CMIC Source Energy and Emissions Analysis Tool Version 9.1 Description

Overview

The Carbon Management Information Center (CMIC) Source Energy and Emissions Analysis Tool (SEEAT), available free to the public at http://seeatcalc.gastechnology.org, determines source energy consumption and related greenhouse gas (GHG) and criteria pollutant emissions for selected fossil fuels and electricity based on point-of-use energy consumed by an appliance, building, industrial application, or vehicle. SEEAT is a flexible and simple tool for comparisons within and across energy forms. SEEAT uses government data and models and other publicly available data sources as the basis of its default energy and emission factors and calculations. The user can choose default input data for numerous parameters necessary for the analysis. SEEAT also offers user-specified input options for most energy and emission parameters to allow users to tailor the analysis as needed.

User Inputs

SEEAT uses six steps in its buildings and transportation modules to determine the source energy and emissions associated with point-of-use energy consumption for baseline and alternative configurations. In the industrial module, four steps are used to determine the source energy and emissions per million dollars of manufactured goods.

In **Step 1**, the user selects the market segment for analysis (e.g., residential buildings), then the geographical region for electricity generation mix and typical point-of-use energy consumption. Region options include State; EPA Emissions & Generation Resources Integrated Database (eGRID) Subregions; National Electric Reliability Council (NERC) Regions; and U.S. Average. The State or eGRID subregion can be automatically selected by inputting Zip Code if desired.

In **Step 2**, the user inputs the annual point-of-use or site energy consumption associated with the baseline and alternative configurations for one or more of the following energy forms: electricity, natural gas, fuel oil, or propane. Point-of-use energy estimation modules can be used to enter annual site energy consumption automatically for user selected options.

In **Step 3**, the user chooses the source energy conversion factors desired for the analysis. The user can choose either default values or enter user-specified efficiency factors for each energy form. Several additional options for determining electricity factors are available in SEEAT.

Users can select electric source energy and GHG emission factors for All Plants (average) or Non-Baseload (marginal) electricity generating plants. Selecting the "Non-Baseload" calculation option for electricity limits user geographical area selection to eGRID subregions. The marginal generation factors impact results most significantly when evaluating source energy and emissions in regions dominated by non-combustion electric generation, such as the NWPP or CAMX subregions, whose marginal or avoided generation will likely be from natural gas or coal power generation.

The user selects the eGRID electric power plant database year from the two most recent releases, 2019 data (eGRID2019) or 2018 data (eGRID2018). eGRID provides plant level and aggregate data on annual electric power plant generation and emissions for the selected year. Users also have the option of choosing the eGRID aggregated databases or the eGRID plant level database for regional or national analysis. The plant level database was screened by CMIC to address some inconsistencies identified in the aggregated databases and align fuel plant classification more closely with primary input fuel. The plant level database option is intended to address inconsistencies identified in the eGRID aggregated regional and national databases.

The user also chooses the desired electricity generation mix, either using the eGRID defaults for the selected region or a user-specified generation mix. Likewise, either default or user-specified full-fuel-cycle efficiency factors can be used for each generation type. Radio button options for all renewable power sources (both non-combustible and combustible) allow the user to choose either incident energy efficiency (thermodynamic efficiency), captured energy efficiency (100% efficiency), or infinite energy efficiency (i.e., zero conversion energy consumption) for hydro, wind, solar, geothermal, biomass, and renewable natural gas power generation. Thermodynamic efficiency permits comparisons within the renewable generation mix, but may not align well with renewable energy policy objectives. The captured energy efficiency may be of interest when the focus is alignment with other policy objectives, but does not capture the efficiency or cost differences among renewable power options. Infinite energy efficiency may be of interest when the focus is alignment with the non-depletable attributes of renewables, irrespective of their relative costs or other comparison parameters, but also does not capture the efficiency or cost differences among renewable power options.

In **Step 4**, the user can choose either default GHG and pollutant emission factors or enter user-specified values for each energy form. Options for determining CO_2e factors include Global Warming Potential (GWP) or Global Temperature Potential (GTP) of emissions from consumed fuels during their pre-combustion and combustion/conversion processes.

In **Step 5**, the user can choose default marginal or average energy prices or enter user-specified values and selects the state when the NERC Region or eGRID Subregion comprises more than one state.

In **Step 6**, the user chooses either default values for Energy, Emissions, and Economics (EEE) Impacts or enters user-specified factors. EEE Impact factors are used to compare the performance of baseline and alternative technologies based on their weighted and aggregated impact on primary energy resources, GHG emissions, and consumer economics. Weighting factors for these three metrics add up to 100% and are used to determine the EEE Index Score for the alternative scenario relative to the baseline which, by definition, has an EEE Index Score of 100.

Point-of-Use and Site Energy Consumption Estimation Modules

SEEAT includes point-of-use and site energy consumption estimation modules to aid users in screening and comparing total annual energy consumption by energy form for baseline and alternative configurations. This information can be submitted to automatically fill in the data input cells for the annual site energy consumption by energy form in Step 2 for use in source energy and emissions calculations. Current modules provide location-specific consumption estimates for residential buildings and several types of commercial buildings, normalized energy consumption estimates for certain industrial applications, and comparative consumption estimates for various types of passenger vehicles.

The **Residential Buildings Module** includes Detached Single-Story, Detached Two-Story, Townhouse, and Multi-family configurations. Energy consumption is calculated for each appliance and the entire building based on modeled energy loads of relatively energy efficient building envelope configurations using GTI's Building Energy Analyzer (BEA). The user selects the desired location, size, number of occupants, and appliances to include in the building, and the module provides an estimate of associated site energy consumption for each appliance and the whole building to meet the associated loads.

Range, refrigerator, dishwasher, washing machine, and dryer site energy consumption estimates are derived from ANSI/RESNET/ICC 301-2014 Standard for the Calculation and Labeling of the Energy Performance of Low-Rise Residential Buildings using an Energy Rating Index (http://www.resnet.us/blog/wp-content/uploads/2016/01/ANSI-RESNET-ICC_301-2014-Second-Edition-Publish-Version.pdf), with adjustments for number of occupants, building location, and building type and size.

Residential domestic hot water (DHW) usage is calculated based on an Florida Solar Energy Center study by D.S. Parker, *Estimating Daily DHW Use in North American Homes* (FSEC-PF-464-15), which developed DHW formulas based on occupancy from measured and modeled data.

HWgpd = 22 × (Occ × Fmix) + CWgpd + DWgpd (Equation 11)

Where:

HWgpd = total residential hot water usage, gallons per day (gpd)
Occ = Occupants in the household
Fmix = variable based on average mains water temperature and DHW temperature set point
CWgpd = clothes washer hot water usage, gallons per day (Equation 2, using 4.0 gallons per cycle)
DWgpd = dishwasher hot water usage, gallons per day (Equation 5, using 8.0 gallons per cycle)

To calculate fixture water usage (sink, showers, etc.), Fmix parameter averaged 0.68 for the measured usage [Parker 2015]. Based on three occupants, this model estimates the daily water usage for a standard clothes washer and dishwasher to be 7.4 gallons (28 liters) per day.

Using these models, SEEAT calculates the average total water consumption as a function of occupancy:

HWgpd = **(22 × Occ × 0.68) + 7.4**

This equation calculates an average 52.3 gpd (198 L/d) for a household of three. This estimate aligns well with measured data from several studies, including the average 46 gpd reported by 2015 study by Ecotope, Inc. for Northwest Energy Efficiency Alliance (NEEA #E15-306) and the average 56 gpd reported by a 2012 GTI study for the California Energy Commission (CEC-500-2013-060). In addition, the current ASHRAE method of test for residential water heaters is based on 55 gpd as a "medium usage" household. DHW energy consumption is then calculated based on HWgpd and adjusted for regional temperature impacts. The regional factor is based on normalized DHW energy use calculated by BEA models for each location listed.

The **Commercial Buildings Module** includes Fast Food, Nursing Home, Retail Store, School, Small Office, and Supermarket configurations. Energy consumption calculations are similar to the residential buildings module.

The **Industrial Applications Module** includes annual industrial energy consumption data collected by the U.S. Energy Information Administration and by the U.S. Census Bureau linked to value-based measures of industrial output (Btu/$ produced) for 12 different major industrial classifications. This data is used by the tool to calculate the source energy and emissions per million dollars produced.

The **Passenger Vehicle Module** includes both conventional and low emission vehicles. All modeled vehicles are passenger cars with a Gross Vehicle Weight Rating (GVWR) less than 6,000 lbs. MPG (per GREET 2012 gasoline equivalent gallon) is based on a gallon of 38/62% mix of conventional and reformulated gasoline with Higher Heating Value of 114,142 Btu. The module includes the following vehicle types:

- **Gasoline - 50/50 Conv. & Ref. Fuel**; Spark ignition gasoline vehicle fueled with 50/50% mix of conventional and reformulated gasoline with a default fuel efficiency of 23.4 MPG
- **Compressed Natural Gas - Dedicated Vehicle**; Dedicated compressed natural gas vehicle with a default fuel efficiency of 22.2 MPG (per gasoline equivalent gallon)
- **Liquid Petroleum Gas - Dedicated Vehicle**; Dedicated liquid petroleum gas (propane) vehicle with a default fuel efficiency of 23.4 MPG (per gasoline equivalent gallon)
- **Diesel - Direct Injection Compression Ignition**; Diesel vehicle fueled with conventional diesel with a default fuel efficiency of 28.1 MPG (per gasoline equivalent gallon)
- **Electric Vehicle**; Electric vehicle with 85% efficient grid to battery charger efficiency with a default fuel efficiency of 84.5 MPG (per gasoline equivalent gallon)
- **Hybrid Electric - 50/50 Conv. & Ref. Gasoline**; Hybrid electric / spark ignition gasoline vehicle fueled with 50/50% mix of conventional and reformulated gasoline with a default fuel efficiency of 32.7 MPG (per gasoline equivalent gallon)
- **Plug-in Hybrid Electric - 50/50 Conv. & Ref. Gasoline**; Plug-in hybrid electric / spark ignition gasoline vehicle fueled with 50/50% mix of conventional and reformulated gasoline with a default fuel efficiency of 48.9 MPGe (per gasoline equivalent gallon). Fully charged vehicle Operational All Electric Range (OAER) is 11.2 miles; percentage of miles driven in Charge Depletion (CD) mode is 25.6%; balance of 74.4% is driven in Charge Sustaining (CS) mode. Grid to battery charger efficiency is assumed to be 85%.

Source Energy and Emissions Calculations

Based on user-specified and default inputs, SEEAT calculates source energy and emissions factors and values for the analysis. Based on annual electricity consumption, SEEAT calculates location-specific:

- Electric distribution efficiency and resulting power plant generation requirement,
- Power plant fuel mix,
- Conversion efficiency and corresponding source energy and GHG and criteria pollutant emissions by fuel type at the power plant,
- Source energy required and corresponding GHG and criteria pollutant emissions by generation fuel type for extraction, processing, and transportation to the power plant
- Source energy and composite GHG and criteria pollutant emission factors
- Total source energy required and corresponding GHG and criteria pollutant emissions
- Annual energy cost
- EEE Impacts compared to baseline

The aggregated source energy factor (s_t) for location-specific electric power generation is calculated as follows:

$$s_t = \begin{bmatrix} m_1 \\ m_2 \\ \dots \\ m_n \end{bmatrix} \cdot \begin{bmatrix} s_1 \\ s_2 \\ \dots \\ s_n \end{bmatrix} \quad (1)$$

where, m_i is the fraction of the power generation from each type of fuel and s_i is the source energy factor of each type of fuel. The subscripts 1 through n for both the generation mix and the source energy factors specifically represent:

1 Coal
2 Oil
3 Natural Gas
4 Renewable Natural Gas
5 Nuclear
6 Hydro
7 Biomass
8 Wind
9 Solar
10 Geothermal
11 Other

The mix fractions m_i are from the applicable eGRID 2019 or eGRID 2018 database.

The source energy factors s_i are calculated as follows:

$$s_i = \frac{1}{e_1 \cdot e_2 \cdot \ldots \cdot e_n} \quad (3)$$

where, e_n is the efficiency of each of the processes contributing to each type of power generation. The subscripts 1 through n specifically represent:

1 Extraction
2 Processing
3 Transportation
4 Conversion
5 Distribution

Based on annual natural gas, oil, or propane site consumption, SEEAT calculates location-specific:

- Source energy required and corresponding GHG and criteria pollutant emissions for extraction, processing, transmission, and distribution to the building. Combustion occurs at the point of use, so an upstream "conversion efficiency" factor is not applicable for these energy forms.
- Source energy and composite GHG and criteria pollutant emission factors
- Total source energy required and corresponding GHG and criteria pollutant emissions
- Annual energy cost
- EEE Impacts compared to baseline

Non-Baseload (Marginal) Source Energy and Emission Factors

A public domain marginal analysis methodology is available from EPA to quantify the emission reduction due to energy efficiency measures or clean energy policies. EPA's interest in this methodology arose from its understanding that clean energy policies and energy efficiency improvements reduce emissions at the marginal or non-baseload electric generating units. Analysts and EPA staff have noted that emission reductions must be quantified using non-baseload emission factors rather than average emission factors[1 2 3] Average electricity generation emission factors can be used appropriately to determine carbon footprint or GHG inventory. However, average emission rates typically under-predict the emission reduction when used for energy savings through efficiency improvements because these averages include baseload generation such as nuclear or hydro power, which would not be affected by the efficiency improvement.[4]

EPA recognizes several valid and established approaches to quantify emission reductions using the non-baseload electricity mix.[5] Non-baseload CO_2e emission factors are published by the EPA to facilitate the calculation of emissions reduction due to energy efficiency improvements. The use of eGRID subregion non-baseload emission factors is recommended by the EPA as a simple, low-cost method to estimate emission reduction potential, to explain emission benefits to the general public, or to determine annual emission reductions or regional / national estimates.[6] EPA's non-baseload emission rates and methodology are currently used in several tools, including EPA's Greenhouse Gas Equivalencies Calculator (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator) and Green Power Partnership's Green Power Equivalency Calculator (https://www.epa.gov/greenpower/green-power-equivalency-calculator).[7]

EPA's non-baseload emission rate methodology also provides a convenient way to determine the primary energy factor associated with marginal non-baseload power plants for each eGRID subregion. The emission factors can be correlated with the associated generation mix of oil, natural gas, and coal. Knowing this mix, the aggregate primary energy conversion factor can be calculated based on marginal power plant efficiency levels for each fuel type. In the absence of marginal power plant efficiency level information, average power plant efficiency levels may provide an acceptable substitute.

Keith and Biewald developed a methodology implemented by the EPA for calculating marginal (or non-baseload) power plant emission rates based on the capacity factor of each plant. The capacity factor methodology allows the user to determine marginal energy consumption and GHG emissions at any level of desired aggregation using historical or projected power plant values for any time period. It provides a simplified and reasonably accurate methodology compared to marginal dispatch models or hourly generation databases. The EPA implemented this methodology in the eGRID database to list the emissions of "non-baseload" power plants for application in marginal generation scenarios and analyses. Using this approach, all plants with generation capacity factors less than 0.2 are considered non-baseload generation in the eGRID non-baseload generation database, and those with capacity factors greater than 0.8 are considered baseload generation, with prorated fractions for capacity factors between 0.2 and 0.8.

Reports

SEEAT output reports include tabular and graphic results for the baseline and alternative configurations as well as a comparison of baseline versus alternative for the following:

- **Annual Site Energy Consumption** by energy form in units delivered to the site
- **Annual Site Energy Cost** by energy form and total in dollars for residential and commercial sites
- **Annual Source Energy Consumption** by energy form and total in units delivered to the site converted to source Btu's
- **Source Energy Factors** for each energy form and composite factor
- **Annual Greenhouse Gas Emissions** (CO_2 and CO_2e) by energy form and total in units delivered to the site converted to source energy emissions in thousand pounds.
- **Annual Emissions - Other Pollutants**, including SO_2 and NO_x by energy form and total in pounds.

1 Jacobson, D. and High, C. , *U.S. Policy Action Necessary to Ensure Accurate Assessment of the Air Emission Reduction Benefits of Increased Use of Energy Efficiency and Renewable Energy Technology*, Journal of Energy and Environmental Law, Vol. 1:1, 2010. (http://www.rsginc.com/assets/Reports--Publications/RSG-Modeling-of-Air-Emission-Reduction-in-the-Electricity-Sector.pdf)
2 DeYoung, R., *Deciding an Approach for Quantifying Emission Impacts of Clean Energy Policies and Programs*, U.S. Environmental Protection Agency, State Climate and Energy Program, January 30, 2012. (http://www.epa.gov/statelocalclimate/documents/pdf/DeYoung_presentation_1-30-2012.pdf)
3 Rothschild, S. and Diam, A., *Total, Non-baseload, eGRID Subregion, State? Guidance on the Use of eGRID Output Emission Rates*, Prepared for the U.S. Environmental Protection Agency, Climate Protection Partnership Division, Washington, DC, 2008. (http://www.epa.gov/ttn/chief/conference/ei18/session5/rothschild.pdf)
4 Jacobson, D., Flawed Methodologies in Calculating Avoided Emissions from Renewable Energy , The GW Solar Institute, October 24, 2009. (http://solar.gwu.edu/index_files/Resources_files/DJ_REILPresentation.pdf)
5 DeYoung, R., *Deciding an Approach for Quantifying Emission Impacts of Clean Energy Policies and Programs*, U.S. Environmental Protection Agency, State Climate and Energy Program, January 30, 2012. (http://www.epa.gov/statelocalclimate/documents/pdf/DeYoung_presentation_1-30-2012.pdf)
6 DeYoung, R., *Quantification Methods using eGRID State and Local Examples*, U.S. Environmental Protection Agency, State Climate and Energy Program, March 31, 2011. (http://www.epa.gov/statelocalclimate/documents/pdf/DeYoung_presentation_3-31-11.pdf)
7 Collison, B., *Green Power 101*, US EPA Green Power Partnership, Renewable Energy Markets Conference, Atlanta, GA, September 13, 2009 (http://www.renewableenergymarkets.com/docs/presentations/2010/Wed_RE%20101_Blaine%20Collison.pdf)

- **Efficiency Factors for Energy Delivered to Building**, including electricity and other energy forms
- **Emission Factors for Energy Delivered to Building**, including electricity and other energy forms
- **Electric Generation Resource Mix** for the region selected for analysis
- **Energy, Emissions, and Economics Impact** compares the EEE Index Score for the alternative scenario relative to the baseline which, by definition, has an EEE Index Score of 100. A higher score indicates worse performance, and a lower score indicates better performance compared to the baseline.

Government and Published Sources for Default Values

Default values for emission and source energy factors in SEEAT were derived from the following sources:

- **Source Energy Factors**
    - Source energy factors for pre-combustion energy consumption are calculated using the Argonne National Laboratory Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET 2012 through 2017) model (http://www.transportation.anl.gov/modeling_simulation/GREET).
    - Source energy factors for nuclear fuel mining, enrichment, and transportation are estimated based on information from the world nuclear organization based on natural uranium (0.7% U_{235}) mining, 5% U_{235} enrichment processes http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/conversion-enrichment-and-fabrication/uranium-enrichment.aspx,and rail transportation of 5% U_{235} enriched fuel.
    - Source energy factors for on-site fuel combustion are assumed to be 100% (i.e., essentially complete combustion).
    - Source energy factors for power plant fuel combustion for conversion to electricity are calculated using the eGRID2019 or 2018 databases (https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid), depending on user selection, which provide detailed and aggregated data on annual power plant generation and emissions. eGRID power generation data is available for nearly all U.S. power plants and aggregated at eGRID subregion, NERC region, state, or national levels. In addition, the database includes the percentage of power supplied by coal, oil, natural gas, hydro, nuclear, and other renewable sources. This generation mix data is used to estimate source energy conversion factors at state, regional, and national levels. Heat rates for electricity generation using fossil fuels like coal, natural gas, and oil as well as electricity transmission and distribution (T&D) losses are also available from eGRID.
    - The "incident energy efficiency" option for non-combustible renewable power generation assumes:
        - Hydroelectric plant 90% conversion efficiency. [1a]
        - Solar power 16% conversion efficiency. [1b]
        - Wind power 30% conversion efficiency. [1c]
        - Geothermal power 16% conversion efficiency. [1d]
    - The "captured energy efficiency" option for renewable power generation assumes 100% conversion efficiency for hydroelectric, solar, wind, geothermal, biomass, and renewable natural gas power.
    - The "zero source energy" option for renewable power generation assumes infinite conversion efficiency (zero source energy use) for hydroelectric, solar, wind, geothermal, biomass, and renewable natural gas power.
    - Nuclear power generation conversion efficiency is a national average value based on DOE EIA data. [2] The nuclear average heat rate is the weighted average tested heat rate for nuclear units as reported on EIA Form EIA-860.
    - Biomass power generation incident energy conversion efficiency is calculated using annual eGRID data.

- **Greenhouse Gas and Criteria Pollutant Emission Factors**
    - Emission factors for fossil fuels pre-combustion emissions are calculated using GREET 2012 data.
    - Emission factors for fossil fuels on-site combustion emissions are calculated using GREET 2012 data.
    - Emission factors for fossil fuels combustion emissions for conversion to electricity are calculated using the eGRID2019 database. The tool also includes an option to use data from previous versions of eGRID for the year 2018. eGRID emissions data includes CO_2, NO_x, SO_2, CH_4, and N_2O emissions for all plants, as well as for non-baseload plants at the eGRID subregion level. eGRID 2019 data for power plant emissions was taken directly from the eGRID release data. However, eGRID 2018 data

had a conversion error in some emission rates from its first release that were adjusted in SEEAT based on communication with EPA.

  - CO_2e emissions calculation options include Global Warming Potential (GWP) or Global Temperature Potential (GTP) of pre-combustion and combustion energy and associated greenhouse gas emissions from fuels. Default calculations are based on:
    1) GWP values, 100 year time horizon, from 2013 Intergovernmental Panel on Climate Change (AR5 pg. 714): CO_2 GWP = 1; CH_4 GWP = 28 ; N_2O GWP = 265
    2) GTP values, 100 year time horizon, from 2013 Intergovernmental Panel on Climate Change (AR5 pg. 714): CO_2 GTP = 1; CH_4 GTP = 4 ; N_2O GWP = 234

- **Energy Prices**
  - Default electric and natural gas residential and commercial prices are based on state-level EIA 2019 annual average data (https://www.eia.gov).
  - Default oil and propane residential prices are based on state-level EIA 2019 weekly data, average over one year (https://www.eia.gov).
  - Default oil and propane commercial prices are estimated as 10% lower than residential state-level EIA 2019 annual average data.
  - U.S. average oil or propane price is used as the default for states with unavailable data.
  - Marginal pricing factors for natural gas were developed by AGA based on a member company survey. (https://www.aga.org/research/reports/aga-marginal-pricing-methodology-furnace-efficiency-rule/)
  - Marginal pricing factors for electricity were developed by the U.S. Department of Energy. (https://www.regulations.gov/document?D=EERE-2014-BT-STD-0048-0030 with methodology described in https://www.regulations.gov/document?D=EERE-2014-BT-STD-0048-0098)

EIA Citations:

[1] U.S. Energy Information Administration - Annual Energy Review 2011, Appendix F
Alternatives for Estimating Energy Consumption, Table F1. Conversion Efficiencies of Noncombustible Renewable Energy Sources. http://www.eia.gov/totalenergy/data/annual/pdf/sec17.pdf

Sources cited by U.S. EIA:

[1a] Conventional Hydroelectric: Based on published estimates for the efficiency of large-scale hydroelectric plants. http://www.usbr.gov/power/edu/pamphlet.pdf.
[1b] Solar Photovoltaic: Based on the average rated efficiency for a sample of commercially available modules. Rated efficiency is the conversion efficiency under standard test conditions, which represents a fixed, controlled operating point for the equipment; efficiency can vary with temperature and the strength of incident sunlight. Rated efficiencies are based on the direct current (DC) output of the module; since grid-tied applications require alternating current (AC) output, efficiencies are adjusted to account for a 20 percent reduction in output when converting from DC to AC.
[1c] Wind: Based on the average efficiency at rated wind speed for a sample of commercially available wind turbines. The rated wind speed is the minimum wind speed at which a turbine achieves its nameplate rated output under standard atmospheric conditions. Efficiency is calculated by dividing the nameplate rated power by the power available from the wind stream intercepted by the rotor disc at the rated wind speed.
[1d] Geothermal: Estimated by EIA on the basis of an informal survey of relevant plants.

[2] The nuclear average heat rate is the weighted average tested heat rate for nuclear units as reported on the Form EIA-860; https://www.eia.gov/electricity/annual/html/epa_08_01.html

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