Shining Cities 2020

The Top U.S. Cities for Solar Energy

ENVIRONMENT MINNESOTA
RESEARCH & POLICY CENTER

FRONTIER GROUP

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Cover photos – *Top*: Solar panels in the Mueller neighborhood of Austin, Texas. *Photo:* RoschetzkyIstockPhoto. *Right*: Installing solar panels in Dover, Delaware. *Photo:* U.S. Air Force photo by Roland Balik. (The appearance of U.S. Department of Defense [DoD] visual information does not imply or constitute DoD endorsement). *Left*: Rooftop solar panels in Albuquerque, New Mexico. *Photo:* City of Albuquerque.

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Executive summary

Solar power is expanding rapidly. The United States now has 77.7 gigawatts (GW) of solar photovoltaic (PV) capacity installed – more than enough to power one in every 10 homes in America.[1] Hundreds of thousands of Americans have invested in solar energy and millions more are ready to join them.

America's major cities have played a key role in the clean energy revolution and stand to reap tremendous benefits from solar energy. As population centers, they are major sources of electricity demand and, with millions of rooftops suitable for solar panels, they have the potential to be major sources of clean energy production as well.

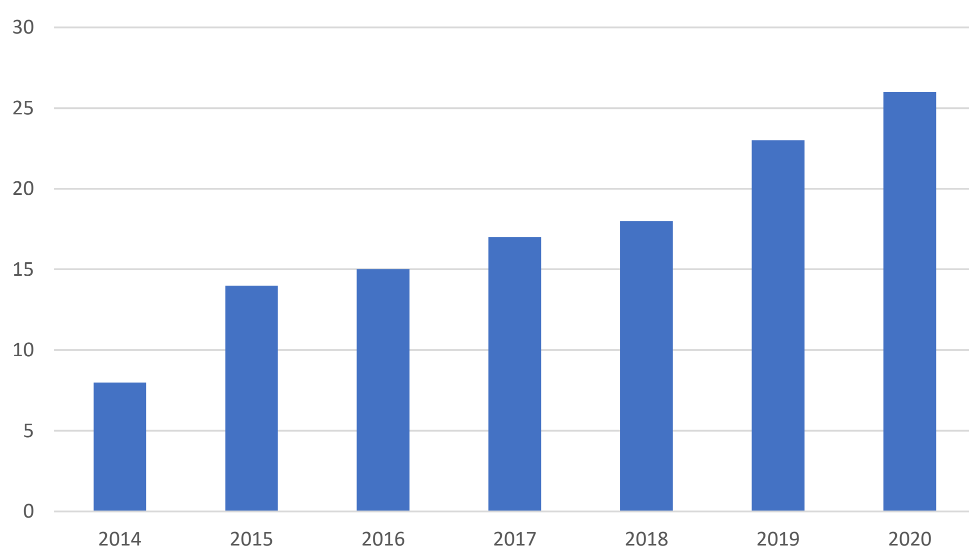

Figure ES-1. The number of "Solar Stars" (cities with >50W of solar PV per capita) in each edition of Shining Cities

Our seventh annual survey of solar energy in America's biggest cities finds that the amount of solar power installed in just seven U.S. cities exceeds the amount installed in the entire United States at the end of 2010.[2] Of the 57 cities surveyed in all seven editions of this report, almost 90 percent more than doubled their total installed solar PV capacity between 2013 and 2019.

To continue America's progress toward renewable energy, cities, states and the federal government should adopt strong policies to make it easy for homeowners, businesses and utilities to "go solar."

The cities with the most solar PV installed per resident are the "Solar Stars" – cities with 50 or more watts of solar PV capacity installed per capita. **In 2013, only eight of the cities surveyed for this report had enough solar PV per capita to be ranked as "Solar Stars," but now 26 cities have earned the title.**

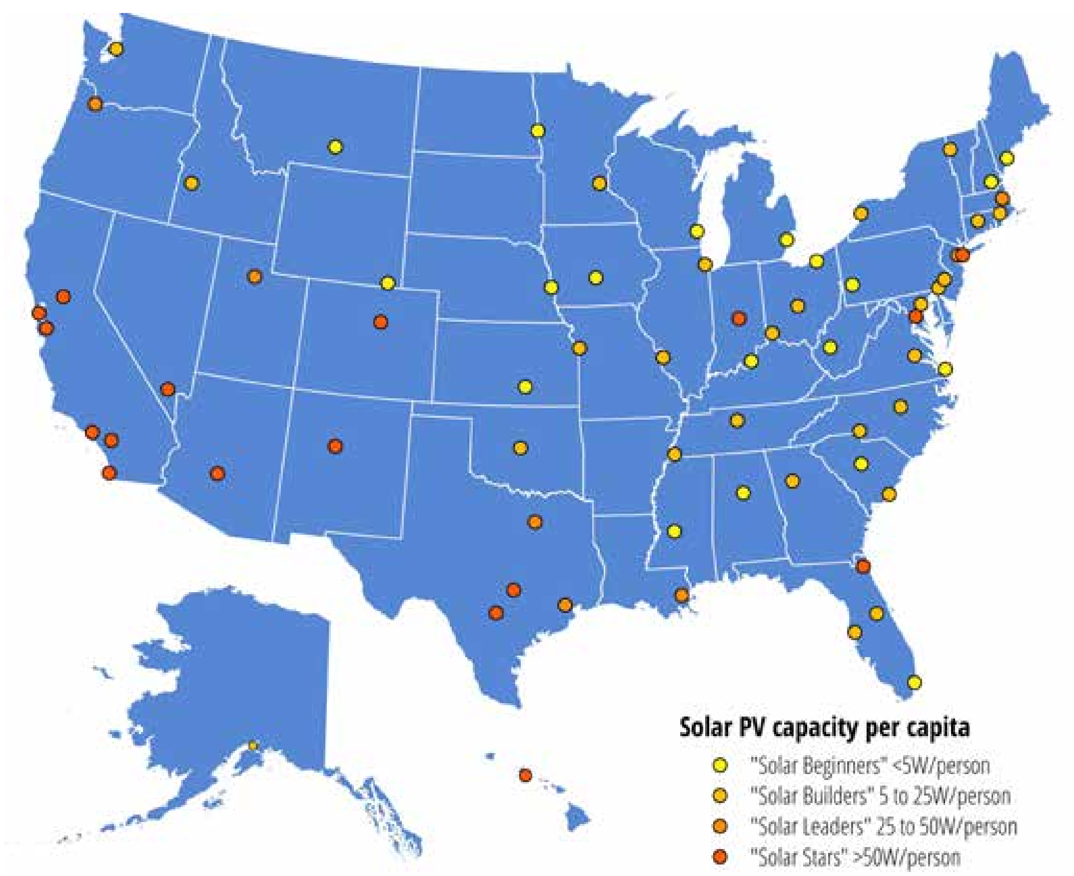

Figure ES-2. Major U.S. cities by installed solar PV capacity per capita, end of 2019 (watts per person)

Table ES-1. The "Solar Stars" (cities with 50 or more watts of solar PV per person, end of 2019)

Per capita rank	City	State	Per capita solar PV (watts DC per person)ǂ	Change in per capita rank 2018 - 2019	Total installed solar PV (MW DC)	Total solar PV rank
1	Honolulu	HI	840.88	0	292.12	3
2	San Diego	CA	294.8	0	420.38	2
3	Albuquerque	NM	273.19	7	153.04	8
4	San Jose	CA	217.13	-1	223.67	7
5	Burlington	VT	183.8	-1	7.88	39
6	San Antonio	TX	166.08	6	254.47	5
7	Las Vegas*	NV	164.1	-2	105.79	10
8	Phoenix	AZ	164.07	-2	272.4	4
9	Riverside	CA	154.17	-1	50.89	17
10	Denver	CO	145.95	-1	104.57	11
11	Salt Lake City	UT	141.17	0	28.32	22
12	Indianapolis*	IN	141.01	-5	122.28	9
13	Washington	DC	126.66	2	88.97	12
14	New Orleans	LA	125.06	-1	48.9	18
15	Los Angeles	CA	121.24	-1	483.8	1
16	Sacramento	CA	112.82	1	57.37	15
17	Newark	NJ	96.9	-1	27.33	24
18	Wilmington*	DE	81.65	9	5.77	47
19	Jacksonville	FL	70.4	0	63.63	13
20	Hartford	CT	69.8	3	8.56	38
21	Austin	TX	64.14	1	61.84	14
22	San Francisco	CA	62.11	-2	54.86	16
23	Portland	OR	57.9	1	37.82	21
24	Charleston	SC	55.52	-6	7.56	41
25	Boston	MA	55.51	-4	38.56	20
26	Portland	ME	54.75	-1	3.64	56

ǂ Throughout the report, includes all solar PV capacity (rooftop and utility-scale solar installations) within the city limits of each city. Does not include solar power installed in the extraterritorial jurisdictions of cities, even those installed by or under contract to municipal utilities. See Methodology for an explanation of how these rankings were calculated. See Appendix B for city-specific sources of data.

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Honolulu leads the United States for solar power per person among cities surveyed, followed by San Diego, Albuquerque and San Jose. All of the "Solar Stars" have experienced dramatic growth in solar energy and are setting the pace nationally for solar energy development.

Almost 45 percent of the 57 cities surveyed in each edition of this report more than quadrupled their installed solar PV capacity from 2013 to 2019.

Los Angeles leads the nation in total installed solar PV capacity among all cities surveyed in this report, as it did from 2013 to 2015 and from 2017 to 2018, after briefly being topped by San Diego in 2016. Los Angeles has added over 215 MW of solar capacity since year-end 2016. (See Figure ES-3 and Table ES-2.)

Leading solar cities can be found in every region of the country. Leaders in per capita solar capacity by census region include **Honolulu** in the Pacific

Figure ES-3. Major U.S. cities by total installed solar PV capacity, end of 2019 (MW)

Table ES-2. Top 20 shining cities by total installed solar PV capacity, end of 2019

Total solar PV rank	City	State	Total installed solar PV (MW DC)	Rooftop solar PV potential on small buildings (MW)ǂ	Population	Per capita rank	Per capita solar PV (watts DC per person)
1	Los Angeles	CA	483.8	5,443.7	3,990,456	15	121.24
2	San Diego	CA	420.38	2,218.8	1,425,976	2	294.8
3	Honolulu	HI	292.12	N/A	347,397	1	840.88
4	Phoenix	AZ	272.4	2,981.4	1,660,272	8	164.07
5	San Antonio	TX	254.47	3,721.4	1,532,233	6	166.08
6	New York	NY	244.78	1,276.6	8,398,748	37	29.14
7	San Jose	CA	223.67	1,638.5	1,030,119	4	217.13
8	Albuquerque	NM	153.04	1,252.3	560,218	3	273.19
9	Indianapolis*	IN	122.28	N/A	867,125	12	141.01
10	Las Vegas*	NV	105.79	946	644,644	7	164.1
11	Denver	CO	104.57	677.4	716,492	10	145.95
12	Washington	DC	88.97	343.9	702,455	13	126.66
13	Jacksonville	FL	63.63	1,714.5	903,889	19	70.4
14	Austin	TX	61.84	1,443	964,254	21	64.14
15	Sacramento	CA	57.37	777.2	508,529	16	112.82
16	San Francisco	CA	54.86	671.5	883,305	22	62.11
17	Riverside	CA	50.89	612.1	330,063	9	154.17
18	New Orleans	LA	48.9	1,276.6	391,006	14	125.06
19	Houston	TX	42.53	4,604.7	2,325,502	44	18.29
20	Boston	MA	38.56	340.8	694,583	25	55.51

ǂ Reflects the maximum technical solar PV capacity that could be installed on appropriate small building rooftops in each city. These figures were calculated by the U.S. Department of Energy (DOE): U.S. DOE, Energy Efficiency & Renewable Energy State & Local Energy Data, available at apps1.eere.energy.gov/sled/#. Data were unavailable for cities with "N/A" listed.

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region, **Albuquerque** in the Mountain region, **Indianapolis** in the North Central region, **San Antonio** in the South Central region, **Washington, D.C.** in the South Atlantic region, and **Burlington, Vermont,** in the Northeast region.

Many smaller cities and towns are also going big on solar energy.

- **Las Cruces, New Mexico,** had 10.4 MW of cumulative solar PV capacity installed as of the end of

2019, equivalent to 101 watts per person, making it a solar all-star.[3]

- **Asheville, North Carolina** has 89.5 watts of solar capacity installed per person, enough to be ranked a "solar star.[4]"

- **El Paso, Texas** has 53.5 MW of solar capacity, with installations on the city's main library and municipal service center.[5]

Fossil fuel interests and some utilities are working to slow the growth of distributed solar energy. Over the past few years, many states have considered or passed rollbacks to net metering – the critical practice of crediting solar energy customers for the excess energy they supply to the grid.[6] Additionally, some states and utilities continue to target solar customers with special fees, charges and rate designs in order to reduce the appeal and financial promise of installing solar panels. These changes, such as imposing demand charges and other electric bill fees only on solar customers specifically, could cause solar panel owners to pay as much for electricity as other customers, even though they consume less electricity from the grid.[7]

U.S. cities have only begun to tap their solar energy potential. Some of the cities in this report could generate hundreds of times more solar power than they do today. A National Renewable Energy Laboratory (NREL) study estimated that building rooftops alone are technically capable of hosting 1,118 gigawatts - enough solar energy to cover the annual electricity needs of more than 130 million American homes.[8] Cities can go even further by encouraging stand-alone utility-scale solar installations.

To take advantage of the nation's vast solar energy potential and move America toward 100 percent renewable energy, city, state and federal governments should adopt a series of strong pro-solar policies.

Local governments should, among other things:

- Establish goals for solar energy adoption and create road maps and programs to meet those goals.

- Implement solar access ordinances to protect residents' right to generate solar energy on their own property.

- Make permitting, zoning and inspection processes easy, quick and affordable.

- Expand access to solar energy to apartment dwellers, low-income residents, small businesses and nonprofits through community solar projects and third-party financing options, such as power purchase agreements (PPAs).

- Implement policies that support energy storage, electric vehicle smart charging and microgrids.

- Require new homes and buildings to be built with solar panels, or at least be constructed to be "solar-ready."

- Support and push for strong state-level solar policies.

State governments should, among other things:

- Set or increase renewable energy targets for utilities to supply 100 percent of their electricity using renewable energy and adopt specific requirements for solar energy adoption.

- Adopt and preserve strong statewide interconnection, net metering and virtual net metering policies.

- Ensure that electric rate designs support, not punish, solar adoption.

- Encourage solar energy installations through rebate programs, tax credits and financing programs such as low- or zero-interest loans, green bonds, and Property Assessed Clean Energy (PACE) financing.

The federal government should, among other things:

- Continue and expand financing support for solar energy, particularly the Solar Investment Tax Credit, which provides a 26 percent tax credit for the cost of installing solar panels.[9] The credit should be extended to apply to energy storage systems, such as stand-alone batteries.

- Continue to support research to drive solar power innovations, such as the U.S. Department of Energy's Solar Energy Technologies Office.

Introduction

Solar power shines as an American success story. A rarity just a decade ago, the United States now has enough solar energy installed to power 14.5 million homes – more than one in every 10 homes in America.[10] After a year of rapid growth for the U.S. solar market, which grew by 23 percent in 2019, America now has a total capacity that exceeds 77 gigawatts (GW).[11] Improvements in solar technology and rapidly declining costs make solar energy more attractive with each passing year.

Photo: City of Albuquerque

Rooftop solar panels on the Albuquerque Museum.

America's cities are at the center of the solar energy revolution. In these densely populated areas, solar energy now powers hundreds of thousands of homes, office buildings, schools and businesses, all while helping to clean the air and reduce carbon pollution.

Many cities have demonstrated exceptional leadership in adopting solar power. The key difference between cities that lead and those that lag is effective public policy.

State and local policies are core ingredients of a successful solar market. In the cities where solar energy succeeds, utilities fairly credit solar homeowners for the energy they supply to the grid, installing solar panels is easy and hassle-free, attractive options for solar financing exist, and local governments and officials are committed to supporting solar energy development.

Solar energy adoption in every city also relies on effective federal policies. Federal tax credits for renewable energy make an important contribution to encouraging growth in solar power. However, the current law calls for commercial solar tax credits to fall to 10 percent and residential credits to phase out in 2022.[12]

American solar energy is at a tipping point. In many states, electricity from solar panels is cost-competitive with electricity generated by fossil fuels when subsidies are included – and unsubsidized, utility-scale solar is now cheaper than coal and natural gas.[13] The rapid spread of low-cost solar power, however, poses a threat to the business models of fossil fuel interests and some utilities, who have united in an effort to slow the progress of solar energy.

In 2019 alone, 30 states took action related to residential fixed charges or minimum electric bill increases, some of which could cause solar customers to pay as much for electricity as regular customers, even though they use much less electricity from the grid.[14] Over the past few years, many states have also considered or passed cuts to net metering – the critical practice of crediting solar energy customers for the excess energy they supply to the grid.[15] The outcome of those battles will determine how rapidly cities and the rest of the nation can gain the benefits of solar energy. The urgent need to reduce America's contribution to global warming – along with the other environmental and public health threats posed by fossil fuel production and use – mean that we cannot afford to wait.

Cities continue to lead the way in the transition to a 100 percent clean, renewable energy system. With tremendous unmet potential for solar energy in every city, now is the time for cities, as well as states and the federal government, to recommit to the policies that are bringing a clean, renewable energy system closer to reality.

Solar energy benefits cities

Solar energy helps cities in many ways, including by combating global warming, reducing local air pollution, strengthening the electric grid, and stabilizing energy costs for residents.

Solar energy reduces greenhouse gas emissions

America can limit future impacts of global warming by slashing the use of fossil fuels.[16] Unlike fossil fuel power plants, solar energy systems produce no carbon emissions. Even when emissions from manufacturing, transportation and installation of solar panels are included, solar energy produces 95 percent fewer greenhouse gas emissions than electricity from coal over its entire life cycle, and 90 percent fewer greenhouse gas emissions than electricity from gas-fired power plants.[17] By replacing electricity from fossil fuels with solar power, we can dramatically cut carbon pollution and reduce the impacts of global warming.

Solar energy reduces air pollution, improving public health

Pollution from fossil fuel combustion causes major health problems in American cities. According to the World Health Organization, outdoor air pollution is linked to strokes, heart disease, acute respiratory disease, asthma and lung cancer.[18] These conditions can lead to disability, prolonged absences from work or school, and even death.[19] One study estimated that the 330 coal plant shutdowns in the U.S. between 2005 and 2016 has saved 26,610 lives.[20] Cities in the Midwest and Mid-Atlantic, such as Baltimore, Indianapolis and St. Louis, bear a particularly heavy health burden from pollution due to the high number of coal-fired power plants remaining in those areas.[21]

Solar energy reduces the need for electricity generated by polluting, fossil fuel resources. From 2007 to 2015, wind and solar energy were estimated to prevent between 3,000 and 12,700 premature deaths in the U.S. by improving air quality. [22] The times when the most solar energy is generated, i.e. when there is the most sunlight, tend to coincide with times of peak demand for air conditioning. As a result, solar energy can help replace the need for "peaker" power plants, which only operate when electricity demand is highest and tend to be the oldest, most expensive and most polluting power stations. [23] Also, some local air pollution impacts are exacerbated by high temperatures, meaning replacing high-polluting "peaker" plants with solar energy further benefits public health.[24]

Solar energy makes cities more resilient to disasters

Solar energy, when paired with energy storage or integrated into microgrids, can help keep the power on during disasters when the main electric grid has gone down. Hospitals, fire stations and storm shelters can use solar and battery storage in order to stay online and respond to community needs in times of crisis.[25] After a devastating hurricane in Puerto Rico in 2017, a water treatment plant and children's hospital installed solar panels and batteries, as did several fire stations and community centers. These microgrids kept their facilities powered even after a 2020 earthquake knocked out the island's largest power plant.[26]

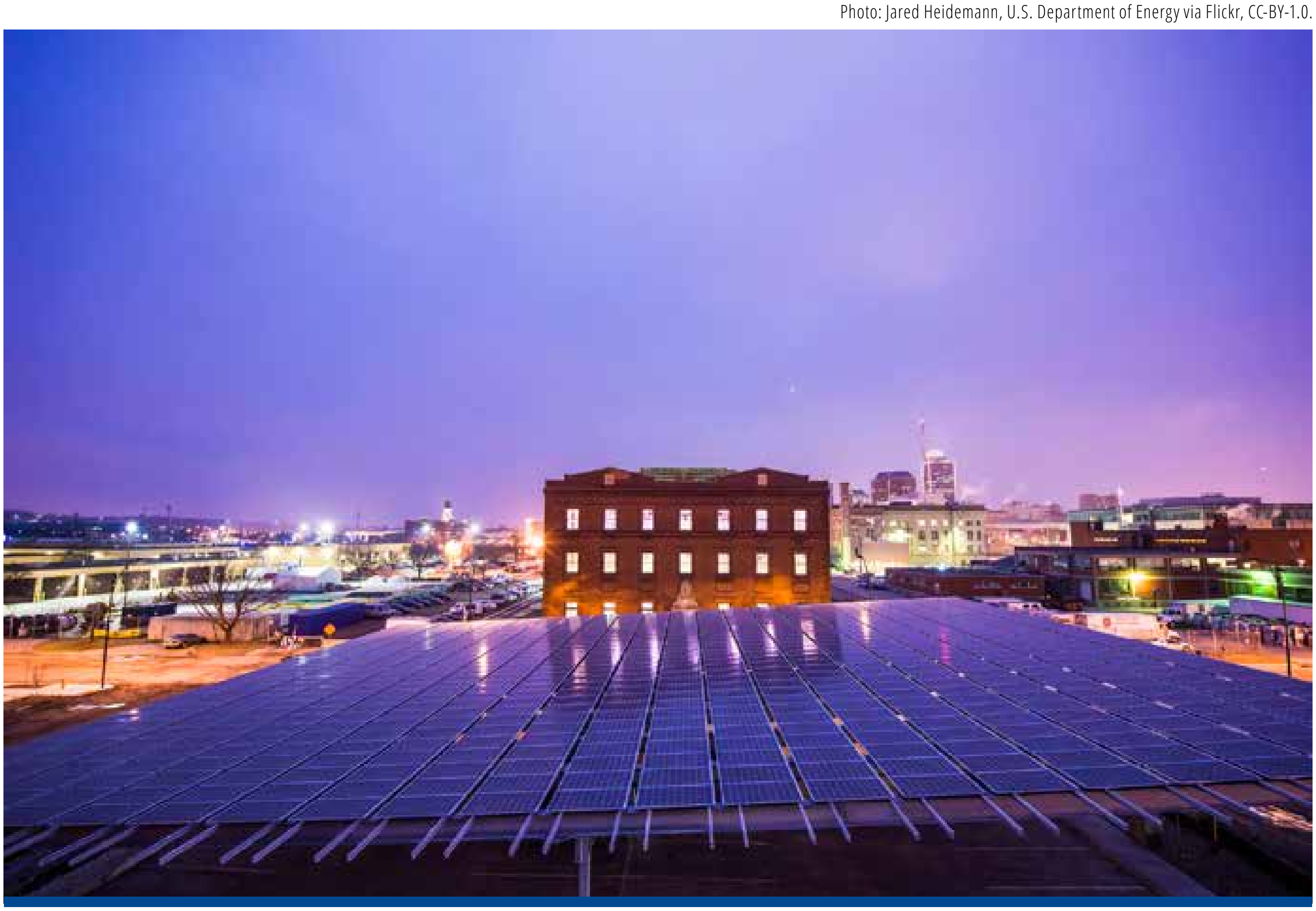
Solar energy also helps cities conserve water in times of drought. Nationally, electricity production accounts for about 34 percent of freshwater withdrawals.[27] Unlike the fossil fuel-fired power plants that currently generate the bulk of American electricity, solar PV systems do not require high volumes of water for cooling.[28] In fact, solar PV systems consume 1/680th of the water of coal power plants and 1/200th of the water of natural gas plants, per unit of electricity produced.[29]

Solar energy benefits consumers

Cities that make solar energy accessible and affordable provide direct and indirect benefits to their residents, including solar energy customers and other members of the community.

Homeowners and business owners who install solar panels on their buildings can generate their own electricity, which helps protect them from spikes and general increases in fossil fuel prices – particularly when they pair their solar panels with energy storage systems, such as batteries.[30]

In states with net metering, when solar panel owners generate more energy than they need at a given point in time they can export this energy to the grid in exchange for credit. They can then use the credit to pay for electricity they receive from the grid later, when their solar panels aren't generating enough energy to provide for their needs. On average, about 20 to 40 percent of a solar energy system's output is exported back to the electric grid, helping meet the need of nearby customers with clean, locally produced solar energy.[31] The credits collected by system owners can help them recoup initial investments made in PV systems.



Solar panels generate power at the Market One commercial building in Des Moines, Iowa.

Distributed solar energy benefits the broader electric grid

The benefits of solar energy extend beyond the buildings on which PV panels are installed. Having more customers produce their own electricity with solar PV panels, particularly when they are paired with batteries, helps utilities avoid the need to turn on – and sometimes even build – "peaker" power plants that are only used when electricity demand is highest. These power plants tend to be the most expensive to operate, so replacing them with solar energy can help save electric utilities money. Also, generating more electricity closer to the locations where it is used reduces the need to construct or upgrade expensive transmission and distribution lines. Localized electricity generation minimizes the amount of energy lost during transmission as well, improving the efficiency of the electric grid.[32] If electric utilities pass these savings on in the form of lower electric bill rates, solar energy can help save all electric customers money.[33]

Batteries and electric vehicles expand solar energy's potential

Energy storage systems and electric vehicles expand the opportunity to use solar power, helping to further reduce greenhouse gas emissions and air pollution by replacing fossil fuels. When solar panels produce more electricity than is immediately needed by a home, energy storage systems can store the energy to be used later. This allows solar panels to meet a higher percentage of electricity needs more of the time. Electric vehicles can serve a similar function by charging when solar panels are producing excess energy. EVs also enable solar energy to power an additional sector of the economy – our transportation system –the leading source of greenhouse gas emissions in the United States in 2017.[34] Fleets of electric vehicles could someday stabilize the grid by banking solar power in their batteries for later deployment.[35]

America's top shining cities are building a clean energy future

City leaders and residents are taking advantage of the opportunities offered by solar energy. In leading cities, officials are setting ambitious goals for solar energy adoption, putting solar panels on city buildings, and working with utilities to upgrade the electric grid and offer their customers incentives to invest in solar energy systems. In these cities, permitting departments are taking steps to reduce fees and processing times for solar installation applications. As a result, city residents, individually and with their neighbors, are cutting their electricity bills and contributing to a cleaner environment by going solar.

This report is our seventh review of installed solar PV capacity in major U.S. cities. This year, the list of cities surveyed starts with the primary cities in the top 50 most populous Metropolitan Statistical Areas in the United States, according to the U.S. Census Bureau.[36] If a state did not have a city included in that list, its most populous city was added. For a complete list of cities, see Appendix A. Sioux Valley Energy, the utility that serves Sioux Falls, South Dakota, reported that there is no solar capacity installed in Sioux Falls' city limits connected to their grid.[37] In previous reports, we have ranked the city of Columbia, South Carolina, but Charleston, South Carolina, now has a higher population, so both cities are featured in this report.

There is no uniform and comprehensive national data source that tracks solar energy capacity by municipality, so the data for this report come from a variety of sources: municipal and investor-owned utilities, city and state government agencies, operators of regional electric grids and non-profit organizations (see Methodology). This may lead to variation among cities in how solar capacity is quantified and in the comprehensiveness of the data. While we endeavored to correct for many of these inconsistencies, readers should be aware that some discrepancies may remain. In some cases, more precise methods were found for measuring solar capacity for this year's report, meaning that comparisons with data reported in previous reports may not be valid. Such cases are noted in Appendix B.

Leading cities continue to grow in solar capacity per capita

The cities ranked in this report vary in size, population and geography. Measuring solar PV capacity installed per city resident, in addition to comparing total installed solar PV capacity, provides a metric for how successfully cities have tapped their solar power potential in relation to their size.

"Solar Stars" are cities with 50 or more watts of installed solar PV capacity per person. These cities have experienced dramatic growth in solar energy in recent years and are setting the pace nationally for solar energy development.

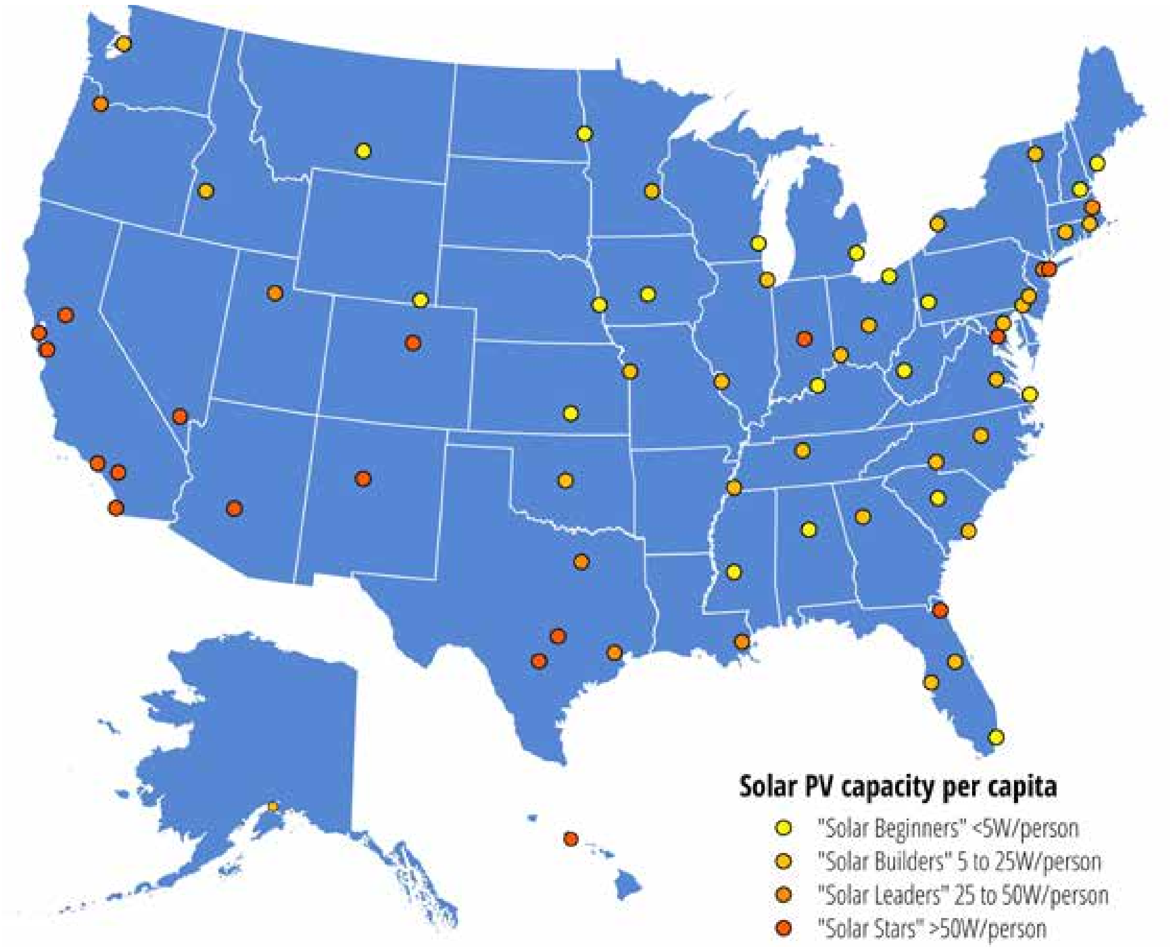


Figure 1. U.S. cities by installed solar PV capacity per capita, end of 2019 (watts per person)

In 2013, only eight of the cities surveyed for this report had enough solar PV capacity per capita to be ranked as "Solar Stars," but now 26 cities have earned the title.

Honolulu ranks first among the surveyed cities in solar PV capacity per person, with over three times as much solar PV capacity per capita as the next highest ranked city, San Diego. Albuquerque, San Jose and Burlington, Vermont round out the top five cities for installed solar PV capacity per person. Wilmington, Portland, Maine, and Portland, Oregon rose to make the "Solar Stars" list for the first time this year.

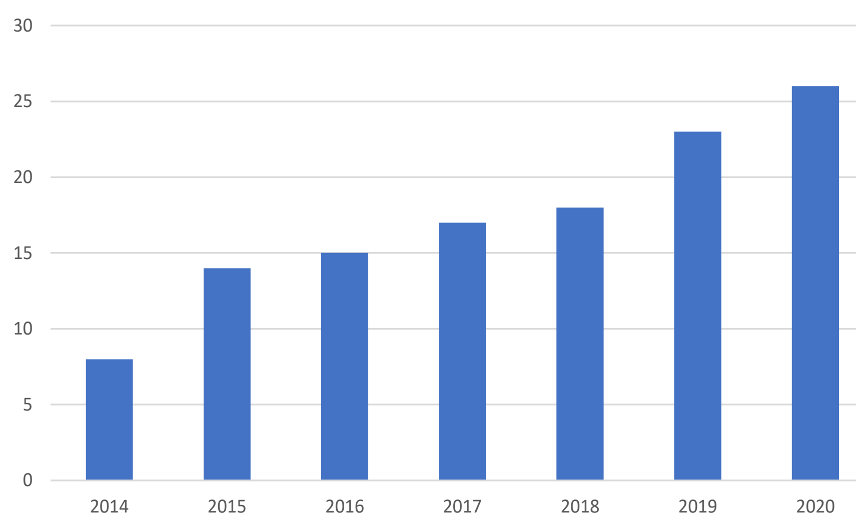


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Table 1. The "Solar Stars" (cities with 50 or more watts of solar PV per person, end of 2019)

Per capita rank	City	State	Per capita solar PV (watts DC per person)ǂ	Change in per capita rank 2018 - 2019	Total installed solar PV (MW DC)	Total solar PV rank
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17	Newark	NJ	96.9	-1	27.33	24
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"Solar Leaders" have between 25 and 50 watts of solar PV installed per person. These cities come from across the country and those with strong policies are rising toward the rank of "Solar Stars." Tampa and Orlando, Florida both showed strong improvement in this ranking during 2019.

Table 2. The "Solar Leaders" (cities with 25 to 50 watts of solar PV per person, end of 2019)

Per capita rank	City	State	Per capita solar PV (watts DC per person)	Change in per capita rank 2018 - 2019	Total installed solar PV (MW DC)	Total solar PV rank
27	Providence	RI	49.76	2	8.92	36
28	Manchester	NH	43.48	3	4.89	51
29	Tampa	FL	42	4	16.5	29
30	Kansas City	MO	39.59	0	19.48	27
31	St. Louis	MO	39.51	1	11.97	32
32	Orlando	FL	34.87	10	9.96	35
33	Boise	ID	33.04	1	7.56	42
34	Seattle	WA	31.85	1	23.73	26
35	Columbia*	SC	31.68	-7	4.23	54
36	Buffalo*	NY	30.54	-10	7.83	40
37	New York	NY	29.14	-1	244.78	6
38	Baltimore	MD	25.42	0	15.31	30

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The "Solar Builders" are cities with between 5 and 25 watts of installed solar PV capacity per person. This diverse group includes cities that have a history of solar energy leadership as well as cities that have only recently experienced significant solar energy development. Dallas, Billings, and Oklahoma City have all worked their way up in the rankings considerably during 2019.

Table 3. The "Solar Builders" (cities with 5 to 25 watts of solar PV per person, end of 2019)

Per capita rank	City	State	Per capita solar PV (watts DC per person)	Change in per capita rank 2018 - 2019	Total installed solar PV (MW DC)	Total solar PV rank
39	Minneapolis	MN	24.18	0	10.29	34
40	Raleigh	NC	23.43	-3	11	33
41	Richmond	VA	22.37	4	5.12	49
42	Cincinnati	OH	22.16	-2	6.7	46
43	Dallas	TX	20.34	10	27.36	23
44	Houston	TX	18.29	6	42.53	19
45	Jackson	MS	16.69	-2	2.74	58
46	Pittsburgh	PA	16.47	-2	4.96	50
47	Charlotte*	NC	15.78	-6	13.76	31
48	Atlanta	GA	14.91	-2	7.43	43
49	Memphis	TN	13.57	-2	8.83	37
50	Philadelphia	PA	10.67	1	16.91	28
51	Nashville	TN	10.6	4	7.09	44
52	Billings	MT	10.54	7	1.16	65
53	Miami	FL	9.99	9	4.7	52
54	Cleveland	OH	9.26	-5	3.56	57
55	Little Rock	AR	9.1	N/A	1.8	62
56	Chicago	IL	9.02	-7	24.42	25
57	Oklahoma City	OK	8.83	8	5.73	48
58	Anchorage	AK	8.22	3	2.4	59
59	Columbus	OH	7.71	-5	6.88	45
60	Milwaukee	WI	7.66	-8	4.54	53
61	Des Moines*	IA	6.79	-13	1.47	64
62	Charleston	WV	6.35	-4	0.3	69
63	Detroit	MI	6.12	3	4.11	55
64	Cheyenne	WY	5.63	-1	0.36	68

* Due to an improvement in methodology or data source for this city, total and per capita solar PV capacity reported in this table are not directly comparable with estimates for this city in previous editions of this report. See Appendix B for details on specific cities.

Table 4. The "Solar Beginners" (cities with less than 5 watts of solar PV per person, end of 2019)

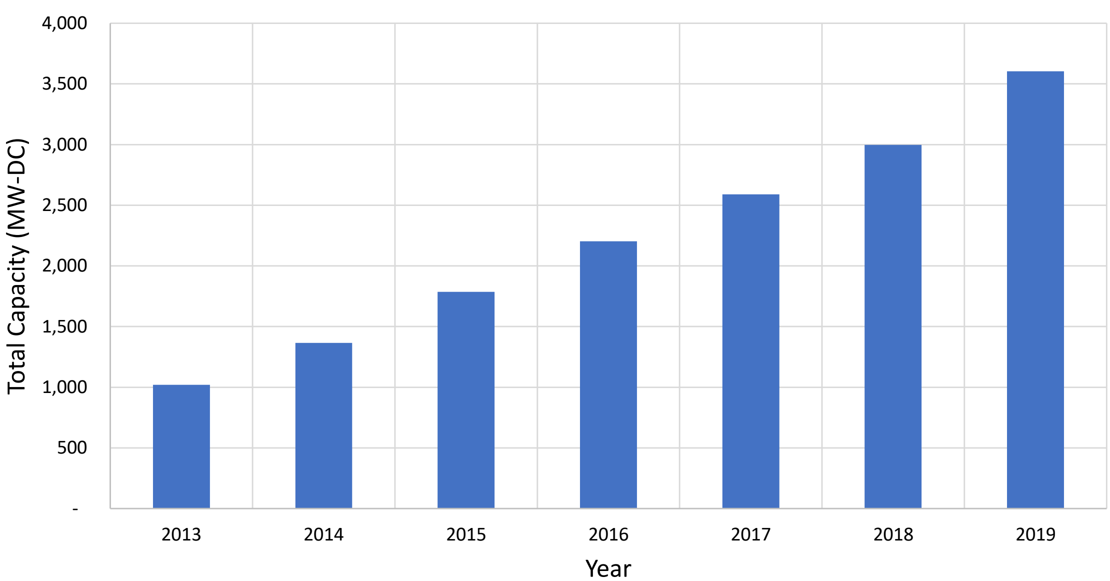
Per capita rank	City	State	Per capita solar PV (watts DC per person)	Change in per capita rank 2018 - 2019	Total installed solar PV (MW DC)	Total solar PV rank
65	Virginia Beach	VA	4.72	4	2.12	61
66	Wichita*	KS	4.54	-6	1.77	63
67	Birmingham*	AL	3.52	-3	0.74	67
68	Louisville*	KY	3.52	-11	2.18	60
69	Omaha	NE	1.77	-2	0.83	66
70	Fargo	ND	1.1	-2	0.14	70

* Due to an improvement in methodology or data source for this city, total and per capita solar PV capacity reported in this table are not directly comparable with estimates for this city in previous editions of this report. See Appendix B for details on specific cities.

The "Solar Beginners" are cities with less than 5 watts of installed solar PV capacity per person. Many of these cities are just beginning to experience significant development of solar energy, while a few have yet to experience much solar energy development. Virginia Beach added 2MW in 2019, up from 0.1MW the year before.

The top seven shining cities have more solar power than the entire U.S. in 2010

Cities that lead the nation in total installed solar PV capacity come from all regions of the U.S. The top seven cities in our report for total solar PV capacity host nearly 2.2 GW of solar PV capacity –



*The solar PV capacities for some individual cities are not directly comparable year to year due to changes in data source or methodology.

Figure 3: Total solar PV capacity of the 57 cities included in all seven editions of Shining Cities*

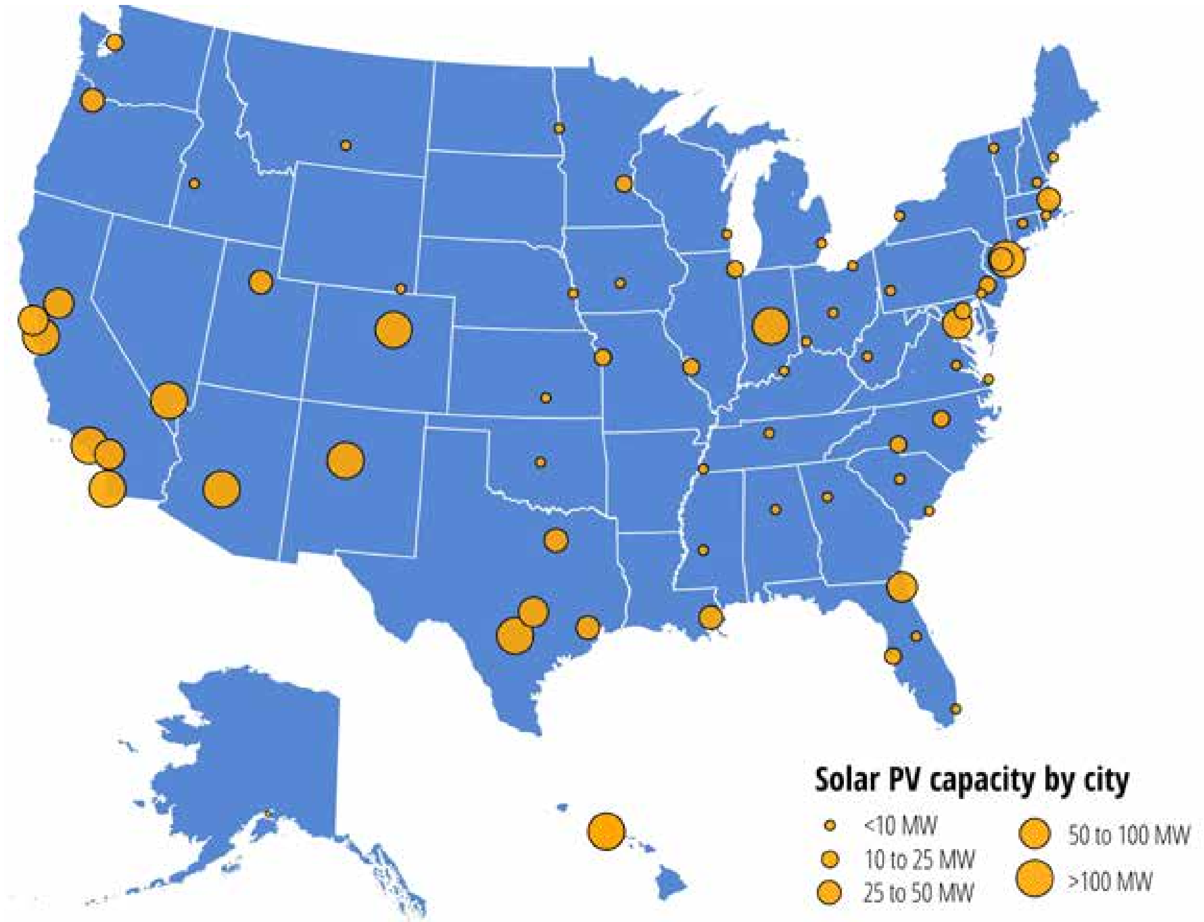


Figure 4. U.S. cities by total installed solar PV capacity, end of 2019 (MW)

more solar power than the entire country had installed at the end of 2010.[38] Despite making up 0.07 percent of the nation's land area, these cities contain almost 3 percent of U.S. solar PV capacity.[39]

Of the 57 cities surveyed in all seven editions of this report, 89 percent more than doubled their total installed solar PV capacity between 2013 and 2019. 44 percent of the surveyed cities more than quadrupled their installed solar PV capacity over that period. Seven cities on this year's list have more solar PV capacity installed than the top city, Los Angeles, did in 2013.

In 2019 Los Angeles defended its title as the leading city for total installed solar PV capacity – a title the city has held from 2013 to 2015 and from 2017 to 2018, after briefly being topped by San Diego in 2016. (See Table 5 and Figure 5.)

Every region of the United States has leading solar cities

Cities in every region of the country have taken leadership in adopting solar energy. Table 6 lists the top two cities in each region with the most installed solar PV capacity per city resident. For this analysis, we used regional designations from the U.S. Census, grouping some regions together for more logical comparisons.[40] We compared cities in the following regions: Pacific, Mountain, North Central, South Central, South Atlantic and the Northeast.

Table 5. Top 20 solar cities by total installed solar PV capacity, end of 2019

Total solar PV rank	City	State	Total installed solar PV (MW DC)	Rooftop solar PV potential on small buildings (MW)‡	Population	Per capita rank	Per capita solar PV (watts DC per person)
1	Los Angeles	CA	483.8	5,443.7	3,990,456	15	121.24
2	San Diego	CA	420.38	2,218.8	1,425,976	2	294.8
3	Honolulu	HI	292.12	N/A	347,397	1	840.88
4	Phoenix	AZ	272.4	2,981.4	1,660,272	8	164.07
5	San Antonio	TX	254.47	3,721.4	1,532,233	6	166.08
6	New York	NY	244.78	1,276.6	8,398,748	37	29.14
7	San Jose	CA	223.67	1,638.5	1,030,119	4	217.13
8	Albuquerque	NM	153.04	1,252.3	560,218	3	273.19
9	Indianapolis*	IN	122.28	N/A	867,125	12	141.01
10	Las Vegas*	NV	105.79	946	644,644	7	164.1
11	Denver	CO	104.57	677.4	716,492	10	145.95
12	Washington	DC	88.97	343.9	702,455	13	126.66
13	Jacksonville	FL	63.63	1,714.5	903,889	19	70.4
14	Austin	TX	61.84	1,443	964,254	21	64.14
15	Sacramento	CA	57.37	777.2	508,529	16	112.82
16	San Francisco	CA	54.86	671.5	883,305	22	62.11
17	Riverside	CA	50.89	612.1	330,063	9	154.17
18	New Orleans	LA	48.9	1,276.6	391,006	14	125.06
19	Houston	TX	42.53	4,604.7	2,325,502	44	18.29
20	Boston	MA	38.56	340.8	694,583	25	55.51

‡ Reflects the maximum technical solar PV capacity that could be installed on appropriate small building rooftops in each city. These figures were calculated by the U.S. Department of Energy (DOE): U.S. DOE, Energy Efficiency & Renewable Energy State & Local Energy Data, available at apps1.eere.energy.gov/sled/#. Data were unavailable for cities with "N/A" listed.

* Due to an improvement in methodology or data source for this city, total and per capita solar PV capacity reported in this table are not directly comparable with estimates for this city in previous editions of this report. See Appendix B for details on specific cities.

In the Pacific region, Honolulu leads with 840.9 watts of solar PV capacity installed per person. Other regional leaders include Indianapolis for the North Central region (141 watts/person), Albuquerque for the Mountain region (273.2 watts/person), San Antonio for the South Central region (166.1 watts/person), Burlington, Vermont, for the Northeast region (183.8 watts/person) and Washington, D.C. for the South Atlantic region (126.7 watts/person).

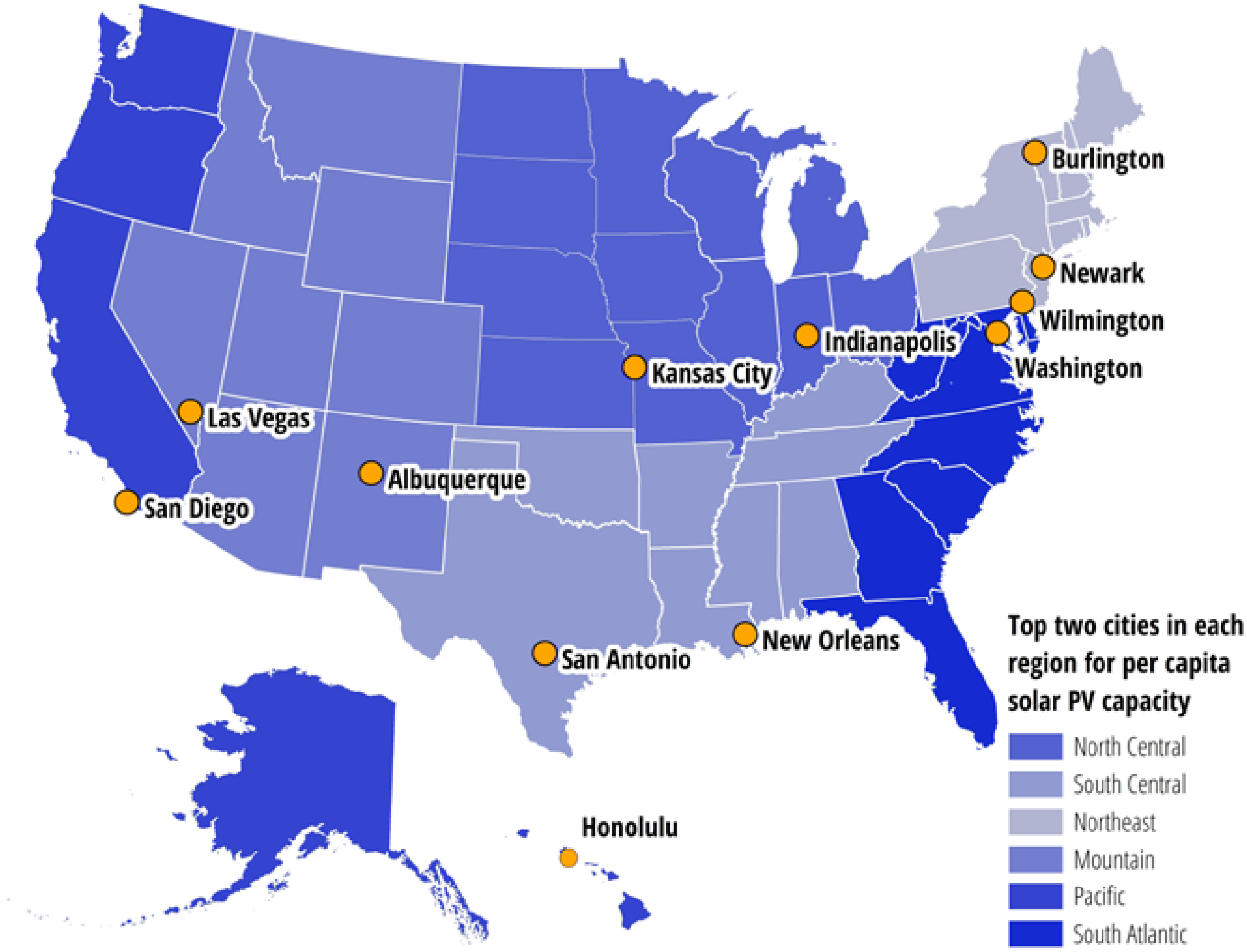


Figure 5. Top two cities in each region ranked by solar PV capacity installed per person, end of 2019

Smaller cities and towns are going big on solar energy

Progress in adopting solar energy is not limited to the nation's largest cities; many smaller cities and towns are going big on solar energy, too. These communities have followed a variety of paths in developing solar energy. In some cases, local governments have played an important role in jumpstarting local solar growth by setting goals for installed solar capacity, implementing solar-friendly laws, and expediting zoning and permitting processes. Some communities with municipal utilities have had an even more direct influence on solar power adoption by establishing ambitious requirements for solar energy adoption and by implementing effective financial incentives. Some places have taken steps to increase the use of solar energy on public facilities, while in other communities, strong state policies are driving local solar power growth. As demonstrated by the following examples, cities can most effectively promote solar power when local, state and utility policies work together.

Table 6. Top two cities in each region ranked by solar PV capacity installed per person, end of 2019

Regional per capita rank	City	State	Region	Per capita solar PV (watts DC per person)	Total installed solar PV (MW DC)
1	Burlington	VT	Northeast	183.8	7.9
2	Newark	NJ	Northeast	96.9	27.3
1	Washington	DC	South Atlantic	126.7	89
2	Wilmington*	DE	South Atlantic	81.7	5.8
1	San Antonio	TX	South Central	166.1	254.5
2	New Orleans	LA	South Central	125.1	48.9
1	Indianapolis*	IN	North Central	141	122.3
2	Kansas City	MO	North Central	39.6	19.5
1	Albuquerque	NM	Mountain	273.2	153
2	Las Vegas*	NV	Mountain	164.1	105.8
1	Honolulu	HI	Pacific	840.9	292.1
2	San Diego	CA	Pacific	294.8	420.4

* Due to an improvement in methodology or data source for this city, total and per capita solar PV capacity reported in this table are not directly comparable with estimates for this city in previous editions of this report. See Appendix B for details on specific cities.

Las Cruces, New Mexico:

After setting a goal of getting 25 percent of its electricity from renewable sources by 2022 and 100 percent by 2050, the city of Las Cruces, New Mexico, has begun replacing energy from fossil fuels with clean energy.[41] The city has solar panels on nine city facilities, and those nine sites produce 2 million kWh annually, offsetting the carbon dioxide of over 1.5 million pounds of coal. In late 2019, the city committed to supporting installations at a dozen more sites by agreeing to buy power from a solar developer who will place panels at the city's airport and at sites owned by the water utility. Over the lifetime of the new panels, the city expects to save $5.8 million on municipal utility costs.[42] Las Cruces has 10.4 MW of installed solar and is in esteemed company with 101 watts per person.[43]

Athens, Georgia:

Athens, in partnership with Clarke County and state and local advocacy groups, has sponsored "solarize" campaigns in which residents who want to go solar can participate in a bulk purchasing program to receive a 10 to 20 percent reduction in the cost of solar energy.[44] Companies and municipal government can also participate. The first Solarize Athens event resulted in 68 installations that added 430 kW of solar capacity.[45] A second Solarize Athens campaign has a goal of 301 kW.[46] Separately, the city has installed more than 1,800 solar panels on its Cedar Creek Water Reclamation Facility, capable of producing more than 1 million kWh of electricity annually.[47] Athens has been recognized for increasing transparency for solar installers and community members, and for addressing zoning restrictions that could inhibit the installation of solar panels.[48] In May 2019, Athens officially committed to switching to 100 percent clean, renewable electricity by 2035, joining Atlanta, Augusta and Clarkston as Georgia cities with a 100 percent clean energy plan.[49] Athens has 3.3 MW of solar and 26 watts per person, making it a true Solar Leader.[50]

El Paso, Texas:

El Paso has a county-wide PACE program that allows access to low-cost financing for solar projects for commercial, industrial, and multi-family residential properties. City zoning codes allow a right to sunlight, forbidding construction that would shade productive solar panels.[51] El Paso Electric, the first utility in Texas and New Mexico to go coal-free, offered a 350MW request for proposals for solar and energy storage in 2019, as part of its promise to increase its investment in utility-scale solar in both states.[52] El Paso's capacity of 50.5 MW of solar power is larger than both Dallas and Houston's, and its per capita capacity of 74 watts per person is comparable with Austin.[53]

El Paso Electric currently offers 5 MW of community solar, capable of powering 2,400 homes, to all ratepayers in its Texas service territory.[54] A public art piece in the style of a contemporary Aztec calendar pavilion, made of concrete, prisms and solar panels, provides public power outlets and educational signs about solar power.[55]

Watertown, Massachusetts:

In late 2018, Watertown became the first community in New England to require solar panels on new commercial buildings.[56] The requirement applies to commercial buildings of more than 10,000 square feet or that have 10 or more units.[57] Parking structures also must have solar panels. Leading by example, Watertown municipal government has installed solar panels on the police station, public works building, and high school.[58] With an installed capacity of 3 MW and 83 watts per person, Watertown ranks among America's Solar Stars.[59]

Palm Springs, California:

Palm Springs has a long history of supporting solar energy. In 2007, the city established a goal of making "maximum use" of solar energy. In 2016, the City Council approved a new sustainability plan that included a requirement that new homes be powered by solar energy, a goal that became official city policy early in 2018.[60] Palm Springs has also been recognized by SolSmart, the federally funded program that recognizes efforts by local governments to lower barriers for solar energy use. Palm Springs received a gold designation for creating an online permitting checklist that makes it easy for citizens and contractors to understand solar permitting requirements, having zoning policies that allow accessory use solar by-right in all major zones, and taking other steps to streamline solar permitting and inspections.[61]

Palm Springs' Sonoran Desert location contributes to its total capacity of over 38.4 MW of installed solar panels. With over 790 watts per person, Palm Springs' per capita capacity is second nationwide only to Honolulu.[62]

Asheville, North Carolina:

In 2018, the U.S. Department of Energy-funded SolSmart program designated Asheville as a gold-level city for its support of solar energy. It received the designation for its commitment to reducing obstacles to solar installations, including by streamlining permitting and training city permit and inspection staff.[63] With 8.3 MW of total capacity and over 89 watts per person, Asheville is also a Solar Star.[64] Also in 2018, Asheville's City Council adopted a resolution committing the city to operate all municipal services with renewable energy and phase out fossil fuels by the end of 2030.[65] As it works to achieve that goal, in partnership with surrounding Buncombe County, Asheville has decided to prioritize local renewable energy development rather than buy clean energy credits from solar and wind projects farther away.[66]

Municipal utilities are advancing solar in their service territories

Every city can implement policies to promote solar energy, but cities with municipal utilities have a unique opportunity to drive the adoption of solar energy. Cities with municipal utilities can set ambitious goals for solar energy and work to meet them by supporting the growth of solar power within their city boundaries, building their own solar power plants outside city limits, or purchasing solar power from facilities owned by others.

We examined municipal utilities in the 70 cities featured in the Shining Cities report to identify the total solar PV capacity installed in the utility's service territory, as well as capacity the utility may own, or have a long-term contract with, located outside of their service territory. We also calculated a per capita solar PV capacity value based on each utility's total electric customers. Researchers attempted to contact all municipal utilities serving cities covered by this report. Data presented here include only those utilities that responded.

Austin Energy, the municipal utility serving Austin and nearby towns, is setting the pace by supplying more than 1,500 watts per person of solar energy to its customers and has a goal to meet 65 percent of customers' energy needs with renewable resources by 2027.[67] LADWP, the nation's largest municipal utility, has installed the most total solar PV capacity, with an impressive 1,842 megawatts. Riverside Public Utilities, which has been owned by its southern Califor-

Table 7. Top municipal utilities among cities surveyed for this report, by solar PV capacity installed, end of 2019

City	Municipal utility*	State	Service territory capacity (MW DC)	Solar owned outside of service territory	Total capacity (MW DC)	Number of electric customers	Per capita solar PV installed (watts-DC/person)
Austin	Austin Energy	TX	137.32	612	749.32	485,204	1,544.34
Los Angeles	LA Department of Water and Power	CA	483.85	1,358.52	1,842.37	1,500,000	1,228.25
Riverside	Riverside Public Utilities	CA	126.1	N/A	126.1	109,000	1,156.88
San Antonio	CPS Energy	TX	314.57	451.2	765.77	820,000	933.86
Sacramento	Sacramento Municipal Utility District (SMUD)	CA	393.18	70	463.18	628,481	729.25
Burlington	Burlington Electric Department	VT	8.48	N/A	8.48	21,500	394.41
Memphis	Memphis Light, Gas, and Water Division	TN	77.83	N/A	77.83	415,000	187.54
Orlando	OUC (Orlando Utilities Commission)	FL	40.28	N/A	40.28	217,919	184.84
Jacksonville	JEA	FL	66.18	N/A	66.18	478,000	138.45
Seattle	Seattle City Light	WA	26.65	N/A	26.65	780,000	34.17
Nashville	Nashville Electric Service	TN	9.58	N/A	9.58	405,636	23.62

* Municipal utility data are not comprehensive.

nia customers since 1895, is one of only two municipal utilities with over a kilowatt of solar per customer.

Fossil fuel interests and some utilities are dimming the promise of solar energy

The fossil fuel industry sees the rapid growth of solar energy as a threat. The rise of consumer interest in installing solar panels is also changing how utilities operate. In resistance to these changes, fossil fuel interests and some utilities are pushing to slow solar energy's growth across the country through various measures, such as rolling back net metering and implementing solar-specific charges on electric bills. The following are just a few examples of cities whose solar energy markets may be hurt going forward by recent policy changes:

- **Detroit:** In June 2018, the state of Michigan replaced its net metering policy with an "avoided cost tariff."[68] Under this new structure, solar energy owners will be credited at a lower rate for the energy they supply to the grid.[69] Solar energy advocates warn that when Nevada implemented a similar change in 2015, the solar energy market there was significantly stunted, and net metering was eventually reinstated in Nevada due to pushback from citizens.[70] In May 2019, the Michigan Public Service Commission approved a new program that would allow DTE Energy, a local utility, to pay less for the power solar rooftops send back to the grid. This is expected to increase the time it takes to recoup an investment in an average solar system from nine years to 13 years. The commission rejected a DTE proposal for even less compensation that would have lengthened that time to 18 years.[71]
- **Baton Rouge:** In September 2019, Louisiana regulators approved a rollback of net metering, scheduled to take effect in 2020. Rather than receiving the retail rate of power, customers will be compensated by utilities for the avoided cost of the power they supply to the grid, less than half the retail value.[72] Utilities supported the decision, which the Public Service Commission claims will allow more investment in utility-scale solar. But local solar advocates argued that utilities are underpaying for the power they receive from distributed generators. New Orleans, where the city council regulates electricity service, is expected to keep net metering.[73]
- **Sacramento:** Despite having procured over 450 megawatts of solar power for its ratepayers, Sacramento Municipal Utility District, or SMUD, has shown resistance to California's new solar rooftop standards. In February 2020, SMUD pushed a proposal through the California Energy Commission to build large, distant solar farms for customers to get solar energy in lieu of installing solar on their rooftops.[74] Critics contend this "SolarShares" plan will squander the opportunity of building solar on suitable new rooftops, lock customers into 20-year commitments to the utility, and compensate residents for power generated on their behalf at below-market rates.[75] SMUD also proposed a "grid access charge" for solar customers that would have added over $40 per month for typical residential solar customers on top of their existing $20 monthly fixed charge, but withdrew the proposal after receiving over 1,200 protest emails in five days.[76]

Solar energy has enormous potential in U.S. cities

While the exponential growth of solar power has already delivered enormous benefits to communities across the U.S., America is still far from tapping its full solar energy potential. A National Renewable Energy Laboratory (NREL) study estimated that building rooftops alone are technically capable of hosting 1,118 GW of solar PV capacity.[77] That is enough solar energy to cover the annual electricity needs of more than 130 million homes, or nine out of every ten homes.[78] Cities also have the potential to develop utility-scale solar installations on open land – adding significantly to the clean energy they can provide to the grid.

Even the nation's leading solar cities have immense untapped solar energy potential – collectively, the cities surveyed in this report have developed five percent of the solar PV capacity they could install on their small building rooftops alone. The leading city for total solar

PV capacity, Los Angeles, could host over 5,000 MW of solar PV capacity on the rooftops of its small buildings alone.[79] That's over 10 times the solar power capacity the city currently has installed.

Washington, D.C, has developed more of its solar PV potential than any other city on this list and its total solar PV capacity is over a quarter of what the city could accommodate on its small building rooftops.[80] Of the cities on this list, 33 could install 50 times as much solar PV as they currently have installed on small rooftops, while 11 have installed over a tenth of their potential. Phoenix, Chicago, San Diego, Oklahoma City and Dallas could each install more than 2,000 MW of solar PV capacity on small rooftops alone. San Antonio could accommodate more than 6,200 MW of solar PV capacity on all of the rooftops in the city.[81]

Policy recommendations

U.S. cities, as centers of population growth and energy consumption, must lead the way in building a grid powered by 100 percent clean, renewable energy. Many cities have already experienced the havoc that global warming can cause through severe weather, drought, increased heavy precipitation and intense heat waves. Increasing solar energy capacity will be critical to reduce greenhouse gas emissions, and create a more resilient and reliable energy system.

Research shows that solar energy policies – more than the availability of sunshine – dictate which states are succeeding in adopting solar energy and which are not.[82] The most effective policies facilitate the wide-scale adoption of small-scale solar energy systems on homes, businesses, and other institutions, while also speeding up the deployment of utility-scale solar energy projects. Policy-makers at every level of government – federal, state and local – have

Solar panels overlook the Tulsa skyline from the city's Central Library.

an important role to play in making sure solar energy continues to thrive.

Local governments should:

- **Set ambitious goals for solar energy adoption –** The cities that are leading in solar energy adoption are not doing so by chance. The second highest-ranked city for total installed solar PV capacity, San Diego, has set the ambitious goal of generating 100 percent of its electricity from renewable sources by 2035.[83] A large part of the city's plan to achieve this goal is implementing programs that promote solar energy.[84] Over 150 cities in the United States have adopted ambitious 100 percent renewable electricity goals, with announcements this past year by Louisville, Philadelphia and Chicago.[85] Burlington, Vermont, one of the top-ranked cities for solar capacity per capita, is one of six communities in the U.S. that have already achieved this goal.[86]
- **Implement solar access ordinances –** These critical protections guard homeowners' right to generate electricity from the sunlight that hits their property, regardless of the actions of their neighbors or homeowners' associations. Laws are in place in 43 states guaranteeing access to a reasonable amount of sunlight.[87] Local governments should also offer clear zoning regulations that allow solar energy installations on residential and commercial rooftops by right, which will help streamline solar installations.[88] The Delaware Valley Regional Planning Commission in the Philadelphia area offers a model ordinance guide that cities can apply to their own local laws.[89]
- **Encourage or require new homes to install solar panels and/or be zero net-energy –** Solar energy is most efficient and cost-effective when it is designed into new construction from the start. State and local governments have adopted policies to require new homes or commercial buildings to have solar power or to be designed so that solar energy can be easily installed. On January 1, 2020, new building codes took effect across the state of California requiring new single-family homes and multi-family homes of up to three stories to install solar PV panels. [90] The City of Tucson requires that new single-family homes or duplexes either include a solar energy system or be pre-outfitted so that future solar PV and hot water systems can be easily installed.[91] Other jurisdictions set goals for new net-zero energy homes, which employ energy efficiency and renewable energy technologies such that they produce as much energy as they consume. By pairing solar energy with highly efficient construction, rooftop solar panels can meet a higher percentage of home energy needs.
- **Make permitting, zoning and inspection processes easy, quick and affordable –** The "soft" costs of solar energy, such as costs related to zoning and permitting and acquiring customers, now make up about two-thirds of the total cost of residential solar energy systems.[92] Reducing fees, making permitting rules clear and readily available, speeding up the permitting process, and making inspections convenient for property owners can significantly lower the barriers for residents to switch to solar energy.[93] Making sure that permitting and inspection staff are properly trained is key to achieving these goals. The SolSmart program, funded by the U.S. DOE Solar Energy Technologies Office (SETO) (formerly known as the SunShot Initiative), provides technical assistance to help cities achieve these goals, such as Chattanooga's work to update its website and solar permitting process and to improve turnaround times for permits.[94] Their website features a webinar and resources on best practices for solar planning and zoning.[95]
- **Expand access to solar energy –** Statewide and citywide financing programs can make solar energy available to all residents, including low-income households, nonprofits, small businesses and apartment dwellers. Community solar programs allow groups of residents to purchase electricity from the same larger solar installation and share in the net metering or other financial benefits. Similarly, "solarize" bulk purchasing programs lower the costs of solar energy so that more residents can

participate.[96] Power purchase agreements (PPAs) are widely utilized and allow apartment occupants and others who cannot install their own solar systems to purchase and benefit from solar energy. The Property Assessed Clean Energy (PACE) program allows local and state governments to loan money to home and business owners for energy improvements. This program includes an option to tie a loan for a solar installation to the property itself so that it is transferred to the new owner if the property is sold. This program has been key for property owners who are concerned that they may move before they recoup their investment in a solar installation.[97]

- **Consider creating a municipal utility or community choice aggregation system in communities where investor-owned utilities are unwilling to cooperate to promote solar power –** Municipally owned utilities have been among the nation's leaders in promoting solar power. Our municipal rankings section showcases examples of municipal utilities that have gone above and beyond in expanding their solar capacity. Cities served by less supportive utilities may want to consider forming a municipal utility in order to gain greater leverage over their local electric grids. The City of Denver, for example, partnered with its local utility, Xcel Energy, in 2018 in order to improve collaboration as the city seeks to meet its goal of reducing emissions by 80 percent by 2050.[98] Community choice aggregation is another option available in some states in which the city, rather than the utility, is responsible for purchasing power for its residents, but unlike a municipal utility, the private utility still maintains the power lines and provides customer service.[99]

- **Install solar panels on public buildings –** Local governments can promote solar energy by installing solar panels and signing solar PPAs for public buildings. A 2017 study found that there are about 5,500 K-12 schools across the country that have installed solar energy systems with a combined capacity of 910 MW.[100] In 2016, the city government of Albuquerque committed to generate 25 percent of its energy needs from solar energy by 2025 and the city government of Las Vegas now gets 100 percent of its energy from renewable sources.[101] Not only do solar installations on public buildings save governments money on their electricity bills, but they also serve as a public example of a smart, clean energy investment.

- **Implement policies that support energy storage, electric vehicle charging and microgrids –** Technological advances are enabling solar energy to be used in new ways, including to charge electric vehicles (EVs) and to be integrated with energy storage technologies and other energy resources in microgrids. Local governments should alter their ordinances to allow these technologies to be easily adopted.[102] See the Environment America Research & Policy Center reports Making Sense of Energy Storage and Plugging In for guidance on making policies friendly to energy storage and EV adoption.[103]

- **Support and push for strong state policies –** State policies can have a large impact on a city's ability to expand solar energy, so it is important that cities work together to support and push their state governments to enact the policies recommended below.

State governments should:

- **Set or increase renewable energy targets for utilities and adopt specific requirements for solar energy –** States should adopt or increase mandatory renewable electricity standards (RES) that move toward 100 percent renewable energy and include solar carve-outs that require a significant and growing share of that state's electricity to come from the sun. States should also ensure that utilities implement solar power wherever it is a beneficial solution for meeting electricity needs, including as part of utilities' long-term resource plans. In 2019, New Mexico passed a law requiring for-profit utilities to generate 100 percent of the electricity they sell from renewable sources by 2045, with phase-in targets along the way.[104] New Mexico joins New York, Maine, Washington and Nevada in passing 100 percent clean energy initiatives in 2019.[105]

- **Adopt and preserve strong statewide interconnection and net metering policies –** Strong interconnection policies ensure that individuals and businesses can easily connect their solar PV systems to the electric grid and move seamlessly between producing their own electricity and using electricity from the grid. It is critical that states ensure that their interconnection process is straightforward and efficient in order to make it easy to "go solar."[106] Net metering policies ensure that solar panel owners are appropriately credited for the electricity that they export to the grid. In states without strong net metering programs, carefully implemented CLEAN contracts (also known as feed-in tariffs) and value-of-solar payments can play an important role in ensuring that consumers receive fair crediting for solar energy, so long as the payments fully account for the benefits of solar energy and are sufficient to spur participation in the market.

- **Reject putative rate designs for solar customers –** Many utilities are now adding or increasing charges on electric bills that can cause solar customers to pay steep fees for generating their own electricity.[107] These include demand charges, which are based on the period of time in the month (typically a 15-60 minute interval) in which a customer used the most power from the grid. Some utilities also assign higher fixed monthly charges to solar customers specifically.[108] State governments and utility regulators should reject proposals such as this that discourage customers from switching to solar energy.

- **Establish policies that expand solar energy access to all residents –** According to NREL, 49 percent of Americans either don't own a home or have insufficient access or space on their rooftops.[109] Policies such as virtual or aggregate net metering and community solar allow low-income households, renters and apartment dwellers to collectively own solar energy systems and share in the net metering credits they generate. Enabling PACE financing can also expand access to solar power.

- **Establish public benefits charges on utility bills or other sustainable financing mechanisms for solar energy –** These practices help fund solar energy for low-income households, non-profits, small businesses, and local municipalities to ensure that all categories of customers have access to the benefits of solar power.

- **Enable third-party sales of electricity –** Financing rooftop solar energy systems through third-party electricity sales significantly lowers the up-front cost of installing solar PV systems for commercial and residential consumers. States should allow companies that install solar panels to sell electricity to their customers without subjecting them to the same regulations as large utilities.

- **Implement, maintain or increase tax credits, rebates and grants for solar energy installations –** Tax credits, rebates and grants are powerful incentives that have made solar energy a financial option for many more Americans.

- **Implement policies that support energy storage, electric vehicle charging and microgrids –** State governments should design policies that facilitate the transition from an electric grid reliant on large, centralized power plants to a "smart" grid where electricity is produced at thousands of locations and shared across an increasingly nimble and sophisticated infrastructure. Such state policies should support the expansion of energy storage technologies, electric vehicle charging and microgrids. In late 2019, Minnesota became the first state to pass national interconnection standards, laying out rules for "smart inverters" which allow the grid to safely use more distributed energy.[110]

Strong and thoughtful federal policies can promote solar power, make it more accessible, and lay an important foundation on which state and local policy initiatives can be built. Among the key policy approaches that the **federal government** should take are the following:

- **Continue and expand financing support for solar energy –** The solar Investment Tax Credit, a key incentive program for solar energy, began a gradual phase down in 2020, and the residential credits will expire completely in 2022.[111] The federal government should maintain federal tax credits for solar energy, but also add provisions as necessary to enable nonprofit organizations, housing authorities and others who are not eligible for tax credits to benefit from those incentives. The tax credit should also be expanded to apply to stand-alone energy storage systems, such as home batteries.
- **Support research to drive solar power innovations –** The U.S. DOE SETO and similar initiatives facilitate solar energy adoption by investigating the best ways to integrate solar energy into the grid, deliver solar energy more efficiently and cost-effectively, and lower market barriers to solar energy. The federal government should also invest in research and development of energy storage, including through ARPA-E, to ease the integration of renewable energy into the grid, to strengthen cities' grids in the face of extreme weather, and to unlock the other benefits of energy storage.[112]
- **Lead by example –** The federal government consumes vast amounts of energy and manages thousands of buildings. If the federal government were to put solar installations on every possible rooftop, it would set a strong example for what can be done to harness the limitless and pollution-free energy of the sun. The Department of Defense, for example, aims to obtain one-quarter of its energy from renewable sources by 2025, and one utility has already installed more than 400 MW of solar energy capacity on military bases in the Southeast.[113]
- **Expand access to solar energy –** Federal agencies such as the Department of Housing and Urban Development and the Department of Education should work to expand access to solar energy for subsidized housing units and schools by installing solar power on those facilities or enabling community solar projects. Programs designed to provide fuel assistance to low-income customers, such as the Low-Income Home Energy Assistance Program, should be expanded to include solar energy.

Methodology

There is no uniform national data source that tracks solar energy by municipality. As a result, the data for this report come from a variety of sources: municipal and investor-owned utilities, city and state government agencies, operators of regional electric grids and non-profit organizations. These data sources have varying levels of comprehensiveness, with varying levels of geographic precision, and often use different methods of quantifying solar PV capacity (e.g., AC versus DC capacity).

We have worked to obtain data that are as comprehensive as possible, resolve discrepancies in various methods of estimating solar PV capacity, limit the solar facilities included to only those within the city limits of the municipalities studied, and, where precise geographic information could not be obtained, use reasonable methods to estimate the proportion of a given area's solar energy capacity that exists within a particular city. Much of the data is provided by utilities, the majority of which only track grid-tied solar energy systems, so most cities lack data for non-grid-tied installations. The data are sufficiently accurate to provide an overall picture of a city's adoption of solar power and to enable comparisons with its peers. Readers should note, however, that inconsistencies in the data can affect individual cities' rankings. The full list of sources of data for each city is provided in Appendix B along with the details of any data analyses performed.

For some cities, our most recent solar capacity estimates are not directly comparable to previous estimates listed in earlier editions of *Shining Cities*. In some cases, this is because some solar energy systems installed toward the end of the year were not reported by the time we collected data. Also, for some cities, we were able to obtain more precise and complete data this year. In a few cases, our current estimate is lower than previous estimates for the same city, due either to inconsistencies in the data reported to us by the cities or improved precision in assigning solar installations to cities. For an explanation of individual discrepancies, see Appendix B.

Selecting the cities

The cities evaluated in this report consist of the principal cities in the top 50 most populous Metropolitan Statistical Areas in the United States according to the U.S. Census Bureau and the most populous cities in each state not represented on that list.[114] In South Carolina, Charleston now has a larger population than Columbia, but we decided to continue to include Columbia in our analysis for continuity with previous reports. Sioux Valley Energy, the utility that serves Sioux Falls, South Dakota, reported that there is no solar capacity installed in Sioux Falls' city limits connected to their grid.[115] For a complete list of cities, see Appendix A.

Converting from AC watts to DC watts

Jurisdictions and agencies often use different methods of quantifying solar PV capacity (e.g., alternating current (AC) and direct current (DC)). Solar PV panels produce energy in DC, which is then converted to AC in order to power a home or business or enter the electric grid. Solar capacity reported in AC watts accounts for the loss of energy that occurs when DC is converted to AC.[116]

We attempted to convert all data to DC watts for the sake of accurate comparison across cities. When we could not determine whether the data were reported in AC watts or DC watts, we made the conservative estimate that the data were in DC watts. To convert the estimate of solar capacity from AC to DC megawatts (MW), we used the default DC to AC ratio in NREL's *PV Watts Calculator* of 1.2.[117] A different conversion factor was used in the 2014 to 2017 versions of this reports, which affects year to year comparisons for some cities.

Using data on solar PV installations by zip code to estimate capacity within city limits

In some cases, we were only able to find data on solar PV capacity installed by zip code in an urban area. Zip codes do not necessarily conform to city boundaries; in many cases, a zip code will fall partially inside and partially outside of a city's boundaries. For these cities, we used QGIS software and U.S. Census Bureau cartographic boundary files for Zip Code Tabulation Areas and city boundaries to determine the share of the area in each zip code that fell within municipal boundaries. We then multiplied the total solar PV capacity within each zip code by that percentage to approximate solar capacity installed within city limits. Details of calculations for cities for which a geospatial analysis was performed are given in Appendix B. For municipal utility analyses, we relied on data provided by the utility for solar PV capacity in their area of coverage, and any additional capacity owned or under long-term contract by the utility.

Appendix A – solar energy in major U.S. cities

City	State	Population	Per capita rank	Per capita solar PV (watts DC per person)	Total solar PV rank	Total installed solar PV (MW DC)‡	Rooftop solar PV potential on small buildings (MW)†
Albuquerque	NM	560,218	3	273.19	8	153.04	1,252.30
Anchorage	AK	291,538	58	8.22	59	2.4	N/A
Atlanta	GA	498,044	48	14.91	43	7.43	495.5
Austin	TX	964,254	21	64.14	14	61.84	1,443.00
Baltimore	MD	602,495	38	25.42	30	15.31	459.7
Billings	MT	109,550	52	10.54	65	1.16	229
Birmingham*	AL	209,880	67	3.52	67	0.74	536.8
Boise	ID	228,790	33	33.04	42	7.56	428.1
Boston	MA	694,583	25	55.51	20	38.56	340.8
Buffalo*	NY	256,304	36	30.54	40	7.83	511.9
Burlington	VT	42,899	5	183.8	39	7.88	43.5
Charleston*	SC	136,208	24	55.52	41	7.56	266.6
Charleston	WV	47,215	62	6.35	69	0.3	152.9
Charlotte*	NC	872,498	47	15.78	31	13.76	1,355.80
Cheyenne	WY	63,957	64	5.63	68	0.36	150.2
Chicago	IL	2,705,994	56	9.02	25	24.42	2,775.30
Cincinnati	OH	302,605	42	22.16	46	6.7	509.7
Cleveland	OH	383,793	54	9.26	57	3.56	734.2
Columbia*	SC	133,451	35	31.68	54	4.23	251.7
Columbus	OH	892,533	59	7.71	45	6.88	1,904.80
Dallas	TX	1,345,047	43	20.34	23	27.36	2,082.70
Denver	CO	716,492	10	145.95	11	104.57	677.4

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City	State	Population	Per capita rank	Per capita solar PV (watts DC per person)	Total solar PV rank	Total installed solar PV (MW DC)‡	Rooftop solar PV potential on small buildings (MW)†
Des Moines*	IA	216,853	61	6.79	64	1.47	351.1
Detroit	MI	672,662	63	6.12	55	4.11	1,255.90
Fargo	ND	124,844	70	1.1	70	0.14	150.6
Hartford	CT	122,587	20	69.8	38	8.56	117.5
Honolulu	HI	347,397	1	840.88	3	292.12	N/A
Houston	TX	2,325,502	44	18.29	19	42.53	4,604.70
Indianapolis*	IN	867,125	12	141.01	9	122.28	N/A
Jackson	MS	164,422	45	16.69	58	2.74	421.9
Jacksonville	FL	903,889	19	70.4	13	63.63	1,714.50
Kansas City	MO	491,918	30	39.59	27	19.48	970.6
Las Vegas*	NV	644,644	7	164.1	10	105.79	946
Little Rock	AR	197,881	55	9.1	62	1.8	398.7
Los Angeles	CA	3,990,456	15	121.24	1	483.8	5,443.70
Louisville*	KY	620,118	68	3.52	60	2.18	N/A
Manchester	NH	112,525	28	43.48	51	4.89	158.6
Memphis	TN	650,618	49	13.57	37	8.83	1,439.30
Miami	FL	470,914	53	9.99	52	4.7	750.7
Milwaukee	WI	592,025	60	7.66	53	4.54	848.7
Minneapolis	MN	425,403	39	24.18	34	10.29	359.4
Nashville	TN	669,053	51	10.6	44	7.09	N/A
New Orleans	LA	391,006	14	125.06	18	48.9	1,276.60
New York	NY	8,398,748	37	29.14	6	244.78	1,276.60
Newark	NJ	282,090	17	96.9	24	27.33	154.1
Oklahoma City	OK	649,021	57	8.83	48	5.73	2,089.30
Omaha	NE	468,262	69	1.77	66	0.83	875.7
Orlando	FL	285,713	32	34.87	35	9.96	582.5
Philadelphia	PA	1,584,138	50	10.67	28	16.91	884.2
Phoenix	AZ	1,660,272	8	164.07	4	272.4	2,981.40
Pittsburgh	PA	301,048	46	16.47	50	4.96	388

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City	State	Population	Per capita rank	Per capita solar PV (watts DC per person)	Total solar PV rank	Total installed solar PV (MW DC)‡	Rooftop solar PV potential on small buildings (MW)†
Portland	OR	653,115	23	57.9	21	37.82	1,396.60
Portland	ME	66,417	26	54.75	56	3.64	108.6
Providence	RI	179,335	27	49.76	36	8.92	195.7
Raleigh	NC	469,298	40	23.43	33	11	673.9
Richmond	VA	228,783	41	22.37	49	5.12	401.1
Riverside	CA	330,063	9	154.17	17	50.89	612.1
Sacramento	CA	508,529	16	112.82	15	57.37	777.2
Salt Lake City	UT	200,591	11	141.17	22	28.32	276.4
San Antonio	TX	1,532,233	6	166.08	5	254.47	3,721.40
San Diego	CA	1,425,976	2	294.8	2	420.38	2,218.80
San Francisco	CA	883,305	22	62.11	16	54.86	671.5
San Jose	CA	1,030,119	4	217.13	7	223.67	1,638.50
Seattle	WA	744,955	34	31.85	26	23.73	1,080.50
St. Louis	MO	302,838	31	39.51	32	11.97	631.7
Tampa	FL	392,890	29	42	29	16.5	783.1
Virginia Beach	VA	450,189	65	4.72	61	2.12	859.9
Washington	DC	702,455	13	126.66	12	88.97	343.9
Wichita*	KS	389,255	66	4.54	63	1.77	802.5
Wilmington*	DE	70,635	18	81.65	47	5.77	72

‡ Includes all solar PV capacity (rooftop and utility-scale solar installations) within the city limits of each city. Does not include solar power installed in the extraterritorial jurisdictions of cities, even those installed by or under contract to municipal utilities. See Methodology for an explanation of how these rankings were calculated. See Appendix B for city-specific sources of data.

† Reflects the maximum technical solar PV capacity that could be installed on appropriate small building rooftops in each city. These figures were calculated by the U.S. Department of Energy (DOE): U.S. DOE, Energy Efficiency & Renewable Energy State & Local Energy Data, available at apps1.eere.energy.gov/sled/#. Data were unavailable for cities with "N/A" listed.

* Due to an improvement in methodology or data source for this city, total and per capita solar PV capacity reported in this table are not directly comparable with estimates for this city in previous editions of this report. See Appendix B for details on specific cities.

Appendix B – detailed sources and methodology by city

Albuquerque, New Mexico

The Public Service Company of New Mexico (PNM), which serves the city of Albuquerque, provided us total solar PV capacity installed within Albuquerque as of 31 December 2019 in DC watts.[118]

Anchorage, Alaska

The two electric utilities serving the city of Anchorage, Chugach Electric and Anchorage Municipal Light and Power, provided us with summary information on the solar PV capacity installed in Anchorage's city limits as of the end of 2019 in AC watts, which we converted to DC watts.[119]

Atlanta, Georgia

Southface (www.southface.org) provided us with a list of solar PV installations in DeKalb and Fulton counties through 31 December 2019 with latitude and longitude coordinates for each installation.[120] Some data were provided in AC watts, which we converted to DC watts, and some were provided in DC watts. We used this information to map the installations using the open source software QGIS to isolate solar capacity within the city limits of Atlanta. Southface maintains a map of "Georgia Energy Data" at www.GeorgiaEnergyData.org.

Austin, Texas

Austin Energy, which serves the greater Austin metropolitan area, provided us with a spreadsheet of all the solar PV installations within Austin-area zip codes as of 31 December 2019 in DC watts.[121] We used geographic analysis to limit our capacity estimates to within city limits. We note that our final figure does not account for solar power generated by the 30 MW Webberville solar farm, which is located in the village of Webberville. [122] While the Webberville Solar Farm supplies solar energy to Austin residents through a PPA with Austin Energy, the facility is located outside of city limits and therefore was excluded from the analysis.

Baltimore, Maryland

Data for solar PV installations in Baltimore, as of December 2019, were downloaded in a spreadsheet called "Renewable Generators Registered in GATS" through the Generation Attribute Tracking System (GATS), an online database administered by the PJM regional transmission organization.[123] To focus on solar PV installations within Baltimore city limits, we filtered by primary fuel type "SUN" for "Baltimore City." Data were assumed to be in DC watts.

Billings, Montana

Northwestern Energy, the utility serving Billings, provided the grid-tied solar PV capacity installed within the city limits of Billings in DC watts as of 31 December 2019.[124]

Birmingham, Alabama

Alabama Power, the electric utility serving the city, provided an estimate of installed solar PV capacity in Birmingham through the end of 2019 in AC watts, which we converted to DC watts.[125] This figure provided was updated to be within city boundaries, so it may not be comparable with the figure from last year's report.

Boise, Idaho

Idaho Power, the electric utility serving Boise, provided the total solar PV capacity of net-metered installations tied to their grid within Boise as of 31 December 2019 in DC watts.[126]

Boston, Massachusetts

We downloaded the "Solar PV Systems in MA Report" spreadsheet from the Massachusetts Clean Energy Center online Product Tracking System.[127] We filtered this list to installations in the city of Boston. This list may be incomplete because it is current only to 1 November 2019, and only includes systems that are fully registered with the Production Tracking System. The total solar PV capacity installed within Boston may, therefore, be higher than the reported figure.

Buffalo, New York

Data on solar PV installations in the city of Buffalo were obtained from the Open NY Database in the spreadsheet "Solar Electric Programs Reported by NYSERDA: Beginning 2000."[128] We summed the capacities, which are listed in DC watts, for installations completed before 31 December 2019 in the city of Buffalo. We then used geographic analysis to limit our capacity estimates to within city limits, so values for this year are not directly comparable with last year's edition.

Burlington, Vermont

A list of solar PV installations in Burlington at the end of 2019 was provided by the City of Burlington's Electric Department.[129] Capacity figures were listed in AC watts, which we converted to DC watts.

Charleston, South Carolina

We estimated the amount of solar PV capacity in Charleston based on zip code-level data provided by the South Carolina Energy Office.[130] We used geographic analysis to limit our capacity estimates to within city limits, so results may not be directly comparable with last year's results.[131] Data were provided in AC watts, which we converted to DC watts. Data were only available through July 31, 2019, so it is likely that systems were added after that date and, thus, that solar PV capacity in Charleston was higher by 31 December 2019. This is the second year that Charleston, South Carolina has been included in the Shining Cities report.

Charleston, West Virginia

American Electric Power Company, the utility serving Charleston, West Virginia, was not able to participate in the data gathering this year and therefore figures are current as of 31 December 2018.[132]

Charlotte, North Carolina

The North Carolina Sustainable Energy Association (NCSEA) provided us with the total solar PV capacity installed within Charlotte in DC Watts, as opposed to last year's source of Duke Energy.[133] We then used geographic analysis to limit our capacity estimates to within city limits based on address-level data, so values for this year are not directly comparable with last year's edition. Data provided for Charlotte were current as of 22 September 2019, so the capacity in Charlotte as of 31 December 2019 may be higher than the figure listed, by an anticipated 1.7MW DC.[134]

Cheyenne, Wyoming

Black Hills Corporation, the electric utility serving Cheyenne, was unable to provide us with an updated figure for 2019, so we used the most recent data provided, total solar PV capacity installed within Cheyenne as of 31 December 2017 in AC watts, which we converted to DC watts.[135]

Chicago, Illinois

Commonwealth Edison, the electric utility serving the city of Chicago, provided us with the total solar

PV capacity tied to their grid within Chicago as of 31 December 2019 in AC watts, which we converted to DC watts.[136]

Cincinnati, Ohio

Duke Energy, the electric utility serving Cincinnati, provided the total solar PV capacity installed within Cincinnati through the end of 2019 in AC watts, which we converted to DC watts.[137]

Cleveland, Ohio

We downloaded a spreadsheet of approved renewable energy generating facilities in Ohio from the Public Utilities Commission of Ohio's (PUCO) web page.[138] We filtered this spreadsheet for solar PV installations approved in 2019 in Cuyahoga County, Ohio. To determine which systems were installed in Cleveland, we looked up the corresponding Case Reference numbers on PUCO's website, which included addresses associated with the installations.[139] The Cuyahoga County Department of Sustainability provided us with the total solar PV capacity of residential co-op systems installed within Cleveland during 2019 in DC watts.[140] These installations did not include the Cleveland systems on the PUCO list, so we added both figures to the total capacity installed within Cleveland at the end of 2018 to estimate the total capacity at the end of 2019. Neither data source is comprehensive, so it is possible that solar PV capacity in Cleveland at the end of 2019 is higher than the figure listed.

Columbia, South Carolina

We estimated the amount of solar PV capacity in Columbia based on zip code-level data provided by the South Carolina Energy Office.[141] We used geographic analysis to limit our capacity estimates to within city limits, so results may not be directly comparable with last year's results. Data were provided in AC watts, which we converted to DC watts. Data were only available through 31 July 2019, so it is likely that the total solar PV capacity in Columbia was higher as of 31 December 2019.

Columbus, Ohio

The City of Columbus Department of Public Utilities provided solar PV capacity installed in Columbus as of 31 December 2019 in DC watts.[142]

Dallas, Texas

Oncor Electric Delivery, the utility serving Dallas, provided solar PV capacity installed in Dallas as of 31 December 2019 in AC watts, which we converted to DC watts.

Denver, Colorado

The City and County of Denver Community Planning and Development Department provided us with a spreadsheet of all permits issued in the city relating to solar PV systems, with capacities listed in DC watts.[143] We filtered these data for new solar PV installation permits completed during 2019. Some permits contained capacity information only in a descriptive note format, so for these installations we identified and included capacity values where clearly noted. We added the estimated total capacity of installations added during 2019 to the cumulative capacity at the end of 2018 to estimate the total solar PV capacity installed within Denver as of 31 December 2019.

Des Moines, Iowa

MidAmerican Energy, the energy company that serves Des Moines, provided us with the solar PV capacity installed by Des Moines-area zip codes as of 31 December 2019 in AC watts.[144] We converted this figure to DC watts and used geographic analysis to limit our capacity estimates to within city limits, so values for this year are not directly comparable with last year's edition.

Detroit, Michigan

Total solar PV capacity added within the city of Detroit during 2019 was provided by DTE Energy, the electric utility serving the city.[145] Data were provided in AC watts, which we converted to DC watts and added to the total solar PV capacity in Detroit as of 31 December 2018. We also added 2.3MW of utility-owned capacity within city limits that was heretofore uncounted and updated last year's totals.

Fargo, North Dakota

An estimate of solar PV capacity in Fargo as of 31 December 2019 was provided in DC watts by Cass County Electric Cooperative, which serves part of the city.[146] Xcel Energy, which serves the other part of Fargo, provided its estimate of solar PV capacity installed within Fargo as of 31 December 2019 in AC watts, which we converted to DC watts.[147] We then summed both figures.

Hartford, Connecticut

The Connecticut Public Utilities Regulatory Authority provided a spreadsheet listing solar facilities approved under Connecticut's Renewable Portfolio Standard in both AC and DC watts.[148] We totaled all solar PV capacity installed in the city of Hartford through 31 December 2019 and converted all AC figures to DC watts.

Honolulu, Hawaii

We estimated the amount of solar PV capacity in Honolulu from county-level data as of 31 December 2019 released by Hawaiian Electric, the company serving the County of Honolulu (which is coterminous with the island of O'ahu).[149] Within the island of O'ahu, the census designated place "Urban Honolulu CDP" is the area most comparable with other U.S. cities. We multiplied the total capacity of solar PV installations within Honolulu County by the portion of county housing units that fall within Urban Honolulu CDP to estimate the solar PV capacity in Honolulu.[150] Solar PV capacity figures are reported to Hawaiian Electric in a combination of AC and DC watts and we were unable to determine which values were given in which units, so we made the conservative assumption that all data were listed in DC watts.

Houston, Texas

Total installed solar PV capacity within Houston city limits as of 31 December 2019 was provided by CenterPoint Energy, the electric utility serving the city, in AC watts, which we converted to DC watts.[151]

Indianapolis, Indiana

Indianapolis Power and Light, the electric utility serving Indianapolis, provided us with the total installed solar PV capacity within Indianapolis as of 31 December 2019 in AC watts, which we converted to DC watts. IPL states that "some of the capacity got double counted last year. That is why – even though we've added a number of net metered customers – there is less capacity than the 2018 submittal."[152]

Jackson, Mississippi

Entergy Mississippi, the electric utility serving Jackson, provided us with the total installed solar PV capacity in Jackson, Mississippi as of 31 December 2019.[153]

Jacksonville, Florida

JEA, formerly Jacksonville Electric Authority, the utility serving Jacksonville, provided us with a spreadsheet of net-metered solar PV installations within their service area through 31 December 2019 in DC watts.[154] We filtered these data for installations within the city of Jacksonville and used geographic analysis to limit our capacity estimates to within city limits.

Kansas City, Missouri

Evergy, the electric utility serving the city, provided total installed solar PV capacity for Kansas City at the end of 2019 in DC watts.[155]

Las Vegas, Nevada

The City of Las Vegas' Office of Sustainability provided us with the total solar PV capacity within the city of Las Vegas through December 2019 in AC watts, which we converted to DC watts.[156] We used geographic analysis to limit our capacity estimates to within city limits, so values for this year are not directly comparable with last year's edition. We also note our geographic analysis excluded significant solar capacity located within the greater Las Vegas metropolitan area but outside of the city's incorporated boundary.

Los Angeles, California

Total installed solar PV capacity in Los Angeles as of 31 December 2019 was provided by the Los Angeles

Department of Water and Power, the city's municipal electric utility, in AC watts, which we converted to DC watts.[157]

Louisville, Kentucky

Louisville Gas & Electric, the electric utility serving Louisville, provided the total solar PV capacity installed in the city as of 31 December 2019 in DC watts.[158] We used geographic analysis to limit our capacity estimates to within city limits, so values for this year are not directly comparable with last year's edition.

Manchester, New Hampshire

Eversource Energy, the electric utility serving Manchester, provided the solar PV capacity installed within the city limits of Manchester through 31 December 2019 in AC watts, which we converted to DC watts.[159]

Memphis, Tennessee

Memphis Light, Gas and Water, the city's municipal electric utility, provided total solar PV capacity installed in Memphis as of 31 December 2019 in DC watts.[160] We note a 65MW solar farm also located in Shelby County was not included.

Miami, Florida

Florida Power & Light (FPL), the municipality serving the city, provided the total solar PV capacity installed within Miami city limits as of 31 December 2019 in AC watts.[161]

Milwaukee, Wisconsin

The City of Milwaukee's Environmental Collaboration Office provided us with total solar PV capacity within Milwaukee city limits as of 31 December 2019 in DC watts.[162]

Minneapolis, Minnesota

Xcel Energy, the electric utility serving the city of Minneapolis, provided us with total solar PV capacity by zip code installed within the city as 31 December 2019 in DC watts.[163] We used geographic analysis to limit our capacity estimates to within city limits.

Nashville, Tennessee

Nashville Electric Service, the electric utility serving the city of Nashville, provided us with total solar PV capacity installed within the Urban Services District of Nashville as of the end of 2019 in DC watts.[164]

New Orleans, Louisiana

Entergy New Orleans, the electric utility serving the city of New Orleans, provided us with a total installed solar PV capacity within New Orleans city limits in DC watts.[165] This figure is current as of as of 31 October 2019, so the solar PV capacity in New Orleans as of the end of 2019 may be higher than the figure published.

New York, New York

Data on solar PV capacity installed within the city limits of New York as of 31 December 2019 were provided by Consolidated Edison, the utility serving the city, in AC watts, which we converted to DC watts.[166]

Newark, New Jersey

The solar PV installations supported by New Jersey's Clean Energy Program (NJCEP) are made available online in the NJCEP Solar Activity Report.[167] We downloaded the Full Installations Project List updated through 31 December 2019. We filtered for solar installations registered in the city names of "Newark," "Newark City," "Newark N," and "Newrk." We conservatively assumed capacities were in DC watts.

Oklahoma City, Oklahoma

The Oklahoma City Office of Sustainability provided us with the total solar PV capacity of net-metered solar installations in Oklahoma City as of 31 December 2019 in DC watts.[168] To this total, we added 1 MW DC for an installation at the city VA hospital and 2.5MW AC for a solar plant at the OGE Mustang Energy Center.[169]

Omaha, Nebraska

Omaha Public Power District (OPPD), the electric utility serving the city of Omaha, provided us with the total capacity of solar PV systems tied to their grid within Omaha city limits as of 31 December 2019.[170]

OPPD did not know whether the figure was in AC watts or DC watts, so we conservatively assumed DC.

Orlando, Florida

Total solar PV capacity installed within the city limits of Orlando, as of 31 December 2019 and serviced by the Orlando Utilities Commission (OUC), was provided by OUC in DC watts.[171]

Philadelphia, Pennsylvania

Data were downloaded from the Solar Renewable Energy Certificates PJM-GATS registry, administered by regional electric transmission organization PJM.[172] These data include installations through December 2019 and were filtered for Primary Fuel Type "SUN" and County "Philadelphia," which is coterminous with the city of Philadelphia. Capacities were listed in DC watts.

Phoenix, Arizona

Phoenix is served by two electric utilities, Arizona Public Service (APS) and Salt River Project (SRP). Data from both service territories were provided by the City of Phoenix as of 31 December 2019 in DC watts.[173]

Pittsburgh, Pennsylvania

Data for solar PV installations in Allegheny County, Pennsylvania, were downloaded in a spreadsheet called "Renewable Generators Registered in GATS" through the online GATS database administered by PJM.[174] To focus on solar PV installations, we filtered by primary fuel type "SUN." To estimate the amount of solar capacity installed within the city of Pittsburgh only, we looked up the number of solar installation permits within Pittsburgh completed between 1/1/13 – 12/31/19 (541 installations) on the Pittsburgh Building Eye website.[175] Based on the PJM data, 2,156 installations were completed in Allegheny County during the same time span, leading to the conclusion that 25 percent of Allegheny County solar projects were installed in Pittsburgh during this time. Based on this, we estimated that 25 percent of the total solar PV capacity installed within Allegheny County as of 31 December 2019 was installed within Pittsburgh.

Portland, Maine

Central Maine Power Company, the utility company serving the central and southern areas of Maine, provided us with the total solar PV capacity connected to their grid within Portland city limits through the end of 2019 in AC watts, which we converted to DC watts.[176]

Portland, Oregon

The city of Portland is served in part by Portland General Electric and in part by Rocky Mountain Power, which operates as Pacific Power in the state of Oregon. Data on solar PV capacity installed by these utilities within Portland city limits through 31 December 2019 were provided by the City of Portland's Bureau of Planning and Sustainability in DC watts.[177]

Providence, Rhode Island

Total solar PV capacity within Providence city limits as of 31 December 2019 was provided by the Rhode Island Office of Energy Resources.[178] Figures were given in AC watts, which we converted to DC watts.

Raleigh, North Carolina

The North Carolina Sustainable Energy Association (NCSEA) provided us with the total solar PV capacity installed within Raleigh in DC watts.[179] We then used geographic analysis to limit our capacity estimates to within city limits based on address-level data. Data provided for Raleigh were current as of 2 December 2019, so the capacity in Raleigh as of 31 December 2019 may be higher than the figure listed.[180]

Richmond, Virginia

Dominion Energy provided a list of interconnected solar PV systems in the city of Richmond in AC watts through 31 December 2019. [181] We then used geographic analysis to limit our capacity estimates to within city limits based on address-level data.

Riverside, California

The total installed solar PV capacity for Riverside as of 31 December 2019 was provided in DC watts by Riverside Public Utilities.[182]

Sacramento, California

The total installed solar PV capacity installed within Sacramento city limits as of 31 December 2019 was provided by Sacramento Municipal Utility District (SMUD) in AC watts, which we converted to DC watts.[183]

Salt Lake City, Utah

The total capacity of solar PV installations within Salt Lake City as of 31 December 2019 was provided by the Salt Lake City Office of Sustainability in DC watts.[184]

San Antonio, Texas

CPS Energy, the utility serving San Antonio, provided us with the total residential solar PV capacity as well as a sum of utility-scale solar PV installations in San Antonio as of 31 December 2019 in AC watts, which we converted to DC watts.[185]

San Diego, California

San Diego Gas & Electric, the electric utility serving the city, provided us with a figure of total solar PV capacity installed within San Diego as of 31 December 2019 in AC watts, which we converted to DC watts.[186]

San Francisco, California

San Francisco's Department of the Environment provided us with the total solar PV capacity installed within San Francisco city limits as of December 2019 in AC watts, which we converted to DC watts.[187]

San Jose, California

The City of San Jose provided us with total solar PV capacity installed within the city limits of San Jose in AC watts, which we converted to DC watts.[188] Data provided for San Jose was current as of 30 November 2019, so the capacity as of 31 December 2019 may be higher than the figure listed.

Seattle, Washington

Seattle City Light, the municipal utility serving the city, provided data on Seattle's total solar PV capacity as of 31 December 2019 in DC watts.[189]

St. Louis, Missouri

Ameren Missouri, the utility serving the city of St. Louis, provided us with total solar PV capacity in zip codes entirely within St. Louis as of 31 December 2019 in DC watts.[190]

Tampa, Florida

TECO Energy, the electric utility serving the city of Tampa, provided us with the total installed solar PV capacity in Tampa as of December 2019 in DC watts.[191]

Virginia Beach, Virginia

Dominion Energy, the utility serving Virginia Beach, provided us with the total installed solar PV capacity of all Virginia Beach zip codes as of 31 December 2019 in DC watts.[192] We then used geographic analysis to limit our capacity estimates to within city limits.

Washington, D.C.

Pepco, the utility serving Washington, D.C., provided us with total solar PV capacity installed within the city as of the end of 2019 in AC watts, which we converted to DC watts.[193]

Wichita, Kansas

Westar Energy, the electric utility serving Wichita, provided us with the total solar PV capacity of systems interconnected to their grid within Wichita zip codes as of 31 December 2019 in DC watts.[194] We then used geographic analysis to limit our capacity estimates to within city limits, so this year's figure is not directly comparable to last year's.

Wilmington, Delaware

Data for solar PV installations in New Castle County, Pennsylvania, were downloaded in a spreadsheet called "Renewable Generators Registered in GATS" through the online GATS database administered by PJM.[195] To focus on solar PV installations, we filtered by primary fuel type "SUN." To estimate the amount of solar capacity installed within the city of Wilmington only, we used data from the 2018 American Community Survey to estimate the proportion of total housing units in New Castle County that are also in Wilmington.[196] This is a different data source than last year, so this year's figure is not directly comparable to last year's.

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