



# Solar on Superstores

**How the Roofs of Big Box Stores Can Help America Shift to Clean Energy**



FRONTIER GROUP

# Solar on Superstores

How the Roofs of Big Box Stores Can  
Help America Shift to Clean Energy



FRONTIER GROUP

Written by:

**Gideon Weissman and Judee Burr**

Frontier Group

**Bret Fanshaw and Rob Sargent**

Environment America Research & Policy Center

Spring 2016

# Acknowledgments

Environment Maine Research & Policy Center sincerely thanks Gary Cook of Greenpeace, Bradley Dakake of Sunpower, and Benjamin Inskeep of NC Clean Energy Technology Center for their review of drafts of this document, as well as their insights and suggestions. Thanks also to Tony Dutzik and Kim Norman of Frontier Group, as well as Jeff Inglis and Lindsey Hallock, formerly of Frontier Group, and Vincent Armentano, former Frontier Group intern, for their contributions and editorial support. Additionally, Frontier Group thanks ESRI for granting the use of their ArcGIS mapping software.

Environment Maine Research & Policy Center thanks the Tilia Fund, the Barr Foundation, the John Merck Fund, Fred & Alice Stanback, the Scherman Foundation, the Arntz Family Foundation, Kendeda Foundation, Gertrude and William C. Wardlaw and the Fund for New Jersey for making this report possible.

The authors bear responsibility for any factual errors. The recommendations are those of Environment Maine 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.

© 2016 Environment Maine Research & Policy Center



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

Frontier Group provides information and ideas to help citizens build a cleaner, healthier, fairer and more democratic America. We address issues that will define our nation's course in the 21st century – from fracking to solar energy, global warming to transportation, clean water to clean elections. Our experts and writers deliver timely research and analysis that is accessible to the public, applying insights gleaned from a variety of disciplines to arrive at new ideas for solving pressing problems. For more information about Frontier Group, please visit [www.frontiergroup.org](http://www.frontiergroup.org).

Layout: Alec Meltzer/meltzerdesign.net

Cover photo: Courtesy of IKEA

# Contents

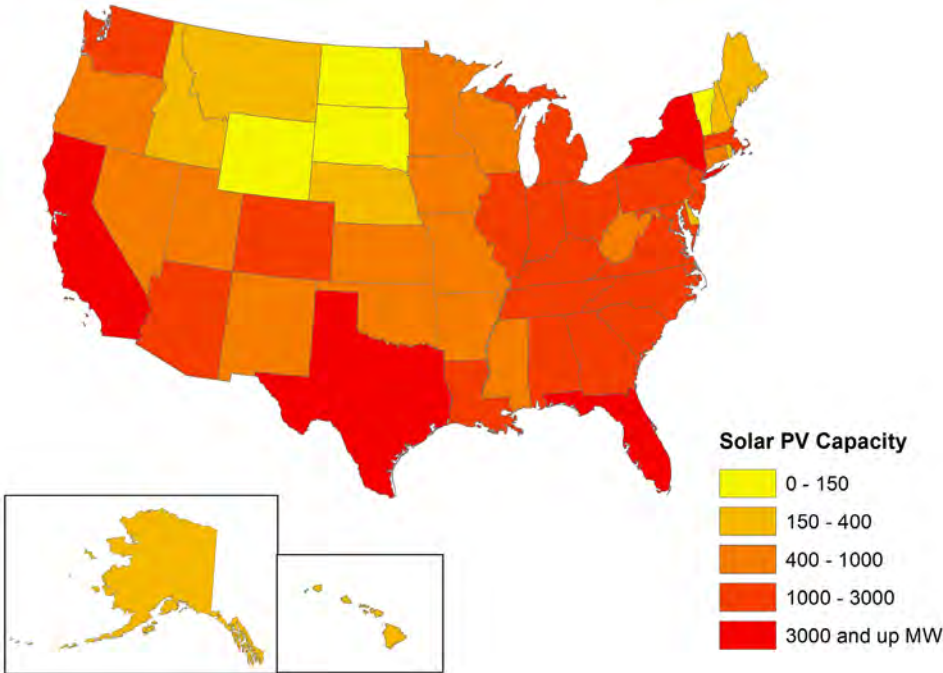
- Executive Summary**..... 1
- Introduction**..... 4
- Large Commercial Buildings Can Be a Significant Source of Solar Energy**.....5
  - The United States Has Vast Solar Energy Potential ..... 5
  - Every State Can Meet Its Electricity Needs with Solar Energy ..... 6
  - The United States Has 100 Times More Solar Photovoltaic Capacity Than It Had in 2005..... 6
  - Solar Energy Costs Continue to Fall ..... 6
  - Commercial Rooftops Can Host a Large Amount of Solar Energy ..... 7
  - Solar Potential on America’s Big Box Stores and Shopping Centers..... 8
- The Benefits of Scaling Up Commercial Rooftop Solar Power**..... 12
  - Big Box Solar Power Brings Widespread Community Benefits ..... 12
    - Reducing Global Warming Pollution ..... 12
    - Creating a Resilient Electricity System..... 14
    - Cutting Consumer Costs ..... 14
    - Reducing Air Pollution ..... 15
    - Creating Jobs..... 15
  - Big Box Stores Directly Benefit from Hosting Solar Panels ..... 16
- New Financing Tools Can Help Businesses Overcome Hurdles to Solar Adoption**..... 18
- Policy Recommendations**..... 19
- Appendix A: Methodology** ..... 21
  - Solar Capacity and Generation on Commercial Buildings..... 21
  - Electricity Consumption of Big Box Stores ..... 23
  - Global Warming Emissions Reductions ..... 23
- Appendix B: Tables**..... 25
- Notes**..... 31

# Executive Summary

Solar energy is expanding rapidly across the United States – increasing more than 100-fold over the past decade. But, there are still many untapped opportunities to harness the nation’s nearly limitless solar potential. The United States has the technical potential to produce more than 100 times as much electricity from solar photovoltaic (PV) and concentrating solar power (CSP) installations as the nation consumes each year. Given our abundant solar resources, America must take advantage of untapped opportunities to install solar technologies – like using rooftops of large superstores and “big box” retail stores as hosts for clean electricity generation.

The roofs of these large stores are perfect locations for solar panels – they are largely flat and vacant and almost always fully exposed to the sun. The big box stores, large grocery stores and malls considered in this report account for 5 percent of electricity use in the United States. Solar panels produce energy that can offset this large electricity demand while contributing to a cleaner grid. Rooftop solar power also brings benefits to the communities in which it is situated. By producing electricity close to its final point of use, distributed rooftop power reduces costs and energy losses associated with electricity transmission and distribution.

Figure ES-1: Potential Solar PV Capacity on Big Box Stores and Shopping Centers, by State (Megawatts)



According to the National Renewable Energy Laboratory (NREL), the United States has the technical potential to generate enough electricity from rooftop solar installations alone to meet nearly a quarter of the nation’s electricity demand. The United States has more than 102,000 big box retail stores, supercenters, large grocery stores and malls with more than 4.5 billion cumulative square feet of available rooftop space on which solar panels could be installed.

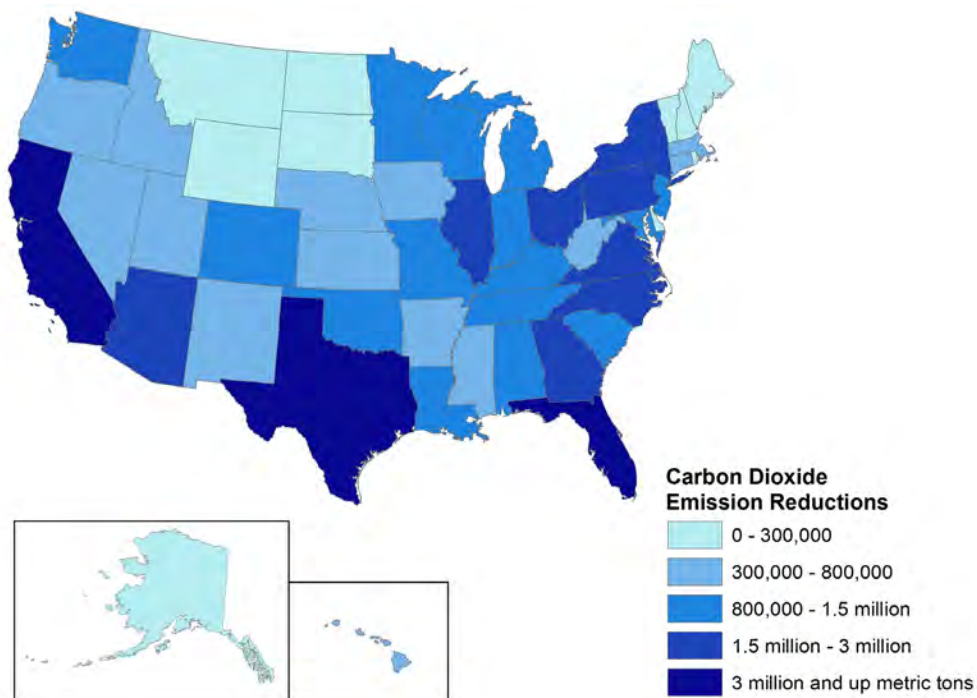
**The rooftops of America’s big box stores and shopping centers could host 62.3 gigawatts (GW) of solar photovoltaic capacity, equivalent to the amount of electricity used by more than 7 million average U.S. homes or more than 7,500 average Walmart stores, and more than double the solar photovoltaic capacity that has been installed in the U.S. to date.** (See Appendix B for state breakdowns.)

Putting solar panels on the nation’s big box grocery and retail stores creates unique benefits for the envi-

ronment, electricity customers and the large commercial businesses themselves.

- Generating clean electricity from rooftop solar panels on existing commercial buildings is good for the environment. **Installing 62.3 GW of clean solar power on America’s big box stores and shopping centers would reduce global warming pollution by nearly 57 million metric tons annually – equivalent to taking nearly 12 million passenger vehicles off the road.**
- Rooftop solar power is good for the grid and electricity consumers. **Producing electricity on rooftops, close to where the electricity will be used, reduces losses that happen during electricity transmission – losses that totaled an estimated 203 million megawatt-hours (MWh), or 5 percent of electricity sales in 2012.** Solar power also reduces costs by producing the most electricity during the sunniest parts of the

**Figure ES-2: Annual Reductions in Global Warming Pollution with Solar Panels on Available Big Box Stores and Shopping Centers by State (Metric Tons CO<sub>2</sub>)**



day, which are often when demand for electricity peaks. This helps utilities avoid firing up expensive, peaking power plants to meet the temporary rise in demand.

- Putting solar panels on the roofs of big box stores is good for business. **Electricity produced by rooftop panels on big box stores and shopping centers could offset the annual electricity use of these buildings by 42 percent, saving these businesses \$8.2 billion annually on their electricity bills.**

Many big box retail stores are already reaping the benefits of installing solar power on their rooftops.

- Of the businesses evaluated by the Solar Energy Industries Association (SEIA), Walmart, Costco, Kohl's, IKEA, and Macy's were the retail giants with the most solar capacity installed as of the end of 2015. Walmart has at least 142 MW of total on-site installed solar capacity.
- From the same survey, the top 25 companies have installed a total of 1,462 solar energy systems at business locations across the United States.
- The 10 big box companies with the largest amount of retail space in the U.S. – Walmart,

Target, Home Depot, Lowe's, Sears Holdings (including Sears and KMart), Macy's, J.C. Penney, Kohl's, Costco, and TJX (including Marshall's and TJMaxx) – have enough rooftop space to host approximately 17 GW of solar capacity on their retail stores, or nearly three quarters of the United States' current solar PV capacity.

- Solar-powered businesses are saving money on their electricity bills and contributing to a cleaner and more resilient electricity grid. By installing solar panels on two California stores, Costco reported savings of \$300 per day on average over three months.

Implementing local, state and federal policies that promote the growth of rooftop solar power – like net metering, third-party financing, community solar power programs, streamlined solar permitting and interconnection and tax credits and incentive programs for new solar energy markets – can spur the development of rooftop solar power on America's big box stores and help America reach its solar potential. **Officials at all levels of government should implement solar-friendly policies that help to accelerate adoption of solar energy by America's businesses.**

# Introduction

Swedish retailer IKEA is known for many things – its bold blue store buildings, build-it-yourself furniture, and store restaurants stocked with Scandinavian treats.

Clean energy might not be the first thing that comes to mind when consumers think of IKEA, but the company is working to change that by adopting bold goals for renewable energy installations on its stores – including solar power installations.

IKEA's adoption of renewable energy is driven by high goals that the company has set for its business practices. According to the company's "People and Planet Positive" sustainability strategy, IKEA is committed to generating more renewable energy than it consumes in its buildings and daily operations by 2020.<sup>1</sup> Of companies evaluated by the Solar Energy Industries Association (SEIA) in 2014, IKEA had the highest percentage of U.S. facilities with solar panels.<sup>2</sup> Today, IKEA ranks sixth among U.S. companies with more than 41 MW of total rooftop solar installed.<sup>3</sup>

According to a recent IKEA report on the company's sustainability practices, increasing reliance on solar power and renewable energy is both good for the

environment and good for business: "This is good for people and the planet and makes good business sense, because it cuts costs and makes us resilient to fluctuating energy prices."<sup>4</sup>

The business case that is motivating IKEA to "go solar" – stable energy costs, improving financial returns from solar energy investments, and the imperative to reduce business and regulatory risks related to climate change – also holds true for retailers and other businesses across the United States.

Big box retailers throughout the nation are beginning to implement solar power on their vast, open rooftops, benefiting themselves and the environment. In places where local, state and federal officials have implemented policies that help business owners make sustainable energy choices, solar power is becoming an increasingly common option for commercial facilities.

This report will outline the vast rooftop solar potential represented by U.S. big box stores and the benefits of commercial rooftop solar power to these businesses and the larger community, and discuss the ways in which governments can encourage increased solar power adoption in the commercial retail sector.



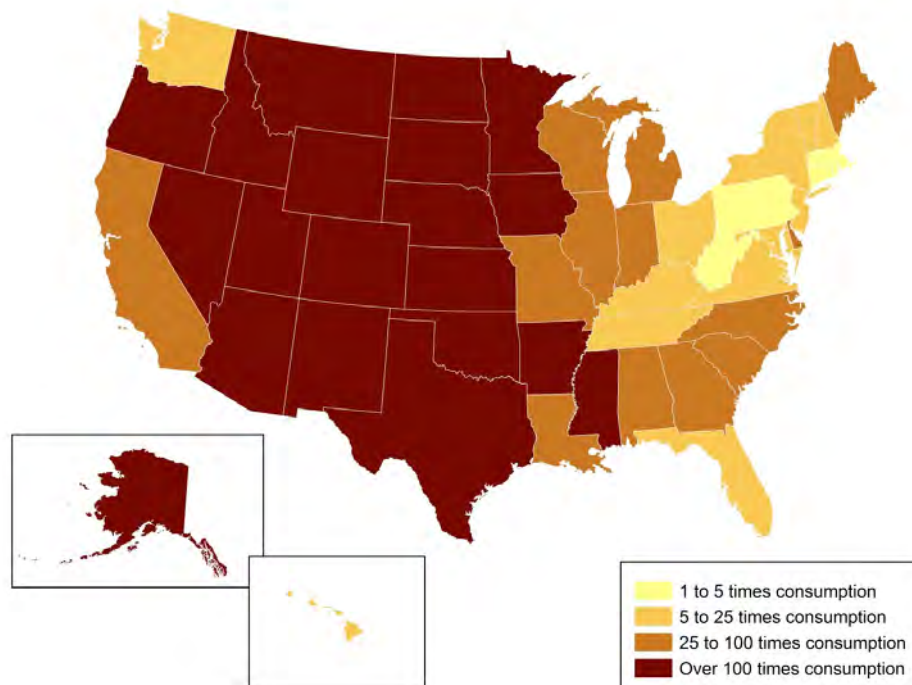
# Large Commercial Buildings Can Be a Significant Source of Solar Energy

The amount of solar energy in the United States has increased exponentially over the last decade, but the nation has barely begun to harness the nearly limitless amount of energy that it receives from the sun. We can use our existing structures to generate clean, local electricity by putting solar panels on the large, flat rooftops of commercial big box stores.

## The United States Has Vast Solar Energy Potential

The United States receives more than enough energy from the sun to meet the nation's electricity needs. Putting solar panels on big box stores is an important step towards harnessing our solar potential and meeting the nation's electricity demand with clean energy.

Figure 1: Every State Can Meet Its Electricity Demand with Solar Power<sup>6</sup>



## Every State Can Meet Its Electricity Needs with Solar Energy

The United States has the technical potential to produce more than 100 times as much electricity from solar photovoltaic (PV) and concentrating solar power (CSP) installations as the nation consumes each year, and every state has the technical potential to meet its electricity demand with solar power.<sup>5</sup> (See Figure 1.)

## The United States Has 100 Times More Solar Photovoltaic Capacity Than It Had in 2005

Solar power is taking off across the nation. At the end of the third quarter of 2015, the United States had more than 24 gigawatts (GW) of installed solar photovoltaic (PV) electric capacity, more than 12 times as much solar PV capacity as was installed in the country at the end of 2010.<sup>7</sup> (See Figure 2.)

Solar power made up 30 percent of all new electricity generating capacity that came online in the United States in the first three quarters of 2015.<sup>9</sup> Given the exponential growth that solar power is experiencing, it is quickly becoming a significant source of America's electricity generation.

## Solar Energy Costs Continue to Fall

The costs of solar panels have fallen year after year in every sector – for residential, commercial and utility scale installations.<sup>10</sup> (See Figures 3 and 4.)

Installing solar panels on commercial rooftops is becoming increasingly affordable. The Solar Energy Industries Association (SEIA) reported that the average cost of a non-residential rooftop solar energy system was \$2.07 per Watt in Q3 2015, a 9 percent drop from Q3 2014.<sup>12</sup>

Figure 2: Solar Power Is Growing Exponentially<sup>8</sup>

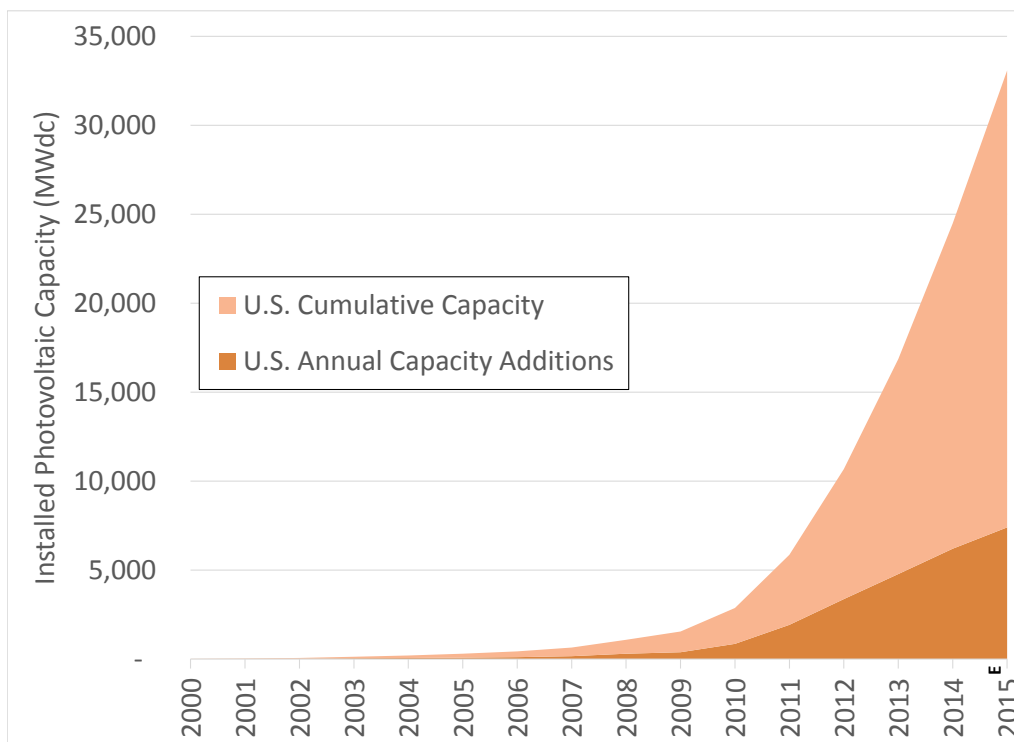
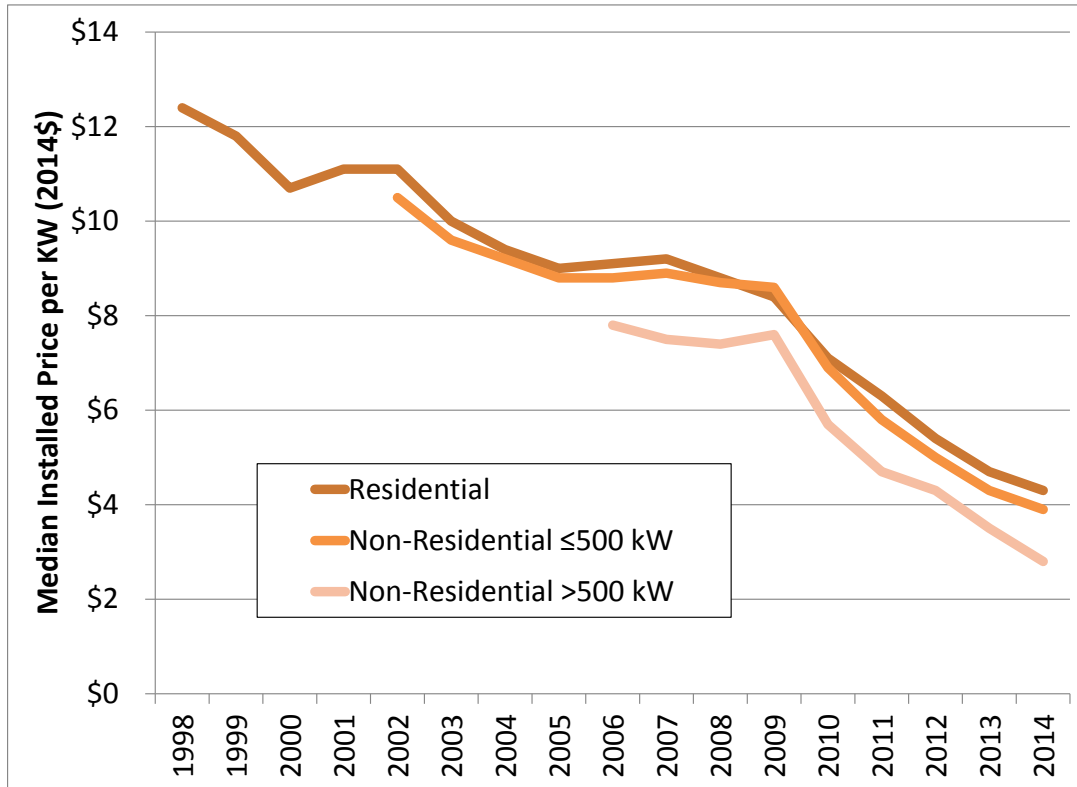


Figure 3: The Cost of Residential and Commercial Solar PV Installations Continues to Fall<sup>11</sup>



## Commercial Rooftops Can Host a Large Amount of Solar Energy

According to the National Renewable Energy Laboratory (NREL), the United States has the technical potential to generate enough electricity from rooftop solar installations alone to meet nearly a quarter of the nation’s electricity demand.<sup>13</sup> Commercial buildings make up an important part of this potential rooftop market for solar power. As we define them in this report, the United States has more than 102,000 “big box” retail stores, supercenters, large grocery stores and malls with rooftop space that could host solar panels.<sup>14</sup> These stores are spread across the United States. (See Table 1.)

Big box retail stores, many of which are household names across the country, represent a significant

number of U.S. stores. Superstores Walmart and Costco and grocery giant Kroger are the nation’s three largest retailers with 7,453 U.S. stores and \$507 billion in sales. The top five department stores – Macy’s, Kohl’s, Sears Holdings, Nordstrom, and J.C. Penney Co. – have 4,037 U.S. stores. The top five electronics and entertainment stores – Best Buy, the Apple Store, AT&T Wireless, Verizon Wireless and Toys “R” Us – have 11,987 U.S. stores. Bed Bath & Beyond and IKEA are two of the largest home goods stores, with 1,503 stores in the United States.<sup>15</sup>

Many U.S. businesses have already begun to make significant investments in solar power. As of mid-2014, the 4.5 gigawatts (GW) of commercial solar power installed in the United States accounted for 30 percent of the nation’s total installed solar capacity.<sup>16</sup>

**Table 1: Number and Average Size of Big Box Stores and Shopping Centers by Region**

Region	Number of Big Box Stores	Average Square Footage of Big Box Store
Northeast	13,788	83,245
Midwest	15,991	86,138
South	45,932	74,726
West	26,436	85,909
<b>Total</b>	<b>102,148</b>	<b>80,556</b>

### **SEIA's Solar Means Business Report Reveals America's Leading Solar-Powered Companies**

At the end of 2015, the Solar Energy Industries Association (SEIA) released the fourth edition of a report ranking top U.S. businesses for their installed solar capacity.<sup>17</sup> SEIA reached out to Fortune 100 companies in the U.S. and other businesses “with known solar portfolios” in order to rank the companies by installed solar capacity and by number of solar installations. Their rankings show that major retailers in the United States are installing a significant amount of solar energy at their business locations.

According to the report, the 25 companies with the most on-site solar capacity installed are home to a combined 700 MW of solar capacity, with Walmart, Prologis (an industrial real estate company), Apple, Costco, and Kohl's leading the way. The 25 companies with the most total solar installations are home to 1,462 individual systems, with Walmart, Walgreens, Kohl's, Costco, Macy's and Prologis leading the way.<sup>18</sup>

In the 2014 edition of its report, SEIA found that IKEA had solar power installed on 87 percent of its facilities, the highest percentage of any company evaluated.<sup>19</sup>

### **Solar Potential on America's Big Box Stores and Shopping Centers**

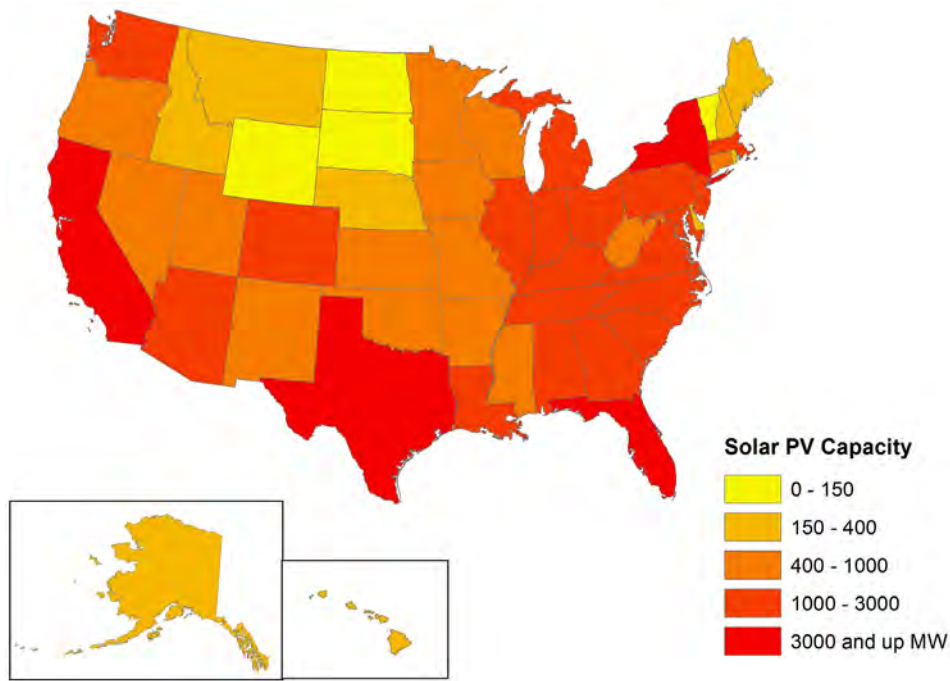
The potential of the nation's commercial buildings to host solar panels is much larger than the capacity that has already been installed. America's big box stores have more than 4.5 billion square feet of available rooftop space on which solar panels could be installed.<sup>20</sup>

**The rooftops of America's big box stores and shopping centers could host 62.3 gigawatts (GW) of solar photovoltaic capacity, equivalent to the amount of electricity used by more than 7 million average U.S. homes or more than 7,500 average Walmart stores, and more than double the solar photovoltaic capacity that has been installed in the U.S. to date.**<sup>21</sup> (See Appendix B for state breakdowns.)

The big box retail stores, large grocery stores and malls considered in this report account for 5 percent of electricity use in the United States.<sup>22</sup> **Electricity produced by rooftop solar panels on big box stores and shopping centers could offset the annual electricity use of these buildings by 42 percent, saving these businesses more than \$8.2 billion annually on their electricity bills.**<sup>23</sup>

Much of the big box retail space in the United States is owned or operated in by a small number of large retail companies. The 10 big box companies with the largest amount of retail space in the U.S. – Walmart,

**Figure 4: Potential Solar PV Capacity on Big Box Stores and Shopping Centers, by State (Megawatts)**



Target, Home Depot, Lowe's, Sears Holdings (including Sears and KMart), Macy's, J.C. Penney, Kohl's, Costco, and TJX (including Marshall's and TJMaxx) – have a combined 2 billion square feet of retail space in the United States, twice the area of Manhattan.<sup>24</sup> These companies alone have the potential to host approximately 17 GW of solar capacity on the roofs of their retail stores, or nearly three quarters of the United States' current solar PV capacity.<sup>25</sup> (See Appendix B for expanded listing.)

These estimates of solar energy potential only include the rooftop space on top of these stores. Big box stores are often surrounded by parking lots and other areas that could host solar energy production. Solar panels are capable of providing shade in parking lots, some of which span several acres, while taking up no additional land and reducing vehicle

fuel consumption for air conditioning use.<sup>26</sup> Many retailers and businesses also own large distribution warehouses that, although not included in this analysis, are also ideal locations for solar panels. By taking advantage of these additional opportunities for solar power generation, big box stores and other retail outlets could produce even more solar energy than is estimated here.

Much of the retail space of large American retailers is leased, not owned, meaning that in many cases solar installations require the involvement of the landlord. Creative financing options like Property Assessed Clean Energy (PACE) financing can help overcome some of the hurdles leased property presents. (See "New Financing Tools Can Help Businesses Overcome Hurdles to Solar Adoption" for more details.)

**Table 2. Solar Capacity Potential for America's Top 10 Big Box Stores (Excluding Grocery-Specific Chains)**

Solar Potential Rank	Company	U.S. Retail Space (Million Sq. Feet)	Potential Rooftop Solar Capacity (MW)	Equivalent to Power Consumed by XX Thousand Households (National Avg. Household Power Use is 10.9 MWh/yr)
1	Walmart	680	5,844	660
2	Target	240	2,062	233
3	Home Depot	206	1,767	200
4	Lowe's Companies	196	1,683	190
5	Sears Holdings (Sears and KMart)	188	1,614	182
6	Macy's	147	1,267	143
7	J.C. Penney Co.	111	950	107
8	Kohl's	84	720	81
9	Costco	70	601	68
10	TJX (Marshall's and TJMaxx)	62	530	60

## Walmart: The Nation's Largest Retailer and Commercial Rooftop Solar Power Producer



*Solar panels on a Walmart in Buckeye, Arizona. Credit: Walmart via Flickr, CC-BY 2.0*

Walmart is the largest retail store chain in the United States – and the leading big box store for installed solar generation capacity. Walmart began installing solar panels on its stores in 2005, and the company has now installed 142 megawatts of solar capacity across 348 locations (at stores and distribution centers).<sup>27</sup> Each installation offsets 15 to 30 percent of the electricity needs of the store on which it is sited.<sup>28</sup> According to the Environmental Protection Agency's Green Power Partnership rankings of organizations and governments using clean power, Walmart ranks third among retail stores, using 315,000 MWh of solar and wind generated electricity annually.<sup>29</sup>

More than 200 of Walmart's solar installations have been completed in partnership with the solar provider SolarCity, and Walmart has contracted with the company to install new solar power systems in 36 states by 2018. Walmart has also been a pilot tester of SolarCity's energy storage systems for businesses.<sup>30</sup>

Walmart has committed to use 7 billion kWh of renewable energy at its facilities around the world and to double the number of U.S. Walmart stores with solar panels by 2020.<sup>31</sup> With nearly 5,000 U.S. stores, Walmart has the national presence to make a significant impact on the electricity grid if it does so.<sup>32</sup>

# The Benefits of Scaling Up Commercial Rooftop Solar Power

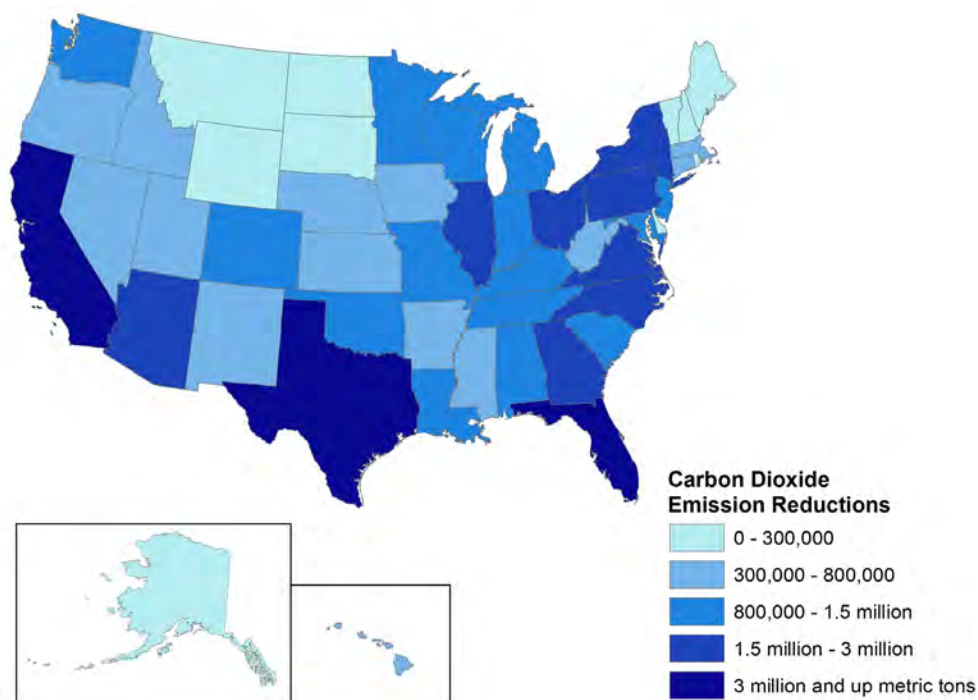
“Going solar” is good for big box stores, good for local electric grids and good for consumers. Studies show that the benefits that solar power brings to the electricity grid, our communities and the environment far outweigh the benefits solar panel owners receive through policies such as net metering.<sup>33</sup> Generating clean solar electricity on the rooftops of big box stores can protect all electricity customers from volatile costs and unnecessary expenses, make our electric grid more resilient, reduce climate-altering pollution and cut costs for the big box businesses themselves.

## Big Box Solar Power Brings Widespread Community Benefits

### Reducing Global Warming Pollution

Increasing the amount of solar power used in the United States will decrease the global warming pollution that comes from fossil fuel combustion. In 2014, the United States emitted 5.6 billion metric tons of carbon dioxide, second only to China; coal-fired power plants accounted for nearly one-third of those emissions.<sup>34</sup> Producing energy from natural gas leads to large emissions of methane, an extremely potent greenhouse

**Figure 5: Annual State Reductions in Global Warming Pollution with Solar Panels on Available Big Box Stores and Shopping Centers (Metric Tons CO<sub>2</sub>)**





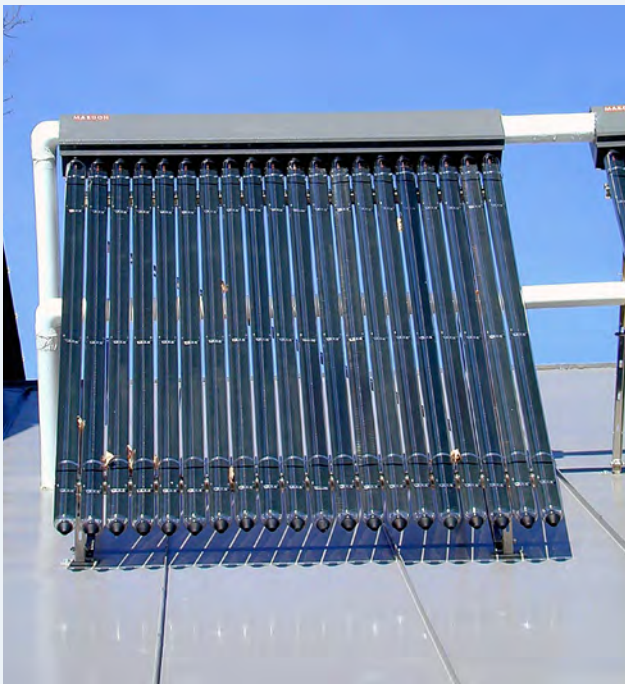
gas, during its production, transportation and storage – emissions that largely negate the reduced carbon dioxide emitted during combustion.<sup>35</sup>

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 a coal-fired power plant over its entire life cycle, and 91 percent less global warm-

ing pollution than a natural gas-fired power plant.<sup>36</sup> By reducing the need for electricity from fossil fuel-fired power plants and by not producing significant global warming pollution itself, solar power reduces the threat posed by global warming and helps to clean the nation's air.

Installing 62.3 GW of solar power on big box stores and shopping centers would reduce global warming pollution by nearly 57 million metric tons annually

## Solar Thermal Technologies Can Expand the Potential of Commercial Buildings to Reduce Global Warming Pollution



*Solar hot water on Vermont farm, credit: Alan D. Ford*

Solar thermal technologies like solar water heating also have the potential to offset energy use on America's commercial buildings. According to the National Renewable Energy Laboratory, the energy savings potential of installing solar hot water heating systems on available residential and commercial rooftops in the United States is equivalent to the an-

nual electricity consumption of Oregon or the electric output of five large power plants.<sup>41</sup> This would lead to an estimated additional annual savings of \$8.4 billion in electricity costs and carbon dioxide emissions reductions of 50 to 75 million metric tons per year, or 2 to 3 percent of emissions from the residential and commercial building sectors.<sup>42</sup> That's the equivalent emissions reduction of taking between 10 and 16 million cars off the road.<sup>43</sup>

A typical solar hot water system in the United States offsets the water heating energy needs of a building by 40 to 80 percent in the United States, and since these systems usually take up less space than solar panel installations they can be a viable option on rooftops too small for photovoltaic systems.<sup>44</sup> Some companies like Nextility offer solar hot water heating systems to businesses and non-residential institutions through a third-party power purchase agreement (in which Nextility owns the solar thermal heating system and charges a guaranteed rate to the business on which the system is installed).<sup>45</sup>

Although this report only discusses the solar PV potential of America's commercial rooftops, solar thermal technologies enhance the opportunity to use solar energy to offset commercial buildings' energy consumption and greenhouse gas emissions.

– equivalent to taking nearly 12 million passenger vehicles off the road.<sup>37</sup>

Many major U.S. businesses are installing solar power as part of their commitments to reduce global warming pollution. IKEA – the company with the highest percentage of U.S. facilities with solar panels – announced in June 2015 that it will spend \$1.13 billion on fighting global warming and has committed to eventually being powered by 100 percent renewable energy.<sup>38</sup> In November 2015 Walmart announced that it had fulfilled its 2010 commitment to cut 20 million metric tons of global warming pollution from its business practices by the end of 2015, in part by increasing its reliance on solar power.<sup>39</sup> Stop & Shop is a New England grocery store chain with more than 400 stores and 63,000 employees. In 2008, the company made a commitment to “reducing their carbon footprint by 20 percent by 2015.” In that pursuit, they have installed solar power systems on 38 stores, producing enough clean electricity to power the equivalent of 730 homes yearly.<sup>40</sup>

## Creating a Resilient Electricity System

Rooftop solar energy also helps communities deal with the erratic weather and climatic stresses exacerbated by global warming. If transmission lines are disrupted from a severe storm or heat wave, solar energy attached to batteries can, in some circumstances, help avoid blackouts.<sup>46</sup> Distributed solar generation paired with microgrids – electricity systems that can operate independently of the central grid and create intentional islands – can also keep the power on after severe weather events that disrupt electricity transmission on the centralized grid.<sup>47</sup> Pairing smart inverter technology with solar panels also improves grid resiliency, even without the use of distributed energy storage.<sup>48</sup>

Solar PV panels also reduce competition for scarce water resources during times of drought, using far less water than conventional fossil fuel and nuclear power plants. The life-cycle water consumption of so-

lar photovoltaics is 1/500<sup>th</sup> of the life-cycle water consumption of coal power plants and 1/80<sup>th</sup> of that of natural gas plants per unit of electricity produced.<sup>49</sup> According to a study by the Union of Concerned Scientists, a scenario with high levels of renewable energy and energy efficiency would withdraw and consume half the amount of water for electricity production as a business-as-usual scenario.<sup>50</sup>

Because solar PV panels do not rely on water for electricity production, communities that generate a significant amount of electricity from solar panels are less susceptible to electricity disruption during droughts. During the Midwest drought of 2012, many fossil-fuel power plants that required cooling water to operate were forced to limit or suspend electricity production.<sup>51</sup> 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.<sup>52</sup> Climate change will only increase the risk of drought and solar power can be a real solution to stabilize electricity production under these conditions.

## Cutting Consumer Costs

Scaling up U.S. solar electricity generation would deliver important benefits to homeowners and businesses, including low-income consumers. All electricity consumers would see less price volatility from fossil fuels and reduced losses of electricity in transmission and distribution.

An electric grid that relies more on solar power and less on fossil fuels can deliver electricity to all customers with much less fossil-fuel related volatility in the price of electricity.<sup>53</sup> Rooftop solar panels also capture the most solar energy during sunny periods of high electricity demand when the cost of producing electricity is normally the highest – saving money for all consumers on their power bills.

With smart public policies and declining prices, more and more people have the opportunity to benefit

from solar energy, including low-income households and those living in multi-family housing. Low income families participating in California's Single-Family Affordable Solar Homes program, for example, cut their monthly electricity bills by 80 percent on average.<sup>54</sup> In multi-family homes, programs that allow for "virtual net metering" can distribute the benefits of one solar installation to multiple families in a housing complex. Virtual net metering enables shared, community solar projects that allow those who are unable to install solar panels on their own properties or live in multi-family homes to "go solar."<sup>55</sup>

Using more distributed solar power for U.S. electricity production would also result in a more efficient electric grid. The U.S. Energy Information Administration estimated that the United States lost about 203 million megawatt-hours (MWh) of electricity in 2012 during transmission, or 5 percent of the total amount of electricity generated that year, leading us to generate more electricity than we needed, increasing costs for ratepayers and causing additional pollution.<sup>56</sup> Distributed solar energy on commercial rooftops avoids these losses by generating electricity at or near the location where it is used.<sup>57</sup> This allows more energy to go straight into homes and businesses, and avoids high-cost investments in expanding transmission capacity.

## Reducing Air Pollution

Installing solar energy on commercial rooftops can improve air quality by reducing our reliance on polluting fossil fuels for electricity. The United States generates 67 percent of its electricity from fossil fuels, including coal, natural gas and oil. Almost 40 percent of U.S. electricity came from coal in 2014.<sup>58</sup> Our outsized dependence on dirty fossil fuels for electricity

takes a toll on public health, as these energy sources release known hazardous pollutants into the air.

Fossil-fuel fired power plants create 70 percent of U.S. sulfur dioxide emissions and 13 percent of nitrogen oxide emissions, affecting air quality in ways that harm human health.<sup>59</sup> Sulfur dioxide contributes to the formation of acid rain, as well as small particles in the air that can penetrate deep into the lungs and trigger respiratory diseases such as bronchitis and emphysema. Particulate pollution has been linked to increased rates of hospital admissions and premature death.<sup>60</sup> According to an MIT study, fine particle pollution caused 52,000 early deaths in the United States in 2005.<sup>61</sup> Nitrogen oxides contribute to the formation of ozone "smog." Ozone reacts with airway tissues and produces inflammation similar to sunburn on the inside of the lungs. This inflammation makes lung tissues less elastic, more sensitive to allergens and less resistant to infections.<sup>62</sup>

## Creating Jobs

Installing more solar power is not only good for the environment and for electricity consumers; it also creates a significant number of local jobs that cannot be outsourced.

America is already experiencing significant job growth in the solar energy industry. Nearly 209,000 Americans worked in the solar energy industry as of November 2015, a 20 percent increase from the previous year, according to The Solar Foundation's annual solar jobs census.<sup>63</sup> According to The Solar Foundation, growth in the solar industry from November 2014 to November 2015 was nearly 12 times faster than the national average employment growth rate.<sup>64</sup> Solar industry investment in the U.S. economy is almost \$15 billion each year.<sup>65</sup>

## Big Box Stores Directly Benefit from Hosting Solar Panels

Large commercial businesses use a significant amount of electricity, taking a toll on the environment and their electricity bills. Electricity rates for commercial customers in the U.S. increased by 20 percent over the last 10 years.<sup>66</sup> On average, each of the nation's big box retail stores, large grocery stores and malls consumes 1,800 megawatt-hours of electricity annually and spends an average of \$190,000 on their electricity bill each year. Electricity produced by rooftop panels could offset the annual electricity use of these buildings by 42 percent, saving these big box stores \$8.2 billion annually on their electricity bills.<sup>67</sup>

Solar businesses are saving money on their electricity bills and contributing to a cleaner and more secure electricity grid. By installing solar panels on two California stores, for example, Costco reported savings of \$300 per day on average over three months.<sup>68</sup>

Solar power provides some particular economic benefits to big box stores and other businesses:

- Because big box stores generally use most of their energy during the day, when the sun is shining, they benefit from instantaneous use of the free electricity solar panels generate. For businesses planning their economic future, solar panels also provide freedom from volatile energy prices – whether they are installed through individual financing or through a long-term power purchase agreement.
- Solar panels paired with energy storage can also reduce demand charges, which for some businesses account for more than half of their monthly electricity costs.<sup>69</sup> Demand charges, which are calculated from peak load times rather than monthly energy use, can be reduced by smart battery installations that supply energy at moments of high energy use.<sup>70</sup>
- Solar panels can indirectly lower business cooling and heating costs by shading roofs during the day, and providing insulation at night – benefits that are particularly pronounced on older warehouse buildings.<sup>71</sup>

## Case Study 2: Clothing Retailers Macy's, Kohl's and Target Invest in Solar Power



*Macy's in Irvine, California. Credit: Woolennium via Flickr, CC-BY-NC-ND 2.0*

Major clothing retailers Macy's and Kohl's are making significant investments in solar energy.

Among businesses surveyed in SEIA's 2015 *Solar Means Business* report, Kohl's ranks fifth in the country with more than 50 MW of solar power installed on its stores.<sup>72</sup> Kohl's ranks first in the nation for green power purchasing according to the Environmental Protection Agency – its purchases of solar energy credits and the solar energy production at its facilities offset 104 percent of the electricity demand at Kohl's facilities.<sup>73</sup> Kohl's has 161 solar power systems on its stores in 13 states, each of which offsets 20 to 50 percent of its store's energy use.<sup>74</sup> Its largest project in Maryland consists of more than 8,000 solar panels and generates more than 3 million kWh of electricity annually.<sup>75</sup>

Macy's has the seventh-highest amount of solar capacity installed on its facilities, with 20.8 MW in

total.<sup>76</sup> Macy's has contracted with Sunpower to install solar panels at 30 locations in California.<sup>77</sup> By signing a power purchase agreement with Sunpower in 17 of these 30 projects, Macy's will purchase the electricity generated by the panels from Sunpower, which owns the panels.<sup>78</sup> This kind of third-party agreement can help businesses avoid the cost of purchasing the panels themselves, making projects more affordable. These projects alone will put 8.9 megawatts of solar power on Macy's stores and help the company reduce global warming pollution from dirty electricity sources by 88,000 metric tons over 30 years.<sup>79</sup>

As of December 2015, Target had nearly 15 MW of installed onsite solar capacity at 41 different locations.<sup>80</sup> In February 2015, Target announced plans to install rooftop solar panels on 500 U.S. locations by 2020, including plans to add solar panels to 250 Target buildings in 2015 and 2016 alone.<sup>81</sup>

# New Financing Tools Can Help Businesses Overcome Hurdles to Solar Adoption

The benefits of solar power are clear: it is good for the environment and can save money. Many businesses are eager to reap these benefits, as demonstrated by companies like Ikea, Walmart, Kohl's, and Macy's. But important hurdles often stand in the way of commercial solar energy installations – barriers that can be overcome with smart public policy.

Efforts to install solar energy on commercial buildings often fall victim to the inherent complexity of commercial contracts and to misaligned incentives between building owners and retail chains. Another set of challenges is in the financing realm, which for commercial customers tends to be more complicated and less standardized than for residential solar.<sup>82</sup> The good news is that new financing mechanisms and risk analysis tools are being developed and rolled out that can solve some of the problems of commercial solar development:

- Lack of standardization for commercial solar lease and power purchase agreements can increase the cost and hassle of “going solar” for businesses. The Solar Access to Public Capital (SAPC) working group, a project of the National Renewable Energy Laboratory (NREL), has worked with hundreds of stakeholders to develop standardized commercial

power purchase agreements and lease agreements. NREL's stated goals for SAPC include minimizing due diligence cost and time, and opening the solar market to investment mechanisms including securitization.

- Many banks will not finance solar projects because there are not established standards for measuring risk and investment return.<sup>83</sup> The truSolar initiative, introduced by Distributed Sun, DuPont and the Rocky Mountain Institute in September 2012, aims to fix those problems by creating a standard ranking system for all of the elements in a solar project.<sup>84</sup>
- Businesses often lease their property, with many businesses unable to make long-term commitments that would extend over the 15- to 20-year lifetime of a solar energy system. Financing options like Property Assessed Clean Energy (PACE) financing, in which the obligation to repay a solar loan passes to the new owner when a property is sold, can ease risk in these cases. (See more on PACE in “Policy Recommendations,” next page.)

As national retailers and big box stores “go solar,” these large businesses can help solidify the commercial solar market, bringing about increased standardization while also lowering their own energy costs and reducing global warming emissions.

# Policy Recommendations

Policies that support rooftop solar power bring the additional environmental, economic and social benefits of local, distributed electricity to America's communities. **Officials at all levels of government must implement solar-friendly policies that help to accelerate America's commercial solar energy adoption.** These should include:

- *Adopting and preserving strong interconnection and net metering policies* – These policies ensure that businesses are appropriately compensated for the electricity that they export to the grid, allow them to move seamlessly between producing their own electricity and using electricity from the grid, and make solar power an affordable business investment for big box stores. In states or utility territories without strong net metering programs, carefully implemented CLEAN contracts (also known as feed-in tariffs) and value-of-solar payments can play an important role in ensuring that consumers receive a fair price for solar energy, so long as the payments fully account for the benefits of solar energy and are sufficient to spur participation in the market.
- *Extending or maintaining state-level solar energy tax credits* – State level tax credits for solar energy are important supports for state commercial solar energy markets. States should offer property tax exemptions that exclude the value of solar equipment from the assessed property value on which homeowners and business owners must pay taxes. States should also offer sales tax exemptions for the sale of solar panels and solar hot water heating equipment, which lowers the up-front cost of buying the equipment.
- *Enabling third-party sales of electricity* – Although businesses that choose to purchase their own solar panels can reap the benefits of faster installation and no monthly payments, alternate “third-party” financing options – like power-purchase agreements and solar leases – have been a particularly important way for businesses to install solar panels on a large scale. These arrangements allow third-party companies to own the panels and help businesses avoid the high up-front costs of solar panel purchases. States should allow companies that install solar panels to sell electricity to their customers without subjecting them to the same regulations as large public utilities.
- *Adopting financing programs like Commercial PACE*– Creative financing options that provide businesses with low up-front costs and long-term repayment options are important for the commercial solar industry. For example, commercial Property-Assessed Clean Energy (PACE) financing programs allow local governments to pay the up-front cost of commercial solar projects, with the expenses repaid by the businesses in their property taxes.<sup>85</sup>
- *Allowing and encouraging community solar programs* – Community solar programs allow people who may not be able to install solar panels themselves to invest in a solar installation sited away from their private properties and share credit for the electricity produced by the solar panels and sent back to the electric grid.<sup>86</sup> Partnering with businesses and non-profit organizations to establish a community solar projects at the local level can be a creative source of financing for solar projects on commercial rooftops.<sup>87</sup>

- *Streamlining solar permitting and instituting affordable permitting fees* – The “soft costs” associated with solar power – costs such as those associated with installing the system, completing paperwork, and paying taxes and permitting fees – typically make up more than half of the total cost of an installed commercial solar energy system.<sup>88</sup> Local governments should work to reduce these costs, accelerate the time it takes to obtain a permit for a solar installation, ensure that permitting rules do not hinder the installation of solar panels, and streamline the paperwork necessary to get a permit.
- *Encouraging electric utilities to adopt solar-friendly rate structures* – Under some rate structures, utilities bill electricity customers in a way that minimizes the savings that they can recoup from rooftop solar energy generation.<sup>89</sup> Regulators should investigate the impacts of rate plans on solar energy adoption and support those that improve the economics of installing solar power for business owners.
- *Enforcing the requirements of the Clean Power Plan* – The federal government should enforce the standards of the Clean Power Plan to reduce global warming emissions 30 percent below 2005 levels by 2030. It should also emphasize programs like the Clean Energy Investment Program, which incentivizes the states’ early deployment of solar, wind and low-income energy efficiency. States should establish effective plans for meeting or surpassing the goals of the Clean Power Plan, with clean and renewable sources of energy such as solar power playing a leading role. Investing in commercial solar power will play a key role in reaching the levels of renewable energy adoption that will be necessary to reach these goals.



# Appendix A: Methodology

## Solar Capacity and Generation on Commercial Buildings

To estimate the technical potential for solar PV systems on large commercial buildings in the United States, we used the U.S. Energy Information Administration’s 2012 Commercial Building Energy Consumption Survey (CBECS) to determine the square footage of large commercial buildings. We defined large commercial buildings using CBECS microdata and the following selection criteria in order to capture

large “big box” retail and grocery store buildings that could host solar panels: buildings over 25,000 square feet with the principal building activities of “food sales,” “strip shopping malls,” “retail (other than mall),” and “enclosed mall.” We excluded buildings of these types with more than 15 floors. This left us with 102,147 big box retail stores, grocery stores and malls to evaluate.

The tables below display characteristics of these big box stores by building activity type and region.

**Table A-1: Number of Big Box Buildings and Shopping Malls by Region and Building Activity Type**

Region	Food Sales	Strip Shopping Malls	Enclosed Malls	Retail (Other than Malls)	Grand Total
Northeast	3,124	6,386	109	4,169	13,788
Midwest	802	7,872	198	7,119	15,991
South	2,222	25,148	497	18,065	45,932
West	2,822	12,950	266	10,398	26,436
Grand Total	8,971	52,356	1,070	39,750	102,148

**Table A-2: Total Square Footage of Big Box Buildings and Shopping Malls by Region and Building Activity Type (Millions of Square Feet)**

Region	Food Sales	Strip Shopping Malls	Enclosed Malls	Retail (Other than Malls)	Grand Total
Northeast	185	556	93	314	1,148
Midwest	29	655	147	546	1,377
South	78	1,828	334	1,192	3,432
West	207	926	244	895	2,271
Grand Total	499	3,965	819	2,947	8,229

**Table A-3: Total Estimated Rooftop Square Footage by Region and Building Activity Type (Millions of Square Feet)**

Region	Food Sales	Strip Malls	Enclosed Malls	Retail (Other than Malls)	Grand Total
Northeast	185	504	41	248	978
Midwest	19	587	101	485	1,192
South	70	1,678	273	1,066	3,087
West	175	884	130	806	1,996
Grand Total	449	3,653	546	2,605	7,253

Using Microsoft Access, we used CBECS microdata to divide the total floor space in each building by the number of floors in each building. This gave us an estimate of rooftop space available on each building and of total rooftop space on large commercial buildings in each U.S. census division.

We then apportioned the total rooftop space on big box stores in each region to each state according to the percentage of the regional population living in each state in 2012 using the U.S. Census Bureau’s American Community Survey 5-Year Estimates.

This yielded 7.2 billion square feet of rooftop area on the selected large retail, grocery store and shopping mall buildings in the United States. We assumed that 65 percent of this rooftop area is suitable for rooftop solar energy systems in designated “cool” climates and 60 percent in “warm” climates, per a 2008 study by Navigant Consulting for the National Renewable Energy Laboratory, *Rooftop Photovoltaics Market Penetration Scenarios*.<sup>90</sup> In calculating this number, Navigant took into account factors such as trees and other shading on residential and larger buildings, roof tilt and orientation, and the room needed on roofs between solar panels and taken up by other objects such as chimneys and fan systems.

This yielded 4.5 billion square feet of rooftop area available and appropriate for rooftop solar PV systems. We assumed solar panel efficiency of 18.5

percent, per the 2008 Navigant Consulting report for the National Renewable Energy Laboratory, *Rooftop Photovoltaics Market Penetration Scenarios*.<sup>91</sup> This efficiency corresponds to an estimated solar power density on commercial buildings of 13.7 megawatts per million square feet of available rooftop space, accounting for space needed for ancillary equipment.<sup>92</sup> This yielded the result that these commercial rooftops could host 62.3 gigawatts of solar PV capacity.

To estimate electricity generation from rooftop solar panels on big box stores in each state, we used state-specific rooftop solar PV capacity factors implied by the data in the National Renewable Energy Laboratory’s *U.S. Renewable Energy Technical Potentials* report.<sup>93</sup> (NREL’s capacity factor accounts for DC-AC inverter efficiency, as well as losses associated with wiring, maintenance and other factors.)<sup>94</sup> We multiplied the potential big box store solar capacity in each state by the solar capacity factors reported by NREL and the number of hours in a year to estimate the solar generation by state by year. For Alaska and Hawaii, we used the national average capacity factor based on the NREL data, as specific estimates of rooftop solar generation in these states were unavailable.

A similar methodology was used to calculate the potential solar capacity of individual big box store companies in Table 2. Because there are no available estimates of rooftop space for each company listed,

we assumed that retail space is equivalent to total rooftop space. For big box retailers where the majority of locations are single-floor standalone retail locations, this calculation may result in an underestimate of total rooftop space because retail space does not include the parts of a building devoted to warehouses, shipping and packing, or office space. For retailers whose stores tend to have more than one floor, or are located within a multi-story mall, this calculation may result in an overestimate of total roof space. We assumed that 62.5 percent of each store's calculated total rooftop space is available for rooftop solar energy systems, based on the average of warm and cool climate available space factors in the previously cited Navigant/NREL report, *Rooftop Photovoltaics Market Penetration Scenarios*. Based on the same report, we calculated that 13.7 MW of solar capacity could be installed per million square feet of available space.

## Electricity Consumption of Big Box Stores

To estimate the electricity consumption and annual electricity expenditures of big box stores in each state, we calculated electricity consumption statistics by building activity type and region from the 2003 Commercial Building Energy Consumption Survey (CBECS) and applied those to buildings of the same type and within the same region in the 2012 CBECS. This estimate was necessary because the U.S. EIA has not yet released updated 2012 statistics on energy consumption of commercial buildings (as of December 2015); only the data on commercial building characteristics has been released (which we used to estimate rooftop space on big box stores). We then apportioned the estimated electricity consumption of big box stores in each region to each state according to the percentage of the region population living in each state in 2012 using the U.S. Census Bureau's American Community Survey 5-Year Estimates.

To estimate annual electricity expenditures by big box stores in each state, we multiplied our state-specific estimates of big box store electricity consumption by 2013 state commercial electricity rates.<sup>95</sup>

## Global Warming Emissions Reductions

When solar panels generate electricity, they displace some other source of electricity on the grid. The type of electricity production that is offset by solar power depends on several factors: regional variations in the electricity resource mix, the degree to which solar energy offsets new versus existing generation capacity, the relative price of competing forms of electricity generation (including marginal prices), and the way in which solar energy is integrated into the grid, among others.

To estimate carbon dioxide emission reductions from solar energy generation on big box stores, we assumed that solar energy added to the grid would offset fossil fuel generation only, and would offset coal and gas-fired generation in proportion to their contribution to each state's particular electricity mix, as defined by the regional electricity grids that serve that state.

Emission reduction rates for each state were based on the actual electricity generation mixes in 2013 for the EIA EMM regions of which they are a part. The EIA's Annual Energy Outlook 2015 provided data on actual annual electricity generation and emissions for coal and natural gas power plants in each EIA region in 2013 (compiled from EIA Form 759). We assigned each EMM region to one of the interconnection regions identified by the North American Electric Reliability Corporation (NERC), using maps of EMM regions and NERC regions. We estimated an emissions factor for fossil fuel-fired generation for each NERC region, using the generation and emissions data for the constituent EMM regions.

To arrive at an emissions factor for each state, we determined the percentage of electricity sales in each state that come from within each NERC region, using data from U.S. Department of Energy, Energy Information Administration, *Electric Power Sales, Revenue, and Energy Efficiency Form EIA-861*, 29 October 2013. State emission factors were created by multiply-

ing each state's percent of sales per NERC region in 2012 by each region's emission factor. The use of a constant emission factor for each state masks hourly variations in the carbon intensity of electricity on the grid, meaning that the estimates in this report do not fully reflect the ways in which additional solar energy might affect hourly dispatch of different electricity generators in each region of the country.

NERC regions could not be identified for utilities responsible for a total of 1.5 percent of electricity sales nationally, including for the states of Alaska and Hawaii. For the state of Alaska, we divided annual carbon dioxide emissions from coal and natural gas sources in the electric power industry by total electricity genera-

tion from coal and natural gas sources in the electric power industry. For the state of Hawaii, most electricity is generated from petroleum (70 percent of electricity generated in 2013 came from petroleum sources). For that reason, we calculated Hawaii's emission factor by dividing annual carbon dioxide emissions from petroleum by annual electricity generation from petroleum. For both Alaska and Hawaii, we used the 2012 emission factor for 2013, based on available data.<sup>96</sup>

To estimate total emissions savings numbers for each state, we multiplied big box store solar generation for that scenario by the emission factor for that state and year. National estimates for each year were based on a sum of all state estimates.

# Appendix B: Tables

**Table B-1: Solar Potential on Big Box Stores, By State<sup>97</sup>**

State	Big Box Store Rooftop Space (million ft <sup>2</sup> )	Potential Solar Capacity on Big Box Stores (MW)	Annual Potential Big Box Solar Generation by State (GWh)	Equivalent to Power Consumed by XX Thousand Households (National Avg Household Power Use is 10.9 MWh/yr)	By XX Wal-Marts (10,320 MWh/year)
Alabama	129	1,056	1,306	120	127
Alaska	20	175	216	20	21
Arizona	178	1,459	2,230	205	216
Arkansas	78	699	875	80	85
California	1,034	8,497	11,911	1,093	1,154
Colorado	140	1,244	1,704	156	165
Connecticut	63	562	630	58	61
Delaware	24	216	251	23	24
District of Columbia	16	145	172	16	17
Florida	508	4,176	5,408	496	524
Georgia	261	2,148	2,716	249	263
Hawaii	38	310	382	35	37
Idaho	43	387	486	45	47
Illinois	228	2,033	2,325	213	225
Indiana	115	1,028	1,187	109	115
Iowa	54	483	581	53	56
Kansas	51	452	590	54	57
Kentucky	117	1,040	1,215	111	118
Louisiana	122	1,002	1,215	111	118
Maine	23	209	239	22	23
Maryland	156	1,386	1,616	148	157
Massachusetts	116	1,032	1,173	108	114
Michigan	176	1,569	1,716	157	166
Minnesota	95	842	966	89	94
Mississippi	80	656	811	74	79
Missouri	107	949	1,172	108	114

**Table B-1 (continued): Solar Potential on Big Box Stores, By State<sup>97</sup>**

State	Big Box Store Rooftop Space (million ft <sup>2</sup> )	Potential Solar Capacity on Big Box Stores (MW)	Annual Potential Big Box Solar Generation by State (GWh)	Equivalent to Power Consumed by XX Thousand Households (National Avg Household Power Use is 10.9 MWh/yr)	By XX Wal-Marts (10,320 MWh/year)
Montana	27	244	286	26	28
Nebraska	33	290	366	34	35
Nevada	75	616	929	85	90
New Hampshire	23	207	231	21	22
New Jersey	155	1,384	1,593	146	154
New Mexico	57	468	722	66	70
New York	343	3,052	3,493	320	338
North Carolina	257	2,286	2,813	258	273
North Dakota	12	107	127	12	12
Ohio	205	1,829	2,001	184	194
Oklahoma	101	898	1,197	110	116
Oregon	106	946	1,004	92	97
Pennsylvania	224	1,998	2,230	205	216
Rhode Island	19	166	185	17	18
South Carolina	125	1,024	1,280	117	124
South Dakota	15	129	160	15	16
Tennessee	171	1,522	1,846	169	179
Texas	678	5,574	7,282	668	706
Utah	77	682	908	83	88
Vermont	11	98	107	10	10
Virginia	216	1,920	2,290	210	222
Washington	187	1,662	1,675	154	162
West Virginia	50	443	491	45	48
Wisconsin	101	902	1,025	94	99
Wyoming	16	139	184	17	18
<b>United States</b>	<b>7,253</b>	<b>62,341</b>	<b>77,515</b>	<b>7,111</b>	<b>7,511</b>

**Table B-2: Electricity Savings, Money Savings and Emissions Reductions from Solar Power on Big Box Stores, by State**

State	Global Warming Pollution Offset by Reaching Big Box Store Solar Potential (thousand metric tons CO2)	Could Offset XX Percent of Big Box Store Electricity Usage in State	Could Save \$XX on Annual Electricity Spending (millions of \$)
Alabama	1,037	39%	\$137
Alaska	151	45%	\$34
Arizona	1,578	51%	\$220
Arkansas	709	42%	\$70
California	8,484	47%	\$1,694
Colorado	1,203	50%	\$168
Connecticut	313	34%	\$92
Delaware	219	39%	\$26
District of Columbia	151	40%	\$21
Florida	3,097	40%	\$508
Georgia	2,153	39%	\$271
Hawaii	301	41%	\$130
Idaho	338	45%	\$36
Illinois	1,927	47%	\$189
Indiana	1,023	47%	\$114
Iowa	554	49%	\$49
Kansas	498	54%	\$57
Kentucky	991	39%	\$104
Louisiana	981	38%	\$109
Maine	119	35%	\$28
Maryland	1,412	39%	\$173
Massachusetts	574	35%	\$167
Michigan	1,490	45%	\$190
Minnesota	919	47%	\$91
Mississippi	645	39%	\$82
Missouri	943	51%	\$103

**Table B-2 (continued): Electricity Savings, Money Savings and Emissions Reductions from Solar Power on Big Box Stores, by State**

State	Global Warming Pollution Offset by Reaching Big Box Store Solar Potential (thousand metric tons CO2)	Could Offset XX Percent of Big Box Store Electricity Usage in State	Could Save \$XX on Annual Electricity Spending (millions of \$)
Montana	208	42%	\$27
Nebraska	345	52%	\$31
Nevada	661	50%	\$84
New Hampshire	114	34%	\$31
New Jersey	1,377	35%	\$204
New Mexico	543	52%	\$70
New York	1,714	35%	\$536
North Carolina	2,225	42%	\$246
North Dakota	122	49%	\$11
Ohio	1,735	45%	\$187
Oklahoma	1,013	45%	\$93
Oregon	717	38%	\$87
Pennsylvania	1,941	34%	\$206
Rhode Island	92	34%	\$24
South Carolina	1,018	39%	\$126
South Dakota	148	51%	\$14
Tennessee	1,477	41%	\$185
Texas	4,466	41%	\$584
Utah	639	48%	\$76
Vermont	52	33%	\$16
Virginia	1,856	40%	\$183
Washington	1,192	36%	\$130
West Virginia	428	37%	\$40
Wisconsin	944	47%	\$110
Wyoming	130	48%	\$16
<b>United States</b>	<b>56,965</b>	<b>42%</b>	<b>\$8,180</b>



**Table B-3: Solar Capacity Potential for America's Top 24 Big Box Stores (Excluding Grocery-Specific Chains)<sup>98</sup>**

Solar Potential Rank	Company	U.S. Retail Space (million sq feet)	Potential Rooftop Solar Capacity (MW)	Equivalent to Power Consumed by XX Thousand Households (National Avg Household Power Use is 10.9 MWh/yr)
1	Walmart	680	5,844	660
2	Target	240	2,062	233
3	Home Depot	206	1,767	200
4	Lowe's Companies	196	1,683	190
5	Sears Holdings (Sears and KMart)	188	1,614	182
6	Macy's	147	1,267	143
7	J.C. Penney Co.	111	950	107
8	Kohl's	84	720	81
9	Costco	70	601	68
10	TJX (Marshall's and TJMaxx)	62	530	60
11	Burlington Coat Factory	42	363	41
12	Best Buy	40	347	39
13	Office Depot	37	314	35
14	Bed Bath & Beyond	32	277	31
15	Dick's Sporting Goods	32	272	31
16	Menard	30	257	29
17	Gap (Gap, Banana Republic, Old Navy, Piperlime, Athleta, and Intermix)	29	252	28
18	Nordstrom	27	231	26
19	Staples	25	211	24
20	Ascena Retail Group (Lane Bryant, maurices, dressbarn, Catherines and justice)	21	179	20
21	BJ's Wholesale Club	21	177	20
22	IKEA	12	106	12
23	Toys "R" Us	5	42	5
24	Foot Locker	4	36	4
	<b>Total</b>	<b>2,339</b>	<b>20,103</b>	<b>2,271</b>

**Table B-4: Solar Capacity Potential for Top Big Box Stores with Current Installed Solar Capacity for Comparison<sup>99</sup>**

Solar Potential Rank	Company	U.S. Retail Space (million sq feet)	Potential Rooftop Solar Capacity (MW)	Existing Solar Capacity (MW) (From <i>SEIA Solar Means Business 2015</i> , where available)
1	Walmart	680	5,844	141.99
2	Target	240	2,062	14.94
6	Macy's	147	1,267	20.78
8	Kohl's	84	720	50.21
9	Costco	70	601	50.75
14	Bed Bath & Beyond	32	277	17.34
19	Staples	25	211	13.66
22	IKEA	12	106	41.41

# Notes

- 1 IKEA, *People & Planet Positive: IKEA Group Sustainability Strategy for 2020*, accessed at [web.archive.org/web/20150706064018/http://www.ikea.com/ms/en\\_GB/pdf/people\\_planet\\_positive/People\\_planet\\_positive.pdf](http://web.archive.org/web/20150706064018/http://www.ikea.com/ms/en_GB/pdf/people_planet_positive/People_planet_positive.pdf), 5 July 2015.
- 2 Solar Energy Industries Association, *Solar Means Business 2014: Top U.S. Commercial Solar Users*, 2014.
- 3 Solar Energy Industries Association, *Solar Means Business 2015: Top U.S. Commercial Solar Users*, 2015.
- 4 IKEA, *Sustainability Report FY15*, available at [ikea.com/ms/en\\_US/img/ad\\_content/2015\\_IKEA\\_sustainability\\_report.pdf](http://ikea.com/ms/en_US/img/ad_content/2015_IKEA_sustainability_report.pdf), 2015.
- 5 This includes potential solar power generation from rooftop solar panels, large utility-scale solar installations, and concentrating solar power plants. Judee Burr and Lindsey Hallock, Frontier Group, Rob Sargent, Environment America Research & Policy Center, *Star Power: The Growing Role of Solar Energy in America*, November 2014.
- 6 Ibid.
- 7 SEIA, *U.S. Solar Market Insight: U.S. Installs 1.3 GW in Q3, Headed Toward Record-Breaking 2015*, archived at [web.archive.org/web/20160201203850/http://www.seia.org/research-resources/us-solar-market-insight](http://web.archive.org/web/20160201203850/http://www.seia.org/research-resources/us-solar-market-insight).
- 8 Historic capacity: Shayle Kann et al., GTM Research and SEIA, *U.S. Solar market insight report - 2014 year in review*, 10 March 2015; 2015 capacity additions: 2015 capacity additions are based on preliminary estimate (noted “E”) of 7.4 GW solar additions in 2015: SEIA, *U.S. Solar Market Prepares for Biggest Quarter in History*, available at [seia.org/news/us-solar-market-prepares-biggest-quarter-history](http://seia.org/news/us-solar-market-prepares-biggest-quarter-history), 9 December 2015.
- 9 Shayle Kann et al., GTM Research and SEIA, *U.S. Solar Market Insight Executive Summary Q3 2015*, December 2015.
- 10 Utility-scale installations are considered to be those larger than 1 MW in size.
- 11 Galen Barbose and Naim Darghouth, Lawrence Berkeley National Laboratory, *Tracking the Sun VIII: The Installed Price of Residential and Non-Residential Photovoltaic Systems in the United States*, August 2015.
- 12 Q3 2015 data: Shayle Kann et al., GTM Research and SEIA, *U.S. Solar Market Insight Executive Summary Q3 2015*, December 2015; Q3 2014 data: Shayle Kann et al., GTM Research and SEIA, *U.S. Solar Market Insight Executive Summary Q3 2014*, 2014.
- 13 22 percent: Anthony Lopez et al., National Renewable Energy Laboratory, *U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis*, July 2012, and U.S. Energy Information Administration, *State Electricity Profiles: Data for 2012*, 1 May 2014, accessed at <http://www.eia.gov/electricity/state>.
- 14 See methodology.
- 15 National Retail Federation, *Top 100 Retailers*, accessed at [web.archive.org/web/20150703213447/https://nrf.com/2015/top100-table](http://web.archive.org/web/20150703213447/https://nrf.com/2015/top100-table), 3 July 2015.
- 16 “As of mid-2014, there were 4,531 MW of commercial solar PV installed on 41,803 business, non-profit and government locations throughout the U.S.”: Solar Energy Industries Association, *Solar Means Business 2014: Top U.S. Commercial Solar Users*, 2014. Cumulative PV capacity as of mid-2014 was 15 GW: Solar Energy Industries Association, *Solar Market Insight Report 2014 Q2*, 2014, available at [web.archive.org/web/20150703181134/http://www.seia.org/research-resources/solar-market-insight-report-2014-q2](http://web.archive.org/web/20150703181134/http://www.seia.org/research-resources/solar-market-insight-report-2014-q2).

- 17 See note 3.
- 18 Ibid.
- 19 See note 2.
- 20 See methodology for our definitions of big box stores and calculation of available rooftop space.
- 21 See methodology. 24.1 GW of solar photovoltaic capacity have been installed in the U.S. as of Q3 2015: SEIA, *U.S. Solar Market Insight: U.S. Installs 1.3 GW in Q3, Headed Toward Record-Breaking 2015*, archived at [web.archive.org/web/20160201203850/http://www.seia.org/research-resources/us-solar-market-insight](http://web.archive.org/web/20160201203850/http://www.seia.org/research-resources/us-solar-market-insight); the average U.S. household consumed 10.908 MWh of electricity annually in 2013: U.S. Energy Information Administration, *Frequently Asked Questions: How much electricity does an American home use?*, available at [web.archive.org/web/20150618232948/http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3](http://web.archive.org/web/20150618232948/http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3); Walmart uses 28.274 MWh per day (10,320.01 MWh/yr): Sierra Club, *What Is Wal-Mart's True Environmental Footprint?*, downloaded from [//web.archive.org/web/20150706053443/http://vault.sierraclub.org/pressroom/media/2011/2011-06-walmart.pdf](http://web.archive.org/web/20150706053443/http://vault.sierraclub.org/pressroom/media/2011/2011-06-walmart.pdf), 5 July 2015.
- 22 See Methodology.
- 23 See Methodology.
- 24 This list excludes grocery retailers. See methodology for details of solar potential calculation. See footnote 98 for full list of sources for retail footprints.
- 25 See Methodology for details on solar capacity calculations. Also, note that retailers often operate in buildings owned by separate real estate companies.
- 26 Will Macht, Urban Land Institute, *Greening the Big Blue Box*, 26 October 2012.
- 27 See note 3.
- 28 Capacity and number of locations: See note 3; 15 to 30 percent: Walmart, *Renewable Energy*, accessed at [web.archive.org/web/20150703230251/http://corporate.walmart.com/global-responsibility/environment-sustainability/energy](http://web.archive.org/web/20150703230251/http://corporate.walmart.com/global-responsibility/environment-sustainability/energy), 3 July 2015.
- 29 U.S. Environmental Protection Agency, *Green Power Partnership: Top 30 Retail*, 27 April 2015, available at [web.archive.org/web/20150703230820/http://www.epa.gov/greenpower/toplists/top30retail.htm](http://web.archive.org/web/20150703230820/http://www.epa.gov/greenpower/toplists/top30retail.htm).
- 30 SolarCity, *SolarCity Announces New Solar Power and Energy Storage Projects with Walmart* (press release), 20 November 2014, available at [web.archive.org/web/20150705223058/http://www.solarcity.com/newsroom/press/solarcity-announces-new-solar-power-and-energy-storage-projects-walmart](http://web.archive.org/web/20150705223058/http://www.solarcity.com/newsroom/press/solarcity-announces-new-solar-power-and-energy-storage-projects-walmart).
- 31 Walmart, *Walmart Puts the Price of Solar Power on Rollback: Commits to Doubling On-Site Solar Projects in the United States by 2020* (press release), 9 May 2014, available at [web.archive.org/web/20150705212829/http://news.walmart.com/news-archive/2014/05/09/walmart-puts-price-of-solar-power-on-rollback](http://web.archive.org/web/20150705212829/http://news.walmart.com/news-archive/2014/05/09/walmart-puts-price-of-solar-power-on-rollback).
- 32 In January 2016 Walmart announced it would close 154 stores; however as of July 2015 the retailer had 5,109 stores nationwide: National Retail Federation, *Top 100 Retailers*, accessed at [web.archive.org/web/20150703213447/https://nrf.com/2015/top100-table](http://web.archive.org/web/20150703213447/https://nrf.com/2015/top100-table), 3 July 2015.
- 33 Lindsey Hallock, Frontier Group, Rob Sargent, Environment America Research & Policy Center, *Shining Rewards: The Value of Rooftop Solar Power for Consumers and Society*, Summer 2015.
- 34 Global Carbon Atlas, *Emissions*, accessed at [www.globalcarbonatlas.org/?q=en/emissions](http://www.globalcarbonatlas.org/?q=en/emissions), 22 January 2015.
- 35 Robert W. Howarth, Cornell University, "A Bridge to Nowhere: Methane Emissions and the Greenhouse Gas Footprint of Natural Gas," *Energy Science & Engineering*, 22 April 2014, doi: 10.1002/ese3.35.

- 36 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 [www.nrel.gov/analysis/sustain\\_lca.html](http://www.nrel.gov/analysis/sustain_lca.html), 15 February 2015.
- 37 Assuming solar power offsets fossil fuels, based on state electricity grids as they were in 2013. See methodology and U.S. Environmental Protection Agency, *Greenhouse Gas Equivalencies Calculator*, accessed at [epa.gov/cleanenergy/energy-resources/calculator](http://epa.gov/cleanenergy/energy-resources/calculator), 19 June 2015.
- 38 IKEA Foundation, *IKEA Group and IKEA Foundation Commit a Total of EUR 1 Billion for Climate Action*, 4 June 2015, available at [web.archive.org/web/20150706023444/http://www.ikeafoundation.org/1-billion-for-climate-action](http://web.archive.org/web/20150706023444/http://www.ikeafoundation.org/1-billion-for-climate-action).
- 39 Walmart, *Walmart Marks Fulfillment of Key Global Responsibility Commitments (press release)*, accessed at [news.walmart.com/news-archive/2015/11/17/walmart-marks-fulfillment-of-key-global-responsibility-commitments](http://news.walmart.com/news-archive/2015/11/17/walmart-marks-fulfillment-of-key-global-responsibility-commitments), 17 November 2015.
- 40 Real Goods Solar, *Real Goods Solar Delivers Solar Power Systems to 4 Stop & Shop Stores in NY*,
- 41 P. Denholm, National Renewable Energy Laboratory, *The Technical Potential of Solar Water Heating to Reduce Fossil Fuel Use and Greenhouse Gas Emissions in the United States*, March 2007.
- 42 Ibid.
- 43 U.S. Environmental Protection Agency, *Greenhouse Gas Equivalencies Calculator*, accessed at [epa.gov/cleanenergy/energy-resources/calculator](http://epa.gov/cleanenergy/energy-resources/calculator), 19 June 2015.
- 44 See note 41.
- 45 Tanja Peschel, "New Business Models for Commercial Solar Thermal," *Sun & Wind Energy*, 30 June 2015, available at [web.archive.org/web/20150709230009/http://www.sunwindenergy.com/solar-thermal/new-business-models-commercial-solar-thermal](http://web.archive.org/web/20150709230009/http://www.sunwindenergy.com/solar-thermal/new-business-models-commercial-solar-thermal).
- 46 Richard Perez, University at Albany, State University of New York, Ken Zweibel, George Washington University, and Thomas Hoff, Clean Power Research, *Solar Power Generation in the US: Too Expensive, or a Bargain?*, 2011.
- 47 Michael Panfil, "Resiliency+: Distributed Generation and Microgrids Can Keep Lights on During the Next Storm," *Environmental Defense Fund Energy Exchange*, 22 May 2014.
- 48 Americans for a Clean Energy Grid, *Smart Solar Inverters*, August 2014, available at [cleanenergytransmission.org/wp-content/uploads/2014/08/Smart-Solar-Inverters.pdf](http://cleanenergytransmission.org/wp-content/uploads/2014/08/Smart-Solar-Inverters.pdf).
- 49 Wendy Wilson, Travis Leipzig & Bevan Griffiths-Sattenspiel, River Network, *Burning Our Rivers: The Water Footprint of Electricity*, April 2012.
- 50 John Rogers et al., Union of Concerned Scientists, *Water-Smart Power: Strengthening the U.S. Electricity System in a Warming World*, July 2013.
- 51 Joe Eaton, "Record Heat, Drought Pose Problems for U.S. Electric Power," *National Geographic News*, 17 August 2012.
- 52 Dana Hull, "Drought Threatens California's Hydroelectricity Supply, But Solar Makes Up the Gap," *San Jose Mercury News*, 11 February 2014.
- 53 Alison Kemper and Roger Martin, "Volatile Fossil Fuel Prices Make Renewable Energy More Attractive," *The Guardian*, 21 March 2013.
- 54 George L. Nichols, Vermont Energy Investment Corporation, and Stanley L. Greschner, Grid Alternatives, *Successful Solar Incentive Programs Grow Solar Penetration Within Low-Income Communities #203*, February 2013.
- 55 Ibid.
- 56 U.S. Energy Information Administration, "Table 10. Supply and Disposition of Electricity, 1990 through 2012," accessed at [www.eia.gov/electricity/state/unitedstates/index.cfm](http://www.eia.gov/electricity/state/unitedstates/index.cfm), 19 June 2014. Electricity sales: U.S. Energy Information Administration, *State Electricity Profiles: Data for 2012*, 1 May 2014, accessed at [www.eia.gov/electricity/state](http://www.eia.gov/electricity/state).

57 L. Bird et al, National Renewable Energy Laboratory and Regulatory Assistance Project, *Regulatory Considerations Associated with the Expanded Adoption of Distributed Solar*, 11 November 2013,.

58 U.S. Energy Information Administration, Monthly Energy Review, "Table 7.2a: Electricity Net Generation: Total (All Sectors)," June 2015.

59 United States Environmental Protection Agency, *Clean Energy*, accessed at [web.archive.org/web/20150617201856/http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html](http://web.archive.org/web/20150617201856/http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html), 9 February 2015.

60 U.S. Environmental Protection Agency, *Sulfur Dioxide: Health*, accessed at [www.epa.gov/oaqps001/sulfurdioxide](http://www.epa.gov/oaqps001/sulfurdioxide), 14 June 2013.

61 Fabio Caiazzo et al., "Air Pollution and Early Deaths in the United States. Part I: Quantifying the Impact of Major Sectors in 2005", *Atmospheric Environment*, 79:198-208, 31 May 2013.

62 M. Lippman, "Health Effects of Ozone: A Critical Review," *Journal of the Air Pollution Control Association*, 39: 672-695, 1989; I. Mudway and F. Kelley, "Ozone and the Lung: A Sensitive Issue," *Molecular Aspects of Medicine*, 21: 1-48, 2000; M. Gilmour et al., "Ozone-Enhanced Pulmonary Infection with *Streptococcus Zooepidemicus* in Mice: The Role of Alveolar Macrophage Function and Capsular Virulence Factors," *American Review of Respiratory Disease*, 147: 753-760, March 1993.

63 The Solar Foundation, *National Solar Jobs Census 2015*, January 2016.

64 Ibid.

65 John Rogers and Laura Wisland, Union of Concerned Scientists, *Solar Power on the Rise: The Technologies and Policies Behind a Booming Energy Sector*, August 2014.

66 Average commercial rate in Q3 2005 was 9.09 cents; in Q3 2015 it was 10.95 cents.

67 See methodology.

68 Southern California Edison, *Costco Eases the Power Peak with a Solar Solution*, accessed at [web.archive.org/web/20150625184122/https://www.sce.com/wps/wcm/connect/6d8dfcc7-10cf-4f5b-8cad-b10b6c8d7d20/NR719\\_1007CostcoCSICaseStudy.pdf?MOD=AJPERES](http://web.archive.org/web/20150625184122/https://www.sce.com/wps/wcm/connect/6d8dfcc7-10cf-4f5b-8cad-b10b6c8d7d20/NR719_1007CostcoCSICaseStudy.pdf?MOD=AJPERES), 25 June 2015.

69 J. Neubauer and M. Simpson, NREL, *Deployment of Behind-The-Meter Energy Storage for Demand Charge Reduction*, January 2015.

70 Ibid.

71 Anthony Dominguez et al., "Effects of solar photovoltaic panels on roof heat transfer," *Solar Energy*, doi:10.1016/j.solener.2011.06.010, 2011.

72 See note 3.

73 U.S. Environmental Protection Agency, *Green Power Partnership: Top 30 Retail*, 27 April 2015, available at [web.archive.org/web/20160201200850/http://www3.epa.gov/greenpower/toplists/top30retail.htm](http://web.archive.org/web/20160201200850/http://www3.epa.gov/greenpower/toplists/top30retail.htm).

74 Kohl's, *Kohl's Department Stores Recognized with 2014 EPA Sustained Excellence in Green Power Award (press release)*, available at [businesswire.com/news/home/20141119005140/en/Kohl's-Department-Stores-Recognized-2014-EPA-Sustained](http://businesswire.com/news/home/20141119005140/en/Kohl's-Department-Stores-Recognized-2014-EPA-Sustained), 19 November 2014.

75 Kohl's, *Kohl's Department Stores Activates Its Largest Solar Project at Maryland E-Commerce Distribution Center (press release)*, available at [www.businesswire.com/news/home/20121218005112/en/Kohl%E2%80%99s-Department-Stores-Activates-Largest-Solar-Project](http://www.businesswire.com/news/home/20121218005112/en/Kohl%E2%80%99s-Department-Stores-Activates-Largest-Solar-Project), 19 November 2014.

76 See note 3.

77 Sunpower, *Macy's Goes Solar in 30 Stores*, accessed at [web.archive.org/web/20150705225342/http://us.sunpower.com/commercial-solar/case-studies/macys](http://web.archive.org/web/20150705225342/http://us.sunpower.com/commercial-solar/case-studies/macys), 5 July 2015.

78 Ibid.

79 Ibid.

80 See note 3.

81 “Target Commits to Solar Power at 500 Stores,” *Green Retail Decisions*, archived at [web.archive.org/web/20160201202306/http://www.greenretaildecisions.com/news/2015/02/26/target-commits-to-solar-power-at-500-stores](http://web.archive.org/web/20160201202306/http://www.greenretaildecisions.com/news/2015/02/26/target-commits-to-solar-power-at-500-stores), 26 February 2015.

82 Peyton Boswell and Joe Stofega, “Commercial Rooftop Success: A Little Ballast and a Lot of Business Sense,” *Solar Industry Mag*, January 2015.

83 Herman Trabish, “Bringing Bank Money to Solar,” *Greentech Media*, 24 January 2013.

84 Ibid.

85 U.S. Department of Energy, *Commercial Property Assessed Clean Energy (PACE) Primer*, accessed at [web.archive.org/web/20150706043227/http://www1.eere.energy.gov/wip/pdfs/commercial\\_pace\\_primer\\_revised.pdf](http://web.archive.org/web/20150706043227/http://www1.eere.energy.gov/wip/pdfs/commercial_pace_primer_revised.pdf), 5 July 2015.

86 Jason Coughlin, et al., National Renewable Energy Laboratory, *A Guide to Community Shared Solar: Utility, Private, and Nonprofit Project Development*, May 2012.

87 Mike Munsell, “Here’s How U.S. Commercial Solar Can Bounce Back in 2015,” *Greentech Media*, 1 April 2015, available at [web.archive.org/web/20150706042215/http://www.greentechmedia.com/articles/read/heres-how-u.s.-commercial-solar-can-bounce-back-in-2015](http://web.archive.org/web/20150706042215/http://www.greentechmedia.com/articles/read/heres-how-u.s.-commercial-solar-can-bounce-back-in-2015).

88 Barry Friedman et al., NREL, *Benchmarking Non-Hardware Balance-of-System (Soft) Costs for U.S. Photovoltaic Systems, Using a Bottom-Up Approach and Installer Survey – Second Edition*, October 2013.

89 Sara Rafalson, “Why Option R Is a Big Deal for Southern California’s Commercial Solar Market,” *SolSystems*, 20 March 2015.

90 J. Paidipati, et al., National Renewable Energy Laboratory, *Rooftop Photovoltaic Market Penetration Scenarios*, February 2008.

91 NREL provided power density factors for solar panels at 13.5 percent efficiency, their estimate for 2008, and 18.5 percent efficiency, their projection for 2015. 18.5 percent is closer to solar panel efficiencies today using current technologies: Sunpower, *Facts about Solar Technology from SunPower*, available at [web.archive.org/web/20150721214056/http://us.sunpower.com/solar-panels-technology/facts](http://web.archive.org/web/20150721214056/http://us.sunpower.com/solar-panels-technology/facts).

92 See note 90.

93 Anthony Lopez et al., National Renewable Energy Laboratory, *U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis*, July 2012.

94 More information about NREL’s capacity factor calculation can be found in: Paul Denholm and Robert Margolis, NREL, *Supply Curves for Rooftop Solar PV-Generated Electricity for the United States*, November 2008.

95 U.S. Energy Information Administration, *Electricity Sales, Revenue and Average Price, 2001-2013*, available at [web.archive.org/web/20150701221341/http://www.eia.gov/electricity/sales\\_revenue\\_price](http://web.archive.org/web/20150701221341/http://www.eia.gov/electricity/sales_revenue_price).

96 U.S. Energy Information Administration, *Electricity*, “U. S. electric power industry estimated emissions by state, back to 1990 (EIA-767 and EIA-906)” and “Electricity net generation: electric power sector by state by type of producer by energy source, annual back to 1990 (EIA-906, EIA-920, and EIA-923,” downloaded from [web.archive.org/web/20150514233503/http://www.eia.gov/electricity/data.cfm](http://web.archive.org/web/20150514233503/http://www.eia.gov/electricity/data.cfm), 14 May 2015.

97 Average household energy consumption: See note 21; Walmart uses 28.274 MWh per day (10,320.01 MWh/yr): Sierra Club, *What Is Wal-Mart’s True Environmental Footprint?*, downloaded from [web.archive.org/web/20150706053443/http://vault.sierraclub.org/press-room/media/2011/2011-06-walmart.pdf](http://web.archive.org/web/20150706053443/http://vault.sierraclub.org/press-room/media/2011/2011-06-walmart.pdf), 5 July 2015.

98 See Methodology for calculation of solar potential from retail space; to estimate household power equivalent, capacity was converted to generation using capacity factor extrapolated from NREL source cited in note 93; for average household electricity consumption see note 21. Total retail space was found in or estimated based on the following sources: Walmart: 2015 Annual Report (Walmart U.S. Segment) available at s2.q4cdn.com/056532643/files/doc\_financials/2015/annual/2015-annual-report.pdf; Costco: 2015 Annual Report available at phx.corporate-ir.net/phoenix.zhtml?c=83830&p=irol-reportsannual; Home Depot: 2014 Annual Report available at media.corporate-ir.net/media\_files/IROL/63/63646/2015%20Annual%20Report\_Home%20Depot.pdf; Target: 2014 Annual Report available at corporate.target.com/\_media/TargetCorp/annualreports/2014/pdf/Target-2014-Annual-Report.pdf?ext=.pdf; Lowe's Companies: 2014 Annual Report available at phx.corporate-ir.net/phoenix.zhtml?c=95223&p=irol-reportsannual; Best Buy: 2015 Annual Report available at investors.bestbuy.com/investor-relations/financial-info/annual-reports-and-proxy-statements/default.aspx; Macy's: 2014 Annual Report available at investors.macysinc.com/phoenix.zhtml?c=84477&p=irol-reportsannual; Sears Holdings (Sears and KMart): 2014 Annual Report available at searsholdings.com/docs/investor/SHC\_2014\_Form\_10-K.pdf; TJX (Marshall's and TJMaxx): 2014 Annual Report available at nasdaqomx.mobular.net/nasdaqomx/7/3475/4966/; Kohl's: 2014 Annual Report available at www.kohlscorporation.com/InvestorRelations/sec-filings.htm; BJ's Wholesale Club: 2011 SEC Filing available at www.sec.gov/Archives/edgar/data/1037461/000119312511079572/d10k.htm; Nordstrom: 2014 SEC Filing available at investor.nordstrom.com/phoenix.zhtml?c=93295&p=irol-report-sannual; Gap (Gap, Banana Republic, Old Navy, Piperlime, Athleta, and Intermix): 2014 SEC Filing available at www.sec.gov/Archives/edgar/data/39911/000003991115000101/fy201410-k.htm; J.C. Penney Co.: 2013 SEC Filing available at ir.jcpenney.com/phoenix.zhtml?c=70528&p=irol-reportsAnnual; Bed Bath & Beyond: 2014 Annual Report available at phx.corporate-ir.net/phoenix.zhtml?c=97860&p=irol-reportsannual (proportion of Bed Bath & Beyonds located in the U.S. versus Canada and Mexico was not clear in report

filing, so estimated that 75% of retail space is located in U.S., in line with similar chains); Menard: average store size not publicly available – total retail space estimated assuming average retail space per store is equal to average store size of Lowes and Home Depot, number of Menard locations in the U.S. is available at web.archive.org/web/20160201205354/http://menards.com/main/footer/company-information/about-us/c-3582.htm; Toys "R" Us: 2015 SEC filing available at phx.corporate-ir.net/phoenix.zhtml?c=120622&p=irol-sec; Dick's Sporting Goods: 2013 SEC Filing available at sec.gov/Archives/edgar/data/1089063/000108906314000046/dks-20140201x10k.htm; Staples: 2015 SEC Filing available at investor.staples.com/phoenix.zhtml?c=96244&p=irol-sec; Office Depot: 2014 SEC Filing available at investor.officedepot.com/phoenix.zhtml?c=94746&p=irol-reportsannual; Foot Locker: 2014 Annual Report available at www.footlocker-inc.com/pdf/2015/pr\_2015\_fl\_2014\_Annual\_Report\_Including\_10-K-Final.pdf; Ascena Retail Group (Lane Bryant, maurices, dressbarn, Catherines and justice): 2015 SEC Filing available at www.ascenaretail.com/investors.jsp; Burlington Coat Factory: 2015 SEC Filing available at burlingtoninvestors.com/sec-filings/SEC-Filings-Details/default.aspx?FilingId=10587323; IKEA: total retail space estimated based on average global store size calculated with data available at ikea.com/ms/en\_EG/about-the-ikea-group/company-information, assuming 40 Ikea locations in the U.S. based on nrf.com/2015/top100-table.

99 See note 98 for estimates of retail space and Methodology for calculation details. See note 3 for source of SEIA capacity data.