Using eGRID for Environmental Footprinting of Electricity Purchases

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Outline

Introduction

Many organizations calculate their emissions inventories or environmental "footprints" to better understand the impact of their activities on the environment. While many organizations promote "carbon footprinting"—calculating the greenhouse gas emissions associated with an organization's activities—the same methodology can be applied to non-greenhouse gas emissions, like sulfur dioxide (SO_2) and nitrogen oxides (NO_X), that have local and regional air quality and health impacts. These emissions can be a significant component of an organization's environmental impact.

Organizations that better understand their environmental footprint associated with electricity purchases can make better-informed decisions about energy use, renewable energy purchases, or energy efficiency investments. This paper provides guidance on calculating the environmental footprint associated with electricity purchases (Scope 2 and Scope 3 emissions) using emission rates from EPA's Emissions and Generation Resource Integrated Database (eGRID). This paper also provides information about estimating avoided emissions from projects (e.g., energy efficiency investments).

Organizations interested in calculating their environmental footprint of electricity purchases and/or the avoided emissions attributable to their renewable energy or energy efficiency investments may find helpful information in this paper.[1]

eGRID

EPA's Clean Air Markets Division (CAMD) publishes eGRID and related tools (e.g., Power Profiler) to provide the public with a comprehensive inventory of air emissions from the U.S. electric power sector. eGRID combines EPA's CAMD Power Sector Emissions Data and U.S. Energy Information Administration (EIA) data to create a complete dataset of nearly every source of electric power generation in the U.S.

eGRID includes operating data—generation and heat input—and emissions data—mass emissions and emission rates for carbon dioxide (CO_2), mercury, methane (CH_4), nitrous oxide (N_2O), NO_X, particulate matter (PM), and SO_2—for each electricity generating unit (EGU). These data are aggregated to calculate plant-, state-, balancing authority-, eGRID subregional-, NERC regional-, and national-level emissions and emission rates for the electric power system. The plant-level data includes all EGUs at a power plant. The state-level data include all power plants within a state's boundaries. The balancing authority-level data include all power plants grouped by the balancing authority that controls the EGU.[2] The eGRID subregion-level data includes all power plants within each eGRID subregion—roughly, a grouping of balancing authorities. The NERC region-level data also roughly aggregates along balancing authority boundaries but uses larger groupings than the eGRID subregion level.[3] There are 26 eGRID subregions and 10 NERC regions. An EGU's assignment to an eGRID subregion and NERC region remains mostly consistent over time. However, EGUs are sometimes reassigned.[4]

The eGRID emission rates are expressed as pounds or tons of pollution per megawatt-hour of electricity generated. To calculate aggregated emission rates, EPA sums emissions from all sources in a particular area and divides the total emissions by the total electricity generated from those same sources. These aggregated emission rates in eGRID are therefore production-based emission rates—they reflect the emissions intensity of electricity generated in a particular area.

EPA's CAMD releases eGRID every other year. Data at the unit level and each aggregation level are available as a Microsoft Excel spreadsheet with summary tables. EPA's eGRID website contains more information about the data available in each release and the methodology for compiling and calculating the data.

[1] The methodology in this paper is based on discussions with stakeholders and information from EPA's voluntary programs. The methodology may not be consistent with other accounting frameworks such as the World Resource Institute's Greenhouse Gas Protocol.

[2] Balancing authorities are entities that manage the generation and flow of electricity along transmission and distribution lines. A balancing authority ensures that electricity demand and supply are balanced in order to maintain the safe and reliable operation of the power system. Local or regional blackouts can result if demand and supply fall out of balance.

[3] North American Electric Reliability Corporation (NERC) oversees and regulates the reliability of the North American electricity grids. It is responsible for developing and enforcing reliability standards.

[4] For more information about levels of aggregation or reassignments, refer to the technical support documentation for each eGRID release.

Emissions Scope

An organization's emissions are generally categorized into three levels, or scopes, based on the source of the emissions.

- Scope 1 emissions are direct emissions from the combustion of fuels at sources (e.g., space heating, vehicles, production equipment) owned or controlled by the organization.
- Scope 2 emissions are emissions that result from electricity, heat, or steam purchased from outside organizations.
- Scope 3 emissions are other emissions that result from the organization's activities but occur at sources not owned or controlled by the organization. This category includes transmission and distribution losses associated with electricity purchases.

This paper provides a methodology for determining Scope 2 emissions associated with electricity purchases and Scope 3 emissions associated with transmission and distribution losses.

Environmental Footprint Methodology

eGRID contains many different types of emission rates for different pollutants. The methodology described in this section explains how to choose from the available emission rates and how to calculate Scope 2 and Scope 3 emissions.

To illustrate how an organization might use the methodology, each step includes an example for a small organization.

Step 1: Select the pollutant(s) and choose the emission rate(s)

When choosing the emission rate(s) to use for an environmental inventory or footprint analysis, you should identify the pollutants you want to assess, the type of emission rate you want to use, and the aggregation level that is appropriate for your analysis.

Determine the pollutant

eGRID contains annual emission rates for CO_2, CH_4, mercury, NO_X,[5] N_2O, PM, SO_2, and CO_2 equivalent (CO_2e).[6] The CO_2e emission rate accounts for the global warming potential of the greenhouse gases CO_2, CH_4, and N_2O. These gases have different heat-trapping potential and lifespans in the atmosphere, so the CO_2e emission rate combines them to create a greenhouse gas emission rate.

Determine the type of emission rate

eGRID contains a variety of emission rates: input emission rate, output emission rate, output combustion emission rate, and non-baseload emission rate.

- The input emission rate represents the efficiency of converting heat energy into electricity. It is expressed as the pounds or tons of emissions per million British thermal units (mmBtu) of heat input.
- The output emission rate represents the emissions intensity of electricity. It is expressed as the pounds or tons of emissions per megawatt hour (MWh) of electricity generated.

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[5] NO_X emission rates are also available for the summer ozone season (May 1-September 30).

[6] EPA works to improve and expand eGRID. Therefore, earlier versions of eGRID may not contain data for all pollutants.

- The output combustion emission rate represents the emissions intensity of electricity from combustion sources (i.e., excludes non-combustion electricity generation such as nuclear and renewables). It is expressed as the pounds or tons of emissions per MWh of electricity generated from combustion sources.
- The non-baseload emission rate represents the emissions intensity of electricity from non-baseload units or marginal generation that might be avoided from efforts to reduce fossil fuel electricity generation, such as energy efficiency or renewable energy projects.

For an emissions inventory or footprint analysis, EPA recommends using the output emission rate. This rate, when multiplied by total electricity purchases, provides a straightforward estimate of total annual emissions. Other rates may be more appropriate for other types of analyses, such as calculating emissions avoided from certain energy efficiency or renewable energy projects, which is discussed in the "Avoided Emissions Methodology" section.

Determine the level of aggregation

The choice of geographic aggregation should reflect the location of facilities in an organization's operation. If you are calculating emissions for only one facility, you should choose the eGRID subregion emission rate. EPA's Power Profiler can assist you in determining the appropriate eGRID subregion based on zip code. If there are multiple facilities across a large geographic area, you may choose to use the NERC region emission rate or even the U.S. emission rate to simplify the analysis.

In general, you should avoid using the emission rates for a nearby power plant when developing an environmental footprint because electricity from a nearby plant may not necessarily supply the region or, if it does, it may not be the only source of electricity for the region. Electricity from many power plants is combined as it travels along transmission and distribution lines to consumers. Therefore, an emission rate aggregated to a higher level (e.g., eGRID subregion) is more appropriate for environmental footprinting.

Example

A small organization with one office located in Atlanta, Georgia is trying to calculate its environmental footprint. The organization does not combust fossil fuels at its office and does not own any fleet vehicles. Therefore, the organization's analyst only needs to calculate Scope 2 and Scope 3 emissions from electricity purchases.

The analyst wants to calculate the CO_2e, NO_X, and SO_2 emissions attributable to the organization's electricity purchases. She can find the emission rates in the eGRID database for each of these pollutants for the eGRID subregion in which her office is located.

Next, the analyst must decide the type of emission rate to use. Since she is assessing the environmental footprint for her organization, she will use the eGRID output emission rate for each pollutant.

The organization has only one facility, so the analyst will use the eGRID subregion emission rate. Using EPA's Power Profiler, she finds the appropriate eGRID subregion—SERC South (SRSO)—by entering the facility's zip code.

The output emission rates for the selected pollutants for SRSO for 2018 are:

CO_2e: 1,033.471 lbs/MWh

NO_X: 0.496 lbs/MWh

SO_2: 0.297 lbs/MWh

Step 2: Collect electricity use data

The organization's emissions related to electricity purchases will depend largely on the amount of electricity purchased. Therefore, you should collect the electricity purchase data, generally available from electricity billing records, for all facilities covered by the environmental footprint analysis and sum the data for the period of the analysis (e.g., calendar year). You can sum the data for each facility or sum the data to the level of aggregation you chose in Step 1.

If the electricity purchases are expressed in kilowatt-hours (kWh), divide the total electricity purchases by 1,000 to convert them to MWh, which is the unit used in eGRID output emission rates.

Example

For the small organization with one office located in Atlanta, Georgia, the analyst will use the organization's monthly electricity bills to calculate total electricity purchases. The result is 110 MWh for the calendar year.

Step 3: Calculate Scope 2 emissions

To calculate the emissions attributable to the organization's electricity purchase, use the following equation:

Equation 1:

$$eGRID\ output\ emission\ rate\ \left(\frac{lbs}{MWh}\right) \times electricity\ usage\ (MWh)$$

This equation multiplies the eGRID output emission rate selected in Step 1 and the electricity purchases calculated in Step 2. If the organization has facilities in several regions, you can use this equation for each level of aggregation you chose in Step 1.

This equation relies on the geographic emission factor that is sometimes referred to as the location-based method. Organizations that purchase electricity from specific facilities or electricity providers might opt to use emission factors from those providers. Using the supplier-provided emission rate is sometimes referred to as the market-based method. However, supplier-provided emission factors often represent the emissions intensity of a limited number of EGUs. If the organization receives the electricity directly from the electricity grid, as opposed to a direct connection to one or more EGUs, EPA recommends using the eGRID output emission factors and the location-based method.

Example

Using the eGRID subregional output emission rates for SRSO and the organization's electricity usage, the analyst finds that her organization's Scope 2 emissions are as follows:

$$1{,}033.471\ \frac{lbs\ CO_2e}{MWh} \times 110\ MWh = 113{,}682\ lbs\ CO_2e$$

$$0.5496\ \frac{lbs\ NO_X}{MWh} \times 110\ MWh = 60\ lbs\ NO_X$$

$$0.297\ \frac{lbs\ SO_2}{MWh} \times 110\ MWh = 33\ lbs\ SO_2$$

Step 4: Calculate Scope 3 emissions

As electricity travels along transmission and distribution lines from the producer to the consumer, some electricity is lost due to dissipation in the equipment and lines. In general, the longer the distance over which electricity is transmitted, the more electricity is lost. The amount of electricity losses can also vary based on other factors, like the voltage of the wires and the electricity load traveling across the wires. These losses are referred to as transmission and distribution (T&D) losses or line losses. eGRID refers to these losses as grid gross loss. eGRID includes grid gross losses at the interconnect level (plus Alaska and Hawaii) as well as for the U.S.

Because some electricity generated by an EGU is lost before the electricity reaches the end consumer, more than 1 MWh of electricity must be produced for the consumer to purchase and use 1 MWh of electricity. This means that the total emissions attributable to an organization's purchase of electricity are slightly higher than the result from Equation 1.

To calculate the transmission and distribution losses associated with electricity, select the appropriate grid gross loss value from eGRID—Alaska, Eastern (approximately all areas east of the Rocky Mountains excluding Texas), ERCOT (Texas), Hawaii, and Western (approximately all areas west of the Rocky Mountains). As with Step 1, if there are multiple facilities across a large geographic area, you may choose to use the U.S. grid gross loss average. Use the selected grid gross loss value and the eGRID emission rate used in Step 1 with the following equation:

Equation 2:

$$\frac{\frac{grid\ gross\ loss}{100} \times eGRID\ output\ emission\ rate\ \left(\frac{lbs}{MWh}\right) \times electricity\ usage\ (MWh)}{\left(1 - \frac{grid\ gross\ loss}{100}\right)}$$

This equation converts the grid gross loss, expressed as a percentage, to a value between 0 and 1. Then the value is multiplied by the eGRID output emission rate selected in Step 1 and the electricity purchases calculated in Step 2. This is then divided by 1 minus the grid gross loss. If the organization has facilities in several regions, you can use this equation for each level of aggregation you chose in Step 1.

Example

Using the grid gross loss for the region and the eGRID subregion output emission rates from Step 2, the analyst can calculate her organization's Scope 3 emissions. The SRSO eGRID subregion is in the Eastern Interconnect. eGRID shows that the grid gross loss rate for the Eastern Interconnect in 2018 was 4.88%. Using Equation 2 yields the following Scope 3 emissions from transmission and distribution losses.

$$\frac{\frac{4.88}{100} \times 1{,}033.471\ \frac{lbs\ CO_2e}{MWh}}{1 - \frac{4.88}{100}} \times 110\ MWh = 5{,}832\,\frac{lbs\ CO_2e}{MWh}$$

$$\frac{\frac{4.88}{100} \times 0.5496 \frac{lbs\ NO_X}{MWh}}{1 - \frac{4.88}{100}} \times 110\ MWh = 3 \frac{lbs\ NO_X}{MWh}$$

$$\frac{\frac{4.88}{100} \times 0.297 \frac{lbs\ SO_2}{MWh}}{1 - \frac{4.88}{100}} \times 110\ MWh = 2\ \frac{lbs\ SO_2}{MWh}$$

These emissions are attributable to transmitting the electricity from the EGU to the consumer. When added together with the Scope 2 emissions, they represent the full environmental footprint of this organization.

$$113{,}682\ lbs\ CO_2e + 5{,}832\ lbs\ CO_2e = 119{,}514\ lbs\ CO_2e\ (59.8\ short\ tons\ CO_2e)$$

$$60\ lbs\ NO_X + 3\ lbs\ NO_X = 63\ lbs\ NO_X$$

$$33\ lbs\ SO_2 + 2\ lbs\ SO_2 = 35\ lbs\ SO_2$$

Avoided Emissions Methodology

Organizations can adapt the environmental footprint methodology to calculate the potential or actual avoided emissions from using lower- or zero-emitting sources of electricity. For example, to lower its environmental footprint, an organization might choose to implement energy efficiency measures or add on-site renewable energy sources (e.g., solar panels) that would reduce electricity purchases. To estimate emissions avoided from these types of actions, you can use a modified version of the environmental footprint methodology.

To illustrate how an organization might use the methodology to calculate avoided emissions, each step includes an example for a small organization.

Step 1: Select the pollutant(s) and choose the emission rate(s)

When choosing the emission rate(s) to use for an environmental inventory or footprint analysis, you should identify the pollutants you want to assess, the type of emission rate you want to use, and the aggregation level that is appropriate for your analysis. Refer to Step 1 in the "Environmental Footprint Methodology" section for more details.

For an avoided emissions analysis, EPA recommends using the eGRID non-baseload emission rate. The non-baseload rate is the emission rate for all sources with a lower capacity factor. These are marginal electricity generators and are usually dispatched after baseload units.[7]

[7] Some environmental footprint programs do not approve of the use of non-baseload emission rates. However, many EPA documents and tools use non-baseload emission rates to quantify avoided emissions.

Example

An organization with a warehouse in Washington state installed on-site solar panels to reduce electricity purchases. The organization would like to calculate the avoided emissions attributable to this renewable energy project for the year 2018.

The analyst wants to calculate the organization's avoided CO_2 and CH_4 emissions. He can find the emission rates for each of these pollutants for the eGRID subregion in which his facility is located in the eGRID database.

Because the analyst is assessing the avoided emissions attributable to electricity usage from the on-site solar panels instead of the grid, he will use the eGRID non-baseload emission rate for each pollutant.

The organization has only one facility, so the analyst will use the eGRID subregion rate. He uses EPA's Power Profiler to find his organization's eGRID subregion—WECC Northwest (NWPP).

The non-baseload emission rates for the selected pollutants for NWPP in 2018 are:

CO_2: 1,575.090 lbs/MWh

CH_4: 0.148 lbs/MWh

Step 2: Calculate electricity saved or displaced

The organization's avoided emissions will depend largely on the amount of electricity saved or displaced. Therefore, you should determine the electricity saved or displaced by determining the impact of the organization's project(s). For example, for on-site renewable electricity projects, you can generally assume the on-site electricity generation displaces electricity purchases by an equal amount.

On the other hand, calculating electricity savings from energy efficiency projects may not be as straightforward. Because electricity usage without the energy efficiency project is not technically observed after the project has been put in place, a baseline level of electricity usage must be established to compare to actual electricity usage with efficiency measures. The difference between baseline electricity usage and actual electricity usage is the displaced electricity. Estimating this baseline is outside the scope of this paper, but once you have estimated the amount of displaced electricity, you can proceed with the next steps in this paper. If the electricity saved or displaced is expressed in kilowatt-hours (kWh), divide the total electricity saved or displaced by 1,000 to convert it to MWh.

Example

The organization has a meter to track how much electricity is generated by the onsite solar panels. Based on the meter readings the panels generated 53 MWh for the calendar year.

Step 3: Calculate avoided emissions

To calculate the avoided emissions attributable to the organization's investments in renewable energy or energy efficiency, use the following equation:

Equation 3:

$$eGRID\ nonbaseload\ emission\ rate\ \left(\frac{lbs}{MWh}\right) \times electricity\ use\ avoided\ (MWh)$$

This equation multiplies the eGRID non-baseload emission rate selected in Step 1 and the electricity avoided or displaced calculated in Step 2. If the organization has facilities in several regions, you can use this equation for each level of aggregation you chose in Step 1.

As in the environmental footprint methodology, this method also relies on the location-based method of accounting. Please refer to Step 3 in the previous section for more discussion of this method.

Example

Using the eGRID subregional non-baseload emission rates for NWPP and the electricity generated by the solar panels, the analyst can calculate that his organization avoided the following emissions:

$$1{,}575.090\ \frac{lbs\ CO_2}{MWh} \times 53\ MWh = 83{,}480\ lbs\ CO_2\ (41.7\ short\ tons\ CO_2)$$

$$0.148\ \frac{lbs\ CH_4}{MWh} \times 53\ MWh = 8\ lbs\ CH_4$$

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Additional Resources

This paper relies on EPA's Emissions and Generation Resource Integrated Database (eGRID). EPA has many additional resources listed below for organizations looking to estimate their environmental impact.

EPA's Power Profiler provides a visual tool displaying eGRID emission rate data as well as a method of determining eGRID subregion based on zip code.

The eGRID Explorer allows you to explore the eGRID data in charts, maps, and other visualizations.

EPA's Energy and the Environment site provides resources for businesses looking to reduce their environmental impact, such as becoming more energy efficient or switching to cleaner energy sources. For example, EPA's Green Power Partnership provides tools and resources for the voluntary renewable electricity market and recognizes organizations across the country for their green power purchases.

EPA's Greenhouse Gas Equivalencies Calculator provides information about what a reduction in electricity use means in everyday terms (like miles driven).

EPA's Simplified Greenhouse Gas Calculator allows organizations to do a more complete assessment of its greenhouse gas emissions from all activities (not just electricity purchases).

EPA also provides two tools for estimating community and health benefits of emissions reductions. EPA's AVoided Emissions and geneRation Tool (AVERT) can be used to estimate the emissions impact of energy efficiency and renewable energy policies and programs. EPA's CO-Benefits Risk Assessment (COBRA) can be used to estimate health benefits of clean energy policies at the county, state, regional, and national level and economically value those benefits.