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

EPA has developed a set of values that help state and local government policymakers and other stakeholders estimate the monetized public health benefits of investments in energy efficiency and renewable energy (EE/RE) using methods consistent with those EPA uses for health benefits analyses 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 the associated documentation will be updated as appropriate to reflect any future changes in methods or assumptions.

When to use Benefits-per-kWh screening values

Benefits-per-kilowatt-hour (BPK) values are reasonable approximations of the health benefits of state EE/RE investments that can be used for preliminary analysis when comparing across state and local policy scenarios to indicate direction and relative magnitude.

Examples of analyses where it would be appropriate to use them include:

- Estimating the public health benefits of regional, state, or local-level investments in EE/RE projects, programs, and policies
- Understanding the cost-effectiveness of regional, state, or local-level EE projects, programs, and policies
- Incorporating health benefits in short-term regional, state, or local policy analyses and decision-making

Audience for BPK screening values

Stakeholders interested in approximating the outdoor air quality-related public health benefits from EE/RE, including:

- State and local energy, air quality, or public health agencies
- Public utility commissions
- Energy efficiency and renewable energy project developers
- Industry organization
- 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.

[1] For more information about the methods and assumptions used, see EPA's technical report, Public Health Benefits per kWh of Energy Efficiency and Renewable Energy in the United States, 2018: https://www.epa.gov/statelocalenergy/public-health-benefits-kwh-energy-efficiency-and-renewable-energy-united-states.

Benefits-per-kWh values

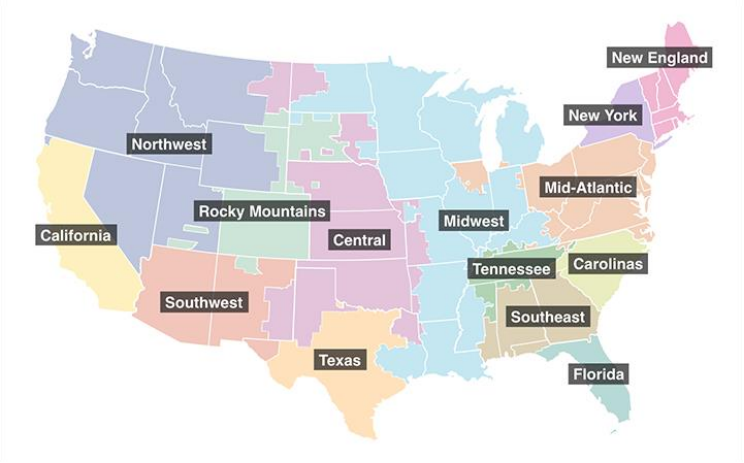
EPA used a peer reviewed methodology and tools to develop a set of screening-level regional estimates of the dollar benefits per kilowatt-hour from six different types of EE/RE initiatives.

- ***Uniform Energy Efficiency*** - Energy efficiency programs, projects, and policies that achieve a constant level of savings over time,
- ***Energy Efficiency at Peak*** - Energy efficiency programs, projects, and policies that achieve savings during 12pm-6pm when energy demand is high (i.e. peak),
- ***Utility Solar Energy*** – Programs, projects, and policies that increase the supply of utility solar energy available,
- ***Distributed Solar Energy*** – Programs, projects, and policies that increase the supply of distributed, or rooftop, solar energy available,
- ***Onshore Wind Energy*** – Programs, projects, and policies that increase the supply of onshore wind available (e.g. wind turbines), and
- ***Offshore Wind Energy*** – Programs, projects, and policies that increase the supply of offshore wind available in select parts of the U.S. with actual of proposed wind lease areas.

Understanding the Values

EPA created BPK values using existing tools, including EPA's AVoided Emissions and geneRation Tool (AVERT) and CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool. BPK values are:

- Available for each of the six project types for each of the 14 AVERT regions shown in the map below
- Based on 2019 electricity generation data and emissions, population, baseline mortality incidence rate, and income growth projections
- Presented in 2017 dollars and reflecting the use of either a 3% or a 7% discount rate as recommended by EPA's Guidelines for Preparing Economic Analyses (2010)



- Calculated using the same health impact functions EPA uses for regulatory impact analyses, including the calculation of low estimates of mortality using health impact functions that assume people are not very sensitive to changes in $PM_{2.5}$ levels and high estimates of mortality using functions that assume people are more sensitive to changes in $PM_{2.5}$

How to use BPK values

States and communities interested in screening-level estimates of outdoor air quality-related health impacts of energy efficiency or renewable energy can multiply the BPK values by the number of kWh saved from EE or generated from RE to estimate annual potential health benefits from projects in dollars saved. Users should note that EPA suggests that the values not be used to determine health benefits more than five years prior to or after 2019.

For more information: See the technical documentation online or contact Emma Zinsmeister at zinsmeister.emma@epa.gov

Example: Benefits of Installing 10-MW of Solar Energy in North Carolina

To estimate the health benefits of 10-megawatt (MW) solar installation in North Carolina, you would 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 electricity the project will generate, you can use a tool such as the National Renewable Energy Laboratory's (NREL) PVWATTs Calculator, which estimates that a 10-MW solar project in North Carolina would generate approximately 13.9 million kWh 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	Estimated Health Benefits
Low estimate, 3% discount rate	1.69	13.9 million kWh	**$234,910**
High estimate, 3% discount rate	3.80		**$528,200**
Low estimate, 7% discount rate	1.50		**$208,500**
High estimate, 7% discount rate	3.39		**$471,210**

According to Lazard's annual Levelized Cost of Energy Analysis, the cost of utility solar in 2019 was 3.2–4.2 ¢/kWh. You can use these values to estimate the cost of the electricity generated by the installation—approximately $444,800 to $583,800. In comparing these costs with the estimated health benefits generated by the project, you can see that the health benefits could cover 35% to over 100% of the cost of the electricity generation. Note that the BPK values do not include other pollution reduction benefits of EE/RE, such as reduced greenhouse gas emissions and reduced impacts to ecosystems.

Example: Benefits of Energy Efficiency in Illinois

According to the U.S. Energy Information Administration, utility investments in EE programs in Illinois resulted in energy savings of approximately 2.5 billion kWh in 2019. However, Illinois is split across two AVERT regions—the Mid-Atlantic and Midwest regions. If you don't know how much of the energy savings occurred in each region, you can estimate based on the portion of generation in each region. AVERT's state apportionment by AVERT region table shows that 65% of generation in Illinois is in the Mid-Atlantic region and 35% is in the Midwest region. To distribute the total state-level energy savings to the two regions, you can multiply it by the portion of generation in each region:

Region	Portion of Generation	Total Energy Savings in Illinois (kWh)	Energy Savings in Each Region (kWh)
Mid-Atlantic	65%	2.5 billion	**1.6 billion**
Midwest	35%		**875 million**

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

Type of BPK Value	Mid-Atlantic			Midwest			Total Health Benefits (Million $)
	BPK Value (¢/kWh)	Energy Savings (kWh)	Health Benefits (Million $)	BPK Value (¢/kWh)	Energy Savings (kWh)	Health Benefits (Million $)	
Low estimate, 3%	3.10	1.6 billion kWh	49.6	2.70	875 million kWh	23.6	**73.2**
High estimate, 3%	7.00		112.0	6.10		53.4	**165.4**
Low estimate, 7%	2.78		44.5	2.41		21.1	**65.6**
High estimate, 7%	6.26		100.2	5.43		47.5	**147.7**

According to the Energy Information Administration data, the incremental cost of the EE programs in Illinois in 2017 was approximately $410 million. The estimated health benefits generated by the EE program would therefore cover 15-40% of the costs using both the low and high BPK values.

2019 Benefits-per-kWh Values (cents per kWh)[2]

Region	Project Type	3% Discount Rate		7% Discount Rate	
		2019 ¢/kWh (low estimate)	2019 ¢/kWh (high estimate)	2019 ¢/kWh (low estimate)	2019 ¢/kWh (high estimate)
California	Uniform EE	0.67	1.51	0.60	1.34
	EE at Peak	0.74	1.67	0.66	1.49
	Utility Solar	0.65	1.47	0.58	1.31
	Distributed Solar	0.64	1.44	0.57	1.29
	Onshore Wind	0.63	1.41	0.56	1.26
	Offshore Wind	0.67	1.50	0.60	1.34
Carolinas	Uniform EE	1.66	3.75	1.48	3.33
	EE at Peak	1.65	3.73	1.48	3.33
	Utility Solar	1.69	3.80	1.50	3.39
	Distributed Solar	1.69	3.81	1.51	3.40
	Onshore Wind	1.66	3.75	1.48	3.34
	Offshore Wind	1.66	3.74	1.48	3.34
Central	Uniform EE	1.37	3.09	1.22	2.75
	EE at Peak	1.33	2.99	1.18	2.67
	Utility Solar	1.34	3.01	1.19	2.69
	Distributed Solar	1.34	3.02	1.20	2.70
	Onshore Wind	1.39	3.14	1.24	2.80
Florida	Uniform EE	0.79	1.79	0.70	1.58
	EE at Peak	0.91	2.05	0.81	1.83
	Utility Solar	0.86	1.93	0.76	1.73
	Distributed Solar	0.87	1.96	0.77	1.75
	Onshore Wind	0.75	1.69	0.67	1.51
Mid-Atlantic	Uniform EE	3.10	7.00	2.78	6.26
	EE at Peak	3.17	7.15	2.83	6.37
	Utility Solar	3.10	7.00	2.77	6.25
	Distributed Solar	3.09	6.98	2.76	6.22
	Onshore Wind	3.04	6.85	2.71	6.11
	Offshore Wind	3.05	6.88	2.72	6.14
Midwest	Uniform EE	2.70	6.10	2.41	5.43
	EE at Peak	2.64	5.97	2.36	5.32
	Utility Solar	2.65	5.98	2.36	5.33
	Distributed Solar	2.65	5.99	2.37	5.34
	Onshore Wind	2.73	6.16	2.44	5.50

[2] In addition to using these regional values, users can also use EPA's AVERT and COBRA tools to develop more specific analyses, such as state- or county-level health benefits estimates. For more information on other more sophisticated options for modeling health benefits for or how to quantify the electricity impacts of energy efficiency and renewable energy, see the EPA report, *Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy: A Guide for State and Local Governments.*

Region	Project Type	3% Discount Rate		7% Discount Rate	
		2019 ¢/kWh (low estimate)	2019 ¢/kWh (high estimate)	2019 ¢/kWh (low estimate)	2019 ¢/kWh (high estimate)
New England	Uniform EE	0.34	0.77	0.32	0.73
	EE at Peak	0.42	0.94	0.37	0.84
	Utility Solar	0.40	0.90	0.36	0.81
	Distributed Solar	0.40	0.91	0.36	0.81
	Onshore Wind	0.35	0.80	0.32	0.71
	Offshore Wind	0.36	0.81	0.32	0.72
New York	Uniform EE	0.99	2.24	0.88	1.98
	EE at Peak	1.19	2.68	1.06	2.39
	Utility Solar	1.10	2.49	0.99	2.22
	Distributed Solar	1.10	2.49	0.98	2.22
	Onshore Wind	0.95	2.13	0.85	1.90
	Offshore Wind	0.94	2.12	0.84	1.89
Northwest	Uniform EE	1.06	2.39	0.95	2.14
	EE at Peak	1.11	2.49	0.99	2.22
	Utility Solar	1.12	2.53	1.00	2.26
	Distributed Solar	1.13	2.54	1.01	2.27
	Onshore Wind	1.04	2.35	0.93	2.10
	Offshore Wind	1.05	2.38	0.94	2.12
Rocky Mountains	Uniform EE	0.93	2.10	0.82	1.84
	EE at Peak	0.91	2.05	0.81	1.83
	Utility Solar	0.91	2.05	0.81	1.83
	Distributed Solar	0.92	2.07	0.82	1.85
	Onshore Wind	0.92	2.08	0.82	1.85
Southeast	Uniform EE	0.69	1.55	0.67	1.51
	EE at Peak	0.84	1.90	0.75	1.70
	Utility Solar	0.81	1.83	0.72	1.63
	Distributed Solar	0.82	1.85	0.73	1.65
	Onshore Wind	0.73	1.65	0.65	1.47
Southwest	Uniform EE	0.58	1.31	0.52	1.16
	EE at Peak	0.63	1.43	0.56	1.27
	Utility Solar	0.61	1.38	0.55	1.23
	Distributed Solar	0.62	1.39	0.55	1.24
	Onshore Wind	0.57	1.28	0.51	1.14
Tennessee	Uniform EE	0.84	1.89	0.75	1.70
	EE at Peak	0.88	1.98	0.78	1.76
	Utility Solar	0.84	1.89	0.75	1.68
	Distributed Solar	0.82	1.85	0.73	1.65
	Onshore Wind	0.82	1.85	0.73	1.65
Texas	Uniform EE	0.91	2.04	0.81	1.83
	EE at Peak	0.97	2.18	0.86	1.94
	Utility Solar	0.95	2.13	0.85	1.90
	Distributed Solar	0.94	2.13	0.84	1.90
	Onshore Wind	0.88	1.99	0.79	1.78