BRIGHTER FUTURE:
A Study on Solar in U.S. Schools

A Report By THE SOLAR FOUNDATION®
Research and Education to Advance Solar Energy

For Powered by SunShot
U.S. Department of Energy

Schools powering minds.

Solar powering schools.

Data and Analysis Support By
SEIA Solar Energy Industries Association®

Report Authors

The Solar Foundation is the primary author of this report, supported by the Solar Energy Industries Association. This report was prepared for the US Department of Energy's SunShot Solar Outreach Partnership program. More about this program can be found at www.solaroutreach.org

About The Solar Foundation

The Solar Foundation (TSF) is an independent national 501(c)(3) nonprofit whose mission is to increase understanding of solar energy through strategic research that educates the public and transforms markets. TSF is considered by the Congressional Research Office and others as the premier research organization on the solar labor force, employer trends, and economic impacts of solar. TSF is also one of the nation's leading providers of solar educational materials and technical assistance support for local governments through its work with the U.S. Department of Energy's SunShot Solar Outreach Partnership.

Over the last several years, TSF has been involved in a number of solar energy and K-12 schools related efforts. Not only is it the sponsor of the *Brian D. Robertson Memorial Solar Schools Fund* and co-chair of the *National Solar Schools Consortium*, but it is the founder of the *National Solar Schools Census* database, which represents the beginning of an intensive data collection effort to understand the baseline of solar energy on school property and in school curricula in the United States and was the inspiration behind this report. More about TSF's research and education at www.thesolarfoundation.org

About the Solar Energy Industries Association

Celebrating its 40th anniversary in 2014, the Solar Energy Industries Association® is the national trade association of the U.S. solar energy industry. Through advocacy and education, SEIA® is building a strong solar industry to power America. As the voice of the industry, SEIA works with its 1,000 member companies to champion the use of clean, affordable solar in America by expanding markets, removing market barriers, strengthening the industry and educating the public on the benefits of solar energy. Visit SEIA online at www.seia.org.

A 5,750 kW solar project in Plympton, MA, that powers Plymouth Public Schools. (Photo: Greg M. Cooper / Borrego Solar)

Cover photo: A 31 kW system at Rainshadow Charter School in Reno, NV. (Photo: Black Rock Solar)

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[1] This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

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A 150 kW system at Robinson Elementary School in Starksboro, Vermont.
(Photo: AllEarth Renewables / Trent Campbell, Addison Independent)

How Can We Grow This Movement?

This seminal report reflects the efforts of teachers, schools, companies, organizations and individuals serving as the driving force behind the nation's burgeoning solar schools movement. Recognizing that these efforts frequently occur in isolation, a number of stakeholders came together over the last 12 months to create the **National Solar Schools Consortium**, which The Solar Foundation hosts and co-chairs. The purpose of the Consortium is threefold: to coordinate member efforts to promote the use of solar on schools, to aggregate and consolidate current and future solar resource development efforts, and amplify its members' successes by acting as a unified voice for the growing national solar schools movement. We welcome your participation. More information about the Consortium is available online at www.solarschools2020.org or by contacting Andrea Luecke directly at aluecke@solarfound.org.

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Executive Summary

The impressive and precipitous rise of the U.S. solar industry is well documented. As of the writing of this report, total installed solar electric capacity neared 16 gigawatts (GW), providing enough solar electricity to power over 3.2 million average U.S. households. By the end of 2014, this figure is expected to surpass 20 GW- more than four times the total amount of solar capacity that existed in the U.S. just three years ago. Of the more than 500,000 homes, businesses and public entities that have now installed a solar energy system, over 3,700 of those systems are located on public and private K-12 schools in the U.S.

While thousands of schools have already realized the cost savings and other benefits of installed solar energy capacity, this opportunity is generally underutilized. The large, flat rooftops typically found on public and private K-12 school buildings throughout the United States make many of these properties excellent candidates for rooftop solar photovoltaic (PV) or solar thermal systems. School parking lots can be put to productive use with solar PV canopies, which provide the added benefit of shading parked vehicles on sunny days, and tracts of vacant land on campus can be used to support modestly-sized solar PV farms. Taken together, this untapped potential for solar on K-12 schools is immense. If each of the more than 72,000 schools for which solar could represent a cost-effective investment were to install an average-sized system, total PV capacity on K-12 schools would reach 5.4 GW – an amount equal to more than one-third of all the solar PV capacity currently installed in the United States.

Offsetting energy consumption with increasingly cost-competitive solar electricity, and space or water heating can deliver a significant cost savings to schools and their districts. Over time, solar can serve as a key hedge against projected increases in utility rates. As a clean energy technology, solar can provide deep reductions in greenhouse gas and criteria air pollutant emissions, helping to protect human health and the environment. Among its environmental attributes, solar PV on schools can also help to save water, as it uses a mere fraction of the water required to produce electricity by conventional means. Perhaps most importantly, solar installations on schools can provide teachers with a unique opportunity to teach concepts in science, technology, engineering, and mathematics (STEM) and pique student interest in these critical subjects.

With these observations in mind, this report was produced to: (1) help K-12 schools understand the motivations and successes of current solar schools; (2) provide insight into the basic technical and financing aspects of these systems; (3) provide the most comprehensive baseline to date of K-12 schools with solar, providing a means for tracking future solar/school installation progress, and; (4) supply prospective solar school stakeholders with actionable information and lessons learned from previous projects so they can "go solar" with greater confidence.

Key Findings:

- An analysis performed for this report found that 450 individual school districts could each save more than $1,000,000 over 30 years by installing a solar PV system. Of the 125,000 schools in the country, between 40,000 and 72,000 could "go solar" cost-effectively.
- There are 3,752 K-12 schools in the United States with solar installations, meaning nearly 2.7 million students attend schools with solar energy systems.
- The electricity generated in one year by all 3,727 PV systems represents a combined $77.8 million per year in utility bills – an average of almost $21,000 per year per school. This combined energy value is roughly equivalent to 155,000 tablet computers or nearly 2,200 new teachers' salaries per year.[2]

[2] Assuming an average tablet cost of $500 each and the 2011-2012 national average starting teacher salary of $35,672 (www.nea.org/home/2011-2012-average-starting-teacher-salary.html).

Table 1

	Installed K-12 School Solar Photovoltaic Capacity (kW)	
1	California	217,636
2	New Jersey	91,410
3	Arizona	66,288
4	Massachusetts	25,400
5	Nevada	15,215
6	Pennsylvania	10,892
7	Ohio	8,526
8	Connecticut	8,428
9	Maryland	8,349
10	New York	7,316

Table 2

	Number of K-12 School Solar Photovoltaic Installations	
1	California	963
2	New Jersey	379
3	Illinois	268
4	Arizona	226
5	Massachusetts	181
6	Florida	163
7	New York	160
8	Nevada	147
9	Wisconsin	147
10	Utah	98

Table 3

	Percent of Schools that Could Save Money by Going Solar	
1	Hawaii	100.0%
2	California	99.6%
3	Rhode Island	99.6%
4	Delaware	99.1%
5	Arizona	99.1%
6	New Jersey	98.7%
7	Alabama	97.5%
8	Connecticut	95.9%
9	New Hampshire	94.5%
10	Nevada	94.1%

Over thirty years with installed costs at $2.00/watt. See page 25 for more.

Other Findings:

- The 3,727 PV systems at all U.S. schools with solar installations have a combined capacity of 490 megawatts (MW), and generate roughly 642,000 megawatt-hours (MWh) of electricity each year.
- More than 3,000 of the 3,752 systems were installed in the last six years. Between 2008 and 2012, solar installations on U.S. schools experienced a compound annual growth rate of 110 percent.
- Nearly half of the systems currently installed are larger than 50 kilowatts (kW) and 55 schools have systems that are 1 megawatt (MW) or larger. About a quarter of the PV systems at schools are smaller than 5 kW.
- As schools system sizes increase, so too does the incidence of third-party ownership.
- Excluding small demonstration systems, the median system size of K-12 school PV systems was found to be 89 kW (approximately equal to 18 average residential solar PV systems).
- As with the solar industry at large, more schools are going solar as installations cost decrease.
- The likelihood of a school having a solar energy system increases with grade level due to the correlation with school size. A larger proportion of high schools have gone solar compared with elementary or middle schools.
- If the 72,000 schools for which solar could be a cost-effective investment were to deploy systems sized proportionally to their student body size, the combined electricity generation would offset greenhouse gas emissions equivalent to taking approximately 1 million passenger vehicles off the road.

The database underpinning this report was carefully built between March 2013 and July 2014 from hundreds of public and private sources. Additional database entries were found via web searches of new articles, press releases, school websites, or other sources. To complement the quantitative information derived from the database, executive interviews were conducted with representatives from 15 existing solar schools. These interviews added a qualitative perspective to the report's findings, capturing challenges and lessons learned from practitioners with first-hand experience in bringing solar to their schools.

Why Are Schools Going Solar?

Investments in solar energy provide schools with a number of benefits that appeal to a broad set of stakeholders. Facilities managers recognize the value of solar energy in providing a long-term hedge against increases in utility rates while school boards and administrators are attracted to the technology's ability to deliver cost savings. Solar also presents teachers with a number of educational opportunities in science, technology, engineering, and mathematics (STEM) subjects. Finally, the increased use of clean energy technologies like solar can help significantly reduce emissions of pollutants that can harm human health and the environment. This section discusses schools' motivations for going solar in greater detail and provides examples of schools that have successfully unlocked these benefits.

Financial Stability

One of the most frequently cited reasons schools give for going solar is the opportunity to save money. This has been largely driven by the rapid decline in system pricing over the last several years. From 2010 to the second quarter of 2014, average installed costs for commercial solar photovoltaic (PV) systems have fallen by over 50 percent, from \$6.00 to \$2.97 per watt-DC (W_{DC})[3], and it is not uncommon for PV systems to be installed in many markets for less than \$2.00/W_{DC}. In addition to this price drop, systems have become more accessible and affordable for more customers due to the increased availability of financing options, including third-party system ownership, improved availability of debt financing, and other traditional school financing vehicles such as bonds and tax-exempt lease purchases (for more on financing, see "Understand Solar Financing Options" on page 34).

Interviews with facilities managers and school administrators across the country show that solar is providing schools with significant cost savings, which has been used to reduce electricity bills, improve education, and retain existing staff and resources in the face of budget cuts. For example, **Clovis Unified School District**, located just northeast of Fresno, California, funded the installation of 5.9 megawatts (MW) across 19 individual PV systems through a bond measure in 2012. Together, these systems are expected to save the district approximately \$2.7 million each year, freeing up space in the district's general fund that can be used for teacher training, new teaching materials, and facilities maintenance. At **Rio Rancho High School** and **Cleveland High School** in New Mexico, district decision makers evaluated several options for reducing utility costs (the district's second-largest expenditure after personnel), and identified solar as offering the greatest potential for cost savings. The \$200,000 in expected annual energy cost savings was originally earmarked for making improvements to existing building systems (e.g., HVAC systems, boilers, etc.), but unexpected budget cuts made it necessary to put this money toward teacher and staff salaries. In rural Utah, a small 10-kW solar energy system at **Milford High School** is saving this small district approximately \$1,500 per year (see the case study on page 11).

These opportunities are not just in the Southwest – schools across the country have gone solar to save money. A 39.5-kW system at **Drury High School** in North Adams, Massachusetts has saved the school over \$16,500 since it was placed in service in the summer of 2011. While these savings may not appear significant when compared with other examples, they were enough to help the school avoid cuts to programs and teachers in the face of low tax revenues. In the Midwest, **Parkway School District** in St. Louis County, Missouri expects to save \$1 million in avoided energy costs over the next 20 years, reducing the need to reallocate funds from other budget areas (especially those impacting educational quality) to pay utility bills as rates continue to rise over time (see case study below). The **Medford Board of Education** in southern New Jersey saw a similar opportunity for solar. The district's combined 2.7 MW of solar PV systems are saving Medford \$300,000 a year in utility costs, freeing up funds to help further improve the education students receive.

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[3] Photovoltaic (PV) panels produce direct current (DC) electricity that is then converted into the alternating current (AC) electricity used in buildings by an inverter. A watt is a unit of power equal to 1 joule per second. Most PV system sizes are measured in W_{DC} under standard test conditions (STC). 1 megawatt (MW) = 1,000, kilowatts (kW) = 1,000,000 watts (W). On average 1 MW of PV in the United States will produce enough electricity each year to supply 160 typical homes. For more information, please visit www.seia.org/policy/solar-technology/photovoltaic-solar-electric/whats-megawatt

As prices continue to fall toward the Department of Energy's SunShot Initiative goal of $1.25/W for commercial rooftop PV systems by 2020,[4] more schools will be able to leverage solar to their financial benefit. According to an original analysis produced for this report, by the end of 2015, up to 60 percent of all K-12 schools in the U.S. could be able to save money by going solar. More information about this analysis can be found in the "Massive Untapped Potential" section starting on page 25.

Case Study: The Million Dollar Rooftop

Parkway Schools (St. Louis County, MO)

Parkway School District is composed of 28 schools in suburban St. Louis County, Missouri. Funded at no up-front cost to the school through a 20-year lease, the 25 kW solar arrays on each school provide the district with a robust cost-savings opportunity. Parkway School District provides an outstanding example of how solar energy is not only an effective way to cut energy costs for the district, but also provides an invaluable educational opportunity for students. Though the interest in going solar initially came from students in the district, school board members were eager to reap the cost-saving, educational, and environmental benefits of solar energy.

An interview with Eric Lueders, Sustainability Manager for Parkway Schools, revealed that the district expects to save a total of $1 million in energy cost savings over the course of the 20-year lease. The fixed lease rate allows the school district to realize larger savings as utility rates increase over time, which in turn helps avoid the need to pull money from other parts of the budget, like academic programs or teacher salaries, to cover energy costs. Because the system is owned by a third party, the school is not directly responsible for operations and maintenance activities, which can reduce the overall cost of the system.

In partnership with local environmental nonprofits, the Parkway School district has provided teachers with curriculum resources to complement the system, which some teachers have already incorporated into their lesson plans. In addition, students have access to solar system performance data in every classroom. Mr. Lueders' advice to other schools who are considering going solar is to just "do it," as he believes that the financial, educational, and environmental benefits make solar energy something behind which people in the community can rally.

[4] Ardani/ National Renewable Energy Laboratory, K., Seif/ Rocky Mountain Institute, D., Margolis/ National Renewable Energy Laboratory, R., Morris/ Rocky Mountain Institute, J., Davidson/ National Renewable Energy Laboratory, C., Truitt/ National Renewable Energy Laboratory, S., & Torbert/ Rocky Mountain Institute, R. (2013).*Non-Hardware ("Soft") Cost-Reduction Roadmap for Residential and Small Commercial Solar Photovoltaics, 2013-2020* (NREL/TP-7A40-59155). Retrieved from National Renewable Energy Laboratory website: www.nrel.gov/docs/fy13osti/59155.pdf

> *"…the district expects to save a total of $1 million in energy cost savings over the course of the 20-year lease…which in turn helps avoid the need to pull money from other parts of the budget, like academic programs or teacher salaries, to cover energy costs."*
> *Case Study: The Million Dollar Rooftop*

Educational Opportunities

Solar also provides schools with a much-needed means of expanding educational opportunities for STEM subjects. According to the latest results for the Programme for International Student Assessment (PISA 2012), which tests 15-year-old students in 65 countries and economies worldwide (including all 34 member countries of the Organization for Economic Cooperation and Development, or OECD) on proficiency in math, reading, and science, students in the U.S. performed "below average" in math and only close to the OECD average in science.[5] Students in Massachusetts – one of the strongest performing states in the nation – were found to be over two years behind those in Shanghai, the top-performers in the math portion of the assessment. Looking at the math results more closely reveals that U.S. students have "particular weaknesses" in "taking real-world situations, translating them into mathematical terms, and interpreting mathematical aspects in real-world problems."

Solar arrays sited on K-12 schools and designed with education in mind can help students overcome these shortcomings, providing a "real-world situation" for students to sharpen their math and science skills. At **Woodstock Union High School** in central Vermont, Jen Stainton, a science teacher, led the effort to install a 10 kW solar PV array and has helped incorporate the system into science and math lesson plans. Students have access to system performance data in order to understand how much electricity is being produced, the amount of carbon emissions offset by the system, and how much money has been saved. The school has also incorporated a unit into its science classes designed to teach students about the physics of solar energy and how the technology compares with conventional sources of electricity. This unit incorporates lessons on system tilt angles and orientation and how changes in these variables affect system production, providing students with a real-world situation to further develop their math and science skills. **Milford High School** seized a unique educational opportunity that arose from complications with the tracking system installed at the school (see case study below). As part of an effort to overcome this technical issue, students devised and proposed their own engineering solutions. Though none of these solutions were ultimately implemented, this unanticipated problem provided students with a unique and valuable STEM educational experience. Finally, teachers at **Drury High School** plan to build on what students have learned about solar and other clean energy options in the classroom through a summer program in which students will conduct an energy audit of a local homeless shelter and make recommendations to reduce its energy consumption (see the case study on page 13).

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[5] Schleicher/ OECD, A., & Davidson/ OECD, M. (2012). Programme for International Student Assessment (PISA) Results from PISA 2012. Retrieved from www.oecd.org/pisa/keyfindings/PISA-2012-results-US.pdf

Case Study: A Teachable Moment

Milford High School (Beaver County, UT)

Milford High School is a 7th through 12th grade public school in rural Utah with a 20 kW PV system providing 20 percent of the total electricity used on campus. Amid general community and school board disinterest in renewable energy projects, engineering and technology students at the school took it upon themselves to research and apply for available renewable energy grants, eventually securing full funding for the array through the Rocky Mountain Power BlueSky Grant program. Andy Swapp, an engineering and technology teacher, recognized the significant educational value in guiding students through the research and grant application process for his renewable energy class, one of few in Utah.

But another, unexpected educational opportunity arose during installation of the project. The 20 kW system was designed as a 10 kW fixed-mount array and a 10 kW tracker array in order to give students the opportunity to understand the impacts of each on system production. In contrast with the "tried and true" tracking systems currently commercially available, this tracking system was a previously untested technology from an inexperienced, non-solar specific vendor that eventually became inoperable. In searching for a resolution to the issue, students developed their own engineering solutions and shared them with the professional engineers tasked with fixing the system, who encouraged the students and gave insightful feedback. To further tap the educational value of the system, Mr. Swapp made the array and its technical components as visible as possible. Both inverters – equipment installed along with solar panels to convert electricity from direct current (dc) to alternating current (ac) for use in homes and across the electricity grid – are mounted in his classroom so he can give students hands-on lessons about solar energy production.

Though educational opportunities were the primary motivator for Milford High School to invest in this particular solar project, other renewable energy projects in the community have provided the school district with substantial financial benefits. For example, taxes collected from commercial-scale geothermal, wind, hydroelectric, biomass, and solar projects in the area provide the school district with more than $2 million in new tax revenues each year. More information on these other projects and the key role students played in their development can be found at: www.youtube.com/watch?v=nf8YcQDedJk

> *"In searching for a resolution to the issue, students developed their own engineering solutions and shared them with the professional engineers tasked with fixing the system..."*
> *Case Study: A Teachable Moment*

While solar energy has proven cross-cutting educational value that merits much more than a brief mention, there is limited discussion on the technology in the Common Core State Standards[6] or the Next Generation Science Standards[7] – the most widely referenced and adopted state standards. This limited acknowledgement forces educators to determine for themselves how and when to incorporate solar into their classrooms, as well as how to measure progress against a non-existent standard/benchmark. Additionally, any significant *inclusions* are likely to require *exclusions* – potentially creating controversy. However, for the motivated solar educator, there are many free, high-quality resources to choose from (see Appendix A for a list of resources).

Did You Know?

450 individual school districts could each save more than $1,000,000 over 30 years by installing a solar PV system.

Some teachers have chosen to supplement their lesson plans with energy science education kits and system monitoring software. As part of the agreement with their solar PV installer, **Jurupa Unified School District** (CA) received a number of high-quality science kits containing PV system components, meters to measure system output, interconnection devices, and water pumps to provide students with a hands-on learning experience and use solar energy as a means of teaching key science and math topics. Still other schools arranged for installation contractors to provide solar monitoring software that students can use to learn about system production and the factors affecting performance, as well as the environmental and economic benefits of solar. Though the capabilities of these monitoring programs can vary widely, all of them provide important basic system information. Examples of monitoring platforms can be found at **Drury High School**,[8] **Carlisle High School** (PA),[9] and **Rapoport Academy** (TX).[10]

Environmental Protection

In addition to economic and educational benefits, using solar energy conserves natural resources and significantly reduces emissions of pollutants that threaten human health and the environment. A 89 kW solar PV system (the median system size from The Solar Foundation's *National Solar Schools Census Database*) that receives an average of 5.0 kWh/m^2/day of solar radiation will produce approximately 117,000 kWh of electricity in its first year of operation. This translates into more than 80 tons of annual avoided carbon dioxide (CO_2) emissions, the equivalent of avoiding more than 9,000 gallons of gasoline and of the amount of carbon sequestered by 66 acres of U.S. forests.[11]

This amount of solar electricity will also reduce nitrogen oxide (NOx) emissions – which contribute to ground-level ozone formation and can adversely affect the human respiratory system – by 11 pounds annually. Beyond these avoided air pollution benefits, solar PV systems also use much less water per unit of electricity generated compared with conventional energy sources. Offsetting this amount of electricity

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[6] Science Net Links. (2010). STEM and the Common Core - Science NetLinks. Retrieved from http://sciencenetlinks.com/collections/stem-and-common-core/

[7] Next Generation Science Standards. (2014). 4.Energy | Next Generation Science Standards. Retrieved September 3, 2014, from www.nextgenscience.org/4e-energy

[8] Solren View. (2011, June 16). SolrenView™ - Drury High School. Retrieved September 3, 2014, from www.solrenview.com/cgi-bin/cgihandler.cgi?&sort=pvi_IDs&cond=site_ID=949

[9] Carlisle High School. (2010, October 13). Carlisle: Solar. Retrieved September 3, 2014, from http://live.deckmonitoring.com/?id=carlisle

[10] Enphase Energy. (2011, October 8). Commercial System. Retrieved September 3, 2014, from https://enlighten.enphaseenergy.com/pv/public_systems/2Snv34553

[11] All avoided emissions or natural resource use are based on estimates for combined cycle natural gas turbines. CO2 emissions: www.eia.gov/tools/faqs/faq.cfm?id=74&t=11; NOx emissions: www.netl.doe.gov/KMD/cds/disk50/NGCC percent20Plant percent20Case_FClass_051607.pdf; Water use: http://iopscience.iop.org/1748-9326/7/4/045802/pdf/1748-9326_7_4_045802.pdf. Greenhouse gas equivalencies are based on estimates provided by the U.S. EPA Greenhouse Gas Equivalencies Calculator: www.epa.gov/cleanenergy/energy-resources/calculator.html

with solar PV results in an annual savings of nearly 24,000 gallons of water over the same amount of production from a natural gas combined-cycle plant.

Case Study:
Engineering a (Clean, Renewable) Future

Drury High School (Berkshire County, MA)

Drury High School in North Adams, Massachusetts has a total of 41 kW of solar PV capacity, split between two 13 kW arrays and a 15 kW array. According to Keith Davis, the technology education teacher for the school, the City of North Adams secured full funding for the system, approximately $400,000, through a combination of federal and state grants.

During the school year, the solar energy systems power about 28 classrooms, with the arrays exporting excess electricity to the grid in the summer or other times that the classrooms are not in use. In the two years since the system began operation in June 2012, Drury High School has offset nearly 140,000 pounds of carbon dioxide emissions and produced more than 110,000 kWh of solar electricity.

A strong believer in clean energy, Mr. Davis indicated that the environmental benefits drove the decision to go solar. Mr. Davis helps to generate student interest in clean energy by incorporating solar into pre-engineering curriculum and through a course called "Engineering the Future," which includes a large unit on energy and features field trips to the roof where students learn firsthand how the system works.

With a declining population and a higher poverty rate than the county and the state, North Adams has a comparatively small local tax base to tap and a correspondingly small budget.[12] In the face of reduced state funding for schools, the cost savings from the solar energy system have allowed Drury High School to preserve its current teaching staff and academic programs. To spread the cost savings and environmental benefits of clean energy to the broader community, Mr. Davis and a team of student volunteers have created a special summer program focused on conducting an energy audit of a local homeless shelter and using what they have learned to make actionable recommendations for reducing its energy consumption and costs.

[12] North Adams - MA. (2012). *North Adams Comprehensive Plan*. Retrieved from http://northadams-ma.gov/UserFiles/Image/NACP_Existing_Conditions_03212012.pdf

> *"In the face of reduced state funding for schools, the cost savings from the solar energy system have allowed Drury High School to preserve its current teaching staff and academic programs."*
> *Case Study: Engineering a (Clean, Renewable) Future*

Resiliency and Emergency Response

An emerging trend in the use of solar energy at K-12 schools is to provide power during times of emergency or when electricity from the grid is otherwise unavailable. One notable example is the Florida Solar Energy Center's "Sun Smart E-Shelter" program, a partnership with multiple state agencies, emergency managers, utilities and 42 school districts to install 100 emergency center systems across the state. At 10 kW each, these systems provide 1 MW worth of solar capacity combined with battery backup. Under normal conditions, these systems provide electricity directly to the schools at which they are sited. When the grid goes down, the batteries attached to these systems provide a basic level of power service to the centers.[13]

Solar energy in an emergency response context took the spotlight during Superstorm Sandy in late 2012. **Midtown Community School** serves the community of Bayonne, New Jersey not only as a combined elementary and middle school, but also as a community emergency evacuation center. With these dual roles in mind, the school facilities manager looked to solar not only to offset utility bills through its daily operation, but also to provide a source of backup power in the event of a loss of power from the grid. Rather than connecting the solar array to a bank of batteries to store energy until it is needed, the Midtown system was specially designed to work in tandem with the school's diesel generator. When the grid goes down, the solar energy system automatically begins providing power to the school's emergency systems, reducing the workload of the diesel generator and helping stretch the available supply of fuel which can be in short supply during emergencies.[14]

A 6 kW system at Doolen Middle School in Tucson, AZ. (Photo: Technicians for Sustainability)

[13] Florida Solar Energy Center. (2014, May 24). *Solar Panel Systems Installed on 100 Emergency Shelter Schools In Florida (VIDEO) | CleanTechnica* [Video file]. Retrieved from http://cleantechnica.com/2014/05/24/solar-panel-systems-installed-100-emergency-shelter-schools-florida-video/

[14] Lacey, S. (n.d.). Amidst a Surge in Extreme Weather, Distributed Energy Takes On New Meaning for the US Grid : Greentech Media. Retrieved from www.greentechmedia.com/articles/featured/after-superstorm-sandy-states-look-to-distributed-energy-and-microgrids; Hunterdon County Democrat. (2012, November 6). Bayonne school stays in power after Sandy: thanks to a solar system from Flemington company | NJ.com. Retrieved from www.nj.com/hunterdon-county-democrat/index.ssf/2012/11/bayonne_school_stays_in_power.html

The First K-12 Solar Schools Baseline

As part of the research for this report, The Solar Foundation (TSF) and the Solar Energy Industries Association (SEIA) completed the most comprehensive census of K-12 school solar installations to date. The Solar Foundation's *National Solar Schools Census* identified 3,752 schools equipped with solar energy systems.[15] Of those, more than 3,000 were installed in the last six years. The 3,752 schools with solar represent 3 percent of public and private K-12 schools and 5 percent of K-12 students in the U.S. While this is encouraging, the potential is immense and the future is bright, with 40,000-72,000 schools likely able to benefit from the installation of a solar energy system in the next few years.

Did You Know?

There are 3,752 K-12 schools in the United States with solar installations, meaning nearly 2.7 million students attend schools with solar energy systems.

The sections that follow describe the findings of the *National Solar Schools Census*. The first section provides a quantitative summary of the use of solar energy systems already deployed at K-12 schools in the U.S. The second section describes the near-term potential for additional solar deployment at schools that have not yet gone solar. Unless stated otherwise, all data below refer to K-12 schools located in the United States.

Existing Solar Energy Systems at K-12 Schools

Over the course of a year, TSF and SEIA spent hundreds of hours collecting data on existing solar energy systems located at K-12 schools in the U.S. This data was compiled from public databases, news reports, solar developers, and direct outreach to school districts. This data was lined up with data from the U.S. Department of Education's National Center for Education Statistics[16] to allow analysis of how solar schools compare with each other and with non-solar schools based on key school metrics. Combined, this data constitute The Solar Foundation's *National Solar Schools Census*.[17]

Overview

The *National Solar Schools Census* identified 3,752 solar energy systems on K-12 schools across the nation. Of those, 3,727 were PV systems that turn sunlight into electricity. The remainder were solar heating and cooling (SHC) systems that turn sunlight into heat that is typically used to heat water or air. Nearly 2.7 million students attend schools with solar energy systems. **See Table 4 below**.

Table 4: Solar and Non-Solar K-12 Schools in the U.S.

	Number of Schools	Number of Students
Schools with Solar Installations	3,752	2,687,539
Schools without Solar Installations	121,797	51,033,544
Total	**125,549**	**53,721,083**

[15] The *National Solar Schools Census* database and interactive map can be accessed at www.schools.tsfcensus.org.
[16] Data from Common Core of Data and Private School Survey for the 2011-2012 school year. http://nces.ed.gov/datatools/index.asp?DataToolSectionID=4
[17] See page 32 for a more thorough description of our research methodology

The 3,727 PV systems have a combined capacity of 489,791 kW and likely generate more than 642,000 MWh[18] of electricity each year. To put this in context, the average American household uses 10.7 MWh of electricity each year.[19] Generation from these PV systems likely offsets the purchase of roughly $77.8 million worth of electricity each year.[20] **See Table 5** for a breakdown of the number of PV systems, capacity, estimated generation and estimated value of generation by state.

Table 5: Schools with Solar Energy Systems by State[21] *(continued on next page)*

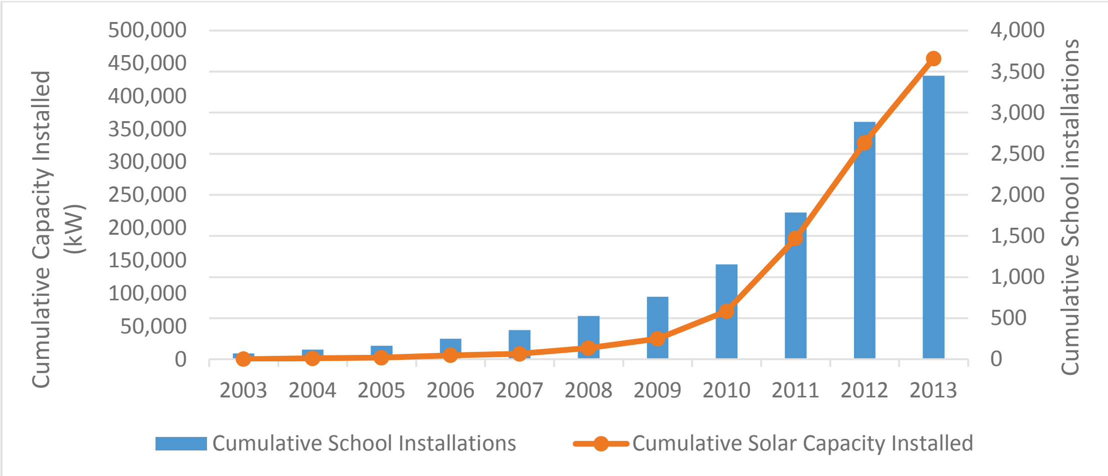
State	Rank by State School Solar Capacity	Schools with Photovoltaic (PV) Systems	PV Capacity (kW)	Generation from Existing PV (kWh/year)	Value of Generation from Existing PV ($/year)
Alabama	45	1	3	3,962	$396
Alaska	43	2	6	4,247	$595
Arizona	3	226	66,288	98,386,571	$9,259,990
Arkansas	44	1	4	4,589	$275
California	1	963	217,636	307,563,190	$40,497,496
Colorado	11	84	5,239	6,792,773	$610,258
Connecticut	8	95	8,428	9,081,323	$1,251,466
Delaware	26	9	646	734,681	$79,734
Florida	16	163	1,578	1,977,418	$179,378
Georgia	21	34	1,048	1,301,022	$104,528
Hawaii	20	30	1,256	1,713,796	$582,691
Idaho	28	23	559	673,859	$46,565
Illinois	22	268	1,037	1,136,911	$101,057
Indiana	39	12	76	86,374	$8,301
Iowa	41	3	52	51,371	$3,117
Kansas	46	3	3	3,817	$320
Kentucky	24	3	777	823,050	$69,321
Louisiana	34	6	265	325,385	$25,725
Maine	36	20	125	129,122	$12,169
Maryland	9	35	8,349	9,485,605	$1,015,168
Massachusetts	4	181	25,400	27,927,014	$3,251,771
Michigan	30	31	357	375,952	$39,863
Minnesota	27	21	607	669,419	$53,800
Mississippi	47	1	3	3,470	$243
Missouri	15	71	1,759	2,048,618	$151,739
Montana	37	34	119	135,395	$10,414
Nebraska	51	0	0	0	$0

[18] Based on production for a reference system tilted at 10 degrees facing south located at the nearest TMY3 site modeled using the System Advisor Model using TMY3 weather data.
[19] Based on data from Energy Information Administration form 861 (EIA-861) data for 2012
[20] Assumes schools are on largely volumetric electricity rate structures. Based on nearest utility average revenue per kWh for commercial customers in 2012 as reported in EIA-861.
[21] The Solar Foundation recognizes that this is not an exhaustive list and hopes to update it on a regular basis. Please contact us to ensure your solar school is counted. schools.tsfcensus.org

Nevada	5	147	15,215	21,906,147	$1,946,444
New Hampshire	32	13	289	303,970	$42,852
New Jersey	2	379	91,410	102,124,312	$13,581,856
New Mexico	12	21	3,353	5,053,851	$511,337
New York	10	160	7,316	7,708,802	$921,342
North Carolina	19	16	1,275	1,497,418	$117,669
North Dakota	51	0	0	0	$0
Ohio	7	40	8,526	9,068,428	$1,035,053
Oklahoma	48	1	2	3,019	$181
Oregon	18	41	1,341	1,309,642	$101,020
Pennsylvania	6	41	10,892	11,748,122	$1,285,416
Rhode Island	35	19	155	167,543	$20,105
South Carolina	40	27	60	74,020	$6,331
South Dakota	51	0	0	0	$0
Tennessee	13	43	2,275	2,645,770	$248,490
Texas	14	95	1,893	2,455,334	$201,286
Utah	25	98	656	862,458	$90,997
Vermont	23	31	924	966,074	$117,503
Virginia	31	13	321	356,472	$28,518
Washington	33	57	280	263,439	$19,411
Washington DC	29	10	432	480,946	$57,714
West Virginia	42	5	16	15,658	$1,289
Wisconsin	17	147	1,465	1,608,442	$173,759
Wyoming	38	3	76	96,876	$7,788
Grand Total		**3,727**	**489,791**	**642,155,676**	**$77,872,740**

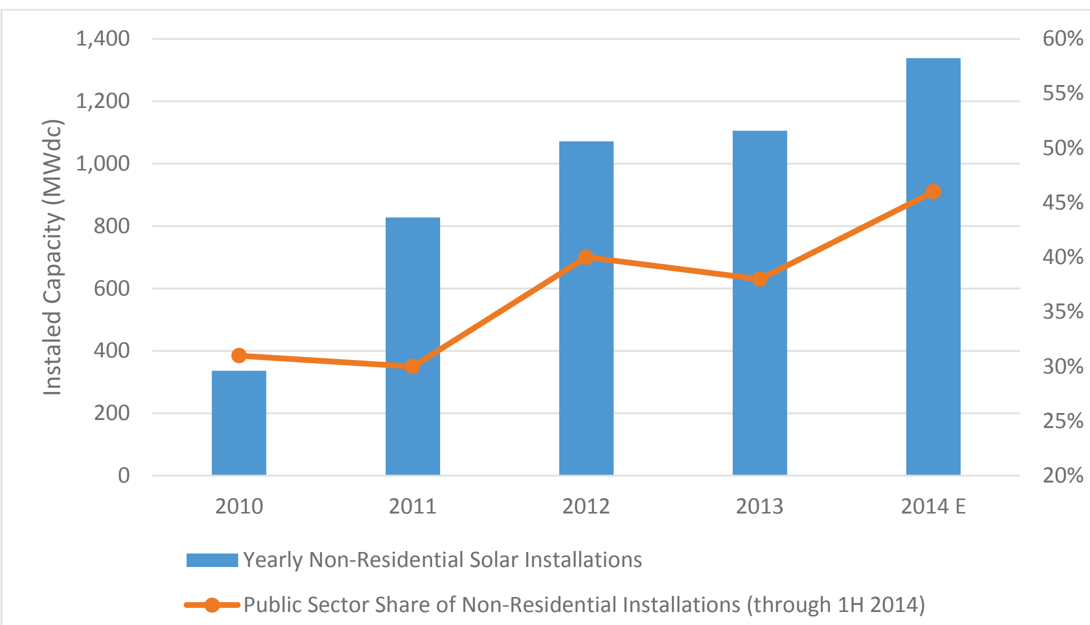
Solar adoption by K-12 schools has increased rapidly over the last several years. **Figure 1** shows that at the end of 2003, there were 303 kW of solar capacity on K-12 schools. By the end of 2013, that number had increased by a factor of 1,000 to over 457,000 kW. Much of this growth has occurred in recent years, with yearly solar installations on U.S. schools achieving a compound annual growth rate of 110 percent between 2008 and 2012. Yearly school solar installations reached their peak in 2012, when the short-term availability of some grant programs and state and utility incentives led to a spike in installations. Still, 2013 was the second-largest year for school installations, as 562 installations with a combined capacity of over 128 MW came online across the country.

Figure 1: Cumulative School Solar Installations, 2003-2013



The robust growth of school solar installations tracks closely with the growth of the broader U.S. solar industry, which is expected to be three times as large this year as it was just three years ago. Moreover, according to SEIA and GTM Research, the public sector (school and government) share of non-residential installations has increased from 31 percent in 2010 to 46 percent through the first half of 2014.[22] **Figure 2** below shows the growth of non-residential solar installations, along with the increasing public sector share of those installations.

Figure 2: Public Sector Share of Non-Residential Solar PV Installations, 2010-2014E



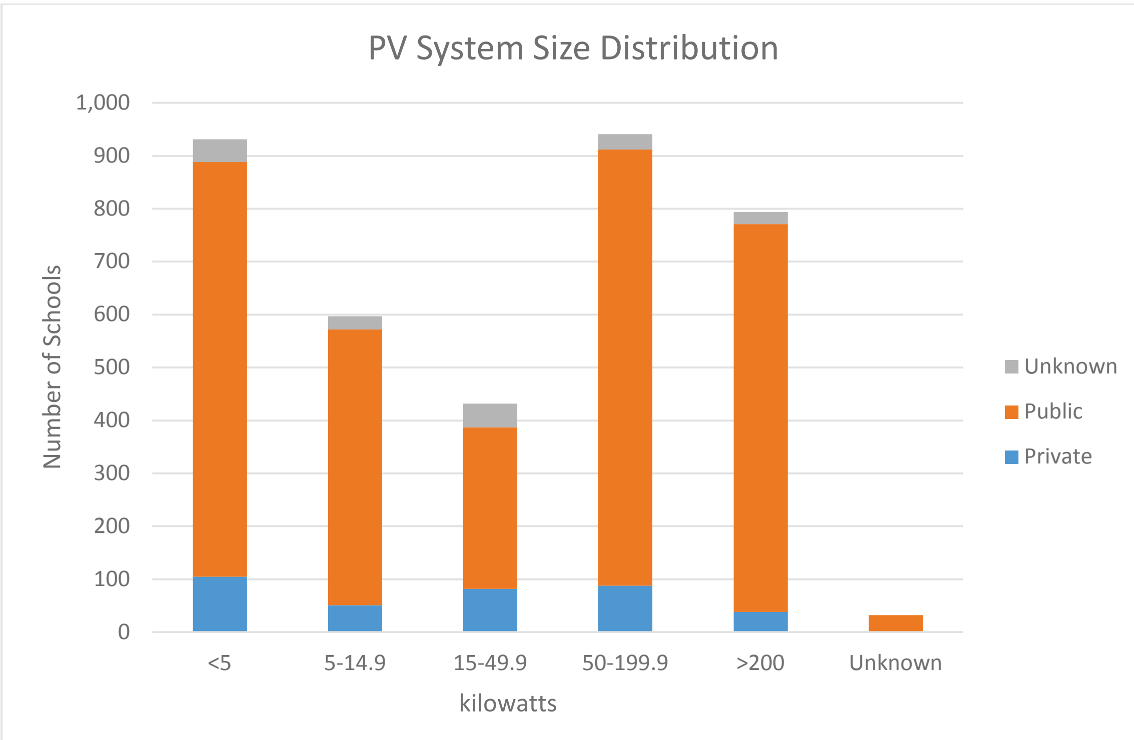
About a quarter of the PV systems at schools are smaller than 5 kW (the average residential PV system size) and likely used as demonstration and education systems. However, solar energy systems benefit from

[22] SEIA/GTM Research U.S. *Solar Market Insight: Q2 2014*. Available at www.seia.org/research-resources/us-solar-market-insight

economies of scale. Many of the costs of developing a solar system are fixed, so adding additional capacity spreads the fixed costs over a larger total capacity, lowering the average cost of capacity for the overall system.

As **Figure 3** illustrates, the *National Solar Schools Census* found that schools are taking advantage of those economies of scale, as nearly half of the systems are larger than 50 kW and 55 schools have systems 1 MW or larger. The largest system is the 6.1-MW system at the Lawrenceville School in Lawrenceville, New Jersey.

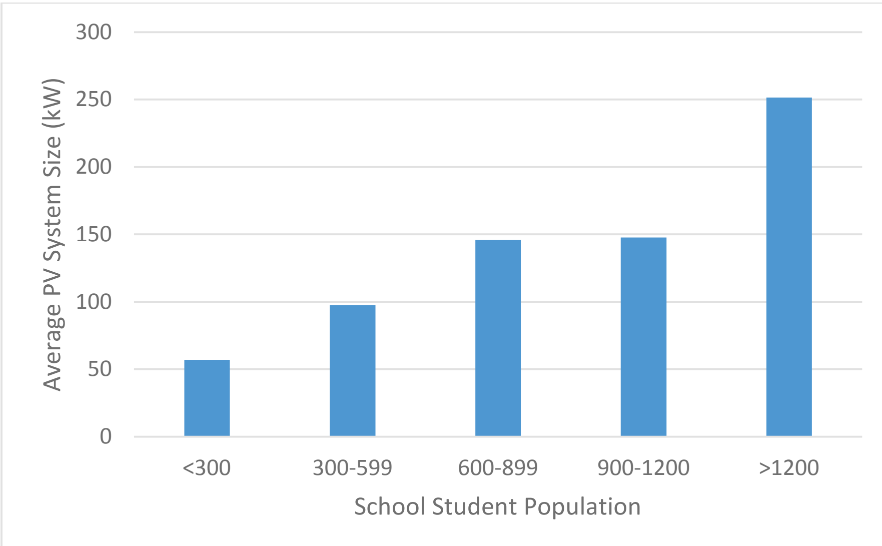
Figure 3: School PV System Size Distribution



A 416 kW system at Analy High School in Sebastopol, CA. (Photo: SunPower)

Schools come in many different sizes from fewer than a dozen students to more than 8,000 students. **Figure 4** shows how school size influences PV system sizing decisions. As school size increases, so does school energy use, resulting in demand for larger PV systems. With the price to install solar PV continuing to decrease, schools will be more likely and able to purchase systems that meet larger portions of their total energy needs, resulting in even greater reinforcement of the data presented in **Figure 4**.

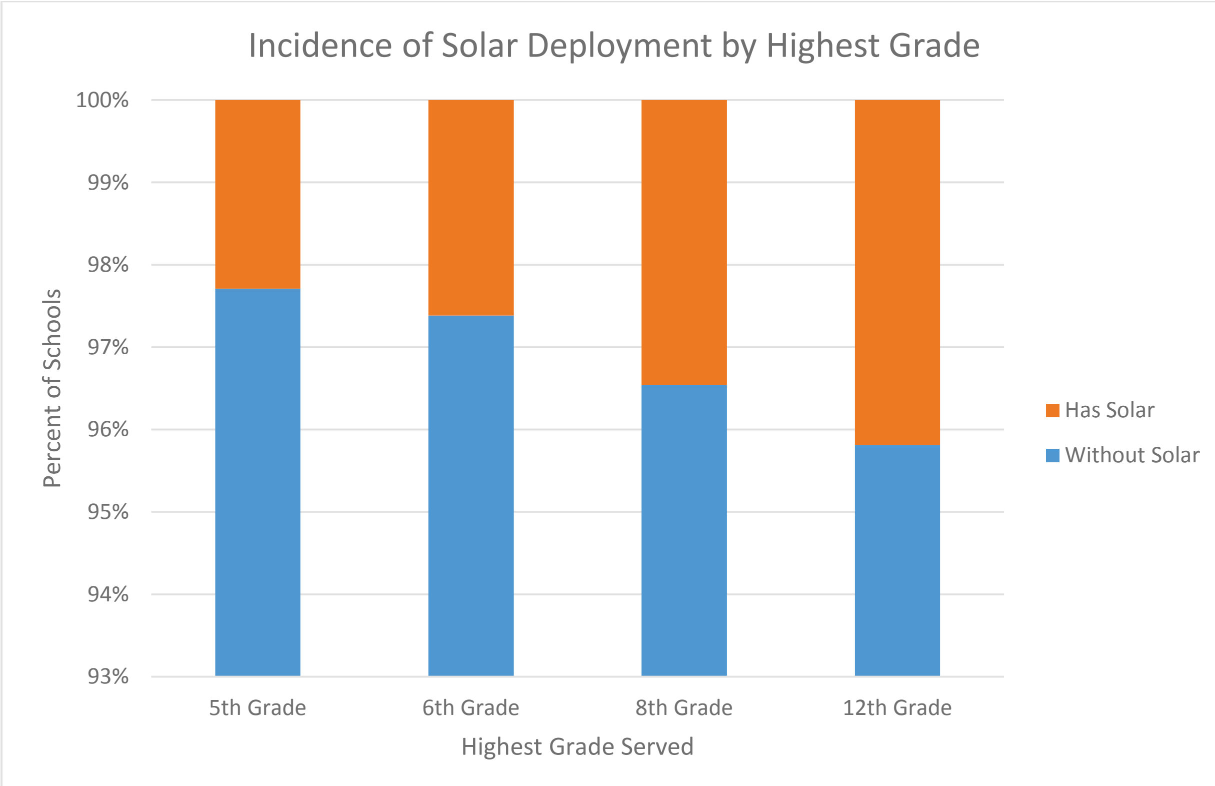
Figure 4: Average PV System Size by School Population



Consistent with the economies of scale, the database shows the likelihood of a school having a solar energy system increases with grade level due to the correlation with school size. As shown in **Figure 5**, more than 4 percent of high schools have solar energy systems whereas less than 3 percent of elementary schools have solar energy systems. In other words, a larger proportion of high schools (which have a higher average number of students and thus larger school sizes) have gone solar compared with elementary or middle schools.

A 135 kW system at Pyramid Lake Paiute Tribe High School in Nixon, NV. (Photo: Black Rock Solar)

Figure 5: Solar Deployment by Grade Level



Trends in Financing Solar Energy at Schools

The cost of PV systems has dropped dramatically in recent years, and those reduced costs are starting to show up in reported school PV system pricing data. While the National Solar Schools Census pricing data is incomplete, largely due to the infrequency with which developers and owners release pricing data, **Table 6** shows a clear trend toward lower system pricing. The values in each cell show the number of systems in the database with installed costs at a particular price point in a given year. These cells have been shaded according to the number of schools displayed in the cell, with darker shades indicating a larger number of schools. Over time, the darker shaded cells move lower down the table, indicating more schools are going solar at a lower installed cost. Looking outside the schools data set, it is increasingly common to see non-residential PV Systems installed for less than\$2.50/W_{DC} and even less than \$2.00/W_{DC}.[23]

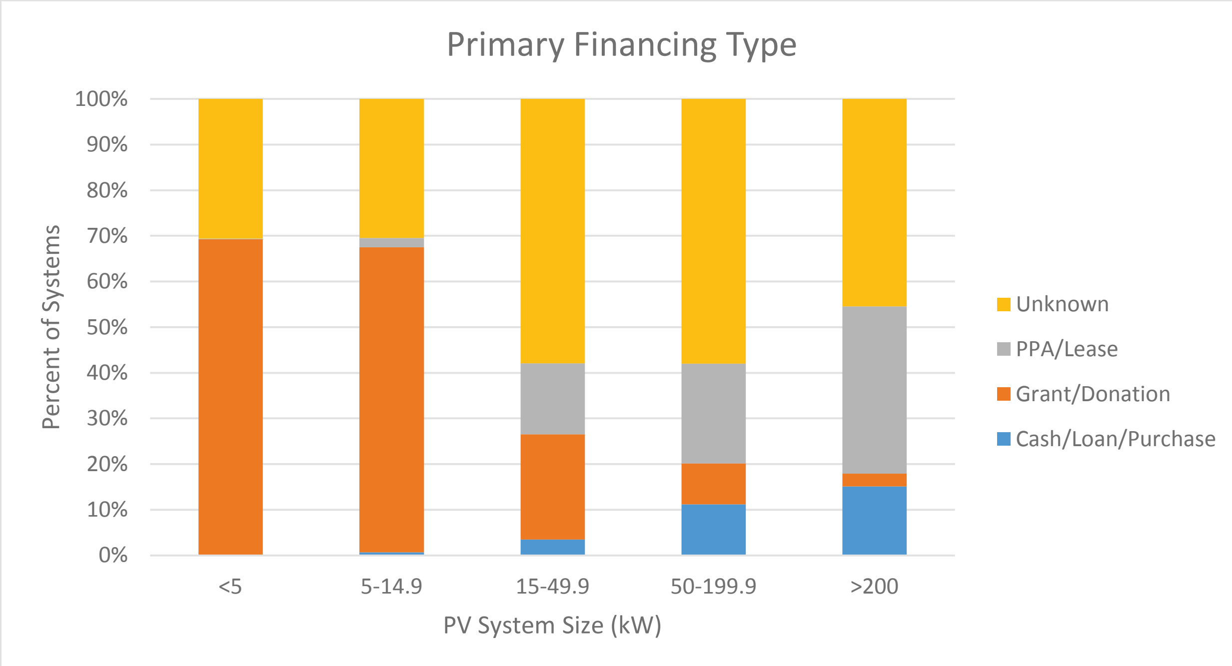
[23] SEIA/GTM Research U.S. *Solar Market Insight: Q2 2014*. Available at www.seia.org/research-resources/us-solar-market-insight

Table 6: School PV System Price Distribution by Year

Costs less than $/watt	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
$10.00					1		2		1			4
$9.50					1	3	2		1			7
$9.00		1		2	1	1	7	2	1			15
$8.50	2		2	1	3		3	3				14
$8.00			1	1	1	1	7	2	2	1		16
$7.50			2			3	7	3	8	1		24
$7.00		3	5				4	6	8	25		51
$6.50			4		1	4	13	8	13			43
$6.00			1	3	4	2	11	18	18			57
$5.50						2	7	24	18	6		57
$5.00							6	28	34	6	1	75
$4.50								9	13	28	1	51
$4.00						1	2	4	10	16	1	34
$3.50								5	9	11	2	27
$3.00							1		1			2
$2.50								1	1	1	1	4
$2.00							1	1				2
$1.50									3			3
$1.00										2		2
Total	2	4	15	7	12	17	73	114	141	97	6	488

While data on financing is incomplete, there does appear to be a trend of increasing reliance on third-party ownership (TPO) financing as system sizes increase. This relationship, demonstrated in **Figure 6**, is largely a function of funding availability and minimum efficient project size for certain deals.

Figure 6: How Solar Has Been Financed at K-12 Schools



Several programs (including the Brian D. Robertson Memorial Solar Schools Fund) seek contributions and equipment donations in order to install PV systems on K-12 schools for demonstration and education purposes. Naturally, due to funding limitations, those systems tend to be smaller. As systems become larger (or are rolled into other capital improvement projects) other financing options become more attractive. **Figures 7 and 8** reflect this trend. While earlier systems were primarily for demonstration and educational purposes (as indicated by the relatively larger proportion of systems that were less than 5 kW until recent years), decreases in the average installed cost of solar have resulted in larger systems that not only provide educational value for students, but also significant cost savings for school districts.

Figure 7: School PV System Size Distribution by Number of Systems

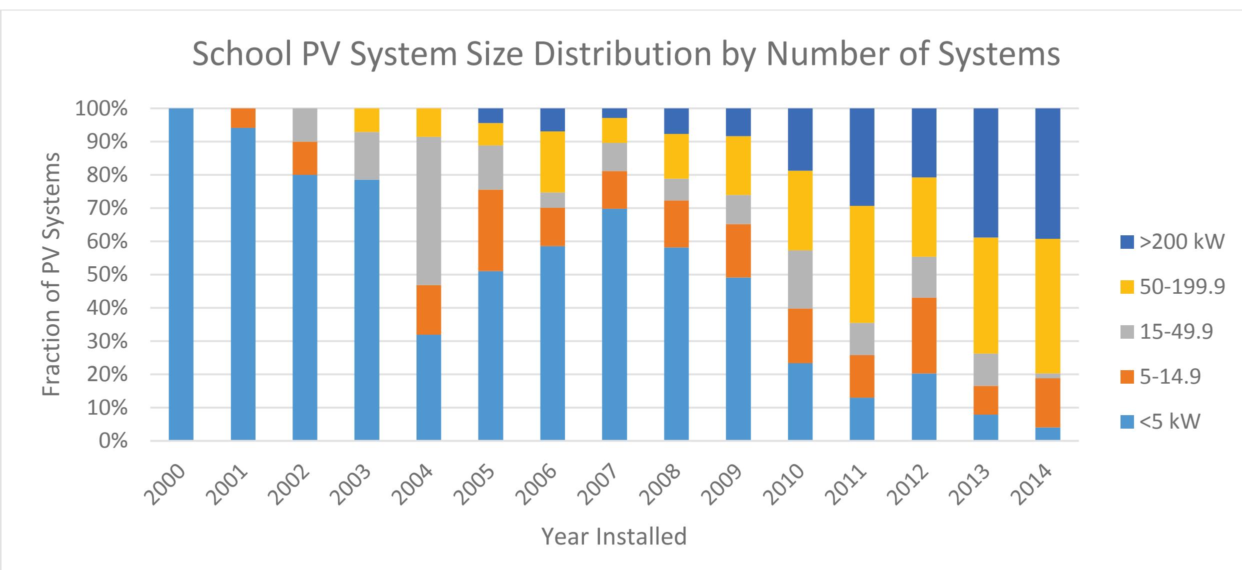
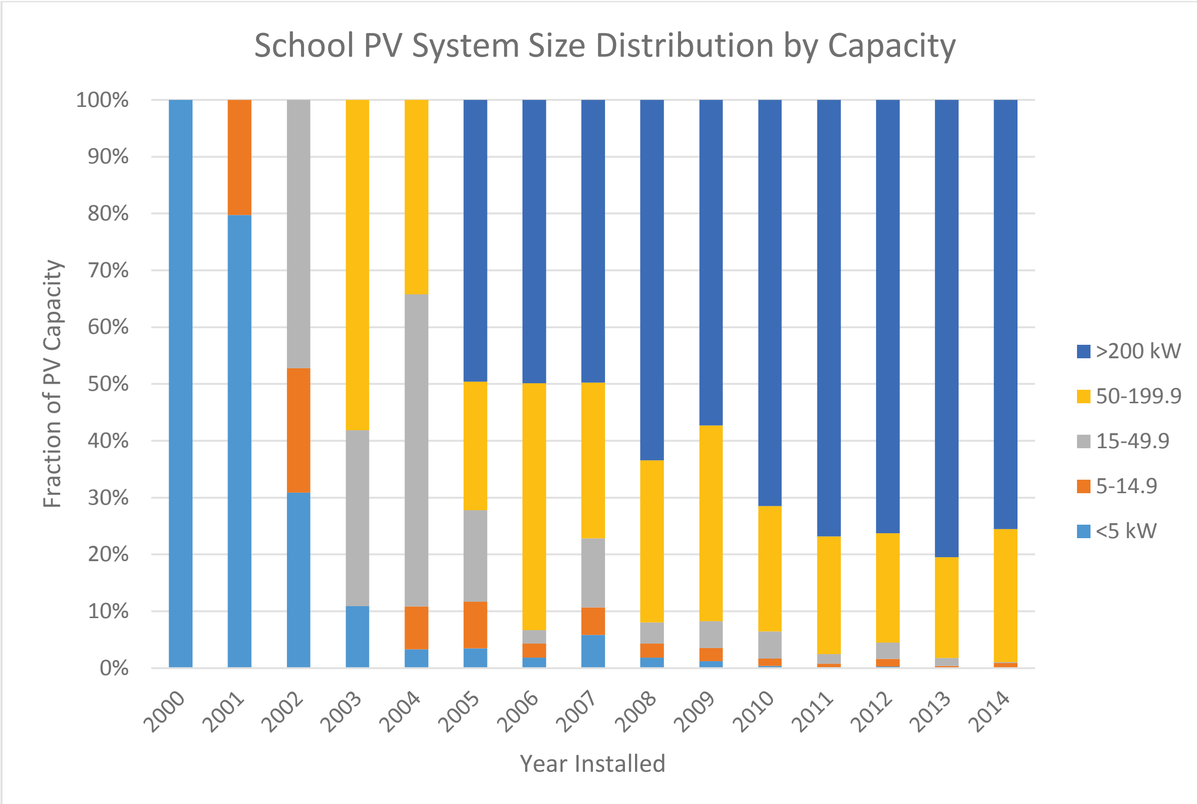


Figure 8: School PV System Size Distribution by Capacity



A 26 kW grid tied photovoltaic array for Good Will-Hinckley school in Hinckley, Maine, installed through a power purchase agreement. (Photo: ReVision Energy)

Massive Untapped Potential

While thousands of schools have already deployed solar, massive untapped potential remains. To analyze the potential for further solar deployment at K-12 schools, SEIA and TSF used the K-12 schools tracked in the National Center for Education Statistics databases. Each school was matched with the closest TMY3 weather station, which collects multi-year data to provide a range and average of the Typical Meteorological Year,[24] and with a proxy for avoided cost of retail electricity purchases.[25] System performance (energy yield and financial performance) was estimated using the System Advisor Model.[26]

For each school in the country, the potential for solar to deliver savings on electricity bills was evaluated. For the purposes of this analysis, any school with a positive net present value over 30 years for an investment in a solar PV system installed for $2.50/watt and $2.00/watt "had potential" as a future solar installation site. The potential size of a PV system at each school (and the additional potential at schools with small systems) was estimated by multiplying the number of students at each school by 172 watts (the median solar capacity-per-student figure found amongst non-demonstration systems in the *National Solar Schools Census*).

Findings

Of the 125,000 schools in the country, between 40,000 (at $2.50/watt) and 72,000 (at $2.00/watt) could be good candidates for saving money by deploying solar energy systems. If all 72,000 of these schools were to deploy median-sized systems adjusted for student body size, total PV capacity on K-12 schools would equal 5,400 MW –more than one-third of the solar PV capacity currently installed in the United States. Combined, these systems would produce 6.9 million MWh of electricity each year, with a total energy value of nearly $800 million. The net present value (NPV) of those systems – the difference between project costs and benefits, adjusted to reflect inflation – analyzed over a 30-year period would be $2.8 billion. Moreover, in 25 states, at least 80% of the schools in each state have a positive 30-year NPV and could save money by installing a solar PV system. This information is presented in **Figure 9**: Potential School Solar Candidates and Savings per Student.

View all schools with a positive NPV on an interactive map at schools.tsfcensus.org.

Modeling Assumptions

Simulated using the PV Watts model

Weather: TMY3
Tilt: 10 degrees
Azimuth: 180 degrees (south)
Net Installed Cost: $2.00/$W_{dc}$ and $2.50/$W_{dc}$
O&M Costs: $15/kW/year
Financing: 20-year financing consistent with some TPO options and tax-exempt lease purchase financing.
Volumetric electricity tariff inflation: 2.5 percent/year
Inflation Rate: 2.5 percent/year
Real Discount Rate: 8 percent/year
Nominal Discount Rate: 10.7 percent/year
Analysis Period: 30 years

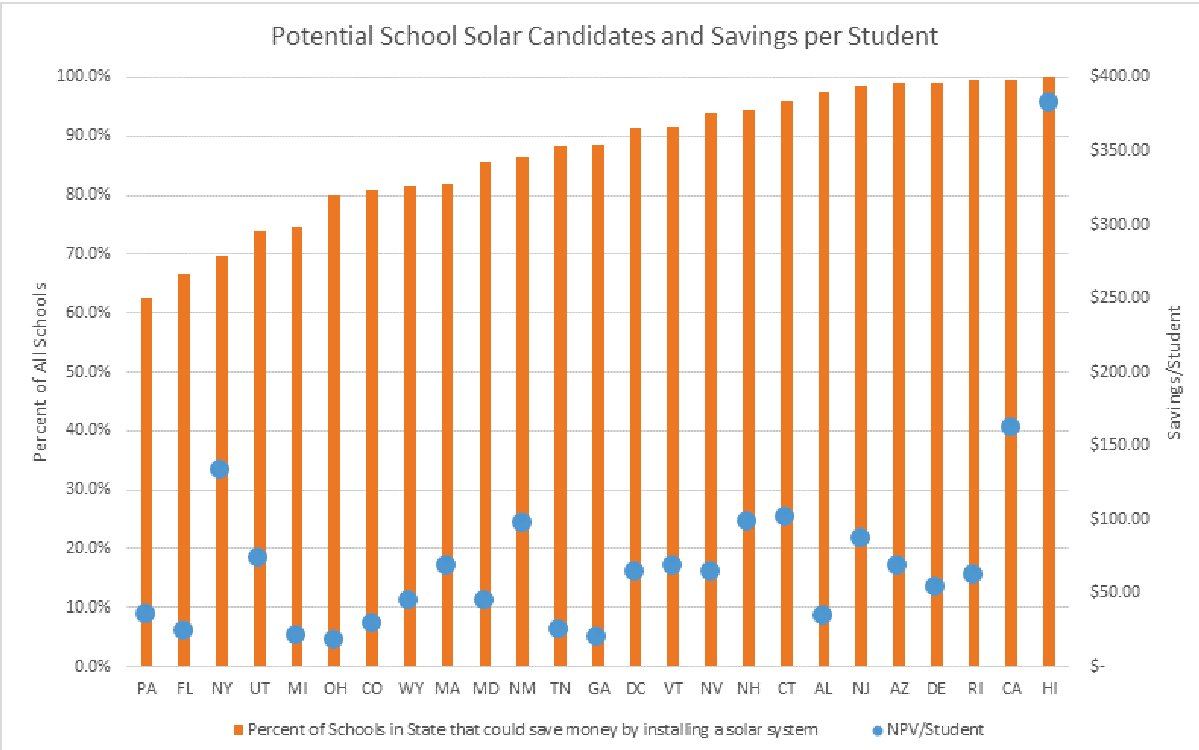
Note on Modeling Assumptions:
The modeling performed for this analysis presents a very rough sketch of what is possible. Since it does not account for factors such as state or utility incentives, it may underestimate the economic potential in many regions. Likewise, this analysis does not include the individual engineering, permitting or financing considerations that apply to a particular school.

While $2.00-$2.50/W_{dc} is significantly less than the average cost of school PV systems installed to-date, and is not possible in all situations, it should be within reach when the right policies are in place to facilitate a smooth deployment process (permitting, financing/tax policy and procurement). Many jurisdictions have found ways to streamline permitting (for example, the California Division of the State Architect has taken steps to approve certain PV racking equipment), but considerable work remains to further optimize the process.

[24] Data from the National Solar Radiation Database http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/
[25] Average utility revenue per kWh for commercial customers in 2012 as reported in EIA-861. Schools were matched to electric utilities by zip code. In cases where an exact match could not be made, the rate from a nearby utility was used.
[26] National Renewable Energy Laboratory. (2010, May 4). System Advisor Model (SAM) |. Retrieved from https://sam.nrel.gov/

Some school districts show an NPV of more than $200/student which, given the size of many school districts, can add up quickly. This analysis suggests that 450 individual school districts could each save more than $1,000,000 over 30 years. See our full listing of school districts with the greatest savings potential at schools.tsfcensus.org.

Figure 9: Potential School Solar Candidates and Savings per Student



Aside from the potential to save money for core education functions, deploying solar at schools can help reduce emissions of air pollutants that harm air quality (and cause air quality warnings to keep children inside in large cities) and cause global warming. If each of the 72,000 schools mentioned above were to deploy solar, electricity generation from those systems would offset the emissions of approximately 4.8 million metric tons of CO_2-equivalent each year.[27] According to the U.S. Environmental Protection Agency's (EPA) *Greenhouse Gas Equivalencies Calculator*, this is roughly equal to the reduction in emissions achieved by taking more than 1 million passenger vehicles off the road or to the amount of carbon sequestered by 3.9 million acres of U.S. forests.

[27] Assumes average emissions reduction from conventional generation of 0.689551 metric tons per MWh.

Potential for Solar Heating and Cooling Systems

While the analysis above focused on solar photovoltaic systems for producing electricity, many schools could also benefit from solar heating and cooling (SHC) technologies.

Schools with swimming pools in particular could be excellent candidates to save money on pool heating costs with solar pool heating systems, long one of the most economical ways to heat swimming pools.

The Bolles School in Jacksonville, Florida has a 15 million BTU/day solar pool heating installation.
(Photo: Solar Source)

Challenges and Lessons Learned

Though the vast majority of schools interviewed for this report had an overall positive experience in going solar and achieved the outcomes desired from their investment, seeing a solar project through to completion can sometimes entail unforeseen challenges. This section summarizes common challenges faced by schools that have already gone solar in order to help ensure a smoother process for future solar schools.

> **Did You Know?**
>
> The electricity generated in one year by all 3,727 PV systems represents a combined $77.8 million per year in utility bills – an average of almost $21,000 per year per school.
>
> This combined energy value is roughly equivalent to 155,000 tablet computers or nearly 2,200 new teachers' salaries per year.

Financing for Solar Energy

One of the major challenges for schools in going solar is figuring out the most cost-effective way of paying for these systems. Compounding this issue is the fact that schools – because they lack a tax liability to do so – are unable to directly take advantage of federal or state tax credits for solar. The wide array of financing options employed by schools interviewed for this report reflects the challenges of investing in solar without easy access to key federal and state incentives, but also underscores the creativity of schools in fully leveraging the available options. Of the 15 executive interviews conducted, no schools relied solely on direct cash payments for their systems. Any cash put into the project by the school – from bond measures, capital or operating budgets, or other means – were combined with other key forms of financial support, such as grants, loans, rebates, and SRECs. Excluding systems financed through third-party ownership, only two of the 15 projects were funded via a single financing option of any kind, reflecting the importance of investigating and fully leveraging all available sources of financing.

Solar Procurement Issues

The most oft-cited set of challenges encountered by schools in their efforts to go solar were related to the procurement process. Some of these issues and many others are covered in greater detail in TSF's *Steps to a Successful Solar Request for Proposal*.[28]

Though schools pointed to a wide variety of procurement issues, a common theme was development risk – that is, issues with the contractor (or other entities affecting the installation process) completing the work or fulfilling other contractual obligations in a timely manner. One school, for example, lamented not having had in place a request for proposal (RFP) or contract language imposing penalties on (or otherwise ensuring accountability of) installers who did not complete all aspects of the work on time. Because the contractor did not fulfill all its obligations, and because the school had little means of compelling the company to do so, the district remains reluctant to pursue any additional solar projects. As mentioned in the TSF guide cited above, contracts and other procurement documents should require contractors to submit and adhere to a list of major project milestones and expected completion dates, and potentially make contractor payments contingent on their ability to do so. As a related issue, procurement staff may also consider adding RFP and contract language to ensure timely contractor responsiveness to any technical issues that may arise after the installation process, especially for those that jeopardize system performance or safety. Finally, schools should consider including language to protect their interests in the event that a company backs out of a contract altogether, which was the case with one interviewee.

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[28] Available at http://thesolarfoundation.org/sites/thesolarfoundation.org/files/TSF_Steps percent20to percent20Successful percent20Solar percent20RFP_Final.pdf

Another procurement issue cited by schools was maintaining the existing roof warranty after the PV system was placed in service. Rooftop solar arrays sometimes require contractors to puncture the roof to install equipment to hold the system in place, which may violate the existing roof warranty. To avoid this issue, contractors should be required to obtain written certification from the company providing the current warranty that the proposed solar installation will not nullify this warranty. In the event this certification cannot be obtained, the contractor should bear the responsibility of securing a new warranty. RFP documents should also specify that the contractor work with the roof manufacturer and not violate any existing roof warranties.

Did You Know?

Of the 125,000 schools in the country, between 40,000 and 72,000 can "go solar" cost-effectively.

Protecting against performance risk is key to ensuring the school receives the full financial benefits of their solar investment. Some schools noted their realized cost savings was sometimes a bit less than what was expected, which can be due to lower solar energy system production than was expected or promised. However, when comparing the actual amount of electricity generated with estimates provided by the installer, it is important to keep in mind that the solar resource varies from year to year. While estimates of solar production are based on a "typical meteorological year" (TMY), the actual weather experienced in a given year varies. For example, 45 years of weather data from Atlantic City, New Jersey shows that annual solar resource availability ranged from 12 percent below to 9 percent above the average estimate that would be used in production calculations.

An easy way to avoid this issue is to require contractors to provide an accurate estimate of system performance and to guarantee the system, when properly maintained, will produce electricity equal to a predefined percentage of this estimate, or else face financial or other penalties. Lower than expected cost savings can also be the result of erroneous assumptions made regarding baseline facility energy use or the value of the solar electricity produced by the system. One effective way to mitigate these risks is to hire an independent consultant with expertise in solar technology, policy, and energy markets to review the assumptions underlying any cost savings estimates provided in contractor proposals. These consultants can also help review final contract terms and provide input on the current policy, regulatory, and legal landscape to help ensure the school is receiving the best deal possible.

Community and School Board Engagement

Because investments in solar energy can come at a large upfront cost and due to the persistence of several myths and misconceptions regarding solar energy,[29] some communities and school boards may be reluctant to embrace proposals to install solar on their schools. Hosting a set of stakeholder meetings or making a formal presentation to the board on the value of solar energy to the community can serve to dispel many misconceptions, provide a clear sense of the solar installation process and its expected outcomes, and help garner community support for the project. The Solar Foundation and other members of the Solar Outreach Partnership have a wealth of experience in engaging local government and community stakeholders and may be able to support your school's own outreach and engagement efforts with free technical assistance services. More information on these U.S. Department of Energy funded services can be found at www.solaroutreach.org/ta.

[29] See two Solar Outreach Partnership factsheets addressing common solar myths and misconceptions at: http://solaroutreach.org/wp-content/uploads/2014/01/Solar-Myths-Misconceptions-Part-I.pdf and http://solaroutreach.org/wp-content/uploads/2013/10/Solar-Myth-II-_-Final.pdf

Regulatory Requirements

Another issue schools have frequently encountered in going solar is the difficulty of understanding and complying with all state and local regulatory requirements. While ensuring these requirements are satisfied should mainly be the responsibility of the contractor, the time and money it takes to comply with these rules are typically passed on to the solar customer in the form of increased project cost. Complex, onerous, or even nonexistent planning and zoning requirements and permitting, inspection, and interconnection processes can serve to drive up the “soft” costs (i.e., the non-hardware or business process costs) of going solar. Taken together, these soft costs account for nearly half of the total cost of installed solar in the U.S.[30]

Fortunately, there are many actions state and local governments can take to help reduce these soft costs, including incorporating solar energy into local planning processes and zoning codes, streamlining and expediting the solar permitting process, developing statewide interconnection standards, working with local lending institutions to develop financial products for solar, and supporting or leading solar market development programs. More information on these topics is available at www.solaroutreach.org/resources or by contacting The Solar Foundation at info@solarfound.org.

The Scottsdale Unified School District in Scottsdale, Arizona installed more than 2 MW of solar across four school sites to lock in years of future energy. (Photo: SolarCity)

[30] Ardani/ National Renewable Energy Laboratory, K., Seif/ Rocky Mountain Institute, D., Margolis/ National Renewable Energy Laboratory, R., Morris/ Rocky Mountain Institute, J., Davidson/ National Renewable Energy Laboratory, C., Truitt/ National Renewable Energy Laboratory, S., & Torbert/ Rocky Mountain Institute, R. (2013).*Non-Hardware ("Soft") Cost-Reduction Roadmap for Residential and Small Commercial Solar Photovoltaics, 2013-2020* (NREL/TP-7A40-59155). Retrieved from National Renewable Energy Laboratory website: www.nrel.gov/docs/fy13osti/59155.pdf

Sources and Methodology

In March 2013, the Solar Foundation began gathering data on K-12 school solar installations around the country, publishing a map showing their initial findings later that spring. Those findings formed the basis of the National Solar Schools Census. In the fall of that year, SEIA joined the Solar Foundation in launching a more comprehensive data collection effort, continuing until July of 2014. Once data collection ended, all schools with solar installations were matched with the appropriate school from the National Center for Education Statistics' comprehensive database of private and public K-12 schools in the U.S. Each school was then matched with its closest TMY3 station[31] and with a proxy for avoided cost of retail electricity purchases.[32] Using NREL's System Advisor Model[33] and the assumptions listed on page 25, system performance was estimated and net present value calculated over a 30 year period. Final data on K-12 schools with solar and on the potential net present value for schools without solar is provided at schools.tsfcensus.org.

Data collected as part of the National Solar Schools Census included the following:

- school name
- school district
- address
- system type (photovoltaic or solar heating/cooling)
- system capacity
- year installed
- installation company
- funding type (cash/loan, grant, PPA/lease)
- installed cost

All data was collected at the system level. When data was only available at the school district or county level, secondary sources were used to trace installations to exact school locations. In instances in which price data was only available at the county or district level, total district or county capacity and total system district or county system cost were used to calculate an average price for each individual school system. Due to reporting differences among available sources, several categories of data were not able to be collected in full (most notably, data on funding type and installed cost).

Schools profiled in the body of this report were selected from the data collected in the National Solar Schools Census. School selection was based primarily on the willingness of participants to respond to a brief email or phone survey. From the list of respondents, final candidates for case studies were selected to ensure diversity among school geography, school size and grade level, system size, and financing type. Executive interviews were ultimately conducted with representatives of 15 of these schools.

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31 Data from the National Solar Radiation Database http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

32 Average utility revenue per kWh for commercial customers in 2012 as reported in EIA-861. Schools were matched to electric utilities by zip code. In cases were an exact match could not be made, the rate from a nearby utility was used.

33 https://sam.nrel.gov/

Most of the data included in the National Solar Schools Census was collected from publically available sources. Data from non-public sources are being provided here with written permission from its original owner. Data sources included state and utility incentive programs, private grant programs, school districts and individual schools, solar developers and installers, and news reports. The majority of the data included in the National Solar Schools Census comes from the sources listed below:

- Connecticut Clean Energy Finance and Investment Authority
- California Solar Initiative
- New Jersey Clean Energy Program
- Brightergy
- Borrego Solar
- The Foundation for Environmental Education/PG&E: California Solar Schools Initiative
- The Smart Energy Living Alliance: Colorado Solar Schools
- Idaho Department of Energy
- Energy Works Michigan
- Los Angeles Unified School district
- Ohio Solar Schools
- RGS Energy
- Walmart Foundation
- Denver Public Schools
- WPPI Energy
- Austin Energy
- Black Rock Solar
- Cupertino Electric, Inc.
- Duke Energy
- California Energy Commission
- Florida Solar Energy Center
- GreenPower EMC
- Johnson Controls
- IEC Corporation
- Illinois Solar Schools
- Environment California
- Montana Green Power
- New York Power Authority
- ReVision Energy
- Texas State Energy Conservation Office
- Bonneville Environmental Foundation: Solar 4R Schools
- SunPower
- SolarCity
- Solectria Renewables
- SMA
- Missouri Department of Natural Resources
- Wisconsin Public Service
- Rocky Mountain Power
- Massachusetts Clean Energy Center
- Nevada Governor's Office of Energy
- NYSERDA
- PJM
- Renewable Energy Vermont
- Focus on Energy: Wisconsin

Appendix A:

Resources for Teaching Solar Energy in the Classroom

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE)
K-12 Lesson Plans & Activities (www1.eere.energy.gov/education/lessonplans/)
This site provides teachers with a large collection of clean energy lesson plans and activities for students at all grade levels. Users can select the activity resources provided at the top of the page, or can choose one or more topics or grade levels from the searchable database to find lesson plans that best meet their students' needs.

U.S. Department of Energy, Solar Decathlon
Solar Decathlon Curriculum (www.solardecathlon.gov/curriculum.html)
Designed as a complement to the biennial *Solar Decathlon*, in which teams from colleges across the nation compete to design and build cost- and energy-efficient solar powered homes, this set of solar lesson plans for middle- and high-school students helps to expand the educational opportunity presented by the program. Lessons range from introductory-level content on the development and use of solar power to using regression analysis to predict energy use and production and solve real-world problems.

National Energy Education Development (NEED) Project
Solar Curriculum Resources (www.need.org/solar)
In pursuit of its mission to promote an energy conscious and educated society, the NEED Project has helped develop curriculum resources covering a wide range of energy topics and across all grade levels. Available resources discussing solar include various energy factsheets, teacher and student guides on solar energy principles and photovoltaic systems, presentations, and animations.

Florida Solar Energy Center
Solar Matters (www.fsec.ucf.edu/en/education/k-12/curricula/index.htm)
Created by the state legislature in 1975 to conduct research and develop education programs on solar energy, the Florida Solar Energy Center provides solar curriculum materials for students of all ages.

Texas State Energy Conservation Office
Renewable Energy Lesson Plans (www.seco.cpa.state.tx.us/schools/infinitepower/lesson-plans.php)
Offered as part of the State Energy Conservation Office's "Infinite Power of Texas" education campaign, these lesson plans provide basic instruction in solar energy starting at the kindergarten level. Topics and educational goals become more sophisticated as units progress through higher elementary and middle school grades, which center on discussing the principles behind solar energy production, and ultimately through high school lesson plans that introduce students to the technical and financial aspects of solar.

Appendix B:

First Steps for Going Solar – A Practical Guide

Once a school or district has a clear understanding of its needs and values – and those of the surrounding community – and has translated these into one or more goals for the solar project, it is ready to being the process of going solar. Though experiences with this process can vary in their details, there are a few steps common to most school solar projects. While not meant to be comprehensive, the process outlined below should provide readers with a general sense of the considerations and actions involved in pursuing a solar energy project.

Evaluate Energy Savings Potential

The first step toward becoming a solar school involves making a determination as to the energy savings potential a solar energy system can offer. Facilities staff should review school or district electric or gas utility bills over the previous 12 months to establish current energy usage and costs and provide a baseline to assess energy and cost savings. As the amount of energy that can be offset by solar is directly related to the size of the solar energy system, it will be necessary to estimate how large a system school rooftops or grounds can support. This can be done through a full solar site assessment, in which a solar installation company evaluates a number of site characteristics, including site orientation, available space, and amount of shading during peak solar hours. For rooftop systems, this process can involve determining roof condition and age and whether the structure can support the static and dynamic loads associated with the solar installation.

A school may not ready or able to commit to a full site assessment right away. In these cases, facilities staff can use a number of free online tools to develop a general sense of a school's suitability for solar. Sun Number (www.sunnumber.com) provides users with a single score – based on building potential for solar, regional climate, utility electricity rates, and the cost of solar – demonstrating the potential for solar at a given site. While not currently available for the entire U.S., Sun Numbers are available for most sites in three dozen major cities and metropolitan areas. Another option is available through Geostellar (www.geostellar.com), which has mapped the solar potential of rooftops in some parts of the country and provides free access to heat maps showing how much sunlight each portion of a given roof receives. In addition, some state and federal agencies have developed resources outlining the site screening process.[34]

Having obtained a basic idea of the system size that can be supported, staff can evaluate potential energy cost savings using a number of free online tools, including the National Renewable Energy Laboratory's *PVWatts Calculator* (pvwatts.nrel.gov) or the *System Advisor Model* (sam.nrel.gov).

Understand Solar Financing Options

Once the school or district has a general idea of site suitability for solar and how large a system can be supported, the next step in estimating energy cost savings is to understand the costs of solar and available financing options. Though the installed cost of solar has fallen quickly over the past few years, these systems still represent a significant investment and therefore often require some form of financing. Fortunately, a number of public and private financing options have been developed to help overcome this barrier. Because of the tax-exempt status of public schools and the local nature of some of these programs, however, not all options will be available in every case. For information on specific incentives or programs for which your school may qualify, visit the Database of State Incentives for Renewables and Efficiency at www.dsireusa.org.

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[34] Leading by Example Program. (n.d.). Solar Site Selection Survey. Retrieved from www.mass.gov/eea/docs/eea/lbe/lbe-solar-site-select-survey.pdf; U.S. Environmental Protection Agency. (n.d.). Screening Sites for Solar PV Potential. Retrieved from www.epa.gov/oswercpa/docs/solar_decision_tree.pdf

Federal Incentives

The primary federal incentives supporting solar are the residential and commercial solar **Investment Tax Credit (ITC)**, providing a federal income tax credit equal to 30 percent of total installed system costs, and the **Modified Accelerated Cost-Recovery System (MACRS)**, which allows non-residential solar customers to recover the value of investments in solar through depreciation deductions on federal taxes. Because both are tax incentives and public schools and districts do not have tax burdens, these customers are unable to take direct advantage of these key financing options, which can pose significant challenges for schools in areas with few state, local, or utility incentives or without access to private financing. In states that allow for third-party ownership of solar energy systems (explained in greater detail on page 36), schools and other tax-exempt entities are able to leverage these credits indirectly by acquiring solar through a Power Purchase Agreement (PPA).

State Incentives and Financing

Recognizing the value of solar energy in helping meet state renewable energy goals, more than 40 states offer some form of incentive or other financing options for solar.[35] Common incentives or programs include **tax credits, deductions, or exemptions** and **grants, loans, or rebates** supporting public and/or private investments in solar energy. In addition, some states have chosen to promote solar through their Renewable Portfolio Standards (RPS) – requirements for utilities to derive a certain percentage of their retail electricity sales from renewable sources by a target year – by mandating that solar electricity constitutes a defined portion of this renewable requirement. In a handful of states with "solar carve-outs," these requirements have given rise to **Solar Renewable Energy Certificate** (SREC) markets. These SRECs represent the environmental or non-energy attributes of solar electricity and can provide system owners with a significant additional project revenue stream.[36]

Utility Incentives and Financing

As with many states, utilities may also offer consumer grants, loans, or rebates for solar energy. In addition to or instead of these incentives and programs, some utilities provide **performance-based incentives** (PBIs) for their solar customers. Rather than being based on the cost of the investment in solar (as is the case with grants, loans, or rebates), PBIs are tied to the amount of electricity produced by a solar energy system. For example, some utilities arrange to purchase all the electricity produced by an eligible solar energy system at a rate higher than the retail price of electricity. In these "buy all, sell all" arrangements, solar customers receive larger total payments as their systems generate more electricity.

In addition to these incentives, utilities in 43 states and the District of Columbia are required to offer **net metering** programs to their solar customers.[37] With net metering, customers are credited by the utility for any excess energy exported to the grid. These credits can in turn be used to offset the cost of electricity used from the grid at night or other times when solar energy systems are not producing enough electricity to meet on-site needs. When classes are in session, schools consume the most energy at times when daily solar electricity production is greatest. Because demand tracks closely with system production during this period, it is possible that comparatively little electricity will be exported to the grid (versus a residential system, for which production peaks when on-site needs are low, as these building are usually unoccupied in the middle of the day). During summer months, however, when demand for electricity is much lower but system production is still high, net metering becomes much more important.

Other Public Financing Options

While schools may be limited in their ability to leverage certain solar incentives, they have access to other funding mechanisms unavailable to private solar customers. As a special-purpose district of a local government, school districts may issue certain types of **bonds** to cover the up-front cost of going solar. Energy cost savings can then be used to repay the principal and interest due to bondholders. Because

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[35] DSIRE Solar. (2013, February). *Financial Incentives for Solar PV* [Map]. Retrieved from http://dsireusa.org/documents/summarymaps/PV_Incentives_Map.pdf
[36] More information on SRECs can be found via SRECTrade (www.srectrade.com) or Flett Exchange (www.flettexchange.com)
[37] DSIRE. (2013, July). *Net Metering* [Map]. Retrieved from http://dsireusa.org/documents/summarymaps/net_metering_map.pdf

municipal bond holders are usually willing to accept lower interest rates than on other debt investments, schools projects can be funded at a lower cost of capital compared with most private sources of debt.

To help further reduce interest payments on municipal bond debts, the federal government has authorized $3.2 billion in funding for state, local, and tribal governments to issue **Qualified Energy Conservation Bonds (QECBs)** to finance certain energy efficiency upgrades and renewable energy projects. Through these QECBs, the federal government provides bond issuers with direct interest rate subsidies. While the subsidy amount varies with U.S. Treasury Qualified Tax Credit Bond Rates, bond issuers have generally received subsidies between approximately 3-4 percent of the bond amount. In one example, a bond with a 6 percent interest rate received a 3.7 percent direct QECB subsidy, leaving the issuer to pay only 2.3 percent in net interest. More information on QECBs as well as updates on program changes and remaining bond authority can be found in a semi-annual report published by the Energy Programs Consortium.[38]

Schools are also somewhat unique in their ability to enter into a **tax-exempt lease-purchase** agreement. Also known as a "Municipal Lease", this financing mechanism allows some local governments or districts to lease solar energy equipment from a solar company at lower payments and longer terms than other leasing options. Due to the inclusion of non-appropriation language, these agreements are usually not considered long-term debt, with lease payments made from operating rather than capital budgets. At the end of the lease term, ownership can be transferred to the municipal customer either outright or for a nominal fee. As with some other lease options, however, the school district is unable to take advantage of federal tax incentives through these arrangements. In considering this option, schools should weigh the benefits of low tax-exempt interest payments and a longer lease term against alternatives that do allow for tax incentives to be passed on to the solar customer.

Private Financing Options

In addition to the wide array of public financing options for solar, there exist a number of private alternatives. The leading private option for the last several years has been **third-party ownership** of solar energy systems. Under these arrangements, the solar customer serves as host for and receives the electricity from – but does not own – the installation. Instead, the solar developer retains ownership of the system, and either enters into a solar lease with the customer or sells them the electricity produced by the system outright through a power purchase agreement (PPA). One of the main advantages of third-party ownership for schools is that – because the solar developer is a tax-paying private enterprise (and is often partnered with other private entities with even larger tax appetites) – tax-exempt solar customers are able to benefit from federal (or state, where available) tax credits through lower lease payments or PPA rates. In addition, the financing offered by the third-party system owner can significantly reduce or eliminate the upfront cost of going solar. Availability of PPAs as a financing option, however, depends on the state utility legal and regulatory framework. To date, only 22 states and the District of Columbia have expressly allowed for third-party solar PPAs.[39]

In some cases, it may be possible to combine school district bond-issuing ability and third-party ownership into a **bond-PPA hybrid** (also known as the "Morris Model", named after the New Jersey county in which the first hybrid deal was completed). Though reliant on a complex financing structure, the basic idea behind the model is relatively simple. Rather than using proceeds from a bond issuance to directly fund the installation of a solar energy system, the customer instead passes this capital on to the solar developer, providing them with lower-cost project capital than they would have otherwise been able to obtain. The developer then has the system installed and enters into a PPA with the customer, who receives the value of any tax credits in

[38] Energy Programs Consortium. (2014, June). *Qualified Energy Conservation Bonds*. Retrieved from www.naseo.org/Data/Sites/1/epc-qecb-paper-june-2014-.pdf
[39] DSIRE Solar. (2013, February). *3rd-Party Solar PV Power Purchase Agreements (PPAs)*[Map]. Retrieved from http://dsireusa.org/documents/summarymaps/3rd_Party_PPA_map.pdf

the form of a lower PPA rate. While this hybrid model can provide significant savings for the solar customer, these deals are often complex and replicability hinges on a number of different laws and regulations.[40]

Energy services performance contracts (ESPCs) can provide schools with another cost-effective means of investing in solar. Through these agreements, customers contract with an energy services company (ESCO) to assess the current energy use of one or more buildings and to propose a package of energy conservation measures to reduce consumption. The ESCO provides a customer with a guaranteed level of performance for these energy upgrades and ensures a minimum level of cost savings. A portion of these energy cost savings compensates the ESCO for their work in making the energy upgrades, with the remainder retained by the customer. While ESPCs have typically involved energy efficiency measures (such as energy efficient lighting, building envelope improvements, etc.) with a relatively short payback, these contracts can also include upgrades with a slower payback, such as solar PV. In states that allow for third-party ownership, tax-exempt customers such as public schools could enter into a PPA with the ESCO for the solar PV system included as part of the performance contract, allowing the customer to invest in solar with little or no upfront cost and for the ESCO to take any available tax credits and pass their value on to the customer. For more information on solar in ESPCs, see *Integrating Solar PV into Energy Services Performance Contracts: Options for Local Governments Nationwide* from the North Carolina Clean Energy Technology Center (www.nccleantech.ncsu.edu).[41]

While not in itself a financing mechanism, **net-zero building** can provide schools with another opportunity for investing in solar. The "net-zero" in this term refers to energy use – that is, the building produces and/or collects as much energy as it uses in a typical year of operation. Energy strategies for net-zero construction can include use of highly efficient equipment, building envelopes that minimize energy losses, passive solar design, and renewable energy generation technologies (such as solar PV), among others. **Richardsville Elementary School** in Warren County, Kentucky illustrates how net-zero building can provide great benefits to schools. The first net-zero public school in the nation, Richardsville Elementary has managed to not only reduce its energy costs to zero, but generated 47.8 MWh more energy than it consumed in 2012, earning the school more than $40,000 that year. Such a dramatic savings was achieved through a combination of energy efficient systems, a high-performance building envelope, a geothermal HVAC system, daylight harvesting, and other measures, including a 208-kW thin film rooftop solar PV system and a 138-kW solar PV parking canopy.[42]

Obtain Approval for Project

Once a clear understanding of the energy savings potential, costs, and financing options for a solar energy system have been developed, the next step is to obtain approval for the project. This process not only involves making the case for solar to decision makers within the school district, but to demonstrate to external stakeholders (including students, parents, and other community members) the value of an investment in solar and how such a project can help attain community goals or otherwise reflects local values. Community Power Network (www.communitypowernetwork.com), a non-profit organization working to promote locally-based renewable energy projects and policies, outlines a step-by-step process for community engagement in the short guide *Solar Schools: A Resource Guide to Help Your School Go Solar*.[43]

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[40] Kreycik/ National Renewable Energy Laboratory, C. (2011, December 13). Financing Solar PV at Government Sites with PPAs and Public Debt | Renewable Energy Project Finance. Retrieved from https://financere.nrel.gov/finance/content/financing-solar-pv-government-sites-ppas-and-public-debt

[41] North Carolina Solar Center. (2014). *Integrating Solar PV Into Energy Services Performance Contracts: Options for Local Governments Nationwide*. Retrieved from Solar Outreach Partnership website: http://solaroutreach.org/wp-content/uploads/2014/04/NCSC-Solar-ESPCs-FINAL.pdf

[42] ICMA. (2014). Solar Powering Your Community Workshop: Owensboro, Kentucky | icma.org. Retrieved from http://icma.org/en/icma/knowledge_network/documents/kn/Document/306104/Solar_Powering_Your_Community_Workshop_Owensboro_Kentucky

[43] Community Power Network. (n.d.). *A Resource Guide to Help Your School Go Solar*. Retrieved from http://communitypowernetwork.com/sites/default/files/Solar percent20Schools_P2 percent20 percent282 percent29.pdf

Draft and Issue Request for Proposal

While the solar procurement process shares many similarities with the steps involved in many other large equipment purchases, the unique nature of solar energy necessitates the inclusion of particular elements in requests for proposals (RFPs). A list of potential solar-specific RFP elements may include, but is not limited to:

- Protection of Roof Integrity and Warranties
- Provisions for Performance Monitoring/Guarantees
- System Technical Specifications
- Assigning Responsibility to Contractors for Obtaining Permits or Interconnection Agreements
- Requirements for an Operation and Maintenance Plan
- Local Equipment or Labor Requirements
- Leveraging Project Educational Value

Not all of these elements will be included for every project. Rather, different provisions will be included or omitted based on the goals set by the school for the project. For example, a project focused on tapping the economic development potential of solar deployment may include requirements for local materials or labor, whereas a system pursued mainly for educational purposes might place greater emphasis on how well the respondent leverages the project to enhance students' learning experiences. The Solar Foundation's *Steps to a Successful Solar Request for Proposal (RFP)* discusses many of the key elements of a solar RFP, as well as best practices in overall RFP development, in greater detail.[44]

[44] The Solar Foundation. (2012). *Steps to a Successful Solar Request for Proposal*. Retrieved from http://thesolarfoundation.org/sites/thesolarfoundation.org/files/TSF_Steps percent20to percent20Successful percent20Solar percent20RFP_Final.pdf

Additional Resources

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