntary Measures in a State Implementation Plan*. Emerging measures are those that cannot be quantified to the same degree of accuracy as traditional SIP measures. EPA suggests applying a discount factor to assessed emission reductions to account for uncertainty. Voluntary measures are those that are not directly enforceable against the emissions source. EPA requires that the state be responsible for verifying such emission reductions and making up any shortfall. Energy efficiency measures could be considered both emerging

[13] In fact, LEED buildings are required to meet ASHRAE Standard 90.1-1999 or local energy codes, whichever are more stringent. LEED score is improved by exceeding these standards. Because the ASHRAE Standard is so recent, buildings are effectively compared to the average new building.

and voluntary.[14] The August document goes into greater detail on the quantification of avoided emissions from energy efficiency and so is more relevant to our discussion.

Selection of Emissions Modeling Tools

Ideally, a state or locality would be able to identify specific facilities at which electricity generation is reduced as a result of an energy efficiency improvement or clean energy system. The MIT, eCalc, and ERT/RSG methodologies take this approach. EPA singles out the ERCOT methodology (used in eCalc) as one approach that uses simplified assumptions but provides "a reasonable approximation of reality." It is important to note that EPA does not actually indicate its approval of this methodology for use in SIPs.

EPA notes that in some cases it is not possible to identify the individual facilities affected. In that case, EPA views the use of "surrogate approaches" such as dispatch modeling to be an effective step. EPA is here referring to the actual models, mentioning PROSYM and IPM as examples, and not to the emissions modeling tools that use fixed displaced emissions rates derived from those models. However, also according to the guidance, "EPA believes that you do not need to necessarily run a dispatch model in order to estimate the locations of the emission reductions expected from a measure." Because the actual dispatch models are expensive to run, this is a welcome opportunity to identify alternative approaches that may be useful.

OTC Workbook and CACPS are singled out as insufficient for stand-alone use in SIPs because they "do not specify any geographic distribution of the emission reductions." Both tools do report regional emission changes, but not county-level changes. EPA does suggest that these tools, along with eGRID, could serve as components of a methodology that did result in "a reasonable geographic distribution of the emission reductions."

EPA's guidance seems to rule out the use of any model that has only regional-level reported emission reductions. This eliminates ADER. NE-MARKAL will have state-level resolution, but that is likely insufficient as well (and it is not designed for near-term analysis). The ERT/RSG and eCalc methodologies seem to meet the requirements in their current forms, and the MIT's PV Assessment methodology would require only disaggregation of geographical data (Professor Connors notes this is possible).

The tools based on historical plant data – MIT's and ERT/RSG's – appear to generally meet the EPA requirements. Because they are based on historical data, these tools require frequent updating. This, in turn, requires a reliable source of emissions data that is promptly updated. They can be used on a case-by-case basis to identify emission reductions from specific measures, and can be used for crediting of emission reductions if a "true-up" is later conducted. GETF would suggest that both of these tools should be regarded as acceptable for including small-scale measures within a set-aside program.[15] If states wish to use these models for SIP inclusion in a way that does not involve annual true-up, they will need some sort of forecasting capability to accurately identify future emission reductions. The eCalc tool is based on historical data from actual plants, but applies EPA modeling to identify future emission reductions. It will therefore be useful for SIP revisions other than set-asides. As 2007 is only 2 years away and the pertinent SIP regulations have been established for several years, we assume that EPA can reasonably identify the generating facilities that will be operating as well as the emissions from those facilities. We assume that this 2-year-ahead modeling is sufficiently accurate.

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[14] While an energy performance contractor may indeed be held responsible for achieving promised energy savings, the emissions avoided by these energy savings depend in part on factors out of the contractor's control.

[15] A set-aside is typically limited to measures that make up 3% of the region's needed NO_x reductions.

For assessing the medium-to-long term impact of a large-scale measure such as a Renewable Portfolio Standard (RPS) or appliance standard, which would not be part of a set-aside program, the large-scale energy system modeling tools such as IPM, NEMS, and AMIGA are more appropriate. An RPS of large size can *significantly* alter a region's electricity profile, so detailed modeling to evaluate this impact would be preferable.

Updating Models

EPA advises that states and localities will need to "make an enforceable SIP commitment to monitor, assess and report on the emission reductions resulting from the measure and to remedy any shortfalls from forecasted emission reductions in a timely manner." A recurring process to examine the tool's accuracy and update the methodology would provide an excellent opportunity to satisfy this requirement. When the emissions for the past year are evaluated for "true-up," developers of forecasting models or other tools can and should evaluate how their methodology has performed.

Emissions Trading

EPA notes that it is theoretically possible for the benefits of an energy efficiency program to be entirely negated by credit trading. EPA advises states and localities to develop some assurance that emission reductions actually occur, and suggests reducing allowances through a set-aside or through some other allowance retirement system. By reducing allowances commensurate with the emission reductions that would otherwise be expected, the state or locality can allow energy efficiency or clean energy to achieve real benefit. This has an important implication: *if a tool already accounts for emissions trading under the current regulatory framework, it must be redesigned as the regulatory framework is redesigned according to EPA's suggestions*. On the other hand, it is quite possible that an existing tool could calculate emission reductions as if there were no trading and the revised regulations could be designed in such a way as to make that assumption accurate.

Duration of Credits

In its most recent guidance, EPA does not suggest how long credits should last, or how long energy efficiency measures should be considered "active." EPA released the guidance document *Creating an Energy Efficiency and Renewable Energy Set-Aside in the NO_x Budget Trading Program: Designing the Administrative and Quantitative Elements* in April 2000. This document suggested that energy efficiency measures receive credits for a period of three years.

Establishing the Baseline

EPA's guidance specifically refers to "programs to replace existing electrical devices with more energy efficient devices" as one example of a project covered by this guidance. Elsewhere, EPA takes care to note that states or localities must not grant additional SIP credit to energy efficiency or renewable energy measures that are already included in the SIP emissions baseline.

If a state has already included energy efficiency improvements due to capital stock turnover in its projected SIP baseline, then it should not grant credit to actions that simply improve efficiency at that level. For example, if energy codes for new buildings are factored in to the SIP baseline, then a company replacing an old and inefficient building with a new one built to code would not gain any credit. A company building a facility *better* than code would receive credit equal to the difference in emissions between the new facility and a hypothetical new facility built with only the efficiency required by the energy code. In the April 2000 guidance document, EPA suggested allowing the actual change in energy consumption to be the metric and applying a "business as usual" discount factor to reflect the fact that some improvement would have occurred even if not for the emission reduction credit program.

Quantifiable, Surplus, Enforceable, Permanent

EPA's guidance document spells out how the criteria "quantifiable, surplus, enforceable, and permanent" apply to energy efficiency and renewable energy measures included in SIPs. "Permanent" in this case means that the measure should reduce emissions for as long as it is receiving emission reduction credits. EPA notes that energy efficiency measures may result in decreasing levels of emission reductions over time, as the grid becomes cleaner.

Recommendations

Based on our findings from Phase II, and based on numerous comments from state energy and air quality officials, GETF presents the following recommendations for EPA's consideration:

1) Continue to support the use of the ERT/RSG methodology as in the Maryland SIP revision.
   Origin of recommendation: Maryland SIP revision for wind power purchase; GETF has filed letter of support for EPA accepting this revision.
   Benefit to states: Allows Maryland to demonstrate ability of wind power within a set-aside to help meet air quality goals. Provides a model for other states to follow.
2) Approve SIP credits requested by TCEQ and ESL using eCalc. EPA has been instrumental in developing this tool, and GETF believes the result has been a success. At the same time, continue to provide feedback to improve the accuracy of eCalc.
   Origin of recommendation: GETF and ESL. Now that eCalc is operational, ESL and TCEQ plan in FY 2004/2005 to seek approval of SIP credits identified through eCalc for measures taken under Senate Bill 5.
   Benefit to states: Allows Texas to demonstrate ability of energy efficiency to help meet air quality goals. Provides a model for other states to follow.
3) Pending the ongoing review of modeling approaches, support the use of the MIT and ERT/RSG methodologies should other states wish to use them, particularly in set-asides or other mechanisms with allowance reductions and annual true-up. EPA should also provide guidance on incorporation of set-asides into Clean Air Interstate Rule (which we understand EPA has promised to do), including guidance on the recommended length of eligibility for a project to receive credits through a set-aside.
   Origin of recommendation: GETF.
   Benefit to states: Allows states to gain credit for emission reduction benefits of energy efficiency and renewable energy within a set-aside.
4) Work with the developers of state-specific models, such as MIT's PV Assessment Methodology or eCalc, to take the necessary steps to expand these models nationally.
   Origin of recommendation: Developers of both tools say their tools were designed to be expandable to nationwide application.
   Benefit to states: Improved model accuracy and potential identification of other critical issues.
   a. In pilot programs such as those under EERE/Air Quality Integration Pilot (an initiative led by NASEO and DOE and supported by GETF, NREL, and EPA), continue to evaluate the accuracy of these emerging tools. Pilots include Texas (using the eCalc) and Shreveport, Louisiana (which has reviewed a number of models).
   b. Develop a form or script to convert existing EPA information such as Air Markets data into the format needed for input into these tools.
   c. Evaluate the accuracy of these tools when applied to other states.
   d. Provide technical support and possibly cost-sharing for states willing to undertake the local customization necessary for any of these tools. We understand that several states have approached ESL about developing versions of eCalc; while the underlying code can be transferred, states will need to customize data such as weather, geography, building standards, emissions regulations, grid characteristics, and other factors.
5) Together with DOE and the National Laboratories, conduct an evaluation of high-level energy system models. Compare the results of model runs among AMIGA, IPM, and NEMS, with the scenarios as identical as possible given the nature of the inputs to each model.
   Origin of recommendation: EPA report to Congress, 2001.

Benefit to states: tools based on these model runs (e.g. CACPS) will have results consistent with other models. Some users note that, possibly because IPM is run by a private company, it is not as transparent as NEMS.

6) Update existing tools and information resources, particularly eGRID.
   Origin of recommendation: Missouri Department of Natural Resources, with concurrence by others.
   Benefit to states: The eGRID tool is used in specific models and is also used in a less structured way for identifying emissions from power plants. However, the most recent version available has data for 2000 emissions. Clean Air Markets data is also an important information resource to maintain, although Dr. Connors of MIT indicated that his staff had managed to patch gaps in this resource where they existed.
   Note: Some respondents suggested that EPA should work with state public utility commissions and air quality offices to ensure that GAT systems under development are designed to facilitate analysis of emission reductions. If resources permit, we would encourage both maintenance of eGRID and support of GAT systems.
7) With NREL and DOE, develop emissions factors for non-woody biomass. Specifically, develop factors for crop waste, energy crops (e.g. switchgrass), and poultry litter. Extend NSR "presumption of benefit" exemption to biomass projects other than coal-to-wood substitution.
   Origin of recommendation: Missouri Department of Natural Resources.
   Benefit to states: Of all the renewable energy resources, biomass currently has the greatest economic potential for the largest number of states. For much of the Southeast U.S., biomass is the only large-scale cost-effective renewable energy resource.
8) With NREL and DOE, conduct analysis of the hourly dispatch of nuclear and hydroelectric facilities. Although they do not need to report emissions to Clean Air Markets, these sources indirectly impact air quality by altering the dispatch of fossil units.
   Origin of recommendation: Massachusetts Institute of Technology.
   Benefit to states: Superior model development.
9) With NREL and DOE, develop superior data on renewable energy production profiles, including derivation of estimates of year-to-year variability. Request that DOE and NREL develop hour-averaged profile of wind generation and superior data on solar insolation (both beam and diffuse).
   Origin of recommendation: Massachusetts Institute of Technology and Energy Systems Laboratory.
   Benefit to states: Superior model development; improved economic assessment of renewable resource utilization. Many states are interested in employing these resource to help meet air quality goals.
   Note: ESL advises that beam and diffuse thermopile-type solar sensors provide greater accuracy than only global horizontal measurements from photovoltaic-type solar sensors.
10) Convene a conference to bring together energy modelers and tool developers. Following the EPA/NREL peer review of methodologies, invite the parties responsible for these tools to attend a national conference. Participants would be invited to discuss their tools and explain how they can be used with a SIP. Participants would also be invited to identify key data needs where EPA, DOE, and NREL could provide support. Conference would provide an additional opportunity for peer review of the various tools.
    Origin of recommendation: Energy Systems Laboratory
    Benefit to states: Superior model development; bringing together disparate initiatives; formal peer review of the various methodologies.