U.S. POLICY ACTION NECESSARY TO ENSURE ACCURATE ASSESSMENT OF THE AIR EMISSION REDUCTION BENEFITS OF INCREASED USE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY TECHNOLOGIES

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INTRODUCTION

Policies encouraging energy efficiency and renewable energy ("EERE") technologies need to ensure that the air emission reduction benefits of these technologies are calculated accurately. Otherwise, the market will not fully capture their important economic and social benefits.

Federal, state, and local governments and private entities have developed protocols for reporting greenhouse gases ("GHG") and other air emissions.[1] Many of these protocols have been designed to allow emissions from individual sources to be aggregated into total emissions for an entire entity, such as a corporation or a governmental body, while appropriately emphasizing consistency, transparency, and the use of publicly available data. When measuring indirect emissions from electric power generation, these protocols have widely relied on total output emissions rates (the "eGRID system average methodology"[2]), which are based on information in the Emissions & Generation Resource Integrated Database ("eGRID"). The eGRID system average methodology is acceptable for reporting by corporations, governmental bodies, or other entities when they are aggregating emissions from all sources into an inventory.[3]

However, inadequate attention has been focused on methodologies for measuring the air emission reduction benefits of increased use of EERE and other low-emission technologies. This Article, presenting results of original research completed in 2008 and 2009, demonstrates that many individuals have misapplied the most commonly used methodology—the eGRID system average methodology. The eGRID system average methodology undervalues the GHG emission reduction benefits of increased use of EERE technologies in most regions of the country.[4]

This Article demonstrates that the eGRID system average methodology, when compared to the Resource System Group's Time Matched Marginal emissions methodology,[5] understates the carbon dioxide ("CO_2") and nitrogen oxide ("NO_x") emission reduction benefits of five EERE technologies[6] by approximately 65% to

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1 *See, e.g.*, WORLD RES. INST. & WORLD BUS. COUNCIL FOR SUSTAINABLE DEV., THE GREENHOUSE GAS PROTOCOL: A CORPORATE ACCOUNTING AND REPORTING STANDARD 3 (2004) [hereinafter GREENHOUSE GAS PROTOCOL], *available at* http://pdf.wri.org/ghg_protocol_2004.pdf.

2 As used in this Article, the term "eGRID system average methodology" is not a methodology "of" eGRID, but refers to a methodology that uses eGRID total output emission rates when verified, utility-specific emissions data is not available. *See generally* U.S. Environmental Protection Agency, eGRID Frequently Asked Questions, http://www.epa.gov/cleanenergy/energy-resources/egrid/faq.html (last visited Mar. 25, 2010) [hereinafter eGRID Frequently Asked Questions] (explaining that eGRID as used by EPA is an inventory of air emission data based on information from US electricity-generating plants).

3 *See infra* Part I.A (discussing two types of GHG protocols).

4 *See infra* Part II.

5 *See infra* Part I.B.3.

6 The five technologies studied in this 2008 and 2009 research work are wind energy, solar photovoltaic energy ("PV"), high-efficiency commercial air conditioning, high-efficiency commercial lighting, and LED traffic signal retrofits. *See infra* Part II (introductory text).

165% in the two power markets studied.[7] This Article also concludes that the emission reduction benefits of increased use of EERE technologies calculated with the Environmental Protection Agency's ("EPA") eGRID non-baseload methodology also are significantly higher than those calculated with the eGRID system average methodology.[8] Recent studies across all regions confirm that these findings are not isolated results but are indicative of widespread misapplication of the eGRID system average methodology by many users.[9]

Although the eGRID system average methodology is generally appropriate for estimating indirect emissions from electricity purchases ("scope 2 emissions") for general emission inventory purposes,[10] it does not accurately estimate the year-to-year impacts on GHG levels resulting from increased use of EERE technologies. The Climate Registry,[11] hundreds of local governments, and others have relied on the eGRID system average methodology since 2008 in their protocols for estimating emissions from electricity purchases in their GHG emission inventories.[12] This Article recommends that The Climate Registry consider developing an additional protocol and registry during the 2010 planned revision of its General Reporting Protocol to more accurately reflect the emission reduction benefits from increased use of EERE technologies by states and other entities.

Similarly, EPA should consider developing an additional protocol in its mandatory GHG reporting rule to fully value emission reduction benefits from increased use of EERE technologies. Specifically, regulatory agencies should use a methodology that calculates emission reductions at marginal units.[13] Ideally, these emission reductions should be calculated on an hourly basis.

Finally, this Article recommends addressing these problems in a cost-effective manner. An investment of limited funds by the Department of Energy ("DOE"), EPA, or state agencies to create an enhanced database of marginal electric generating units would enable government agencies and businesses to more accurately evaluate the cost-effectiveness of EERE programs in reducing emissions.

I. BACKGROUND

A. Role of EERE in Reducing Air Emissions from Electric Power Generation

The electric power sector is responsible for approximately forty percent of the CO_2 emissions in the United States[14] as well as significant direct and indirect emissions of methane and other greenhouse gases.[15] According to leading energy experts, the electric power sector requires a dramatic transformation to meet national targets for GHG emission reductions over the next several decades.[16] Adopting energy efficiency and zero or low-carbon emission technologies, such as renewable energy, is a key part of this transformation.[17] For example, the International Energy Agency has stated that a "global revolution is needed in ways that energy is supplied and used," and it has cited energy efficiency and renewable energy as central to this energy revolution.[18] Building and product efficiency measures, such as high-efficiency lighting and appliances, and dramatic increases in the use of wind and solar energy, are among the high priority technologies cited by the Agency.[19] In addition, many promising strategies for reducing GHG emissions from

7 The study focused on the PJM Interconnection and the Upstate New York power markets. *See infra* Part II.
8 *See infra* Part I.B.2 and Table 1.
9 *See infra* Part II.
10 THE CLIMATE REGISTRY, THE GENERAL REPORTING PROTOCOL FOR THE VOLUNTARY REPORTING PROGRAM, VERSION 1, at 97 (2008), *available at* http://www.theclimateregistry.org/downloads/GRP.pdf.
11 *Id.* at 8, 99.
12 *See infra* Part III.A.
13 Marginal units are fossil fuel-fired units whose power output varies with the overall level of power demand over time. *See* WORLD RES. INST. & WORLD BUS. COUNCIL FOR SUSTAINABLE DEV., GUIDELINES FOR QUANTIFYING GHG REDUCTIONS FROM GRID-CONNECTED ELECTRICITY PROJECTS 13-14, 54-57 (2007) [hereinafter QUANTIFYING GHG REDUCTIONS], *available at* http://pdf.wri.org/GHGProtocol-Electricity.pdf.
14 ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2010, EARLY RELEASE OVERVIEW 11 (2009), *available at* http://www.eia.gov/oiaf/aeo/pdf/overview.pdf.
15 *See* U.S. ENVTL. PROT. AGENCY, eGRID 2007, YEAR 2005 SUMMARY TABLES 1 (2008) [hereinafter EGRID SUMMARY TABLES], *available at* http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2007V1_1_year05_SummaryTables.pdf.
16 *See* INT'L ENERGY AGENCY, LAUNCHING AN ENERGY REVOLUTION IN A TIME OF ECONOMIC CRISIS: THE CASE FOR A LOW-CARBON ENERGY TECHNOLOGY PLATFORM 3 (2009), *available at* http://www.iea.org/G8/docs/Energy_Revolution_g8july09.pdf.
17 *Id.*
18 INT'L ENERGY AGENCY, ENERGY TECHNOLOGY PERSPECTIVES 2008: SCENARIOS AND STRATEGIES TO 2050 IN SUPPORT OF THE G8 PLAN OF ACTION 1-7 (2008).
19 *Id.*

the transportation sector involve advanced energy technologies, such as plug-in electric hybrid vehicles and electric cars, which reduce petroleum use through electrification.[20]

Implementing these strategies will increase the importance of ensuring the accurate assessment of the effects of EERE technologies on the electric grid, particularly hourly and seasonal differences in GHG emissions. In order to comprehensively report GHG emissions and to measure cost-effectiveness, it is necessary to improve the accuracy and lower the costs of methodologies applied by state and local governments and the private sector to estimate the emission reduction benefits of increased use of EERE technologies.[21]

Other air quality goals, including reducing ozone levels, also can be advanced by increasing use of EERE technologies and practices.[22] Many of these air quality problems are most serious during certain seasons, such as the summer ozone season, and certain hours of the day, such as summer afternoons.[23] Federal, state, and local agencies benefit from accurate and low-cost methodologies to estimate the impact of EERE strategies in the air quality planning process.[24]

In all energy sectors, it is important not only to use improved methods but also to obtain agreement on consistent protocols for quantification and reporting GHG emissions.[25] The need for more accurate methodologies intensified when the EPA adopted the first mandatory GHG reporting rules last year.[26] Moreover, the EPA is now considering options to expand its GHG registry to include indirect emissions from electricity purchases.[27]

There are currently two types of protocols relating to GHG emissions from the use of electric power. Confusion about the appropriate use of these two types of protocols lies at the heart of the issues discussed in this Article.

The first type of protocol is an emissions inventory to provide accounting of GHG emissions for a corporation or other entity.[28] The protocol is designed to facilitate reporting by the owners or operators of individual units, such as business plants and government buildings, so that these emissions can be aggregated for an entire corporation or governmental unit.[29] This protocol typically requires reporting of both indirect emissions and direct emissions.[30] Indirect emissions, also known as Scope 2 emissions, are air emissions that result from activities, such as electricity purchases, of one entity that occur at sources owned or controlled by another entity, such as an electric generating plant.[31] In contrast, direct emissions, also known as Scope 1 emissions, are air emissions from sources owned or operated by the reporting entity, such as GHG emissions from the smokestacks owned by a power generating company.[32]

The *Greenhouse Gas Protocol* of the World Resources Institute and the *General Reporting Protocol* of The Climate Registry are examples of emissions inventories that track both scope 1 and scope 2 emissions.[33] Electricity emission factors from the eGRID system average database are often used under these protocols to represent the amount of GHGs

20 INT'L ENERGY AGENCY, TRANSPORT, ENERGY, AND CO2: MOVING TOWARDS SUSTAINABILITY, EXECUTIVE SUMMARY 32-33 (2009), *available at* http://www.iea.org/Textbase/npsum/transport2009SUM.pdf.

21 *See infra* Part I.B.

22 U.S. ENVTL. PROT. AGENCY, GUIDANCE ON STATE IMPLEMENTATION PLAN (SIP) CREDITS FOR EMISSION REDUCTIONS FROM ELECTRIC-SECTOR ENERGY EFFICIENCY AND RENEWABLE ENERGY MEASURES 1 (2004) [hereinafter GUIDANCE ON STATE IMPLEMENTATION PLAN].

23 DEBRA JACOBSON & COLIN HIGH, ROLE OF ENERGY EFFICIENCY PROGRAMS IN BUILDINGS IN ADDRESSING AIR QUALITY AND GREENHOUSE GAS REDUCTION GOALS 1-3 (2008) [hereinafter ROLE OF ENERGY EFFICIENCY PROGRAMS], *available at* http://apps1.eere.energy.gov/wip/pdfs/tap_webcast_20080717_fact_sheet.pdf.

24 *See infra* Part III.

25 *See generally id*. (discussing technological improvements that would enhance federal and local air quality programs).

26 Mandatory Reporting of Greenhouse Gases, 74 Fed. Reg. 56,260 (Oct. 30, 2009) (to be codified at 40 C.F.R pt. 98); *see also infra* Part III.B.

27 Mandatory Reporting of Greenhouse Gases, 74 Fed. Reg. at 56,288.

28 GREENHOUSE GAS PROTOCOL, *s*upra note 1, at 3.

29 *Id*.

30 *Id.* at 26-27. Under reporting standards developed by the World Resources Institute and the World Business Council for Sustainable Development, operational boundaries have been established with respect to direct emissions and indirect emissions to assist entities in better managing the full spectrum of GHG risks and opportunities for reducing such risks. For many companies, indirect emissions from purchased electricity represent one of the largest sources of GHG emissions and the most significant opportunity to reduce these emissions. *Id.*

31 *Id.* at 25-27.

32 *Id.* at 27.

33 *Id.* at 25; THE CLIMATE REGISTRY*, supra* note 10, at 1. The eGRID system average methodology is typically used in cases where no verified, utility-specific data is available. See *infra* Part I.B.1 for a fuller discussion of the eGRID system average database and calculations.

emitted per unit of electricity consumed.[34] These emission factors are "usually reported in units of pounds of GHGs per kilowatt-hour or megawatt-hour."[35]

A second type of protocol has been developed to quantify reductions in GHG emissions that result from projects that either generate low-carbon electricity or reduce the consumption of electricity transmitted over electric power grids.[36] The most well-known protocol in this area is the *Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects*, developed by the World Resources Institute ("WRI Guidelines").[37] The WRI Guidelines are intended for use by two primary groups: (1) "project developers seeking to quantify GHG reductions outside the context of a particular GHG offset program or regulatory program"; and (2) "designers of initiatives, systems, and programs that incorporate grid-connected GHG projects."[38]

The basic approach set forth by the WRI Guidelines involves the calculation of both an "operating margin" and a "build margin."[39] According to the WRI Guidelines, the operating margin is defined as "electricity generation from existing power plants whose output is reduced in response to a project activity."[40] The WRI Guidelines use EERE technologies as the primary examples of such project activities.[41] The WRI Guidelines state that:

> [Operating margin] emissions are estimated using methods that attempt to approximate the emissions from the specific power plants whose operation is displaced. In theory, this estimation requires identifying which power plants are providing electricity at the margin . . . during the times that the project activity is operating. . . . Generation provided or avoided by the project activity may therefore affect a different marginal resource in each hour. . . . [E]stimating [operating margin] emissions can be a complex and data intensive task, matching a project activity's output to the marginal generating sources in each hour. In practice, a diversity of estimation methods can be used that vary in their complexity and accuracy.[42]

A spectrum of methodologies thus exist that have been used (and misused)[43] to estimate the operating margin. At one end of the spectrum are imprecise tools that estimate the impact of EERE measures on the average mix of emissions in the grid.[44] On the other end of the spectrum are methodologies, such as computer-based "hourly dispatch" models, that "capture a high level of detail on the specific electric generating units displaced by [EERE] projects or programs."[45] These dispatch models can be expensive and "difficult for non-experts to evaluate,"[46] and are therefore too advanced for most state and local governments. In addition, these dispatch models are generally proprietary,[47] which means that the assumptions used in calculating emission reduction benefits are not transparent to third parties.

B. Methodologies for Calculating Emission Reductions from EERE Technologies

Grid-connected EERE technologies, such as wind power, have zero direct air emissions[48] and displace emissions from fossil fuel-fired electric power generation.[49] These emission reductions occur because

34 GREENHOUSE GAS PROTOCOL, *supra* note 1, at 99.
35 *Id.*
36 *See* QUANTIFYING GHG REDUCTIONS, *supra* note 13, at 4.
37 *Id.*
38 *Id.* at 6.
39 *Id.* at 11-16.
40 *Id.* at 13.
41 *Id.* at 11.
42 *Id.*
43 *See infra* Part I.B.
44 STEVEN R. SCHILLER, NATIONAL ACTION PLAN FOR ENERGY EFFICIENCY MODEL ENERGY EFFICIENCY PROGRAM IMPACT EVALUATION GUIDE 6-5 (2007), *available at* http://www.epa.gov/cleanenergy/documents/evaluation_guide.pdf.
45 *Id.* at 6-7.
46 *Id.*
47 *Id.*
48 DEBRA JACOBSON & COLIN HIGH, U.S. DEP'T OF ENERGY OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, COMPARISON OF ALTERNATIVE AVOIDED EMISSIONS METHODOLOGIES APPLIED TO SELECTED NORTHEAST POWER MARKETS 4, *available at* http://www.mwcog.org/uploads/committee-documents/bf5dwFtb20081216140014.pdf.
49 QUANTIFYING GHG REDUCTIONS, *supra* note 13, at 11-12. In our Article, EERE is generally used to refer to energy efficiency and zero-emission renewable electric power generation, including solar energy, wind energy, geothermal energy, and tidal energy. Other renewable energy technologies, such as biomass, waste-to-energy, and landfill gas, do have some direct GHG emissions from combustion and other processes.

of the way the electric power system works. EERE technologies have zero fuel costs and very low incremental operating costs. In other words, when renewable generation produces power, electricity supplies from other sources generally will be reduced or not brought on-line.[50] For example, "a wind-generated kilowatthour displaces a kilowatthour that would have been generated by another source—usually one that burns a fossil fuel. . . The wind-generated kilowatthour therefore avoids the fuel consumption and emissions associated with that fossil-fuel kilowatthour."[51] When available, EERE technologies generally will displace generation at facilities with higher operating costs and varying output over time.[52]

The specific mix of coal, oil and gas-fired power units that will be displaced by EERE technologies varies significantly among states and regions of the country.[53] Some states, such as West Virginia and Pennsylvania, rely on coal plants for a majority of their generation, and in those States, coal units are displaced by EERE technologies during some seasons and times of day.[54] In comparison, natural gas units are more typically displaced in other states and regions, such as California and New England.[55]

EERE technologies "almost never displace nuclear power on the electric grid. Nuclear power plants are normally operated as baseload generators that run at full capacity (unless there is a planned or unplanned outage) because of low operating costs."[56]

In addition, EERE technologies generally do "not reduce hydroelectric power on the grid because of its low operating costs and flow constraints."[57] Although the operators of hydroelectric plants may shift the timing of their generation as a result of renewable energy use or energy savings, the "[t]otal generation at such hydroelectric plants is generally not reduced on average."[58]

Finally, the total amount of emission reductions resulting from EERE technologies also varies by time of day and season.[59] For example, emission reductions are highest in the middle of the day because energy efficiency savings, particularly from high-efficiency commercial air conditioners, "are greatest at the hours of the day with the highest temperatures and the highest electricity demand in offices and other commercial buildings."[60] Similarly, the energy savings and air emission reduction benefits of high-efficiency air conditioners are "concentrated in the summer months" whereas "high-efficiency refrigerators and dishwashers provide year-round energy savings."[61]

In this Article, we review three common methodologies used for quantifying emission reductions from increased use of EERE technologies, along with specific examples to illustrate the range of results. The three methodologies produce data with the following parameters: eGRID system average emission rates, eGRID non-baseload emission rates, and Time Matched Marginal ("TMM") emission rates.

Proprietary electric grid system dispatch models also have been used as a basis for calculating marginal emission rates from EERE technologies.[62] These models are not reviewed because they are proprietary, and as a result, the costs are often prohibitive. They also are not sufficiently transparent or replicable to be suitable for use in public accounting of air emissions.

1. EPA eGRID System Average Methodology

The eGRID database is maintained by the EPA and is "a comprehensive inventory of environmental attributes of electric power systems" in the United States.[63] According to EPA, eGRID is "[t]he

50 *Id.* at 11.
51 Michael Milligan et al., *Wind Power Myths Debunked,* IEEE POWER & ENERGY MAG., Nov.-Dec. 2009, at 89, 94.
52 DEBRA JACOBSON & COLIN HIGH, NAT'L RENEWABLE ENERGY LAB. SUBCONTRACTOR REPORT #SR-500-42616, WIND ENERGY AND AIR EMISSION BENEFITS: A PRIMER 9-10 (2008), *available at* http://www.windpoweringamerica.gov/pdfs/policy/wind_air_emissions.pdf. For more information on the complexities of analyzing avoided emissions under cap-and-trade programs, *see id.* at 12-17.
53 *Id.* at 10.
54 *Id.*
55 *Id.*
56 *Id.*
57 *Id.*
58 *Id.* The operating schedule of hydroelectric plants also may be limited by environmental constraints. *Id.*
59 ROLE OF ENERGY EFFICIENCY PROGRAMS, *supra* note 23, at 1-4. *See also* Press Release, PJM Interconnection, PJM Reports New Carbon Dioxide Emissions Data (Mar. 25, 2010) [hereinafter PJM Press Release], *available at* http://www.pjm.com/~/media/about-pjm/newsroom/2010-releases/20100325-pjm-reports-new-carbon-dioxide-emissions-data.ashx (attached graphic and tables comparing CO_2 emission rates of marginal generating units compared to CO_2 emission rates of system average generating units for 2005 to 2009).
60 *Id.* at 3.
61 *Id.* at 1.
62 *See supra* text accompanying note 45-47.
63 eGRID Frequently Asked Questions, *supra* note 2.

preeminent source of air emissions data for the electric power sector. . . ."[64] The eGRID database is derived from:

> [A]vailable plant-specific data for all U.S. electricity generating plants that provide power to the electric grid and report data to the U.S. government. eGRID integrates many different federal data sources on power plants and power companies, from three different federal agencies: EPA, the Energy Information Administration (EIA), and the Federal Energy Regulatory Commission (FERC).[65]

This database contains air emissions data for several GHGs, including CO_2, methane ("CH_4") and nitrous oxide ("N_2O").[66] It also provides data for the following criteria and hazardous air pollutants: NO_x, sulfur dioxide ("SO_2"), and mercury ("Hg").[67]

The eGRID database is provided in a web-based application, eGRIDweb, as well as in Microsoft Excel format.[68] The database is publicly accessible on the EPA's web site.[69] The EPA funds a contractor[70] to compile various types of data, including aggregated emissions data by state, electric generating company, parent company, power control area, eGRID subregion, North American Electric Reliability Corporation ("NERC") region, and total U.S. levels.[71] "Total emissions and emission rates, and total generation and resource mix are displayed for each of these levels."[72] The two most important eGRID output emission rates are the system average emission rates (also called "total output emission rates") and the non-baseload emission rates.[73]

The system average emissions rate is calculated by dividing the total annual emissions of a particular pollutant[74] from all units in a region or power system (i.e., within the relevant grid boundary) by the total energy output of those units over the year.[75] This system, or grid average, includes all units that report data to the government, including nuclear power plants, hydroelectric plants, and other zero-emission sources as well as fossil fuel-fired generation units.[76] The system average emission rates rely on information from electric generation companies required to provide emissions data to both the EPA, including data from Continuous Emissions Monitors ("CEMs"), and to the Energy Information Administration.[77]

The EPA reports the system average emission rates for the NERC regions and eGRID subregions shown in Figure 1.[78] The twenty-six eGRID subregions are subsets of the NERC regions.[79]

Figure 1: Map of U.S. EPA eGRID Subregions.

The most recent eGRID database available includes emissions data for calendar year 2005.[80] The eGRID system average emission rates for each eGRID subregion vary considerably depending on the amount

64 *Id.*
65 *Id.*
66 *Id.*
67 *Id.*
68 SUSY ROTHSCHILD & ART DIEM ET AL., THE VALUE OF EGRID AND EGRIDWEB TO GHG INVENTORIES 1 (2009).
69 *See* U.S. Environmental Protection Agency, eGRID, http://www.epa.gov/egrid (last visited Mar. 25, 2010) [hereinafter eGRID].
70 *See* E.H. PECHAN & ASSOC., INC., EGRID EMISSIONS AND GENERATION RESOURCE INTEGRATED DATABASE VERSION 1.0 USER'S MANUAL (2009).
71 eGRID, *supra* note 69.
72 *Id.*
73 *See* ROTHSCHILD & DIEM ET AL., *supra* note 68, at 5-7.
74 Measurements are typically in pounds. *See* SCHILLER, *supra* note 44, at 6-5.
75 *See id*. Total energy output of units over a year is typically measured in Megawatt-hours or MWh.
76 *See* E.H. PECHAN & ASSOC., INC., THE EMISSIONS & GENERATION RESOURCE INTEGRATED DATABASE FOR 2007 TECHNICAL SUPPORT DOCUMENT (2008), *available at* http://www.epa.gov/RDEE/documents/egridzips/eGRID2007TechnicalSupportDocument.pdf.
77 *See id.* at 4.
78 EGRID SUMMARY TABLES, *supra* note 15, at 6, 10.
79 eGRID Frequently Asked Questions, *supra* note 2; *see* ROTHSCHILD & DIEM ET AL., *supra* note 68, at 1.
80 *See* eGRID, *supra* note 69.

of zero emission sources, such as nuclear and hydroelectric power, in the subregion.[81] Analyses conducted by Resource Systems Group, Inc. ("RSG") reveal that the system average emission rates are the lowest of the three methods discussed here in most eGRID subregions.[82]

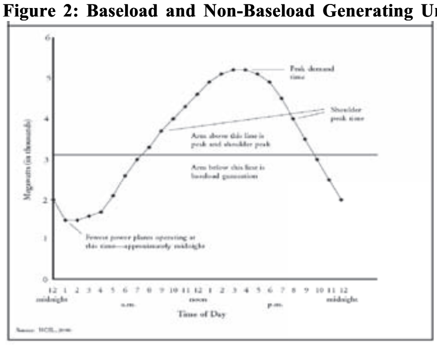
The methodology for calculating indirect emissions from electricity purchases, as adopted by The Climate Registry, relies on system average emission rates (when verified, utility-specific data is not available).[83] As a result, this methodology implicitly values emission reduction benefits of EERE technologies at the same emissions rate as the system average rate. Under the system average methodology, year-to-year changes in electric power purchases resulting from increased use of EERE technologies are accounted for by calculating the difference between the indirect emissions from electricity purchases in successive years based on the eGRID system average emission rates.[84]

However, according to the WRI Guidelines, "because calculating a simple average is significantly less precise than other methods," the system average approach "should only be used where other methods are not practicable [for calculating the operating margin for EERE projects]."[85] As discussed below, the eGRID system average methodology has been found to significantly understate the emission reduction benefits of increased use of EERE technologies in most regions.[86]

2. eGRID Non-Baseload Average Methodology

The eGRID non-baseload methodology is based on an understanding of the way in which increased EERE technology use displaces fossil fuel-fired electric generation.[87] This type of methodology focuses on electric generating units whose output varies according to the overall level of power demand (the "load" level) in the regional power market.[88] These load-following generating units are generally fossil fuel-fired, and include generating units usually classified as intermediate (shoulder) load and peak load plants.[89] These units are also called "marginal units" because they provide electricity "at the margin," and their output varies depending on the load.[90] Baseload units are generally excluded but may function as marginal units during certain hours and seasons of the year.[91] For example, some coal plants operate as intermediate plants in the PJM[92] Interconnection power market during certain times of the year.[93] Figure 2 highlights the distinction between baseload and non-baseload (shoulder/intermediate and peak load) generating units.[94]

Figure 2: Baseload and Non-Baseload Generating Units



Source: National Conference on State Legislatures, 2005.[95]

81 The EPA eGRID summary tables provide information on the generation resource mix (percent of generation from coal, oil, natural gas, other fossil fuels, biomass, hydro, nuclear, wind, solar, geothermal, and other) in each of the eGRID subregion. These summary tables also provide information on the eGRID emissions rates in each of these regions. A comparison of these tables demonstrates that the eGRID system average emission rates are lower when a subregion or region has a high percentage of nuclear and hydro resources in the generation mix. *See* EGRID SUMMARY TABLES, *supra* note 15, at 6, 10.

82 *See infra* Part II.

83 THE CLIMATE REGISTRY, *supra* note 10, at 99.

84 *See id.* at 99-100.

85 QUANTIFYING GHG REDUCTIONS, *supra* note 13, at 55.

86 *See* discussion *infra* Part II. *See also* PJM Press Release, *supra* note 59 (attached graphic and tables comparing CO_2 emission rates of marginal generating units compared to CO_2 emission rates of system average generating units for 2005 to 2009).

87 *See supra* Part I.B.1.

88 QUANTIFYING GHG REDUCTIONS, *supra* note 13, at Annex A.1.

89 Matthew Brown et al., NAT'L CONFERENCE OF STATE LEGISLATURES, ENERGY AND AIR QUALITY: THE POWER INDUSTRY AND AIR QUALITY 6-7 (2005).

90 QUANTIFYING GHG REDUCTIONS, *supra* note 13, at 55.

91 JACOBSON & HIGH, *supra* note 52, at 10.

92 PJM is a regional transmission organization supplying Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia. *See* PJM: Who We Are, http://www.pjm.com/about-pjm/who-we-are.aspx (last visited Mar. 25, 2010).

93 JACOBSON & HIGH, *supra* note 52, at 10.

94 Brown et al., *supra* note 89, at 6.

95 *Id.*

The major difference between the eGRID system average methodology and the eGRID non-baseload methodology is the group of generating units that is considered in calculating the avoided emissions rate. Whereas the eGRID system average methodology considers the emissions of *all* generating units operating on the regional or subregional power grid, the non-baseload calculation excludes all generation from resources that are not fossil fuel-fired.[96] Thus, "[p]lants with 100% hydro, nuclear, wind, solar, and/or geothermal generation are removed from the non-baseload calculation."[97] In addition, "[no] generation at plants with high capacity factors (0.8 and greater) is considered in the calculation of the non-baseload emissions rate."[98] Thus, the non-baseload average emission rates do not include consideration of emissions from baseload units[99] such as nuclear power plants, hydroelectric power plants, and many coal-fired plants.[100]

As highlighted by a sample of subregional power markets in the 2005 eGRID Subregion Emission Rates table, the eGRID non-baseload emission rate is significantly higher than the system average rate in most regions[101] because it excludes zero-emission nuclear and hydropower units and renewable energy generation.[102]

Table 1: Comparison of eGRID Non-Baseload Methodology and eGRID System Average Methodology for Selected eGRID Subregions[103]

Subregional Power Market	Non-Baseload Methodology (lb. CO_2 /MWh)	System Average Methodology (lb. CO_2/MWh)
Midwest (MROW)	2,158.79	1,821.84
Midwest (SRMW)	2,101.16	1,830.51
Mid-Atlantic (RFCE)	1,790.50	1,139.07
California (CAMX)	1,083.02	724.12
Southwest (AZNM)	1,201.44	1,311.05

Comparison of the eGRID database reveals that the eGRID non-baseload emissions rate is higher than the eGRID system average rate in twenty out of the twenty-six eGRID subregions.[104] Experts involved in the 2005 eGRID database confirmed this conclusion in a recently published paper, stating that "in general, with few exceptions, the non-baseload values are larger than the total output emission rates."[105]

The eGRID non-baseload average emission rates for eGRID subregions are also provided by the EPA on its website and in its summary reports.[106] The EPA's Green Power Partnership appropriately relies on the eGRID non-baseload average methodology in calculating emission reductions resulting from the use of renewable energy generation.[107] This EPA program has developed a calculator tool that incorporates the eGRID non-baseload methodology.[108]

96 *See* E.H. Pechan & Assoc., Inc., *supra* note 76, at 15.
97 *Id.*
98 *Id.* According to the technical document, the non-baseload average is calculated from a percentage of each plants emissions and generation (depending upon capacity factor) that combusts fuel and has a capacity factor of less than 0.8. *Id.* at 15.
99 *Id.*
100 *Id*. Nuclear, hydroelectric, and coal plants are considered baseload plants because their capacity factor is greater than 0.8. *Id.*
101 *See* eGRID Summary Tables, *supra* note 15, at 6.
102 E.H. Pechan & Assoc., Inc., *supra* note 76, at 15.
103 eGRID Summary Tables, *supra* note 15, at 6.
104 eGRID Summary Tables, *supra* note 15, at 6.
105 Rothschild & Diem et al., *supra* note 68, at 7.
106 *Id.*
107 *See* U.S. Environmental Protection Agency, Green Power Partnership, http://www.epa.gov/greenpower/index.htm (last visited Mar. 5, 2010) [hereinafter Green Power Partnership]. The Green Power Partnership is a voluntary EPA program that supports the organizational procurement of green power by offering expert advice, technical support, tools and resources. For purposes of this program, green power is defined as electricity produced from a subset of renewable resources, such as solar, wind, geothermal, biomass, and low-impact hydro. *See id.*
108 *See* U.S. Environmental Protection Agency, Green Power Equivalency Calculator,

3. Time-Matched Marginal Emissions Methodology ("TMM")

Over the course of several years, Resource Systems Group ("RSG") has developed a methodology for estimating air emissions avoided by the increased use of EERE technologies. This TMM emissions methodology differs from the eGRID system average approach in several fundamental ways.

First, the TMM methodology is based on emissions monitoring data for each of the 8,760 hours of the year for generating units that submit hourly data to EPA. In comparison, the eGRID database focuses on *annual* averages of emissions for grid-connected electric generators.[109] The significance of this difference is underscored by the National Action Plan for Energy Efficiency, a coalition of the DOE, EPA, and more than fifty other agencies and organizations.[110] The National Action Plan's *Model Energy Efficiency Program Evaluation Guide*, released in November 2007, emphasizes that the eGRID system average approach to estimating avoided emissions has several major limitations.[111] The first major limitation is summarized as follows:

> [One] shortcoming of this approach is that energy efficiency savings tend to vary over time, such as savings from an office lighting retrofit that only occurs during the workday. Using an annual average emission factor that lumps daytime, nighttime, weekday, and weekend values together can skew the actual emissions benefits calculation.[112]

The second difference between the TMM methodology and the eGRID system average methodology is that the TMM methodology focuses on the actual generating units expected to be displaced when renewable energy generation or energy savings take place. Nuclear units and hydropower units are thus generally not considered by the TMM methodology when calculating avoided emissions.

In comparison, the eGRID system average methodology considers nuclear and hydroelectric units in calculating avoided emissions, even though such units are rarely displaced by increased use of EERE technologies.[113] The National Action Plan's *Program Evaluation Guide* views the inclusion of nuclear and hydroelectric units as a shortcoming of the methodology:

> A shortcoming of this [system average] approach is that it does not account for the complexity of regional power systems. . . . In many regions, the marginal units displaced by energy efficiency programs can have very different emissions characteristics from the base load units [such as nuclear and hydropower] that dominate the average emissions rate.[114]

The eGRID non-baseload methodology also shares the first limitation of the eGRID system average methodology because it is based on the annual average avoided emissions,[115] instead of a more accurate hourly measure. However, it differs from the system average methodology and shares a benefit of the TMM methodology because it focuses on the non-baseload units that are actually displaced when EERE technology comes online.[116]

Thus, RSG's TMM methodology provides a marginal rather than a system average emission rate. In addition, it uses a time-matching approach that is specific to the EERE technology under consideration. The TMM methodology is based on the following steps:

1. Estimating the hourly electric power generation for each fossil fuel-fired unit in a specific power market area;
2. Identifying the marginal fossil fuel-fired units at each hour by using the hourly generation to identify units that follow the total load at each hour. Based on this information, RSG's TMM method estimates average emission rates of the marginal units based on their incremental contribution to the load;
3. Using data to compile a profile of the energy savings or energy generation on an hourly basis over

http://www.epa.gov/greenpower/pubs/calculator.htm (last visited Mar. 5, 2010). This tool is only available to Partnership members.

109 *See supra* Part I.B.1.

110 SCHILLER, *supra* note 44.

111 *Id.* at 6-5.

112 *Id.*

113 *See* Part I.B.

114 SCHILLER, *supra* note 44, at 6-5.

115 E.H. PECHAN & ASSOC., INC., *supra* note 76, at 15.

116 *Id.*

the 8760 hours of the year. This profile is prepared for a particular technology, such as wind power or high-efficiency commercial air conditioning, and for a particular region;[117]

4. The "time-matching" occurs when the load profile is matched for a specific technology on an hourly basis against the marginal emissions profile for the same hours;

5. The avoided emission rates can be used to produce, in Microsoft Excel format, a calculator that provides total avoided emissions from annual generation or savings, using either project-specific profiles or default regional profiles. This calculator also can be used to estimate avoided emissions on a monthly or seasonal basis.

Although RSG pioneered the TMM methodology, at least one other prominent energy consulting firm has used a conceptually similar approach. In July 2008, Synapse Energy Economics published a report for the EPA using an hourly approach to estimate avoided emissions based on hourly EPA CEM data from intermediate and peak load generating units.[118] This report, entitled *Analysis of Indirect Emissions Benefits of Wind, Landfill Gas, and Municipal Solid Waste Generation*, calculates avoided emissions for the three selected renewable energy technologies in each of the EPA's twenty-two eGRID subregions in the continental U.S.[119] The regional, hourly power profiles for each of the three renewable resources are combined with the hourly indirect emissions factors to yield annual indirect emissions benefits for each type of resource for each eGRID subregion.[120]

Researchers at the Laboratory for Energy and the Environment at the Massachusetts Institute of Technology ("MIT") also have studied the emission reductions from another renewable energy technology, solar photovoltaics ("PV"), using a methodology similar to the TMM method.[121] The MIT study relies on "matching up PV generation with associated changes in unit generation on an hourly basis."[122] It focuses on the fossil fuel units offset by PV generation in each region and each hour of the day.[123]

Moreover, the MIT study expresses serious concerns about the system average approach.[124] The researchers stressed that "[t]his report also challenges the simple averages approach on the ground that there is no evidence that average . . . emission rates occurring when PV is generating are representative of the fossil units that respond to changes in load, to be met by dispatchable generation."[125]

Finally, the DOE's Loan Guarantee Program Office ("LGPO") has adopted the RSG TMM methodology as a component in its review of loan guarantee applications for EERE projects.[126] The LGPO is applying the methodology in its evaluation of comparative GHG and air emission reduction benefits of projects competing for loan guarantees.[127]

II. FINDINGS FROM COMPARISON OF THREE AVOIDED EMISSIONS METHODOLOGIES

In 2008, RSG conducted an analysis of results from the three different methodologies that measure the emissions impact of increased use of EERE technologies. The analysis focused on five EERE technologies: high-efficiency commercial lighting, high-efficiency commercial air conditioning, LED traffic lights, solar PV, and wind energy. In each case, RSG compared the avoided emissions from a specific technology using its TMM methodology, the eGRID system average methodology, and the eGRID non-baseload methodology. RSG analyzed both the PJM

117 The recommendations in Part IV*, infra*, highlight the need for additional work to refine these load profiles and to make them publicly available.

118 *See* BRUCE BIEWALD ET AL., U.S. ENVTL. PROT. AGENCY, OFFICE OF RESEARCH AND DEV., ANALYSIS OF INDIRECT EMISSIONS BENEFITS OF WIND, LANDFILL GAS, AND MUNICIPAL SOLID WASTE GENERATION i (2008), *available at* http://www.synapse-energy.com/Downloads/SynapseReport.2008-07.EPA.EPA-Indirect-Emissions-Benefits.06-087.pdf.

119 *Id.*

120 *Id.*

121 *See* THE ANALYSIS GROUP FOR REG'L ENERGY ALTERNATIVES, EMISSIONS REDUCTIONS FROM SOLAR PHOTOVOLTAIC (PV) SYSTEMS 1-4 (2004), *available at* http://web.mit.edu/agrea/docs/MIT-LFEE_2004-003a_ES.pdf.

122 *Id.* at 1-2.

123 *Id.* at ES-1.

124 *Id*. at 1-4.

125 *Id*.

126 The LGPO subcontracted with RSG to conduct the analysis of GHG and air emission reduction benefits on the electric grid resulting from alternative technologies competing for loan guarantees, and RSG is applying its TMM methodology in this process. *See generally* RSG, Inc., Avoided CO2 Emissions, http://www.rsginc.com/avoided-co2-emissions-2/ (last visited Mar. 25, 2010). The DOE required applicants to set forth the hourly load profiles for electric generation or savings under their technologies as part of the loan guarantee application process. See LOAN GUARANTEE PROGRAM OFFICE, U.S. DEP'T OF ENERGY, ELECTRICAL PROFILES—GENERATION, PURCHASES, SAVINGS AND TRANSFERS WORKSHEET (2008), *available at* http://www.lgprogram.energy.gov/lew.xls.

127 *Id.*

Interconnection power market and the Upstate New York power market.

The findings of this analysis are as follows:

1. Avoided air emission benefits for the five EERE technologies for CO_2 and NO_x are from 65% to 165% or more higher using the TMM methodology when compared to the eGRID system average method;

2. Avoided air emissions benefits for the five EERE technologies for CO_2 are from approximately fifteen percent higher using the TMM methodology when compared to the eGRID non-baseload methodology;

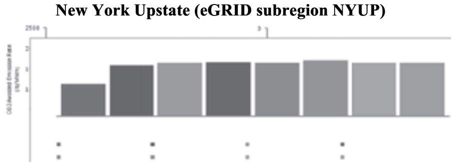
3. Within the two power market areas studied, the emission reduction benefits associated with the five different EERE technologies varied by only up to three percent. The variability is mainly associated with the degree of seasonal variation in electricity savings or additional renewable energy generation.

4. In all cases, the results for NO_x are more complicated and more variable than the results for CO_2. This complexity is related to the highly variable emission rates for NO_x resulting from large differences in the efficiency of pollution control technologies for this pollutant. In comparison, there are no pollution controls for CO_2 on the units studied.

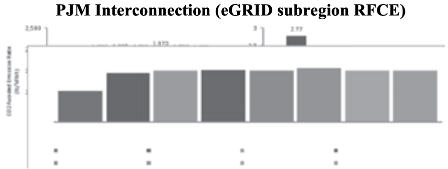
Figure 3 highlights these results, and the actual data relating to these summary findings is set forth in the Appendix.

Figure 3: Comparison of RSG TMM Avoided Emissions Rates for NO_x and CO_2 with eGRID Emission Rates for the Upstate New York and PJM Interconnection Power Markets

New York Upstate (eGRID subregion NYUP)



PJM Interconnection (eGRID subregion RFCE)



The wide variation in the results poses significant challenges to state and local governments in preparing GHG inventories and conducting other GHG accounting.[128] The following hypothetical example highlights the differences among the three methodologies. (It should, however, be noted that the eGRID system average methodology is not recommended for this type of estimation even though it is often inappropriately used for calculating emission reductions resulting from increased use of EERE technologies).[129]

This hypothetical involves a municipality in western New York that is tracking its GHG emissions and reporting under The Climate Registry protocols—using system average emission rates for its purchase of electricity. Assume that the municipality decided to reduce its GHG emissions to meet a target in its Climate Action Plan and decided to install a municipal wind farm to power its own facilities and generate 10,000 MWh per year. The reported avoided emissions from the three alternative emissions assessment methodologies are shown in Table 2.

Table 2: Avoided CO_2 Emissions from 10,000 MWh of Wind Energy Generation in Upstate New York. Based on 2005 Data.

Avoided Emissions Methodology	Avoided CO_2 Emissions (Tons per Year)	Organization Using Methodology
eGRID System Average	3,600	Climate Registry[130]
eGRID Non-Baseload Average	7,571	EPA Green Power Partnership
Time-Matched Marginal (TMM)	9,160	DOE Loan Guarantee Program, Metro Washington COG

128 In this example (and for simplicity), we only have considered avoided emissions from operational changes in generation in the near-term. We have not considered the added complexity that additional generation may have on reducing the need to build new electric generating capacity in the future.

129 *See generally* Part III (discussing the widespread use of the eGRID system average methodology).

130 *See infra* Part III.A.

Under this example, the municipality's own wind power project would result in a decrease in reported CO_2 emissions to The Climate Registry of approximately 3,600 tons per year.[131] On the other hand, the municipality might be a member of EPA's Green Power Partnership and calculate the air emission benefits from its new wind farm using the eGRID non-baseload methodology. Under this methodology, the emission reduction benefits claimed would be 7,571 tons of CO_2.[132] The amount of avoided CO_2 emissions reported under this non-baseload methodology would thus differ substantially from the amount of avoided CO_2 emissions calculated under the eGRID system average methodology. Moreover, using an hourly marginal emissions analysis, such as the TMM method, a more accurate estimate of the avoided emissions benefits of a municipal purchase of 10,000 MWh of wind power would be about 9,160 tons of CO_2.

If the municipality wanted to quantify its progress toward a GHG reduction target, the TMM methodology would be most accurate in the near-term. This hypothetical illustrates the need for greater consistency and accuracy in calculating and reporting CO_2 reduction benefits.

The analysis described above is based on only two of the twenty-six NERC subregions. However, subsequent to the completion of the research included in this Article, RSG analyzed the emission reduction benefits of a wide range of EERE projects across all of the NERC regions and virtually all of the NERC subregions. RSG's analysis confirms that the use of the TMM methodology results in significantly higher emission reduction benefits than using the eGRID system average methodology in most regions of the country. The comparison with the non-baseload average is more complex, making it difficult to draw clear conclusions.

Thus, this recent work further confirms that the eGRID system average methodology is an inappropriate approach for assessing the avoided emissions benefits of specific EERE programs and projects, which is implicit in how state and national registries and accounting programs currently estimate indirect emissions from electricity purchases.[133] This conclusion was supported by EPA eGRID experts at the recent Energy and Environmental Conference 2010 (commonly called the EUEC 2010) in Phoenix.[134] According to a paper presented by the eGRID experts, the eGRID non-baseload emission rates, rather than the eGRID total output emission rates (system average rates), are recommended for use in estimating "the emissions benefits of reductions in grid supplied electricity use, especially those that are somewhat coincident with peak demand."[135] The experts specifically recommended the eGRID non-baseload methodology to calculate emission reductions from using high-efficiency air conditioning.[136]

III. Improved Methodologies Would Benefit Federal and State Climate and Air Quality Programs

A. The Climate Registry's Reliance on the eGRID System Average Methodology

It is very important to promptly address the inappropriate use of the eGRID system average methodology for calculating changes in CO_2 emissions resulting from increased use of EERE technologies. Unfortunately, a large majority of states and hundreds of local governments and private entities using GHG emission protocols are misapplying the system average avoided emissions methodology in these circumstances.[137] Reliance on the eGRID system average methodology has significant ramifications because of the possibility that other government entities and the authors of national climate legislation will follow this precedent.

Most importantly, the General Reporting Protocol of The Climate Registry—a non-profit organization

131 The Climate Registry's General Protocol does suggest the reporting of supplemental information about green power purchases in its entity-wide report on indirect emissions from electricity purchases. The Climate Registry, *supra* note 10, at 101. However, the indirect emissions that are reported as scope 2 emissions from electricity purchases would only be reduced by 3,600 tons.

132 U.S. Environmental Protection Agency, eGRID2007 Version 1.1 Year 2005 GHG Annual Output Emission Rates, http://cfpub.epa.gov/egridweb/ghg (last visited Mar. 23, 2010) (listing the "[a]nnual non-baseload output emissions rates" for Upstate New York (NYUP) as 1511.14 lb CO2/KWH); U.S. Environmental Protection Agency, Green Power Partnership, Green Power Equivalency Calculator, http://www.epa.gov/greenpower/pubs/calculator.htm (last visited Mar. 23, 2010).

133 *See infra* Part III.C.

134 *See* Rothschild & Diem et al., supra note 68, at 6.

135 *Id.*

136 *See id.*

137 *See infra* notes 171-73 and accompanying text.

comprised of forty states and the District of Columbia—recommends the use of system average emissions rates to calculate indirect GHG emissions from electricity purchases if utility-specific emissions information is not available.[138] The Climate Registry's General Reporting Protocol incorporates a table that contains specific emission factors to apply in such cases—the eGRID system average.[139]

The General Reporting Protocol does suggest the reporting of supplemental information regarding green power purchases in its entity-wide report on indirect emissions from electricity purchases.[140] However, this Protocol does not require any reductions in the level of indirect emissions from electricity purchases (scope 2 emissions) reported as a result of the increased use of renewable energy technologies and does not require an additional inventory to reflect emission reductions that result from increased use of renewable energy technologies.[141] The General Reporting Protocol, moreover, does not discuss any adjustments to account for reductions in energy use from major energy efficiency projects undertaken by an entity.[142]

In comparison to the TMM methodology, the General Reporting Protocol methodology does not involve marginal emissions rates, nor does it require time-varying profiles of specific EERE technologies.[143] A companion Protocol developed by the Local Governments for Sustainability ("ICLEI") in partnership with The Climate Registry, the California Climate Action Registry, and the California Air Resources Board, uses a similar approach.[144] In addition, as discussed below, Climate Registry protocols have been referenced in several major pieces of national climate legislation.[145]

It should be noted that The Climate Registry's General Reporting Protocol "recognizes the need to develop a specific accounting framework for green power purchases in order to encourage and incentivize emission reduction efforts."[146] The General Reporting Protocol, however, asserts that "[t]here is not yet consensus on how to accurately and credibly track green power purchases in an accounting framework, beyond allowing Reporters to provide supplementary information about their green power purchases in annual emission reports."[147]

In its General Reporting Protocol, The Climate Registry committed to "incorporating a framework for accounting for contractual purchases of electricity, such as green power," as it "develop[ed] an industry specific protocol for the power and utility sector. . . ."[148] Unfortunately, The Climate Registry did not resolve this issue when it issued its voluntary reporting protocol for the electric power sector in June 2009.[149]

The Climate Registry's Protocols raise particular concerns about the disconnect between year-to-year changes in CO_2 emissions reported to The Climate Registry, as compared to energy efficiency savings, and related GHG emission reductions reported by state energy agencies and electric utilities. For example, if the State of Maryland—a member of The Climate Registry—reports its CO_2 inventory under the General Reporting Protocol, it is likely to underestimate the benefits of energy savings from high-efficiency heating equipment in the State for a variety of reasons, including the fact that the eGRID system average methodology does not reflect seasonal changes in avoided emissions.[150]

This issue of seasonal variation is significant because the avoided CO_2 emissions from energy efficiency technologies in Maryland are greater in the

138 *See* THE CLIMATE REGISTRY, *supra* note 10, at 99. The Climate Registry is a non-profit organization that supports public reporting of greenhouse gas emissions throughout North America in a single unified registry. The Protocol indicates that generator-specific emission factors are preferred instead of eGRID data but allows the use of eGRID data when such generator-specific emission factors are not available. Even with respect to the generator-specific data, the Protocol does not require the use of marginal emissions data. *See id.* at 99.
139 *See id.* at 99, 104.
140 *See id.* at 101.
141 *See id.*
142 *See id.* at 97-108.
143 *Compare id.*, *with supra* Part I.B.3 (discussing TMM methodology).
144 LOCAL GOV'TS FOR SUSTAINABILITY ET AL., LOCAL GOVERNMENT OPERATIONS PROTOCOL, VERSION 1.0, at 169, 175-76 (2008), *available at* http://www.icleiusa.org/action-center/tools/lgo-protocol-1 (using system average data in Tables providing default electricity emissions factors).
145 *See infra* notes 160-67 and accompanying text.
146 THE CLIMATE REGISTRY, *supra* note 10, at 101.
147 *Id.*
148 *Id.*
149 THE CLIMATE REGISTRY, ELECTRIC POWER SECTOR PROTOCOL FOR THE VOLUNTARY REPORTING PROGRAM, ANNEX 1 TO THE GENERAL REPORTING PROTOCOL, VERSION 1.0, at 54, 64-67, 76-77 (2009), *available at* http://www.theclimateregistry.org/downloads/2009/05/Electric-Power-Sector-Protocol_v1.0.pdf.
150 *See* NAT'L ACTION PLAN FOR ENERGY EFFICIENCY, MODEL ENERGY EFFICIENCY PROGRAM IMPACT GUIDE 6-5 (2007), *available at* http://www.epa.gov/cleanenergy/energy-programs/napee/resources/guides.html#guide5.

winter months.[151] The fossil fuel-fired units displaced in the regional power market are more often coal-fired units with high CO_2 emissions.[152] As Maryland implements its new EmPOWER Maryland efficiency initiative,[153] The Climate Registry methodology is thus unlikely to reflect the full benefits of the new initiative.

The eGRID system average methodology also will not provide an accurate comparison of the cost-effectiveness of alternative GHG reduction strategies that rely on EERE technologies, particularly comparisons of actions in different regions and power markets. For example, the MIT study emphasized that the degree of reliance on higher emitting fossil fuel-fired electricity in a particular power grid will be a greater determinant of the level of avoided emissions from solar photovoltaic energy than the amount of sunshine in a particular region.[154] This fact may heighten the CO_2 reduction value of solar energy in certain regions, such as the Northern Plains and the Tennessee Valley, which generally are not viewed as promising solar generation areas.[155] Furthermore, the adoption of time-of-use pricing in electricity markets[156] will require increased emphasis on time-of-use avoided emissions analysis if the cost-effectiveness of energy efficiency programs is to be properly evaluated.

The misapplication of the eGRID system average is likely to have sweeping impacts because the broad geographic membership of The Climate Registry has spurred partnerships with other important organizations. For example, in December 2008, ICLEI announced a partnership with The Climate Registry to encourage local governments to report their emissions as members of The Climate Registry.[157] Previously, ICLEI had worked with The Climate Registry to develop the Local Government Operations Protocol to facilitate reporting of GHGs by local governments.[158] More than 600 local governments in the United States are members of the ICLEI organization.[159]

Several pieces of national climate legislation also have referenced The Climate Registry's protocol. For example, H.R. 2454, the American Clean Energy and Security Act of 2009, approved by the House of Representatives in June 2009, references The Climate Registry in its provisions establishing a greenhouse gas registry.[160] Section 713(b)(1) requires the EPA Administrator to issue regulations establishing a federal greenhouse gas registry, and subsection (b)(1)(E) requires the Administrator to: "[T]ake into account the best practices from the most recent federal, state, tribal and international protocols for the measurement, accounting, reporting, and verification of greenhouse gas emissions, *including protocols from The Climate Registry* and other mandatory state or multistate authorized programs."[161]

Moreover, H.R. 2454 requires the EPA Administrator to explain any major differences in the approach between the registry established under the new regulations and The Climate Registry and other mandatory state and multistate programs.[162] The Climate Registry is defined in the legislation as "the greenhouse gas emissions registry jointly established and managed by more than 40 States and Indian tribes

151 Information is based on RSG Inc. TMM emissions methodology discussed *supra* Part I.B.3.

152 *Id*.

153 *See* Maryland Energy Administration, Energy Facts and Programs, http://www.energy.maryland.gov/facts/empower/index.asp (last visited Mar. 25, 2010). Under Maryland's "EmPOWER Maryland" initiative, the state is working with its utilities to require actions to reduce energy consumption by fifteen percent by the year 2015. *Id*.

154 STEPHEN CONNORS ET AL., LAB. FOR ENERGY & THE ENV'T, EMISSIONS REDUCTIONS FROM SOLAR PHOTOVOLTAIC SYSTEMS ES-2, at 8-1 (2005), *available at* http://solar.gwu.edu/index_files/Resources_files/MIT_Solar%20PV%20Report2004.pdf.

155 *Id.* at 6-7.

156 Time-of-use rates provide electric consumers with rates that vary over time to reflect the "value and cost of electricity in different time periods." The purpose of this approach is to encourage consumers "to use less electricity at times when electricity prices are high." U.S. DEP'T OF ENERGY, BENEFITS OF DEMAND RESPONSE IN ELECTRICITY MARKETS AND RECOMMENDATIONS FOR ACHIEVING THEM: A REPORT TO THE U.S. CONGRESS PURSUANT TO SECTION 1252 OF THE ENERGY POLICY ACT OF 2005, at v, xi (2006), *available at* http://www.oe.energy.gov/DocumentsandMedia/congress_1252d.pdf.

157 Press Release, The Climate Registry and Local Gov'ts for Sustainability, ICLEI and the Climate Registry Partner to Track Rigorous GHG Emissions Accounting for Local Governments (Dec. 2, 2008).

158 *See* Open Letter from Rachel Tornek, Senior Policy Manager, Cal. Climate Action Registry & Garrett Fitzgerald, Dir. Of Programs, ICLEI — Local Govt's for Sustainability, Local Government Protocol Invitation (Mar. 2, 2008), *available at* http://www.icleiusa.org/programs/climate/protocol-invitation-letter/?searchterm=LocalGovernmentOperationsProtocol.

159 ICLEI — Local Governments for Sustainability, About ICLEI, http://www.icleiusa.org/about-iclei (last visited Mar. 5, 2010).

160 *See* American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. § 713 (2009).

161 H.R. 2454 §§ 713(b)(1), (b)(1)(E) (emphasis added).

162 H.R. 2454 § 713.

in 2007 to collect high-quality greenhouse gas emission data from facilities, corporations, and other organizations to support various greenhouse gas emission reporting and reduction policies for the member States and Indian tribes."[163]

Similarly, the provisions of the Senate version of climate legislation establishing a GHG registry also reference The Climate Registry protocols.[164] Section 713(b)(1)(E) of the Clean Energy Jobs and American Power Act states that the regulations issued by the EPA Administrator to establish a GHG registry shall "take into account the best practices from the most recent Federal, State, tribal and international protocols for the measurement, accounting, reporting, and verification of greenhouse gas emissions, *including protocols from The Climate Registry* and other mandatory State or multistate authorized programs."[165]

In summary, The Climate Registry is in a key position to develop additional protocols that more accurately reflect the emission reduction benefits of increased use of EERE technologies. The leadership of the Climate Registry has emphasized that corrections and clarifications to its General Reporting Protocol will be necessary as the program evolves.[166] The organization has announced plans to release a new version of its General Protocol in 2010,[167] and the Authors have sought to facilitate necessary clarifications by sharing the results of the methodology issues raised in this Article with the Climate Registry staff.

B. Mandatory GHG Reporting Rules

On October 30, 2009, the EPA published a final rule requiring the first-ever national mandatory reporting system for GHGs in the United States.[168] Although the October 2009 rule only focused on direct emissions and did not require reporting of indirect emissions from electricity purchases,[169] the preamble to the final rule indicated that reporting of indirect emissions was likely to be considered in the future.[170] Any methodology ultimately adopted by the EPA in a future rulemaking for mandatory reporting of GHG emissions will be extremely important in establishing a precedent for the treatment of indirect emissions from electricity purchases.

According to the preamble, the EPA stated:

> While EPA is not collecting data on electricity purchases in this rule, we understand that acquiring such data may be important in the future. Therefore, we are exploring options for possible future data collection on electricity purchases and indirect emissions, and the uses of such data. Such a future data collection on indirect emissions would complement EPA's interest in spurring investment in energy efficiency and renewable energy.[171]

To date, the EPA has not addressed the option of developing two separate inventories for indirect emissions—one to help aggregate reports of GHG emissions from individual entities and a second to account for changes in GHG emissions resulting from increased use of EERE technologies.[172] However, since the EPA views the encouragement of EERE technologies as an important goal, it is essential for the EPA to use the appropriate methodology to accomplish its objective.

Consistent with the WRI Guidelines, the EPA should use a marginal emissions methodology in any emissions inventory intended to measure reductions in GHGs resulting from increased use of EERE.[173] Businesses and policymakers seeking a level playing field for EERE technologies should closely follow EPA's future rulemaking activities in this area.

Moreover, EERE technologies are not the only technologies affected by this methodological problem. The evaluation of air emissions reductions from other electric technologies, such as fuel cells, grid-connected batteries, compressed air and pumped storage and plug-

163 H.R. 2454 § 713(a)(1).
164 Clean Energy Jobs and American Power Act, S. 1733, 111th Cong. § 713(b)(1)(E) (2009).
165 S. 1733 § 713(b)(1)(E) (emphasis added).
166 THE CLIMATE REGISTRY, GENERAL REPORTING PROTOCOL 1.1 CLARIFICATIONS AND CORRECTIONS 1 (2008), *available at http://www.theclimateregistry.org/downloads/08.11.24_GRP_Clarifications_and_Corrections.pdf*.
167 *Id.*
168 Mandatory Reporting of Greenhouse Gases, 74 Fed. Reg. 56,260 (Oct. 30, 2009) (to be codified at 40 C.F.R. pt. 98).
169 *Id.* at 56,289.
170 *Id.*
171 *Id.*
172 *See id.*
173 *See infra* Part IV (providing a more extensive elaboration of this recommendation); *see supra* Part I.B.2.-3 (providing a description of the non-baseload and TMM methodologies).

developed with support from the DOE Clean Energy/Air Quality Integration Initiative, could fulfill this essential need. It has already been employed by the Metropolitan Washington Council of Governments (MWCOG), the Commonwealth of Virginia, the State of Maryland, and the District of Columbia.[188]

The MWCOG calculator, which is based on the RSG TMM methodology, allows the user to use standard load profiles for a specific renewable energy or energy savings technology, or project-specific load profiles, and to enter these profiles into an Excel-based spreadsheet.[189] In developing its air quality plan to meet the eight-hour ozone standard, the MWCOG staff used the calculator to compute the annual or monthly avoided emission estimates for NO_X using the hourly TMM emission rates that were embedded in the calculator.[190]

An hourly marginal emissions methodology is also ideally suited to assess the benefits of EERE measures on high electric demand days. Energy savings measures that reduce summer electric use "during the days and hours with the highest electrical demand, such as high-efficiency air conditioning and commercial lighting, are particularly valuable in reducing emissions of NO_X—a precursor to ground-level ozone that causes adverse respiratory effects in adults and children."[191] "Ozone is formed on hot summer days, and the hottest summer days also are typically the days of highest electrical demand—the so-called 'high electric demand days."[192]

Research has demonstrated that daily NO_X emissions on high electric demand days from fossil fuel-fired electric generating units in certain regions of the country, such as the Northeast and the Mid-Atlantic regions, substantially exceed emissions on more typical summer days.[193] "This result occurs because the peak load generating units used on these limited number of days each year (generally fewer than a dozen days) are typically older units with limited pollution controls."[194]

There is a major opportunity to provide access to the TMM method and calculator to state and local governments. States have time to develop and distribute the database and calculator prior to the submission of the SIPs in 2013 and to train state employees to use this tool.

IV. Recommendations

Based on the findings presented above, this Article offers five recommendations. Adopting these recommendations would substantially advance efforts to measure the full air emission reduction benefits of EERE technologies.

First, DOE, EPA, and state air, climate, and energy agencies, including the Board of The Climate Registry, should fund an enhancement of the eGRID database to provide a profile of hourly marginal emissions for each of the 8,760 hours of the year in each of the eGRID subregions. This enhanced eGRID database should cover all power markets as well as all regions and subregions of the North American Electric Reliability Corporation.

The enhanced eGRID database would include additional information based on the TMM methodology or a similar methodology (initially using data from

188 The following document issued by the Metropolitan Washington Council of Governments ("MWCOG") relies on the analysis from the TMM calculator in its chapter on voluntary control measures (Chapter 6) and in Appendix H. METRO. WASH. COUNCIL OF GOV'TS, PLAN TO IMPROVE AIR QUALITY IN THE METROPOLITAN WASHINGTON, DC-MD-VA REGION: STATE IMPLEMENTATION PLAN FOR 8-HOUR OZONE STANDARD 6-61 to 6-82, Appendix H (2007), *available at* http://www.mwcog.org/environment/air/downloads/SIP_APP/default.asp.
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189 METRO. WASH. COUNCIL OF GOV'TS, *supra* note 188, at 6-61.

190 *Id.* The calculator tool that was initially developed in 2007 has been refined in 2008 and 2009 under a grant issued by the DOE's Office of Energy Efficiency and Renewable Energy (EERE). The grant was issued to the Virginia Department of Mines, Minerals and Energy under the EERE's state Energy Program to support a project titled "Promoting Air Quality with Clean Energy in the Metropolitan Washington Region." The methodology has been further refined under work performed for the DOE's Loan Guarantee Project Office to encompass GHGs and other pollutants. In view of the NOx emissions trading regime in effect in Maryland, the District of Columbia, and Virginia, the air agencies in these jurisdictions committed to retire NOx allowances in an amount commensurate with the amount of calculated emissions. *See id.* at Appendix H.

191 ROLE OF ENERGY EFFICIENCY PROGRAMS, *supra* note 23, at 2.

192 *Id.*

193 *See* NE. STATES FOR COORDINATED AIR USE MGMT., FINAL WHITE PAPER: HIGH ELECTRIC DEMAND DAY AND AIR QUALITY IN THE NORTHEAST (2006).

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IV. RECOMMENDATIONS

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Continuous Emission Monitors and other data reported to the EPA). As a result, it should be possible to compile this database for a relatively modest amount of funding relative to the potential benefits. Since the enhanced eGRID database would be extremely useful in obtaining air quality, climate, and energy goals by federal, state, and local agencies, some type of cost-sharing arrangement among these agencies appears reasonable.

Alternatively, it seems appropriate to fund such a database on a longer-term basis with funds from allowance auction revenues generated under regional or national climate change legislation. This funding can be justified on the grounds that the data will directly facilitate the development of more accurate GHG reduction estimates.

Second, as an interim measure pending the completion of the eGRID enhancement set forth in our first recommendation, the federal government and states should utilize the eGRID non-baseload emissions methodology for calculating the emission reduction benefits of increased use of EERE technologies. This non-baseload methodology is far more representative than the eGRID system average methodology and has already been developed by the EPA. Moreover, the eGRID non-baseload methodology is recommended for estimating emissions reductions from EERE,[195] and this methodology has been adopted by the EPA Green Power Partnership to calculate the GHG emission reduction benefits of renewable power.[196]

The eGRID non-baseload methodology could therefore serve as a valuable interim approach. During the interim period before the development of an enhanced eGRID database, appropriate agencies should consider allowing state and local governments, such as the MWCOG, and private entities to submit marginal emissions calculations from other verified sources, such as the RSG TMM, instead of using the EPA non-baseload emissions estimates.[197]

As noted above, recent research by RSG has determined that the difference between the eGRID non-baseload methodology and the TMM methodology can be quite significant for certain regions and technologies. Therefore, reliance on this eGRID non-baseload approach should be only an interim step.

Third, DOE, the EPA, and other interested agencies and parties should consider continuing their support of the Northeast Energy Efficiency Partnerships ("NEEP") Evaluation, Measurement, and Verification ("EMV") Forum,[198] and other similar efforts to develop hourly load profiles for specific EE technologies. The EMV Forum was initiated in 2008 with funding from a number of entities, including DOE and the EPA. There remains strong synergy between the proposed work of the EMV Forum to compile hourly load profiles of various energy efficiency measures with the proposed compilation of hourly marginal emission rates under the TMM and the eGRID non-baseload methodologies.

As stated in Part I.B.3, *supra*, the "time-matching" aspect of the TMM methodology involves matching the load profile for a specific technology against the emissions profile of the marginal units.[199] The recommendation for the eGRID enhancement would provide information to generate the hourly emissions data on the marginal units, but the NEEP process and other similar efforts will provide the second piece of the puzzle for energy efficiency resources—the load profile for specific energy efficiency technologies, such as high-efficiency commercial air conditioning and high-efficiency residential lighting.[200]

195 ROTHSCHILD & DIEM ET AL., *supra* note 68, at 6.

196 *See* Green Power Partnership, *supra* note 107.

197 For example, shortly before the publication of this Article, the PJM Interconnection announced the availability of CO_2 emissions data for marginal generating units from January 2005 to December 2009. The related press release stated that this data "can be used to estimate carbon dioxide reductions from demand response, energy efficiency measures and increases in emissions-free generation." PJM Press Release, *supra* note 59 (attached graphic and tables comparing CO_2 emission rates of marginal generating units compared to CO_2 emission rates of system average generating units for 2005 to 2009).

198 *See* SUSAN COAKLEY ET AL., NE. ENERGY EFFICIENCY P'SHIP, NORTHEAST EVALUATION MEASUREMENT AND VERIFICATION FORUM: THREE-YEAR PLAN 3 (2008), *available at* http://neep.org/uploads/EMV%20Forum/EMV_forum_plan_4.08.pdf.

199 *See supra* Part I.B.3.

200 With respect to renewable energy resources, many of the load shape profiles are already readily available. For example, the National Renewable Energy Laboratory has developed the PVWatts™ calculator to allow researchers to easily determine the energy production of grid-connected "PV" energy systems in different regions of the U.S. and the world. National Renewable Energy Laboratory, Renewable Resource Data Center, PVWatts, http://www.nrel.gov/rredc/pvwatts (last visited Mar. 5, 2010). The PVWatts calculator works by creating hour-by-hour performance simulations that provide estimated monthly and annual energy production in kilowatts and energy value. Users can select a location and choose to use default values or their own system parameters for size, electric cost, array type, tilt angle, and azimuth angle. In addition, the PVWatts calculator can provide hourly performance data for the selected location. *See id.*

Fourth, DOE, the EPA, and other agencies and entities should initiate additional research to refine the time-matched marginal emissions methodology. Although both marginal emissions methodologies are far more accurate than the system average methodology in estimating avoided emissions from EERE technologies, these marginal methodologies require additional research to overcome certain limitations discussed below.[201] Federal and state agencies should consider funding this research to increase the value of the marginal methodologies measurement approach.

The most valuable improvement in both the eGRID non-baseload and TMM methodologies would be an expansion of the methodologies to include the impact of significant grid changes in the mid-term and long-term. This refinement would capture changes in emissions caused by the construction of new power generation units and by the retirement of old units.

The two eGRID methodologies and the initial TMM methodology (used for the analysis of the two power markets discussed in this Article) only capture the displacement of *existing* fossil fuel-fired units on the grid by EERE technologies because they are based on the analysis of historic data. These analyses thus reflect the so-called operating margin[202] that dominates near-term changes in emissions.

However, leading experts on GHG emission analysis emphasize that the analysis of avoided emissions from grid-connected electric generation over several decades also must consider the impact of new units that may be built on the grid—the so-called build margin.[203] Further work is needed to develop cost-effective and transparent methods to capture this "build margin."[204]

In addition, electric generation modeling experts suggest that it would be useful to compare the results of at least one leading proprietary dispatch model with the results of the TMM methodology.[205] This comparison would be useful to further validate the methodology and to identify any areas of necessary improvement.

Finally, we recommend that federal and state regulatory agencies, as well as electric utilities and their trade associations, consider the GHG emission profiles of electric generation in evaluating charging strategies for electric and plug-in hybrid vehicles as well as energy storage technologies. The GHG emissions profile of electric generation varies by region, season, and hour of the day. Unless governmental agencies consider the specific emissions profile of each region, they may fail to develop the optimal strategy for reducing GHG emissions from new technologies for energy storage and advanced electric vehicles.

CONCLUSION

Federal and state agencies involved in climate, air pollution, and energy matters should act promptly to ensure that accurate methodologies are used in calculating reductions in emissions of GHGs and other air pollutants resulting from increased use of EERE technologies on the electric power grid. In particular, the forty states involved in The Climate Registry should consider developing an additional protocol and registry during their planned revisions of the General Reporting Protocol in 2010. The proposed supplementary protocol should incorporate a more accurate methodology based on marginal emissions to account for the increased use of EERE technologies on the electric power grid. Such an approach also should be incorporated into EPA's Mandatory Greenhouse Gas Reporting Rule and in requirements of climate legislation relating to GHG inventories.

201 *See infra* Part I.B.3.
202 *See* QUANTIFYING GHG REDUCTIONS, *supra* note 13, at 13.
203 *See Id.*
204 RSG has undertaken initial work related to three NERC subregions to expand its TMM methodology to include projections of the construction of new electric generating capacity based on construction in progress, planned additions, and projections of future plant additions (reflecting alternative public policy scenarios).
205 Telephone Interview with Chris James, Senior Assoc., Synapse Energy Econ., & Jeremy Fisher, Scientist, Synapse Energy Econ. (Winter, 2009).

APPENDIX

Comparison of RSG TMM Avoided Emissions Rates for NOx and CO2 with eGRID Emission Rates for Two NERC Subregions

New York Upstate (NERC subregion NYUP)

Avoided Emissions Methodology	**CO2** Avoided Emission Rate *(lb/MWh)*	**CO2** Difference from eGRID System *(Average %)*		**NOx** Avoided Emission Rate *(lb/MWh)*	**NOx** Difference from eGRID System *(Average %)*
eGRID Output System Average	721	0%		0.83	0%
eGRID Non-Baseload Average	1,706	137%		1.82	119%
RSG Average TMM Rate	1,813	151%		2.14	158%
TMM-Wind	1,832	154%		2.01	142%
TMM-PV	1,805	150%		2.12	155%
TMM-AC	1,798	149%		2.20	165%
TMM-Lighting	1,808	151%		2.18	163%
TMM-LED Traffic Signals	1,822	153%		2.17	161%

For the New York Upstate data, 8760 hour generation or savings profile was simulated based on comparable profiles for the TMM-Wind, TMM-PV, TMM-AC, TMM-Lighting, and TMM-LED Traffic Signals.

Note: The results are based on 2005 eGRID data and 2005 Continuous Emission Monitors (CEM) and other 2005 emissions data reported to the EPA. The year 2005 is the most recent for which comprehensive verified emissions data is available from the EPA.

PJM Interconnection — (NERC subregion RFCE)

	CO2 Avoided Emission Rate *(lb/MWh)*	**CO2** Difference from eGRID System *(Average %)*		**NOx** Avoided Emission Rate *(lb/MWh)*	**NOx** Difference from eGRID System *(Average %)*
Avoided Emissions Methodology					
eGRID Output System Average	1,139	0%		1.63	0%
eGRID Non-Baseload Average	1,790	57%		2.77	70%
RSG Average TMM Rate	1,888	66%		2.14	31%
TMM-Wind	1,905	67%		2.01	23%
TMM-PV	1,892	66%		2.12	30%
TMM-AC	1,870	73%		2.2	35%
TMM-Lighting	1,894	66%		2.18	34%
TMM-LED Traffic Signals	1,881	65%		2.17	33%

For the PJM Interconnection data, 8760 hour generation or savings profile was simulated based on comparable profiles for the TMM-Wind data. 8760 hour generation or savings profile was based on actual profiles for the region for the TMM-PV, TMM-AC, TMM-Lighting, and TMM-LED Traffic Signals.

Note: The results are based on 2005 eGRID data and 2005 EPA Continuous Emission Monitors (CEM) and other 2005 emissions data reported to the EPA. The year 2005 is the most recent for which comprehensive verified emissions data is available from the EPA.