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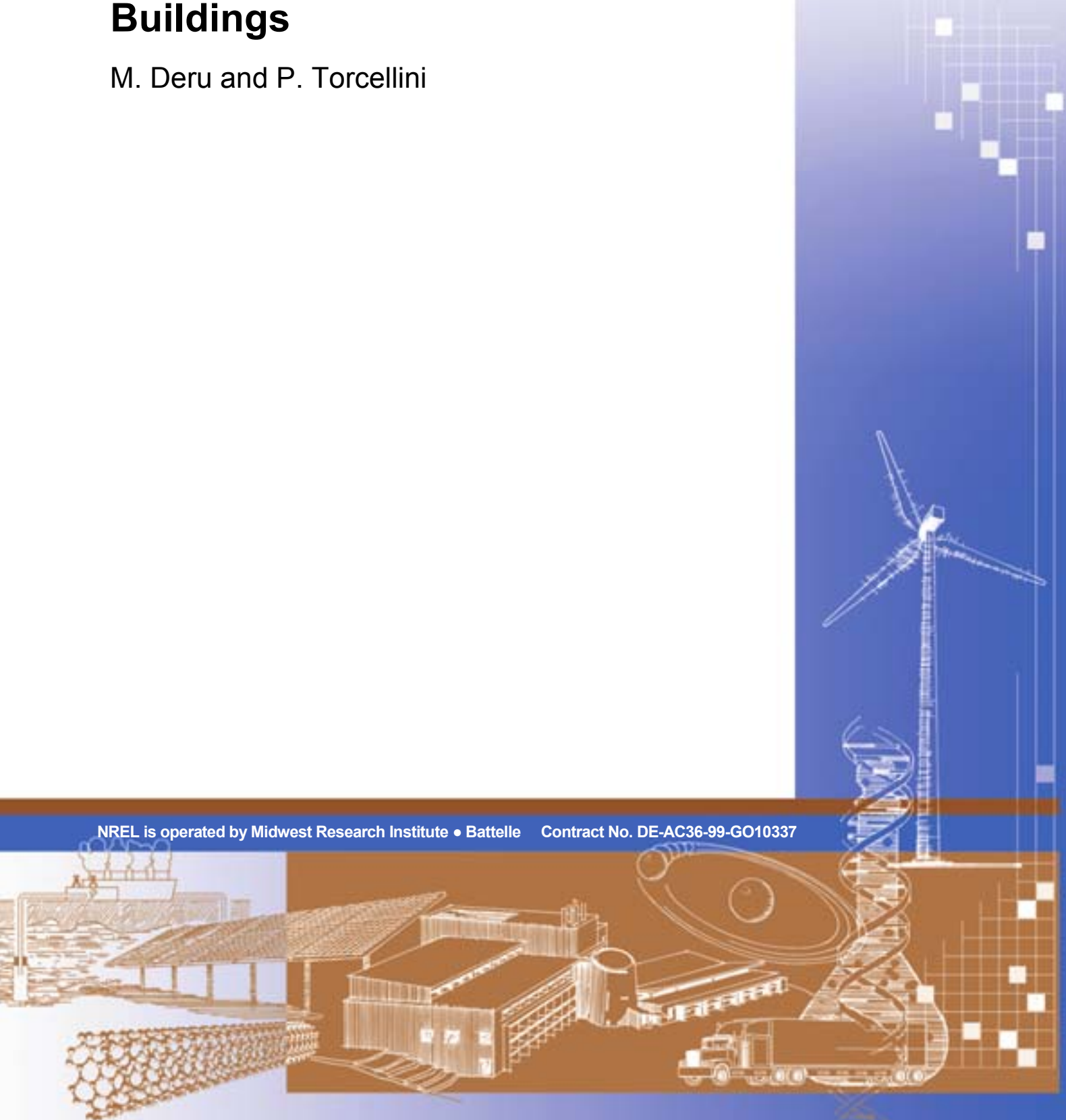
National Renewable Energy Laboratory

Innovation for Our Energy Future

Source Energy and Emission Factors for Energy Use in Buildings

M. Deru and P. Torcellini

Technical Report
NREL/TP-550-38617
Revised June 2007



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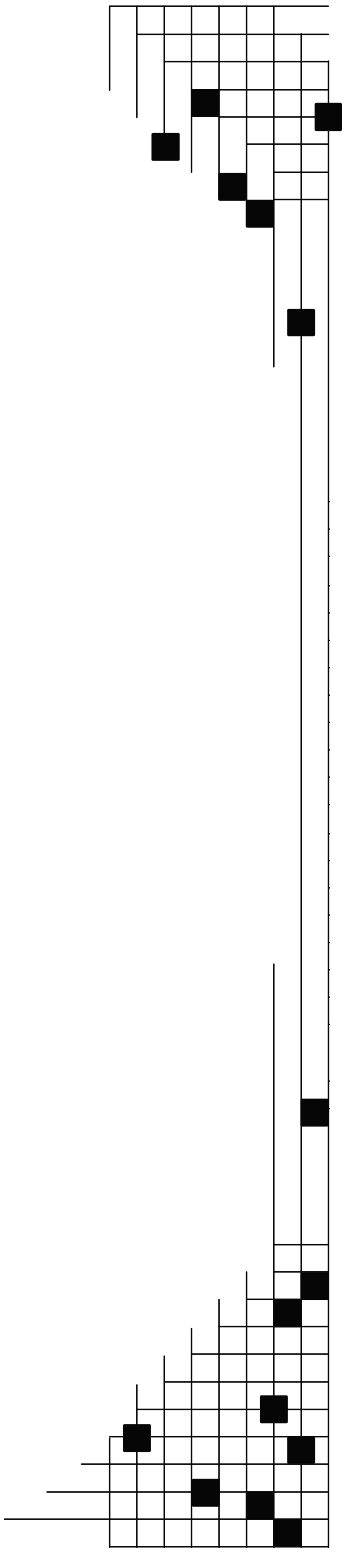

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Errata

The June 2006 version of NREL/TP-550-38617 contained errors in the emissions data that have been corrected with this revised version of the report. The wrong numbers were displayed for the emission factors for mercury, PM10, and solid waste. In addition to correcting the errors, revised calculation methods were used and subbituminous coal was treated separately from bituminous coal. In addition, the emissions for CO_2, SO_2, NO_X, and mercury from fossil fuels was adjusted to align with data from the EIA Electric Power Annual 2006 and EPA eGRID 2006. Finally, ozone season NO_X emission factors by state are included at the end of the document.

The following specific changes were made to the document:

1. The emission factor name "Equivalent carbon dioxide (CO_{2e})" replaces "global warming potential (GWP)." GWP is an index comparing the radiative properties of a compound to that of CO_2.
2. The following tables were updated with revised energy and emission factors: 1 to 4, 6 to 11, B-1 to B-11.
3. Figure 1 was replaced with the new figure from NERC with the new subregions.
4. Figure 2 was replaced with a graph of the revised data.
5. Table B-12 was added.
6. Two references were added with life cycle analysis data on the construction and operation of coal and natural gas fired power plants.

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Contents

Foreword

People measure and analyze the energy performance of buildings for many reasons. Comparisons of energy use may be made between nations, regions, individual buildings, or systems within a building. Policy makers, owners, designers, operators, raters, and researchers use energy performance data. Many tools (or approaches) have been developed to analyze energy performance in different ways, at different levels of effort and precision, and at different stages in the life of a building. Each tool quantifies the building energy performance to fit the users' needs. However, methods and metrics are often inconsistent with each other. In addition, performance numbers may be misrepresented or misused to predict energy savings beyond the accuracy of the numbers.

The Performance Metrics Project is a U.S. Department of Energy commercial buildings research activity whose goal is to standardize the measurement and characterization of building energy performance. Its main products are clearly defined energy performance metrics and standard procedures for determining the performance metrics; its intents are to define common language and to create standards that produce consistent results independently of the user. Therefore, the terms and techniques are clearly defined with little room for interpretation. The more opportunity there is for interpretation, the higher the probability for disparity and "gaming" of the results. These procedures focus on reporting absolute numbers and not on comparisons of energy performance. Benchmarks are included only where well-established values apply. However, benchmarking of results by others can be improved by using the clearly defined absolute metrics determined by these procedures.

This document supports the other measurement procedures and all building energy-monitoring projects by providing methods to calculate the source energy and emissions from the energy measured at the building. Energy and emission factors typically account for the conversion inefficiencies at the power plant and the transmission and distribution losses from the power plant to the building. The energy and emission factors provided here also include the precombustion effects, which are the energy and emissions associated with extracting, processing, and delivering the primary fuels to the point of conversion in the electrical power plants or directly in the buildings. Source energy factors for electricity are provided for the total fossil fuel, total nonrenewable energy, and total energy. The breakdown of the energy used to generate electricity is provided on the national level, interconnection level, and state level.

Section 1 – Purpose

This procedure provides source energy factors and emission factors to calculate the source (primary) energy and emissions from a building's annual site energy consumption.

Section 2 – Scope

2.1 – Overview

Source energy consumption and emissions from energy use must be calculated to determine the environmental impact of buildings; however, these calculations are often not completed and are usually not done in a consistent manner. Most analyses use the energy measured at the site, which is useful for understanding the performance of the building and the building systems, but it is not a good indicator of the environmental impacts from resource consumption and emissions associated with energy use. Site energy is also not a good metric for comparing buildings that use different energy types, buildings with on-site energy generation such as photovoltaics (PV), or buildings with cogeneration systems.

2.2 – What This Report Does

This report provides the energy and emission factors to calculate the source energy and emissions for electricity and fuels delivered to a facility and combustion of fuels at a facility. The factors for electricity are broken down by fuel type and presented for the continental United States, three grid interconnections, and each state. The electricity fuel and emission factors are adjusted for the electricity and the useful thermal output generated by combined heat and power (CHP) plants larger than one megawatt. The energy and emissions from extracting, processing, and transporting the fuels, also known as the precombustion effects, are included.

2.3 – What This Report Does Not Do

This report does not provide hourly or seasonal source energy factors. Time of use effects for electricity can be significant, but the data for such an analysis are difficult to obtain on a national basis and are beyond the scope of this report. The emissions from and the energy used for construction and decommissioning the power plants, hydroelectric dams, and energy infrastructure are not included. The energy and climate change emissions from these phases form a small fraction of the energy and emissions produced over the life of the facilities (Spath et al. 1999; Spath and Mann 2000). The energy associated with storage and disposal of spent nuclear waste is not included because reliable data are not available. This information should be analyzed when it becomes available to determine whether it is significant.

Section 3 – Definitions, Abbreviations, and Acronyms

3.1 – Definitions

Annual
: A period that consists of 12 consecutive months.

Criteria Pollutants
: The U.S. Environmental Protection Agency (EPA) has set national air quality standards for six principal air pollutants (also referred to as criteria pollutants): nitrogen dioxide (NO_2), ozone, sulfur dioxide (SO_2), particulate matter (PM), carbon monoxide (CO), and lead. Four of these pollutants (CO, lead, NO_2, and SO_2) result primarily from direct emissions from a variety of sources. PM results from direct emissions, but is also commonly formed when emissions of nitrogen oxides (NO_x), sulfur oxides (SO_x), ammonia, organic compounds, and other gases react in the atmosphere. Ozone is

not directly emitted, but is formed when NO_x and volatile organic compounds react in the presence of sunlight (EPA 2005a).

Emission Factor

The mass of a pollutant emitted to the environment per unit of energy or fuel associated with the production, distribution, and use of the energy or fuel.

Facility

A set of one or more buildings or outdoor applications, or both, that is defined for the purpose of an energy analysis. The boundary of the facility used in the energy analysis should be clearly defined.

Fuel Oil

A liquid petroleum product that includes distillate fuel oil (No. 1, No. 2, and No. 4), and residual fuel oil (No. 5 and No. 6).

Distillate Fuel Oil: A general classification for one of the petroleum fractions produced in conventional distillation operations. It is used primarily for space heating, on- and off-highway diesel engine fuel (including railroad engine fuel and fuel for agriculture machinery), and electric power generation. Included are Fuel Oils No. 1, No. 2, and No. 4; and Diesel Fuels No. 1, No. 2, and No. 4. Fuel oils and diesel fuel oils are very similar, but they do have different specifications.

Residual Fuel Oil: The topped crude of refinery operation that includes No. 5 and No. 6 fuel oils as defined in American Society for Testing and Materials Specification D396 and Federal Specification VV-F-815C; Navy Special fuel oil as defined in Military Specification MIL-F-859E, including Amendment 2 (NATO Symbol F-77); and Bunker C fuel oil. Residual fuel oil is used to produce electric power, space heating, vessel bunkering, and for various industrial purposes. Imports of residual fuel oil include imported crude oil burned as fuel (EIA 2005a).

Global Warming Potential (GWP)

GWP is an index that describes the radiative characteristics of well-mixed greenhouse gases. It represents the combined effect of the times these gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation. This index approximates the time-integrated warming effect of a unit mass of a given greenhouse gas in today's atmosphere, relative to that of carbon dioxide (CO_2). GWP is an index for estimating the relative global warming contribution of atmospheric emissions of 1 kg of a particular greenhouse gas compared to emissions of 1 kg of CO_2. This document uses the following GWPs based on a 100-year time horizon: 1 for CO_2, 23 for methane (CH_4), and 296 for nitrous oxide (N_2O) (IPCC 2001). The equivalent CO_2 emissions are calculated with the GWPs.

Measure

To determine a quantity with a calibrated instrument. This includes using previously measured data such as those shown on a utility bill or engineering log.

Metric

A standard definition of a measurable quantity.

Particulate Matter PM10 and PM2.5

Particulates can be directly introduced to the atmosphere from transportation vehicles, combustion, farming, and dirt roads. Particulates can also be formed in the atmosphere from chemical reactions of sunlight with emissions of NO_x, SO_x, ammonia, organic compounds, and other gases. PM10 is measure of particles in the atmosphere with a diameter of 10 micrometers or smaller. PM2.5 is a measure of particles 2.5 micrometers and smaller in the air and are sometimes called fine particles. PM2.5 have been associated with significant respiratory and cardiovascular health risks; however,

consistent and reliable data for emission factors are not available. EPA maintains separate National Ambient Air Quality Standards for PM10 and PM2.5 because they have different monitoring and implementation plans (EPA 2005a).

Performance Metric
: A standard definition of a measurable quantity that indicates some aspect of performance. Section 4 contains definitions of the specific performance metrics used in this procedure.

Power Control Area (PCA)
: A PCA is a portion of an integrated power grid for which a single dispatcher has operational control of all electric generators. There are 112 PCAs reported in eGRID2006 (EPA 2007).

Precombustion Effects
: The source energy used for and the emissions resulting from extracting, processing, and delivering a fuel to the point of use in a power plant or a building.

Primary Energy
: The sum of the energy consumed at a facility and the energy required to extract, convert, and transmit that energy to the facility. (same as *source energy*)

Site Energy
: The energy directly consumed at a facility typically measured with utility meters.

Source Energy
: The sum of the energy consumed at a facility and the energy required to extract, convert, and transmit that energy to the facility. The source energy for electricity from hydroelectric power, solar energy, and wind is assumed to be equal to the electricity produced at the source; however, the transmission and distribution losses are accounted for in the electricity delivered to the facility. Source energy for electricity from thermal electric power plants fueled by geothermal and biomass is determined by assuming an efficiency of 33% for electricity production.

Source Energy Factor
: The unit of *source energy* consumed per unit of energy or fuel delivered to the facility.

Useful Thermal Output
: The thermal energy made available for use in any industrial or commercial process, or used in any heating or cooling application; i.e., total thermal energy made available for processes and applications other than electrical generation (EIA 2005b).

Year
: A period of 365 consecutive days.

3.2 – Abbreviations

Anth	anthracite coal
Bit	bituminous coal
Btu	British thermal unit
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_{2e}	equivalent carbon dioxide based on the GWP

GWP	global warming potential
HPS	pumped hydro storage
IP	inch-pound – refers to the English system of measurement units
kWh	kilowatt hour
LCI	life cycle inventory
LPG	liquefied petroleum gas
NO	nitrogen oxide
NO_x	nitrogen oxides
N_2O	nitrous oxide
PCA	power control area
PV	photovoltaic
PM2.5	particulate matter 2.5 micrometers in diameter and smaller
PM10	particulate matter 10 micrometers in diameter and smaller
SI	International System of Units – refers to the metric system of measurement units
SO_x	sulfur oxides
SO_2	sulfur dioxide
Sub	subituminous coal
T&D	transmission and distribution
TNMOC	total non-methane organic compounds

3.3 – Acronyms

DOE	U.S. Department of Energy
eGRID	Emissions & Generation Resource Integrated Database
EIA	Energy Information Administration
EPA	U.S. Environmental Protection Agency
ERCOT	Electric Reliability Council of Texas
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
NERC	North American Electrical Reliability Council

Section 4 – Background

4.1 – General

Most building energy analyses are completed with the energy measured on site. The building site energy is typically measured by the utility meters and is the total of the electrical, gas, and other energies delivered to the facility. Site energy consumption can be useful for understanding the performance of the building and the building systems, but it does not tell the whole story of the environmental impacts from resource consumption and emissions associated with the energy use. In addition, site energy is not a good comparison metric for buildings that have different mixes of energy types, buildings with on-site energy generation such as PV, or buildings with cogeneration units.

Energy analyses that use source or primary energy consumption typically use a fixed multiplier or source energy factor to estimate the source energy consumed to generate electricity based on national averages. There is usually no support or reference for the derivation of the source energy factor. For electricity production, the source energy multiplier typically varies from 3.0 to 3.33 depending on the study. This number is based on the assumption that most of the electricity was produced from thermal electric power plants. The result tells nothing of the fuel types consumed or the emissions from the electricity production.

4.2 – Electricity Generation and Distribution

The electricity grid in the continental United States is divided into three main grids that have few connections and little energy transfer between them. These grids are named the Western Interconnection, Eastern Interconnection, and Electric Reliability Council of Texas (ERCOT) Interconnection (Figure 1). Note that the U.S., Canadian, and Mexican grids are separate with limited connections and energy transfer. Alaska and Hawaii have a variety of small local grids. The grid interconnections are managed by NERC through 10 regional reliability councils. The energy mixtures used to generate electricity in the continental United States, the three interconnections, Alaska, and Hawaii are listed in Table 1 and shown in Figure 2. For 2004 in the continental United States, the mix of primary energy used to generate electricity was 71% fossil fuels, 20% nuclear, 7% hydro, and 2% renewable. The "Other Fossil" fuel category includes tire-derived fuels, purchased steam, and other fuels.

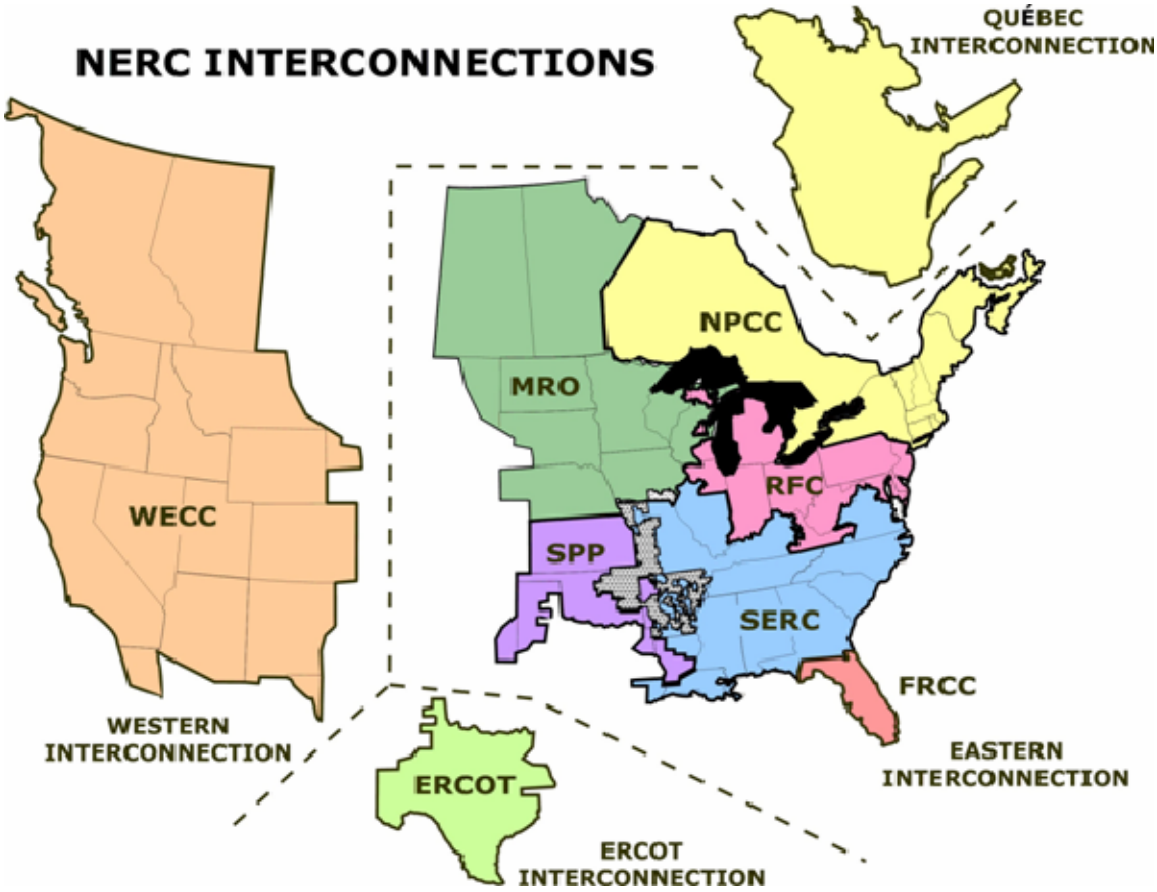

Figure 1 North American electrical grid interconnections, including the 10 NERC regional reliability councils (NERC 2007)

Table 1 Percent Electricity Generation by Energy Type for 2004

Energy Type	National %	Eastern %	Western %	ERCOT %	Alaska %	Hawaii %
Bituminous Coal	27.8	34.3	13.1	0.0	0.0	1.0
Subbitumious Coal	19.8	19.6	19.8	21.4	9.9	13.1
Lignite Coal	2.3	1.4	0.0	14.8	0.0	0.0
Natural Gas	18.3	12.7	27.4	49.4	55.5	1.5
Petroleum Fuels	2.8	3.6	0.5	0.5	11.5	77.4
Other Fossil Fuel	0.2	0.2	0.3	0.2	0.0	0.2
Nuclear	19.9	23.0	9.9	12.4	0.0	0.0
Hydro	6.8	3.4	24.6	0.3	23.0	0.8
Renewable Fuels	1.5	1.7	1.3	0.2	0.1	4.2
Geothermal	0.4	0.0	2.1	0.0	0.0	1.9
Wind	0.4	0.1	1.0	0.9	0.0	0.1
Solar (PV)	0.0	0.0	0.1	0.0	0.0	0.0
Fossil Fuel Total	71.2	71.8	60.9	86.2	76.9	93.1
Renewable (non hydro)	2.2	1.8	4.6	1.1	0.1	6.1

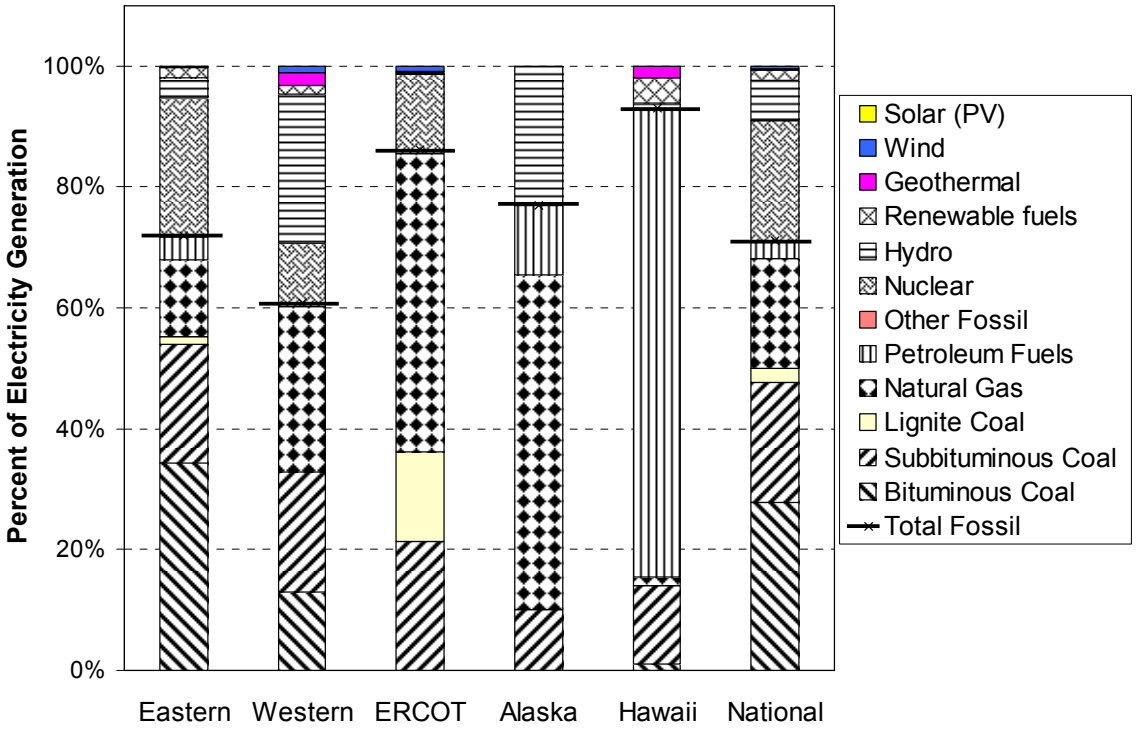

Figure 2 Electricity generation fuel mix for the continental United States (national), three interconnections, Alaska, and Hawaii for 2004 (EIA 2006a)

The question of what level of electricity generation data to use for a source energy analysis is not easy to answer. The options are national, interconnection, NERC region, NERC subregion, state, PCA, and utility. Typically, the goal of an energy analysis is to understand the impact of energy use or energy savings in a building compared to other options or to other buildings. It is often tempting to use source energy information at the utility level, which delivers the energy to the building. However, utilities are

not isolated; energy is transferred around the grid where it is needed. Even between states, there is significant energy transfer; nine states in the Eastern Interconnection import more than 25% of their electricity. The District of Columbia imports more than 98% of its electricity. The source of the imported energy is difficult to account for. However, less than 1% of the energy generated and used with the interconnections is transferred to an adjacent interconnection. The interconnection level for fuel and emission factors within the continental United States should be used to ensure consistent analysis. The information for Alaska and Hawaii should be used for buildings in these states. One problem with using the interconnection level is that the boundaries of the interconnections are not well defined, and determining the correct interconnection for locations near the boundaries may be difficult. For example, some parts of Texas are outside of ERCOT; parts of northern and eastern Texas are in the Eastern Interconnection and parts of western Texas are in the Western Interconnection. The national fuel and emission factors should be used for cases where the interconnection is not known.

In cases where the analyzed building is within a state that has a small net imported amount of electricity or is a net exporter of electricity, the state-level data can be used. The net imports and exports of electricity by state are supplied in Table B-7 (Appendix B). Source energy and emission factors for electricity generation at the state level are listed in Tables B-9 and B-10.

Section 5 – Energy and Emission factors

5.1 – Electricity Energy and Emission Factors

Data from several sources were used to derive the energy and emission factors for electricity generation. (These data are summarized in Table A-1, and the calculation methods are presented in Appendix A. Addition data are presented in Appendix B.) The data presented are based on electricity generation in 2004 reported on EIA Forms 906 and 920 (EIA 2006a) and the U.S. Life Cycle Inventory (LCI) Database (NREL 2005).

Source energy factors per unit of delivered electricity are provided in Table 2. These factors include the transmission and distribution (T&D) losses (first row of Table 2). Precombustion effects, which include extraction, processing, and transportation of the fuels, are also included. The precombustion energy accounts for 5% of the national total source energy factor and almost 12% of the total source factor for Hawaii. Energy to construct the power plants and energy infrastructures is not included as it is insignificant compared to the energy generated over the life of the facility. The Renewable Energy source energy factors are calculated using the fuel consumption reported on EIA forms 906 and 920 for geothermal and renewable fuels and assuming an energy factor of one for hydro, wind, and PV power plants. The T&D losses are then added to get the source energy factor for the delivered electricity.

Table 2 Source Energy Factors for Delivered Electricity for 2004
(kWh of source energy per kWh of delivered electricity)

	National	Eastern	Western	ERCOT	Alaska	Hawaii
T&D Losses	9.9%	9.6%	8.4%	16.1%	12.9 %	8.9 %
Fossil Fuel Energy *	2.500	2.528	2.074	3.168	3.368	3.611
Nonrenewable Energy **	3.188	3.321	2.415	3.630	3.386	3.653
Renewable Energy ***	0.177	0.122	0.480	0.029	0.264	0.368
Total Energy	3.365	3.443	2.894	3.658	3.650	4.022

* Fossil Fuel Energy includes all coal, natural gas, petroleum fuels, and other fossil fuel
** Nonrenewable Energy includes Fossil Fuel Energy and nuclear
*** Renewable Energy includes hydro, renewable fuels, geothermal, wind, and solar PV

The total emission factors (combustion plus precombustion) per delivered kWh of electricity for major pollutants in the continental United States and each major grid are shown in Tables 3 and 4. The separate emission factors from combustion and precombustion effects for electricity generation are shown in Tables B-3 through B-6 in IP and SI units. The precombustion emissions account for about 5% of the CO_2 and 10% of the CO_{2e} emissions. The precombustion emissions of CH_4 are approximately two orders of magnitude greater than the combustion emissions because of the high amount of CH_4 released when coal is mined and processed.

The PM factors are for direct emissions and do not include the effect of particulate formation in the atmosphere from chemical reactions of sunlight with emissions of NO_X, SO_X, organic compounds, and other gases. The PM composition and emission levels are complex functions of boiler firing configuration, boiler operation, pollution control equipment, and fuel properties. The solid waste emissions consists of bottom ash, fly ash, boiler slag, and flue gas desulfurization sludge, minus the amount diverted from the waste stream and used in other products. The GWPs are based on 100-year time horizon for CO_2, CH_4, and N_2O. See the definition for GWP in Section 3.1 for more information.

Table 3 Total Emission Factors for Delivered Electricity (lb of pollutant per kWh of electricity)

Pollutant (lb)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	1.67E+00	1.74E+00	1.31E+00	1.84E+00	1.71E+00	1.91E+00
CO_2	1.57E+00	1.64E+00	1.22E+00	1.71E+00	1.55E+00	1.83E+00
CH_4	3.71E-03	3.59E-03	3.51E-03	5.30E-03	6.28E-03	2.96E-03
N_2O	3.73E-05	3.87E-05	2.97E-05	4.02E-05	3.05E-05	2.00E-05
NO_X	2.76E-03	3.00E-03	1.95E-03	2.20E-03	1.95E-03	4.32E-03
SO_X	8.36E-03	8.57E-03	6.82E-03	9.70E-03	1.12E-02	8.36E-03
CO	8.05E-04	8.54E-04	5.46E-04	9.07E-04	2.05E-03	7.43E-03
TNMOC	7.13E-05	7.26E-05	6.45E-05	7.44E-05	8.40E-05	1.15E-04
Lead	1.31E-07	1.39E-07	8.95E-08	1.42E-07	6.30E-08	1.32E-07
Mercury	3.05E-08	3.36E-08	1.86E-08	2.79E-08	3.80E-08	1.72E-07
PM10	9.16E-05	9.26E-05	6.99E-05	1.30E-04	1.09E-04	1.79E-04
Solid Waste	1.90E-01	2.05E-01	1.39E-01	1.66E-01	7.89E-02	7.44E-02

Table 4 Total Emission Factors for Delivered Electricity (kg of pollutant per kWh of electricity)

Pollutant (kg)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	7.58E-01	7.88E-01	5.94E-01	8.34E-01	7.74E-01	8.65E-01
CO_2	7.14E-01	7.45E-01	5.54E-01	7.74E-01	7.05E-01	8.32E-01
CH_4	1.68E-03	1.63E-03	1.59E-03	2.40E-03	2.85E-03	1.34E-03
N_2O	1.69E-05	1.76E-05	1.35E-05	1.82E-05	1.38E-05	9.06E-06
NO_X	1.25E-03	1.36E-03	8.84E-04	9.98E-04	8.83E-04	1.96E-03
SO_X	3.79E-03	3.89E-03	3.09E-03	4.40E-03	5.09E-03	4.10E-03
CO	3.65E-04	3.87E-04	2.48E-04	4.12E-04	9.31E-04	3.37E-03
TNMOC	3.24E-05	3.29E-05	2.93E-05	3.38E-05	3.81E-05	5.20E-05
Lead	5.92E-08	6.30E-08	4.06E-08	6.44E-08	2.86E-08	5.99E-08
Mercury	1.39E-08	1.52E-08	8.42E-09	1.27E-08	1.72E-08	7.79E-08
PM10	4.16E-05	4.20E-05	3.17E-05	5.92E-05	4.94E-05	8.12E-05
Solid Waste	8.63E-02	9.28E-02	6.29E-02	7.55E-02	3.58E-02	3.37E-02

5.2 – Delivered Fuel Energy and Emission Factors

The source energy factors for fuel delivered to buildings are listed in Table 5. These factors represent the energy required to extract, process, and deliver the fuel to the building per unit of energy in the fuel assuming the heating values listed in the table. The precombustion emission factors for delivering fuels to buildings are shown in Tables 6 and 7. These numbers are based on national averages and are derived from the Fuels and Energy Precombustion LCI data module (NREL 2005). These emission factors do not include emissions from use of the fuel in the building, which is reported in Section 5.3.

Table 5 Source Energy Factors for Fuel Delivered to Buildings

Fuel	Source Energy Factor	Higher Heating Value	
Anthracite Coal	1.029	12,700 Btu/lb	29,539 kJ/kg
Bituminous Coal	1.048	12,155 Btu/lb	28,270 kJ/kg
Subbitumious Coal	1.066	8,818 Btu/lb	20,509 kJ/kg
Lignite Coal	1.102	6,465 Btu/lb	15,038 kJ/kg
Natural Gas	1.092	1,010 Btu/ft^3 *	37,631 kJ/m^3 *
Residual Fuel Oil	1.191	149,500 Btu/gal	41,666 kJ/L
Distillate Fuel Oil	1.158	138,700 Btu/gal	38,656 kJ/L
Gasoline	1.187	100,000 Btu/gal	27,870 kJ/L
LPG	1.151	91,000 Btu/gal	25,362 kJ/L
Kerosene	1.205	135,000 Btu/gal	27,870 kJ/L

* Heating value for 60°F and 14.70 psia (15.6°C and 101325 Pa).

Table 6 Precombustion Emission Factors for Fuel Delivered to Buildings (lb of pollutant per unit of fuel)

Pollutant (lb)	Anthracite Coal	Bituminous Coal	Lignite Coal	Natural Gas	Residual Fuel Oil	Distillate Fuel Oil	Gasoline	LPG	Kerosene
	1000 lb	1000 lb	1000 lb	1000 ft^3 *	1000 gal	1000 gal	1000 gal	1000 gal	1000 gal
CO_{2e}	9.76E+1	1.89E+2	1.37E+2	2.78E+1	4.47E+3	4.10E+3	3.50E+3	2.56E+3	3.83E+3
CO_2	5.85E+1	9.32E+1	1.07E+2	1.16E+1	3.57E+3	3.28E+3	2.80E+3	2.05E+3	3.06E+3
CH_4	1.69E+0	4.15E+0	1.30E+0	7.04E-1	3.81E+1	3.49E+1	2.98E+1	2.18E+1	3.26E+1
N_2O	1.08E-3	1.80E-3	1.45E-3	2.35E-4	6.57E-2	6.03E-2	5.14E-2	3.77E-2	5.63E-2
NO_X	2.51E-1	7.69E-1	3.33E-1	1.64E-2	2.73E+1	2.50E+1	2.13E+1	1.57E+1	2.34E+1
SO_X	2.02E-1	3.34E-1	4.52E-1	1.22E+0	3.86E+1	3.55E+1	3.02E+1	2.22E+1	3.31E+1
CO	2.40E-1	4.30E-1	4.73E-1	1.36E-2	1.15E+2	1.06E+2	9.00E+1	6.61E+1	9.86E+1
TNMOC	3.74E-4	7.36E-4	8.55E-4	4.56E-5	2.31E-2	2.12E-2	1.81E-2	1.33E-2	1.98E-2
Lead	3.44E-6	5.21E-6	3.13E-5	2.41E-7	1.47E-4	1.35E-4	1.15E-4	8.43E-5	1.26E-4
Mercury	7.45E-7	1.29E-6	1.20E-6	5.51E-8	2.42E-5	2.22E-5	1.89E-5	1.39E-5	2.07E-5
PM10	6.04E-3	2.10E-2	1.01E-2	8.17E-4	6.99E-1	6.42E-1	5.47E-1	4.01E-1	5.99E-1
PM-unspecified	2.11E+0	1.65E+0	1.31E-1	1.42E-3	2.71E+0	2.49E+0	2.12E+0	1.56E+0	2.32E+0
Solid Waste	2.74E+2	2.40E+2	5.77E+0	1.60E+0	4.21E+2	3.87E+2	3.30E+2	2.42E+2	3.61E+2

* Gas volume at 60°F and 14.70 psia.

Table 7 Precombustion Emission Factors for Fuel Delivered to Buildings (kg of pollutant per unit of fuel)

Pollutant (kg)	Anthracite Coal	Bituminous Coal	Lignite Coal	Natural Gas	Residual Fuel Oil	Distillate Fuel Oil	Gasoline	LPG	Kerosene
	1000 kg	1000 kg	1000 kg	1000 m^3 *	1000 L	1000 L	1000 L	1000 L	1000 L
CO_{2e}	9.76E+1	1.89E+2	1.37E+2	4.46E-1	5.35E+2	4.92E+2	4.19E+2	3.07E+2	4.59E+2
CO_2	5.85E+1	9.32E+1	1.07E+2	1.86E-1	4.28E+2	3.93E+2	3.35E+2	2.46E+2	3.67E+2
CH_4	1.69E+0	4.15E+0	1.30E+0	1.13E-2	4.56E+0	4.19E+0	3.57E+0	2.62E+0	3.91E+0
N_2O	1.08E-3	1.80E-3	1.45E-3	3.77E-6	7.87E-3	7.23E-3	6.16E-3	4.52E-3	6.74E-3
NO_X	2.51E-1	7.69E-1	3.33E-1	2.62E-4	3.27E+0	3.00E+0	2.56E+0	1.88E+0	2.80E+0
SO_X	2.02E-1	3.34E-1	4.52E-1	1.95E-2	4.63E+0	4.25E+0	3.62E+0	2.66E+0	3.96E+0
CO	2.40E-1	4.30E-1	4.73E-1	2.18E-4	1.38E+1	1.27E+1	1.08E+1	7.91E+0	1.18E+1
TNMOC	3.74E-4	7.36E-4	8.55E-4	7.30E-7	2.77E-3	2.54E-3	2.17E-3	1.59E-3	2.37E-3
Lead	3.44E-6	5.21E-6	3.13E-5	3.86E-9	1.76E-5	1.62E-5	1.38E-5	1.01E-5	1.51E-5
Mercury	7.45E-7	1.29E-6	1.20E-6	8.82E-10	2.89E-6	2.66E-6	2.26E-6	1.66E-6	2.48E-6
PM10	6.04E-3	2.10E-2	1.01E-2	1.31E-5	8.38E-2	7.70E-2	6.56E-2	4.81E-2	7.18E-2
PM-unspecified	2.11E+0	1.65E+0	1.31E-1	2.27E-5	3.25E-1	2.98E-1	2.54E-1	1.86E-1	2.78E-1
Solid Waste	2.74E+2	2.40E+2	5.77E+0	2.57E-2	5.05E+1	4.64E+1	3.95E+1	2.90E+1	4.32E+1

* Gas volume at 15.6°C and 101325 Pa.

5.3 – Emission Factors for On-Site Combustion

The emission factors for combustion of fuels in buildings are listed in Tables 8 to 11. Unless otherwise noted, these emission factors are based on data from GREET 1.6 (ANL 2005), which uses EPA AP-42 (EPA 2005B) and other sources. The numbers include the emissions from combustion on site; the precombustion emissions in Tables 6 and 7 are not included. No data are available for some pollutants; this does not mean that the emissions are zero or negligible. The emission factors should be calculated for these pollutants when reliable data are available.

Emissions from combustion depend on the composition of the fuel, the equipment, and the maintenance of the equipment. In general, these factors provide baseline emissions from uncontrolled combustion sources. If more detailed information is known about the fuel or the combustion equipment, it should be used.

Table 8 Emission Factors for On-Site Combustion in a Commercial Boiler (lb of pollutant per unit of fuel)

Pollutant (lb)	Commercial Boiler					
	Bituminous Coal *	Lignite Coal **	Natural Gas	Residual Fuel Oil	Distillate Fuel Oil	LPG
	1000 lb	1000 lb	1000 ft^3 ***	1000 gal	1000 gal	1000 gal
CO_{2e}	2.74E+03	2.30E+03	1.23E+02	2.56E+04	2.28E+04	1.35E+04
CO_2	2.63E+03	2.30E+03	1.22E+02	2.55E+04	2.28E+04	1.32E+04
CH_4	1.15E-01	2.00E-02	2.50E-03	2.31E-01	2.32E-01	2.17E-01
N_2O	3.68E-01	ND †	2.50E-03	1.18E-01	1.19E-01	9.77E-01
NO_X	5.75E+00	5.97E+00	1.11E-01	6.41E+00	2.15E+01	1.57E+01
SO_X	1.66E+00	1.29E+01	6.32E-04	4.00E+01	3.41E+01	0.00E+00
CO	2.89E+00	4.05E-03	9.33E-02	5.34E+00	5.41E+00	2.17E+00
VOC	ND †	ND †	6.13E-03	3.63E-01	2.17E-01	3.80E-01
Lead	1.79E-03	6.86E-02	5.00E-07	1.51E-06	ND †	ND †
Mercury	6.54E-04	6.54E-04	2.60E-07	1.13E-07	ND †	ND †
PM10	2.00E+00	ND †	8.40E-03	4.64E+00	1.88E+00	4.89E-01

* from the U.S. LCI data module: Bituminous Coal Combustion in an Industrial Boiler (NREL 2005)
** from the U.S. LCI data module: Lignite Coal Combustion in an Industrial Boiler (NREL 2005)
*** Gas volume at 60°F and 14.70 psia.
† no data available

Table 9 Emission Factors for On-Site Combustion in a Commercial Boiler (kg of pollutant per unit of fuel)

Pollutant (kg)	Commercial Boiler					
	Bituminous Coal *	Lignite Coal **	Natural Gas	Residual Fuel Oil	Distillate Fuel Oil	LPG
	1000 kg	1000 kg	1000 m^3 ***	1000 L	1000 L	1000 L
CO_{2e}	2.74E+03	2.30E+03	1.97E+00	3.06E+03	2.73E+03	1.62E+03
CO_2	2.63E+03	2.30E+03	1.96E+00	3.06E+03	2.73E+03	1.59E+03
CH_4	1.15E-01	2.00E-02	4.00E-05	2.76E-02	2.78E-02	2.60E-02
N_2O	3.68E-01	ND †	4.00E-05	1.41E-02	1.43E-02	1.17E-01
NO_X	5.75E+00	5.97E+00	1.78E-03	7.68E-01	2.58E+00	1.88E+00
SO_X	1.66E+00	1.29E+01	1.01E-05	4.79E+00	4.09E+00	0.00E+00
CO	2.89E+00	4.05E-03	1.50E-03	6.40E-01	6.48E-01	2.60E-01
VOC	ND †	ND †	9.82E-05	4.35E-02	4.39E-02	4.55E-02
Lead	1.79E-03	6.86E-02	8.01E-09	1.81E-07	ND †	ND †
Mercury	6.54E-04	6.54E-04	4.16E-09	1.35E-08	ND †	ND †
PM10	2.00E+00	ND †	1.35E-04	5.56E-01	2.25E-01	5.86E-02

* from the U.S. LCI data module: Bituminous Coal Combustion in an Industrial Boiler (NREL 2005)
** from the U.S. LCI data module: Lignite Coal Combustion in an Industrial Boiler (NREL 2005)
*** Gas volume at 15.6°C and 101325 Pa.
† no data available

Table 10 Emission Factors for On-Site Combustion in Other Equipment (lb of pollutant per unit of fuel)

Pollutant (lb)	Stationary Reciprocating Engine			Small Turbine		Residential Furnace *
	Natural Gas	Distillate Fuel Oil	Gasoline	Natural Gas	Distillate Fuel Oil	Natural Gas
	1000 ft^3 **	1000 gal	1000 gal	1000 ft^3 **	1000 gal	1000 ft^3 **
CO_{2e}	1.37E+02	2.27E+04	1.76E+04	1.25E+02	2.29E+04	1.21E+02
CO_2	1.16E+02	2.25E+04	1.72E+04	1.22E+02	2.28E+04	1.20E+02
CH_4	8.38E-01	1.20E+00	8.31E+00	5.26E-02	2.58E-01	2.30E-03
N_2O	3.41E-03	6.11E-01	5.51E-01	4.54E-03	6.11E-01	2.20E-03
NO_X	3.56E+00	4.76E+02	3.02E+02	3.51E-01	4.02E+01	9.40E-02
SO_X	6.32E-04	3.24E+01	4.18E+00	6.32E-04	3.24E+01	6.00E-04
CO	2.29E+00	1.26E+02	1.22E+03	1.75E-01	2.66E+00	4.00E-02
VOC	2.06E-03	1.22E+01	2.56E+01	2.06E-03	4.08E-01	5.50E-03
Lead	5.00E-07	ND †	ND †	5.00E-07	1.40E-08	5.00E-07
Mercury	2.60E-07	ND †	ND †	2.60E-07	1.20E-09	2.60E-07
PM10	1.66E-02	1.49E+01	2.40E+00	2.64E-02	5.19E+00	7.60E-03

* data from EPA's AP-42, volume 1, 5th edition, 1995 (EPA 2005b)
** Gas volume at 60°F and 14.70 psia.
† no data available

Table 11 Emission Factors for On-Site Combustion in Other Equipment (kg of pollutant per unit of fuel)

Pollutant (kg)	Stationary Reciprocating Engine			Small Turbine		Residential Furnace *
	Natural Gas	Distillate Fuel Oil	Gasoline	Natural Gas	Distillate Fuel Oil	Natural Gas
	1000 m^3 **	1000 L	1000 L	1000 m^3 **	1000 L	1000 m^3 **
CO_{2e}	2.19E+00	2.72E+03	2.11E+03	2.00E+00	2.75E+03	1.93E+00
CO_2	1.86E+00	2.70E+03	2.07E+03	1.96E+00	2.73E+03	1.92E+00
CH_4	1.34E-02	1.44E-01	9.96E-01	8.42E-04	3.09E-02	3.68E-05
N_2O	5.46E-05	7.32E-02	6.60E-02	7.28E-05	7.32E-02	3.52E-05
NO_X	5.70E-02	5.70E+01	3.62E+01	5.62E-03	4.82E+00	1.51E-03
SO_X	1.01E-05	3.88E+00	5.01E-01	1.01E-05	3.88E+00	9.61E-06
CO	3.66E-02	1.51E+01	1.46E+02	2.81E-03	3.19E-01	6.41E-04
VOC	1.36E-03	1.46E+00	3.07E+00	3.30E-05	4.89E-02	8.81E-05
Lead	8.01E-09	ND †	ND †	8.01E-09	1.68E-09	8.01E-09
Mercury	4.16E-09	ND †	ND †	4.16E-09	1.44E-10	4.16E-09
PM10	2.67E-04	1.78E+00	2.87E-01	4.22E-04	6.22E-01	1.22E-04

* data from the EPA's AP-42, volume 1, 5th edition, 1995 (EPA 2005B)
** Gas volume at 15.6°C and 101325 Pa.
† no data available

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Appendix A – Derivation of Energy and Emission Factors

Table A-1 summarizes the data sources used in deriving the energy and emission factors. The EIA uses 34 fuel type codes for reporting electricity generation. Table A-2 shows how these fuel type codes were mapped to the 11 energy groups used in this document based on similar production and combustion effects.

Table A-3 presents a summary of the steps used for calculating the source energy factors. The electricity from pumped hydro storage (HPS) is sometimes reported as a negative number and sometimes as a positive number. When it was positive, it was added to the Hydro electricity total. Negative values were divided and subtracted from the bituminous coal and nuclear totals, which are the most probable base load energy groups.

The emission factors were calculated by following the steps in Table A-4.

Nomenclature

$e_{i,k}$	Combustion emissions per physical quantity of fuel for each pollutant
$e_{pc_{i,k}}$	Combustion emissions per physical quantity of fuel for each pollutant
E_j	Total annual electricity generation by region
E_{pc_i}	Precombustion energy per quantity of fuel type
$f_{i,j}$	Combustion source energy factor by energy type and region
$f_{pc_{i,j}}$	Precombustion source energy factor by energy type and region
F_{d_j}	Total source energy factor for delivered electricity by region (includes precombustion)
F_{g_j}	Combustion source energy factor for generated electricity by region
F_{pc_j}	Precombustion source energy factor by region
L_j	T*D losses by region
$M_{i,j}$	Physical quantity of fuel used for electricity generation by fuel type and region (adjusted for useful thermal heat from CHP plants greater than 1 MW)
$P_{g_{k,j}}$	Total emission factor per generated kWh of electricity by pollutant and region
$P_{d_{k,j}}$	Total emission factor per delivered kWh of electricity by pollutant and region
$S_{i,j}$	Energy quantity of fuel used for electricity generation by fuel type and region (adjusted for useful thermal heat from CHP plants greater than 1 MW)
$\delta_{i,j}$	Fraction of electricity generated by energy type and region
$\varepsilon_{i,j}$	Adjusted electricity generation totals for HPS by source energy type and region
$\rho_{k,j}$	Combustion emission factor per generated kWh of electricity by pollutant and region
$\rho_{pc_{k,j}}$	Precombustion emission factor per generated kWh of electricity by pollutant and region
$\vartheta_{i,j}$	Combustion source energy factor for a composite unit of electricity by energy type and region

Subscripts:

i	Fuel type index
j	Region index
k	Pollutant index
pc	Precombustion

Table A-1 Data Sources

Data Source	Data Used
EIA Forms 906/920 for 2004 (EIA 2006a)	Power plant data for: Electric fuel consumption by quantity Electric fuel consumption by energy Net electricity generation
EIA Electric Power Annual 2005 (EIA 2006b)	CO_2 emission factors for bituminous, subbituminous, and lignite coals; natural gas; and residual fuel oil. Total annual emissions for CO_2, NOx, and SOx for 2004.
eGRID 2000 (EPA 2002)	T&D losses by NERC region Annual net imported and exported electricity by state
eGRID 2006 version 2.1 (EPA 2007)	Hg, NOx, and SOx emission factors for bituminous, subbituminous, and lignite coals; natural gas; and residual fuel oil. Total annual emissions for CO_2, NOx, Sox, and Hg for 2004.
Electricity Generation LCI data module (NREL 2005)	T&D losses by NERC region
LCI data modules for Fuels and Energy Precombustion and Petroleum Refining (NREL 2005)	Precombustion energy and emissions for processing the fuels per physical quantity of fuel
Biomass Combustion in Utility Turbine LCI data module (NREL 2005)	Precombustion energy for wood Emissions for wood combustion in utility turbines
LCI data modules for Combustion in Utility Boilers for Bituminous Coal, Lignite Coal, Natural Gas, Residual Fuel Oil, and Distillate Fuel Oil (NREL 2005)	Emissions for combustion in utility boilers for each fuel type
LCI data modules for Combustion in Industrial Boilers for Bituminous Coal and Lignite Coal (NREL 2005)	Emission data for on-site combustion in building equipment
GREET 1.6 (ANL 2005)	Emission data for on-site combustion in building equipment
Clearing House for Inventories & Emissions Factors (EPA 2005b)	Emission data for natural gas combustion in a residential furnace
Climate Change 2001 (IPCC 2001)	GWP indices

Table A-2 Mapping of EIA Fuel Type Codes to Energy Groups

Energy Group	EIA Fuel Type Codes	EIA Fuel Descriptions
Bituminous Coal	BIT, WC, SC	bituminous coal, anthracite coal, coal, waste coal, coal based synfuel
Subbituminous Coal	SUB	subbituminous coal
Lignite Coal	LIG	lignite coal
Natural Gas	NG, BFG, OG, PG	natural gas, blast furnace gas, other gas, gaseous propane
Petroleum Fuels	DFO, JF, KER, PC, RFO, WO	distillate fuel oil, jet fuel, kerosene, petroleum coke, residual fuel oil, waste oil
Other Fossil Fuel	TDF, OTH, PUR	Tire-derived fuels, other, purchased steam
Nuclear	NUC	nuclear
Hydro	HYC	conventional hydro power
Renewable Fuels	AB, MSW, OBS, WDS, OBL, BLQ, SLW, WDL, LFG, OBG	agricultural crop by-product, municipal solid waste, other biomass solids, wood solids, other biomass liquids, black liquor, sludge waste, wood waste liquids, landfill gas, other biomass gas
Geothermal	GEO	geothermal
Wind	WND	wind
Solar (PV)	SUN	PV solar
	HPS *	pumped hydro storage

* The electricity from HPS was added to the hydro electricity if it was positive and subtracted from the Bit/sub/anth Coal and Nuclear electricity if it was negative.

Table A-3 Steps for Calculating Electricity Source Energy Factors

Step	Description
1	Starting with the EIA 906/920 2004 data (EIA 2006a), fill in missing NERC region names for imputed data based on the reported state. Use the NERC region that most of the state lies in. The imputed data represent 2.3% of the total generation.
2	Sort the data by NERC region and fuel type. Sort this data again by mapping the EIA Fuel Type codes to the energy groups as shown in Table A-2. Repeat at the state level.
3	Adjust the electricity generation totals ($\varepsilon_{i,j}$) to include the HPS. Assumptions: Add positive values to the hydro electricity total. Subtract negative values from the bituminous coal and nuclear totals
4	Calculate the fraction of electricity generated by energy type and region (see Table 1). $\delta_{i,j} = \frac{\varepsilon_{i,j}}{E_j}$
5	Calculate the combustion source energy factors by energy type and region (see Table B-1). $f_{i,j} = \frac{S_{i,j}}{\varepsilon_{i,j}}$ Assumptions: The source energy factor for hydro, wind, and solar PV is one.
6	Calculate the combustion source energy factors for a composite unit of electricity by energy type and region (see Table B-2). $\vartheta_{i,j} = f_{i,j} * \delta_{i,j}$
7	Calculate the total combustion source energy factors for generated electricity by region. $F_{g_j} = \sum_i \vartheta_{i,j}$
8	Determine the precombustion source energy factors by energy type and region. The precombustion energy per quantity of fuel is from the Fuels and Energy Precombustion LCI data module (NREL 2005). $f_{pc_{i,j}} = \frac{E_{pc_i} \times M_{i,j}}{E_j}$
9	Calculate the total precombustion source energy factors by region (see Table B-2). $F_{pc_j} = \sum_i f_{pc_{i,j}}$
10	Calculate the total fuel factors for delivered energy including the T&D losses (see Table B-2). The T&D losses (see Table 1) are from the Electricity Generation LCI data module (NREL 2005) and eGRID 2000 (EPA 2002). $F_{d_j} = \left(F_{g_j} + F_{pc_j}\right)\left(1 + L_j\right)$

Table A-4 Steps for Calculating Emission Factors for Electricity Generation

Step	Description
1	Extract the emission factors for fuel combustion in utility boilers for each pollutant and fuel type from the appropriate LCI data module. Use the CO_2 emission factors for coal, natural gas, and residual fuel oil from EIA Electric Power Annual (EIA 2006b). Determine the NOx, SOx, SO_2, and Hg emission factors for coal, natural gas, and residual fuel oil from eGRID 2006 version 1 (EPA 2006). Assumptions: Emission factors for combustion of residual fuel oil are used for all petroleum fuels. Emission factors for bituminous coal are used for other fossil fuels. Emissions for electricity generation from gasification of wood are used for all renewable fuels.
2	Compile the precombustion emission factors for each pollutant and fuel type from the Fuels and Energy Precombustion LCI data module. Assumptions: The emissions for petroleum products were allocated by mass between all of the petroleum refining coproducts.
3	Calculate the combustion emissions for each pollutant and region in lb pollutant/kWh generated electricity. $$\rho_{k,j} = \sum_i e_{i,k} \times M_{i,j}$$
4	Calculate the precombustion emissions for each pollutant and region in lb pollutant/kWh generated electricity. $$\rho_{pc_{k,j}} = \sum_i e_{pc_{i,k}} \times M_{i,j}$$
5	Calculate the total emissions for generated electricity for each pollutant and region. $$P_{g_{k,j}} = \rho_{k,j} + \rho_{pc_{k,j}}$$
6	Calculate the total emissions for generated electricity for each pollutant and region. $$P_{d_{k,j}} = P_{g_{k,j}} \left(1 + L_{TD_j}\right)$$

Appendix B – Additional Energy and Emission Data

The source energy factors for generating electricity for each fuel type are listed in Table B-1. These numbers are calculated from the source energy used and electricity generated as reported by the electricity generators in the EIA Forms 906 and 920 (step 5 of Table A-3). The source energy for hydro, wind, and solar are set equal to the electricity generated, which provides a source energy factor of 1.0.

Table B-1 Source Energy Factors by Fuel Type for Generating Electricity (kWh of source energy per kWh of generated electricity)

Energy Group	National	Eastern	Western	ERCOT	Alaska	Hawaii
Bituminous Coal	2.996	2.993	3.035			5.696
Subbituminous Coal	3.089	3.084	3.126	3.059	3.937	2.863
Lignite Coal	3.262	3.252		3.272		
Natural Gas	2.627	2.629	2.631	2.620	3.405	3.198
Petroleum Fuels	3.117	3.094	3.404	4.022	3.311	3.049
Other Fossil Fuel	2.465	2.377	2.859	2.140		2.856
Nuclear	3.075	3.075	3.083	3.060		
Hydro	1.000	1.000	1.000	1.000	1.000	1.000
Renewable Fuels	4.459	4.527	3.947	6.419	2.868	5.157
Geothermal	6.160		6.160			6.160
Wind	1.000	1.000	1.000	1.000		1.000
Solar (PV)	1.000		1.000			

The source energy factors for delivered electricity are listed in Table B-2. These factors represent the components by energy type used to generated one kWh of electricity based on annual energy totals. For example, for every kWh of electricity delivered to the consumer in the United States, the first column lists all the fuel that went into that electricity based on annual totals. The numbers in table were calculated following steps in Table A-3 (the top section from step 6, the precombustion energy from steps 8 and 9, and the totals from step 10).

Table B-2 Source Energy Factor Components per Delivered kWh of Electricity for 2004 (kWh of source energy per kWh of delivered electricity)

Energy Group	National	Eastern	Western	ERCOT	Alaska	Hawaii
Bituminous Coal	0.916	1.125	0.430	0.000	0.000	0.061
Subbituminous Coal	0.672	0.663	0.670	0.759	0.442	0.407
Lignite Coal	0.081	0.049	0.000	0.562	0.000	0.000
Natural Gas	0.528	0.367	0.780	1.502	2.134	0.051
Petroleum Fuels	0.096	0.122	0.017	0.024	0.428	2.568
Other Fossil Fuel	0.005	0.005	0.008	0.005	0.000	0.007
Nuclear	0.671	0.774	0.329	0.441	0.000	0.000
Hydro	0.074	0.037	0.267	0.003	0.259	0.009
Renewable Fuels	0.073	0.083	0.057	0.015	0.005	0.233
Geothermal	0.025	0.000	0.143	0.000	0.000	0.125
Wind	0.004	0.002	0.011	0.010	0.000	0.001
Solar (PV)	0.000	0.000	0.001	0.000	0.000	0.000
Fossil Precombustion Energy	0.152	0.148	0.128	0.233	0.283	0.413
Total Precombustion Energy	0.168	0.166	0.140	0.253	0.300	0.455
Totals without Precombustion Energy						
Total Fossil Fuel	2.299	2.332	1.905	2.851	3.004	3.094
Total Nonrenewable Energy	2.970	3.106	2.234	3.292	3.004	3.094
Total Energy	3.146	3.228	2.713	3.321	3.268	3.462
Totals with Precombustion Energy						
Total Fossil Fuel	2.450	2.480	2.033	3.084	3.287	3.507
Total Nonrenewable Energy	3.138	3.272	2.374	3.545	3.304	3.549
Total Energy	3.315	3.394	2.853	3.574	3.568	3.917

Tables B-3 through B-6 show the emission factors per generated kWh for combustion in utility boilers and precombustion effects in IP and SI units. The emissions are based on the emissions data from the LCI data modules for each fuel type combustion in utility boilers (NREL 2005), and on the fuel totals used for electricity generation as reported on the 2004 EIA Forms 906 and 920 (EIA 2006). These numbers do not include the effects of losses in T&D of the electricity.

Table B-3 Combustion Emission Factors for Generated Electricity (lb of pollutant per kWh of electricity)

Emission (lb)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	1.37E+00	1.43E+00	1.07E+00	1.38E+00	1.26E+00	1.48E+00
CO_2	1.36E+00	1.42E+00	1.06E+00	1.37E+00	1.25E+00	1.47E+00
CH_4	1.45E-05	1.43E-05	1.26E-05	2.01E-05	2.01E-05	1.87E-05
N_2O	3.25E-05	3.39E-05	2.62E-05	3.27E-05	2.46E-05	1.44E-05
NO_X	2.03E-03	2.21E-03	1.45E-03	1.53E-03	1.24E-03	2.29E-03
SO_X	5.25E-03	5.98E-03	3.27E-03	2.78E-03	1.77E-03	6.03E-03
CO	2.82E-04	2.59E-04	2.95E-04	4.69E-04	6.24E-04	3.22E-04
TNMOC	4.71E-05	4.64E-05	4.37E-05	6.11E-05	7.21E-05	5.62E-05
Lead	1.14E-07	1.23E-07	8.00E-08	1.12E-07	5.21E-08	1.12E-07
Mercury	2.70E-08	2.98E-08	1.65E-08	2.32E-08	3.28E-08	1.56E-07
PM10	6.96E-05	6.98E-05	5.42E-05	1.00E-04	8.13E-05	1.21E-04
Solid Waste	5.20E-02	5.40E-02	3.43E-02	7.07E-02	1.55E-02	1.28E-02

Table B-4 Combustion Emission Factors for Generated Electricity (kg of pollutant per kWh of electricity)

Emission (kg)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	6.20E-01	6.50E-01	4.86E-01	6.24E-01	5.72E-01	6.69E-01
CO_2	6.15E-01	6.46E-01	4.82E-01	6.19E-01	5.69E-01	6.67E-01
CH_4	6.58E-06	6.50E-06	5.69E-06	9.11E-06	9.11E-06	8.48E-06
N_2O	1.47E-05	1.54E-05	1.19E-05	1.48E-05	1.12E-05	6.53E-06
NO_X	9.19E-04	1.00E-03	6.59E-04	6.93E-04	5.64E-04	1.04E-03
SO_X	2.38E-03	2.71E-03	1.48E-03	1.26E-03	8.04E-04	2.74E-03
CO	1.28E-04	1.17E-04	1.34E-04	2.13E-04	2.83E-04	1.46E-04
TNMOC	2.14E-05	2.10E-05	1.98E-05	2.77E-05	3.27E-05	2.55E-05
Lead	5.19E-08	5.56E-08	3.63E-08	5.07E-08	2.36E-08	5.10E-08
Mercury	1.22E-08	1.35E-08	7.50E-09	1.05E-08	1.49E-08	7.09E-08
PM10	3.16E-05	3.16E-05	2.46E-05	4.55E-05	3.69E-05	5.50E-05
Solid Waste	2.36E-02	2.45E-02	1.56E-02	3.21E-02	7.03E-03	5.81E-03

Table B-5 Precombustion Emission Factors for Generated Electricity (lb of pollutant per kWh of electricity)

Emission (lb)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	1.54E-01	1.52E-01	1.38E-01	2.09E-01	2.50E-01	2.77E-01
CO_2	7.63E-02	7.63E-02	6.32E-02	1.04E-01	1.22E-01	2.14E-01
CH_4	3.36E-03	3.26E-03	3.23E-03	4.55E-03	5.54E-03	2.70E-03
N_2O	1.46E-06	1.47E-06	1.25E-06	1.90E-06	2.40E-06	3.94E-06
NO_X	4.80E-04	5.24E-04	3.45E-04	3.68E-04	4.81E-04	1.68E-03
SO_X	2.36E-03	1.85E-03	3.02E-03	5.57E-03	8.17E-03	2.27E-03
CO	4.50E-04	5.20E-04	2.09E-04	3.12E-04	1.19E-03	6.50E-03
TNMOC	1.78E-05	1.98E-05	1.58E-05	2.97E-06	2.25E-06	4.92E-05
Lead	4.44E-09	4.22E-09	2.54E-09	1.04E-08	3.74E-09	8.93E-09
Mercury	8.13E-10	8.50E-10	6.16E-10	8.96E-10	7.86E-10	1.53E-09
PM10	1.37E-05	1.47E-05	1.03E-05	1.19E-05	1.51E-05	4.33E-05
Solid Waste	1.21E-01	1.33E-01	9.37E-02	7.26E-02	5.44E-02	5.55E-02

Table B-6 Precombustion Emission Factors for Generated Electricity (kg of pollutant per kWh of electricity)

Emission (kg)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	6.99E-02	6.88E-02	6.25E-02	9.47E-02	1.13E-01	1.26E-01
CO_2	3.46E-02	3.46E-02	2.87E-02	4.70E-02	5.53E-02	9.71E-02
CH_4	1.52E-03	1.48E-03	1.46E-03	2.06E-03	2.51E-03	1.23E-03
N_2O	6.64E-07	6.65E-07	5.66E-07	8.60E-07	1.09E-06	1.79E-06
NO_X	2.18E-04	2.38E-04	1.56E-04	1.67E-04	2.18E-04	7.60E-04
SO_X	1.07E-03	8.38E-04	1.37E-03	2.53E-03	3.71E-03	1.03E-03
CO	2.04E-04	2.36E-04	9.49E-05	1.42E-04	5.42E-04	2.95E-03
TNMOC	8.05E-06	9.00E-06	7.17E-06	1.35E-06	1.02E-06	2.23E-05
Lead	2.01E-09	1.91E-09	1.15E-09	4.74E-09	1.70E-09	4.05E-09
Mercury	3.69E-10	3.85E-10	2.79E-10	4.06E-10	3.56E-10	6.92E-10
PM10	6.23E-06	6.68E-06	4.68E-06	5.41E-06	6.84E-06	1.97E-05
Solid Waste	5.49E-02	6.02E-02	4.25E-02	3.29E-02	2.47E-02	2.52E-02

Data on the electricity generation by state are shown in Tables B-7 through B-12. The state data for electricity generation and the fuel used for electricity generation are derived from 2004 EIA Forms 906 and 920 (EIA 2006). The state level data should be used with caution, because several states import electricity from neighboring states, Canada, or Mexico, and the source energy for the imported electricity is not always known. Thirteen states (including the District of Columbia) imported more than 15% of their electricity in 2000. Table B-7 shows the net imported electricity in GWh (+ for imports and – for exports) and as a percent of the consumed electricity for net importers of electricity and as a percent of the generated electricity for net exporters of electricity. The state net import and export data are from year 2000 data reported in eGRID (EPA 2002).

The percent of electricity generation by fuel type for each state is shown in Table B-8. The source energy factors are in Table B-9 and the emission factors are shown in Tables B-10 and B-11. The ozone season is from May to September, and the NO_X emissions for this season are shown Table B-12. The ozone season NO_X emissions do not include precombustion emissions because these emissions do not occur at the power plant, and we are typically only concerned about ozone formation near the power plant. These numbers are for electricity generated within the states and do not include the electricity imported into the state.

Table B-7 Net Imported Electricity by State for 2000 (EPA 2002)

	AK	AL	AR	AZ	CA	CO	CT	DC	DE	FL	GA	HI	IA
Net Imported Electricity (GWh) (neg. for exported)	0	-28,838	1,988	-20,072	66,974	3,127	-301	10,526	5,960	23,606	8,423	0	1,662
Net Imported (+ % of consumption) or Net Exported (− % of generation)	0.0%	-23.2%	4.8%	-22.5%	26.1%	7.2%	-0.9%	98.8%	52.7%	12.0%	7.0%	0.0%	4.2%

	ID	IL	IN	KS	KY	LA	MA	MD	ME	MI	MN	MO	MS
Net Imported Electricity (GWh) (neg. for exported)	11,891	-25,084	-17,822	-4,350	-5,231	-350	16,479	15,408	384	10,835	13,543	3,646	11,517
Net Imported (+ % of consumption) or Net Exported (− % of generation)	52.0%	-14.1%	-13.9%	-9.7%	-5.6%	-0.4%	31.8%	25.3%	3.2%	10.3%	22.6%	5.0%	25.3%

	MT	NC	ND	NE	NH	NJ	NM	NV	NY	OH	OK	OR	PA
Net Imported Electricity (GWh) (neg. for exported)	-11,784	9,883	-18,764	-1,864	-3,349	17,454	-12,292	-4,807	17,665	31,362	-320	3,295	-51,727
Net Imported (+ % of consumption) or Net Exported (− % of generation)	-40.9%	8.2%	-60.0%	-6.4%	-22.4%	24.9%	-36.2%	-13.5%	12.4%	18.9%	-0.6%	6.5%	-25.2%

	RI	SC	SD	TN	TX	UT	VA	VT	WA	WI	WV	WY	
Net Imported Electricity (GWh) (neg. for exported)	1,951	-6,486	-394	9,097	-143	-10,236	30,141	-20	-1,067	11,758	-56,173	-29,066	
Net Imported (+ % of consumption) or Net Exported (− % of generation)	26.7%	-7.0%	-4.1%	9.5%	0.0%	-28.0%	30.2%	-0.3%	-1.0%	18.0%	-60.5%	-64.2%	

Table B-8 Percent Electricity Generation by Energy Type by State for 2004 (not counting imported electricity)

Energy Type	AK	AL	AR	AZ	CA	CO	CT	DC	DE	FL	GA	HI	IA
Bit. Coal (%)	0.0	40.3	0.2	17.6	1.1	26.0	4.9	0.0	60.5	29.7	44.4	1.0	3.9
Sub. Coal (%)	9.9	14.2	48.6	20.4	0.0	48.6	8.2	0.0	0.0	0.0	18.2	13.1	77.7
Lignite Coal (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas (%)	55.5	11.8	9.7	27.0	52.5	22.4	24.8	0.0	25.6	35.1	4.9	1.5	1.9
Pet. Fuels (%)	11.5	0.2	1.0	0.0	1.2	0.0	5.3	100.0	13.9	17.1	0.7	77.4	0.3
Other Fossil (%)	0.0	0.0	0.2	1.3	0.1	0.0	0.5	0.0	0.0	1.0	0.0	0.2	0.0
Nuclear (%)	0.0	23.0	29.8	26.8	15.1	0.0	50.7	0.0	0.0	14.3	26.4	0.0	11.4
Hydro (%)	23.0	7.7	7.1	6.7	17.5	2.5	1.4	0.0	0.0	0.1	2.9	0.8	2.2
Ren. Fuel s (%)	0.1	2.7	3.4	0.0	3.2	0.1	4.1	0.0	0.0	2.7	2.5	4.2	0.3
Geothermal (%)	0.0	0.0	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0
Wind (%)	0.0	0.0	0.0	0.0	2.2	0.5	0.0	0.0	0.0	0.0	0.0	0.1	2.4
Solar (PV) (%)	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fossil Fuel (%)	76.9	66.5	59.8	66.4	54.9	97.0	43.7	100.0	100.0	82.9	68.2	93.1	83.7
Renewable (%) **(non Hydro)**	0.1	2.7	3.4	0.0	12.4	0.5	4.1	0.0	0.0	2.7	2.5	6.1	2.7

Energy Type	ID	IL	IN	KS	KY	LA	MA	MD	ME	MI	MN	MO	MS
Bit. Coal (%)	0.4	10.5	66.3	1.4	88.1	0.0	21.5	56.1	1.9	18.5	1.1	3.6	32.7
Sub. Coal (%)	0.5	38.7	28.2	72.5	3.0	19.3	0.0	0.0	0.0	39.2	63.9	81.9	0.0
Lignite Coal (%)	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	7.3
Natural Gas (%)	15.7	1.9	4.4	1.8	0.6	49.9	44.2	3.1	51.4	12.7	2.9	3.3	26.7
Pet. Fuels (%)	0.0	0.4	0.4	1.8	3.8	3.9	15.8	6.3	6.9	0.8	1.5	0.2	6.4
Other Fossil (%)	0.2	0.1	0.4	0.0	0.0	0.8	0.0	0.0	2.1	0.1	0.2	0.1	0.0
Nuclear (%)	0.0	48.0	0.0	21.7	0.0	17.4	12.1	28.0	0.0	25.1	25.4	8.9	23.4
Hydro (%)	77.9	0.1	0.3	0.0	4.0	1.1	2.1	4.8	18.0	1.3	1.4	1.8	0.0
Ren. Fuel s (%)	5.3	0.4	0.1	0.0	0.4	2.8	4.3	1.6	19.7	2.3	2.2	0.0	3.4
Geothermal (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wind (%)	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0
Solar (PV) (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fossil Fuel (%)	16.8	51.5	99.5	77.5	95.6	78.7	81.5	65.5	62.3	71.3	69.5	89.2	73.2
Renewable (%) **(non Hydro)**	5.3	0.4	0.1	0.8	0.4	2.8	4.3	1.6	19.7	2.3	3.7	0.0	3.4

Table B-8 (page 2) Percent Electricity Generation by Energy Type by State for 2004 (not counting imported electricity)

Energy Type	MT	NC	ND	NE	NH	NJ	NM	NV	NY	OH	OK	OR	PA
Bit. Coal (%)	1.1	59.8	0.0	0.0	17.1	18.3	0.1	48.5	13.8	79.4	3.7	0.0	54.4
Sub. Coal (%)	62.5	0.0	1.9	63.9	0.0	0.0	88.8	0.0	2.6	7.1	51.8	6.9	0.0
Lignite Coal (%)	1.2	0.0	91.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas (%)	0.2	2.0	0.2	0.9	22.6	28.7	9.1	43.5	19.8	1.1	38.2	26.2	4.8
Pet. Fuels (%)	1.6	0.5	0.1	0.1	8.2	2.5	0.1	0.3	15.3	0.9	0.1	0.1	1.9
Other Fossil (%)	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nuclear (%)	0.0	31.7	0.0	32.0	42.6	48.1	0.0	0.0	29.1	10.8	0.0	0.0	36.0
Hydro (%)	33.1	4.4	5.2	2.9	5.5	0.1	0.4	4.3	17.4	0.5	4.9	64.4	1.5
Ren. Fuel s (%)	0.2	1.4	0.0	0.1	4.0	2.3	0.0	0.0	1.9	0.3	0.4	1.1	1.3
Geothermal (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0
Wind (%)	0.0	0.0	0.7	0.1	0.0	0.0	1.6	0.0	0.1	0.0	0.9	1.2	0.1
Solar (PV) (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fossil Fuel (%)	66.7	62.5	94.1	64.9	47.9	49.5	98.0	92.3	51.6	88.5	93.8	33.3	61.2
Renewable (%) **(non Hydro)**	0.2	1.4	0.7	0.2	4.0	2.3	1.6	3.4	2.0	0.3	1.3	2.3	1.4

Energy Type	RI	SC	SD	TN	TX	UT	VA	VT	WA	WI	WV	WY	Total
Bit. Coal (%)	0.0	39.2	0.0	47.0	0.0	95.8	44.4	0.0	0.0	10.2	97.6	0.5	27.7
Sub. Coal (%)	0.0	0.0	48.2	12.3	24.5	0.0	0.0	0.0	10.2	59.5	0.0	96.2	19.8
Lignite Coal (%)	0.0	0.0	0.0	0.0	13.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
Natural Gas (%)	96.8	3.9	1.5	0.3	49.4	2.4	8.1	0.1	8.6	4.0	0.4	0.2	18.3
Pet. Fuels (%)	1.0	0.9	0.3	0.2	0.4	0.1	6.5	0.3	0.1	1.2	0.3	0.1	3.0
Other Fossil (%)	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.2
Nuclear (%)	0.0	51.6	0.0	29.0	10.4	0.0	35.2	70.5	8.8	19.7	0.0	0.0	19.7
Hydro (%)	0.1	2.5	47.9	10.7	0.3	1.2	2.0	21.7	70.1	3.3	1.5	1.3	6.8
Ren. Fuel s (%)	2.1	1.8	0.0	0.6	0.3	0.0	3.7	7.2	1.6	1.9	0.0	0.0	1.5
Geothermal (%)	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Wind (%)	0.0	0.0	2.1	0.0	0.8	0.0	0.0	0.2	0.7	0.2	0.2	1.4	0.4
Solar (PV) (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fossil Fuel (%)	97.8	44.1	50.0	59.7	88.2	98.3	59.0	0.4	18.8	75.0	98.3	97.3	71.2
Renewable (%) **(non Hydro)**	2.1	1.8	2.1	0.6	1.1	0.5	3.7	7.4	2.3	2.0	0.2	1.4	2.2

Table B-9 Source Energy Factors for Delivered Electricity by State for 2004
(kWh of source energy consumed per kWh of delivered electricity)

	AK	AL	AR	AZ	CA	CO	CT	DC	DE	FL	GA	HI	IA	ID	IL	IN	KS
Without Precombustion																	
Fossil Fuel	3.004	2.103	1.909	2.039	1.631	3.082	1.208	6.790	3.580	2.468	2.189	3.094	2.982	0.448	1.733	3.285	2.757
Nonrenewable	3.004	2.876	2.907	2.931	2.147	3.082	2.908	6.790	3.580	2.948	3.081	3.094	3.364	0.448	3.341	3.285	3.483
Total	3.268	3.155	3.074	3.004	2.951	3.117	3.160	6.790	3.580	3.103	3.231	3.462	3.427	1.546	3.360	3.296	3.492
With Precombustion																	
Fossil Fuel	3.290	2.228	2.049	2.181	1.766	3.264	1.311	7.835	3.842	2.663	2.305	3.509	3.184	0.485	1.847	3.513	3.290
Nonrenewable	3.308	3.016	3.068	3.089	2.291	3.283	3.028	7.938	3.862	3.161	3.215	3.551	3.593	0.488	3.477	3.535	3.308
Total	3.572	3.296	3.235	3.163	3.095	3.318	3.281	7.938	3.862	3.317	3.364	3.920	3.656	1.586	3.496	3.546	3.572

	KY	LA	MA	MD	ME	MI	MN	MO	MS	MT	NC	ND	NE	NH	NJ	NM	NV
Without Precombustion																	
Fossil Fuel	3.202	2.452	2.352	2.161	1.662	2.297	2.362	2.966	2.384	2.389	1.984	3.337	2.207	1.449	1.591	3.311	2.802
Nonrenewable	3.202	3.035	2.771	3.100	1.662	3.162	3.214	3.266	3.170	2.389	3.048	3.337	3.280	2.878	3.218	3.311	2.802
Total	3.277	3.128	3.029	3.248	2.693	3.285	3.348	3.288	3.273	2.776	3.172	3.402	3.317	3.187	3.333	3.333	3.079
With Precombustion																	
Total Fossil Fuel	2.952	3.351	2.658	2.556	2.335	1.817	2.433	2.521	3.166	2.568	2.565	2.074	3.640	2.360	1.565	1.706	3.531
Total Nonrenewable	3.705	3.367	3.259	2.993	3.294	1.829	3.314	3.396	3.492	3.374	2.586	3.153	3.678	3.458	3.012	3.349	3.556
Total	3.714	3.442	3.352	3.250	3.442	2.860	3.437	3.530	3.513	3.476	2.973	3.276	3.743	3.495	3.320	3.464	3.577

	NY	OH	OK	OR	PA	RI	SC	SD	TN	TX	UT	VA	VT	WA	WI	WV	WY
Without Precombustion																	
Fossil Fuel	1.723	2.871	3.023	0.839	2.002	2.414	1.420	1.772	1.933	2.957	3.197	1.993	0.018	0.580	2.631	3.165	3.348
Nonrenewable	2.710	3.232	3.023	0.839	3.211	2.414	3.173	1.772	2.916	3.325	3.197	3.196	2.383	0.871	3.290	3.165	3.348
Total	3.011	3.245	3.095	1.597	3.292	2.495	3.258	2.320	3.056	3.357	3.251	3.439	3.031	1.692	3.407	3.183	3.377
With Precombustion																	
Fossil Fuel	1.879	3.012	3.234	0.908	2.110	2.625	1.486	1.898	2.026	3.210	3.354	2.111	0.021	0.624	2.800	3.310	3.574
Nonrenewable	2.885	3.390	3.254	0.913	3.336	2.635	3.255	1.913	3.025	3.600	3.370	3.333	2.400	0.922	3.483	3.324	3.602
Total	3.185	3.403	3.326	1.671	3.417	2.716	3.340	2.461	3.165	3.632	3.424	3.576	3.048	1.742	3.600	3.343	3.632

Table B-10 Total Emission Factors for Delivered Electricity by State (lb of pollutant per kWh of electricity)

Pollutant (lb)	AK	AL	AR	AZ	CA	CO	CT	DC	DE	FL	GA	HI	IA
CO_{2e}	1.71E+00	1.58E+00	1.57E+00	1.67E+00	7.75E-01	2.23E+00	7.29E-01	4.26E+00	2.43E+00	1.49E+00	1.62E+00	1.91E+00	2.41E+00
CO_2	1.55E+00	1.50E+00	1.48E+00	1.56E+00	6.88E-01	2.10E+00	6.76E-01	4.11E+00	2.28E+00	1.40E+00	1.54E+00	1.83E+00	2.28E+00
CH_4	6.28E-03	3.23E-03	3.47E-03	4.02E-03	3.60E-03	4.96E-03	2.14E-03	6.27E-03	5.94E-03	3.74E-03	2.95E-03	2.96E-03	4.90E-03
N_2O	3.05E-05	3.55E-05	4.16E-05	3.69E-05	1.39E-05	5.36E-05	1.48E-05	2.89E-05	4.56E-05	2.63E-05	3.75E-05	2.00E-05	6.51E-05
NO_X	1.95E-03	2.78E-03	2.65E-03	2.64E-03	5.88E-04	3.68E-03	1.10E-03	9.94E-03	3.92E-03	2.46E-03	2.98E-03	4.32E-03	4.14E-03
SO_X	1.12E-02	8.24E-03	5.13E-03	8.86E-03	6.42E-03	9.64E-03	4.23E-03	2.15E-02	1.53E-02	9.44E-03	7.73E-03	9.04E-03	6.75E-03
CO	2.05E-03	5.33E-04	6.44E-04	6.16E-04	5.36E-04	7.78E-04	7.89E-04	1.96E-02	1.85E-03	1.80E-03	5.20E-04	7.43E-03	8.19E-04
TNMOC	8.40E-05	8.18E-05	9.48E-05	5.34E-05	8.89E-05	6.72E-05	8.71E-05	1.28E-04	7.93E-05	8.88E-05	7.60E-05	1.15E-04	7.09E-05
Lead	6.30E-08	1.22E-07	1.48E-07	1.19E-07	6.95E-09	1.87E-07	4.00E-08	2.71E-07	1.42E-07	8.22E-08	1.37E-07	1.32E-07	2.46E-07
Mercury	3.80E-08	2.50E-08	3.15E-08	2.41E-08	2.86E-09	3.75E-08	1.81E-08	4.44E-07	4.91E-08	4.29E-08	2.82E-08	1.72E-07	4.93E-08
PM10	1.09E-04	7.82E-05	9.07E-05	8.36E-05	4.71E-05	1.16E-04	4.78E-05	4.25E-04	1.27E-04	8.91E-05	7.98E-05	1.79E-04	1.34E-04
Solid Waste	7.89E-02	1.88E-01	2.27E-01	1.84E-01	1.25E-02	2.88E-01	5.39E-02	7.07E-02	2.03E-01	1.05E-01	2.11E-01	7.44E-02	3.78E-01

Pollutant (lb)	ID	IL	IN	KS	KY	LA	MA	MD	ME	MI	MN	MO	MS
CO_{2e}	2.43E-01	1.41E+00	2.87E+00	2.23E+00	2.45E+00	1.59E+00	1.39E+00	1.82E+00	2.26E+00	1.65E+00	1.84E+00	2.37E+00	1.66E+00
CO_2	2.18E-01	1.33E+00	2.71E+00	2.11E+00	2.34E+00	1.47E+00	1.30E+00	1.71E+00	2.12E+00	1.56E+00	1.74E+00	2.24E+00	1.57E+00
CH_4	1.03E-03	2.77E-03	5.93E-03	4.56E-03	3.88E-03	5.02E-03	3.94E-03	4.02E-03	5.43E-03	3.57E-03	3.82E-03	4.85E-03	3.72E-03
N_2O	5.43E-06	3.63E-05	6.37E-05	5.96E-05	5.21E-05	3.42E-05	2.38E-05	3.54E-05	4.73E-05	4.07E-05	5.01E-05	6.39E-05	3.26E-05
NO_X	2.81E-04	2.46E-03	4.94E-03	3.83E-03	4.71E-03	2.00E-03	2.16E-03	3.10E-03	3.91E-03	2.80E-03	3.16E-03	4.05E-03	2.63E-03
SO_X	1.92E-03	4.76E-03	1.49E-02	6.24E-03	1.34E-02	9.05E-03	9.18E-03	1.11E-02	1.42E-02	6.74E-03	5.20E-03	6.70E-03	9.86E-03
CO	1.53E-04	4.85E-04	9.42E-04	9.19E-04	7.25E-04	9.84E-04	1.91E-03	1.19E-03	1.46E-03	6.38E-04	6.67E-04	7.98E-04	1.18E-03
TNMOC	8.67E-05	4.33E-05	8.08E-05	6.26E-05	5.95E-05	1.05E-04	1.14E-04	7.74E-05	3.51E-04	8.03E-05	8.27E-05	6.69E-05	9.95E-05
Lead	4.30E-09	1.36E-07	2.21E-07	2.26E-07	1.98E-07	9.63E-08	6.56E-08	1.16E-07	1.33E-07	1.43E-07	1.86E-07	2.40E-07	1.22E-07
Mercury	1.09E-09	2.79E-08	4.48E-08	4.88E-08	4.13E-08	2.40E-08	4.15E-08	3.56E-08	3.98E-08	3.02E-08	3.80E-08	4.81E-08	3.53E-08
PM10	1.80E-05	7.54E-05	1.38E-04	1.26E-04	1.08E-04	1.01E-04	8.89E-05	9.25E-05	1.31E-04	8.91E-05	1.05E-04	1.31E-04	1.07E-04
Solid Waste	7.33E-03	2.09E-01	3.42E-01	3.45E-01	3.03E-01	1.31E-01	7.80E-02	1.69E-01	1.95E-01	2.20E-01	2.86E-01	3.70E-01	1.46E-01

Table B-10 (page 2) Total Emission Factors for Delivered Electricity by State (lb of pollutant per kWh of electricity)

Pollutant (lb)	MT	NC	ND	NE	NH	NJ	NM	NV	NY	OH	OK	OR	PA
CO_{2e}	1.99E+00	1.47E+00	2.68E+00	1.81E+00	8.60E-01	9.31E-01	2.43E+00	1.88E+00	1.03E+00	2.20E+00	2.08E+00	4.85E-01	1.55E+00
CO_2	1.87E+00	1.41E+00	2.61E+00	1.71E+00	8.05E-01	8.61E-01	2.29E+00	1.76E+00	9.61E-01	2.10E+00	1.93E+00	4.40E-01	1.48E+00
CH_4	4.17E-03	2.37E-03	2.41E-03	3.70E-03	2.19E-03	2.79E-03	5.38E-03	4.81E-03	2.59E-03	3.71E-03	5.67E-03	1.83E-03	2.70E-03
N_2O	5.29E-05	3.11E-05	5.92E-05	4.94E-05	1.53E-05	1.76E-05	6.50E-05	3.75E-05	1.68E-05	4.73E-05	5.09E-05	1.04E-05	3.22E-05
NO_X	3.33E-03	2.83E-03	3.71E-03	3.09E-03	1.44E-03	1.32E-03	4.00E-03	2.89E-03	1.72E-03	4.14E-03	3.02E-03	5.21E-04	2.91E-03
SO_X	5.88E-03	8.26E-03	1.00E-02	4.79E-03	5.47E-03	6.34E-03	7.30E-03	1.21E-02	6.23E-03	1.19E-02	8.88E-03	3.03E-03	8.88E-03
CO	7.40E-04	4.31E-04	1.07E-03	6.09E-04	1.13E-03	6.69E-04	8.66E-04	7.39E-04	1.75E-03	6.38E-04	8.67E-04	2.72E-04	6.01E-04
TNMOC	6.02E-05	5.25E-05	5.34E-05	5.23E-05	8.62E-05	6.92E-05	7.27E-05	6.23E-05	6.38E-05	5.41E-05	8.01E-05	3.90E-05	5.46E-05
Lead	1.99E-07	1.16E-07	4.23E-07	1.87E-07	4.57E-08	4.27E-08	2.37E-07	1.09E-07	5.59E-08	1.76E-07	1.61E-07	2.05E-08	1.17E-07
Mercury	4.08E-08	2.40E-08	7.52E-08	3.73E-08	2.60E-08	1.44E-08	4.75E-08	2.27E-08	3.99E-08	3.59E-08	3.27E-08	4.59E-09	2.70E-08
PM10	1.14E-04	6.55E-05	3.03E-04	1.01E-04	5.47E-05	5.14E-05	1.36E-04	8.97E-05	6.87E-05	9.87E-05	1.16E-04	2.87E-05	7.14E-05
Solid Waste	3.01E-01	1.78E-01	3.33E-01	2.88E-01	5.65E-02	6.23E-02	3.65E-01	1.68E-01	6.18E-02	2.71E-01	2.49E-01	3.25E-02	1.78E-01

Pollutant (lb)	RI	SC	SD	TN	TX	UT	VA	VT	WA	WI	WV	WY	
CO_{2e}	1.18E+00	1.00E+00	1.45E+00	1.46E+00	1.99E+00	2.62E+00	1.40E+00	1.88E-02	4.11E-01	2.03E+00	2.41E+00	2.67E+00	
CO_2	1.04E+00	9.57E-01	1.36E+00	1.40E+00	1.85E+00	2.51E+00	1.33E+00	1.78E-02	3.82E-01	1.92E+00	2.31E+00	2.52E+00	
CH_4	5.65E-03	1.72E-03	3.02E-03	2.43E-03	5.80E-03	4.21E-03	2.52E-03	2.25E-05	1.13E-03	4.13E-03	3.85E-03	5.42E-03	
N_2O	2.04E-05	2.12E-05	3.91E-05	3.28E-05	4.37E-05	5.53E-05	2.81E-05	1.70E-06	1.05E-05	5.32E-05	5.08E-05	7.30E-05	
NO_X	7.91E-04	1.90E-03	2.45E-03	2.77E-03	2.42E-03	5.00E-03	2.67E-03	1.38E-04	6.13E-04	3.51E-03	4.62E-03	4.58E-03	
SO_X	9.90E-03	5.73E-03	3.97E-03	7.32E-03	1.05E-02	1.47E-02	8.04E-03	1.13E-04	1.70E-03	6.60E-03	1.35E-02	7.05E-03	
CO	8.52E-04	3.22E-04	5.26E-04	4.14E-04	9.77E-04	6.89E-04	9.74E-04	5.90E-05	1.80E-04	7.13E-04	6.50E-04	9.00E-04	
TNMOC	9.92E-05	4.89E-05	4.12E-05	4.17E-05	8.22E-05	5.78E-05	8.77E-05	1.02E-04	3.74E-05	8.26E-05	5.26E-05	7.43E-05	
Lead	6.87E-09	7.66E-08	1.47E-07	1.24E-07	1.49E-07	2.08E-07	1.02E-07	6.33E-10	3.21E-08	1.97E-07	1.92E-07	2.77E-07	
Mercury	4.09E-09	1.62E-08	3.01E-08	2.50E-08	2.96E-08	4.15E-08	3.24E-08	1.03E-09	6.62E-09	4.01E-08	3.87E-08	5.54E-08	
PM10	7.02E-05	4.61E-05	8.12E-05	6.75E-05	1.37E-04	1.14E-04	7.25E-05	7.67E-06	2.46E-05	1.11E-04	1.05E-04	1.49E-04	
Solid Waste	1.31E-02	1.17E-01	2.26E-01	1.91E-01	1.82E-01	3.20E-01	1.47E-01	2.83E-04	4.96E-02	3.03E-01	2.95E-01	4.26E-01	

Table B-11 Total Emission Factors for Delivered Electricity by State (kg of pollutant per kWh of electricity)

Pollutant (kg)	AK	AL	AR	AZ	CA	CO	CT	DC	DE	FL	GA	HI	IA
CO_{2e}	7.74E-01	7.17E-01	7.13E-01	7.57E-01	3.51E-01	1.01E+00	3.31E-01	1.93E+00	1.10E+00	6.78E-01	7.35E-01	8.65E-01	1.09E+00
CO_2	7.05E-01	6.79E-01	6.71E-01	7.10E-01	3.12E-01	9.52E-01	3.06E-01	1.86E+00	1.03E+00	6.35E-01	6.99E-01	8.32E-01	1.03E+00
CH_4	2.85E-03	1.46E-03	1.57E-03	1.82E-03	1.63E-03	2.25E-03	9.72E-04	2.84E-03	2.69E-03	1.70E-03	1.34E-03	1.34E-03	2.22E-03
N_2O	1.38E-05	1.61E-05	1.88E-05	1.68E-05	6.32E-06	2.43E-05	6.73E-06	1.31E-05	2.07E-05	1.19E-05	1.70E-05	9.06E-06	2.95E-05
NO_X	8.83E-04	1.26E-03	1.20E-03	1.20E-03	2.67E-04	1.67E-03	4.97E-04	4.51E-03	1.78E-03	1.12E-03	1.35E-03	1.96E-03	1.88E-03
SO_X	5.09E-03	3.74E-03	2.33E-03	4.02E-03	2.91E-03	4.37E-03	1.92E-03	9.74E-03	6.95E-03	4.28E-03	3.51E-03	4.10E-03	3.06E-03
CO	9.31E-04	2.42E-04	2.92E-04	2.79E-04	2.43E-04	3.53E-04	3.58E-04	8.91E-03	8.38E-04	8.19E-04	2.36E-04	3.37E-03	3.71E-04
TNMOC	3.81E-05	3.71E-05	4.30E-05	2.42E-05	4.03E-05	3.05E-05	3.95E-05	5.81E-05	3.60E-05	4.03E-05	3.45E-05	5.20E-05	3.21E-05
Lead	2.86E-08	5.53E-08	6.73E-08	5.38E-08	3.15E-09	8.46E-08	1.82E-08	1.23E-07	6.44E-08	3.73E-08	6.22E-08	5.99E-08	1.11E-07
Mercury	1.72E-08	1.13E-08	1.43E-08	1.09E-08	1.30E-09	1.70E-08	8.19E-09	2.01E-07	2.23E-08	1.95E-08	1.28E-08	7.79E-08	2.24E-08
PM10	4.94E-05	3.55E-05	4.11E-05	3.79E-05	2.14E-05	5.24E-05	2.17E-05	1.93E-04	5.75E-05	4.04E-05	3.62E-05	8.12E-05	6.07E-05
Solid Waste	3.58E-02	8.53E-02	1.03E-01	8.34E-02	5.67E-03	1.31E-01	2.45E-02	3.21E-02	9.21E-02	4.75E-02	9.55E-02	3.37E-02	1.71E-01

Pollutant (kg)	ID	IL	IN	KS	KY	LA	MA	MD	ME	MI	MN	MO	MS
CO_{2e}	1.10E-01	6.38E-01	1.30E+00	1.01E+00	1.11E+00	7.23E-01	6.32E-01	8.24E-01	1.02E+00	7.49E-01	8.36E-01	1.07E+00	7.54E-01
CO_2	9.89E-02	6.04E-01	1.23E+00	9.55E-01	1.06E+00	6.66E-01	5.88E-01	7.77E-01	9.60E-01	7.06E-01	7.89E-01	1.02E+00	7.11E-01
CH_4	4.67E-04	1.26E-03	2.69E-03	2.07E-03	1.76E-03	2.28E-03	1.79E-03	1.82E-03	2.46E-03	1.62E-03	1.73E-03	2.20E-03	1.69E-03
N_2O	2.46E-06	1.65E-05	2.89E-05	2.71E-05	2.36E-05	1.55E-05	1.08E-05	1.60E-05	2.14E-05	1.85E-05	2.27E-05	2.90E-05	1.48E-05
NO_X	1.27E-04	1.12E-03	2.24E-03	1.74E-03	2.14E-03	9.06E-04	9.79E-04	1.41E-03	1.77E-03	1.27E-03	1.44E-03	1.84E-03	1.19E-03
SO_X	8.69E-04	2.16E-03	6.74E-03	2.83E-03	6.08E-03	4.10E-03	4.17E-03	5.04E-03	6.46E-03	3.06E-03	2.36E-03	3.04E-03	4.47E-03
CO	6.95E-05	2.20E-04	4.27E-04	4.17E-04	3.29E-04	4.46E-04	8.67E-04	5.40E-04	6.61E-04	2.89E-04	3.02E-04	3.62E-04	5.35E-04
TNMOC	3.93E-05	1.96E-05	3.67E-05	2.84E-05	2.70E-05	4.75E-05	5.16E-05	3.51E-05	1.59E-04	3.64E-05	3.75E-05	3.03E-05	4.51E-05
Lead	1.95E-09	6.18E-08	1.00E-07	1.03E-07	8.97E-08	4.37E-08	2.97E-08	5.27E-08	6.01E-08	6.50E-08	8.44E-08	1.09E-07	5.54E-08
Mercury	4.93E-10	1.27E-08	2.03E-08	2.21E-08	1.87E-08	1.09E-08	1.88E-08	1.61E-08	1.81E-08	1.37E-08	1.72E-08	2.18E-08	1.60E-08
PM10	8.18E-06	3.42E-05	6.26E-05	5.70E-05	4.91E-05	4.57E-05	4.03E-05	4.19E-05	5.94E-05	4.04E-05	4.76E-05	5.95E-05	4.85E-05
Solid Waste	3.33E-03	9.49E-02	1.55E-01	1.56E-01	1.37E-01	5.92E-02	3.54E-02	7.68E-02	8.84E-02	9.98E-02	1.30E-01	1.68E-01	6.64E-02

Table B-11 (page 2) Total Emission Factors for Delivered Electricity by State (kg of pollutant per kWh of electricity)

Pollutant (kg)	MT	NC	ND	NE	NH	NJ	NM	NV	NY	OH	OK	OR	PA
CO_{2e}	9.01E-01	6.67E-01	1.22E+00	8.20E-01	3.90E-01	4.22E-01	1.10E+00	8.54E-01	4.65E-01	9.98E-01	9.43E-01	2.20E-01	7.04E-01
CO_2	8.50E-01	6.38E-01	1.18E+00	7.75E-01	3.65E-01	3.91E-01	1.04E+00	7.99E-01	4.36E-01	9.53E-01	8.77E-01	2.00E-01	6.71E-01
CH_4	1.89E-03	1.08E-03	1.09E-03	1.68E-03	9.96E-04	1.27E-03	2.44E-03	2.18E-03	1.18E-03	1.68E-03	2.57E-03	8.30E-04	1.23E-03
N_2O	2.40E-05	1.41E-05	2.69E-05	2.24E-05	6.94E-06	8.00E-06	2.95E-05	1.70E-05	7.62E-06	2.15E-05	2.31E-05	4.71E-06	1.46E-05
NO_X	1.51E-03	1.28E-03	1.68E-03	1.40E-03	6.53E-04	5.97E-04	1.81E-03	1.31E-03	7.81E-04	1.88E-03	1.37E-03	2.36E-04	1.32E-03
SO_X	2.67E-03	3.75E-03	4.54E-03	2.17E-03	2.48E-03	2.88E-03	3.31E-03	5.50E-03	2.82E-03	5.41E-03	4.03E-03	1.38E-03	4.03E-03
CO	3.36E-04	1.95E-04	4.84E-04	2.76E-04	5.11E-04	3.04E-04	3.93E-04	3.35E-04	7.93E-04	2.89E-04	3.93E-04	1.23E-04	2.73E-04
TNMOC	2.73E-05	2.38E-05	2.42E-05	2.37E-05	3.91E-05	3.14E-05	3.30E-05	2.83E-05	2.89E-05	2.46E-05	3.63E-05	1.77E-05	2.47E-05
Lead	9.03E-08	5.26E-08	1.92E-07	8.47E-08	2.07E-08	1.94E-08	1.07E-07	4.92E-08	2.53E-08	7.99E-08	7.29E-08	9.31E-09	5.32E-08
Mercury	1.85E-08	1.09E-08	3.41E-08	1.69E-08	1.18E-08	6.53E-09	2.15E-08	1.03E-08	1.81E-08	1.63E-08	1.49E-08	2.08E-09	1.22E-08
PM10	5.15E-05	2.97E-05	1.38E-04	4.59E-05	2.48E-05	2.33E-05	6.18E-05	4.07E-05	3.11E-05	4.48E-05	5.27E-05	1.30E-05	3.24E-05
Solid Waste	1.37E-01	8.06E-02	1.51E-01	1.30E-01	2.56E-02	2.83E-02	1.66E-01	7.64E-02	2.80E-02	1.23E-01	1.13E-01	1.47E-02	8.07E-02

Pollutant (kg)	RI	SC	SD	TN	TX	UT	VA	VT	WA	WI	WV	WY	
CO_{2e}	5.34E-01	4.55E-01	6.56E-01	6.64E-01	9.04E-01	1.19E+00	6.35E-01	8.53E-03	1.87E-01	9.19E-01	1.09E+00	1.21E+00	
CO_2	4.72E-01	4.34E-01	6.19E-01	6.34E-01	8.37E-01	1.14E+00	6.05E-01	8.07E-03	1.73E-01	8.69E-01	1.05E+00	1.14E+00	
CH_4	2.56E-03	7.81E-04	1.37E-03	1.10E-03	2.63E-03	1.91E-03	1.14E-03	1.02E-05	5.12E-04	1.87E-03	1.74E-03	2.46E-03	
N_2O	9.23E-06	9.64E-06	1.78E-05	1.49E-05	1.98E-05	2.51E-05	1.27E-05	7.70E-07	4.75E-06	2.41E-05	2.31E-05	3.31E-05	
NO_X	3.59E-04	8.62E-04	1.11E-03	1.25E-03	1.10E-03	2.27E-03	1.21E-03	6.27E-05	2.78E-04	1.59E-03	2.10E-03	2.08E-03	
SO_X	4.49E-03	2.60E-03	1.80E-03	3.32E-03	4.77E-03	6.67E-03	3.65E-03	5.14E-05	7.73E-04	2.99E-03	6.13E-03	3.20E-03	
CO	3.86E-04	1.46E-04	2.39E-04	1.88E-04	4.43E-04	3.13E-04	4.42E-04	2.68E-05	8.16E-05	3.23E-04	2.95E-04	4.08E-04	
TNMOC	4.50E-05	2.22E-05	1.87E-05	1.89E-05	3.73E-05	2.62E-05	3.98E-05	4.62E-05	1.70E-05	3.74E-05	2.39E-05	3.37E-05	
Lead	3.12E-09	3.48E-08	6.67E-08	5.62E-08	6.76E-08	9.42E-08	4.63E-08	2.87E-10	1.45E-08	8.93E-08	8.70E-08	1.25E-07	
Mercury	1.85E-09	7.36E-09	1.36E-08	1.14E-08	1.34E-08	1.88E-08	1.47E-08	4.66E-10	3.00E-09	1.82E-08	1.76E-08	2.51E-08	
PM10	3.18E-05	2.09E-05	3.69E-05	3.06E-05	6.19E-05	5.15E-05	3.29E-05	3.48E-06	1.12E-05	5.05E-05	4.75E-05	6.77E-05	
Solid Waste	5.92E-03	5.32E-02	1.02E-01	8.64E-02	8.25E-02	1.45E-01	6.67E-02	1.28E-04	2.25E-02	1.37E-01	1.34E-01	1.93E-01	

Table B-12 Ozone Season NO_X Emissions by State for 2004
(mass of NO_X per kWh of delivered electricity without precombustion emissions)

	AK	AL	AR	AZ	CA	CO	CT	DC	DE	FL	GA	HI	IA	ID	IL	IN	KS
lb/kWh	4.69E-3	2.54E-3	2.73E-3	2.66E-3	4.35E-4	3.19E-3	1.41E-3	5.59E-3	3.05E-3	2.90E-3	1.69E-3	4.86E-3	4.61E-3	1.15E-4	2.03E-3	2.85E-3	8.63E-3
kg/kWh	2.13E-3	1.15E-3	1.24E-3	1.21E-3	1.97E-4	1.45E-3	6.38E-4	2.54E-3	1.39E-3	1.31E-3	7.66E-4	2.21E-3	2.09E-3	5.22E-5	9.22E-4	1.29E-3	3.92E-3

	KY	LA	MA	MD	ME	MI	MN	MO	MS	MT	NC	ND	NE	NH	NJ	NM	NV
lb/kWh	2.24E-3	2.38E-3	1.44E-3	2.76E-3	9.82E-4	2.82E-3	5.09E-3	2.75E-3	4.27E-3	5.59E-3	2.28E-3	5.60E-3	4.69E-3	1.74E-3	1.84E-3	4.91E-3	2.67E-3
kg/kWh	1.01E-3	1.08E-3	6.55E-4	1.25E-3	4.45E-4	1.28E-3	2.31E-3	1.25E-3	1.94E-3	2.54E-3	1.03E-3	2.54E-3	2.13E-3	7.89E-4	8.35E-4	2.23E-3	1.21E-3

	NY	OH	OK	OR	PA	RI	SC	SD	TN	TX	UT	VA	VT	WA	WI	WV	WY
lb/kWh	2.62E-3	2.91E-3	4.93E-4	2.07E-3	3.27E-4	2.52E-3	4.18E-3	2.07E-3	1.43E-3	4.14E-3	2.69E-3	6.83E-4	4.76E-4	3.69E-3	2.31E-3	4.63E-3	2.62E-3
kg/kWh	1.19E-3	1.32E-3	2.24E-4	9.38E-4	1.48E-4	1.14E-3	1.90E-3	9.37E-4	6.48E-4	1.88E-3	1.22E-3	3.10E-4	2.16E-4	1.67E-3	1.05E-3	2.10E-3	1.19E-3

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This document supports the other measurement procedures and all building energy-monitoring projects by providing methods to calculate the source energy and emissions from the energy measured at the building. Energy and emission factors typically account for the conversion inefficiencies at the power plant and the transmission and distribution losses from the power plant to the building. The energy and emission factors provided here also include the precombustion effects, which are the energy and emissions associated with extracting, processing, and delivering the primary fuels to the point of conversion in the electrical power plants or directly in the buildings.

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