For Point Sources paper session

eGRID Emission Estimation Methods

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ABSTRACT

This paper, in response to the questions asked by eGRID users about emissions, describes the methods used to estimate 2000 emissions in EPA's Emissions & Generation Resource Integrated Database (eGRID), a comprehensive source for air quality attributes of electric power generated in the U.S. eGRID is a valuable resource for States implementing air pollution control policies/regulations and as a tool for tracking changes in power plant air emissions as the electricity industry grows and changes.

Developing emissions for eGRID is complicated because of the many Federal data sources used; a further complication is that adjustments are made to eGRID emissions. Initial emission estimates are primarily obtained from EPA's Emissions Tracking System/Continuous Emissions Monitoring (ETS/CEM), which contains reported SO_2, NO_x, and CO_2 emissions. Emissions are secondarily derived from DOE's Energy Information Administration (EIA) electricity survey data. Two EPA data files are used for mercury emissions: EPA's 2000 large municipal solid waste combustors and EPA's 1999 ICE coal-fired boilers mercury emission files. Adjustments are made to emissions for biomass and CHP plants; eGRID emissions may not always match either the reported or calculated initial emissions.

The latest edition of the inventory, eGRID2002, contains emissions data for 1996 through 2000, and reflects the relationships among the various entities as the industry was configured on December 31, 2002. The forthcoming edition, eGRID2004, will add emissions for 2001 and 2002. Although EIA electricity survey forms significantly changed in 2001, these changes are not expected to affect the basic methodology for developing eGRID2004 emissions estimates.

This paper describes the methods use to estimate emissions in EPA's Emissions & Generation Resource Integrated Database (eGRID)[1]. eGRID provides information on the air quality attributes of virtually all of the electric power generated in the United States It is a comprehensive source of data for States implementing air pollution control policies/regulations, and gives policy makers a powerful tool for tracking changes in power plant air emissions as the electricity industry grows and changes. This paper is in response to the many questions asked by eGRID users about emissions for the most recently available eGRID data year (2000).

The inventory contains emissions data for nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon dioxide (CO_2), and mercury (Hg). Generation and resource mix for power plants, companies, and U.S. regions are also included. Since available data from 24 existing Federal data sources are used and data are reported differently, developing emissions for eGRID can be complicated; a further complication is that adjustments are made to eGRID emissions.

Initial emission estimates for eGRID are primarily obtained from EPA's Emissions Tracking System/Continuous Emissions Monitoring (ETS/CEM)[2,3], which contains reported SO_2, NO_x, and CO_2 emissions. Emissions are secondarily derived from DOE's Energy Information Administration (EIA) electric power survey data. Additionally, two fuel-specific EPA data files are used to estimate mercury emissions.

For combined heat and power/cogeneration plants and for plants that burn biomass (and especially renewable methane such as landfill or digester gas), adjustments are made to the reported and calculated emissions. Thus, the eGRID emissions may not always match either the reported emissions or those calculated from the data sources' original values.

The latest published edition of eGRID, eGRID2002, displays emissions data for 1996 through 2000; the boilers, generators, plants, operator and owner and parent companies, power control areas, eGRID subregions, and NERC regions relate to each other as the industry was configured on December 31, 2002. Although there have been changes in methodology in the present edition of eGRID from the three previous editions, this paper will focus on the fourth edition's 2000 emissions. For the forthcoming fifth edition, eGRID2004, 2001 and 2002 emissions estimates have not yet been developed since the final EIA data are not yet available. However, despite the significant changes and realignment of the 2001 and 2002 EIA data and survey forms, the methodology for 2001 and 2002 emissions estimates and adjustments are not expected to change.

The eGRID emissions methods are discussed below.

Unadjusted Emission Estimates for 2000

Emissions in eGRID are estimated in tons, using data from a variety of sources from EPA and EIA. Although many small units, as well as some nonutilities and cogenerators, are not subject to ETS/CEM data reporting, the vast majority of emission tons reported in eGRID are from the ETS/CEM data. Sources that report to ETS/CEM are generally utility and non-utility steam units with at least 25 MW capacity, nonsteam units – gas turbines, internal combustion engines -- that came on-line after 1990, and independent power producers/cogenerators that sell a specific amount of electricity.

Plant-level emissions in eGRID are often built by summing its parts – which could be simply boilers or a combination of boilers and prime movers representing an aggregation of like nonsteam generating units. In general, eGRID plant-level emissions reflect a combination of monitored and estimated data. Depending on the source of data and the emissions type, emission tons are summed to the plant level before making adjustments specific to eGRID.

Annual NO_x, SO_2, and CO_2

The initial source for eGRID's SO_2, NO_x, and CO_2 emissions data is EPA's unit-level ETS/CEM data. If ETS/CEM data are not reported, the emissions are generally estimated using fuel quantity – on a boiler-fuel level if the data are in the EIA-767[4], on a plant-fuel level if the data are only in the EIA-860B[5], and/or on a prime mover-fuel level if the data are only in the EIA-906 utility file (formerly called the EIA-759)[6].

- For NO_x, uncontrolled emissions factors[7] and control efficiencies, if available, are also used in the calculation of the emissions.

- For SO_2, uncontrolled emissions factors, sulfur content, and control efficiencies, if available, are also used in the calculation of the emissions. EPA also developed 2000 SO_2 and NO_x emissions for large Municipal Solid Waste Combustors (MWC)[8]; since there is no overlap with the ETS/CEM emissions for MWC boilers, these developed emissions are used instead of EIA-derived SO_2 and NO_x emissions.

- For CO_2, the greenhouse gas methodology that uses the heat input (based on fuel quantity and heat content), the fuel-specific carbon coefficient[9], and the fraction of carbon oxidized, are additional components in the emission calculations.

If a plant has nonsteam generating units in addition to steam boilers or has only nonsteam generating units, fuel use is aggregated at the prime mover level (such as gas turbines or internal combustion engines) as reported on the EIA-906; along with plant-level fuel quality data from the EIA/FERC-423[10] (for SO_2, the sulfur content and for CO_2, the heat content); these initial EIA-based emission estimates are developed in a fashion similar to that for estimating EIA-767 boiler emissions, although no emission control data are available.

For nonutility plants that only report to the EIA-860B, initial emissions are estimated in the same way as explained above, using reported plant fuel type, fuel quantity, sulfur content, and heat content..

Annual Mercury (Hg)

Reliable emission factors were not available at the time that eGRID was being developed, so mercury emissions are only included for fuel with available emissions data. The most important mercury electric power sources – coal and solid waste boilers – are represented in eGRID using two EPA-developed data files: one with 2000 Hg emissions for large municipal solid waste combustors and one with 1999 Hg emissions for coal-fired boilers[11]. Original 1999 mercury coal emissions at the plant level are included in the eGRID plant file for 1999, but the 2000 mercury coal emissions are estimated by multiplying the 1999 emissions by the ratio of the plant's 2000 to 1999 coal tons.

Ozone Season NO_x

EPA provides ozone season ETS/CEM NO_x emissions that are used in eGRID if the annual ETS/CEM NO_x emissions are also available. Otherwise, for those boilers that report to the EIA-767, as well as large plants with nonsteam prime movers that report to the EIA-906 utility file, monthly fuel quantity is provided so that five-month (May through September) ozone season NO_x emissions can be estimated in the same way as for annual EIA-based NO_x emissions. For those remaining (plants whose data are derived from either EIA-860B or annual-only EIA-759, or obtained/estimated from EPA's large MWC file), the ozone season NO_x estimates are calculated as the annual estimates multiplied by 5/12.

Adjusted Emission Estimates for 2000

Emissions reported in eGRID represent emissions from fuel utilized only for electricity generation. Thus, for certain plants, there are two possible adjustments to the eGRID plant-level emission estimates: if the plant burns biomass, including renewable methane (such as landfill methane or digester gas) and/or if the plant is a combined heat and power (CHP) facility.

<u>**Adjustments for Biomass**</u>

eGRID makes adjustments for biomass emissions, for renewable methane biomass emissions, and for solid waste emissions (since solid waste typically consists of a mixture of renewable materials – biomass such as wood, paper, and food waste – and non-renewable materials – fossil-based materials such as plastics and tires). Beginning with 1998 data, eGRID2002 applies a standard assumption that 70 percent of the heat value of the waste stream comes from renewable materials and 30 percent comes from non-renewables (fossil waste), so 70% of its emissions are adjusted in the same fashion as are those from biomass. (Note that emissions from solid waste facilities in 1998, 1999, and 2000 are not comparable to those for prior years. eGRID previously assigned zero emissions to all solid waste combustion facilities.) The possible adjustments for CO_2, NO_x, and SO_2 emissions are explained below.

- **CO_2** – Since biomass is a fuel derived from organic matter(wood and paper products, agricultural waste, or methane (e.g., from landfills)), eGRID assumes that these materials are subject to the natural carbon cycle and therefore do not contribute to global warming. Thus, all biomass CO_2 emissions are assigned a value of zero because these organic materials would otherwise release CO_2 (or other greenhouse gases) through decomposition.

- **NO_x and SO_2** – Emissions from renewable methane such as landfill gas and digester gas emissions in most cases must be flared if the gas is not utilized to generate electricity, so eGRID assumes that renewable methanes would not have been flared if used to generate electricity. For 2000 (and 1999) data, the amount of incremental NO_x and SO_2 emissions attributable to utilizing renewable methane to generate electricity is what is considered for eGRID's emissions. Thus, emissions from these fuels are adjusted by decreasing the emission factors (used to estimate the emissions) by the emissions factor represented by a typical flare.

For NO_x, the flare emission factor is assumed to be 40 lb per MMBtu of methane, 20 lb per MMBtu of methane for landfill gas, and 26 lb per MMBtu of methane for digester gas. (Prior to the 1999 data year, eGRID did not account for incremental NO_x emissions associated with using renewable methane to generate electricity. For data years 1996, 1997, and 1998, emissions from landfill methane and digested gas was

assigned a value of zero, reflecting the assumption that NO_x emissions from the generator were equivalent to those from flaring the methane.)

For SO_2, the flare emission factor is assumed to be the same as the flare's, so there are no incremental SO_2 emissions attributable to utilizing renewable methane to generate electricity, and a value of zero is assigned. This has the case for emissions calculated for all years of eGRID data.

Adjustments for CHP

Combined heat & power (CHP) is a type of generating facility that produces electricity and another form of useful thermal energy (such as heat or steam) used for industrial, commercial, heating, or cooling purposes. CHP, also known as cogeneration, converts energy more efficiently than facilities that produce heat and electricity individually. Since emissions reported in eGRID represent electricity generation only, emissions associated with useful thermal output are excluded (and a plant's emissions data reported in eGRID may be different from that reported in other EPA sources). Thus, eGRID's methodology is designed to share CHP's efficiency gains between electricity and useful thermal output, allocating emissions between them by using an electric allocation factor that discounts the value of useful thermal output by 50 percent. This electric allocation factor is applied to all unadjusted emissions and heat input associated with the CHP. (This methodology is different for 1996 and 1998 data, which relied on an EIA allocation methodology that did not recognize CHP efficiency gains in reporting electricity emissions.)

For 2000 (and 1998 and 1999), if the useful thermal output value is known, the electric allocation factor is calculated as the ratio of the electricity heat output to the sum of the electricity and steam heat outputs, where electricity heat output MMBtu = net generation MWh * 3.412 and steam heat output MMBtu = .5 * useful thermal output.

If the useful thermal output is unknown, the electric allocation factor is estimated assuming an 8500 Btu/kWh median plant nominal heat rate and the plant's heat input and generation (heat rate = electric allocation factor * 1000 * heat input MMBtu / net generation MWh). Thus the electric allocation factor for CHP plants without a given useful thermal output is calculated as (8500 * plant net generation)/(1000 * unadjusted plant heat input).

Emission Rate Estimates

Both output and input emission rates are calculated for eGRID, beginning with the plant level of aggregation. In addition to emission values, annual and ozone season net generation and heat input values are required for emission rate calculations.

Plant-level annual generation (in MWh) for eGRID is almost always obtained from the EIA-906 for utility plants and from EIA-860B for nonutility plants. (For plants that are sold/transferred from a utility (a regulated entity) to a nonutility (a nonregulated entity) during the specified year, the net generation from the two different EIA sources is summed, when possible, to obtain a complete year of data.) For large plants with EIA-906 utility net generation, generation is reported monthly as well as annually, so ozone season generation is calculated by summing up the generation for the five months; otherwise, ozone season generation is calculated as 5/12 of the annual net generation. For plants with EIA-860B annual gross generation, gross generation is converted to net generation at the generator level using EIA's methodology (see an *Electric Power Annual*

Technical Notes appendix[12]) and then summed to the plant level; and ozone season net generation is estimated as 5/12 of the annual net generation.

Annual boiler-level heat input (MMBtu) for eGRID is initially obtained from ETS/CEM data, if available. Otherwise, it is calculated by multiplying the EIA-767 fuel consumption and heat content and/or by multiplying the EIA-906 utility fuel consumption and FERC-423 heat content, and summing to the plant-level; or by multiplying the EIA-860B annual plant fuel consumption and heat content. For large plants with EIA-906 fuel use and FERC-423 heat content, fuel use is reported monthly as well as annually, so ozone season heat input is calculated by calculating the monthly heat input for the five months and summing it up; otherwise, ozone season heat input is estimated as 5/12 of the annual heat input. For plants with EIA-860B annual heat input, ozone season heat input is also calculated as 5/12 of the annual heat input.

The measurement units for output rates are lb/MWh for SO_2, NO_x, and CO_2, and lb/GWh for Hg; these rates are calculated as the emissions divided by the net generation and multiplied by a units conversion factor. For input rates, the measurement units are lb/MMBtu for SO_2, NO_x, and CO_2, and lb/BBtu for Hg; these rates are calculated as the emissions divided by the heat input and multiplied by a units conversion factor. (Note that in some cases, a calculated rates was clearly an outlier, outside the range of probable values, so the rate was assigned a value of 'N/A' in eGRID.)

For further information, go to eGRID's website, www.epa.gov/cleanenergy/egrid to read the *eGRID2002 Technical Support Document*, or email this paper's authors.

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KEYWORDS