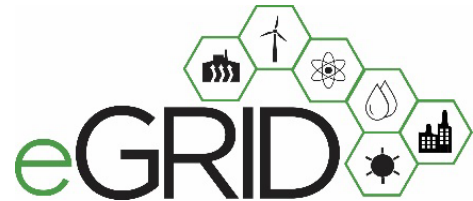


Particulate Matter Emissions for eGRID2021



DRAFT White Paper

September 2023

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Introduction

EPA's Emissions & Generation Resource Integrated Database (eGRID) is a comprehensive source of data on air pollution emissions and electricity generation for virtually all electric generating units in the United States. Currently, eGRID includes emissions data on carbon dioxide (CO₂), nitrogen oxides (NO_x), sulfur dioxide (SO₂), methane (CH₄), and nitrous oxide (N₂O), but does not include information on particulate matter (PM). PM pollution—principally fine particulate matter 2.5 microns in diameter or smaller (PM_{2.5})—can lead to negative health impacts, including asthma exacerbations, heart attacks, and premature mortality. For example, Lelieveld et al. (2015) estimated that in 2010, 55,000 premature deaths in the United States were attributable to two types of air pollution — PM_{2.5} and ozone.¹ Additionally, EPA's retrospective analysis of the Clean Air Act found that approximately 85 percent of the public health benefits of air quality regulations are due to PM_{2.5} reductions, rather than ozone (EPA 2011a).² PM_{2.5} can also lead to reduced visibility, known as haze, which negatively affects much of the country, including national parks.

This white paper provides an overview of the methodology used to develop the draft PM_{2.5} emissions rates and the emissions rates for eGRID2021. eGRID uses CAMD's Power Sector Emissions Data reported to EPA's Clean Air Markets Division (CAMD)³ to determine the CO₂, NO_x, and SO₂ emissions at many electric generating units. For electric generating units that do not report to CAMD, eGRID estimates emissions based on fuel use, as reported to the Energy Information Administration (EIA).⁴ Neither CAMD nor EIA collect data on PM_{2.5} emissions.⁵ For this reason, it is not possible to use PM data from either CAMD or EIA to estimate the PM_{2.5} emissions and PM_{2.5} emission rates from power plants.

EPA's National Emissions Inventory (NEI) is a source of PM_{2.5} emissions data. The annual emissions of air pollutants, including PM_{2.5}, from most electric generating units get reported to the NEI.⁶ While EPA has not previously used the NEI data for eGRID, EPA is proposing to use NEI data to determine PM_{2.5} emissions at electric generating units. The most recent data year for both eGRID and NEI data is 2021.

This paper discusses EPA's proposed methods to determine PM_{2.5} emission rates for each power plant, including steps to estimate emissions for units that may not report to the NEI. The accompanying Excel data file, "eGRID2021 DRAFT PM Emissions.xlsx," lists the unit- and plant-level heat input, plant-level generation, and unit-, plant-, and eGRID subregion-level PM_{2.5} emissions and emission rates for 2018, 2019, 2020, and 2021.

Note that PM can be emitted in two forms—as particles (filterable PM) or as a gas that later condenses into particles when it enters the atmosphere (condensable PM). The eGRID methodology is designed to

¹ Lelieveld, J., J.S. Evans, M. Fnais, D. Giannadaki, and A. Pozzer. 2015. The contribution of outdoor air pollution sources to premature mortality on a global scale. *Nature* 525: 367–371.

² EPA. 2011a. *The Benefits and Costs of the Clean Air Act from 1990 to 2020*. U.S. Environmental Protection Agency Office of Air and Radiation. Final Report – Rev. A. April. Available: https://www.epa.gov/sites/production/files/2015-07/documents/fullreport_rev_a.pdf. U.S. Environmental Protection Agency.

³ These data are reported to EPA under chapter 40 of the Code of Federal Regulations part 75 (40 CFR part 75) for several Clean Air Act programs, including the Acid Rain Program and Cross-state Air Pollution Rule.

⁴ These data are reported to EIA through form EIA-923.

⁵ EIA collects some data on PM emission rates, but it does not specify whether the rates are for PM_{2.5} or PM₁₀ (particulate matter 10 microns in diameter or smaller).

⁶ Electric generating units and other point sources of air pollution emissions do not report emissions directly to the NEI. Rather they report to state, local, or tribal agencies, which then report the data to the NEI.

include both types of PM, also known as primary PM_{2.5}.⁷

Methodology

The most recent year in which both eGRID and NEI data are available is 2021.⁸ To estimate PM_{2.5} emissions and emission rates for 2021, unit-level PM_{2.5} emission rates (lb/MMBtu) were developed using the 2021 NEI PM_{2.5} mass data and the 2021 EIA heat input data. The 2021 unit-level PM_{2.5} emissions were summed to the plant-level, state-level, and eGRID subregion-level to estimate 2021 plant-level PM_{2.5} emissions and state-level and eGRID subregion-level PM_{2.5} output emission rates.

The following methodology discusses how the 2021 unit-, plant-, and eGRID subregion-level PM_{2.5} emissions and emission rates were calculated. The NEI contains annual PM_{2.5} emissions data for electric generating units, but the first step in integrating NEI data is to match the electric generating units to the eGRID data. The NEI uses Emissions Inventory System (EIS) codes to identify facilities and units, while eGRID uses Office of Regulatory Information Systems Plant (ORISPL) codes to identify facilities and units. EPA's Office of Air Quality Planning and Standards (OAQPS), which compiles the NEI, has matched electric generating units between EIS identifiers used in the NEI and the ORISPL identifiers used in eGRID.⁹ The EIS and ORISPL systems do not always have a one-to-one relationship; in some cases, multiple EIS IDs are used to refer to a single unit in eGRID (or vice versa). In order to use the NEI data in eGRID, the NEI data are mapped to the appropriate ORISPL plant and unit ID. Multiple units in the NEI that are reported as matching to one eGRID unit are grouped and summed to determine the total emissions for each eGRID unit. For units that cannot be matched directly to the NEI, EPA estimated the PM_{2.5} emissions using a series of emissions factors. In general, the process of determining the PM_{2.5} emissions for each unit follows a four-step process:

1. **Direct match.** First the EPA matched operational combustion units with positive heat input directly between the 2021 NEI and 2021 eGRID. Units that could not be matched directly between the NEI and eGRID either do not report to the NEI as point sources or an adequate match between NEI and eGRID could not be determined.
2. **Average emissions factors by fuel type, unit firing type, and prime mover.** EPA developed average emissions factors by grouping the units from the NEI that can be matched to eGRID by fuel type (e.g., bituminous coal), unit firing type (e.g., wall-fired), and prime mover (e.g., steam turbine). The PM_{2.5} emissions and heat input, expressed as million British thermal units (MMBtu), for all units in each group were summed. The emissions factor was calculated by dividing the total emissions in each group by the total heat input in each group. This emissions factor was multiplied by the heat input reported by EIA for all units that could not be matched to a unit in the NEI, but which have the same fuel type, firing type, and prime mover.
3. **Average emissions factors by fuel type and prime mover.** For units that could not be matched directly between eGRID and the NEI or that could not be matched using the emissions factors developed under step 2, EPA next developed more general average emissions factors by grouping

⁷ In addition to primary PM_{2.5} emitted by electric generating units, secondary PM_{2.5} can form in the atmosphere based on reactions of gases, such as NO_x, SO₂, and ammonia. This proposed method only addresses primary PM_{2.5}.

⁸ The National Emissions Inventory is compiled for all sources every three years, and the most recent release is for 2017 data. However, data on point sources, including electricity generating units, is collected annually, and the most recent data for the point source emissions is 2021.

⁹ This analysis uses the data from the 2016v1 air emissions modeling platform (available at <https://www.epa.gov/airemissions-modeling/2016v1-platform>) to identify PM_{2.5} emissions from power plants.

the units from the NEI by fuel and prime mover. To capture more units, firing type was not included in this step because not all units have firing type data.

4. **Emissions factors from AP-42.** For the remaining units, EPA estimated the PM_{2.5} emissions using an emissions factor reported in EPA's AP-42.¹⁰ The emissions factors from AP-42 are specific to the unit's fuel, firing type, and prime mover. For some of these units, EPA was able to match the units to a PM control efficiency reported in the EIA-923. Therefore, for these units, the PM_{2.5} emissions estimated using the emissions factor were adjusted to account for the control efficiency. Since the NEI emissions included in step 1 and the average emissions factors developed in steps 2 and 3 are based on reported emissions to the NEI, the control efficiency is already accounted for in these emissions factors. The emissions in steps 1 through 3 therefore did not need to be further adjusted for any control efficiencies.

There are some fuel types for which there are no emissions factors in AP-42 or another source. For these factors, an emissions factor from a similar fuel type was applied. For example, there is no emission factor for other gas (OG), so the emissions factor for natural gas (NG) was used. For some fuel types, including lignite coal, petroleum coke, and waste oil, the PM_{2.5} emissions factors depend on the ash content of the fuel. For the units combusting these fuels that could not be directly matched to the NEI, an ash content of the fuel was first estimated. EIA-923 reports ash content at the unit-level for each month. A weighted average ash content was calculated for each unit that uses lignite, petroleum coke, or waste oil, weighted by the amount of heat input for each unit in each month, which were used with equations from AP-42 to determine unit-specific emissions factors for those three fuel types.

Results

Figure 1 displays the 27 eGRID subregions for eGRID2021. The 2021 subregion-level annual net generation, PM_{2.5} emissions, and PM_{2.5} output emission rates are shown in Figure 2 and in Table 1. The 2018, 2019, 2020, and 2021 unit-, plant-, and subregion-level annual net generation, PM_{2.5} emissions, and PM_{2.5} output emission rates are included in the Excel data file "eGRID2021 DRAFT PM Emissions.xlsx."

The 2021 subregion-level PM_{2.5} output emission rates range from 0.016 lbs/MWh in the NYUP subregion to 1.016 lbs/MWh in the HIMS subregion. The highest output emission rates are in the subregions in Alaska and Hawaii, which have a higher percentage of generation from oil and a lower percentage of generation from natural gas when compared to the subregions in the contiguous United States. These higher output emission rates are explained by the fact that oil has a high PM_{2.5} output emission rate compared to natural gas.

¹⁰ United States Environmental Protection Agency, Office of Air Quality Planning and Standards. Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources

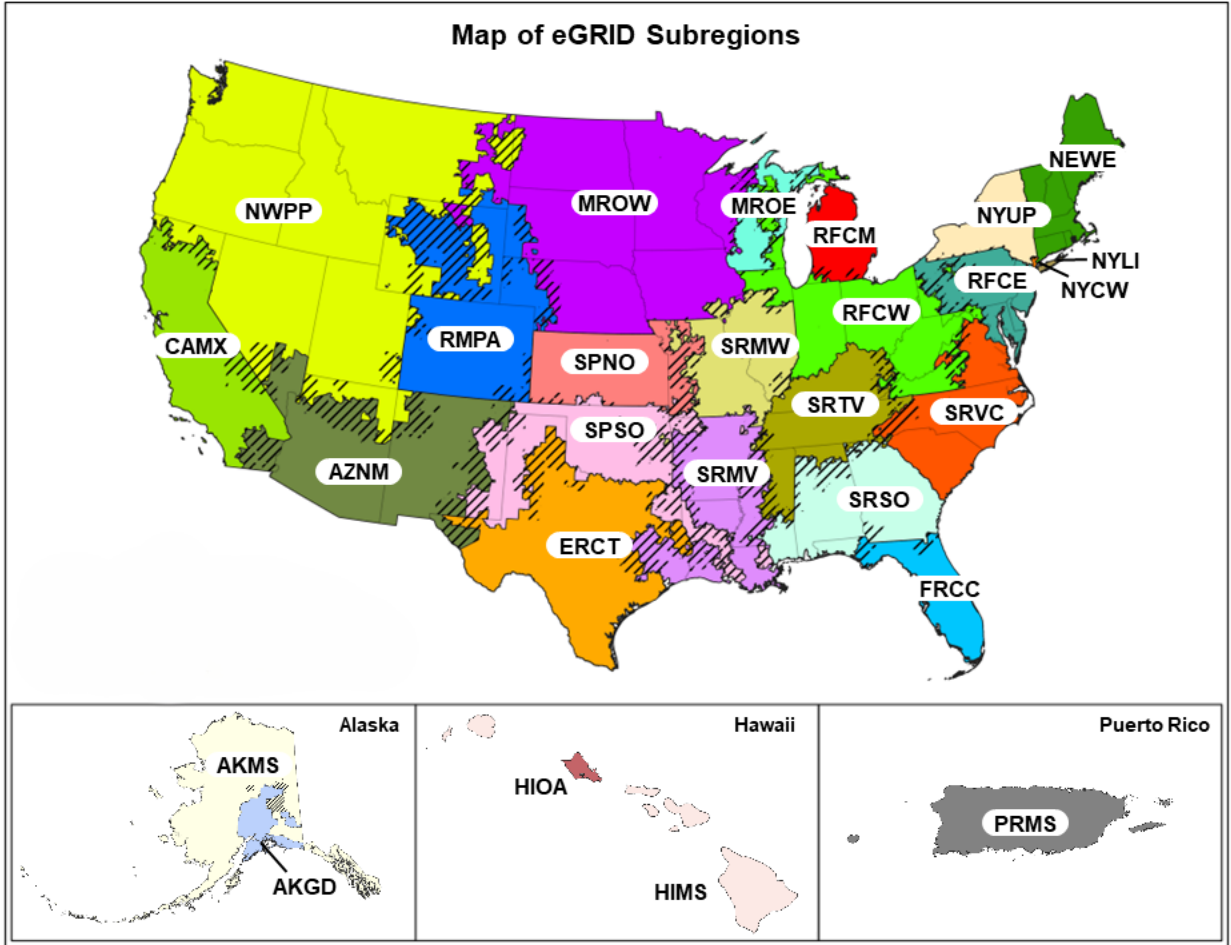


Figure 1. eGRID subregion map

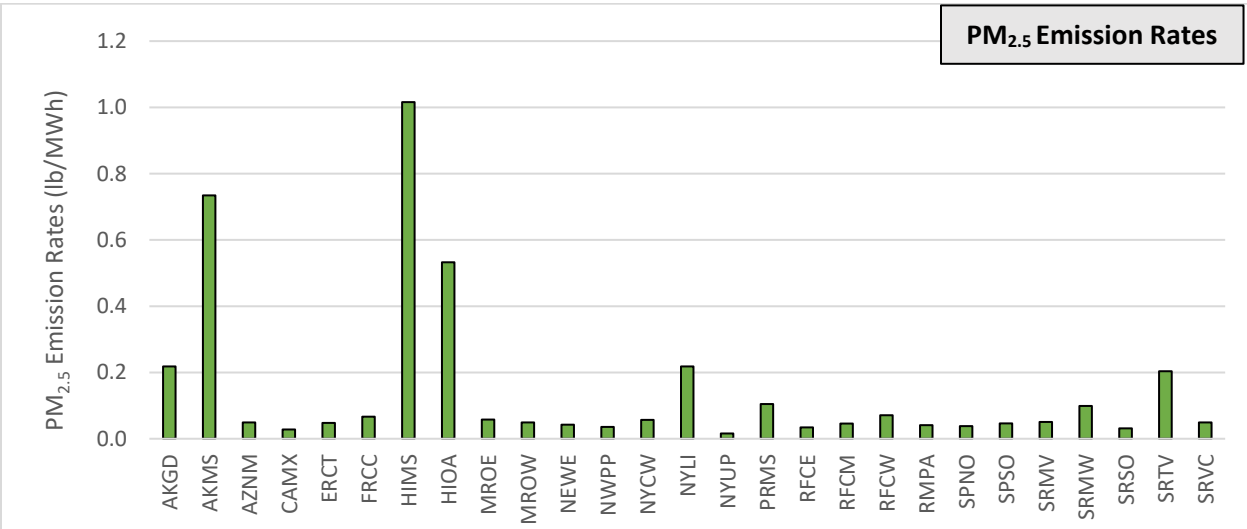
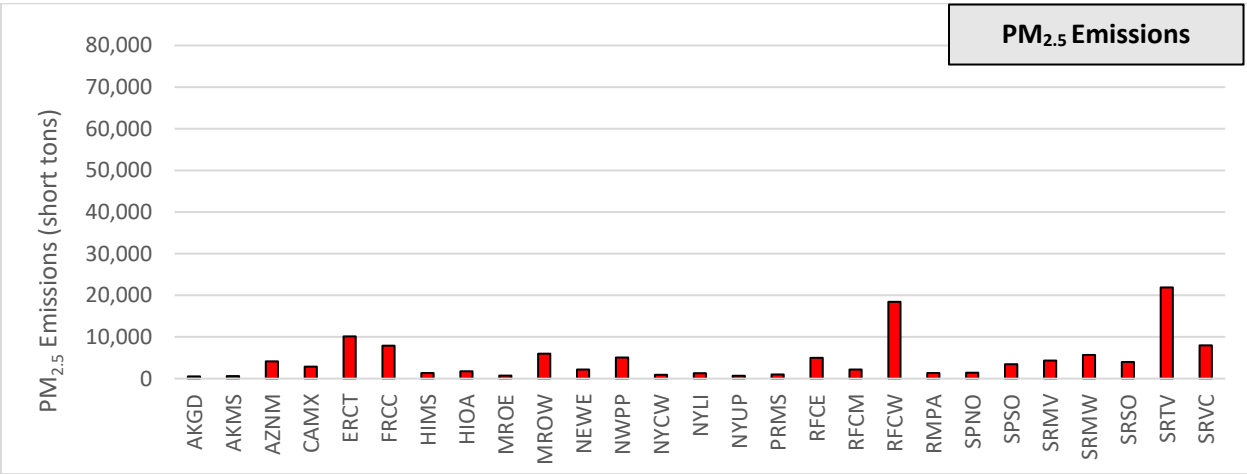
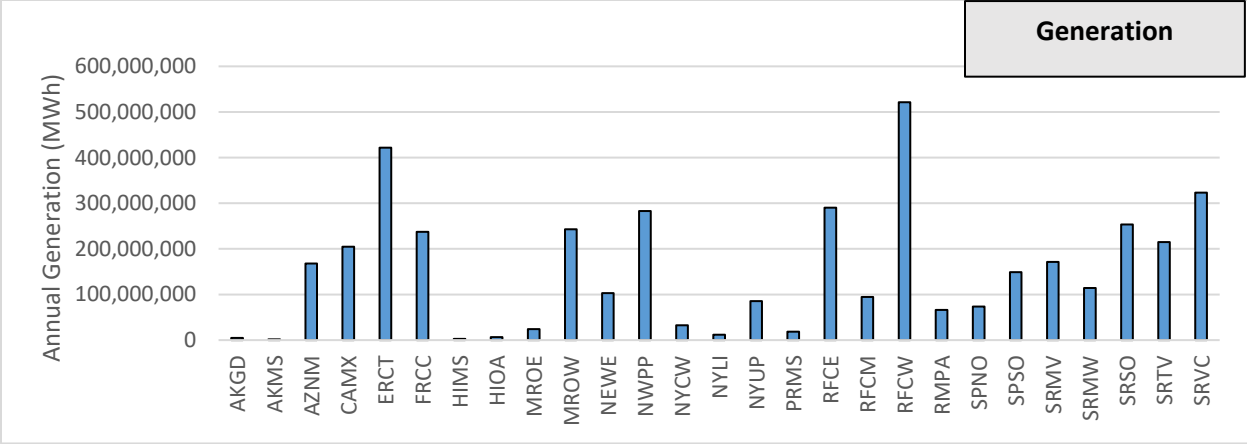


Figure 2. eGRID Subregion-level 2021 generation, PM_{2.5} emissions, and PM_{2.5} emission rates

Table 1. eGRID Subregion-level 2021 generation, PM_{2.5} emissions, and PM_{2.5} output emission rates

Subregion	Annual Generation (MWh)	Annual PM _{2.5} Emissions (short tons)	Annual PM _{2.5} Output Emission Rate (lbs/MWh)
AKGD	4,923,740	537	0.2182
AKMS	1,672,078	614	0.7344
AZNM	167,984,970	4,144	0.0493
CAMX	204,553,916	2,874	0.0281
ERCT	421,638,208	10,117	0.048
FRCC	237,351,634	7,903	0.0666
HIMS	2,616,354	1,329	1.0158
HIOA	6,564,236	1,748	0.5325
MROE	24,114,781	701	0.0581
MROW	242,821,306	6,000	0.0494
NEWE	103,068,944	2,182	0.0423
NWPP	282,815,849	5,064	0.0358
NYCW	32,499,681	924	0.0568
NYLI	11,938,038	1,302	0.2181
NYUP	85,506,174	678	0.0159
PRMS	18,578,947	975	0.1049
RFCE	290,415,250	4,990	0.0344
RFCM	94,434,454	2,161	0.0458
RFCW	521,426,350	18,446	0.0708
RMPA	66,044,054	1,349	0.0409
SPNO	73,370,171	1,393	0.038
SPSO	148,803,953	3,440	0.0462
SRMV	171,263,642	4,350	0.0508
SRMW	114,130,604	5,658	0.0991
SRSO	253,393,159	3,984	0.0314
SRTV	214,888,097	21,880	0.2036
SRVC	323,326,029	7,976	0.0493
U.S.	4,120,144,619	122,719	0.0596