Shining Cities

At the Forefront of America's Solar Energy Revolution

Written by:

Judee Burr, Tony Dutzik and Jordan Schneider
Frontier Group

Rob Sargent
Environment America Research & Policy Center

April 2014

Acknowledgments

Environment New York Research & Policy Center sincerely thanks Kevin Armstrong, The Vote Solar Initiative; Justin Baca, The Solar Energy Industries Association; John Farrell, The Institute for Local Self-Reliance; Chad Laurent and Wilson Rickerson, Meister Consultants Group; DeWitt Jones and Emily Rochon, Boston Community Capital/Solar Energy Advantage; Kevin McCarty, U.S. Conference of Mayors; Ted Quinby, National Renewable Energy Laboratory; Karl Rabago, Rabago Energy, LLC.; Amit Ronan, George Washington University Solar Institute; and Anya Schoolman, Community Power Network, for their review of drafts of this document, as well as their insights and suggestions. Thanks to everyone who went out of their way to provide us with data for this report. Thanks also to Benjamin Davis of Frontier Group for editorial support and to ESRI for their grant of ArcGIS software that we used for our data analysis in this report.

Environment New York Research & Policy Center thanks the Tilia Fund, the John Merck Fund, the Energy Foundation, the Arntz Family Foundation, the Scherman Foundation, Fred and Alice Stanback, the Meyer Memorial Trust and the Cynthia and George Mitchell Foundation for making this report possible.

The authors bear responsibility for any factual errors. The recommendations are those of Environment New York Research & Policy Center. The views expressed in this report are those of the authors and do not necessarily reflect the views of our funders or those who provided review.

© 2014 Environment New York Research & Policy Center

Environment New York Research & Policy Center is a 501(c)(3) organization. We are dedicated to protecting our air, water and open spaces. We investigate problems, craft solutions, educate the public and decision-makers, and help the public make their voices heard in local, state and national debates over the quality of our environment and our lives. For more information about Environment New York Research & Policy Center or for additional copies of this report, please visit www.environmentnewyorkcenter.org.

Frontier Group conducts independent research and policy analysis to support a cleaner, healthier and more democratic society. Our mission is to inject accurate information and compelling ideas into public policy debates at the local, state and federal levels. For more information about Frontier Group, please visit www.frontiergroup.org.

Layout: To the Point Publications, www.tothepointpublications.com

Cover photo: top left, Austin, Meridian Solar; top middle, San Diego, SPG Solar; top right, Honolulu, Hawaiian Electric Company; bottom right, Seattle, NW Wind and Solar; bottom left, Denver, Namaste Solar Electric and Vantage Point Imagery.

Table of Contents

Executive Summary 4

Introduction 10

Solar Energy Is Good for the Environment, Consumers and the Economy in America's Cities 12

Solar Power Prevents Smog and Global Warming Pollution. 12

Solar Energy Increases City Resiliency 13

Solar Energy Is Good for City Residents and the Local Economy 14

Solar Power Is on the Rise 15

The Promise of Solar Energy Is Increasingly Within Reach 15

America's Solar Energy Capacity Tripled in Two Years 16

America's Top Solar Cities Are Leading the Way 17

America's Leading Solar Cities Span the Country. 17

Smart Policies Have Fueled Growth in America's Top Solar Cities 24

Policy Recommendations. 36

Taking Advantage of America's Solar Energy Potential 36

Recommendations for Local Government 37

Recommendations for State Government 38

Recommendations for Federal Government 38

Methodology 40

Selecting the 57 Major Cities. 40

Collecting Data on Installed Solar PV Capacity 40

Appendix A: Solar Energy in Major American Cities 42

Appendix B: City-By-City Data Sources 44

Notes 52

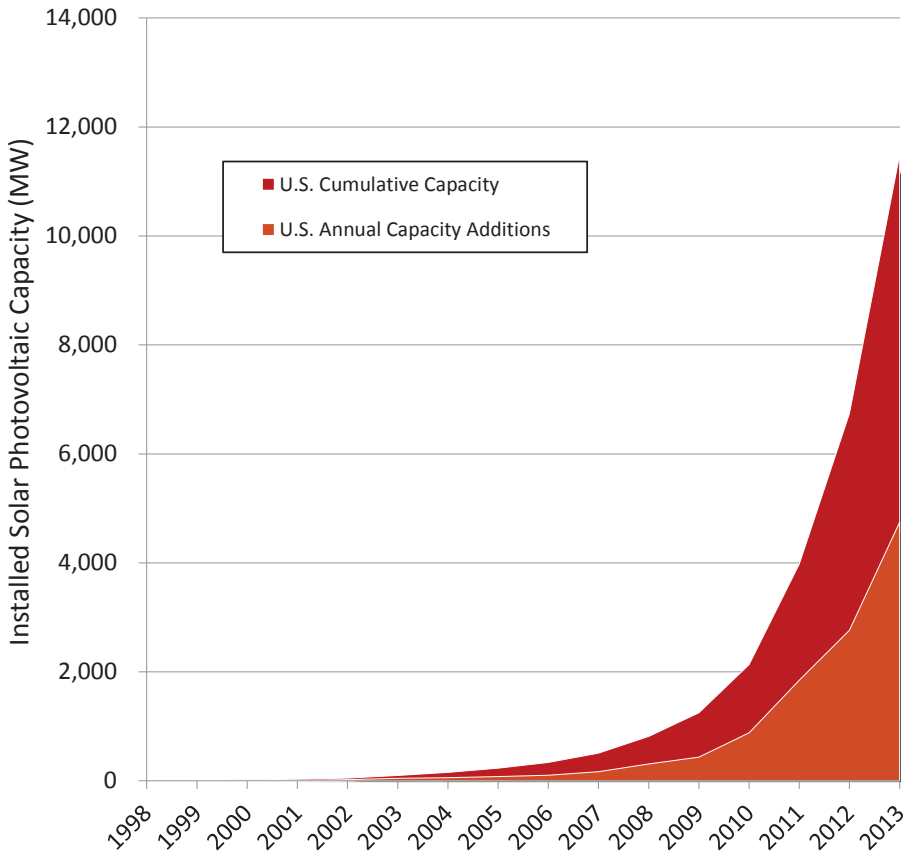
Executive Summary

Solar power is on the rise across the country. The United States has more than 200 times as much solar photovoltaic (PV) capacity installed today as it did in 2002. With solar module prices coming down, increasing national awareness of solar energy, and a growing legion of solar businesses large and small, solar power is emerging as a mainstream energy solution with widespread benefits for our health, our economy and the environment.

America's major cities are helping to lead this clean energy revolution. Forward-thinking local governments and large cities in leading states are benefiting from smart policies that encourage investment in solar PV installations and the growth of local jobs.

This report provides a first-of-its-kind comparative look at the growth of solar power in major American cities. **Just 20 cities, representing just 0.1 percent of the land area of the United States, account for**

Figure ES-1. Annual and Cumulative Installed Photovoltaic (PV) Capacity through 2013, United States



7 percent of solar PV capacity in the United States. These top 20 cities contain more solar power today than was installed in the entire U.S. just six years ago.

Solar energy brings important benefits to cities.

- **Solar energy avoids pollution**—Pollution-free energy from the sun displaces fossil fuel-powered energy sources, reducing a major source of pollution that contributes to urban smog and global warming. Outdoor air pollutants endanger the health of city residents, and many urban centers are vulnerable to the global warming-induced threats of sea-level rise, increasingly frequent and severe extreme weather events, and the public health impacts of heat waves. Rooftop solar energy also increases city resilience to extreme weather events, which are only due to get worse with increased global warming. For example, solar energy can power cities when drought strikes without diverting precious water resources and help prevent blackouts by reducing strain on the grid. As the electric system evolves, solar panels will be able to provide backup power during power outages caused by storms or other disasters.
- **Solar energy protects consumers**—Cities often depend on electricity transmitted from power plants hundreds of miles away to meet

Table ES-1. Top 20 Solar Cities by Total Installed Solar PV Capacity, End of 2013*

Principal City	State	Cumulative Solar PV Capacity (MW)	Cumulative Solar PV Capacity Rank
Los Angeles	CA	132	1
San Diego	CA	107	2
Phoenix	AZ	96	3
San Jose	CA	94	4
Honolulu	HI	91	5
San Antonio	TX	84	6
Indianapolis	IN	56	7
New York	NY	33	8
San Francisco	CA	26	9
Denver	CO	25	10
New Orleans	LA	22	11
Sacramento	CA	16	12
Jacksonville	FL	16	13
Albuquerque	NM	16	14
Portland	OR	15	15
Austin	TX	13	16
Las Vegas	NV	13	17
Newark	NJ	13	18
Raleigh	NC	12	19
Boston	MA	12	20

** This includes all solar PV capacity (rooftop and utility-scale solar installations) within the city limits of each city. See methodology for an explanation of how these rankings were calculated. See Appendix B for city-specific sources of data.*

local demand. Using local solar energy reduces the need for electricity transmission and the need for costly and inefficient "peaking" power plants. Solar energy also typically supplies electricity on hot, sunny days when grids are under the most strain and electricity is most expensive. In addition, since there are no fuel costs associated with solar energy, it can reduce the vulnerability of city economies to price increases for fossil fuels.

- **Solar energy helps the economy**—Solar power creates local jobs in solar installations and manufacturing. Solar industry employment grew 10 times faster than the national average growth in employment in 2013 and employed 142,000 Americans as of November 2013.

The top 20 cities have a total installed solar PV capacity of over 890 MW and are located in almost every region of the U.S.

On a per-capita basis, Honolulu is the leading solar city, followed by San Jose, and Wilmington, Delaware.

America's leading solar cities are increasing their use of solar energy in a variety of ways. Some cities are focusing on distributed solar PV on homes and small businesses, others are building utility-scale solar power plants, while still others are developing solar energy at the neighborhood scale or through community projects. What makes these top cities solar leaders?

- **Commitment from local governments**. Cities can lead and catalyze local markets by installing solar power on city buildings and setting ambitious but achievable targets for solar energy. Leading solar cities, including Denver and Portland, are driving solar growth starting with their public buildings.

Figure ES-2. Map of 57 Principal Cities Ranked by Cumulative Installed Solar PV Capacity, End of 2013

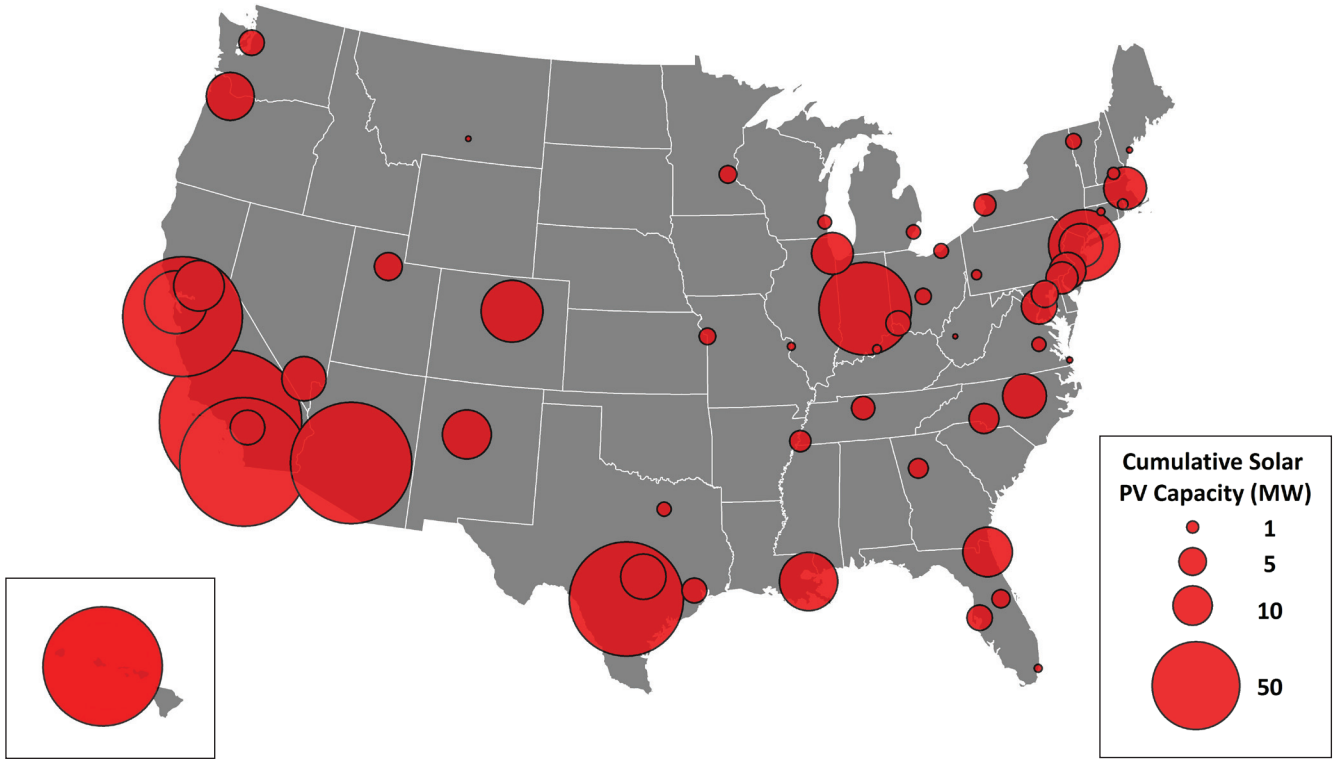


Table ES-2. The "Solar Stars" (Cities with More Than 50 Watts of Installed Solar PV Capacity per Person, End of 2013)

Principal City	State	Cumulative Solar PV Capacity (MW)	Solar PV Capacity per Capita (Watts/Person)	Solar PV Capacity per Capita Rank
Honolulu	HI	91	265	1
San Jose	CA	94	97	2
Wilmington	DE	7	96	3
San Diego	CA	107	81	4
Indianapolis	IN	56	68	5
Phoenix	AZ	96	65	6
San Antonio	TX	84	62	7
New Orleans	LA	22	60	8

- **Support from city policies and programs**. Cities can create policies that promote solar power in their communities. Cities can encourage local lending for solar projects, provide predictable and accessible tax incentives that make solar energy more affordable and welcoming to businesses, and adopt solar-friendly permitting policies and building codes. New York City, for example, has a property tax credit for residents who install solar panels. Cities can also run "Solarize" programs that use collective purchasing and educational campaigns to help neighbors "go solar" together, as Portland, Oregon did, or create programs to facilitate solar project financing like Property Assessed Clean Energy (PACE) financing.

- **Partnership with local utilities**. Municipal utilities in several cities have driven the growth of solar power by setting renewable energy goals and offering attractive financial incentives for solar projects. Austin Energy, the municipal utility serving Austin, has set a goal of installing 200 MW of solar power by 2020 and offers an array of solar financing options and monetary incentives to its customers. Seattle City Light allows its customers to invest in community solar projects that are not located on their properties but whose output is still credited on their utility bill. Other cities have effectively partnered with investor-owned utilities to incentivize solar power. New York City partnered with Con Edison, its local investor-owned utility, to connect solar power to the city grid for the first time and create designated "Solar Empowerment Zones" where solar power could deliver the most benefits.

- **Strong state-level policies.** New Jersey, Delaware and Massachusetts have among the strongest standards in the country, boosting the solar capacity of cities such as Newark, New Jersey, Wilmington, Delaware and Boston, Massachusetts. Hawaii, California, Arizona and New York also benefit from strong state policies that make them home to some of the most prominent solar cities. Net metering policies that allow solar producers to receive the full benefits of their solar power production are important for a robust solar market; states should also allow for virtual net metering that facilitates shared solar projects.

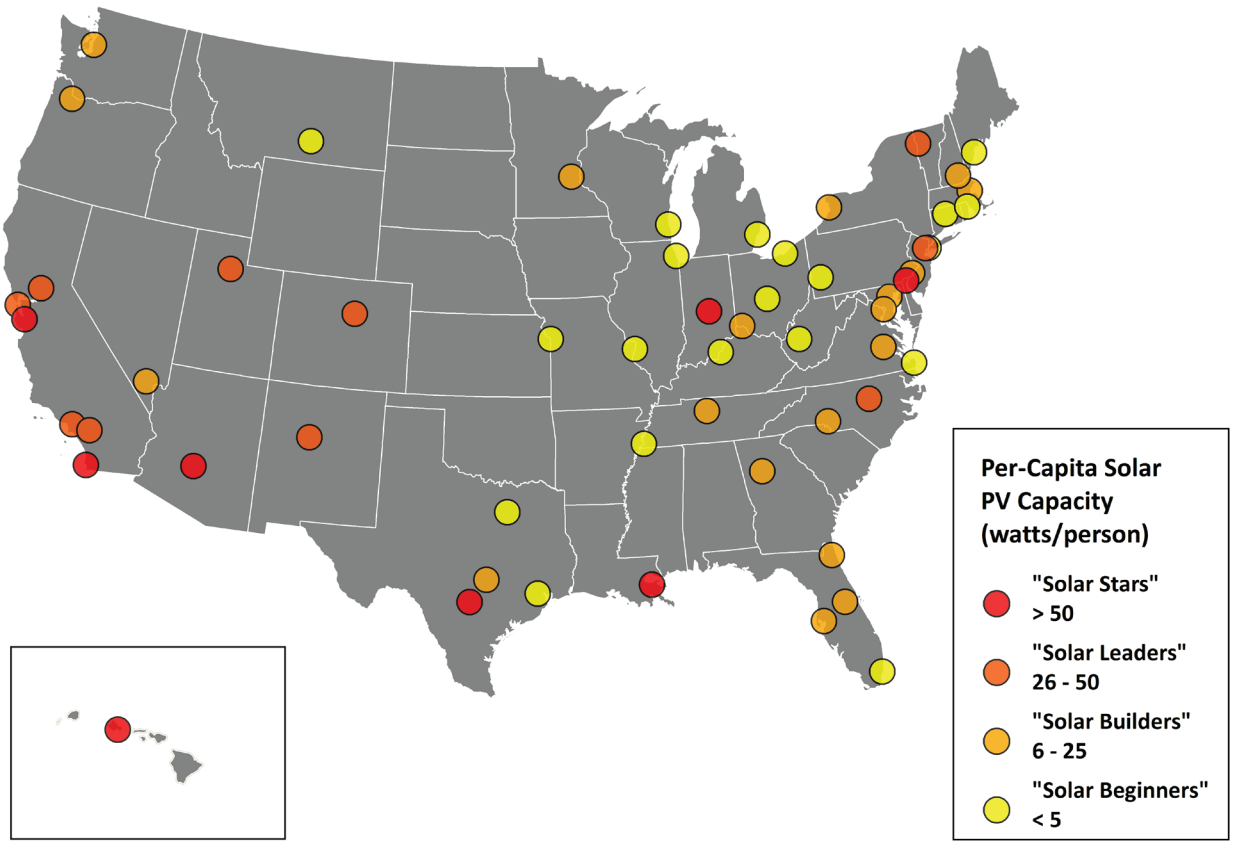
- **Support from federal programs.** Federal renewable energy tax credits and funding from federal programs like the Solar America Cities program, the Energy Efficiency and Conservation Block

Grant program and the U.S. Department of Energy's Sunshot Initiative provide support for local solar power growth and valuable technical assistance to local governments.

America's leading cities have made significant progress but have just begun to tap solar energy's immense potential. **Strong public policies at every level of government can help America continue to harness clean solar energy and overcome legislative and regulatory barriers to distributed generation.** To achieve America's full solar potential:

- **Local governments** should follow the lead of America's top solar cities by adopting programs that promote the rapid expansion of solar power and by demanding that state and federal officials and investor-owned utilities facilitate that expansion.
- **State governments** should set ambitious goals for solar energy and adopt policies to meet them. State governments should also use their role as the primary regulators of electric utilities to encourage utility investments in solar energy and implement rate structures that maximize the benefits of solar energy to consumers. States can streamline permitting, inspections and net metering rules to reduce the non-equipment costs of getting solar power on rooftops. States should require that upcoming investments in the electric grid are designed to ensure that clean, distributed energy such as solar power plays a larger role.
- **The federal government** should continue to provide long-term support for solar power through tax credits and other incentives. The federal government should continue to support

Figure ES-3. Map of 57 Principal Cities Ranked by Installed Solar PV Capacity per Person, End of 2013



research, development and deployment efforts designed to reduce the cost of solar energy and related storage and smart grid technologies; this will enable more solar energy to be reliably incorporated into the electric grid. The federal government should continue to offer programs like the Solar America Cities program, the Energy Efficiency Conservation Block Grant program and the U.S. Department of Energy's Sunshot Initiative, which provide support and technical assistance while fostering innovations that drive solar development at the state and local levels.

- **All levels of government** should lead by example by installing solar energy technologies on government buildings.

Photo: Social Security Administration via NREL Image Gallery

Just 20 cities, representing just 0.1 percent of the land area of the United States, account for 7 percent of solar PV capacity in the United States.

Introduction

Portland, Oregon is not known for its sunshine. Portland's reputation for rainy weather is only partially deserved—summers are often sunny, compensating for the frequently cloudy winters. Nonetheless, the city with the reputation for gray skies has emerged as one of the nation's bright spots for solar energy—largely due to the creative efforts of local residents and city officials.

Portland's path to solar leadership began in 2007 when the city was selected for the federal government's "Solar America Cities" program. This program provided the city with funding and support for its efforts to develop local solar power.[1] Two years later, when a neighborhood in Portland wanted to install solar panels, they partnered with the non-profit Energy Trust of Oregon to hold workshops, select a contractor and purchase the panels collectively, cutting costs for themselves and their solar installer.[2]

The successful collective purchasing model was quickly replicated citywide. Portland's Bureau of Planning and Sustainability worked with Portland's Neighborhood Coalition network, the Energy Trust of Oregon and Solar Oregon to establish the "Solarize Portland" program.[3] Between 2009 and 2011, six Solarize Portland campaigns empowered neighborhood associations to work with residents. These campaigns helped residents learn about solar incentives and provided them access to solar panels, supplied by contractors that obtained a large volume of business at low marketing costs.[4]

As a result of these campaigns, Portland added 1.7 megawatts (MW) of solar power on 560 homes in the city between 2009 and 2011.[5] The "solarize" model has since been adopted by other cities, such as Boston and Seattle.[6]

However, the city of Portland didn't stop with collective purchasing. City officials are working to streamline the solar permitting process by launch-

Overall, city action strengthened by state policy has allowed Portland to jump from less than 1 MW of installed solar PV capacity in 2007 to more than 15 MW of solar PV capacity at the end of 2013.

ing online permitting in 2016 and have launched "Solar Forward," a crowd-sourcing initiative that asks community members to donate money to fund solar projects on community facilities.[7] Portland's efforts have been supported by state-level policies, including a renewable energy standard with specific requirements for solar energy, tax credits for residential and some commercial solar energy installations, and a pilot feed-in tariff program.

Overall, city action strengthened by state policy has allowed Portland to jump from less than 1 MW of installed solar PV capacity in 2007 to more than 15 MW of solar PV capacity at the end of 2013.[8] This puts Portland in the top 15 of the 57 major cities we surveyed in this report.

Portland is not the only U.S. city to use creative and strong public policies to vault into solar leadership. Other cities in every region of the United States have experienced dramatic progress in recent years in expanding solar energy.

In July 2013, we released *Lighting the Way*, which identified the nation's top states for solar energy and linked their success to the adoption of smart public policies that have fueled the growth of solar energy. In this report, we provide the first national-scale comparison of solar photovoltaic (PV) installations in some of America's largest cities.

The lesson of cities like Portland is clear: cities that take effective action to lower the barriers to solar energy development for their residents and businesses can make a dramatic leap toward a cleaner energy economy.

That pathway is open to any city that wishes to pursue it. For the sake of the environment, public health and the health of local economies, the time has come for all states and local governments to follow the example of the nation's leading "solar cities" by finding new and creative ways to encourage their residents, businesses and local utilities to "go solar."

Solar Energy Is Good for the Environment, Consumers and the Economy in America's Cities

Solar energy makes sense for America—especially American cities. Each new solar panel helps to clean our air, fight global warming, boost the economy, and create jobs. American cities have vast potential for solar power, with millions of empty rooftops, parking lots and brownfields ideal for solar energy development.

Solar Power Prevents Smog and Global Warming Pollution

America's cities bear the brunt of much of the environmental damage caused by our reliance on fossil fuels. According to the American Lung Association, more than 131 million people live in counties with dangerous levels of ozone. In these areas, many of them urban, simply breathing the air puts residents at increased risk for asthma and cardiovascular issues.[9] The Institute of Physics estimates that human-caused outdoor air pollution causes more than 2 million deaths worldwide each year.[10]

Similarly, many American cities face significant threats from global warming:

- Coastal cities will experience the impacts of **rising sea levels**. Five feet of sea level rise, which could happen in the next century if global warming pollution continues unabated, could flood almost 90 percent of New Orleans, 95 percent of Miami Beach, Florida, and 11 percent of Wilmington, Delaware.[11]
- Global warming is expected to increase the severity of **extreme weather events** that threaten cities. More than 76 million Americans live in counties affected by weather-related disasters in 2012. There were at least 11 disasters in 2012 that each inflicted more than $1 billion in damage, including Hurricane Sandy, which caused estimated damages of at least $50 billion.[12]
- More **severe heat waves and fire seasons** will affect America's cities. More than 1.2 million homes in the western United States, representing $189 billion in property value, are at risk for wildfire damage, with Los Angeles containing the most properties at risk.[13]

Fossil fuel power plants are significant contributors to both of these threats. Power plants emit dangerous air pollutants including nitrogen oxides, which contribute to the formation of ozone "smog"; sulfur dioxide, which contributes to the formation of small particles in the air that can trigger respiratory diseases such as bronchitis and emphysema; and mercury, a potent neurotoxicant.[14] Producing more electricity with clean solar power instead of fossil-fueled power plants is an important step toward reducing emissions of these air pollutants.

Power plants are also America's largest source of carbon dioxide, the leading global warming pollutant. If the 50 dirtiest U.S. power plants were an independent nation, they would be the seventh-largest emit-

ter of carbon dioxide pollution in the world.[15] (See Figure 1.) In 2011, U.S. power plants were responsible for one-third of the nation's greenhouse gas emissions, which include carbon dioxide emissions.[16]

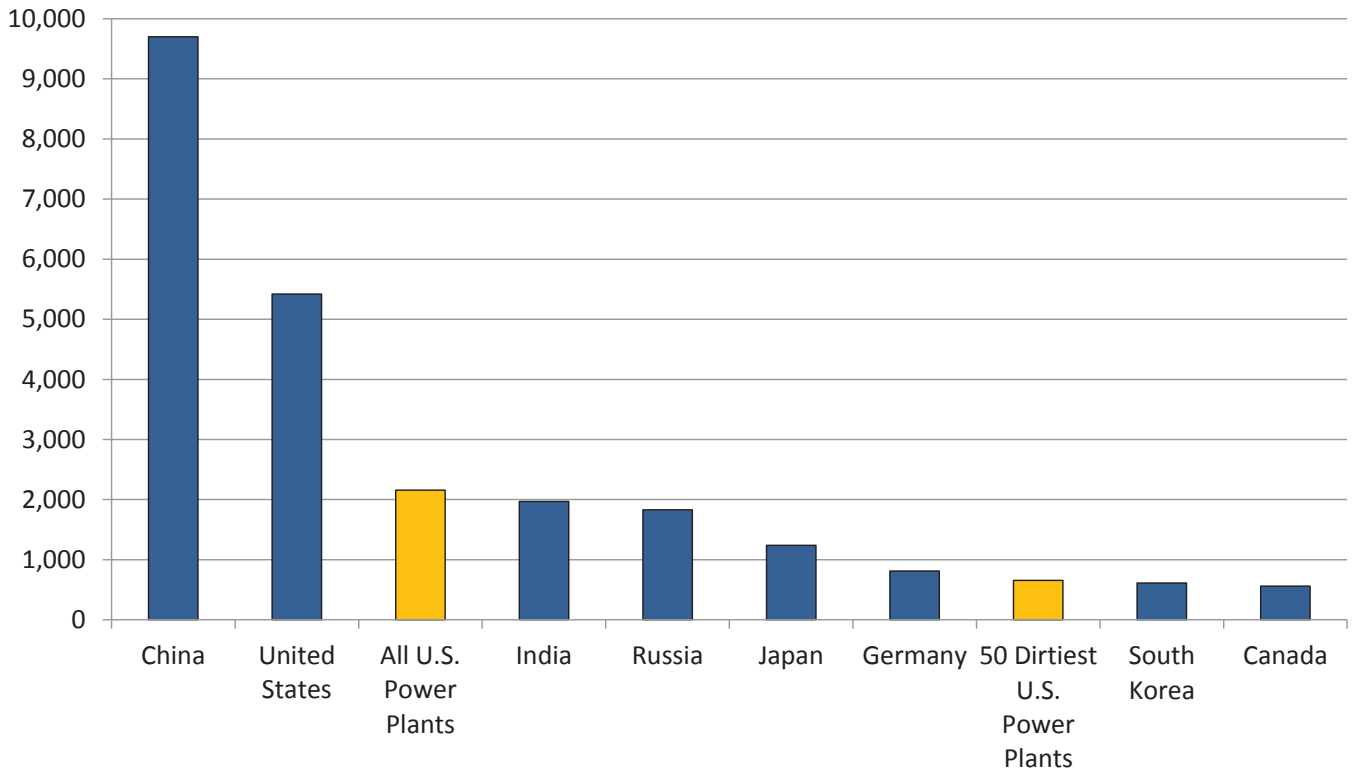
Solar power generation produces no global warming pollution. Even when emissions from manufacturing, transportation and installation of solar panels are included, solar power produces 96 percent less global warming pollution than coal-fired power plants over their entire life-cycle, and 91 percent less global warming pollution than natural gas-fired power plants.[18]

By reducing the need for electricity from fossil fuel-fired power plants, solar power reduces the threat posed by global warming and helps to clean the nation's air.

Solar Energy Increases City Resiliency

Rooftop solar energy also increases city resiliency to severe storms and heat waves, which global warming will worsen. If transmission lines are disrupted from a severe storm or heat wave, solar energy attached to batteries or generators can help avoid black outs.[19] During Hurricane Sandy, solar power systems with attached batteries or generators continued to produce energy while the electric grid was offline, providing hard-hit communities with heat and light during the storm.[20] Solar power also helps prevent blackouts by reducing strain on the grid, and as the electric system evolves, solar panels will be able to provide backup power during power outages caused by storms or other disasters.

Figure 1. Carbon Dioxide Pollution Emitted by the 50 Dirtiest Power Plants Compared to Other Countries, 2011 (MMT CO2)[17]



Drought also creates difficult conditions for cities dependent on fossil fuels or nuclear power. During the Midwest drought of 2012, many fossil-fuel power plants that require cooling water to operate were forced to limit or suspend electricity production.[21] Texas had to divert water away from farmers and ranchers in order to keep lights on at the height of the drought of 2011.[22] Unlike fossil fuel and nuclear power plants that consume vast amounts of water for cooling, solar PV installations consume virtually no water in everyday operation, reducing the strain on water supplies in arid regions of the country and those experiencing drought.[23] This can be a significant benefit in times of drought. The California drought caused a drop in hydroelectricity generation at the beginning of 2014, but the state's solar energy helped to compensate and guard against electricity outages across the state.[24] Climate change will only exacerbate these types of issues and fossil fuel plants could face real limitations as a result.

Solar Energy Is Good for City Residents and the Local Economy

Cities that encourage investments in solar energy offer their residents many important economic and other benefits.

Homeowners and businesses who install solar panels can offset major portions—in some cases all—of their electric bills and see double-digit returns on their investment. Because energy from the sun is free (after the initial investment is made), consumers who invest in solar panels are insulated from the volatile prices of fossil fuel markets. Solar energy can also be a near-term economic winner for consumers and businesses—especially in states where electricity prices are high, owners of solar panels are allowed to recoup the full benefits of the electricity they produce, and there are other strong, pro-solar policies in place.

The benefits of solar energy extend far beyond the home or commercial building where solar panels are installed—solar energy benefits all consumers by reducing many of the costs of operating the electricity system. Among the benefits of distributed solar electricity to the grid are:

- **Reduced need for expensive "peaking" power**—Solar panels usually produce the most electricity on sunny days when demand for power is at its highest. These are the times when utilities must generate or purchase power from expensive, often inefficient "peaking" power plants that may operate only a few hours each year. Expanding solar power can reduce the cost of providing power during these peak periods.[25]
- **Reduced need for investment in transmission capacity**—Similarly, generating more electricity closer to the locations where it is used reduces the need to construct or upgrade expensive transmission capacity.
- **Reduced energy losses**—Many cities depend on electricity transmitted from hundreds of miles away to meet local needs. Roughly 5 to 7 percent of the electricity transmitted over long distance transmission lines is lost.[26] Distributed solar energy avoids these losses by generating electricity at or near the location where it is used.

Solar Energy Creates Jobs

Solar energy also helps the economy by boosting employment. More than 142,000 Americans worked in the solar energy industry as of November 2013, a 20 percent increase from the previous year, and these numbers are expected to grow.[27] In 2013, the number of solar jobs grew 10 times faster than the national average growth in employment.[28] Most of these jobs are in the installation and maintenance of solar panels, while about 20 percent of all solar workers are in manufacturing.[29] Because most solar energy is located onsite, jobs installing and maintaining solar projects are created in the communities where solar panels are sited and cannot be outsourced.

Solar Power Is on the Rise

The amount of solar power in the United States is rising rapidly—reducing America's dependence on dirty sources of energy. America's solar revolution is occurring most dramatically in cities where strong clean energy policies are leading to the rapid adoption of solar energy by homeowners, businesses and electric utilities.

The Promise of Solar Energy Is Increasingly Within Reach

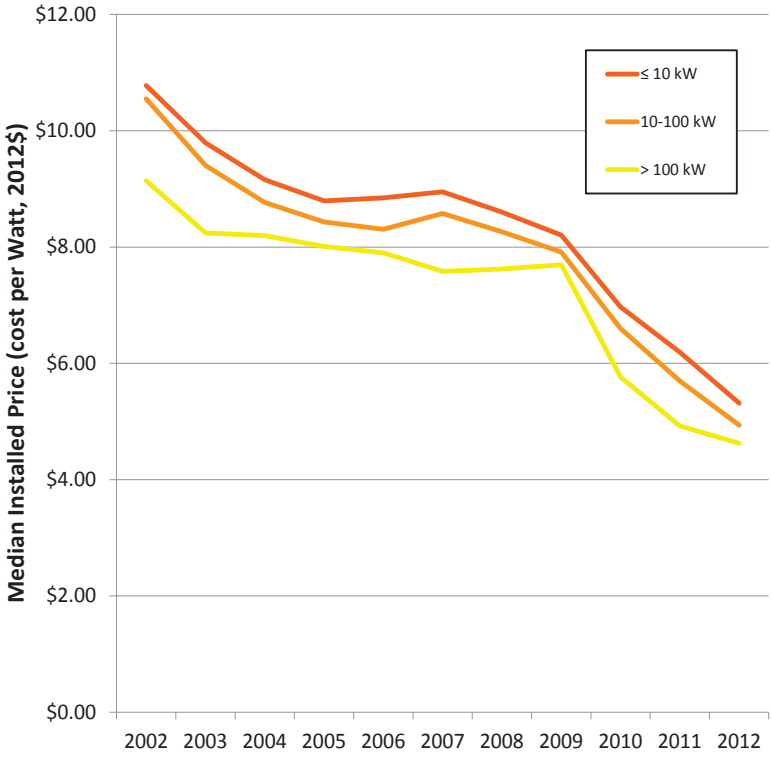
Solar energy is evolving quickly into a mainstream energy source. That evolution has been made possible by a series of innovations that have taken place throughout the solar energy industry and economies of scale that have driven down the cost of solar equipment.

Decades of research have resulted in solar cells that are more efficient than ever at converting sunlight into energy—enabling today's solar energy systems to generate more electricity using the same amount of surface area as those of a decade ago.[30] Researchers continue to discover new ways to make solar panels more efficient at converting sunlight to electricity, which will make solar panels even more powerful tools for electricity generation.[31]

Innovations in manufacturing, the creation of new financing and business models, and improvements in other areas have also helped solar energy become more accessible and less costly over time. An analysis by the National Renewable Energy Laboratory (NREL) shows that large-scale solar manufacturing operations can produce solar equipment at a lower cost, creating opportunities to develop further economies of scale and achieve greater cost reductions.[32]

As a result of these innovations and growing economies of scale, the cost of solar energy has plummeted in recent years and continues to fall. The average cost of solar PV panels less than 10 kilowatts (kW) in size fell by 14 percent between 2011 and 2012, and the cost of solar panels of all sizes continues to drop.[33] (See Figure 2.) In Hawaii, solar energy has already achieved "grid parity"—that is, solar electricity is cheaper than electricity from the grid, even without government incentives.[34]

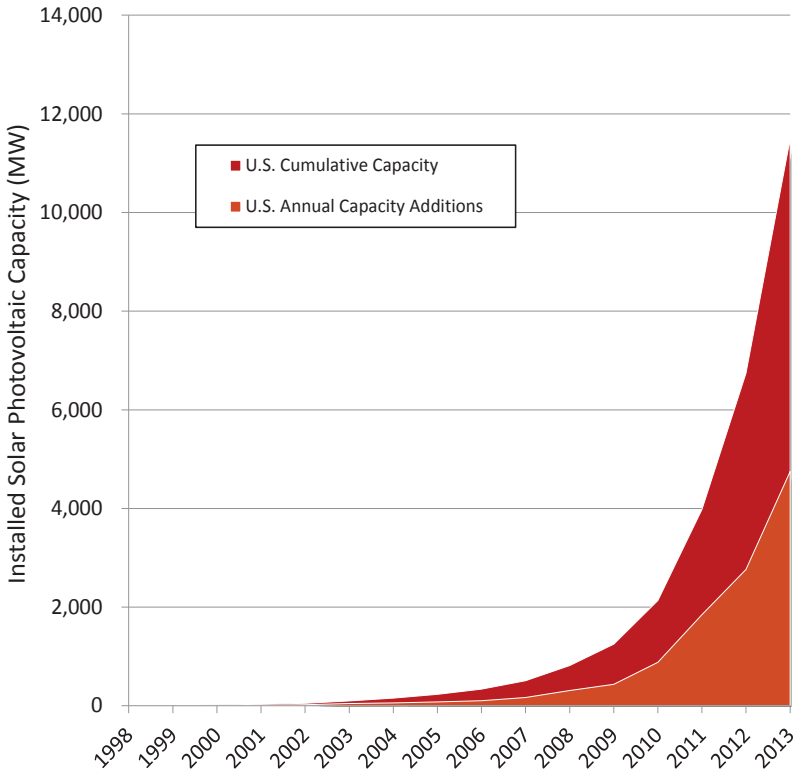
Figure 2. The Median Installed Price of Residential and Commercial Solar Photovoltaic Systems Continues to Fall[35]



Evidence from elsewhere in the world suggests that solar energy prices still have room to fall further. The cost per watt of an installed solar energy system in Germany is roughly half that of the United States due to a variety of factors, including larger average system size, but primarily due to lower "soft costs"—costs such as those associated with attracting customers, installing the systems, completing paperwork, and paying taxes and permitting fees. Installations in Germany had quicker project development timelines and lower overhead.[36] Another recent analysis found that the same set of non-panel related solar project installation costs were nearly four times higher in the U.S. than in Germany, adding an additional 90 cents/watt to the cost of solar installations.[37]

While there are still opportunities to reduce the cost of solar panels, the greatest immediate savings can be achieved by reducing these soft costs.[38] Soft costs in the U.S. have remained relatively consistent—even while panel prices have dropped 60 percent between 2011 and 2013—and can make up to 64 percent of the total cost of an installed solar energy system as of 2013.[39] The U.S. Department of Energy's (DOE) SunShot Initiative, which seeks to lower the cost of installing a solar project to $1 a watt by 2020, is working with the solar industry and other stakeholders in a comprehensive effort to reduce soft costs. If successful, and the DOE recently announced they are 60 percent of the way toward their goal for cost-competitiveness of utility-scale solar projects, solar energy will be even more cost competitive in the years to come.[40]

Figure 3. Annual and Cumulative Installed Photovoltaic (PV) Capacity through 2013, United States[44]



America's Solar Energy Capacity Tripled in Two Years

The year 2013 was a historic year for solar power. The United States passed the 10 gigawatt (GW) mark for solar electric capacity mid-year and installed 4.75 GW of solar PV in 2013 alone, which is the most solar power the United States has ever installed in a single year.[41] (See Figure 3.) The solar power installed in the U.S. in 2013 was worth $13.7 billion and was the second-largest source of new generating capacity in the U.S. that year.[42] The amount of solar PV capacity in the United States tripled between 2011 and 2013 and increased over 200-fold from 12 years ago to the more than 12,000 MW installed by the end of 2013.[43]

A notable portion of America's solar growth is happening in America's cities. Leadership from municipal utilities, solar-friendly city policies and statewide renewable electricity standards are allowing residents, businesses and solar developers to shift urban electricity sources to clean solar power. While still accounting for a relatively small percentage of America's energy needs, the recent phenomenal growth rate of solar power indicates that, with smart public policies, solar energy can continue to emerge as an important source of electricity in America's cities.

America's Top Solar Cities Are Leading the Way

America's cities have made a major contribution to the solar boom. With hundreds of thousands of rooftops that can host solar energy systems, cities have a unique opportunity to be leaders in America's clean energy revolution.

In this report, we review solar photovoltaic (PV) installations in 57 American cities. Each of these cities is within a state that had a substantial amount of installed solar energy capacity (more than 1.5 MW) at the end of 2012.[45] Cities in those states were selected for inclusion in this report if they were:

- The principal city of one of the 50 largest metropolitan areas in the United States, or
- For states with a significant amount of solar capacity but without a city in the 50 largest metropolitan areas nationwide, the state's largest city.[46]

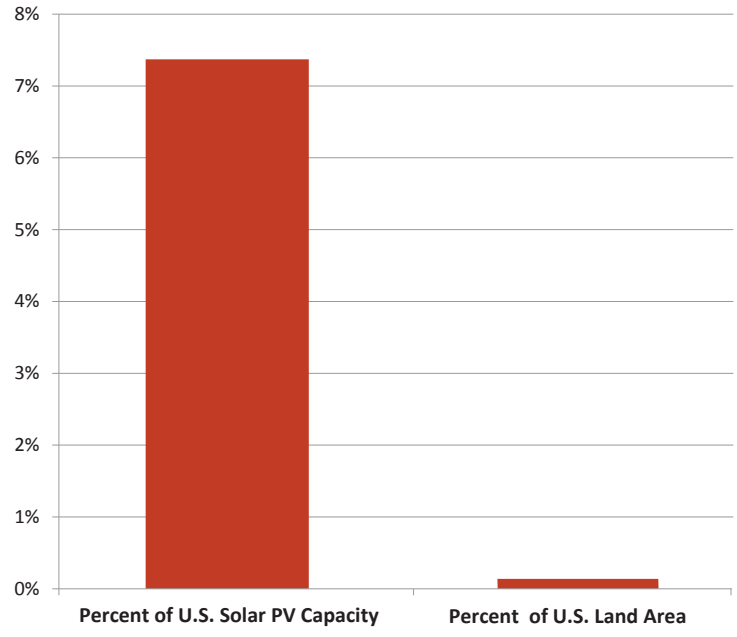
This report represents, to the authors' knowledge, the first national-scale comparison of its kind of solar PV installations in major American cities. There is no uniform national data source that tracks solar energy by municipality, so the data for this report come from a wide variety of sources—municipal and investor-owned utilities, city and state government agencies, operators of regional electric grids, non-profit organizations, and the National Renewable Energy Laboratory's "Open PV" database. (See Methodology.) The use of multiple data sources leads to the possibility of 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 and should interpret the data accordingly.

America's Leading Solar Cities Span the Country

As of the end of 2013, the 57 cities considered in this report had installed 1 gigawatt (GW) of solar PV capacity—more solar PV capacity than existed in the entire United States at the end of 2008.[47] The solar PV capacity installed within these 57 major cities generates more electricity than is consumed in more than 100,000 average U.S. homes in a year.[48]

America's top 20 solar cities—led by Los Angeles, San Diego, Phoenix, San Jose and Honolulu—take up 0.1 percent of the land area of the United States, but account for 7 percent of solar power capacity in the United States.[49]

Figure 4. America's Top 20 Solar Cities as a Percent of U.S. Land Area and U.S. Solar PV Capacity

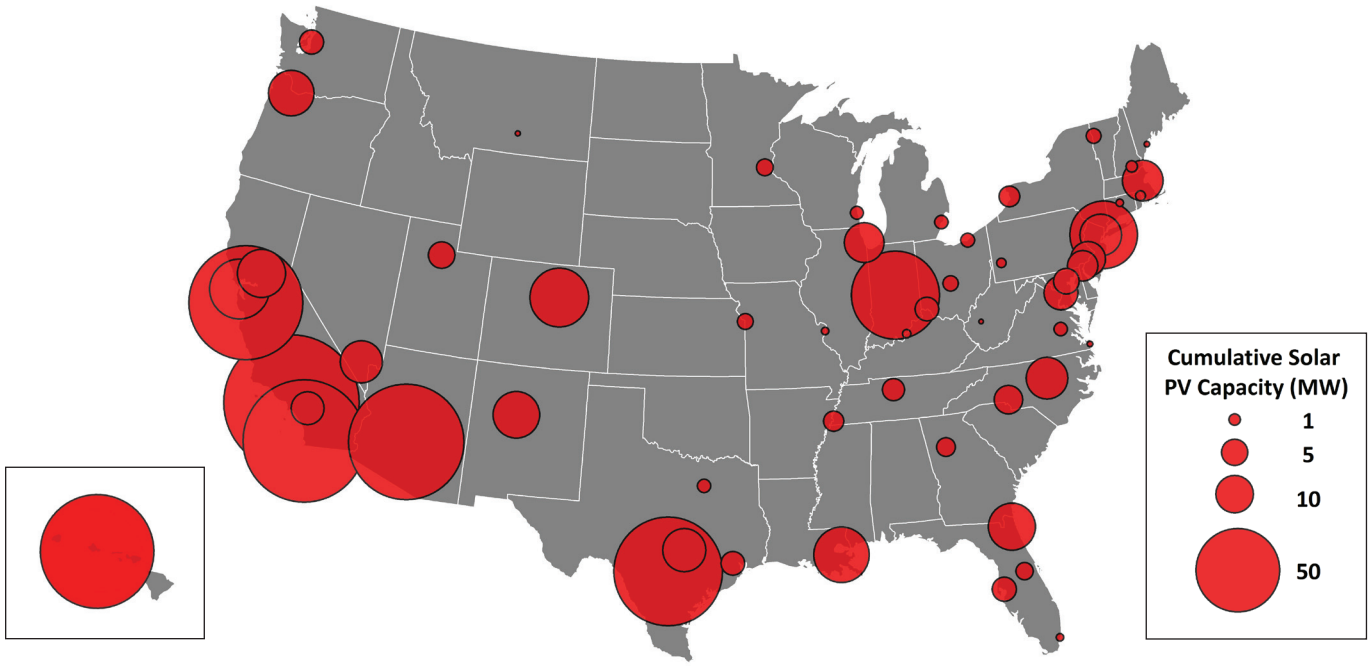


These top 20 cities have a total installed PV capacity of over 890 MW, containing more solar power today than was installed in the entire U.S. just six years ago.[50] These leading cities are located in almost every region of the U.S. (See Table 1 and Figure 5.)

Table 1. Top 20 Solar Cities by Cumulative Installed Solar PV Capacity, End of 2013

Principal City	State	Cumulative Solar PV Capacity (MW)	Cumulative Solar PV Capacity Rank
Los Angeles	CA	132	1
San Diego	CA	107	2
Phoenix	AZ	96	3
San Jose	CA	94	4
Honolulu[51]	HI	91	5
San Antonio	TX	84	6
Indianapolis	IN	56	7
New York	NY	33	8
San Francisco	CA	26	9
Denver	CO	25	10
New Orleans	LA	22	11
Sacramento	CA	16	12
Jacksonville	FL	16	13
Albuquerque	NM	16	14
Portland	OR	15	15
Austin[52]	TX	13	16
Las Vegas	NV	13	17
Newark	NJ	13	18
Raleigh	NC	12	19
Boston	MA	12	20

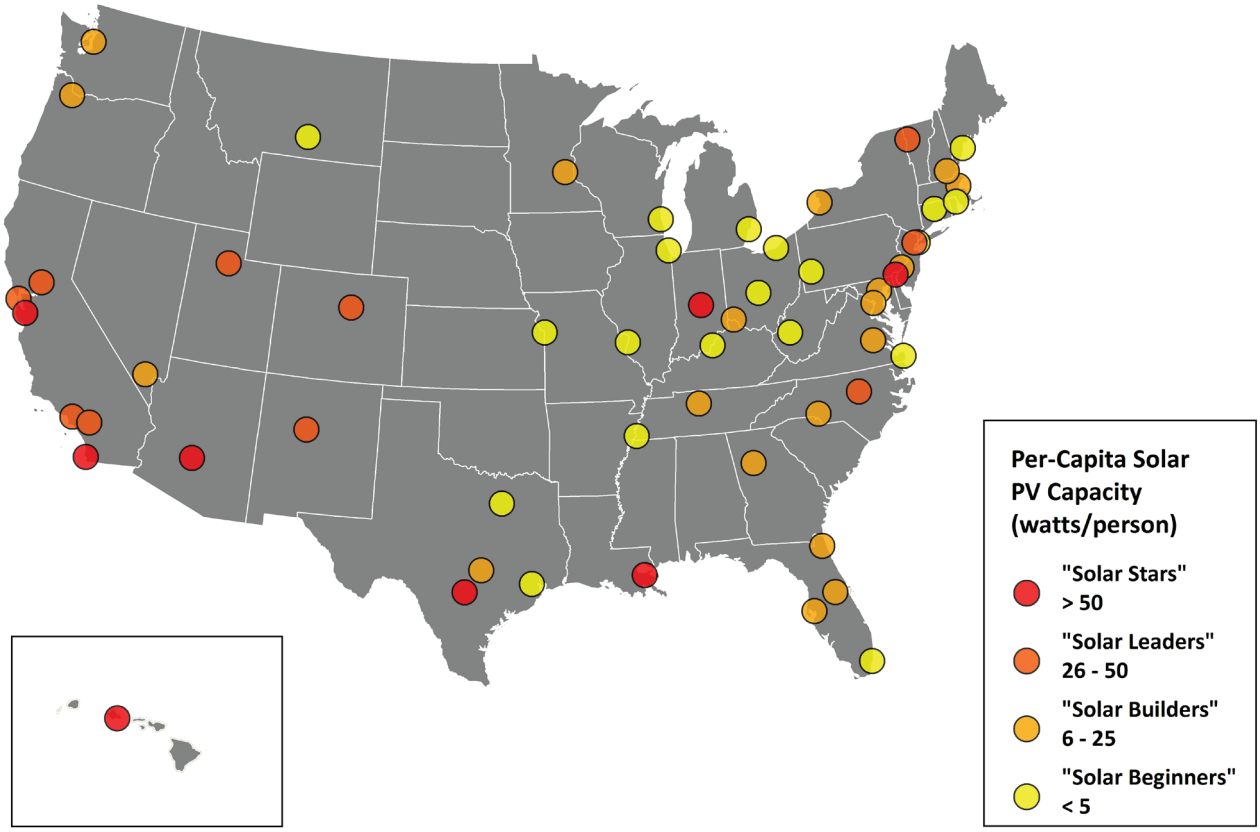
Figure 5. Map of 57 Principal Cities Ranked by Cumulative Installed Solar PV Capacity, End of 2013



On a per-capita basis, Honolulu is the leading solar city, followed by San Jose and Wilmington, Delaware. (See Figure 6 and Table 2.)

By comparing solar capacity per-capita, one can group the cities into several categories.

Figure 6. Map of 57 Principal Cities Ranked by Installed Solar PV Capacity per Person, End of 2013



Stars

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

Table 2. The "Solar Stars" (Cities with More Than 50 Watts of Installed Solar PV Capacity per Person, End of 2013)

Principal City	State	Cumulative Solar PV Capacity (MW)	Solar PV Capacity per Capita (Watts/Person)	Solar PV Capacity per Capita Rank
Honolulu	HI	91	265	1
San Jose	CA	94	97	2
Wilmington	DE	7	96	3
San Diego	CA	107	81	4
Indianapolis	IN	56	68	5
Phoenix	AZ	96	65	6
San Antonio	TX	84	62	7
New Orleans	LA	22	60	8

Leaders

Solar Leaders are cities that have more than 25 and less than 50 watts per person. These cities include several of those (such as Los Angeles, San Francisco and Denver) that lead the nation for total solar capacity.

Table 3. The "Solar Leaders" (Cities with Between 25 and 50 Watts of Installed Solar PV Capacity per Person, End of 2013)

Principal City	State	Cumulative Solar PV Capacity (MW)	Solar PV Capacity per Capita (Watts/ Person)	Solar PV Capacity per Capita Rank
Newark	NJ	13	46	9
Denver	CO	25	40	10
Burlington	VT	2	37	11
Sacramento	CA	16	35	12
Los Angeles	CA	132	34	13
San Francisco	CA	26	31	14
Raleigh	NC	12	30	15
Albuquerque	NM	16	28	16
Salt Lake City	UT	5	27	17
Riverside	CA	8	26	18

Builders

The Solar Builders are those with at least 5 and no more than 25 watts of solar PV capacity per person. This diverse group of cities includes cities that have a history of solar energy leadership as well as cities that have only recently experienced significant solar energy development.

Table 4. The "Solar Builders" (Cities with Between 5 and 25 Watts of Installed Solar PV Capacity per Person, End of 2013)

Principal City	State	Cumulative Solar PV Capacity (MW)	Solar PV Capacity per Capita (Watts/ Person)	Solar PV Capacity per Capita Rank
Portland	OR	15	24.8	19
Las Vegas	NV	13	22	20
Jacksonville	FL	16	19	21
Boston	MA	12	19	22
Austin	TX	13	16	23
Cincinnati	OH	4	14	24
Washington	DC	8	13	25
Tampa	FL	4	12	26
Buffalo	NY	3	12	27
Manchester	NH	1	9	28
Orlando	FL	2	9	29
Charlotte	NC	6	8	30
Baltimore	MD	5	8	31
Seattle	WA	4	7	32
Richmond	VA	1	6	33
Atlanta	GA	3	6	34
Philadelphia	PA	9	6	35
Nashville	TN	4	6	36
Minneapolis	MN	2	5	37

Beginners

The Solar Beginners include 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 experienced little solar energy development at all. New York, with its preponderance of high-rise buildings and more people than many states, has a lower per-capita ranking, but ranks seventh in the nation for total solar capacity and has experienced substantial growth in solar energy in recent years.

Table 5. The "Solar Beginners" (Cities with Less Than 5 Watts of Installed Solar PV Capacity per Person, End of 2013)

Principal City	State	Cumulative Solar PV Capacity (MW)	Solar PV Capacity per Capita (Watts/ Person)	Solar PV Capacity per Capita Rank
Memphis	TN	3	4.6	38
Providence	RI	1	4	39
Chicago	IL	11	4	40
New York	NY	33	4	41
Kansas City	MO	2	4	42
Cleveland	OH	1	4	43
Portland	ME	< 1	3	44
Hartford	CT	< 1	3	45
Charleston	WV	< 1	3	46
Pittsburgh	PA	1	2	47
Milwaukee	WI	1	2	48
Columbus	OH	2	2	49
Billings	MT	< 1	2	50
Detroit	MI	1	2	51
Houston	TX	4	2	52
St. Louis	MO	< 1	1	53
Dallas	TX	1	1	54
Miami	FL	< 1	1	55
Louisville	KY	1	1	56
Virginia Beach	VA	< 1	1	57

Little Cities That Could: Lancaster, Sebastopol, Gainesville and New Bedford Drive Solar Power with Strong Policies

We focus on 57 major cities in this report, but smaller cities have taken noteworthy steps to promote the growth of solar power.

Lancaster and Sebastopol, California

Two California cities—Lancaster and Sebastopol—have adopted requirements that all newly built and renovated homes and commercial buildings incorporate solar energy.[53] These cities were the first in the country to enact such a requirement, and these forward-looking policies were driven by determined local officials. The Sebastopol City Council unanimously voted to pass the policy, which requires 2 watts of solar power per square foot for new buildings, or enough solar power to offset 75 percent of the building's annual electricity usage.[54]

Lancaster City Council passed a similar law requiring every new housing development to install an average of 1 kilowatt (kW) of solar power per home.[55] According to Lancaster Mayor Rex Parris, 26 percent of the city's electrical needs were met with solar power as of January 2014.[56] This includes 7.5 MW of solar power installed on 25 schools and 8 MW of solar power installed at Lancaster High School and Antelope Valley College.[57] Lancaster's program to buy solar power back from schools will save these schools $43 million in energy bills over the next 25 years.[58] Lancaster is creating a model for other cities to follow according to Mayor Parris, who said, as quoted by *The Planning Report*: "The goal is to create a template for other cities. Ultimately the world is going to wake up and realize that climate change threatens the very existence of the species. Once people wake up to that fact, they'll want a template set—so this is what you do to do your part. Each city can do this to lower their carbon footprint."[59]

Gainesville, Florida

Officials in Gainesville, Florida, have implemented several effective policies making solar energy more accessible to its citizens. The most prominent program contributing to Gainesville's solar success was the city's feed-in tariff (FiT) for solar photovoltaic systems, which was offered until the end of 2013.[60]

The city was first in the nation to introduce per-kilowatt hour incentive payments for solar power. The city's municipal utility, Gainesville Regional Utilities (GRU), provided predetermined rate payments to owners of qualified residential and commercial photovoltaic (PV) systems based on the amount of electricity they generated. In March 2014, GRU's total solar capacity reached 18 MW from its FiT program and 2 MW from net metering, for a total of 20 MW of installed solar capacity in GRU's service area.[61] While Gainesville accounts for only 0.7 percent of Florida's population, the service area of the Gainesville utility (which includes some outlying areas around Gainesville) accounted for 9 percent of the state's total installed solar energy capacity at the end of 2013.[62] Gainesville is no longer offering the FiT in 2014 but will continue to offer net metering to its customers; this means Gainesville solar producers can no longer receive above-retail rate FiT payments for solar power production but will receive credit for the electricity they deliver to the electric grid through net metering.[63]

Continued on page 23

Continued from page 22

New Bedford, Massachusetts

New Bedford is a powerful example of smart solar policies at work. The city has faced high levels of poverty and low average incomes, but, despite these challenges, the city has adopted aggressive local policies to promote renewable energy and energy efficiency and reduce its electricity spending. Scott Durkee, director of the New Bedford Energy Office, said that the city's ability to spur solar energy despite economic troubles shows that any city can "go solar."[64]

New Bedford created its Energy Office in 2010 and set a goal of installing 10 MW of solar power in the city within five years. The city is currently on track to hit that goal more than a year early.[65] Currently, 5.2 MW of solar power are installed within the city, with 7 MW set to come online in areas in and around the city by the summer of 2014.[66] New Bedford also offers a "Clean Energy Results" program to promote solar farms on unusable "brownfields," or environmentally contaminated land, thereby creating a sustainable energy source from an otherwise unusable area.[67] New Bedford has contracted with Con Edison Solutions and Blue Wave Capital to construct a solar farm on a brownfield site adjacent to a middle school and high school, which is helping teachers at these schools develop clean energy curricula and connect students to jobs in the solar industry. New Bedford's public buildings with solar installations include three schools, a public gym and their Department of Public Infrastructure Building.[68] The city of New Bedford signed a power purchase agreement with Con Edison Solutions, the firm that will own the solar projects, to purchase all the solar power generated by these installations.[69]

The Massachusetts State Energy Office recognized New Bedford with a "Leading by Example Award" in 2013, as a city that has "established and implemented policies and programs resulting in significant and demonstrable energy and environmental benefits."[70]

Smart Policies Have Fueled Growth in America's Top Solar Cities

Those cities that have opened the door for solar energy with the adoption of strong, smart public policies are building the nation's most successful solar markets, not necessarily the cities that receive the most sunlight. Cities where homeowners are paid a fair price for the energy they supply to the grid, where installing solar panels is easy and hassle-free, where there are attractive options for solar financing, and where there has been a strong commitment to support solar energy development, are seeing explosive growth in solar power.

Top solar cities have followed a variety of paths in developing solar energy. In some cases, city governments have played an important role in jump-starting local solar growth by setting goals for installed solar capacity, implementing solar-friendly laws, and welcoming solar businesses. Cities with municipal utilities have had an even more direct influence on solar power adoption by establishing ambitious requirements for solar energy and implementing effective financial incentives. Some cities have taken steps to increase the use of solar energy on public facilities, while, in other cities, strong state policies are driving local solar power growth.

Cities can most effectively promote solar power when city, state and utility policies work together. This section will describe policies and practices that have encouraged solar power growth in leading solar cities.

City Policies Set an Example and Encourage Solar Growth

Local governments have a special role in fostering the growth of solar energy. City governments can promote solar power by streamlining the permitting and installation process, offering financial management options, and installing solar power on city property. By establishing pro-solar policies, cities can create local installation and manufacturing economies of scale that drive solar development.

City Governments Lead by Example

Many government buildings—from schools to libraries to government offices—are excellent candidates for solar energy. Installing solar power on city buildings can model environmentally responsible behavior and demonstrate city leadership with the adoption of technologies that benefit residents.

Leading solar cities, including Denver and Portland, are driving solar power growth starting with their public buildings. Denver has installed 9.4 MW of solar power on city and county buildings, and the city has partnered with the Denver Public Schools to install solar power on 28 school buildings.[71] To encourage community participation and support for city solar power, Portland has also launched "Solar Forward," an initiative that asks community members to chip in to fund city solar projects.[72]

Cities Streamline Solar Permitting and Protect Residents' "Solar Rights"

Helping reduce the "soft costs" of installing solar PV is a crucial step in making a community hospitable to solar power. Some of the most significant expenses and hurdles faced by potential solar power installers are fees for permitting, inspection and interconnection.[73] Local governments can play an important role in preparing the way for solar energy through the adoption of smart permitting and zoning rules that eliminate unnecessary obstacles to solar development. Local building codes can also help spark the widespread adoption of solar energy, either by requiring new homes and businesses to be

"solar-ready" or by requiring the use of small-scale renewable energy in new or renovated buildings.

Leading solar cities have taken significant steps to streamline the permitting and installation process for solar power.

- Chicago's "Green Permit Program" allows solar PV projects to receive permits in less than 30 days.[74] The cities of Portland and San Francisco have also streamlined the permitting process by reducing wait times for solar PV applications and creating online permitting tools.[75]
- San Jose and Philadelphia have reduced permitting fees and streamlined the application process for solar PV installations. In San Jose, the solar permit application is only one page long, and, in Philadelphia, solar permitting fees are reduced to include only the cost of labor, not labor and equipment costs.[76]

In addition to adopting solar-friendly zoning ordinances and streamlining permitting requirements for solar PV systems, local governments can also adopt "solar rights policies," which protect access to solar power by overriding local ordinances or homeowners' association policies that bar residents from installing solar power equipment on their properties. Cities including Austin have passed laws to allow solar installations to exceed height restrictions stated in the city zoning code.[77] Solar rights policies have also been passed at the state level to stop homeowners' associations from interfering with the installation of solar panels; states that have passed such policies include Hawaii, New Jersey, Virginia and Texas.[78]

As highlighted in the introduction, collective purchasing programs can also drive solar power in cities. "Solarize" programs streamline the process of purchasing solar power and can bring down the cost for solar installers and consumers installing solar panels. Portland, Oregon was the first to offer this program, and city and state programs—like Solarize Boston, Solarize Massachusetts and Solarize Connecticut—have followed suit.[79]

Financing Options Make Solar Power Viable

Often, the biggest hurdle standing in the way of solar energy adoption is not the total cost, but rather the up-front cost of solar power, the amount due at the time of installation. For many homeowners and small businesses, the prospect of buying 20 years' worth of electricity up-front is daunting—particularly if there is a chance that one might move during that time. Creative financing options at the local level can help home and business owners manage the expenses associated with installing solar power.[88]

Local governments can partner with local lending institutions to provide solar financing options that help community members manage the up-front cost of solar power. City governments can facilitate this process by educating the public on solar PV financing options and offering Solarize programs that connect community members directly with lending programs.[89] In Milwaukee, the city "Milwaukee Shines" program partnered with Summit Credit Union to offer low-interest loans of up to $20,000 for eligible solar PV installations. Austin has partnered with Velocity Credit Union to provide a solar loan program that can lend customers up to $20,000.[90]

Cities can also offer tax breaks for solar power. New York City offers a property tax credit for homeowners who install solar panels and exempts residential solar panels from sales tax.[91] Ohio cities Cleveland and Cincinnati offer property tax abatements for buildings that are certified as "green," including many that incorporate solar energy.[92]

Commercial PACE Programs Help Communities Finance Solar Power

Property Assessed Clean Energy (PACE) financing is a tool that cities can use to make solar power affordable. PACE programs can be established and run directly by a local government, or sponsored locally and administered by an outside third-party organization. PACE financing allows property owners to borrow money from a specially created fund for clean energy projects. The loan is paid off on property tax bills over a number of years, thus, future repayment of the loan is assured, even if the property changes hands.[93]

Communities are beginning to make commercial PACE programs a reality. Connecticut has launched a statewide commercial PACE program, managed by the Clean Energy Finance and Investment Authority and endorsed by the Connecticut Bankers Association.[94] This program has given commercial property owners loans to install onsite renewable energy or undergo energy efficiency upgrades, and enabled them to pay back these loans over a number of years on their property taxes.[95] South Florida communities have also taken steps to create a financing district for commercial PACE. Cities including Miami and Coral Gables have joined the "Green Corridor District," where a PACE program backed by Lockheed Martin, Barclays Capital and Ygrene Energy Fund is slated to fund $550 million in energy retrofits, which can include solar installations.[96]

Residential PACE programs have the same potential to unlock investments in solar energy and energy efficiency improvements. Unlike commercial PACE programs, however, residential PACE programs are largely on hold due to opposition from the Federal Housing Finance Agency and the mortgage lenders Fannie Mae and Freddie Mac.[97]

Cities Can Partner with Utilities to Drive Solar Development

City governments with control over their electric utilities are able to implement policies that directly encourage solar power growth, and, with a large percentage of utility customers, cities can use their negotiating power to influence the investor-owned utilities that serve them. Cities with municipal utilities, including Los Angeles, Austin, San Antonio and Jacksonville (along with New Orleans, which has regulatory authority over its investor-owned utility) have taken strong action to promote local solar power. New York City has also effectively partnered with Con Edison, an investor-owned utility, to promote local solar power.

Los Angeles Establishes a Feed-In Tariff

Municipal utilities may set up a feed-in tariff (FiT), which gives energy producers a fixed and long-term contract for the solar electricity produced. These are also known as CLEAN (Clean Local Energy Available Now) contracts, and their effectiveness depends on a number of factors including how quickly customers can get a return on their investment in solar power.

The Los Angeles Department of Water and Power launched the nation's largest FiT program in July 2013, which will bring 100 MW of solar power online.[98] This program will help the Los Angeles Department of Water and Power meet its state-mandated requirement of generating 33 percent of its energy

America's Leading Solar Cities Are Bringing the Benefits of Solar Power to Residents

Solar power offers an array of environmental, public health and economic benefits for cities—benefits that some of the nation's leading solar cities are working to realize.

Since Hurricane Katrina, New Orleans has been a symbol of the disastrous impacts of extreme weather events. As a "Solar Star" city, New Orleans is doing its part to help mitigate the adverse impacts of global warming by generating more electricity with solar power and less with fossil-fueled energy sources. The solar PV capacity installed in New Orleans at the end of 2013 can produce more energy than 2,500 average homes consume in a year, and this is clearly just a start in a city of 370,000 people.[80]

Credit: Gulf South Solar

A rooftop solar installation generates clean energy in New Orleans.

In cities vulnerable to drought or prone to water shortages, solar power is also a water-saver. In drought-stricken Texas, for example, San Antonio and Austin are avoiding millions of gallons of water waste by transitioning to solar power.[81] In California, where more than 90 percent of the state was experiencing severe to exceptional drought conditions as of February 2014, solar PV capacity in California cities will be an important energy solution in a state that cannot needlessly waste water on electricity generation.[82]

Solar power can also save city governments money. In Neptune Beach, Florida, right outside the city of Jacksonville, energy bills for city hall have been dropping rapidly thanks to the 140 solar panels that have been installed on top of the city building. Harnessing solar energy has reduced electricity costs for the Neptune Beach city hall by $7,300 in 2013, as compared to 2012.[83] Like Neptune Beach, Jacksonville encourages sustainable city buildings; it established a "Sustainable Building Program" in 2009 that required all new city buildings to meet green building certification standards, which can include solar panel installations on buildings.[84]

Cities and states that install a significant amount of solar power are attracting solar jobs. Los Angeles's "100 MW Feed-in Tariff" program is expected to create more than 2,000 local jobs within the city.[85] As California leads the country in solar capacity, it is also home to the largest number of solar jobs in the country, with more than 47,000 statewide jobs in solar installation and solar manufacturing.[86] A study of Colorado's solar industry also revealed statewide economic benefits. Since 2007, the Colorado solar industry has created the equivalent of 10,790 full-time jobs, and solar employees have amassed over $500 million in earnings.[87]

Indianapolis Goes Solar: Indianapolis Power & Light Creates a Feed-In Tariff Program

In 2012, Indiana had only a little over 4 MW of solar capacity installed in the entire state—one 600th the amount installed in California and only about 2 percent as much as was installed in Massachusetts.[102] But Indianapolis Power & Light's feed-in tariff program changed the picture for solar energy in Indianapolis.

In 2010, Indianapolis Power and Light (IP&L) took the first step toward diversifying its energy sources, which largely consisted of coal at the time, by instituting a voluntary feed-in tariff program.[103] This program pays solar power producers fixed, above-market rates for solar power generated. Once this program was running, Indianapolis became an attractive place for solar developers to generate power. In 2013, a 12 MW solar installation came online at the Indianapolis airport and three utility-scale installations—over 25 MW in capacity—came online, with the power sold to IP&L.[104] Over 59 MW of additional solar PV is in development in Indianapolis as of the beginning of 2014—which will bring the city's solar PV capacity to 98 MW.[105]

IP&L's FiT was discontinued in March 2013, which may mean slower solar power growth going forward.[106] IP&L continues to offer net metering and a small-scale solar PV incentive program that provides rebates for qualifying residential solar installations.[107] For Indianapolis, solar energy has meant reduced reliance on polluting coal-fired power plants, valuable new investments in the city, and jobs created through construction of these large scale solar projects.[108]

Photo: Dominion

The "Indy I" Solar Array depicted is one of three utility-scale solar projects owned by Dominion Energy Resources—these projects represent a combined 28.6 MW of solar power in Indianapolis.

Photo: Solar San Antonio

A solar energy system installed on the roof of a house in San Antonio with the help of CPS Energy.

with renewable sources by 2020.[99] It is projected to create more than 2,000 jobs and generate $300 million of investment in Los Angeles.[100] A University of California Los Angeles report from February 2014 shows that the first 100-MW component of the FiT is on target to meet its capacity and solar jobs goals.[101]

San Antonio and Austin Set Solar Goals and Offer Incentive Programs

In Texas, the cities of San Antonio and Austin have led solar development through their respective municipal utilities, Austin Energy and CPS Energy. Both utilities have set high goals for solar power adoption. CPS Energy has adopted a goal of using renewable energy to meet 20 percent of its electricity demand by 2020, with at least 100 MW of energy derived from non-wind renewable sources.[109] The city of Austin enacted a renewable electricity standard in 2011 that requires its municipal utility, Austin Energy, to get 35 percent of its energy from renewable sources by 2020, including 200 MW from solar power.[110]

With these goals to drive them, CPS Energy and Austin Energy have offered an array of solar financing options and incentives from which residents can choose. To help residential customers overcome the up-front costs of installing solar power, Austin Energy offers a solar rebate program that pays qualifying customers $1,250 per kilowatt of solar PV capacity installed and has partnered with Velocity Credit Union to provide a solar loan program that can lend customers up to $20,000.[111] CPS Energy also offers a solar PV rebate program, with tiered incentives for residential, school and commercial installations and extra funding for those customers that use local solar installers.[112] Austin Energy also offers a performance-based incentive for commercial and multi-family installations; this is a payment from the utility to the commercial or multi-family customer per kilowatt-hour of solar power produced for up to 10 years.[113]

Austin Energy is offering a "value-of-solar" tariff in place of net metering, and CPS Energy is considering the same transition. Austin Energy's value of solar tariff sets a fixed rate each year at which the

Photo: NW Wind & Solar

A community solar project atop the Seattle City Aquarium.

utility will credit customers for the solar power they generate—this rate is based on energy savings and environmental benefits that are meant to quantify the value of solar power to the electricity grid and compensate solar producers accordingly.[114] While the tariff does provide compensation to owners of solar energy systems, it lacks the long-term predictability of net metering and is unlikely to capture the environmental benefits of solar power.[115]

At the end of 2012, solar power in the city limits of San Antonio and Austin accounted for over 44 percent of all utility-supported solar power in Texas.[116]

Seattle City Light Supports Community Solar Gardens

Community solar programs make solar power a viable option for every resident in a utility's service territory. These programs work when utilities allow their customers to fund ideally-situated community solar projects that are not necessarily connected to every customer; customers funding the project then receive credit for the output of the solar project on their utility bills.[117] Community solar, which may offer ratepayers lower upfront costs, economies of scale and more optimally sited facilities, are an attractive alternative for homeowners or renters who cannot site solar on their residences.

Seattle City Light allows their customers to invest in community solar projects that are not located on their properties but whose output is still credited on their utility bill. The utility's community solar program recently funded an installation on the Seattle Aquarium.[118]

Jacksonville Electric Authority Supports a 15 MW Solar PV Facility

Jacksonville Electric Authority (JEA), the municipal electric utility serving Jacksonville, Florida, has taken action to get more power from clean energy sources. JEA signed an agreement in 2010 to buy all solar power from a 15 MW solar power facility in Jacksonville for 30 years, thereby avoiding 22,430 tons of global warming pollution each year and bringing online enough energy to power 1,400 homes annually.[119] At the time, this was the largest solar PV facility in northern Florida, and it created 70-75 direct jobs for Floridians.[120] This large solar project is an important start toward cleaning up Jacksonville's energy sources; by encouraging more onsite solar on city buildings, JEA can bring more benefits to the city's citizens and businesses. JEA also offers net metering to its customers, which helps to incentivize rooftop solar power development in the city.[121]

New York City and Con Edison Create Solar Power in the Big Apple

In New York City, partnership with Con Edison, the investor-owned utility serving the city, was a key driver of the pro-solar policies that helped solar power take off in the city. In 2007, New York City was designated a "Solar America City" by the U.S. Depart-

New Orleans Goes Solar: State and Local Policies Work Together to Rebuild a Clean Energy Community

New Orleans is a national leader in installed solar power thanks to strong city regulations.

New Orleans had no solar power capacity in 2007, and less than 1 MW was installed by the end of 2010.[122] Today, however, the city is ranked eleventh on our list of cities for total installed solar PV capacity and has the eighth most installed solar PV capacity per person of the 57 major cities we analyzed. New Orleans is emerging as one of the nation's leading solar cities thanks in large part to the actions of local officials in regulating the city's electric utility, Entergy New Orleans.

With the help of a Solar America Cities grant, city government action brought solar power to New Orleans. The utility serving New Orleans, Entergy New Orleans, is an investor-owned utility regulated by the city of New Orleans.[123] The city of New Orleans worked with Entergy to streamline the application process for solar panels, reducing the application length from 50 pages to two pages. In 2007, the city also required Entergy to offer net metering to its customers, standards that would ensure small renewable energy generators receive full, fair credit for the excess energy they deliver back to the utility grid.[124] After Hurricane Katrina devastated the city, government funds also helped rebuild some communities, like the St. Thomas Housing Project, in a sustainable manner; the solar arrays on the rooftops of this revitalized area save residents about $50 per month on utility bills.[125]

State policies also combined with these city initiatives to help make New Orleans an attractive place for solar power. In 2007, Louisiana passed legislation creating statewide solar tax incentives. Two years later, legislation passed that allowed third parties to own residential renewable energy credits and allowed for the creation of renewable energy financing districts.[126] Louisiana has no renewable energy standard, however, making New Orleans' actions at the city level particularly important to drive local solar development.

The city of New Orleans now has almost three times as much solar power as was present in Mississippi, Alabama, South Carolina and Arkansas combined at the end of 2012.[127]

ment of Energy (DOE), helping to kick off a collaboration between the City University of New York, Con Edison, the New York City Department of Builders, the New York State Energy Research and Development Authority (NYSERDA) and the DOE's Solar America Cities program.[128] This collaboration proved fruitful—from 1 MW of installed solar PV capacity in 2007, New York City met its Solar America Cities goal of 8.1 MW in mid-2012, three years ahead of schedule.[129]

Effective partnership with Con Edison was a significant contributor to this success. Con Edison introduced a new net metering policy in 2009 that allowed more solar installations to connect to the grid and receive credit for the excess energy they fed back into it.[130] In 2010, Con Edison also worked with NYSERDA and city agencies to launch the "100 Days of Solar" initiative to streamline the process of issuing a solar permit, interconnecting customers to the grid, and issuing them a rebate.[131] That year, Con Edison also developed "solar empowerment zones" through its partnership with the city and other stakeholders; these are geographic regions in the city identified to be ideal for solar power production, in which solar projects are eligible for additional solar incentives.[132] The collaboration between Con Edison and NYC solar stakeholders has helped bring New York City into the top 10 cities for cumulative installed solar PV.

Strong State Policies Enable the Creation of Solar Cities

State-level policies to promote solar energy have been critical to building successful solar energy markets in several of America's cities. States can set statewide solar energy requirements and establish standardized incentive programs to help residents finance solar projects. As the nation's primary regulators of electric utilities, state governments have a critical role to play in ensuring that interconnection rules and net metering policies are clear and fair and that utilities are considering renewable energy technologies such as solar power in their own resource investment decisions.

In addition, as solar power comes to supply an increasing share of the nation's energy supply, state governments will need to be at the forefront of designing policies that transition the nation from a power 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. The development of policies that allow for the integration of high percentages of solar energy in the electric grid will present the next challenge to the growth of solar energy.

Statewide Renewable Energy Standards with a Meaningful Solar Carve-Out

Setting specific, statewide requirements for the adoption of solar power can create an attractive environment for solar investments in a given state, including in its major cities.

New Jersey and Delaware

New Jersey and Delaware have among the strongest solar-specific renewable electricity standards (RES) in the country.[133] New Jersey's standard aims to have solar energy provide 4.1 percent of the state's electricity use by 2028, and Delaware's standard is ramping up to get 3.5 percent of its utilities' electricity supply from solar PV by 2026.[134] These strong policies have made these states—and the cities of Newark, New Jersey and Wilmington, Delaware—national solar leaders. Wilmington ranked third out of the 57 cities we surveyed for per-capita solar PV capacity with 96 watts installed per person, and Newark ranks among the "Solar Leaders." Wilmington boasts more solar power capacity than Houston, Texas, which is 55 times its size.[135]

Massachusetts

In Massachusetts, a strong renewable energy standard is paired with state government policies to make solar power an attractive investment. These policies have helped to bolster Boston's city-level programs.

Massachusetts requires that investor-owned utilities and retail electric suppliers generate 21.1 percent of their power from renewable energy sources by 2020, including 1,600 MW of solar power.[136] Utilities demonstrate compliance with the solar power requirement by purchasing solar renewable energy credits (SRECs). These SRECs are accumulated by owners of solar panels for every megawatt-hour (MWh) of power those panels produce. To ensure that those investments retain their value, the state has established an auction mechanism with a floor price.[137]

Massachusetts also offers solar rebates to residents and businesses through its "Commonwealth Solar II" program. This is a rebate program that provides money back to approved residential, commercial and industrial solar projects.[138] In addition to these incentives, qualifying solar power installations can be exempt from sales and property taxes for 20 years in Massachusetts, and Massachusetts offers net metering and interconnection policies that make it easier for small generators to connect to the grid.[139]

These policies combine to support solar power development in Boston—putting it in the top 20 cities for total installed solar PV capacity and ranking it 22nd of the 57 cities reviewed in this report for per-capita solar PV capacity.

Net Metering and Interconnection Standards

Most small solar generators do not use all of the electricity that their solar panels generate. In order to make solar power an affordable option, small clean energy producers must be able to get credit for the excess power that they return to the utility grid. Net metering allows utility customers who install solar panels to be treated fairly for the excess electricity they provide to the grid, only charging them for their net electricity usage. The best net metering policies allow customers to get credit for excess electricity they send back to the grid at the same retail rate at which they purchased electricity from their utility. The most solar-friendly states have established requirements for net metering that apply to all utilities; this ensures that solar power producers are not charged unfair fees when benefiting from the energy they produce.

Weakening Net Metering Regulations Could Jeopardize Solar Power Growth in Cities

The growth of solar power is empowering residents and businesses to look beyond the dirty energy alternatives of the past. Yet some utilities, as more and more of their customers generate their own electricity, have begun to see solar energy as a threat to their business model. As a result, some utilities have begun to attack net metering policies designed to help solar power generators recoup the cost of their solar installations.

Arizona, for example, was recently the site of such a battle between Arizona Public Service Company (APS) (one of the utilities that serve Phoenix) and Arizona solar power net metering customers. APS campaigned to charge solar power generators a large fee. Following an outpouring of opposition from the public to APS's proposal, the Arizona Corporation Commission approved a small fee, and otherwise net metering remained unchanged.[140] Net metering has helped Phoenix rank third on our list for cumulative solar PV capacity and sixth for watts of solar power installed per person.

Net metering is an essential policy for encouraging distributed solar power on residential rooftops. It is an important protection for solar producers who are using a beneficial technology to reduce their electricity bills; solar producers should receive the full benefits of power production and utilities should not be able to penalize customers for generating clean energy. Utility attacks on strong net metering policies will only unfairly prevent viable homes and otherwise eager residents from taking part in the solar revolution.

It is also important for states to have clear interconnection standards that do not impose additional expenses on people wishing to install solar power. Interconnection standards clarify how and under what conditions utilities must connect solar panels to the grid while preserving the reliability and safety of the electricity system. Good interconnection policies reduce the time and hassle required for individuals and companies to connect solar energy systems to the grid. California, Massachusetts, New Mexico, Oregon, Utah and Virginia have received an "A" grade for their net metering and interconnection policies from the Vote Solar Initiative and Interstate Renewable Energy Council's joint "Freeing the Grid" assessment, meaning these states have regulations in place that make it easier and more economical for customers to connect their rooftop solar panels to the grid.[141]

"Virtual net metering" is another important state policy to encourage solar power in apartments and multi-tenant housing facilities. Once states approve this policy, electricity customers in apartment buildings or multi-tenant homes can share the benefits of a rooftop solar installation, even if their meters are not directly connected to the solar project. Credits from solar power produced at one location can offset energy bills at another location. Currently, virtual net metering is available in eleven states, including Minnesota and D.C., which passed virtual net metering policies in 2013.[142]

Statewide Solar Energy Rebate Programs

Like cities, states can offer incentive programs that reduce the upfront cost of solar PV installations. Hawaii, California, New York and Massachusetts offer successful statewide programs that have helped residents take advantage of solar power. While rebates were essential for incentivizing new solar markets in years past, now they are expanding to make solar power accessible to low income communities and other underserved sectors.

Hawaii

Hawaii has the highest rates of solar PV grid penetration in the country, likely due to high electricity prices on the

Photo: Hawaiian Electric Company

Solar panels on the roof of the non-profit Easter Seals Society building with downtown Honolulu in the background.

islands, the falling costs of solar equipment and the state's strong renewable energy goals.[143] Hawaii has one of the strongest renewable energy standards in the country, with a requirement of meeting 40 percent of its energy needs with renewables by 2030. In 2008, it formed the "Hawaii Clean Energy Initiative"—a partnership between the State of Hawaii and the U.S. Department of Energy—to help meet this goal.[144]

Hawaii has taken other steps to bring more renewable energy to the state. In 2013, the Hawaii Legislature adopted a measure that enables "on-bill financing" for solar energy and other forms of clean energy technology.[145] On-bill financing allows customers to pay for solar projects over time on their utility bills. Hawaii also offers a statewide feed-in tariff that credits small solar power producers with 21.8 cents per kilowatt-hour of energy generated, with slightly lower rates available for solar PV projects more than 20 kW but less than 5 MW.[146] Hawaii continues to grapple with the challenge of transitioning the small islands' electric grids to accommodate more rooftop solar generation, but Hawaiian solar power is only growing in popularity.[147] The state and its electric utilities should continue to be innovators and leaders in making this transition to a smarter, cleaner electric grid, as the rest of the country can learn from its example.

California

Five of the six California cities included in this report are among the top 15 cities nationally for installed total solar PV capacity—and this dominance is due in large part to California's statewide solar incentive program. In 2006, the California Legislature created the Million Solar Roofs Initiative, now part of the "Go Solar California" campaign, to direct the investment of $3.3 billion in small-scale solar electric power systems. The initiative is on track to reach its 2016 goal of increasing the state's solar generation capacity by 3,000 MW, which will help cut the cost of solar power in half and create a mainstream market for solar power.[148]

The Million Solar Roofs Initiative is composed of three main parts:

1. *The California Solar Initiative*, managed by the state Public Utilities Commission, which seeks to expand the number of solar energy systems installed on existing homes in investor-owned utility territories.
2. *Programs led by publicly-owned utilities*, such as the Sacramento Municipal Utility District or the Los Angeles Department of Water and Power.
3. *The New Solar Homes Partnership*, managed by the California Energy Commission, which seeks to expand the number of solar energy systems installed on new homes in investor-owned utility territories.

California's efforts are working. With 132 MW of solar power, the city of Los Angeles now has more solar power capacity than 39 states had installed at the end of 2012.[149] Its solar power has grown rapidly—Los Angeles had almost three times as much solar PV capacity at the end of 2013 as it had at the end of 2011.[150]

San Diego is hot on Los Angeles' trail with the second highest total solar PV capacity. San Jose ranks second for per-capita solar PV capacity and fourth for cumulative solar PV capacity.

New York

Solar power has also exploded in New York, following the implementation of the "NY-SUN Initiative." This initiative was launched in 2012 and provides cash incentives for residential and commercial customers looking to install solar panels. The program has $800 million to spend on these incentives and on research that will bring down the cost of solar power.[151] In his State of the State address in January 2014, Governor Andrew Cuomo pledged another $1 billion to this program in order to support clean energy development in New York.[152] There are 299 MW of solar power under development in New York State as of January 2014, more than the state had installed in the 10 years prior to the launch of the NY-Sun Initiative.[153] This strong state solar policy has helped place New York City squarely in the top 20 cities for total installed solar PV capacity.

Policy Recommendations

American cities are increasingly leaders in the nation's move toward adoption of clean, affordable solar energy. But there is much remaining that cities can do to take advantage of their solar energy potential.

As solar power continues to grow and thrive, cities should develop good policies to manage distributed generation and work with local utilities to prepare the electric grid to handle more solar power. Cities that begin to incorporate solar power into the grid now will protect residents' health, build more resilient communities and create stronger local economies. In coming years, solar-ready cities will also be ideally situated to benefit from innovative new solar technologies. Adopting strong solar policies at the local, state and federal levels will continue to promote solar energy in leading cities and encourage solar development in those lagging behind, allowing cities to take full advantage of the benefits of clean solar power.

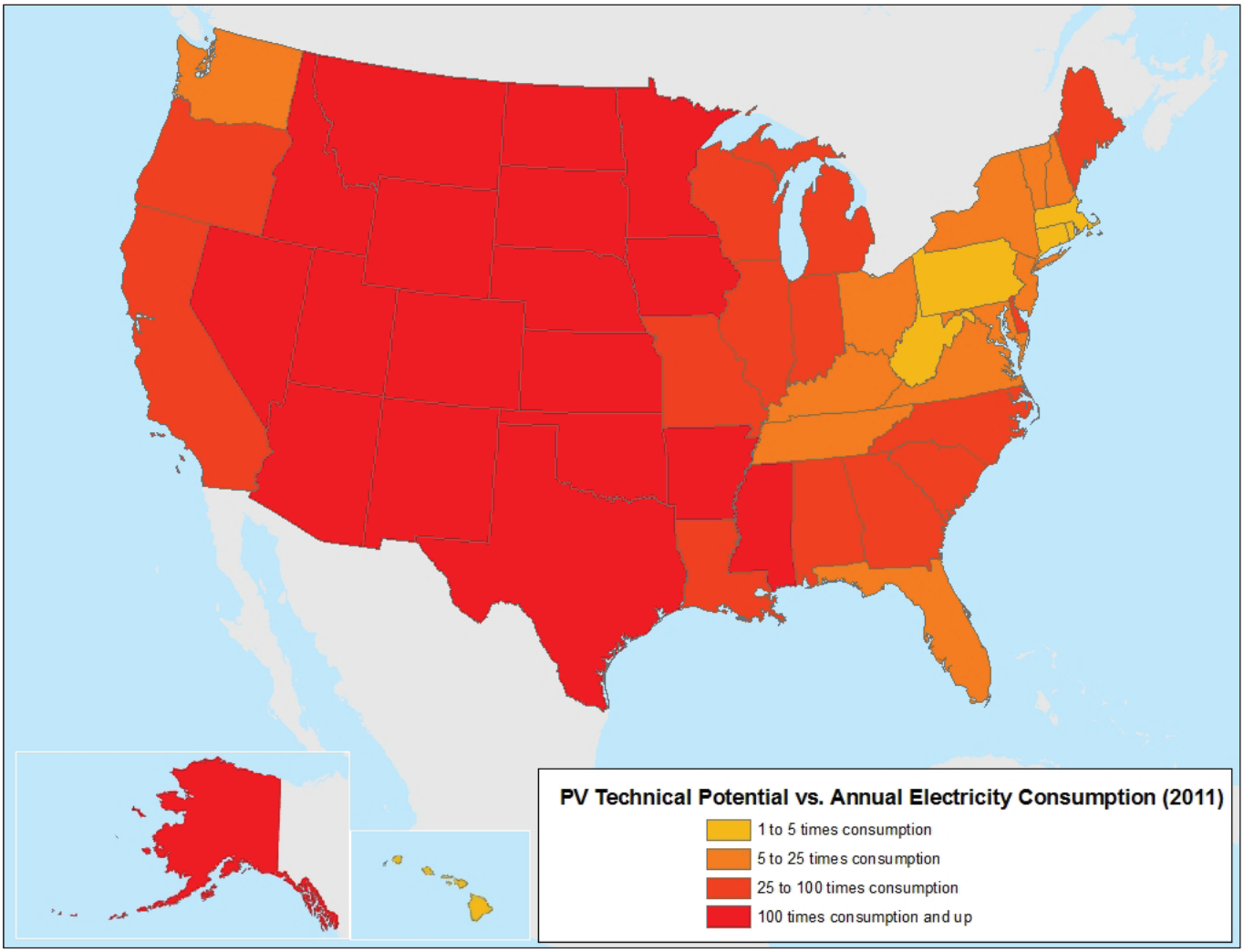
Taking Advantage of America's Solar Energy Potential

America has enough solar energy potential to power the nation several times over. Every one of the 50 states has the technical potential—through both utility-scale and rooftop solar energy systems—to generate more electricity from the sun than it uses in the average year. In 19 states, the technical potential for electricity generation from solar PV exceeds annual electricity consumption by a factor of 100 or more.[154] (See Figure 7.)

An analysis by researchers with the National Renewable Energy Laboratory estimated that rooftop photovoltaic (PV) systems could generate more than 20 percent of the electricity used in the United States each year.[156] Harnessing available rooftop potential is especially important for America's cities, where millions of empty rooftops could be used to generate clean energy. Cities in every region of the United States have enough solar energy potential to power a large share of the economy. The city of Orlando, for example, has 163 million square feet of rooftop space available to support solar power—taking full advantage of that potential would produce enough solar energy to supply 52 percent of the city's electricity demand.[157]

The path to a clean energy future powered increasingly by solar energy is open to every city and state. By adopting strong policies to remove barriers to solar energy and providing individuals and businesses with incentives and financing tools, cities across the country can take part in America's clean energy revolution. State and federal government actions can also support cities in their efforts to "go solar."

Figure 7. Solar PV Technical Potential versus Annual Electricity Consumption by State[155]



Recommendations for Local Government

Cities should take the lead in installing solar power. Local governments should set an example by putting **solar panels on public property**.

Local governments should ensure that every homeowner and business with access to sunlight can exercise the option of generating electricity from the sun. **Solar access ordinances**—which protect homeowners' right to generate electricity from the sunlight that hits their property, regardless of the actions of neighbors or homeowners' associations—are essential protections.

Local governments can also eliminate red tape and help residents to go solar by **reforming their permitting processes**—reducing fees, making permitting rules clear and readily available, speeding up

permitting, and making inspections convenient for property owners.[158] The Vote Solar Initiative has laid out a series of best practices that local governments can follow in ensuring that their permitting process is solar-friendly, and the U.S. Department of Energy's SunShot Solar Outreach Partnership provides online tools and case studies to help cities streamline their permitting processes for solar power.[159] Local governments can also ensure that their zoning regulations are clear and unambiguous in allowing solar energy installations on residential and commercial rooftops**. Solarize programs** can facilitate the solar installation process by connecting solar installers with a number of solar customers at once.

Cities can also provide **financial or zoning incentives** to encourage the construction of green buildings that incorporate small-scale renewable energy technologies such as solar power. **Property tax credits or abatements** for solar power can effectively incentivize rooftop solar PV installations. Cities can encourage **local lenders to offer financing options** for solar installations. **Building codes** can also help spark the widespread adoption of solar energy, either by requiring new homes and businesses to be "solar-ready" or by requiring the use of small-scale renewable energy in new or renovated buildings. Cities in states where **property assessed clean energy (PACE)** financing is an option for commercial establishments can allow for property tax bills to be used for the collection of payments toward a solar energy system.

Cities with municipal utilities have even greater potential to encourage solar energy. The establishment of **local renewable electricity standards**, strong **net metering and interconnection policies**, **local incentive and rebate programs,** and other pro-solar policies can help fuel the rapid spread of solar energy in the territories of municipal utilities. Regulations allowing for **community solar gardens** also create a significant boost in the local solar market by allowing residents who live in shaded homes or who cannot afford their own rooftop solar projects to invest in community solar projects whose output is credited on their utility bill.

Recommendations for State Government

State governments should set **ambitious targets** for the growth of solar energy, and revisit these targets on a regular basis. For many states, a goal of getting 10 percent of their energy from the sun would set an ambitious standard and make a major difference in reducing the state's dependence on fossil fuels well into the future.

To help achieve those goals, local officials should support states' adoptions of **renewable electricity standards with solar carve outs** that require a significant and growing share of that state's electricity to come from the sun. States should also adopt strong statewide **interconnection and net metering policies**, along with **community solar** policies and **virtual net metering**, to ensure that individuals and businesses are able to sell their excess power back to the electric grid and receive a fair price when they do. **CLEAN contracts** and **value-of-solar credits** can play an important role in ensuring that consumers receive fair compensation for solar energy, so long as the credits fully account for the benefits of solar energy and are sufficient to spur participation in the market. Finally, states should allow **third-party sales** of power to customers; third-party sales allow customers to lease rooftop space to a solar developer for a solar PV installation and then purchase the power from that third-party solar developer. This allows customers who do not wish to own solar panels to participate in the solar market and benefit from doing so with lower electricity bills.[160] States should also take action now to begin planning for the integration of high percentages of solar energy in the electric grid.

Recommendations for Federal Government

The federal government is also responsible for developing the nation's solar energy potential. Strong and thoughtful federal policies lay an important foundation on which state and local policy initiatives are built. Among the key policy approaches that the federal government should take are the following:

- **Continue policies that work**—The federal government has often taken an "on-again/off-again" approach to its support of renewable energy. With federal tax credits for residential solar installations now scheduled to expire and federal tax incentives for business solar installations ramping down from 30 percent to 10 percent at the end of 2016, the federal government should extend these tax credits and ensure that they are sufficiently long-term to provide investor confidence to encourage the development of solar energy markets.[161] The federal government should also continue to offer funding to cities for solar development, as it has been effective in the past: according to a survey from the U.S. Conference of Mayors, funding from the Energy Efficiency and Conservation Block Grant (EECBG) program was effectively used to promote city-level solar projects, with 31 percent of cities using EECBG funding for solar power projects on public buildings. Cities also used funding to advance clean energy financing strategies including PACE and on-bill financing.[162] The U.S. Department of Energy's Solar America Cities program was another effective federal initiative which allowed the federal government to directly incentivize solar power in cities. In 2007 and 2008, the U.S. Department of Energy designated 25 cities as "Solar America Cities," providing $200,000 of financial assistance and $250,000 in technical assistance to remove barriers to the proliferation of solar power in these cities.[163] Many of the "Solar America Cities" in this program are also the top ranked cities in this report.[164] The federal government should continue to offer funding and support for local solar development through programs like Solar America Cities.

- **Continue to set high standards and goals for solar energy—**The U.S. Department of Energy's SunShot Initiative has served as a rallying point for federal efforts to bring the cost of solar energy to competitiveness with electricity from fossil fuel systems, and the federal government should continue to support it. The SunShot Initiative recognizes that while traditional research and development efforts for solar energy remain important, a new set of challenges is emerging around the question of how to bring solar energy to large-scale adoption. This initiative builds on lessons learned from the Solar America Cities program; by continuing to investigate how to best integrate solar energy into the grid, how to deliver solar energy more efficiently and cost-effectively, and how to lower market barriers to solar energy, the SunShot Initiative and other efforts play a key supporting role in the nation's drive to embrace the promise of solar energy.

- **Lead by example—**In December 2013, President Obama signed an executive order directing federal agencies to obtain 20 percent of their annual electricity use from renewable sources by 2020.[165] Solar energy will likely be a major contributor to reaching that goal. The U.S. military has been particularly aggressive in developing its renewable energy capacity, committing to getting one-quarter of its energy from renewable sources by 2025. The military has already installed more than 130 megawatts of solar energy capacity and has plans to install more than a gigawatt of solar energy by 2017.[166] Federal agencies should continue to invest in solar energy. In addition, agencies such as the Department of Housing and Urban Development and Department of Education should work to encourage the expanded use of solar energy in schools and in subsidized housing.

Methodology

This report represents, to the authors' knowledge, the first national-scale comparison of its kind of solar photovoltaic installations in major American cities. There is no uniform national data source that tracks solar energy by municipality and there are only a handful of states that compile this information in a comparable format. As a result, the data for this report come from a wide variety of sources—municipal and investor-owned utilities, city and state government agencies, operators of regional electric grids, non-profit organizations, and the National Renewable Energy Laboratory's "Open PV" database. The data on solar energy installations included in this report come from data sources of various levels of comprehensiveness, with various levels of geographic precision, and that often use different methods of quantifying solar photovoltaic capacity (e.g. alternating current (AC) versus direct current (DC) capacity).

We have worked to obtain data that are as comprehensive as possible, to resolve discrepancies in various methods of estimating solar PV capacity, to 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, to use reasonable methods to estimate the proportion of a given area's solar energy capacity that exists within a particular city. 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 the data-related challenges described here could have minor impacts on individual cities' rankings. We look forward to building on and further developing our methodology and data sources in future reports and encourage other researchers to do the same. The full list of sources of data for each city is provided in Appendix B along with the details of any data manipulations made.

Selecting the 57 Major Cities

We selected the cities for this report from the 38 states (including the District of Columbia) shown to have installed more than a negligible amount of solar energy (1.5 MW) by the end of 2012, per L. Sherwood, Interstate Renewable Energy Council, *U.S. Solar Market Trends 2012,* July 2013. Cities were selected from within those states that were:

- The principal city of one of the 50 largest metropolitan areas in the United States, or
- For states with a significant amount of solar capacity but without a city in the 50 largest metropolitan areas nationwide, the state's largest city.

We did not include a city from South Carolina.

Collecting Data on Installed Solar PV Capacity

This report compares the capacity of all solar PV installations within the city limits of the chosen 57 cities as of the end of 2013. See Appendix B for a detailed account of the sources of data for each city.

Using the "Open PV" Dataset

In cases where we could not obtain a reliable estimate of solar installations for a particular city, we used the solar capacity estimate reported in Open PV, an open online database of solar energy installations operated by the National Renewable Energy Laboratory (NREL) and funded by the U.S. Department of Energy's Sunshot Initiative. The data in Open PV comes from a variety of sources. Much of it comes in aggregate form from state-level PV incentive programs or utilities. NREL then screens these data for obvious errors before uploading it. A much smaller portion of their data comes from public contributors (installers and other individuals) who create an account on the website and upload information for an installation. These are not initially screened in the same way as other data, but there is a function allowing users to "flag" installations that look suspicious. NREL also has a scheduled automated screen for duplicates that flags potential duplicate installations, which they then follow up on.

NREL performs a thorough update of the Open PV data once a year in which NREL and the Lawrence Berkeley National Laboratory (LBNL) jointly solicit updated information from their data contributors. At the time we conducted our data search, NREL and LBNL had not yet done this update for 2013, meaning the city numbers from Open PV are likely conservative and missing solar PV capacity. Data in the "Open PV" dataset are reported in DC watts.

To calculate city totals from the "Open PV" dataset, we downloaded the full dataset from the website and used the latitude and longitude coordinates associated with each installation to map them in ArcMap. We then "joined" these installations with a layer of Census designated places provided by ESRI to calculate the total solar PV capacity for each city. The vast majority of the data received by Open PV do not have an address, only a zip code. As a result, the totals for some cities may include some PV systems that are outside a city's boundaries but still within the boundaries of a zip code that includes part of a city.

We also used Open PV data when these solar PV capacity totals captured more solar power than other available sources of data. We used the Open PV solar capacity estimate for the following cities: Boston, MA; Dallas, TX; Las Vegas, NV; and Washington, D.C.

NREL's Open PV Website: National Renewable Energy Laboratory, *The Open PV Project*, downloaded from https://openpv.nrel.gov/, 6 March 2014.

Converting from AC watts to DC watts

Jurisdictions and agencies often use different methods of quantifying solar photovoltaic 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 enter the electric grid. Solar capacity reported in AC watts accounts for the loss of energy that occurs when DC is converted to AC.[167]

We attempted to convert all data to DC watts for the sake of accurate comparison. 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 numbers to DC MW, we used NREL's PV watts default derate factor of 0.77. See NREL's website for a detailed explanation of this conversion factor: http://rredc.nrel.gov/solar/calculators/pvWatts/system.html.

The data for the following cities were reported in AC watts and were converted to DC watts: Burlington, VT; Charlotte, NC; Houston, TX; Indianapolis, IN; Los Angeles, CA; Louisville, KY; Manchester, NH; New Orleans, LA; New York City, NY; Raleigh, NC; Sacramento, CA; San Diego, CA; San Jose, CA; and Virginia Beach, VA.

Appendix A: Solar Energy in Major American Cities

Table A-1: Installed Cumulative and Per-Capita Solar PV Capacity by City, End of 2013

Principal City	State	Cumulative Solar PV Capacity (MW)	Cumulative Solar PV Capacity Rank	Solar PV Capacity per Capita (Watts/Person)	Solar PV Capacity per Capita Rank
Albuquerque	NM	16	14	28	16
Atlanta	GA	3	36	6	34
Austin	TX	13	16	16	23
Baltimore	MD	5	28	8	31
Billings	MT	< 1	56	2	50
Boston	MA	12	20	19	22
Buffalo	NY	3	34	12	27
Burlington	VT	2	41	37	11
Charleston	WV	< 1	57	3	46
Charlotte	NC	6	26	8	30
Chicago	IL	11	21	4	40
Cincinnati	OH	4	31	14	24
Cleveland	OH	1	42	4	43
Columbus	OH	2	40	2	49
Dallas	TX	1	44	1	54
Denver	CO	25	10	40	10
Detroit	MI	1	43	2	51
Hartford	CT	< 1	52	3	45
Honolulu	HI	91	5	265	1
Houston	TX	4	32	2	52
Indianapolis	IN	56	7	68	5
Jacksonville	FL	16	13	19	21
Kansas City	MO	2	39	4	42
Las Vegas	NV	13	17	22	20
Los Angeles	CA	132	1	34	13
Louisville	KY	1	50	1	56
Manchester	NH	1	47	9	28
Memphis	TN	3	35	5	38
Miami	FL	< 1	53	1	55

Continued on page 43

Continued from page 42

Principal City	State	Cumulative Solar PV Capacity (MW)	Cumulative Solar PV Capacity Rank	Solar PV Capacity per Capita (Watts/Person)	Solar PV Capacity per Capita Rank
Milwaukee	WI	1	46	2	48
Minneapolis	MN	2	38	5	37
Nashville	TN	4	33	6	36
New Orleans	LA	22	11	60	8
New York	NY	33	8	4	41
Newark	NJ	13	18	46	9
Orlando	FL	2	37	9	29
Philadelphia	PA	9	22	6	35
Phoenix	AZ	96	3	65	6
Pittsburgh	PA	1	49	2	47
Portland	OR	15	15	25	19
Portland	ME	< 1	55	3	44
Providence	RI	1	48	4	39
Raleigh	NC	12	19	30	15
Richmond	VA	1	45	6	33
Riverside	CA	8	24	26	18
Sacramento	CA	16	12	35	12
Salt Lake City	UT	5	27	27	17
San Antonio	TX	84	6	62	7
San Diego	CA	107	2	81	4
San Francisco	CA	26	9	31	14
San Jose	CA	94	4	97	2
Seattle	WA	4	29	7	32
St. Louis	MO	< 1	51	1	53
Tampa	FL	4	30	12	26
Virginia Beach	VA	< 1	54	1	57
Washington	DC	8	23	13	25
Wilmington	DE	7	25	96	3

Appendix B: City-By-City Data Sources

In the descriptions below, we detail the sources of our solar PV capacity totals for each city. We note when the data were reported in AC watts and converted to DC watts. Unless otherwise mentioned, the data were either reported in DC watts, or we made the conservative assumption that the data were in DC watts.

Where we or our data source used zip codes or postal addresses to determine what amount of solar capacity fell within the city limits, the result may be a small overestimation or underestimation of the total solar capacity within the city limits. Estimates based on zip codes or postal addresses may contain a small number of installations that are not within the city limits or miss some installations that are within the city limits.

Albuquerque, New Mexico—16 MW

This number is based on the U.S. Energy Information Administration's report on utility-scale solar PV in Albuquerque as of 2012, plus an estimate of distributed solar PV capacity based on the total amount of customer distributed solar PV capacity in the Public Service Company of New Mexico's (PNM's) service territory (which covers the city of Albuquerque) as of 31 December 2013.[168]

According to PNM, their customers had installed 31 MW of solar PV as of 31 December 2013. PNM was unable to provide an Albuquerque-specific solar capacity total.[169] We scaled this number based on the number of households in Albuquerque in relation to the total number of PNM customers:[170]

Solar PV Capacity in Albuquerque Estimate (MW) = Total Known Solar PV Capacity in Albuquerque + (Total Distributed Solar PV Capacity in PNM Service Territory)*(Households in Albuquerque/Number of PNM Customers in Service Territory)

Solar PV Capacity in Albuquerque Estimate (MW) = 2 MW + ((31 MW)*(222,584/507,000))

Atlanta, Georgia—3 MW

Southface (http://www.southface.org/) provided us with a list of solar PV installations in DeKalb and Fulton counties through 31 December 2013, with latitude and longitude information for each installation. Southface maintains a map of "Georgia Energy Data" at www.georgiaenergydata.org/solarmap, which is believed to be the most comprehensive source of data on solar energy installations in the state of Georgia. These data are believed to be largely in DC watts, but some sources of data relied on by Southface did not specify whether capacity was in DC or AC watts.[171]

The information provided by Southface allowed us to map the solar PV installations using ArcMap, and isolate the capacity within the city limits of Atlanta.

Austin, Texas—13 MW

Austin Energy provided us with a list of customer-rebated solar PV installations and utility-scale solar PV projects with zip codes as of 31 December 2013. They also reported that there is "at least another 700 kW-DC of privately owned non-rebated solar in the city."[172] Within the customer-rebated systems, there

were municipal installations that were not listed by zip code, but Austin Energy identified these as almost certainly falling within Austin city limits.

We used ArcMap to determine which zip code points were centered within the city limits of Austin, and counted only installations within those zip codes. The total amount of solar PV in Austin was calculated by adding the customer generation within zip codes centered in Austin (as determined using ArcMap) to the utility-scale projects in Austin to the 0.7 MW of non-rebated solar PV in the city.

Austin Energy, the municipal utility serving Austin, Texas, also generates solar power at a 30-MW solar facility that exists partially in Austin's "extraterritorial jurisdiction" (ETJ). Austin's ETJ includes unincorporated land within 5 miles of Austin's city limits, per AustinTexas.gov, Planning and Development Review Department, *Extraterritorial Jurisdiction: What Is It?*, downloaded from http://www.austintexas.gov/faq/extraterritorial-jurisdiction-etj-what-it, 5 March 2014. Because this solar farm lies outside what are technically the city limits of Austin, we did not include it in Austin's solar total.

Baltimore, Maryland—5 MW

Data on solar PV installed in the city of Baltimore was taken from the SREC registry PJM-GATS.[173] These data only include solar PV installations that are registered in the system before 31 December 2013, but the 4.7 MW included in the GATS report downloaded on 6 March 2014 is larger than the 3.45 MW of solar PV reported in Open PV, and so the larger and more comprehensive estimate was used here.

Billings, Montana—0.2 MW

Northwestern Energy, the utility serving Billings, provided the known amount of solar PV capacity installed in Billings as of 31 December 2012 (0.191 MW), and an estimate of the solar PV capacity installed in Billings during 2013 (0.016 MW).

Boston, Massachusetts—12 MW

The solar PV capacity installed in Boston is taken from NREL's Open PV database. See the Methodology for a description of the data from Open PV.

Data for Boston were also calculated using data from the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) in its worksheet, "RPS Solar Carve-Out Qualified Renewable Generation Units," last updated 20 December 2013, downloaded from http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/rps-solar-carve-out/current-status-of-the-rps-solar-carve-out-program.html. This worksheet tracks solar energy projects that receive SREC credit through the state's RES solar carve-out. Because the amount of solar capacity reported to the Massachusetts EOEEA data set was lower than reported in Open PV, the larger and more comprehensive estimate was used here.

Buffalo, New York—3 MW

Data on solar PV capacity in the city limits of Buffalo as of 31 December 2013 was provided by the New York State Energy Research and Development Authority (NYSERDA). This includes only solar PV installations that were funded through NYSERDA, which manages New York's solar PV financial incentive program.

Burlington, Vermont—2 MW

Data were obtained from the Vermont Energy Atlas (http://www.vtenergyatlas.com) a project of the Vermont Sustainable Jobs Fund, the Vermont Center for Geographic Information, Fountains Spatial and Overit Media. Data for the map are provided by the Vermont Clean Energy Development Fund, the Vermont Public Service Board and other sources. Installations were sorted by town name, and we totaled the installations labeled with "Burlington." The data were last updated 16 December 2013. A review of

several of the installations found them to be reported in AC watts, so we assumed the total was in AC watts and converted it to DC watts (see Methodology).

Charleston, West Virginia—0.2 MW

The Appalachian Power Company provided an aggregate sum of solar PV capacity within Charleston zip codes.[174] These data were provided through 8 January 2014, so solar PV capacity installed in the first eight days of 2014 may be included.

Charlotte, North Carolina—6 MW

Solar PV capacity within Charlotte was determined by identifying solar PV projects in North Carolina from the North Carolina Utilities Commission (NCUC) worksheet, "New Renewable Energy Facility Registrations Accepted by the North Carolina Utilities Commission, 2008-2013," last updated 31 December 2013. The NCUC docket for each registered solar PV installation was then reviewed, using the NCUC's electronic docket, to determine whether the location of the system was within the city of Charlotte. The NCUC docket for several of the projects referred to their capacity in terms of AC watts, and it was assumed that this held true for the other projects as well. We converted these capacity figures to DC watts (see Methodology).

Chicago, Illinois—11 MW

Commonwealth Edison, the power company serving Chicago, provided us with data on solar PV capacity within the city limits of Chicago.[175] The data includes all installations within the city limits of Chicago through 31 December 2013. Two installations with a combined capacity of 0.8 MW were excluded because the capacity was reported as "a combination of wind and solar PV," and we could not isolate the solar PV capacity. These data were reported in DC watts.

Cincinnati, Ohio—4 MW

The Public Utilities Commission of Ohio provided us with a list of certified renewable energy installations, with address information, updated as of 31 December 2013.[176] We isolated the solar PV capacity of installations within the city limits of Cincinnati by mapping the installation addresses in ArcMap, joining them to the "USA Census Populated Places" layer, and choosing the Cincinnati total. It is important to note that these are "certified" installations; some may have completed the certification process but are not yet online, making this possibly an overestimate of installed solar PV capacity as of 31 December 2013.

Cleveland, Ohio—1 MW

See "Cincinnati, Ohio."

Columbus, Ohio—2 MW

See "Cincinnati, Ohio."

Dallas, Texas—1 MW

The solar PV capacity installed in Dallas is taken from NREL's Open PV database. See the Methodology for a description of the data from Open PV.

Data for Dallas were also provided by Clean Energy Associates (CEA), a clean energy consulting company that ran Dallas-electric utility Oncor's solar PV incentive program through 2012. This solar PV capacity total for Dallas provided by CEA only reflects solar PV installations with the city label "Dallas" through 31 December 2012.[177] The authors requested data for 2013 from Oncor, which now manages its own solar PV incentive program in Dallas, but the company declined to provide Dallas-specific data.[178] That solar PV capacity total is therefore missing a year of solar PV, and a small number of installations listed as "Dallas" may actually fall outside the Dallas city limits. Because the Open PV total was larger than the 1.24 MW reported by Clean Energy Associates, we used the more comprehensive Open PV total.

Denver, Colorado—25 MW

This solar PV capacity total for Denver is an estimate provided by Xcel Energy, the utility that serves the city of Denver. Aside from this estimate, Xcel declined to provide more detailed data on solar PV capacity in Denver as of the end of 2013.[179]

Detroit, Michigan—1 MW

DTE Energy Company provided us with the solar PV capacity within the city limits of Detroit as of 29 January 2014.[180]

Hartford, Connecticut—0.4 MW

This total is the sum of the solar PV capacities of solar facilities listed as approved under Connecticut's Renewable Portfolio Standard, based on a worksheet obtained from the Connecticut Public Utilities Regulatory Authority (PURA) labeled "RPS," obtained from http://www.ct.gov/pura/lib/pura/rps/rps.xls, and last updated on 13 November 2013.

Honolulu, Hawaii—91 MW

We estimated the amount of solar PV capacity in urban Honolulu from county-level data released by Hawaiian Electric, the company serving the county of Honolulu (which is coterminous with the island of Oahu).[181] Within the island of Oahu, the census designated place "urban Honolulu" is the place most comparable with other U.S. cities.[182] Data that would allow for more precise identification of PV facilities within urban Honolulu were requested from Hawaiian Electric Company, the city of Honolulu permitting department, and the Hawaii State Energy Office, but none of these sources could provide data more geographically specific than the county level.

We used the total capacity of solar PV installations within Honolulu County to estimate what percent of this capacity would fall in urban Honolulu.[183]

Solar PV Capacity in urban Honolulu Estimate (MW) = Total Solar PV Capacity in Honolulu County*(Urban Honolulu Households/Honolulu County Households)

Solar PV Capacity in Honolulu Estimate (MW) = 221 MW *(127,652/308,490)

Houston, Texas—4 MW

Centerpoint Energy, the electric utility serving the city of Houston, provided us with solar PV capacity installed in its service area broken down by city.[184] These city breakdowns were compiled using addresses, not city limits, so a small number of installations included in the Houston total may fall outside of the city limits. The data were up to date through 31 December 2013. These data were reported in AC watts, and were converted to DC watts (see Methodology).

Indianapolis, Indiana—56 MW

Indianapolis Power & Light, the investor-owned utility serving Indianapolis, provided us with an aggregate total of solar PV capacity installed within the city limits.[185] The data were up to date through 31 December 2013. These data were reported in AC watts, and were converted to DC watts (see Methodology).

Jacksonville, Florida—16 MW

Jacksonville Electric Authority (JEA), the municipal utility serving the city, provided us with 1) JEA net metering subscriptions with zip codes, and 2) JEA's identified systems within Jacksonville, which included the 15 MW Jacksonville Solar facility where JEA receives energy though a power purchase agreement.[186] Data were complete through 31 December 2013.

Using ArcMap, we identified zip codes that are centered in the city limits of Jacksonville, and summed the capacity of solar PV installations in those zip codes to estimate the solar capacity in Jacksonville. The total amount of solar PV in Jacksonville was calculated by adding the customer generation within Jacksonville zip codes to the other projects JEA identified as being within Jacksonville.

Kansas City, Missouri—2 MW

This solar PV capacity total is based on data that Kansas City Power & Light (KCP&L) reported to the U.S. Energy Information Administration on net metered solar PV installed in its service territory as of September 2013.[187]

The solar PV capacity in Kansas City was estimated based on the total net metered solar PV capacity in KCP&L's service territory using the ratio of households in Kansas City to customers in KCP&L's service territory.[188] KCP&L declined to provide more detailed data on solar capacity within Kansas City.[189]

Solar PV Capacity in Kansas City Estimate (MW) = (Total Non-Located Solar PV Capacity in KCP&L Service Territory)*(Households in Kansas City/Number of KCP&L Customers in Service Territory)

Solar PV Capacity in Kansas City Estimate (MW) = (4.81 MW)*(192,048/511,100)

Las Vegas, Nevada—13 MW

The solar PV capacity installed in Las Vegas is taken from NREL's Open PV database. See the Methodology for a description of the data from Open PV.

Nevada Energy provided us with data on solar PV installations, broken down by zip code, as of 2 January 2014.[190] Using ArcMap, we identified zip codes that are centered in the city limits of Las Vegas, and summed the capacity of solar PV installations in those zip codes to estimate the solar PV capacity in Las Vegas. Using this method and the data from NV Energy, the solar PV capacity in Las Vegas was found to be 12.7 MW. Because this total was smaller than that reported in Open PV, we used the more comprehensive Open PV total.

Los Angeles, California—132 MW

The Los Angeles Department of Water and Power provided us with the solar PV capacity total within the city of Los Angeles.[191] This includes solar PV installed through the Solar Incentive Program, Los Angeles' Feed-in Tariff Program, and their community solar program, through 31 December 2013. These data were reported in AC watts, and were converted to DC watts (see Methodology).

Louisville, Kentucky—1 MW

Louisville Gas & Electric provided us with an aggregate total of installed solar PV capacity within the city limits of Louisville, through 31 December 2013.[192] These data were reported in AC watts, and were converted to DC watts (see Methodology).

Manchester, New Hampshire—1 MW

Public Service of New Hampshire, the electric utility company serving the city of Manchester, provided us with an aggregate total of installed solar PV capacity within the city limits of Manchester, through 31 December 2013.[193] These data were reported in AC watts, and were converted to DC watts (see Methodology).

Memphis, Tennessee—3 MW

The Tennessee Valley Authority renewables program provided us with an aggregate total for solar PV capacity within the city limits of Memphis as of 31 December 2013.[194]

Miami, Florida—0.4 MW

Florida Power & Light provided us with solar PV installed in their service area, broken down by zip code, as of 31 December 2013.[195] We used ArcMap to isolate those zip codes that are centered within the city limits of Miami and counted only solar PV installations in those Miami zip codes in the solar PV capacity total for the city.

Milwaukee, Wisconsin—1 MW

As reported on the website of the city of Milwaukee, the city has "more than 1.25 MW of solar energy being produced in Milwaukee."[196] Our use of 1.25 MW is therefore an underestimate, but we were unable to determine how much over 1.25 MW of solar power the city had installed.[197]

Minneapolis, Minnesota—2 MW

The city of Minneapolis provided us with an aggregate solar PV capacity total as of the end of 2012.[198] This total

was aggregated by Xcel, the electric utility serving Minneapolis, which declined to provide us data from 2013.[199] Solar PV installations in 2013 are, therefore, not included in this estimate.

Nashville, Tennessee—4 MW

See "Memphis, Tennessee."

New Orleans, Louisiana—22 MW

Entergy New Orleans, the electric utility serving New Orleans, provided us with this solar PV capacity total, as of 31 December 2013.[200] These data were reported in AC watts, and were converted to DC watts (see Methodology).

New York, New York—33 MW

Data on solar PV capacity in the city limits of New York as of 31 December 2013 were provided by Con Edison, the utility serving New York City.[201] These data were reported in AC watts, and were converted to DC watts (see Methodology).

Newark, New Jersey—13 MW

The solar PV installations supported by New Jersey's Clean Energy Program (NJCEP) are made available online in "NJCEP Solar Installations Report" with city and zip code information.[202] When we collected the data, information was available through 31 December 2013. We found the Newark solar PV total by filtering "city name" for Newark.

Orlando, Florida—2 MW

Orlando Utilities Commission, the municipal utility serving the city of Orlando, provided us with a spreadsheet of solar installations in OUC's service territory, with address information and updated as of 31 December 2013.[203] We filtered this list for "solar PV" projects only, and filtered out any "discontinued" or "pending" projects. We then mapped the qualifying projects in ArcMap and found the capacity of those installations within the city limits of Orlando, as was delimited by the "US Census Populated Places" layer.

Philadelphia, Pennsylvania—9 MW

This solar PV capacity total was found using the SREC-tracker PJM-GATS dataset.[204] We downloaded this list and summed the solar PV capacity within "Philadelphia County" registered before 31 December 2013.

Phoenix, Arizona—96 MW

These data were obtained from the Arizona "Go Solar" website, managed by the Arizona Corporation Commission with information provided by regulated electric utilities.[205] Spreadsheets of solar PV installations are downloadable by utility by zip code on this website. The electric utilities Arizona Public Service (APS) and the Salt River Project (SRP) serve the city of Phoenix. We downloaded their spreadsheets of installations, and selected those installations that were assigned the status of "installed," were listed as "PV," were installed before 31 December 2013, and fell into zip codes centered in the Phoenix city limits. We used ArcMap to identify zip codes that are centered in the city limits of Phoenix, and we used only installations in those zip codes to determine the solar PV capacity in Phoenix.

Pittsburgh, Pennsylvania—1 MW

We received data on the solar PV capacity within the city limits of Pittsburgh from the Office of the Mayor.[206] These data were collected by PennFuture from the Pennsylvania Public Utilities Commission. The data are current to the middle of December 2013.

Portland, Maine—0.2 MW

The solar PV capacity installed in Portland was provided by Central Maine Power.[207] These data are up to date through December 2013.

Portland, Oregon—15 MW

The Portland Bureau of Planning and Sustainability provided us with a solar PV capacity total for the city of Portland (based on Portland zip codes), as of 31 December 2013.[208] The solar PV installations included in this total were part of the two mutually-exclusive

Oregon solar incentive programs, Energy Trust of Oregon and the Oregon Volumetric Incentive Rate pilot program. This number was reported in DC watts.

Providence, Rhode Island—1 MW

The Rhode Island Office of Energy Resources provided us with a spreadsheet of solar installations by city, taken from National Grid's net metering spreadsheet, as of 31 December 2013.[209] We included only those installations within "Providence."

Raleigh, North Carolina—12 MW

See "Charlotte, North Carolina."

Richmond, Virginia—1 MW

The city of Richmond obtained a list of net metered solar PV installations from the Virginia Department of Mines, Minerals and Energy as of 21 January 2014.[210] We used installations listed with the "city name" of Richmond.

Riverside, California—8 MW

The installed solar PV capacity total for Riverside was taken from a solar map maintained by the Riverside Power District: http://www.greenriverside.com/Green-Map-9. This map is updated daily, and the total we used was recorded on 9 January 2014; therefore, some solar PV capacity in this total may have been installed in the first nine days of 2014.

Sacramento, California—16 MW

The Sacramento Municipal Utility District (SMUD) provided us with spreadsheets of individual solar PV installations within the SMUD service area, including address information.[211] These installations included residential and commercial installations that had been incentivized by SMUD and solar PV installed through the Solar Smart new homes program. These installations were mapped in ArcMap using the addresses provided, and joined with the city limits of Sacramento to determine the solar PV capacity within the city limits. The data were provided in AC watts, and were converted to DC watts (see Methodology).

Salt Lake City, Utah—5 MW

The Rocky Mountain Power Company, the electric utility serving Salt Lake City, provided us with solar PV capacity installed as of 31 December 2013 within Salt Lake City.[212]

San Antonio, Texas—84 MW

Solar San Antonio, a non-profit organization in San Antonio, provided us with data on solar installations by zip code as of 31 December 2013.[213] These data are from CPS Energy, the municipal utility serving the city of San Antonio. We used ArcMap to identify zip codes that are centered in the city limits of San Antonio, and we used only installations in those zip codes to determine the solar PV capacity in San Antonio.

San Diego, California—107 MW

San Diego Gas and Electric provided us with this total, which includes net metered installations and non-net metered solar projects within the city limits of San Diego, through 31 December 2013.[214] These data were reported in AC watts, and were converted to DC watts (see Methodology).

San Francisco, California—26 MW

The City and County of San Francisco provided us with the installed solar PV capacity within the city limits of San Francisco, which includes "everything connected to the grid" in San Francisco. They could only provide data through August 2013.[215]

San Jose, California—94 MW

This solar PV capacity total for San Jose was provided by Pacific Gas & Electric within the city limits of San Jose as of 5 January 2014.[216] These data were reported in AC watts, and were converted to DC watts (see Methodology).

Seattle, Washington—4 MW

Seattle City Light (SCL), Seattle's municipal utility, and Seattle's Department of Planning and Development estimate that there are 6 MW of solar PV capacity installed within SCL's service territory as of the end of 2013, which is larger than the city of Seattle. Seattle City Light and Seattle's Department of Planning and Development did not have a more specific number available.[217] We scaled this number based on the number of homes in Seattle and the number of total customers in Seattle City Light's service territory.[218]

Solar PV Capacity in Seattle Estimate (MW) = (Total Non-Located Solar PV Capacity in Seattle City Light's Service Territory)*(Households in Seattle/ Number of Seattle City Light Customers in Service Territory)

Solar PV Capacity in Seattle Estimate (MW) = 6 MW * (285,476/403,000)

St. Louis, Missouri—0.4 MW

The Missouri Department of Economic Development maintains a list of "Certified Solar Renewable Generation Facilities," which includes information on customer solar generation in Ameren Missouri's service territory (Ameren is the utility serving St. Louis Missouri).[219] As of 17 April 2013, Ameren had 3.66 MW of solar PV installed within its service territory. We scaled that figure to St. Louis using the number of households in St. Louis as compared to the total number of customers in Ameren Missouri's service territory.[220]

Solar PV Capacity in St. Louis Estimate (MW) = (Total Non-Located Solar PV Capacity in St. Louis City Light's Service Territory)*(Households in St. Louis/ Number of Ameren Customers in Service Territory)

Solar PV Capacity in St. Louis Estimate (MW) = 3.66 MW*(139,840/1,200,000)

Tampa, Florida—4 MW

Tampa Electric provided a spreadsheet of installed solar PV capacity, with city name and zip code information.[221] We used ArcMap to determine which zip codes are centered within the city limits of Tampa and used only the reported solar capacity within those zip codes to estimate the capacity within the city limits.

Virginia Beach, Virginia—0.3 MW

Dominion Virginia Power provided us with data on solar PV installed in the city limits of Virginia Beach as of 31 December 2013.[222] These data were reported in AC watts, and were converted to DC watts (see Methodology).

Washington, D.C.—8 MW

The solar PV capacity installed in Washington, D.C. is taken from NREL's Open PV database. See the Methodology for a description of the data from Open PV.

PJM GATS also tracks solar PV installed in Washington D.C., but its total was less complete than the solar PV capacity reported in Open PV.

Wilmington, Delaware—7 MW

The Delaware Public Service Commission maintains a downloadable spreadsheet of certified renewable energy facilities.[223] We used this spreadsheet to find the solar PV capacity in Wilmington, based on postal address, as of 31 December 2013.

Notes

1. U.S. Department of Energy, *Solar in Action: Portland, OR*, October 2011.

2. Linda Irvine, Alexandra Sawyer and Jennifer Grove, Northwest Sustainable Energy for Economic Development, *The Solarize Guidebook: A Community Guide to the Collective Purchasing of Residential PV Systems*, May 2012.

3. Ibid.

4. Ibid.

5. Ibid.

6. Boston: Renew Boston Solar, *Switch to Solar*, accessed at www.renewboston.org/solar, 6 February 2014; Seattle: Solarize Washington, *Home*, accessed at www.solarizewa.org, 17 March 2014.

7. Streamlined solar permitting: U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: City of Portland: Streamlined Building Permits for Residential Solar Systems*, 26 November 2012, available at www.dsireusa.org; The City of Portland Planning and Sustainability, *Community Energy Meets Crowdsourcing*, accessed at www.portlandoregon.gov, 6 March 2014.

8. See note 1.

9. American Lung Association, *State of the Air 2013: Key Findings*, 2013, accessed at www.stateoftheair.org/2013/key-findings/ozone-pollution.html.

10. Raquel A. Silva et al, "Global premature mortality due to anthropogenic outdoor air pollution and the contribution of past climate change," *Environmental Research Letters* 8 (2013), doi:10.1088/1748-9326/8/3/034005.

11. Sea Level Rise: A. Dutton and K. Lambeck, "Ice Volume and Sea Level During the Last Interglacial," *Science*, 337 (6091):216-219, doi: 10.1126/science.1205749; Analysis of which cities are in danger: Baden Copeland, Josh Keller and Bill Marsh, "What Could Disappear," *New York Times*, 24 November 2012.

12. Tony Dutzik, Elizabeth Ridlington and Tom Van Heeke, Frontier Group and Nathan Wilcox, Environment America Research & Policy Center, *In the Path of the Storm: Global Warming, Extreme Weather and the Impacts of Weather-Related Disasters in the United States from 2007 to 2012*, April 2013.

13. CoreLogic, *2013 CoreLogic Wildfire Hazard Risk Report*, 10 October 2013.

14. Power plants are responsible for 23 percent of U.S. emissions of nitrogen oxides and produce two-thirds of the nation's emissions of sulfur dioxide: U.S. Environmental Protection Agency, *Clean Energy: Air Emissions*, accessed at www.epa.gov/cleanenergy, 14 June 2013; Health effects of sulfur dioxide: U.S. Environmental Protection Agency, *Sulfur Dioxide: Health*, accessed at www.epa.gov/oaqps001/sulfurdioxide/health.html, 14 June 2013; Dangers of mercury: U.S. Environmental Protection Agency, *Mercury: Basic Information*, accessed at www.epa.gov/hg/about.htm, 14 June 2013.

15. Jordan Schneider and Travis Madsen, Frontier Group, and Julian Boggs, Environment America Research & Policy Center, *America's Dirtiest Power Plants: Their Oversized Contribution to Global Warming and What We Can Do About It*, September 2013.

16. U.S. Environmental Protection Agency, *National Greenhouse Gas Emissions Data*, accessed at www.epa.gov/climatechange/ghgemissions/usinventoryreport.html, 14 June 2013.

17. U.S. sources of carbon dioxide emissions: U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011, 12 April 2013; Worldwide carbon dioxide emissions: European Commission, Joint Research Center and PBL Netherlands Environmental Assessment Agency, *Emission Database for Global Atmospheric Research (EDGAR*) (v. 4.2), 2011.

18. Based on harmonized data for all energy sources other than natural gas (for which published data were used) from National Renewable Energy Laboratory, *LCA Harmonization*, accessed at en.openei.org/apps/LCA/, 14 June 2013.

19. Richard Perez, University at Albany, Ken Zweibel, George Washington University, and Thomas Hoff, Clean Power Research, *Solar Power Generation in the US: Too Expensive, or a Bargain?*, 2011, available at http://www.asrc.cestm.albany.edu/perez/2011/solval.pdf.

20. Diane Cardwell, "Q. and A.: In a Blackout, Solar Exceptions," *The New York Times*, 21 November 2012.

21. Joe Eaton, "Record Heat, Drought Pose Problems for U.S. Electric Power," *National Geographic News,* 17 August 2012.

22. Paul Faeth, "In Drought-Prone Texas, A Threat to the Energy Supply," *Dallas News*, 20 December 2013.

23. U.S Department of Energy, SunShot Vision Study, *Solar Power Environmental Impacts and Siting Challenges*, February 2012.

24. Dana Hull, "Drought Threatens California's Hydroelectricity Supply, But Solar Makes Up the Gap," *San Jose Mercury News*, 11 February 2014.

25. Keyes, Fox and Wiedman, LLP, Interstate Renewable Energy Council, *Unlocking DG Value: A PURPA-Based Approach to Promoting DG Growth,* May 2013.

26. Based on California data from Lana Wong, California Energy Commission, *A Review of Transmission Losses in Planning Studies*, August 2011.

27. The Solar Foundation, *National Solar Jobs Census 2013: A Review of the U.S. Solar Workforce*, 27 January 2014.

28. Ibid.

29. Ibid.

30. National Renewable Energy Laboratory, *Best Research Cell Efficiencies*, accessed at www.nrel.gov/ncpv/images/efficiency_chart.jpg, 8 July 2013.

31. Tracey Peake, North Carolina State University, *Researchers Find Simple, Cheap Way to Increase Solar Cell Efficiency* (media advisory), 2 January 2014.

32. Alan C. Goodrich et al, "Assessing the Drivers of Regional Trends in Solar Photovoltaic Manufacturing," *Energy & Environmental Science* 6 (2013): 2811-2821, doi: 10.1039/c3ee40701b.

33. Galen Barbose, Naïm Darghouth, Samantha Weaver and Ryan H. Wiser, Lawrence Berkeley National Laboratory, *Tracking the Sun VI: The Installed Price of Photovoltaics in the United States from 1998 to 2012*, July 2013, data downloaded from http://emp.lbl.gov/publications/tracking-sun-vi-historical-summary-installed-price-photovoltaics-united-states-1998-201.

34. John Farrell, Institute for Local Self-Reliance, *Hawaiian Sunblock: Solar Facing Unexpected Barriers Despite Low Cost*, July 2012.

35. See note 33.

36. Joachim Seel, Galen Barbose and Ryan Wiser, Lawrence Berkeley National Laboratory*, Why Are Residential PV Prices in Germany So Much Lower than in the United States?*, revised version, February 2013.

37. Jesse Morris et al, Rocky Mountain Institute, *Reducing Solar PV Soft Costs: A Focus on Installation Labor*, December 2013, 9, available at http://www.rmi.org/PDF_reducing_solar_pv_soft_costs.

38. See note 36.

39. Dropped 60 percent: Solar Energy Industries Association, *Solar Energy Facts: 2013 Year in Review* (factsheet), 5 March 2014; 64 percent: U.S. Department of Energy, SunShot Initiative, *Reducing Non-Hardware Costs*, 14 November 2013, available at www1.eere.energy.gov/solar/sunshot/nonhardware_costs.html.

40. U.S. Department of Energy, *U.S. Utility-Scale Solar 60 Percent Towards Cost-Competition Goal* (press release), 12 February 2014.

41. Past 10 GW: Silvio Marcacci, "U.S. Passes 10 GW Installed Solar PV Capacity Milestone," *Clean Technica*, 9 July 2013; 4.75 GW: Solar Energy Industries Association, *Solar Market Insight 2013 Year in Review* (executive summary), downloaded from http://www.seia.org/research-resources/solar-market-insight-report-2013-year-review, 7 March 2014.

42. Ibid, "Solar Energy Industries Association."

43. The cumulative U.S. grid-connected solar PV capacity reported by the Solar Energy Industries Association (SEIA) as of 2013, 12,100 MW, is higher than the cumulative solar PV capacity displayed in Figure 3, which represents year-by-year data from the Lawrence Berkeley National Laboratory's *Tracking the Sun VI* report through 2012, and SEIA's reported 2013 capacity additions. SEIA does not provide a year-by-year breakdown of its reported cumulative U.S. grid-connected solar PV capacity, so we used a combination of LBNL and SEIA data to produce Figure 3. U.S. grid-connected PV capacity through 2012: see note 33; Installed solar PV capacity at the end of 2013: Ibid.

44. Ibid.

45. Data on solar capacity by state were obtained from Larry Sherwood, Interstate Renewable Energy Council, *U.S. Solar Market Trends 2012*, July 2013.

46. We did not include a major city from South Carolina.

47. 817 MW of solar PV was installed at the end of 2008: see note 33.

48. Average energy consumption of a U.S. home: U.S. Energy Information Administration, *Short-Term Energy Outlook*, 7 January 2014.

49. See Appendix B for sources of solar PV capacity; Installed solar PV capacity: see "Solar Energy industries Association," note 41; Land area of the top 20 cities and the United States: U.S. Census Bureau State and County Quickfacts, *Land Area in Square Miles, 2010*, downloaded from http://quickfacts.census.gov, 27 January 2014.

50. Installed solar PV capacity of the U.S. in 2008: see note 33.

51. "Honolulu" is defined as the census-designated place "urban Honolulu": U.S. Census Bureau State and County Quickfacts, *Urban Honolulu CDP, HI,* downloaded from http://quickfacts.census.gov, 11 March 2014.

52. Austin Energy, the municipal utility serving Austin, TX, also generates solar power at a 30-MW solar facility that exists partially in Austin's "extraterritorial jurisdiction" (ETJ). Austin's ETJ includes unincorporated land within 5 miles of Austin's city limits, per AustinTexas.gov, Planning and Development Review Department, Extraterritorial Jurisdiction: What Is It?, downloaded from http://www.austintexas.gov/faq/extraterritorial-jurisdiction-etj-what-it, 5 March 2014. Because this solar farm lies outside what are technically the city limits of Austin, we did not include it in Austin's solar total.

53. Matt Hickman, "Sebastopol Is Second California City Requiring Solar on New Homes," *Mother Nature Network*, 13 May 2013.

54. Guy Kovner, "Sebastopol Council Votes to Require Solar Power on New Homes, Buildings," *The Press Democrat*, 7 May 2013.

55. Herman K. Trabish, "Lancaster, CA Becomes First U.S. City to Require Solar," *GreenTech Solar*, 27 March 2013.

56. The Planning Report, *Lancaster, California's Mayor Rex Parris Leads City to Become First to Mandate Residential Solar Energy*, 24 January 2014, available at www.planningreport.com.

57. Felicity Barringer, "With Help from Nature, A Town Aims to Be a Solar Capital," *New York Times*, 8 April 2013.

58. John Farrell, Institute for Local Self-Reliance, *City Power Play: 8 Practical Local Energy Policies to Boost the Economy*, September 2013.

59. See note 56.

60. Christopher Curry, "City Commission Will Not Add to Feed-in Tariff in 2014," *The Gainesville Sun*, 19 December 2013.

61. Jim Gilmartin, Gainesville Regional Utilities, personal communication, 13 March 2014.

62. Florida had installed 213 MW at the end of 2013: Solar Energy Industries Association, *State Solar Policy: Florida Solar*, accessed at www.seia.org/state-solar-policy/florida, 14 March 2014; Population: U.S. Census Bureau State and County Quickfacts, *State and County Quickfacts: Gainesville (city), Florida*, accessed at http://quickfacts.census.gov, 14 March 2014.

63. Gainesville Regional Utilities, *Net Metering for Solar PV Systems for Homes,* accessed at www.gru.com, 11 March 2014.

64. New Bedford has high poverty levels and low income as compared to the state average: Southcoast Urban Indicators Project, *Poverty – New Bedford*, accessed at http://southcoastindicators.org/economy/poverty-new-bedford/, 14 March 2014; Scott Durkee, Director of the New Bedford Energy Office, personal communication, 14 March 2014.

65. WilmerHale, Publications and News, *City of New Bedford Launches Groundbreaking Solar Power Initiative*, 21 October 2011.

66. See "Scott Durkee," note 64.

67. Naomi Arenberg, Living on Earth, *PowerShift: New Bedford Goes Solar* (radio transcript), 25 October 2013.

68. Ibid.

69. Ibid., and see note 65.

70. Massachusetts Department of Energy Resources, Leading by Example Program, *2013 Leading by Example Awards*, accessed at http://www.mass.gov/eea/docs/eea/lbe/2013-lbe-award-winners.pdf, 14 March 2014.

71. Greenprint Denver, *Solar*, accessed at www.greenprintdenver.org/energy-emissions/solar/, 28 January 2014.

72. See "The City of Portland Planning and Sustainability," note 7.

73. U.S Department of Energy SunShot Vision Study, *Solar Power Environmental Impacts and Siting Challenges*, February 2012.

74. City of Chicago, *Overview of the Green Permit Program*, 2010-2014, available at www.cityofchicago.org.

75. San Francisco: SF Environment, *San Francisco's Streamlined Solar Permitting*, downloaded from www.sfenvironment.org/download/san-franciscos-streamlined-solar-permitting, 17 February 2014; Portland: see "U.S. Department of Energy," note 7.

76. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: City of San Jose: Photovoltaic Permit Requirements*, 9 July 2012, available at www.dsireusa.org; U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: City of Philadelphia: Streamlined Solar Permitting and Fee Reduction*, 2 April 2013, available at www.dsireusa.org.

77. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: City of Austin: Zoning Code*, 15 May 2012, available at www.dsireusa.org.

78. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: Incentives/Policies for Renewable Energy: Solar/Wind Access Policy*, downloaded from www.dsireusa.org, 16 March 2014.

79. See "Boston," note 6.

80. Average yearly energy consumption of a U.S. home: see note 48; This assumes solar PV operates at 15 percent capacity: U.S. Department of Energy, *2010 Solar Technologies Market Report (Chapter 3.2.3)*, November 2011; 370,000 people: U.S. Census Bureau State and County Quickfacts, *New Orleans (city), Louisiana*, downloaded from http://quickfacts.census.gov, 7 March 2014.

81. Elizabeth Ridlington and Judee Burr, Frontier Group, Luke Metzger, Environment Texas Research & Policy Center, *Keeping Water in Our Rivers: Strategies for Conserving Limited Water Supplies*, March 2013.

82. California drought: National Drought Mitigation Center, *U.S. Drought Monitor: California*, 11 February 2014.

83. Jim Schoettler, "Electric Bills Plummet, Thanks to Solar Panels in Neptune Beach," *The Florida-Times Union*, 11 January 2014.

84. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: City of Jacksonville: Sustainable Public Buildings*, 21 September 2012, available at www.dsireusa.org.

85. J.R. DeShazo and Alex Turek, Luskin Center for Innovation, *FiT 100 in Los Angeles: An Evaluation of Early Progress*, February 2014.

86. See note 27.

87. The Solar Foundation, *An Assessment of the Economic, Revenue and Societal Impacts of Colorado's Solar Industry*, October 2013.

88. U.S. Department of Energy and Meister Consultants Group, *Local Lending for Solar PV: A Guide for Local Governments Seeking to Engage Financial Institutions*, November 2013; U.S. Department of Energy, *Solar Powering Your Community: A Guide for Local Governments, Second Edition*, January 2011.

89. See "Local Lending," Ibid.

90. Ibid.

91. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: New York City: Property Tax Abatement for Photovoltaic Equipment Expenditures*, 30 August 2012, available at www.dsireusa.org; U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: New York City: Residential Solar Sales Tax Exemption*, 18 February 2012, available at www.dsireusa.org.

92. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: City of Cincinnati: Property Tax Abatement for Green Buildings*, 21 February 2013, available at www.dsireusa.org; U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: City of Cleveland – Property Tax Abatement for Green Buildings,* 30 April 2012, available at www.dsireusa.org.

93. PACE Now, *What Is PACE?*, accessed at www.pacenow.org/about-pace/what-is-pace, 18 March 2014.

94. Justin Gerdes, "Connecticut to Launch First Statewide Commercial Clean Energy PACE Program," *Forbes*, 28 June 2012.

95. PACE Now, *Case Study No. 4: Connecticut PACE Program Completes Its First Project*, 2013.

96. Justin Gerdes, "Greater Miami To Launch $550 Million Energy Retrofit Fund; Billions In Unfunded Projects Wait Nationwide," *Forbes*, 27 April 2012.

97. Renewable Funding, Clinton Climate Initiative, and the Lawrence Berkeley National Laboratory, *Policy Brief: Property Assessed Clean Energy (PACE) Financing: Update on Commercial Programs,* 23 March 2011.

98. See note 85.

99. Los Angeles Department of Water and Power, *Feed-in Tariff (FiT) Program*, downloaded from www.ladwp.com, 6 March 2014.

100. See note 85.

101. Ibid.

102. State cumulative solar PV capacity at the end of 2012, see note 45.

103. Dependent on coal at the time: John Haselden, Indianapolis Power and Light, Corporate Affairs, personal communication, 4 February 2014.

104. Kari Lydersen, "Indianapolis Solar Shines, but Will the Boom Continue," *Midwest Energy News*, 23 April 2013.

105. 98 MW in AC watts.

106. See note 104.

107. Indianapolis Power & Light, *Renewable Energy Incentive Program*, downloaded from www.iplpower.com, 14 March 2014.

108. Permanent jobs created were not available, but 220 people were employed during construction of Indy I, II, and III: Dan Genest, Media Relations, Dominion, personal communication, 6 February 2014.

109. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: San Antonio City Public Service (CPS Energy): Renewables Portfolio Goal*, 20 November 2012, available at www.dsireusa.org.

110. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: City of Austin: Renewable Portfolio Standard*, 5 October 2012, available at www.dsireusa.org.

111. Austin Energy, *Solar Photovoltaics (PV) Rebate*, accessed at www.austinenergy.com, 6 February 2014; Austin Energy, *Solar Photovoltaics (PV) Loan*, accessed at www.austinenergy.com, 6 February 2014.

112. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: CPS Energy – Solar PV Rebate Program,* 27 September 2013, available at www.dsireusa.org.

113. Austin Energy, *Solar Photovoltaics, Commercial*, accessed at www.austinenergy.com, 6 February 2014.

114. Austin Energy, News, *New Value of Solar Rate Takes Effect January*, 6 December 2013; Karl R. Rabago, Leslie Libby and Tim Harvey, Austin Energy, *Designing Austin Energy's Solar Tariff Using a Distributed PV Value Calculator*, downloaded from http://www.cleanpower.com/wp-content/uploads/090_DesigningAustinEnergysSolarTariff.pdf, 8 March 2014.

115. Amy Smith, "Then There's This: Clouds Over Solar," *The Austin Chronicle*, 10 January 2014.

116. Elizabeth Ridlington and Judee Burr, Frontier Group, Luke Metzger, Environment Texas Research and Policy Center, *Reaching for the Sun: How San Antonio and Austin Are Showing that Solar Is a Powerful Energy Option for Texas*, February 2013.

117. Seattle City Light, *Community Solar: Community Solar Project at the Seattle Aquarium Is Now Online*, accessed at www.seattle.gov, 9 March 2014.

118. Ibid.

119. Jacksonville Electric Authority, *JEA Facilities*, accessed at www.jea.com, 17 February 2014.

120. PSEG Energy Holdings, *PSEG Jacksonville Solar Farm*, accessed at www.pseg.com, 17 February 2014.

121. Jacksonville Electric Authority, *Tier 1 and 2 Program*, accessed at www.jea.com, 11 March 2014.

122. U.S. Department of Energy, Solar America Cities, *Solar in Action: Challenges and Successes on the Path toward a Solar-Powered Community, New Orleans, Louisiana*, October 2011.

123. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: City of New Orleans: Net Metering*, 1 August 2012, available at www.dsireusa.org.

124. See note 122, 4.

125. James Ayre, "Largest Solar Power Neighborhood in Southeast Built in New Orleans," *CleanTechnica*, 7 November 2012.

126. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: Louisiana: Tax Credit for Solar Energy Systems on Residential Property*, 10 July 2013, available at www.dsireusa.org; see note 122, 4.

127. Mississippi, Alabama, South Carolina and Arkansas had a combined 7.9 MW-DC of solar PV installed at the end of 2012, see note 45.

128. The City University of New York, *NYC Reaches DOE Solar America City Goal 3 Years Early* (press release), 4 April 2012; The City University of New York, *Sustainable CUNY: Strategic Zones*, accessed at www.cuny.edu, 7 March 2014.

129. See "NYC Reaches DOE Solar America City Goal 3 Years Early," Ibid.

130. Con Edison Media Relations, *Con Edison to Customers: Let the Sun Shine In* (press release), 28 January 2009.

131. Meister Consultants Group, *New York City's Solar Energy Future: 2011 Update*, March 2011.

132. See "Sustainable CUNY: Strategic Zones," note 128.

133. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: Renewable Portfolio Standard Policies with Solar/Distributed Generation Provisions*, March 2013, available at www.dsireusa.org.

134. Ibid.

135. Wilmington, DE is 10.9 square miles while Houston, TX is 599.6 square miles: U.S. Census Bureau State and County Quickfacts, *Wilmington (city), Delaware* and *Houston (city), Texas*, accessed at http://quickfacts.census.gov, 27 January 2014.

136. Massachusetts Energy and Environmental Affairs, *Solar*, accessed at www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar, 6 March 2014.

137. SREC Trade, *Massachusetts*, accessed at www.srectrade.com/srec_markets/massachusetts, 11 March 2014.

138. Massachusetts Clean Energy Center, *Commonwealth Solar II – Block 17*, accessed at www.masscec.com/solicitations/commonwealth-solar-ii-block-17, 19 February 2014.

139. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: Massachusetts: Incentives/Policies for Renewables & Efficiency, Financial Incentives*, 30 July 2013, available at www.dsireusa.org.

140. Chris Meehan, "APS Wins Solar Net Metering Battle—Kind Of," *Renewable Energy World*, 18 November 2013.

141. Vote Solar and IREC, *Freeing the Grid: Best Practices in State Net Metering Policies and Interconnection Procedures*, accessed at www.freeingthegrid.org, 10 February 2014.

142. Emily Hois, Clean Energy Collective, *Virtual Net Metering and the Future of Community Solar Energy*, accessed at www.theenergycollective.com, 9 March 2014.

143. Scott Cooney, "Hawaii's Test Case for Solar Grid Penetration," *Huffington Post*, 22 February 2014.

144. Kevin Eber and David Corbus, National Renewable Energy Laboratory, *Hawaiian Solar Integration Study: Executive Summary*, June 2013.

145. State of Hawaii, Public Utilities Commission, *On-Bill Financing*, accessed at http://puc.hawaii.gov/energy/on-bill-financing/, 11 March 2014.

146. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: Hawaii: Feed-in Tariff*, 26 September 2012, available at www.dsireusa.org.

147. Mileka Lincoln, "Lawmakers Call Hearing to Discuss HECO's Solar Policy Changes," *Hawaii News Now*, 14 October 2014; see note 143.

148. Travis Madsen, Frontier Group, Michelle Kinman and Bernadette Del Chiaro, Environment California Research & Policy Center, *Building a Brighter Future: California's Progress Toward a Million Solar Roofs*, November 2011.

149. See note 45.

150. Benjamin Davis and Travis Madsen, Frontier Group, Michelle Kinman, Environment California Research and Policy Center, *California Solar Cities 2012: Leaders in the Race Toward a Clean Energy Future*, January 2012.

151. The NY-SUN Initiative, *Programs and Incentives*, accessed at www.ny-sun.ny.gov/programs-incentives, 10 February 2014.

152. James Burgess, "Governor of New York Pledges Another $1 Billion to NY-Sun Initiative," *OilPrice*, 13 January 2014.

153. Dayle Zatlin, NYSERDA, Assistant Director of Communications, personal communication, 22 January 2014.

154. Technical potential: Anthony Lopez, et al., National Renewable Energy Laboratory, *U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis*, July 2012; Annual electricity sales for 2011: U.S. Department of Energy, Energy Information Administration, *Retail Sales of Electricity by State by Sector by Provider, 1990-2011* (Excel workbook), 1 October 2012.

155. Ibid.

156. See "Anthony Lopez, et al.," note 154.

157. 52 percent of Orlando's 2011 electricity demand: Orlando Runs on Sun, *Solar Rooftop Analysis*, accessed at www.orlandorunsonsun.com/solar-resources/solar-rooftop-analysis/, 23 January 2014.

158. Vote Solar Initiative and Interstate Renewable Energy Council, *Project Permit: Best Practices in Solar Permitting*, May 2013; U.S. Department of Energy SunShot Solar Outreach Partnership, *Resources*, accessed at www.solaroutreach.org/resources, 7 March 2014.

159. See "Vote Solar Initiative," Ibid.

160. U.S. Department of Energy, Interstate Renewable Energy Council and North Carolina Solar Center, *DSIRE Solar: Summary Maps: 3rd Party Solar PV Power Purchase Agreements*, February 2013, downloaded from www.dsireusa.org.

161. U.S. Department of Energy, *Residential Renewable Energy Tax Credit*, downloaded from http://energy.gov/savings/residential-renewable-energy-tax-credit, 11 March 2014; U.S. Department of Energy, *Business Energy Investment Tax Credit (ITC)*, accessed at http://energy.gov/savings/business-energy-investment-tax-credit-itc, 11 March 2014.

162. The United States Conference of Mayors, *Successful City Initiatives with Energy Efficiency and Conservation Block Grant (EECBG) Funding: A 204-City Survey*, February 2014.

163. Dick Fate, Sandia Tiger Team Lead, U.S. Department of Energy, *Solar America Cities: Accelerating Solar on a Local Level* (powerpoint), downloaded from http://www.epa.gov/region6/6sf/pdffiles/lrb2g_fate.pdf, 5 March 2014.

164. These "Solar America Cities" are Ann Arbor, Austin, Berkeley, Boston, Denver, Houston, Knoxville, Madison, Milwaukee, Minneapolis, New Orleans, New York, Orlando, Philadelphia, Pittsburgh, Portland (OR), Sacramento, Salt Lake City, San Antonio, San Diego, San Francisco, San Jose, Santa Rosa, Seattle and Tucson.

165. The White House, Office of the Press Secretary, *Presidential Memorandum – Federal Leadership on Energy Management*, 5 December 2013.

166. Solar Energy Industries Association, *Enlisting the Sun: Powering the U.S. Military with Solar Energy*, 17 May 2013.

167. National Renewable Energy Laboratory, *PVWatts: Changing System Parameters*, downloaded from http://rredc.nrel.gov/solar/calculators/pvWatts/system.html, 4 February 2014.

168. EIA Utility-Scale Report: U.S. Energy Information Administration, *Form EIA-860 detailed data (2012 data)*, 13 October 2013, available at http://www.eia.gov/electricity/data/eia860/; Estimate of PNM's distributed solar PV capacity: Kumiko Styes, Manager of Retail Renewable Energy Programs, Public Service of New Mexico, personal communication, 6 February 2014.

169. See "Kumiko Styes," Ibid.

170. Total Number of PNM customers: Public Service Company of New Mexico, *About PNM*, accessed at www.pnm.com, 3 February 2014; Total Number of Households in Albuquerque: U.S. Census Bureau, Quickfacts, *Albuquerque (city)*, accessed at http://quickfacts.census.gov, 7 January 2014.

171. Shan Arora, Southface, personal communication, 28 January 2014.

172. Tim Harvey, Austin Energy, Conservation Program Coordinator, personal communication, 16 January 2014.

173. PJM Environmental Information Services, *Public Reports: Renewable Generators Registered in GATS,* downloaded from https://gats.pjm-eis.com/gats2/PublicReports/RenewableGeneratorsRegisteredinGATS, 6 March 2014.

174. Terry Hansworth, Appalachian Power Company, personal communication, 8 January 2014.

175. Robyn I. Mackey, ComEd, Senior Business Analyst, personal communication, 17 January 2014.

176. Sarah Parrot, Public Utilities Commission of Ohio, Legal Department, personal communication, 20 February 2014.

177. Steve Wiese, Clean Energy Associates, personal communication, January 2013.

178. Darryl Nelson, Oncor Electric Delivery, Manager Load Research and Regulatory Affairs, personal communication, 29 January 2014.

179. Jaclyn Webb, Xcel Energy, Associate Product Manager, personal communication, 21 January 2014.

180. Scott Simons, DTE Energy, personal communication, 29 January 2014.

181. Hawaiian Electric Company, Quarterly Installed PV Data, *Cumulative Installed PV – As of December 31, 2013*, downloaded from http://www.hawaiianelectric.com/heco/Clean-Energy/Going-Solar/More-Solar-Information, 7 March 2014.

182. See note 51.

183. Urban Honolulu and Honolulu County Population Figures: US Census Quickfacts, *2008-2012 Survey Household Estimates*, accessed at http://quickfacts.census.gov, 11 March 2014.

184. Bruce Raborn, Centerpoint Energy, personal communication, 10 January 2014.

185. Anita Johnson, Indianapolis Power & Light, Administrative Assistant, personal communication, 10 January 2014.

186. Jay Worley, Jacksonville Electric Authority, Director Environmental Programs, personal communication, 27 January 2014.

187. KCP&L net metered solar PV capacity: U.S. Energy Information Administration, *Form EIA-826 detailed data, Net Metering*, September 2013.

188. Customers in KCP&L service territory: Bloomberg Businessweek, *Company Overview of Kansas City Power & Light Company*, accessed at http://investing.businessweek.com/research/stocks/private/snapshot.asp?privcapId=3097815, 5 February 2014; Households in Kansas City: US Census State and County Quickfacts, *Kansas City (city), Missouri,* accessed at http://quickfacts.census.gov, 5 February 2014.

189. Brad Lutz, Kansas City Power & Light, Manager Regulatory Affairs, personal communication, 15 January 2014.

190. Sean Sullivan, NV Energy, Renewable Generations, personal communication, 14 February 2014.

191. Kimberly Hughes, Los Angeles Department of Water and Power, Communications, personal communication, 22 January 2014.

192. Tim Melton, Louisville Gas and Electric, Manager Customer Commitment, personal communication, 13 January 2014.

193. Martin Murray, Public Service of New Hampshire, Media Relations, personal communication, 14 January 2014.

194. Ashley Dickins, Tennessee Valley Authority, Renewable Energy, personal communication, 8 January 2014.

195. John Mccomb, Florida Power & Light, personal communication, 9 January 2014.

196. The City of Milwaukee, Milwaukee Shines, *About Us*, accessed at http://milwaukee.gov/milwaukeeshines/AboutUs.htm, 16 March 2013.

197. The Office of Environmental Sustainability and the Milwaukee Shines program failed to return our calls, despite repeated attempts.

198. Gayle Prest, City of Minneapolis, personal communication, 4 February 2014.

199. John Wold, Xcel Energy, Consumer Product Marketing, personal communication, 13 February 2014.

200. See note 153.

201. Allan Drury, Con Edison, personal communication, 11 February 2014.

202. New Jersey's Clean Energy Program, *New Jersey Solar Installations Update: Solar Installations Report*, downloaded from http://www.njcleanenergy.com/renewable-energy/project-activity-reports/installation-summary-by-technology/solar-installation-projects, 20 January 2013.

203. Jennifer Szaro, Orlando Utilities Commission, Renewables Manager, personal communication, 28 January 2014.

204. See note 173.

205. Arizona Goes Solar, Utility Incentives, *Salt River Project and Arizona Public Service: Installations*, downloaded from http://arizonagoessolar.org, 17 March 2014.

206. Matthew Barron, Policy Manager, Office of Mayor William Peduto, personal communication, 6 March 2014.

207. Richard Hevey, Legal Department, Central Maine Power, personal communication, 4 March 2014.

208. Jaimes Valdez, Portland Bureau of Planning and Sustainability, Renewable Energy Specialist, personal communication, 17 January 2014.

209. Danny Musher, Rhode Island Office of Energy Resources, Programming Services Officer, personal communication, 3 February 2014.

210. Amy George, City of Richmond, Sustainability Management Analyst, personal communication, 21 January 2014. She received the data from Ken Jurman at the Virginia Department of Mines, Minerals and Energy.

211. Jim Barnett, Sacramento Municipal Utility District, Principal Architect, personal communication, 8 January 2014.

212. Rocky Mountain Power, Net Metering Department, personal communication, 22 January 2014.

213. Devon Rood, Solar San Antonio, Research Associate, personal communication, 8 January 2014.

214. Ken Parks, San Diego Gas & Electric, Manager Customer Generation, personal communication, 27 January 2014.

215. Charles Sheehan, City and County of San Francisco, personal communication, 8 January 2014.

216. David Eisenhauer, Pacific Gas & Electric, personal communication, 12 February 2014.

217. Jack Brautigam, Seattle City Light, personal communication, 9 January 2014; Duane Jonlin, Seattle's Department of Planning and Development, personal communication, 21 January 2014.

218. Seattle City Light Customers: Seattle City Light, *Annual Report 2012*, 2012.

219. Missouri Department of Economic Development, *Table 2 Certified Solar Renewable Energy Generation Facilities (As of December 10, 2013)*, downloaded from http://ded.mo.gov/energy/docs/Solar%20List.pdf, 10 February 2014.

220. St. Louis households: U.S. Census Bureau State and County Quickfacts, *St. Louis (City), Missouri*, accessed at http://quickfacts.census.gov, 5 February 2014; Ameren Customers: Ameren Missouri, *About Us*, downloaded from www.ameren.com, 5 February 2014.

221. Shelly Aubuchon, TECO Energy, personal communication, 15 January 2014.

222. James Tew, Program Manager, Dominion Virginia Power, personal communication, 12 March 2014.

223. Delaware Public Service Commission, *Delaware's Renewable Portfolio Standard, "List of Certified Eligible Energy Resources,"* downloaded from http://depsc.delaware.gov/electric/delrps.shtml, 17 February 2014.