AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Emission Factors from AVERT

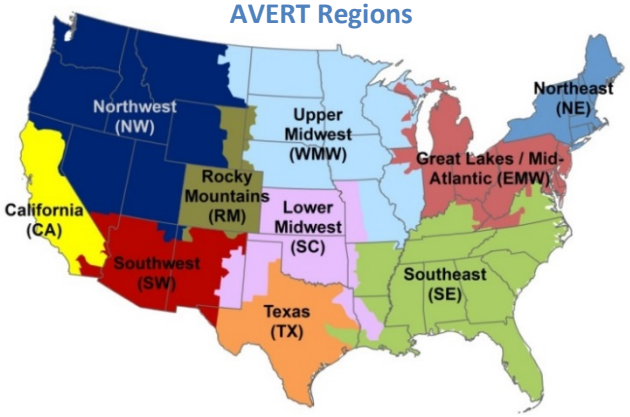
Estimating the emission benefits of energy efficiency (EE) and renewable energy (RE) policies and programs

What is AVERT?

The AVoided Emissions and geneRation Tool (AVERT) is a free EPA tool with a simple user interface. Environmental agency staff, air quality planners, energy officials, public utility commission staff, and others can use AVERT to evaluate the fine particulate matter ($PM_{2.5}$), carbon dioxide (CO_2), nitrogen oxides (NO_X), and sulfur dioxide (SO_2) emissions avoided at electric power plants by EE/RE policies and programs. AVERT calculates displaced emissions based on actual historical hourly patterns in generation by electric power plants within the contiguous 48 states and DC.

Emission Factors

AVERT uses a peer-reviewed methodology to analyze electric power sector impacts on an hour-by-hour basis, but it can also produce average emission factors for each AVERT region and for the nation. The tables in this file provide marginal emission factors for specific EE/RE resources, which EPA pre-generated by running AVERT with data for each year from 2007 to 2017.



When to Use AVERT Emission Factors

The emission factors presented here are intended for quick estimates of avoided emissions from EE/RE programs, policies, or projects. For more detailed planning, download and use AVERT to generate a custom analysis that accounts for seasonal and time-of-day variations or to analyze different EE/RE combinations.

The emission factors in this compendium were calculated by assuming a 0.5% displacement of the existing demand in each AVERT region. They are divided into four categories: wind, utility photovoltaic (PV), portfolio EE, and uniform EE. Use the portfolio EE factors if you are assessing a wide range of EE programs. Use the uniform EE factors if energy savings are consistent throughout the year. If you have a RE project, use the appropriate renewable energy technology type: utility PV or wind. Emission factors should not be used to examine the emission impacts of changes that extend more than 5 years into the future. All avoided emission rates in this document were produced on a net generation basis.

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Using Capacity Factors for Wind and PV Power Generation

Estimating avoided emissions of wind and solar projects involves multiplying the appropriate emission factor from this document (in pounds per megawatt-hour [MWh]) by the size of the RE resource and the RE technology's capacity factor. It is not appropriate to simply multiply the emission factor by the size of the RE installation because a wind turbine or PV panel rarely (if ever) achieves its maximum possible output under actual operating conditions. This is a consequence of natural hourly, daily, and seasonal fluctuations in wind speed, cloud cover, the sun's angle of incidence, and hours of sunlight per day. These factors all vary regionally; for example, the Southwest has more sunny days per year than the Northeast.

To estimate avoided emissions from wind or PV, multiply the RE capacity by an additional *capacity factor* that reflects actual operating conditions. If actual capacity factors are unavailable, the table at right provides an average capacity factor for wind and PV resources for each AVERT region as well as the contiguous 48 states, for national-scale analysis. These factors reflect annual averages based on the hourly RE profiles embedded in AVERT. Appendix C of the AVERT User Manual describes how these hourly profiles were developed.

Annual Average Capacity Factors		
	Wind	*Utility PV*
Northeast	19.93%	17.93%
Great Lakes / Mid-Atlantic	26.00%	17.69%
Southeast	13.75%	19.35%
Lower Midwest	40.14%	21.51%
Upper Midwest	41.22%	19.26%
Rocky Mountains	35.04%	22.48%
Texas	33.86%	20.85%
Southwest	24.45%	25.80%
Northwest	25.24%	19.90%
California	17.32%	22.18%
Contiguous 48 states	27.70%	20.70%

Example

For illustration, consider the avoided $PM_{2.5}$ emissions from a project to add 100 MW of wind capacity in the Texas region:

Annual generation = capacity factor for RE technology (0.3386) × installed capacity (100 MW) x hours in a year (8,760 h, except leap years) = ***296,614 MWh***

Avoided $PM_{2.5}$ emissions = avoided electricity generation (296,614 MWh) × emission factor (0.08 lb/MW h) = ***23,729 lb***

Unit Conversions

1 MW = 1,000 kW = 0.001 GW.

To convert units from power (**kW, MW, GW**) to energy (**kWh, MWh, GWh**), multiply by the total number of hours in the year.

To convert in the other direction, divide by the total number of hours in the year. There are 8,760 hours in a non-leap year and 8,784 hours in a leap year.

For More Information

- Visit the AVERT website at www.epa.gov/avert.
- Contact EPA's AVERT manager at avert@epa.gov.

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Emissions Accounting and Claims

Although the avoided emission estimates provided by AVERT are intended to support RE initiatives, AVERT is a marginal emissions assessment tool and not a tool for emissions accounting. EPA cautions RE users and retailers from using AVERT's avoided emissions estimates to take or give credit for emission reductions, particularly in corporate greenhouse gas (GHG) accounting and reporting. While RE users that own renewable energy certificates (RECs) or similar market-based energy attribute certificates have unique ownership and claim to the emissions attributes of the associated electricity generation, they generally do not have a unique claim to the impacts on regional grid operations and emissions.

Corporate GHG accounting typically includes an inventory of emissions associated with purchased electricity, but not an assessment of the impact of an organization's purchased electricity on regional grid emissions. Organizations interested in quantifying RE's impact on regional grid emissions should consider project accounting. This type of emissions accounting is designed to quantify the benefits of emission mitigation projects.

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Data Year: 2017

National Emission Factors

National Weighted Averages (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Avoided CO_2 Rate	1,485	1,486	1,559	1,564
Avoided NO_x Rate	0.88	0.93	0.96	0.94
Avoided SO_2 Rate	1.00	0.96	1.03	1.05
Avoided $PM_{2.5}$ Rate	0.11	0.11	0.11	0.11

- **Wind** = Wind power generation
- **Utility PV** = Utility-scale photovoltaic power generation
- **Portfolio EE** = Represents a wide range of EE program types
- **Uniform EE** = Represents consistent energy savings throughout the year

National factors presented here reflect a weighted average of the avoided emission rates of AVERT's 10 regions. Averages are weighted by the fraction of 2017 fossil generation in each region.

Regional Emission Factors

Avoided CO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1,058	1,075	1,139	1,116
Great Lakes / Mid-Atlantic	1,592	1,592	1,674	1,670
Southeast	1,404	1,465	1,521	1,501
Lower Midwest	1,749	1,669	1,773	1,818
Upper Midwest	1,884	1,800	1,926	1,967
Rocky Mountains	1,618	1,568	1,648	1,682
Texas	1,331	1,265	1,355	1,389
Southwest	1,260	1,269	1,312	1,317
Northwest	1,558	1,592	1,606	1,640
California	1,034	1,052	1,096	1,088

Avoided NO_x Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.37	0.46	0.50	0.42
Great Lakes / Mid-Atlantic	0.93	0.93	0.98	0.96
Southeast	0.82	0.95	0.95	0.91
Lower Midwest	1.10	1.16	1.22	1.18
Upper Midwest	1.31	1.24	1.33	1.36
Rocky Mountains	1.34	1.27	1.34	1.38
Texas	0.60	0.65	0.69	0.65
Southwest	0.89	0.93	0.97	0.95
Northwest	1.18	1.22	1.22	1.25
California	0.32	0.32	0.32	0.33

Avoided SO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.27	0.30	0.33	0.28
Great Lakes / Mid-Atlantic	1.06	1.18	1.24	1.22
Southeast	0.73	0.75	0.78	0.77
Lower Midwest	1.80	1.62	1.74	1.84
Upper Midwest	1.94	1.69	1.87	1.99
Rocky Mountains	0.58	0.52	0.55	0.58
Texas	1.31	1.05	1.17	1.31
Southwest	0.27	0.21	0.20	0.24
Northwest	0.83	0.86	0.89	0.89
California	0.07	0.07	0.07	0.08

Avoided $PM_{2.5}$ Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.04	0.05	0.05	0.04
Great Lakes / Mid-Atlantic	0.20	0.20	0.21	0.21
Southeast	0.09	0.10	0.10	0.10
Lower Midwest	0.09	0.09	0.10	0.10
Upper Midwest	0.09	0.09	0.09	0.10
Rocky Mountains	0.03	0.04	0.04	0.03
Texas	0.07	0.07	0.07	0.08
Southwest	0.07	0.07	0.07	0.07
Northwest	0.08	0.08	0.08	0.08
California	0.04	0.05	0.05	0.05

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Data Year: 2016

National Emission Factors

National Weighted Averages (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Avoided CO_2 Rate	1,564	1,572	1,639	1,642
Avoided NO_x Rate	1.07	1.13	1.16	1.13
Avoided SO_2 Rate	1.51	1.46	1.53	1.56
Avoided $PM_{2.5}$ Rate	0.11	0.11	0.12	0.12

- **Wind** = Wind power generation
- **Utility PV** = Utility-scale photovoltaic power generation
- **Portfolio EE** = Represents a wide range of EE program types
- **Uniform EE** = Represents consistent energy savings throughout the year

National factors presented here reflect a weighted average of the avoided emission rates of AVERT's 10 regions. Averages are weighted by the fraction of 2016 fossil generation in each region.

Regional Emission Factors

Avoided CO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1,079	1,139	1,190	1,150
Great Lakes / Mid-Atlantic	1,719	1,715	1,797	1,799
Southeast	1,477	1,541	1,586	1,569
Lower Midwest	1,681	1,675	1,750	1,759
Upper Midwest	1,913	1,847	1,955	1,994
Rocky Mountains	1,828	1,766	1,873	1,898
Texas	1,480	1,436	1,522	1,547
Southwest	1,447	1,411	1,437	1,473
Northwest	1,643	1,619	1,690	1,713
California	1,000	1,008	1,067	1,055

Avoided NO_x Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.43	0.60	0.62	0.51
Great Lakes / Mid-Atlantic	1.35	1.33	1.39	1.38
Southeast	0.94	1.08	1.08	1.03
Lower Midwest	1.18	1.33	1.35	1.28
Upper Midwest	1.50	1.46	1.53	1.57
Rocky Mountains	1.29	1.22	1.29	1.32
Texas	0.67	0.78	0.79	0.74
Southwest	1.37	1.28	1.23	1.32
Northwest	1.31	1.29	1.35	1.37
California	0.34	0.36	0.41	0.38

Avoided SO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.33	0.42	0.44	0.36
Great Lakes / Mid-Atlantic	2.10	2.04	2.14	2.19
Southeast	1.37	1.42	1.44	1.43
Lower Midwest	1.84	1.74	1.82	1.89
Upper Midwest	2.31	2.02	2.20	2.36
Rocky Mountains	0.73	0.73	0.78	0.78
Texas	1.68	1.48	1.60	1.70
Southwest	0.44	0.37	0.35	0.40
Northwest	0.93	0.88	0.94	0.95
California	0.07	0.06	0.07	0.07

Avoided $PM_{2.5}$ Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.04	0.05	0.05	0.05
Great Lakes / Mid-Atlantic	0.20	0.20	0.21	0.21
Southeast	0.10	0.11	0.11	0.11
Lower Midwest	0.10	0.10	0.10	0.10
Upper Midwest	0.10	0.09	0.10	0.10
Rocky Mountains	0.03	0.03	0.04	0.03
Texas	0.08	0.08	0.08	0.08
Southwest	0.08	0.08	0.07	0.08
Northwest	0.09	0.08	0.09	0.09
California	0.04	0.04	0.04	0.04

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Data Year: 2015

National Emission Factors

National Weighted Averages (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Avoided CO_2 Rate	1,569	1,563	1,643	1,645
Avoided NO_x Rate	1.13	1.15	1.20	1.18
Avoided SO_2 Rate	2.10	1.96	2.06	2.12
Avoided $PM_{2.5}$ Rate	0.12	0.12	0.12	0.12

- **Wind** = Wind power generation
- **Utility PV** = Utility-scale photovoltaic power generation
- **Portfolio EE** = Represents a wide range of EE program types
- **Uniform EE** = Represents consistent energy savings throughout the year

National factors presented here reflect a weighted average of the avoided emission rates of AVERT's 10 regions. Averages are weighted by the fraction of 2015 fossil generation in each region.

Regional Emission Factors

Avoided CO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1,146	1,166	1,222	1,203
Great Lakes / Mid-Atlantic	1,780	1,757	1,846	1,856
Southeast	1,511	1,516	1,589	1,586
Lower Midwest	1,765	1,724	1,825	1,847
Upper Midwest	1,877	1,824	1,938	1,961
Rocky Mountains	1,835	1,779	1,883	1,914
Texas	1,403	1,439	1,500	1,486
Southwest	1,243	1,232	1,289	1,295
Northwest	1,526	1,569	1,648	1,624
California	1,045	1,051	1,110	1,101

Avoided NO_x Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.63	0.69	0.73	0.68
Great Lakes / Mid-Atlantic	1.54	1.48	1.56	1.56
Southeast	1.01	1.04	1.07	1.06
Lower Midwest	1.27	1.38	1.41	1.36
Upper Midwest	1.49	1.40	1.49	1.54
Rocky Mountains	1.83	1.72	1.84	1.89
Texas	0.65	0.83	0.82	0.73
Southwest	0.93	0.95	0.96	0.96
Northwest	1.12	1.25	1.30	1.24
California	0.52	0.47	0.48	0.52

Avoided SO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.71	0.72	0.76	0.71
Great Lakes / Mid-Atlantic	3.89	3.61	3.81	3.91
Southeast	1.91	1.78	1.85	1.89
Lower Midwest	2.15	1.97	2.08	2.20
Upper Midwest	2.59	2.36	2.56	2.66
Rocky Mountains	0.87	0.79	0.86	0.89
Texas	1.43	1.35	1.44	1.47
Southwest	0.71	0.59	0.62	0.69
Northwest	0.62	0.72	0.76	0.70
California	0.07	0.06	0.07	0.07

Avoided $PM_{2.5}$ Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.04	0.05	0.05	0.05
Great Lakes / Mid-Atlantic	0.23	0.21	0.23	0.23
Southeast	0.11	0.11	0.11	0.11
Lower Midwest	0.10	0.10	0.10	0.10
Upper Midwest	0.09	0.09	0.10	0.10
Rocky Mountains	0.03	0.04	0.04	0.04
Texas	0.08	0.08	0.08	0.08
Southwest	0.05	0.06	0.06	0.06
Northwest	0.08	0.08	0.09	0.09
California	0.04	0.04	0.04	0.04

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Data Year: 2014

National Emission Factors

National Weighted Averages (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Avoided CO_2 Rate	1,547	1,498	1,593	1,613
Avoided NO_x Rate	1.23	1.21	1.28	1.28
Avoided SO_2 Rate	2.32	2.19	2.35	2.41
Avoided $PM_{2.5}$ Rate	0.12	0.11	0.12	0.12

- **Wind** = Wind power generation
- **Utility PV** = Utility-scale photovoltaic power generation
- **Portfolio EE** = Represents a wide range of EE program types
- **Uniform EE** = Represents consistent energy savings throughout the year

National factors presented here reflect a weighted average of the avoided emission rates of AVERT's 10 regions. Averages are weighted by the fraction of 2014 fossil generation in each region.

Regional Emission Factors

Avoided CO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1,175	1,155	1,231	1,214
Great Lakes / Mid-Atlantic	1,745	1,704	1,803	1,824
Southeast	1,489	1,419	1,524	1,543
Lower Midwest	1,726	1,654	1,766	1,801
Upper Midwest	1,891	1,814	1,939	1,977
Rocky Mountains	1,814	1,768	1,868	1,889
Texas	1,304	1,266	1,353	1,373
Southwest	1,162	1,138	1,194	1,205
Northwest	1,585	1,603	1,627	1,664
California	1,019	1,027	1,077	1,072

Avoided NO_x Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.79	0.82	0.87	0.82
Great Lakes / Mid-Atlantic	1.61	1.58	1.67	1.68
Southeast	1.10	1.11	1.16	1.15
Lower Midwest	1.52	1.53	1.59	1.59
Upper Midwest	1.63	1.55	1.67	1.70
Rocky Mountains	1.61	1.52	1.62	1.65
Texas	0.67	0.70	0.73	0.72
Southwest	0.73	0.68	0.72	0.74
Northwest	1.38	1.39	1.40	1.45
California	0.63	0.58	0.58	0.63

Avoided SO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1.05	1.01	1.06	0.98
Great Lakes / Mid-Atlantic	4.02	3.90	4.15	4.23
Southeast	2.24	2.13	2.30	2.33
Lower Midwest	2.18	2.00	2.14	2.24
Upper Midwest	2.94	2.70	2.94	3.05
Rocky Mountains	1.09	1.01	1.08	1.13
Texas	1.48	1.27	1.42	1.53
Southwest	0.30	0.24	0.25	0.29
Northwest	0.98	1.00	0.97	1.03
California	0.06	0.05	0.05	0.06

Avoided $PM_{2.5}$ Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.04	0.05	0.05	0.05
Great Lakes / Mid-Atlantic	0.22	0.20	0.22	0.22
Southeast	0.11	0.11	0.11	0.11
Lower Midwest	0.10	0.10	0.10	0.11
Upper Midwest	0.10	0.09	0.10	0.10
Rocky Mountains	0.03	0.04	0.04	0.04
Texas	0.07	0.07	0.07	0.07
Southwest	0.06	0.05	0.06	0.06
Northwest	0.08	0.08	0.08	0.09
California	0.04	0.04	0.04	0.04

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Data Year: 2013

National Emission Factors

National Weighted Averages (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Avoided CO_2 Rate	1,508	1,493	1,575	1,582
Avoided NO_x Rate	1.22	1.25	1.30	1.29
Avoided SO_2 Rate	2.26	2.20	2.34	2.38
Avoided $PM_{2.5}$ Rate	0.12	0.12	0.12	0.13

- **Wind** = Wind power generation
- **Utility PV** = Utility-scale photovoltaic power generation
- **Portfolio EE** = Represents a wide range of EE program types
- **Uniform EE** = Represents consistent energy savings throughout the year

National factors presented here reflect a weighted average of the avoided emission rates of AVERT's 10 regions. Averages are weighted by the fraction of 2013 fossil generation in each region.

Regional Emission Factors

Avoided CO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1,174	1,219	1,258	1,234
Great Lakes / Mid-Atlantic	1,678	1,664	1,753	1,760
Southeast	1,421	1,445	1,513	1,504
Lower Midwest	1,697	1,606	1,725	1,761
Upper Midwest	1,889	1,811	1,935	1,965
Rocky Mountains	1,804	1,708	1,832	1,867
Texas	1,354	1,306	1,393	1,416
Southwest	1,164	1,152	1,207	1,212
Northwest	1,447	1,444	1,498	1,519
California	1,006	1,025	1,079	1,066

Avoided NO_x Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.74	0.88	0.88	0.79
Great Lakes / Mid-Atlantic	1.46	1.50	1.55	1.54
Southeast	1.00	1.08	1.10	1.07
Lower Midwest	1.64	1.69	1.75	1.74
Upper Midwest	1.85	1.73	1.87	1.91
Rocky Mountains	1.83	1.69	1.83	1.86
Texas	0.70	0.76	0.78	0.76
Southwest	0.84	0.76	0.81	0.83
Northwest	1.67	1.74	1.79	1.76
California	0.68	0.64	0.68	0.70

Avoided SO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1.05	1.17	1.11	1.06
Great Lakes / Mid-Atlantic	3.94	3.85	4.13	4.18
Southeast	2.09	2.26	2.30	2.25
Lower Midwest	2.22	1.88	2.10	2.24
Upper Midwest	3.02	2.69	2.98	3.10
Rocky Mountains	1.33	1.15	1.30	1.36
Texas	1.58	1.25	1.42	1.58
Southwest	0.26	0.28	0.26	0.27
Northwest	0.86	0.86	0.85	0.91
California	0.08	0.07	0.07	0.08

Avoided $PM_{2.5}$ Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.05	0.05	0.06	0.05
Great Lakes / Mid-Atlantic	0.19	0.18	0.20	0.20
Southeast	0.12	0.12	0.13	0.13
Lower Midwest	0.10	0.09	0.10	0.10
Upper Midwest	0.13	0.13	0.14	0.14
Rocky Mountains	0.06	0.07	0.07	0.07
Texas	0.07	0.07	0.07	0.08
Southwest	0.07	0.07	0.07	0.07
Northwest	0.08	0.08	0.08	0.09
California	0.06	0.06	0.06	0.06

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Data Year: 2012

National Emission Factors

National Weighted Averages (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Avoided CO_2 Rate	1,565	1,559	1,640	1,645
Avoided NO_x Rate	1.29	1.33	1.39	1.37
Avoided SO_2 Rate	2.43	2.43	2.57	2.58
Avoided $PM_{2.5}$ Rate	0.13	0.13	0.14	0.14

- **Wind** = Wind power generation
- **Utility PV** = Utility-scale photovoltaic power generation
- **Portfolio EE** = Represents a wide range of EE program types
- **Uniform EE** = Represents consistent energy savings throughout the year

National factors presented here reflect a weighted average of the avoided emission rates of AVERT's 10 regions. Averages are weighted by the fraction of 2012 fossil generation in each region.

Regional Emission Factors

Avoided CO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1,099	1,179	1,232	1,188
Great Lakes / Mid-Atlantic	1,746	1,744	1,830	1,834
Southeast	1,508	1,540	1,610	1,602
Lower Midwest	1,668	1,590	1,706	1,738
Upper Midwest	1,908	1,826	1,946	1,983
Rocky Mountains	1,878	1,797	1,900	1,939
Texas	1,380	1,384	1,450	1,451
Southwest	1,298	1,203	1,281	1,314
Northwest	1,664	1,646	1,714	1,742
California	1,030	1,074	1,122	1,095

Avoided NO_x Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.50	0.74	0.75	0.62
Great Lakes / Mid-Atlantic	1.67	1.70	1.76	1.75
Southeast	1.09	1.18	1.22	1.19
Lower Midwest	1.89	1.96	2.03	2.01
Upper Midwest	1.69	1.64	1.74	1.76
Rocky Mountains	2.09	1.94	2.07	2.13
Texas	0.60	0.75	0.74	0.67
Southwest	1.36	1.02	1.13	1.25
Northwest	1.58	1.55	1.64	1.66
California	0.55	0.55	0.58	0.58

Avoided SO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.63	0.92	0.92	0.77
Great Lakes / Mid-Atlantic	4.32	4.35	4.57	4.58
Southeast	2.24	2.47	2.55	2.47
Lower Midwest	1.97	1.61	1.85	1.99
Upper Midwest	3.60	3.21	3.53	3.69
Rocky Mountains	1.46	1.28	1.40	1.48
Texas	1.32	1.20	1.26	1.33
Southwest	0.59	0.49	0.51	0.56
Northwest	1.41	1.26	1.40	1.43
California	0.10	0.09	0.10	0.10

Avoided $PM_{2.5}$ Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.04	0.05	0.05	0.05
Great Lakes / Mid-Atlantic	0.21	0.21	0.23	0.23
Southeast	0.13	0.14	0.14	0.14
Lower Midwest	0.10	0.10	0.10	0.10
Upper Midwest	0.14	0.14	0.14	0.15
Rocky Mountains	0.07	0.07	0.07	0.07
Texas	0.06	0.07	0.07	0.07
Southwest	0.09	0.07	0.08	0.09
Northwest	0.11	0.11	0.11	0.11
California	0.06	0.07	0.07	0.07

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Data Year: 2011

National Emission Factors

National Weighted Averages (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Avoided CO_2 Rate	1,619	1,586	1,673	1,692
Avoided NO_x Rate	1.46	1.46	1.51	1.52
Avoided SO_2 Rate	3.40	3.17	3.36	3.48
Avoided $PM_{2.5}$ Rate	0.15	0.14	0.15	0.15

- **Wind** = Wind power generation
- **Utility PV** = Utility-scale photovoltaic power generation
- **Portfolio EE** = Represents a wide range of EE program types
- **Uniform EE** = Represents consistent energy savings throughout the year

National factors presented here reflect a weighted average of the avoided emission rates of AVERT's 10 regions. Averages are weighted by the fraction of 2011 fossil generation in each region.

Regional Emission Factors

Avoided CO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1,224	1,275	1,321	1,295
Great Lakes / Mid-Atlantic	1,816	1,785	1,878	1,893
Southeast	1,592	1,597	1,670	1,676
Lower Midwest	1,646	1,543	1,667	1,711
Upper Midwest	1,985	1,863	2,015	2,057
Rocky Mountains	1,877	1,797	1,906	1,947
Texas	1,308	1,284	1,364	1,379
Southwest	1,299	1,211	1,292	1,323
Northwest	1,675	1,643	1,662	1,742
California	979	973	1,021	1,025

Avoided NO_x Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.64	0.80	0.81	0.72
Great Lakes / Mid-Atlantic	1.77	1.74	1.82	1.84
Southeast	1.43	1.46	1.48	1.49
Lower Midwest	1.94	1.94	2.07	2.06
Upper Midwest	1.88	1.73	1.88	1.93
Rocky Mountains	2.11	1.95	2.10	2.16
Texas	0.69	0.86	0.87	0.79
Southwest	1.22	0.98	1.08	1.16
Northwest	1.61	1.54	1.54	1.66
California	0.50	0.38	0.39	0.48

Avoided SO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1.86	1.97	1.99	1.94
Great Lakes / Mid-Atlantic	5.71	5.49	5.78	5.87
Southeast	3.52	3.41	3.54	3.64
Lower Midwest	2.21	1.68	2.00	2.22
Upper Midwest	4.64	4.09	4.54	4.73
Rocky Mountains	1.81	1.66	1.78	1.84
Texas	1.43	1.01	1.18	1.39
Southwest	0.52	0.37	0.43	0.48
Northwest	1.40	1.36	1.27	1.42
California	0.09	0.06	0.06	0.08

Avoided $PM_{2.5}$ Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.05	0.05	0.06	0.05
Great Lakes / Mid-Atlantic	0.24	0.22	0.24	0.24
Southeast	0.16	0.17	0.17	0.17
Lower Midwest	0.10	0.09	0.10	0.10
Upper Midwest	0.14	0.13	0.15	0.15
Rocky Mountains	0.06	0.06	0.06	0.07
Texas	0.06	0.06	0.07	0.07
Southwest	0.09	0.07	0.08	0.08
Northwest	0.11	0.11	0.10	0.11
California	0.05	0.05	0.05	0.05

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Data Year: 2010

National Emission Factors

National Weighted Averages (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Avoided CO_2 Rate	1,592	1,539	1,633	1,658
Avoided NO_x Rate	1.43	1.40	1.48	1.49
Avoided SO_2 Rate	3.43	3.02	3.31	3.47
Avoided $PM_{2.5}$ Rate	0.19	0.19	0.20	0.20

- **Wind** = Wind power generation
- **Utility PV** = Utility-scale photovoltaic power generation
- **Portfolio EE** = Represents a wide range of EE program types
- **Uniform EE** = Represents consistent energy savings throughout the year

National factors presented here reflect a weighted average of the avoided emission rates of AVERT's 10 regions. Averages are weighted by the fraction of 2010 fossil generation in each region.

Regional Emission Factors

Avoided CO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1,252	1,280	1,343	1,326
Great Lakes / Mid-Atlantic	1,805	1,753	1,850	1,880
Southeast	1,556	1,509	1,598	1,619
Lower Midwest	1,629	1,523	1,638	1,687
Upper Midwest	1,955	1,834	1,979	2,025
Rocky Mountains	1,717	1,650	1,765	1,792
Texas	1,358	1,306	1,397	1,424
Southwest	1,311	1,225	1,303	1,329
Northwest	1,453	1,471	1,514	1,545
California	941	970	1,011	990

Avoided NO_x Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.60	0.79	0.82	0.70
Great Lakes / Mid-Atlantic	1.84	1.77	1.86	1.89
Southeast	1.32	1.34	1.41	1.40
Lower Midwest	2.09	1.98	2.13	2.18
Upper Midwest	1.87	1.70	1.85	1.91
Rocky Mountains	1.96	1.78	1.95	1.99
Texas	0.67	0.74	0.76	0.73
Southwest	1.24	0.97	1.07	1.15
Northwest	1.47	1.57	1.56	1.59
California	0.23	0.24	0.23	0.22

Avoided SO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1.27	1.37	1.45	1.38
Great Lakes / Mid-Atlantic	5.82	5.21	5.63	5.87
Southeast	3.58	3.27	3.54	3.65
Lower Midwest	2.58	1.95	2.28	2.55
Upper Midwest	4.72	4.03	4.56	4.81
Rocky Mountains	1.36	1.28	1.37	1.41
Texas	1.68	1.10	1.37	1.65
Southwest	0.54	0.40	0.48	0.52
Northwest	0.91	0.94	0.91	0.98
California	0.02	0.02	0.01	0.02

Avoided $PM_{2.5}$ Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.06	0.08	0.08	0.07
Great Lakes / Mid-Atlantic	0.41	0.38	0.41	0.42
Southeast	0.18	0.18	0.19	0.19
Lower Midwest	0.10	0.10	0.10	0.10
Upper Midwest	0.13	0.13	0.14	0.14
Rocky Mountains	0.09	0.11	0.11	0.10
Texas	0.07	0.08	0.08	0.08
Southwest	0.09	0.07	0.08	0.09
Northwest	0.09	0.08	0.09	0.09
California	0.03	0.03	0.03	0.03

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Data Year: 2009

National Emission Factors

National Weighted Averages (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Avoided CO_2 Rate	1,595	1,541	1,638	1,661
Avoided NO_x Rate	1.43	1.42	1.49	1.49
Avoided SO_2 Rate	4.09	3.87	4.12	4.22
Avoided $PM_{2.5}$ Rate	0.20	0.20	0.21	0.21

- **Wind** = Wind power generation
- **Utility PV** = Utility-scale photovoltaic power generation
- **Portfolio EE** = Represents a wide range of EE program types
- **Uniform EE** = Represents consistent energy savings throughout the year

National factors presented here reflect a weighted average of the avoided emission rates of AVERT's 10 regions. Averages are weighted by the fraction of 2009 fossil generation in each region.

Regional Emission Factors

Avoided CO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1,270	1,237	1,318	1,309
Great Lakes / Mid-Atlantic	1,821	1,783	1,890	1,908
Southeast	1,550	1,492	1,586	1,607
Lower Midwest	1,680	1,560	1,688	1,734
Upper Midwest	1,995	1,910	2,044	2,076
Rocky Mountains	1,749	1,667	1,785	1,823
Texas	1,319	1,259	1,346	1,377
Southwest	1,311	1,222	1,313	1,337
Northwest	1,368	1,398	1,403	1,463
California	1,011	1,045	1,093	1,073

Avoided NO_x Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.70	0.76	0.79	0.72
Great Lakes / Mid-Atlantic	1.68	1.72	1.77	1.76
Southeast	1.33	1.35	1.40	1.39
Lower Midwest	2.07	2.02	2.14	2.16
Upper Midwest	1.95	1.86	1.98	2.02
Rocky Mountains	2.07	1.88	2.04	2.12
Texas	0.80	0.93	0.95	0.89
Southwest	1.27	0.94	1.11	1.20
Northwest	1.32	1.36	1.36	1.45
California	0.47	0.48	0.50	0.50

Avoided SO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1.83	1.69	1.81	1.77
Great Lakes / Mid-Atlantic	7.79	7.71	8.09	8.17
Southeast	4.06	3.91	4.14	4.20
Lower Midwest	2.45	1.90	2.20	2.42
Upper Midwest	5.36	4.99	5.36	5.50
Rocky Mountains	2.36	2.06	2.28	2.36
Texas	1.64	1.07	1.29	1.56
Southwest	0.58	0.41	0.46	0.52
Northwest	0.92	0.95	0.83	1.01
California	0.07	0.05	0.05	0.07

Avoided $PM_{2.5}$ Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.07	0.07	0.08	0.07
Great Lakes / Mid-Atlantic	0.45	0.44	0.46	0.47
Southeast	0.18	0.18	0.18	0.19
Lower Midwest	0.10	0.10	0.11	0.11
Upper Midwest	0.14	0.13	0.14	0.14
Rocky Mountains	0.09	0.10	0.10	0.10
Texas	0.06	0.06	0.06	0.06
Southwest	0.09	0.07	0.08	0.08
Northwest	0.08	0.09	0.08	0.09
California	0.03	0.03	0.04	0.03

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Data Year: 2008

National Emission Factors

National Weighted Averages (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Avoided CO_2 Rate	1,590	1,530	1,636	1,659
Avoided NO_x Rate	1.98	1.73	1.90	1.95
Avoided SO_2 Rate	4.72	3.99	4.52	4.77
Avoided $PM_{2.5}$ Rate	0.20	0.18	0.20	0.20

- **Wind** = Wind power generation
- **Utility PV** = Utility-scale photovoltaic power generation
- **Portfolio EE** = Represents a wide range of EE program types
- **Uniform EE** = Represents consistent energy savings throughout the year

National factors presented here reflect a weighted average of the avoided emission rates of AVERT's 10 regions. Averages are weighted by the fraction of 2008 fossil generation in each region.

Regional Emission Factors

Avoided CO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1,216	1,242	1,302	1,285
Great Lakes / Mid-Atlantic	1,815	1,743	1,866	1,893
Southeast	1,556	1,468	1,586	1,616
Lower Midwest	1,621	1,528	1,644	1,681
Upper Midwest	1,921	1,840	1,974	2,002
Rocky Mountains	1,788	1,714	1,835	1,865
Texas	1,387	1,354	1,439	1,456
Southwest	1,203	1,194	1,251	1,254
Northwest	1,485	1,463	1,527	1,558
California	997	1,057	1,091	1,064

Avoided NO_x Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.68	0.81	0.83	0.74
Great Lakes / Mid-Atlantic	3.02	2.41	2.75	2.85
Southeast	1.92	1.61	1.78	1.87
Lower Midwest	2.22	2.14	2.30	2.33
Upper Midwest	2.41	2.18	2.42	2.46
Rocky Mountains	2.38	2.17	2.37	2.44
Texas	0.77	0.95	0.94	0.87
Southwest	1.10	1.08	1.12	1.12
Northwest	1.52	1.46	1.54	1.61
California	0.33	0.36	0.37	0.36

Avoided SO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1.38	1.36	1.43	1.41
Great Lakes / Mid-Atlantic	8.92	7.86	8.75	9.09
Southeast	5.31	4.13	4.85	5.26
Lower Midwest	2.67	2.14	2.47	2.67
Upper Midwest	4.74	4.27	4.75	4.90
Rocky Mountains	1.88	1.74	1.86	1.89
Texas	1.55	0.99	1.30	1.55
Southwest	0.34	0.25	0.31	0.32
Northwest	1.97	2.24	2.06	2.26
California	0.02	0.02	0.02	0.02

Avoided $PM_{2.5}$ Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.06	0.07	0.07	0.07
Great Lakes / Mid-Atlantic	0.43	0.39	0.43	0.44
Southeast	0.19	0.17	0.19	0.19
Lower Midwest	0.10	0.10	0.10	0.10
Upper Midwest	0.13	0.12	0.13	0.13
Rocky Mountains	0.08	0.10	0.09	0.09
Texas	0.06	0.06	0.06	0.06
Southwest	0.07	0.06	0.06	0.06
Northwest	0.09	0.09	0.10	0.10
California	0.03	0.03	0.03	0.03

AVERT
AVoided Emissions and geneRation Tool
www.epa.gov/avert

May 2018

Data Year: 2007

National Emission Factors

National Weighted Averages (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Avoided CO_2 Rate	1,571	1,510	1,613	1,634
Avoided NO_x Rate	2.07	1.82	1.98	2.03
Avoided SO_2 Rate	4.96	4.03	4.59	4.89
Avoided $PM_{2.5}$ Rate	0.19	0.17	0.19	0.20

- **Wind** = Wind power generation
- **Utility PV** = Utility-scale photovoltaic power generation
- **Portfolio EE** = Represents a wide range of EE program types
- **Uniform EE** = Represents consistent energy savings throughout the year

National factors presented here reflect a weighted average of the avoided emission rates of AVERT's 10 regions. Averages are weighted by the fraction of 2007 fossil generation in each region.

Regional Emission Factors

Avoided CO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	1,291	1,313	1,372	1,354
Great Lakes / Mid-Atlantic	1,775	1,696	1,816	1,842
Southeast	1,568	1,483	1,595	1,621
Lower Midwest	1,605	1,496	1,616	1,661
Upper Midwest	1,909	1,812	1,955	1,984
Rocky Mountains	1,668	1,589	1,717	1,737
Texas	1,259	1,226	1,314	1,325
Southwest	1,113	1,106	1,173	1,171
Northwest	1,525	1,570	1,578	1,611
California	1,059	1,098	1,135	1,118

Avoided NO_x Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.96	1.11	1.11	1.03
Great Lakes / Mid-Atlantic	3.12	2.46	2.76	2.88
Southeast	2.05	1.78	1.94	2.02
Lower Midwest	2.47	2.33	2.50	2.56
Upper Midwest	2.54	2.32	2.54	2.59
Rocky Mountains	1.82	1.63	1.83	1.88
Texas	0.70	0.84	0.83	0.78
Southwest	0.94	0.96	1.04	1.01
Northwest	1.64	1.87	1.68	1.78
California	0.41	0.42	0.42	0.42

Avoided SO_2 Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	2.02	1.98	2.03	2.02
Great Lakes / Mid-Atlantic	9.39	7.77	8.75	9.22
Southeast	5.60	4.30	5.03	5.46
Lower Midwest	2.83	2.08	2.50	2.77
Upper Midwest	5.19	4.58	5.13	5.31
Rocky Mountains	1.46	1.19	1.44	1.51
Texas	1.12	0.72	0.98	1.10
Southwest	0.19	0.20	0.23	0.23
Northwest	1.40	1.41	1.18	1.38
California	0.04	0.03	0.03	0.03

Avoided $PM_{2.5}$ Rate (lb/MWh)				
	Wind	*Utility PV*	*Portfolio EE*	*Uniform EE*
Northeast	0.07	0.08	0.09	0.08
Great Lakes / Mid-Atlantic	0.39	0.34	0.38	0.39
Southeast	0.19	0.17	0.19	0.19
Lower Midwest	0.10	0.09	0.10	0.10
Upper Midwest	0.14	0.13	0.14	0.14
Rocky Mountains	0.12	0.15	0.14	0.13
Texas	0.06	0.06	0.06	0.06
Southwest	0.06	0.05	0.05	0.06
Northwest	0.09	0.09	0.09	0.09
California	0.03	0.04	0.04	0.04