Estimating the Public Health Benefits of Energy Efficiency and Renewable Energy with EPA's Benefits-per-kWh Values

Third Edition, December 2024 (Preview)

EPA has developed a set of values that helps state, local, and Tribal government policymakers and other stakeholders estimate the monetized public health benefits of air quality changes due to investments in energy efficiency, renewable energy, and solar photovoltaic paired with energy storage (EE/RE/ES^+). EPA developed these monetized values using the same methods it uses to analyze health benefits at the federal level.[1] It's important to note that EPA is continually reviewing methods and assumptions for quantifying public health benefits. The values presented here and in the associated documentation will be updated as appropriate to reflect future changes in methods or assumptions.

What's new for benefits-per-kWh screening values?

EPA has updated the benefits-per-kilowatt-hour (BPK) values with the following changes in the Third Edition of Public Health Benefits per Kilowatt-Hour of Energy Efficiency and Renewable Energy in the United States: A Technical Report:

- Updated power sector data: The Third Edition of the technical report uses 2023 power sector and transmission and distribution loss data from version 4.3 of the AVoided Emissions and geneRation Tool (AVERT).
- Updated health impacts data: The Third Edition uses version 5.1 of the CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA), which includes updated underlying health data and air quality models, the addition of ozone health impacts, and a default discount rate of 2 percent.
- Additional energy storage types: The Third Edition includes values for utility-scale and distributed photovoltaic-plus-storage resources (solar photovoltaic, or PV, paired with energy storage).
- Updated peak energy efficiency definition: The Third Edition uses a new peak energy efficiency definition that distinguishes between summer and non-summer peak hours.

[1] For more information about the methods and assumptions used, see EPA's technical report, Public Health Benefits per Kilowatt-Hour of Energy Efficiency and Renewable Energy in the United States, Third Edition, 2024: https://www.epa.gov/statelocalenergy/public-health-benefits-kwh-energy-efficiency-and-renewable-energy-united-states.

When to use benefits-per-kWh screening values

BPK values are reasonable approximations of the monetized health benefits of state, local, and Tribal EE/RE/ES+ investments. Stakeholders can use them for preliminary analysis when comparing policy scenarios to indicate the direction and relative magnitude of impacts.

The following are examples of analyses where it would be appropriate to use the BPK values:

- Estimating the public health benefits of investments in EE/RE/ES+ projects, programs, and policies
- Understanding the cost-effectiveness of energy efficiency projects, programs, and policies
- Incorporating health benefits in short-term policy analyses and decision-making

Audience for BPK screening values

Stakeholders interested in approximating the monetized value of outdoor air-quality-related public health benefits of EE/RE/ES+ may include:

- State, local, and Tribal energy, air quality, or public health agencies
- Public utility commissions
- Energy efficiency and renewable energy project developers
- Nongovernmental organizations
- Other researchers

When not to use benefits-per-kWh values

BPK values are not a substitute for sophisticated analysis and should not be used to justify or inform federal regulatory decisions. They are based on data inputs, assumptions, and methods that approximate the dynamics of energy, environment, and health interactions and include uncertainties and limitations, as documented in the technical report. While many of these health benefits are likely to accrue within the given region, the estimated health benefits are based on national-level modeling and are not appropriate for understanding localized impacts. To estimate subnational impacts, consider using AVERT, COBRA, or another air quality modeling platform.

Benefits-per-kWh screening values

EPA used a peer reviewed methodology to develop a set of screening-level regional estimates of the dollar benefits (in cents per kilowatt-hour) from the eight different types of EE/RE/ES+ initiatives listed below.

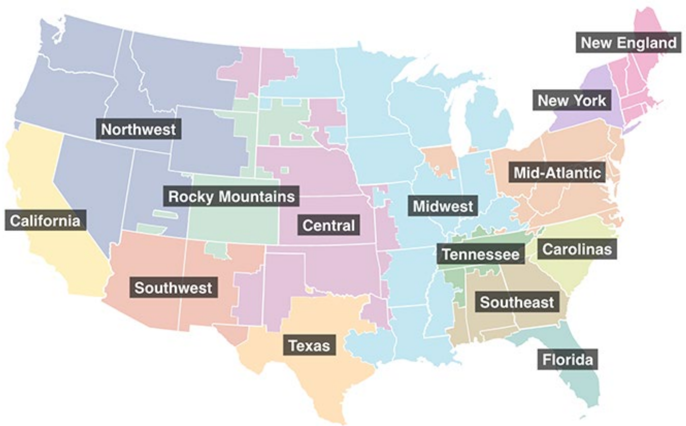
- **Uniform energy efficiency:** Energy efficiency measures that achieve a constant level of savings over one year.
- **Energy efficiency at peak:** Energy efficiency measures that achieve savings when energy demand is high (i.e., from noon to 8:00 p.m. on weekdays and non-federal holidays in June–September and from 6:00 a.m. to 9:00 p.m. on weekdays and non-federal holidays in October–May).
- **Distributed solar energy:** Interventions that increase the supply of distributed solar energy available (e.g., rooftop solar generation).
- **Utility solar energy:** Interventions that increase the supply of energy available from utility-scale solar.
- **Distributed PV-plus-storage:** Interventions that increase the supply of energy available from paired distributed solar-plus-storage resources.
- **Utility PV-plus-storage:** Interventions that increase the supply of energy available from paired utility-scale solar-plus-storage resources.
- **Onshore wind energy:** Interventions that increase the supply of onshore wind available (e.g., wind turbines).

- **Offshore wind energy:** Interventions that increase the supply of offshore wind available (e.g., wind turbines).

Understanding the values

EPA created BPK values using existing tools, including AVERT and COBRA. BPK values are:

- Available for each of the eight project types for each of the 14 AVERT regions shown in the map (right). If you don't know your region, you can use the AVERT Web Edition to find a region based on your selected state and county.



- Based on 2023 electricity generation data, and emissions, population, baseline mortality incidence rate, and income growth projections.
- Presented in 2023 dollars and reflect the use of a 2 percent discount rate.
- Calculated using the same health impact functions EPA uses for regulatory impact analyses. For example, EPA created the BPK values from low estimates of mortality using health impact functions that assume people are not very sensitive to changes in fine particulate matter ($PM_{2.5}$) levels and high estimates of mortality using functions that assume people are more sensitive to changes in $PM_{2.5}$.
- Include the contiguous United States, but do not include Alaska, Hawaii, Puerto Rico and other U.S. territories. These states and territories are not included in AVERT because the necessary operation and emissions data for electric generating units in these states are currently not available to EPA. These states and territories are also not included in COBRA (used to estimate the health impacts of EE/RE/ES$^+$) because they were not included in the air quality modeling originally used to develop the tool.

How to use BPK values

States, Tribes, and local communities interested in screening-level estimates of the outdoor air-quality-related health impacts of EE/RE/ES$^+$ can multiply the BPK values by the number of kilowatt-hours saved from energy efficiency or generated from RE/ES$^+$ to estimate potential health benefits from projects in dollars saved. Users should note that EPA suggests that the values not be used to determine health benefits for more than five years before or after 2023.

BPK values are provided with up to four significant figures. EPA recommends that when these BPK values are multiplied by a kilowatt-hour intervention, the resulting dollar benefits are reported with two significant figures, in keeping with the reporting recommendations for the COBRA model.

For more information: See the technical documentation online or contact a help desk at cobra@epa.gov or avert@epa.gov.

Example: Benefits of installing 10 megawatts of solar energy in North Carolina

To estimate the health benefits of a 10-megawatt solar installation in North Carolina, you can use the utility solar BPK values for the Carolinas and multiply them by the amount of electricity the project will generate. If you don't have project-level information about the amount of electricity generation, you can use a tool such as the National Renewable Energy Laboratory's PVWATTs Calculator, which estimates that a 10-megawatt solar project in North Carolina would generate approximately 13.9 million kilowatt-hours per year. The estimated monetized health benefits of the project are calculated as shown below:

Type of BPK Value	BPK Value for the Carolinas Region (¢/kWh)	Generation from Solar Project (kWh)	Estimated Health Benefits
Low estimate	4.55	13.9 million	**$630,000**
High estimate	7.15	13.9 million	**$990,000**

According to Lazard's annual Levelized Cost of Energy Analysis, the cost of utility solar in 2023 was 2.9 to 9.2 cents per kilowatt-hour. You can use these values to estimate the cost of the electricity the installation generates—about $403,100 to $1,278,000. In comparing these costs with the estimated health benefits the project generates in the first year[2], you can see that the health benefits could equate to 49 percent to over 100 percent of the cost of the electricity generation. Currently, BPK values do not include other pollution reduction benefits of EE/RE/ES+, such as reduced greenhouse gas emissions.

Example: Benefits of energy efficiency in Illinois

According to the U.S. Energy Information Administration, utility investments in energy efficiency programs in Illinois resulted in energy savings of approximately 2.4 billion kilowatt-hours in 2022. Since Illinois is split across two AVERT regions—the Mid-Atlantic and Midwest regions—this state-level analysis needs to consider both regions. If you don't know how much of the energy savings occurred in each region, you can estimate based on the portion of load in each region. AVERT's state apportionment by AVERT region table shows that 65 percent of electricity sales in Illinois is in the Mid-Atlantic region and 35 percent is in the Midwest region. To distribute the total state-level savings to the two regions, you can multiply it by the portion of sales in each region:

Region	Portion of Electricity Sales	Total Savings in Illinois (kWh)	Savings in Each Region (kWh)
Mid-Atlantic	65%	2.4 billion	**1.6 billion**
Midwest	35%	2.4 billion	**0.8 billion**

You can then apply the BPK values for each region to estimate the health benefits in Illinois:

Type of BPK Value	Mid-Atlantic BPK Value (Uniform EE) (¢/kWh)	Mid-Atlantic Energy Savings (kWh)	Mid-Atlantic Health Benefits (Million $)	Midwest BPK Value (Uniform EE) (¢/kWh)	Midwest Energy Savings (kWh)	Midwest Health Benefits (Million $)	Total Health Benefits (Million $)
Low	5.26	1.6 billion	$84.2	6.27	0.8 billion	$50.2	**$130**
High	8.97	1.6 billion	$143.5	10.70	0.8 billion	$85.6	**$230**

According to the Energy Information Administration data, the incremental cost of energy efficiency programs in Illinois in 2022 was approximately $450 million. The estimated health benefits generated by the energy efficiency program in the first year would therefore cover 16 to 27 percent of the costs based on the low and high BPK values, respectively.

[2] BPK estimates are based on the emission reductions occurring from the intervention only in the first year that it impacts the grid. If the emissions rate is not expected to change substantially across analysis years (or if your intervention is expected to last for five years or less), it is appropriate to simply apply the same BPK value to the intervention estimated in each year. More complex modeling is required to estimate lifetime impacts for interventions that persist longer than five years where structural changes to the electricity grid will likely occur and emissions rates will likely change.

Benefits-per-kWh Values, Third Edition (2023 Cents per kWh, 2% Discount Rate)[3]

Region	Project Type	BPK, Low (2023 ¢/kWh)	BPK, High (2023 ¢/kWh)
California	Uniform EE	0.75	1.26
California	Peak EE	0.85	1.42
California	Utility PV	0.69	1.15
California	Distributed PV	0.75	1.25
California	Utility PV-plus-storage	0.74	1.24
California	Distributed PV-plus-storage	0.83	1.37
California	Onshore wind	0.68	1.14
California	Offshore wind	0.69	1.16
Carolinas	Uniform EE	5.13	8.04
Carolinas	Peak EE	5.99	9.40
Carolinas	Utility PV	4.55	7.15
Carolinas	Distributed PV	4.84	7.62
Carolinas	Utility PV-plus-storage	4.51	7.12
Carolinas	Distributed PV-plus-storage	4.79	7.57
Carolinas	Onshore wind	4.66	7.30
Carolinas	Offshore wind	4.66	7.31
Central	Uniform EE	4.63	7.49
Central	Peak EE	5.16	8.03
Central	Utility PV	4.60	7.25
Central	Distributed PV	4.96	7.81
Central	Utility PV-plus-storage	4.65	7.29
Central	Distributed PV-plus-storage	5.02	7.87
Central	Onshore wind	4.14	6.79
Central	Offshore wind	N/A	N/A
Florida	Uniform EE	2.82	4.38
Florida	Peak EE	3.29	5.10
Florida	Utility PV	2.86	4.44
Florida	Distributed PV	3.09	4.80
Florida	Utility PV-plus-storage	2.90	4.50
Florida	Distributed PV-plus-storage	3.13	4.86
Florida	Onshore wind	2.47	3.83
Florida	Offshore wind	N/A	N/A
Mid-Atlantic	Uniform EE	5.26	8.97
Mid-Atlantic	Peak EE	5.95	10.21
Mid-Atlantic	Utility PV	5.23	8.94
Mid-Atlantic	Distributed PV	5.60	9.57
Mid-Atlantic	Utility PV-plus-storage	5.28	9.02
Mid-Atlantic	Distributed PV-plus-storage	5.67	9.68
Mid-Atlantic	Onshore wind	4.73	8.07
Mid-Atlantic	Offshore wind	4.76	8.11
Midwest	Uniform EE	6.27	10.70
Midwest	Peak EE	6.73	11.39
Midwest	Utility PV	5.99	10.18
Midwest	Distributed PV	6.46	10.97
Midwest	Utility PV-plus-storage	5.99	10.17
Midwest	Distributed PV-plus-storage	6.47	10.96
Midwest	Onshore wind	5.75	9.81
Midwest	Offshore wind	N/A	N/A

Region	Project Type	BPK, Low (2023 ¢/kWh)	BPK, High (2023 ¢/kWh)
New England	Uniform EE	1.07	1.81
New England	Peak EE	1.46	2.44
New England	Utility PV	1.07	1.80
New England	Distributed PV	1.13	1.91
New England	Utility PV-plus-storage	1.20	2.01
New England	Distributed PV-plus-storage	1.30	2.18
New England	Onshore wind	0.92	1.56
New England	Offshore wind	0.92	1.56
New York	Uniform EE	4.25	7.91
New York	Peak EE	5.37	9.93
New York	Utility PV	4.28	7.96
New York	Distributed PV	4.56	8.48
New York	Utility PV-plus-storage	4.48	8.34
New York	Distributed PV-plus-storage	4.81	8.95
New York	Onshore wind	3.65	6.79
New York	Offshore wind	3.56	6.62
Northwest	Uniform EE	1.64	2.43
Northwest	Peak EE	1.74	2.56
Northwest	Utility PV	1.40	2.09
Northwest	Distributed PV	1.52	2.27
Northwest	Utility PV-plus-storage	1.44	2.13
Northwest	Distributed PV-plus-storage	1.56	2.32
Northwest	Onshore wind	1.50	2.22
Northwest	Offshore wind	1.52	2.26
Rocky Mountains	Uniform EE	1.80	2.73
Rocky Mountains	Peak EE	1.77	2.66
Rocky Mountains	Utility PV	1.62	2.46
Rocky Mountains	Distributed PV	1.78	2.70
Rocky Mountains	Utility PV-plus-storage	1.62	2.46
Rocky Mountains	Distributed PV-plus-storage	1.78	2.69
Rocky Mountains	Onshore wind	1.66	2.53
Rocky Mountains	Offshore wind	N/A	N/A
Southeast	Uniform EE	3.64	5.00
Southeast	Peak EE	4.59	6.26
Southeast	Utility PV	3.60	4.93
Southeast	Distributed PV	3.88	5.32
Southeast	Utility PV-plus-storage	3.68	5.05
Southeast	Distributed PV-plus-storage	3.99	5.46
Southeast	Onshore wind	2.97	4.10
Southeast	Offshore wind	N/A	N/A
Southwest	Uniform EE	0.88	1.21
Southwest	Peak EE	0.97	1.31
Southwest	Utility PV	0.83	1.14
Southwest	Distributed PV	0.91	1.26
Southwest	Utility PV-plus-storage	0.87	1.20
Southwest	Distributed PV-plus-storage	0.98	1.35
Southwest	Onshore wind	0.77	1.06
Southwest	Offshore wind	N/A	N/A

[3] Key abbreviations in the table include energy efficiency (EE) and photovoltaic-plus-storage (PV-plus-storage).

Region	Project Type	BPK, Low (2023 ¢/kWh)	BPK, High (2023 ¢/kWh)
Tennessee	Uniform EE	3.10	5.42
Tennessee	Peak EE	3.80	6.57
Tennessee	Utility PV	3.20	5.58
Tennessee	Distributed PV	3.41	5.94
Tennessee	Utility PV-plus-storage	3.20	5.57
Tennessee	Distributed PV-plus-storage	3.43	5.95
Tennessee	Onshore wind	2.54	4.45
Tennessee	Offshore wind	N/A	N/A

Region	Project Type	BPK, Low (2023 ¢/kWh)	BPK, High (2023 ¢/kWh)
Texas	Uniform EE	3.13	5.01
Texas	Peak EE	3.56	5.45
Texas	Utility PV	3.09	4.85
Texas	Distributed PV	3.22	5.07
Texas	Utility PV-plus-storage	3.16	4.88
Texas	Distributed PV-plus-storage	3.31	5.10
Texas	Onshore wind	2.89	4.67
Texas	Offshore wind	N/A	N/A