How to use eGRID for Carbon Footprinting Electricity Purchases in Greenhouse Gas Emission Inventories

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ABSTRACT

There has been some confusion about which year of Emissions & Generation Resource Integrated Database (eGRID)'s eGRID subregion GHG emissions factors to use for specified years of electricity data under different conditions. There is no one completely consistent method that will work in all cases since the plants whose emissions are aggregated in the eGRID subregions can change from year to year and the eGRID subregions can sometimes change considerably.

The purpose of this paper is to provide some recommendations (and caveats) regarding which year(s) of eGRID subregion GHG emissions factors to use for estimating Scopes 2 and 3 GHG emissions from electricity use under various conditions.

The paper also reviews other recommendations and rationale for decisions relating to the use of eGRID data to estimate indirect emissions from electricity, including, but not limited to which output emission rates to use, which aggregation level to use, how to find the applicable electric grid region, how to include line losses. Examples and key data sets from the newly released eGRID2012 year 2009 data, found at www.epa.gov/egrid, will be presented.

INTRODUCTION

The Emissions & Generation Resource Integrated Database (eGRID), published by the U.S. Environmental Protection Agency is a globally recognized source of emissions data for the electric power generated in the United States. eGRID uniquely links air emissions with electricity generation. The most recent eGRID data are available from the eGRID website, www.epa.gov/egrid.

This paper highlights recommendations for the use of Emissions & Generation Resource Integrated Database (eGRID) output emission rates to estimate the indirect emissions from grid supplied electricity purchases for greenhouse gas (GHG) inventories, carbon footprint calculators, or avoided emissions calculations. eGRID contains emissions data related to grid connected power plants in the United States; therefore, indirect emissions from electricity use may be calculated whenever these data are available. The eGRID output emission rates, sometimes referred to as emission factors, are expressed in pounds (lb) per megawatt-hour (MWh) or lb per gigawatt-hour (GWh) and are particularly valuable for GHG emissions estimations.

eGRID

eGRID includes operational data such as emissions, different types of emission rates, generation, resource mix, and heat input. Emissions are reported for three greenhouse gases (GHGs) – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O); two criteria pollutants – nitrogen oxides (NO_x), and sulfur dioxide (SO_2); and one toxic air pollutant, mercury (Hg). Table 2 below shows the years for which each pollutant is included in eGRID.

Eight editions of eGRID have been published to date. The most recent edition, eGRID2012, and archived edition, eGRID2002, contain all the years of data ever published in eGRID, that is, 1996 – 2000, 2004, 2005, 2007, 2009. The most recent edition, eGRID2012, newly provides year 2009 data and also includes year 2004, 2005 and 2007 data published in previous editions of eGRID. The archived eGRID2002 contains operational information from years 1996 through 2000. Table 1 below shows the edition name, years of new data, and disposition for each edition of eGRID.

Industry structural information have been reconfigured in eGRID to reflect a more current point in time, including plant ownership and operators, parent company affiliations, company mergers, and grid configurations. For example, in eGRID2010, the year 2007 operational data are associated with entities that have been reconfigured to reflect the industry's current structure as of December 31, 2010. An example serves to explain this concept: A plant with specified environmental characteristics has owner(s) and an operator that is part of a parent company and is associated with an eGRID subregion by the end of year 2007. By 2010, the operator and owner(s) have changed, the new operator is associated with a different parent company (or no parent company), and the eGRID subregion has changed. In this example, in eGRID2010, the year 2007 environmental characteristics of this plant are attributed to the year 2010 operator, owner, parent company (or no parent company), and eGRID subregion – not to those from year 2007. Hence, the name eGRID2010 (with year 2007 data) reflects the year 2010 industry configuration. For eGRID2012, company level data are not presented and the operators and owners of each plant were not reconfigured as in previous editions. However, the year 2009 data are configured to reflect the power control areas (a.k.a. balancing authorities) established by NERC as of March 2012.

Table 1. The editions of eGRID

eGRID edition iteration	eGRID edition name	Year(s) of new data	Current disposition
1st	eGRID1998	1996	Included with eGRID2002
2nd	eGRID1999	1997	Included with eGRID2002
3rd	eGRID2000	1998	Included with eGRID2002
4th	eGRID2002	1999, 2000	This archived edition is available for download at epa.gov/egrid
5th	eGRID2006	2004	Included with eGRID2012
6th	eGRID2007	2005	Included with eGRID2012
7th	eGRID2010	2007	Included with eGRID2012
8th	eGRID2012	2009	This edition is available for download at epa.gov/egrid

Table 2. Years for which each pollutant is included in eGRID

Pollutant	Data Year								
	1996	1997	1998	1999	2000	2004	2005	2007	2009
CO_2	Y	Y	Y	Y	Y	Y	Y	Y	Y
CH_4	N	N	N	N	N	N	Y	Y	Y
N_2O	N	N	N	N	N	N	Y	Y	Y
NO_x	Y	Y	Y	Y	Y	Y	Y	Y	Y
SO_2	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hg	N	N	Y	Y	Y	Y	Y	N	N

The eGRID emissions data are associated with the generation of electricity at the generating facilities, not with the consumption of electricity; therefore, these values do not account for transmission and distribution losses, imports and exports among subregions (or any other geographic area), transmission constraints within any geographic area, or life cycle emissions at electric generating units (e.g. emissions from the extraction, processing, and transportation of fuels). eGRID does provide grid gross loss factors that can be used to estimate emissions associated with transmission and distribution losses for scope 3 emissions in inventories. Recommendations about using this data to estimate scope 3 transmission and distribution loss emissions are provided in this paper below.

The eGRID plant file also provides plant identification, location information in which the plant is located, structural information about the plant's operator and owners(s), and the operator's parent company (if there is one). However, in eGRID2012, parent company data are not provided and operator company data have not been consolidated as in previous editions of eGRID. The plant file also displays the plant's power control area (PCA), also known as the balancing authority, which is the entity that dispatches power. The plant file also provides the plant's eGRID subregion and North American Electric Reliability Corporation (NERC) region, both of which are associated with the plant's PCA.

eGRID data support a wide variety of users globally through a wide variety of uses. eGRID is valuable to those in the Federal Government, state and local governments, non-governmental organizations, academia, and provides constructive direction to companies who are generally seeking environmental information from the electric power sector in the United States. eGRID is most often used for the estimation of indirect emissions from electricity purchases, in GHG inventories, for carbon footprinting, and for estimating avoided emissions from programs and projects that would reduce the consumption for grid supplied electricity. eGRID data are cited by emission inventory and registry protocols, by various emission calculation tools and applications, by many academic papers, by many consultants, and is used for many research applications and efforts. Within EPA, eGRID data are used in the following applications and programs: Power Profiler web application, Climate Leaders protocols, ENERGYSTAR's Portfolio Manager and Target Finder, Waste Wise Office Carbon Footprint Tool, the Personal Greenhouse Gas Emissions Calculator, the Greenhouse Gas Equivalencies Calculator, and the Green Power Equivalency Calculator. Please see the eGRID Technical Support document for more details regarding the users and uses of eGRID data.

eGRID Adjustments

In eGRID, there are two possible adjustments to the emissions and heat input that separate eGRID data from some of the other available Federal data. At the plant level, adjustments are made for the burning of biomass and for combined heat and power (CHP) plants. The adjusted emissions are used to estimate the eGRID output emissions rates for the different aggregation levels.

Biogenic fuels (often referred to as biomass) are biologically based materials that are either used for combustion or product processes or otherwise decompose. Biogenic fuels include, but are not limited to, wood and paper products, agricultural waste, and methane from landfills and digesters. Since the first edition of eGRID, all CO_2 emissions from the combustion of biogenic fuels (including those from renewable methane) are assigned a value of zero. It is assumed that renewable methane, such as landfill gas and digester gas, used to generate electricity would have otherwise been flared, because flaring is usually required if the gas is not used to generate electricity. The amount of incremental emissions attributable to utilizing renewable methane to generate electricity is what is considered for eGRID's emissions, which are adjusted by decreasing the uncontrolled emission factors (used to estimate the emissions) by the emissions factor represented by a typical flare. For CO_2, CH_4, and N_2O, the emission factors are assumed to be the same as the flares', so there are no incremental CO_2, CH_4, and N_2O emissions attributable to utilizing renewable methane to generate electricity, and values of zero are assigned.

eGRID's emissions, as its full name implies, represent emissions from the combustion of fuel only for electricity generation, while a CHP plant produces both electricity and useful thermal energy used for industrial, commercial, heating, or cooling purposes. CHP, also known as cogeneration, converts energy more efficiently than facilities that separately produce heat and electricity. The plants labeled as CHP in eGRID are an EPA designation based on a CHP file developed for the U.S. Department of Energy. Since emissions reported in eGRID represent electricity generation only, emissions associated with useful thermal output – the amount of heat produced in a CHP facility that is used for purposes other than making electricity – are excluded. In the eGRID plant file, both adjusted emissions and unadjusted emissions are displayed, although only the adjusted emissions are used for the output emission rates at the plant and subsequent aggregation levels. A plant's adjusted emissions data reported in eGRID may be different from that reported in other EPA sources.

Beginning with year 2004 data, eGRID presents unadjusted emissions at the plant level, but not at other levels of aggregation. For years 2007 and 2009 data, the unadjusted emissions includes the biomass GHG emissions; in previous years of data, the unadjusted emissions do not include any GHG emissions from the combustion of biomass.

Transmission and Distribution Losses

eGRID output emission rates do not account for any line losses between the points of consumption and the points of generation. For example, because there are line losses, one kilowatt hour of electricity consumption requires a little more than one kilowatt hour of electricity generation. In many GHG protocols, the scope 2 indirect emissions from electricity purchases should not include the line losses, which would be scope 2 emissions for the owners and operators of the electric transmission and distribution systems. However, corporations may typically include the transmission and distribution losses as part of their scope 3 emissions. For other efforts to estimate indirect GHG emissions from the purchases of grid supplied electricity that are not bound by such protocols (for example, a generic carbon footprint calculator), combining the emissions associated with the generation and the line losses together may be desirable.

eGRID publishes grid gross loss factors, which are displayed in Table 3 below. For year 2009 data, these factors are based on the consumption, generation, foreign net imports, and interchanges within and between the U.S. balancing authorities that comprise each of the continental interconnections, and Alaska and Hawaii. For previous years, consumption, generation, and foreign net imports for the groups of states that generally comprise the three grid regions in the continental U.S., Alaska, and Hawaii, were used to prepare the eGRID grid gross loss factors. Table 4 below displays the eGRID subregions, each corresponding power grid, and the association grid gross loss factor. Power grid specific factors should be used where practical, otherwise the U.S. factor can be used.

To account for just the emissions associated with the transmission and distribution line losses for electricity purchases (scope 3), an emission factor can be calculated as indicated in Equation 1 below. The electricity purchases can be multiplied by the resulting emission factor to estimate scope 3 emissions associated with line losses.

Equation 1. Line loss emission rate

$$ER_{s3} = \frac{GGL \times ER_g}{(1 - GGL)}$$

$$where:$$
$$ER_{s3} = emission\ rate\ to\ estimate\ scope\ 3\ emissions\ from\ line\ losses$$
$$GGL = eGRID\ grid\ gross\ loss\ factor\ (decimal)$$
$$ER_g = eGRID\ generation\ based\ output\ emission\ rate$$

To account for both the indirect emissions associated with electricity purchases (scope 2) and the line losses from the electricity purchases (scope 3) together, an emission factor can me calculated as indicated in Equation 2 below. The electricity purchases can be multiplied by the resulting emission factor to estimate the emissions associated with the purchase of electricity, including the line losses.

Equation 2. Combined emission rate for purchases and line losses

$$ER_c = \frac{ER_g}{(1 - GGL)}$$

$$where:$$
$$ER_c = emission\ rate\ to\ estimate\ emissions\ from\ combined\ generation\ and\ line\ losses$$
$$ER_g = eGRID\ generation\ based\ output\ emission\ rate$$
$$GGL = eGRID\ grid\ gross\ loss\ factor\ (decimal)$$

Table 3. eGRID grid gross loss factors.

Power Grid	Grid Gross Loss Factor (%)	Grid Gross Loss Factor (decimal)
Eastern Grid	5.82	0.0582
Western Grid	8.21	0.0821
ERCOT	7.99	0.0799
Alaska	5.84	0.0584
Hawaii	7.81	0.0781
U.S.	6.50	0.0650

Table 4. Grid gross loss factors by eGRID subregion.

eGRID Subregion Name	eGRID Subregion Acronym	Power Grid	Grid Gross Loss Factor (%)	Grid Gross Loss Factor (decimal)
ASCC Alaska Grid	AKGD	Alaska	5.84	0.0584
ASCC Miscellaneous	AKMS	Alaska	5.84	0.0584
ERCOT All	ERCT	ERCOT	7.99	0.0799
FRCC All	FRCC	Eastern	5.82	0.0582
HICC Miscellaneous	HIMS	Hawaii	7.81	0.0781
HICC Oahu	HIOA	Hawaii	7.81	0.0781
MRO East	MROE	Eastern	5.82	0.0582
MRO West	MROW	Eastern	5.82	0.0582
NPCC Long Island	NYLI	Eastern	5.82	0.0582
NPCC New England	NEWE	Eastern	5.82	0.0582
NPCC NYC/Westchester	NYCW	Eastern	5.82	0.0582
NPCC Upstate NY	NYUP	Eastern	5.82	0.0582
RFC East	RFCE	Eastern	5.82	0.0582
RFC Michigan	RFCM	Eastern	5.82	0.0582
RFC West	RFCW	Eastern	5.82	0.0582
SERC Midwest	SRMW	Eastern	5.82	0.0582
SERC Mississippi Valley	SRMV	Eastern	5.82	0.0582
SERC South	SRSO	Eastern	5.82	0.0582
SERC Tennessee Valley	SRTV	Eastern	5.82	0.0582
SERC Virginia/Carolina	SRVC	Eastern	5.82	0.0582
SPP North	SPNO	Eastern	5.82	0.0582
SPP South	SPSO	Eastern	5.82	0.0582
WECC California	CAMX	Western	8.21	0.0821
WECC Northwest	NWPP	Western	8.21	0.0821
WECC Rockies	RMPA	Western	8.21	0.0821
WECC Southwest	AZNM	Western	8.21	0.0821

eGRID Aggregation Levels

Data in eGRID are displayed at the plant level and are also aggregated to state, electric generating company (EGC), parent company, power control area (PCA), eGRID subregion, NERC region, and the U.S. total levels. The boilers and generators associated with the eGRID plants are also included as eGRID data. Development of the aggregate data begins with the plant level data. Each plant record includes the operator (also known as the location (operator)-based EGC), the owner(s) (also known as the owner-based EGC(s), the operator's parent company (also known as the location (operator)-based parent company), the plant's PCA, the plant's eGRID subregion and the plant's NERC region. When aggregating to any one of these aforementioned aggregation levels, the values of the emissions, net generations, heat input, and nameplate capacity of the plants are attributed to that entity (and in the case of multiple owner EGCs, the plant ownership percentage of each of these). As an example, the emissions, net generations, heat input, and nameplate capacity of all plants whose PCA is

PJM Interconnection will be summed, and emission rates and resource mix will be calculated for this PCA.

Sometimes the composition of non-state level aggregations levels may not be geographically obvious. In particular, the plant composition of the State of Florida and the eGRID subregion/NERC region FRCC are not the same; nor is the State of Texas's and the eGRID subregion ERCOT's/NERC region TRE's, nor the State of California's and the eGRID subregion CAMX's. The Intermountain Power Project plant is a good illustration. Although this plant is physically located in the State of Utah, not California, it is in the eGRID subregion CAMX because its PCA is the Los Angeles Department of Water and Power PCA, which is connected to the CAMX eGRID subregion.

eGRID subregions are identified and defined by EPA – using the NERC regions and PCAs as a guide. An eGRID subregion is often, but not always, equivalent to an Integrated Planning Model (IPM) subregion. The 26 eGRID subregions in eGRID2012 are subsets of the NERC regions (see Figure 1). A plant's associated PCA determines the plant's associated eGRID subregion, which is defined as a subset of the NERC region and is composed of entire PCAs, with the exception of PJM Interconnection and New York Independent System Operator PCAs (which are each associated with three eGRID subregions).

The eGRID subregion level data includes generation that takes place within the eGRID subregion and does not include any imports of electricity from other areas to satisfy demand within the eGRID subregion and does not account for any exports of electricity to other eGRID subregions. eGRID subregion level data offers consistent regional generation data that are either whole NERC regions or parts of NERC regions. Most of the system power within each of these eGRID subregions originates from within the eGRID subregion. Although, some eGRID subregions import more electricity than other regions. Upon examination of FERC-714 data for year 2009, which is the same data year of the most recent eGRID edition, there are varying degrees of imports for each of the eGRID subregions. The FERC-714 data includes generation and interchanges between each of the PCAs (monthly and annual). Examining the annual data, most PCAs have both deliveries and receipts of electricity with neighboring PCAs. If deliveries are greater than receipts, then the PCA is a net exporter of electricity, otherwise it is a net importer of electricity. For many eGRID subregions, it is possible to gather all of the data from the PCAs that comprise the eGRID subregion and examine the generation, deliveries and receipts. However, the PCAs MISO, PJM, and NYISO each encompass more than one eGRID subregion. MISO and PJM do not align with NERC regions. There are several ways to examine the imports of electricity as a percentage of native system power, depending on how the relationship between imports and exports are viewed. On one extreme, all imports are compared to the native system power. On the other extreme, net imports are compared to native system power. In both cases, native system power is viewed the total amount of native generation plus imports minus exports. The first case, examining all imports as a percentage of native system power, effectively presumes that all exports are native generation that are not needed for use within the native system. On second case, examining net imports as a percentage of native system power, exports are effectively considered as "wheeled" imports that are being transferred from one neighboring system to another neighboring system until either all imports or all exports are accounted, after which there are no net imports if the system is a net exporter or the net imports are compared to the native system power. Figure 2 below shows the results of this examination of the FERC 714 data. The eGRID subregions in Alaska and Hawaii are not included in this analysis because the FERC data indicates no interchange of electricity for them. NYISO consists of the combination of the three eGRID subregions NYUP, NYCW, and NYLI. The eGRID subregion SRVC includes the Dominion Energy territory, however, this territory is part of the PJM PCA. Therefore, the data shown in the figure for "SRVC-Dominion" is as if SRVC did not include Dominion Energy. MISO and PJM were examined separately and together. The figure shows the corresponding eGRID subregions (or parts of eGRID subregions or combination of eGRID subregions) that correspond with each of the associated PCAs. The bars show the range of the percentage of imports by the two methods described above. eGRID subregions that are net exporters of electricity have a range beginning with zero. CAMX and ERCT are both net importing eGRID subregions having low amounts of exports, and, therefore, have the lowest variation between the two ways of viewing imports. ERCT being its own interconnection, has the least amount of imports and exports, and therefore has the least amount of non-native power in its mix. In all cases, imports are less than 30% of the native system power. Therefore the generation within each of these eGRID subregions is most of the electricity that is used within each eGRID subregion.

Figure 1. eGRID2012 eGRID subregion representational map.

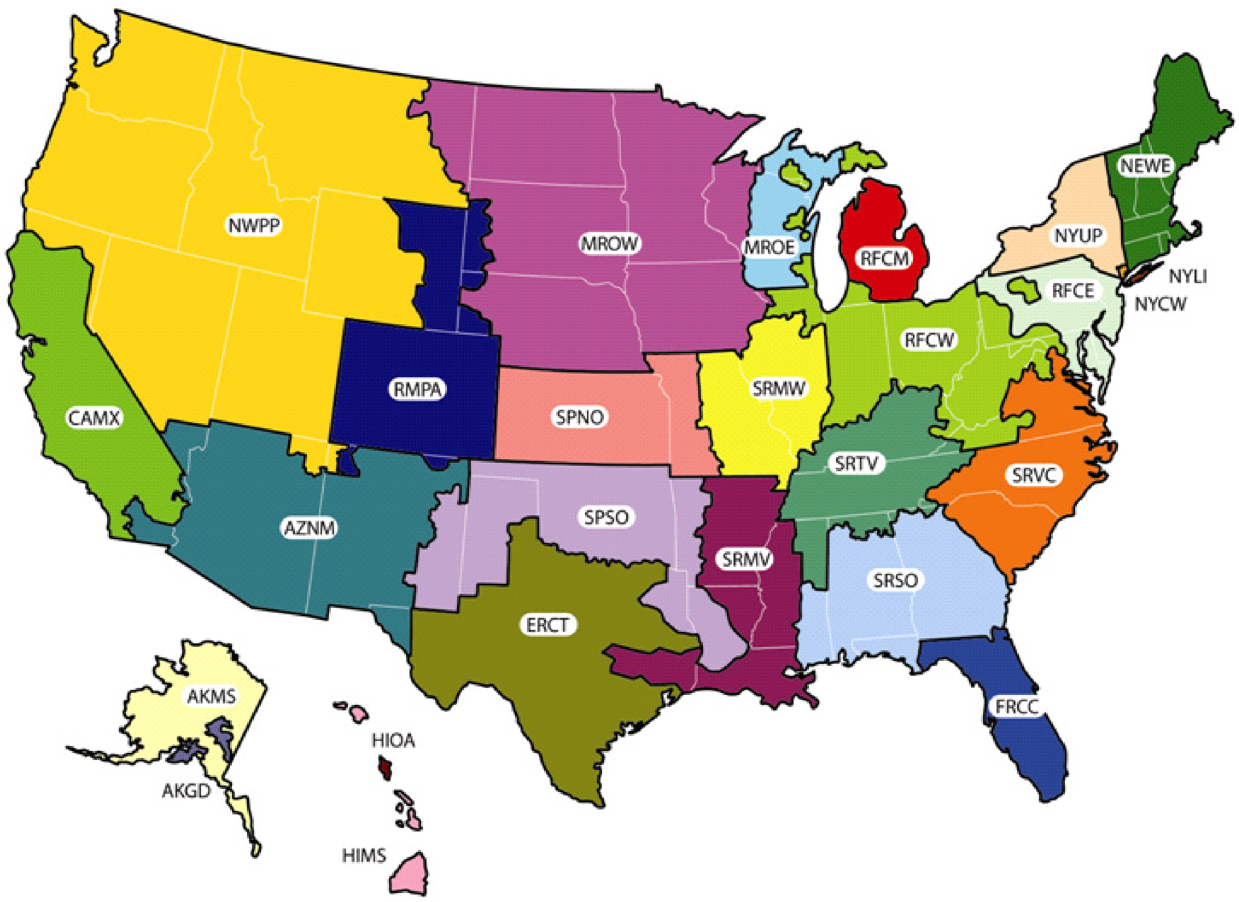
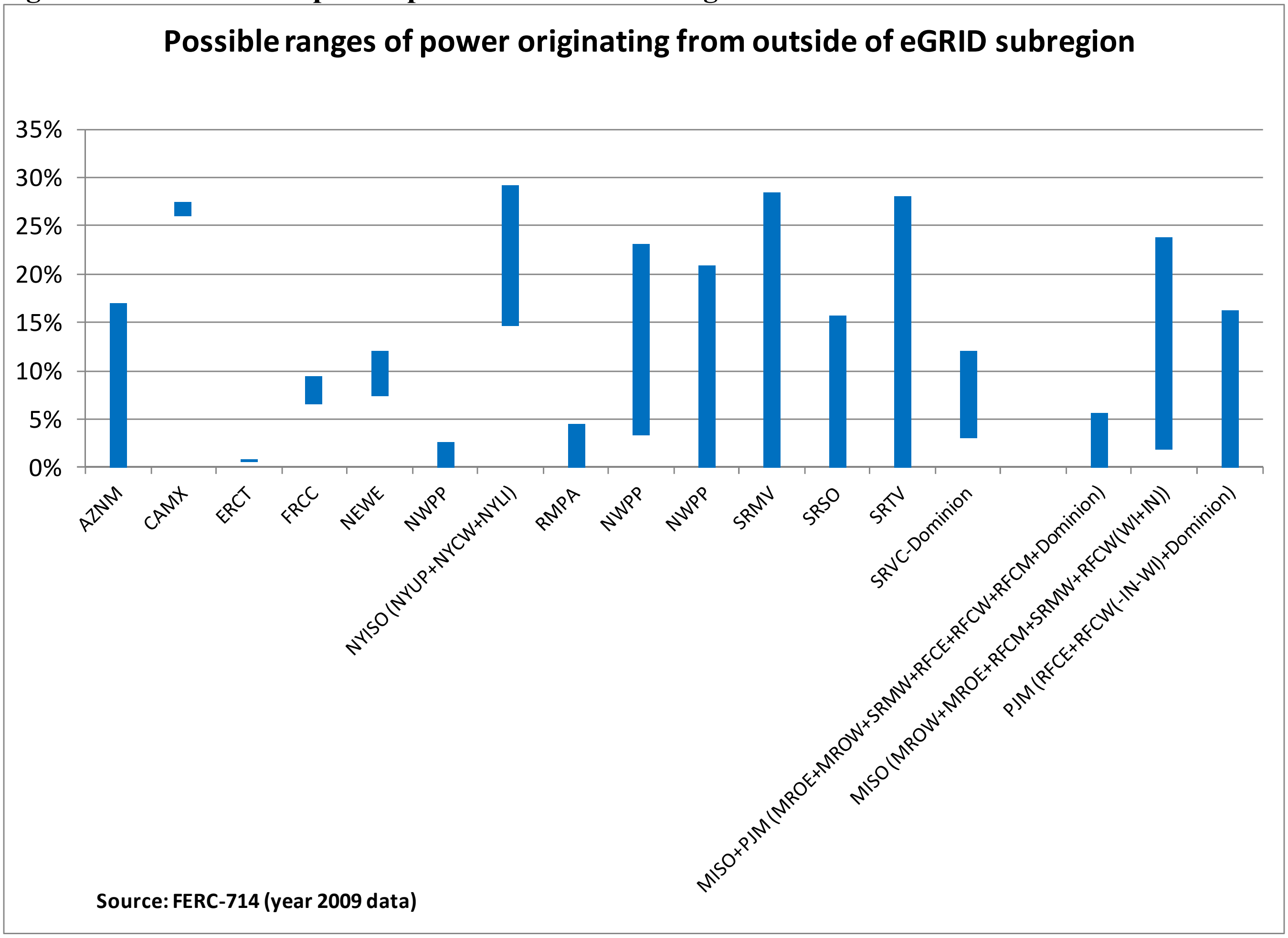


Figure 2. Amount of imported power in eGRID subregions



Annual Output Emission Rates

There are various eGRID emission rates at the different levels of aggregation. Three annual output emission rates described below relate the emissions to generation and serve different purposes: annual total output emission rates, annual non-baseload output emission rates, and fossil fuel output emission rates.

Total Output Emission Rates

Description

The eGRID annual total output emission rate is the measure of the emissions as it relates to the net generation output. It is calculated as the emissions mass divided by the generation MWh multiplied by a unit conversion factor. Units are in lb/MWh for CO_2 and lb/GWh for CH_4 and N_2O. The total output emission rate is the appropriate value to use for inventory development and carbon footprinting. The eGRID subregion total output emission rates are the default value recommended by various protocols to assign an emissions value for scope 2 emissions from the consumption of purchased electricity.

Application

The eGRID subregion total output emission rates are the underlying data for EPA's Power Profiler tool (http://epa.gov/powerprofiler), which allows the user to assess the impacts of electricity use as well as to compare the fuel mix and air emission rates of the electricity in the user's region with that of the nation. These rates are also the underlying data for EPA's Household Carbon Footprint Calculator (http://www.epa.gov/climatechange/ghgemissions/ind-calculator.html), which helps the user to estimate a personal (or family) carbon footprint and for EPA's Office Carbon Footprint Tool (http://www.epa.gov/smm/wastewise/carboncalc.htm), which estimates office GHG emissions from a variety of sources including company-owned vehicle transportation; purchased electricity; waste disposal; and leased assets, franchises, and outsourced activities. Additionally, the eGRID subregion total output emission rates are used for estimating scope 2 indirect emissions under the World Resources Institute (WRI), The Climate Registry (TCR), the California Climate Action Registry (CCAR), and the former EPA Climate Leaders protocols.

Fossil Fuel Output Emission Rates

Description

eGRID fossil fuel output emission rates are calculated based on plants' fossil fuel category, which in turn is based on the plants' primary fuel. If a plant's primary fuel is in the coal, oil, gas, or other fossil category, then all of its adjusted emissions and heat input, and combustion net generation are included in the respective aggregation level for that fuel category. These output emission rates are available for all eGRID data years.

Application

eGRID fossil fuel output emission rates have been used to estimate avoided emissions from resources that would displace grid supplied electricity, especially before the non-baseload emission rates were developed for eGRID. The EPA's CHP Partnership's CHP Emissions Calculator (http://www.epa.gov/chp/basic/calculator.html) uses eGRID heat rates and emissions factors as the basis to calculate avoided emissions from CHP units. The EPA CHP Partnership recommends the use of the fossil fuel output emission rates for displaced grid supplied electricity from a CHP application because CHP units tend to operate on a continuous basis, characteristic of baseload generating units. For CHP units that do not operate on a continuous basis or as non baseload units, the CHP Partnership recommends eGRID non-baseload average heat rate and emissions factor which were developed as a refinement for sources that displace marginal electricity generation. These rates are further described below in the next section.

Fossil fuel output rates are also appropriate to estimate avoided emissions from resources that would displace grid supplied electricity around the clock or during times of when the grid is operating at baseload conditions (for example, energy savings from the installation of efficient traffic lights). These rates are not appropriate for estimating the carbon footprint of purchases of grid supplied electricity (scope 2 emissions in GHG inventories).

Non-baseload Output Emission Rates

Description

Non-baseload output emission rates were developed for eGRID to provide an improvement over the fossil fuel output emission rates as an estimate of emission reduction benefits from energy efficiency and clean energy projects. These values are available beginning with data year 2004. Non-baseload values should not be used for assigning an emission value for electricity use in carbon footprinting or GHG emissions inventory efforts. Non-baseload values may be less appropriate when attempting to determine the emissions benefits of resources that operate fairly constantly or operate mostly during off peak times, are not very coincident with some intermittent resources, such as CHP or wind power in some locations.

Demand for electricity changes diurnally and seasonally. The term "baseload" refers to those plants that supply electricity to the grid when demand for electricity is low. Baseloaded plants are usually called upon to provide electricity to the grid no matter what the demand for electricity is during any given period of time, and generally operate except when undergoing routine or unscheduled maintenance.

eGRID non-baseload emission rates are a portion of the system total mix, with a greater weight given to plants that operate coincident with peak demand for electricity. In eGRID, the capacity factor of each plant is used as a surrogate for determining whether a plant is baseloaded and how much of each plant's generation is considered to be non-baseloaded. Non-baseload emissions rates are calculated from the generation and emissions of plants that combust fuel and have capacity factors less than 0.8, weighted by plant generation and a percent of plant generation determined by capacity factor. The non-baseload emissions and generation include only emissions and generation from combustion sources and exclude emissions and generation from plants that have high capacity factors. The remaining emissions and generation are weighted by a factor which is a function of capacity factor. These data values are derived from plant level data and factor out baseload generation, which is generally unaffected by measures that affect marginal generation. This rate is the sum of the non-baseload emissions divided by the sum of non-baseload net generation, divided by a unit conversion factor.

Application

Several tools use the eGRID subregion CO_2 non-baseload output emission rates as the underlying data. Two calculators that do are EPA's Greenhouse Gas Equivalencies Calculator (http://epa.gov/cleanenergy/energy-resources/calculator.html), since the results of the calculation is the potential amount of avoided CO_2 emissions; and EPA's Green Power Equivalency Calculator http://www.epa.gov/greenpower/pubs/calculator.htm), which helps to translate a green power kilowatt-hour (kWh) purchase into more understandable everyday terms such as, for example, CO_2 emissions equivalencies in terms of the number of coal fired power plants, the number of passenger vehicles, or electricity use in a number of American homes**.**

eGRID non-baseload output emission rates can be useful when attempting to estimate the emissions benefits of reductions in grid supplied electricity use, especially those that are at least somewhat coincident with peak demand. For example, if a user is interested in estimating the CO_2 emission reductions associated with the installation of energy efficient equipment or products (e.g., an ENERGYSTAR heating, ventilating, and air conditioning [HVAC] system); or the installation of building envelop technologies (e.g., sealing air leaks and insulation improvements), then the user could use the eGRID subregion CO_2 non-baseload output emission rate and the expected or actual energy savings resulting from reduced electricity consumption from the installation to estimate the CO_2 emission reductions.

Example

To better illustrate how the total and non-baseload output emission rates are developed, an example of two plants may be helpful. In Alabama in 2005, the McWilliams gas plant (with a nameplate capacity of 654 MW and net generation of 0.99 million MWh) operated at a 17 percent capacity factor, while the Charles Lowman coal plant (with a nameplate capacity of 538 MW and net generation of 3.86 million MWh) operated at an 82 percent capacity factor. The McWilliams and Charles Lowman plants are both included in the total output emission rate calculations for the SERC South eGRID subregion. However, for the SERC South eGRID subregion non-baseload output emission rates, the McWilliams plant is included in the calculations, while the Charles Lowman plant is excluded.

Table 5 displays the eGRID subregion and U.S. output emission rates for CO_2, CH_4, and N_2O for eGRID2012 (year 2009 data). In general, with few exceptions, the non-baseload values are larger than the total output emission rates. The non-baseload rate varies across subregions because of the many factors affecting its estimation, including, but not limited to, the distribution of fuel resources used to generate electricity, the efficiency of plants, and the plant capacity factors. The fossil fuel CO_2 output emission rates are also provided for comparison.

Table 6 displays the eGRID subregion carbon dioxide equivalent (CO_2e) output emission rates calculated using the eGRID subregion output emission rates for CO_2, CH_4, and N_2O and the Global Warming Potentials from the International Panel on Climate Change's Second Assessment Report. This table shows the relative contributions of including the CH_4 and N_2O emissions from electric generation along with the CO_2 emissions. The eGRID subregion CO_2e output emission rates are 0.1 to 0.8 percent higher than the CO_2 output emission rates.

CAVEATS

If total output emission rates are used for initial electricity use, non-baseload output emission rates are used to calculate the displaced GHG emissions from a project that would reduce the consumption of grid supplied electricity, and then total output emission rates are used for electricity use after it has changed, then the implicit displaced emissions in the post-project inventory year is valued at eGRID's total output emission rate rather than at eGRID's non-baseload output emission rate. This disconnect results from the nature of the data. Both the total and non-baseload annual output emission rates are estimates and annual averages; however, a displaced emission reduction calculation using a non-baseload output emission rate is a different approach and makes different assumptions from an inventory approach that values all electricity use at the total output emission rate.

Table 5. eGRID subregion and U.S. greenhouse gas annual output emission rates comparison (eGRID2012 version 1.0, year 2009 data).

eGRID subregion acronym	eGRID subregion name	Total output emission rate			Fossil fuel output emission rate	Non-baseload output emission rate		
		CO_2 (lb/MWh)	CH_4 (lb/GWh)	N_2O (lb/GWh)	CO_2 (lb/MWh)	CO_2 (lb/MWh)	CH_4 (lb/GWh)	N_2O (lb/GWh)
SUBRGN	**SRNAME**	**SRCO2RTA**	**SRCH4RTA**	**SRN2ORTA**	**SRFSC2RT**	**SRNBCO2**	**SRNBCH4**	**SRNBN2O**
AKGD	ASCC Alaska Grid	1,280.86	27.74	7.69	1,399.52	1,320.75	33.16	6.34
AKMS	ASCC Miscellaneous	521.26	21.78	4.28	1,463.10	1,469.44	61.53	12.10
ERCT	ERCOT All	1,181.73	16.70	13.10	1,440.55	1,155.44	19.66	7.59
FRCC	FRCC All	1,176.61	39.24	13.53	1,366.08	1,301.40	36.04	11.91
HIMS	HICC Miscellaneous	1,351.66	72.40	13.80	1,724.53	1,615.98	91.06	17.19
HIOA	HICC Oahu	1,593.35	101.74	21.98	1,566.50	1,621.42	107.94	18.73
MROE	MRO East	1,591.65	23.98	27.04	2,077.79	1,868.23	29.40	30.40
MROW	MRO West	1,628.60	28.80	27.79	2,256.66	2,114.93	61.83	37.41
NYLI	NPCC Long Island	1,347.99	96.86	12.37	1,260.34	1,336.59	30.78	3.51
NEWE	NPCC New England	728.41	75.68	13.86	1,136.96	1,157.44	61.72	14.43
NYCW	NPCC NYC/Westchester	610.67	23.75	2.81	1,000.81	1,118.06	22.47	2.31
NYUP	NPCC Upstate NY	497.92	15.94	6.77	1,403.80	1,347.12	41.08	16.87
RFCE	RFC East	947.42	26.84	14.96	1,687.74	1,628.97	32.94	22.46
RFCM	RFC Michigan	1,659.46	31.41	27.89	2,002.36	1,834.66	35.17	29.15
RFCW	RFC West	1,520.59	18.12	25.13	2,048.18	2,001.76	24.56	32.10
SRMW	SERC Midwest	1,749.75	19.57	28.98	2,161.67	2,192.85	25.04	35.89
SRMV	SERC Mississippi Valley	1,002.41	19.45	10.65	1,432.49	1,201.66	25.72	7.11
SRSO	SERC South	1,325.68	22.27	20.78	1,775.84	1,622.00	27.22	23.50
SRTV	SERC Tennessee Valley	1,357.71	17.28	22.09	1,987.68	1,921.12	25.16	30.61
SRVC	SERC Virginia/Carolina	1,035.87	21.51	17.45	1,877.08	1,677.35	38.55	25.56
SPNO	SPP North	1,815.76	21.01	28.89	2,215.16	2,147.53	26.32	31.82
SPSO	SPP South	1,599.02	23.25	21.79	1,784.02	1,513.73	25.22	15.11
CAMX	WECC California	658.68	28.94	6.17	1,042.50	993.89	33.52	4.07
NWPP	WECC Northwest	819.21	15.29	12.50	1,793.31	1,404.55	38.56	18.79
RMPA	WECC Rockies	1,824.51	22.25	27.19	2,018.00	1,756.62	23.54	22.51
AZNM	WECC Southwest	1,191.35	19.13	15.58	1,601.05	1,187.67	22.25	9.12
		USCO2RTA	**USCH4RTA**	**USN2ORTA**	**USFSC2RT**	**USNBCO2**	**USNBCH4**	**USNBN2O**
U.S.		**1,216.18**	**24.03**	**18.08**	**1,743.11**	**1,555.48**	**30.83**	**19.76**

Table 6. eGRID subregion and U.S. carbon dioxide equivalent (CO_2e) output emission rates.

eGRID subregion acronym	eGRID subregion name	eGRID subregion annual CO_2 equivalent total output emission rate (lb/MWh)	eGRID subregion annual CO_2 equivalent non-baseload output emission rate (lb/MWh)
SUBRGN	**SRNAME**	**SRCO2RTA**	**SRNBC2ER**
AKGD	ASCC Alaska Grid	1,283.82	1,323.41
AKMS	ASCC Miscellaneous	523.05	1,474.49
ERCT	ERCOT All	1,186.14	1,158.20
FRCC	FRCC All	1,181.63	1,305.85
HIMS	HICC Miscellaneous	1,357.46	1,623.22
HIOA	HICC Oahu	1,602.30	1,629.49
MROE	MRO East	1,600.54	1,878.27
MROW	MRO West	1,637.82	2,127.82
NYLI	NPCC Long Island	1,353.86	1,338.32
NEWE	NPCC New England	734.29	1,163.21
NYCW	NPCC NYC/Westchester	612.04	1,119.25
NYUP	NPCC Upstate NY	500.35	1,353.21
RFCE	RFC East	952.63	1,636.62
RFCM	RFC Michigan	1,668.76	1,844.44
RFCW	RFC West	1,528.76	2,012.22
SRMW	SERC Midwest	1,759.15	2,204.50
SRMV	SERC Mississippi Valley	1,006.12	1,204.40
SRSO	SERC South	1,332.59	1,629.86
SRTV	SERC Tennessee Valley	1,364.92	1,931.14
SRVC	SERC Virginia/Carolina	1,041.73	1,686.09
SPNO	SPP North	1,825.15	2,157.95
SPSO	SPP South	1,606.26	1,518.94
CAMX	WECC California	661.20	995.85
NWPP	WECC Northwest	823.40	1,411.18
RMPA	WECC Rockies	1,833.41	1,764.09
AZNM	WECC Southwest	1,196.58	1,190.97
U.S.		**1,222.29**	**1,562.22**

As a hypothetical example of this disconnect, assume that a building located in the RFC East subregion uses 9,000 kWh of electricity in 2010. This translates to a 2010 carbon footprint of grid supplied electricity use of 8,573.67 pounds of CO_2e, using the year 2009 RFCE eGRID subregion total output emission rate of 952.63 lb CO_2e per MWh (see Table 6). If solar panels are then installed on site and reduce grid supplied electricity use in the building by 2,000 kWh to 7,000 kWh in 2011, then the carbon footprint of grid supplied electricity use would decrease to 6668.41 lb CO_2e using the same RFCE eGRID subregion total output emission rate. This is a reduction of 1,905.26 lb CO_2e. However, if no carbon footprint had been prepared and the decision was made to reduce electricity use by 2,000 kWh from whatever it presently was, then the estimated annual indirect CO_2e emission reduction from the solar panel installation would be 3273.24 lb CO_2e per year, using the year 2009 non-baseload emission rate of 1,636.62 lb CO_2e per MWh for the RFCE eGRID subregion. The change in carbon footprint values from the two different inventory years is 42 percent less than project specific emission reduction value using the non-baseload output emission rate. Although, the project specific value using the non-baseload emission rate is likely the better value for the reduction of indirect CO_2 emissions, if a corporate inventory has either been prepared or is the driving force behind the installation of technologies that reduce grid supplied electricity use over time, then the effective carbon footprint reduction expressed in the corporate inventory is controlled by the total output emission rate.

RECOMMENDATIONS

Three general recommendations are made in this paper. In most cases, use of the eGRID subregion output emission rates are recommended to attribute emissions to the purchases of grid supplied electricity or to changes in use of grid supplied electricity. Second, the eGRID total output emission rates are recommended for attributing purchases of grid supplied electricity, while the eGRID non-baseload or fossil fuel output emission rates are recommended for estimating the impact of changes in grid supplied electricity purchases, depending on how coincident the changes are with peak power demand. Third, regarding which year of eGRID data to use, for recent years, use the most recent edition of eGRID, and, for prior years, use the year of data that best matches the year of the grid supplied electricity purchases. Discussion of these recommendations follows.

Aggregation level

In most cases, using eGRID subregion emission rates are highly preferable. An EGC may purchase power and/or export its power to other EGCs; state electricity generation may not serve all of the consumption within the state. eGRID subregion emissions and resource mix (based on generation, not consumption) uniformly attribute electric generation in a specific region based on the generation that takes place in that part of the country.

If a facility obtains all of its electricity from a specific utility, the eGRID subregion output emission rate, and not the eGRID EGC output rate for the utility, should be used when preparing an emission inventory. The reason is that the eGRID EGC output emission rate only accounts for emissions and generation of generators owned or operated by that utility and does not account for imports and exports of electricity from/to other utilities that may have attributes that are significantly different from the EGC's. Of course, if the utility is able to provide an actual utility rate, which includes exports and imports, that rate should be used.

Choosing an aggregation level that is too large (for example, the entire U.S.) includes generation that is not relevant to the regional resource mix. Conversely, an aggregation level that is too small (for example, EGC) may exclude generation that is relevant to the area. Ideally, information about all of the interchanges of electricity between all of the utilities and all of the generators of electricity would be useful along with the generation data in creating output emission rates that account for the wholesale transactions between utilities and EGCs. However, in the absence of public availability of such information, the eGRID subregion level data is generally considered the best generation based aggregation level that minimizes the import/export issues. As discussed above, the eGRID subregion level does not eliminate the issue of imports of electricity from other areas to satisfy demand within the eGRID subregion. However, most or all of the system power in each eGRID subregion originates from within an eGRID subregion.

Lastly, if a facility purchases electricity directly from a specific power plant and has transmission lines that run directly from this plant, then the plant's output emission rate should be used for electricity generated by and purchased from this power plant.

An eGRID subregion can be easily discovered from a building's ZIP code using the Power Profiler eGRID Subregion and GHG Emissions Finder Tool, available at www.epa.gov/powerprofiler and under "quick links" at www.epa.gov/egrid.

Year of eGRID data to Use

To estimate indirect emissions from the purchase of grid supplied electricity (scope 2), the data year of the eGRID subregion output emission rate should be best matched to the year of the electricity purchases. This recommendation is an update to previous papers on this topic. Table 7 below shows the recommended best fits. The rationale for the change in this recommendation is that the resource mix of the subregions change over time and that the most recent year of eGRID data is less relevant for years that are further in the past. For most eGRID subregions, the GHG output emission rates have been declining over the years. The eGRID year 1998 data is the first year for which eGRID subregion data is provided. For years prior to 1998, the year 1998 eGRID subregion data may be used, however, the further back in time these data re used, the less representative of actual scope 2 emissions they would be. For years 1996 and 1997, eGRID NERC region level data exists corresponding to a few current eGRID subregions, that is, NERC region ERCOT corresponds with current eGRID subregion ERCOT All (ERCT), NERC Region FRCC corresponds with current eGRID subregion FRCC All (FRCC), and NERC Region MAAC corresponds with current eGRID subregion RFC East (RFCE). For years that are in between two eGRID data years (that is, 2001, 2002, 2003, 2006, and 2008), the prior released year of eGRID data is selected in Table 7 because it would have been most recent available eGRID data, had the inventory been prepared soon after the inventory year.

There was a major realignment of the eGRID subregion boundaries between the archived edition (eGRID2002) and more recent editions of eGRID. The following eGRID subregions were largely unaffected by this shift:

- ASCC Alaska Grid (AKGD);
- ASCC Miscellaneous (AKMS);
- ERCOT All (ERCT);
- FRCC All (FRCC);
- HICC Miscellaneous (HIMS);
- HICC Oahu (HIOA);
- NPCC New England (NEWE);
- NPCC NYC/Westchester (NYCW);
- NPCC Long Island (NYLI);
- NPCC Upstate NY (NYUP);
- RFC East (RFCE) - previously MAAC All (MAAC);
- RFC Michigan (RFCM) - previously ECAR Michigan (ECMI);

- SERC Mississippi Valley (SRMV);
- SERC South(SRSO);
- SERC Virginia/Carolina (SRVC);
- SPP North (SPNO);
- SPP South (SPSO);
- WECC California (CAMX) - previously abbreviated CALI;
- WECC Rockies (RMPA) – previously abbreviated ROCK; and
- WECC Southwest (AZNM - previously abbreviated WSSW).

Other current eGRID subregions were configured differently in the eGRID year 1996-2000 data from the current eGRID subregion configurations. That is, what is now WECC Northwest, used to be two separate eGRID subregions - WECC Great Basin (NWGB) and WECC Pacific Northwest (NWPN). SERC Tennessee Valley (SRTV) now also includes parts of Kentucky that used to be in ECAR Ohio Valley (ECOV). RFC West (RFCW) is predominantly what used to be ECAR Ohio Valley (ECOV) with some significant differences. MRO East (MROE) is predominantly what used to be MAIN North (MANN) with some significant differences. MRO West (MROW) is predominantly what used to be MAPP All (MAPP) with some significant differences. SERC Midwest (SRMW) is predominantly what used to be MAIN South (MANS) with some significant differences.

Figures 3 and 4 below show the eGRID subregion CO_2 total output emission rates from years 1998 through 2009. The current eGRID subregion abbreviations are used in the legend, with previous corresponding eGRID subregion abbreviations shown in parentheses where appropriate. The symbols for each eGRID subregion are the same in both figures. Data for the following eGRID subregions are displayed for years 2004 through 2009 only, as there are no corollary eGRID subregions for previous years of eGRID data: MRO East (MROE), MRO West (MROW), RFC West (RFCW), SERC Midwest (SRMW), SERC Tennessee Valley (SRTV). For NWPP, year 1998 through 2000 data are presented by combining the data for WECC Great Basin (NWGB) and WECC Pacific Northwest (NWPN) for these years. Figure 3 expresses the output emission rates in pounds of CO_2 per MWh, with the order of the eGRID subregions in the legend in descending order by 2009 data values. Figure 4 expresses the CO_2 output emission rates as a ratio of the specific year data divided by the year 2009 values, with the order of the eGRID subregion in the legend in descending order by year 1998 values.

Figure 3. eGRID subregion CO_2 total output emission rates, years 1998 – 2009, pounds per MWh

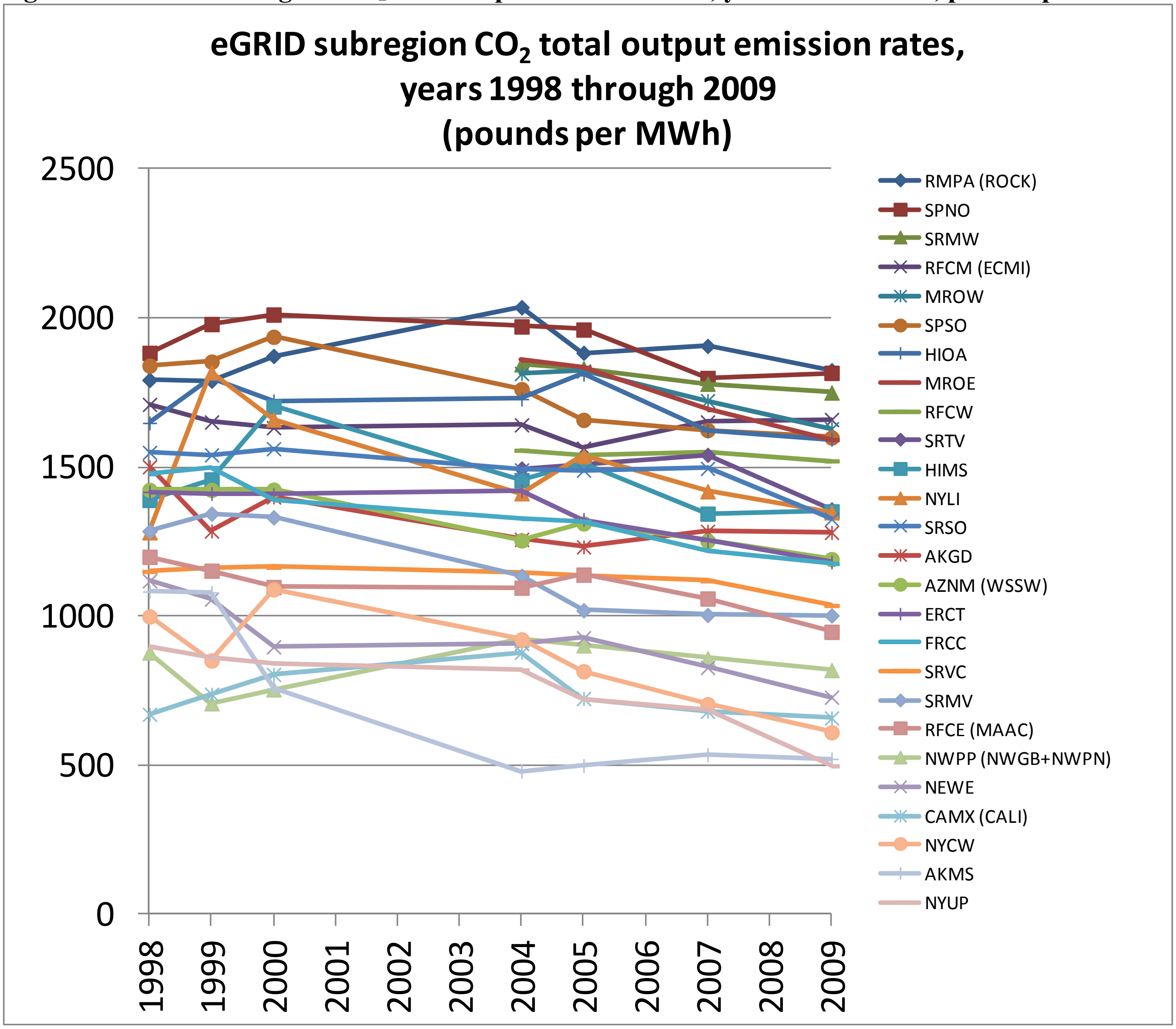
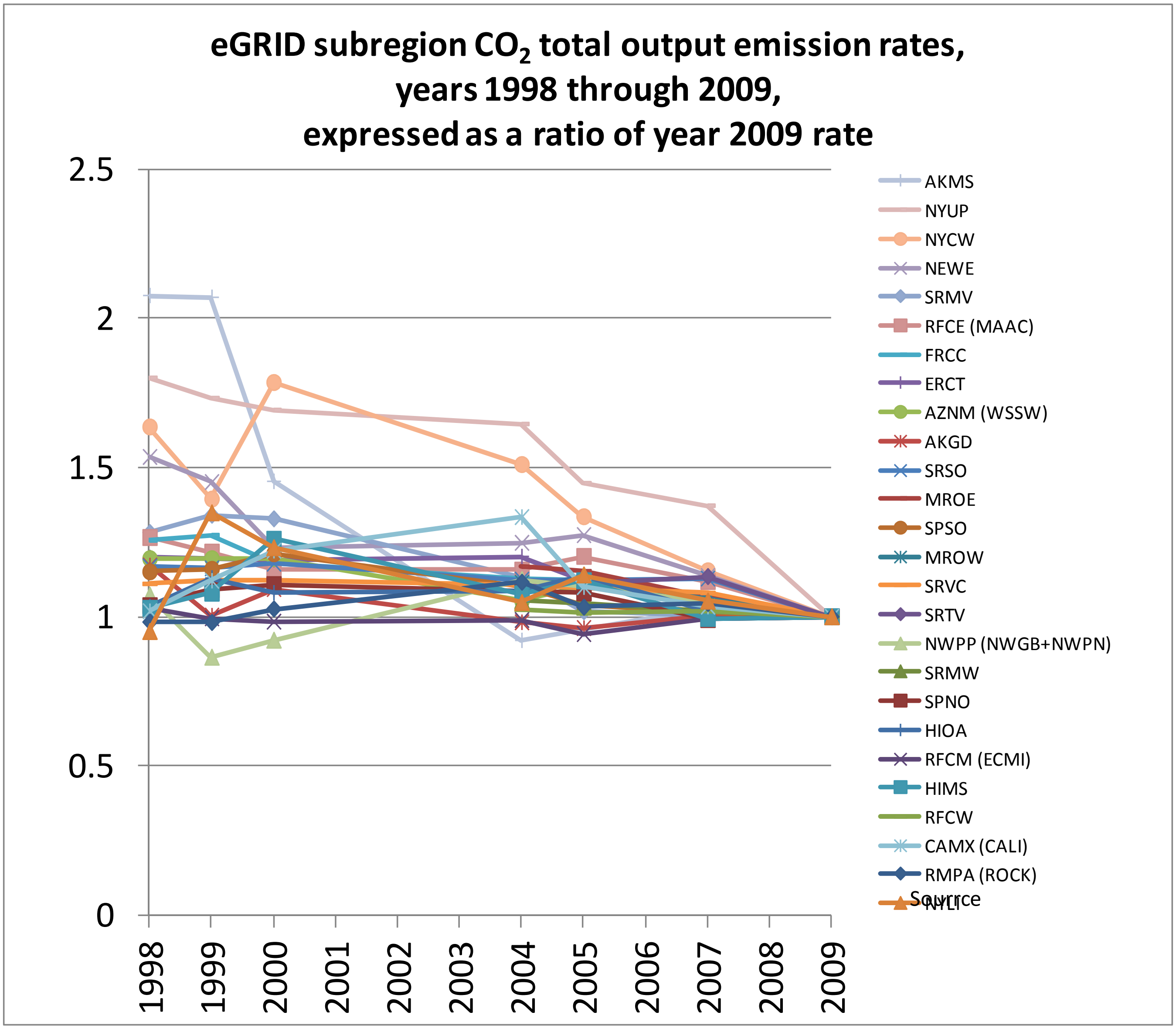


Figure 4. eGRID subregion CO_2 total output emission rates, years 1998 – 2009, as a ratio of year 2009 rate



The reasons for the changes in eGRID subregion CO_2 output emission rates are primarily due to changes in resource mix in each eGRID subregion, with shifts away from high emitting combustion resources lowering the rates. Changes in assignments of eGRID subregions at a few plants between eGRID editions and slight changes to GHG emissions estimation methodologies and factors for plants that do not report emissions directly to EPA had very minor effects on overall eGRID subregion total output emission rates.

There is an overall trend of gradually reducing GHG emission rates over time for the eGRID subregions. There are a few exceptions, as can be seen in figure 4 for points below 1.0. Comparing year 2009 data with year 1998 data for eGRID subregions that can be compared, CO_2 total output emission rates were slightly higher in 2009 for NYLI and RMPA. Comparing year 2009 data with year 1999 data, these rates were higher in 2009 for NWPP and RMPA. Comparing year 2009 data with year 2000 data, these rates were higher in 2009 for NWPP and RFCM. Comparing year 2009 data with year 2004 data, these rates were higher in 2009 for AKMS, AKGD, and RFCM (ECMI).

If the task is to determine whether a GHG emissions goal is being met, the above recommendation should be used in all cases, with one exception. The one exception is for the case when the eGRID subregion output emission rates increased from what was used in the baseline to such an extent that it impedes an entity from reaching its goal. In such a case, the output emission rates used for the baseline emissions should be used since the emission rate increase is a result of factors outside of the entity's control. For example, if scope 2 emissions from electricity is the predominant source of an entity's emissions, and the entity reduced its electricity use by a certain percentage that is aligned with the entity's goals, but the eGRID subregion output emission rate increased by a much greater percentage, the emissions from electricity use would be higher than in the baseline. In such a case, for emissions inventory tracking purposes, the latest eGRID subregion output emission rate would be used, but for determining whether a goal had been met, the baseline's eGRID subregion output emission rate would be used if the latest eGRID subregion output emission rates are impeding the entity from meeting its goal.

Table 7. Recommended matching of eGRID data years with emission inventory years.

Inventory Year	eGRID data year	eGRID edition to find data
1998	1998	eGRID2002
1999	1999	eGRID2002
2000	2000	eGRID2002
2001	2000	eGRID2002
2002	2000	eGRID2002
2003	2000	eGRID2002
2004	2004	eGRID2012
2005	2005	eGRID2012
2006	2005	eGRID2012
2007	2007	eGRID2012
2008	2007	eGRID2012
2009	2009	eGRID2012
2010	2009 *	eGRID2012
2011	2009 *	eGRID2012
2012	2009 *	eGRID2012
* unless more recent edition exists at time of preparation		

CONTACT INFORMATION

For more details on any aspect of this paper, see the Technical Support Document, which can be downloaded from the eGRID website and/or email either diem.art@epa.gov or caquirozpacheco@transystems.com.

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KEY WORDS

- Aggregation levels
- California Climate Action Registry (CCAR)
- Carbon dioxide (CO_2)
- Carbon dioxide equivalent (CO_2e)
- Climate Leaders
- Combustion
- eGRID
- eGRID subregion
- Electric power
- Electricity
- Emissions
- Environmental Protection Agency (EPA)
- Fossil fuel
- Generation
- GHG emission factors
- Greenhouse gas
- Grid gross loss factor
- Methane (CH_4)
- NERC region
- Nitrous oxide (N_2O)
- Non-baseload
- Power control area (PCA)
- Resource mix
- Scope 2 emissions
- Scope 3 emissions
- The Climate Registry (TCR)