Entergy New Orleans, Inc.
1600 Perdido Street, Bldg #505
New Orleans, LA 70112
Tel 504 670 3680
Fax 504 670 3615

Gary E. Huntley
Vice President,
Regulatory and Governmental Affairs
ghuntle@entergy.com

January 17, 2014

Via Hand Delivery

Ms. Lora Johnson
Clerk of Council
Council of the City of New Orleans
Room 1E09, City Hall
1300 Perdido Street
New Orleans, LA 70112

Re: Filing of the Solar Pilot Photovoltaic Pilot Report (Resolution R-09-136; UD-08-02)

Dear Ms. Johnson:

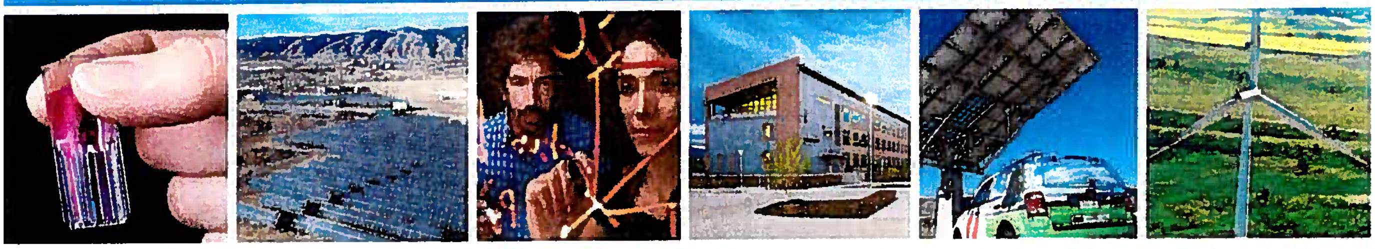
On April 2, 2009, the Council of the City of New Orleans ("Council") adopted Resolution R-09-136 that approved Entergy New Orleans, Inc.'s ("ENO") inclusion of a 12 month Solar Photovoltaic Pilot to provide information on the benefits, costs and overall performance specific to the New Orleans area associated with these applications. The 12 month pilot program concluded on March 31, 2013.

On behalf of the National Renewable Energy Laboratory, ENO submits the enclosed Solar PV Pilot report. Should you have any questions regarding this filing, please contact my office at (504) 670-3680.

Sincerely,

Gary E. Huntley

cc via email: All Councilmembers
Council Utilities Regulatory Office
Clinton A. Vince, Esq
Presley Reed, Esq
Walter J. Wilkerson, Esq
Joseph A. Vumbaco, PE
Erroll Smith, CPA
Ken Pailet, CPA



Energy Smart Residential and Commercial Solar Photovoltaic Monitoring Pilot Project

R. Romero, J. Simon, and A. Watson

Produced by the National Renewable Energy Laboratory (NREL) under Interagency Agreement TSA-11-403 and Task No WTBC1000 at the request of Entergy New Orleans via the New Orleans City Council Energy Smart Program in cooperation with Gulf States Renewable Energy Industry Association and Make It Right.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Technical Report
NREL/TP-7A40-58976
August 2013

Contract No. DE-AC36-08GO28308

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Energy Smart Residential and Commercial Solar Photovoltaic Monitoring Pilot Project

R. Romero, J. Simon, and A. Watson

Prepared under Task No. WTBC1000

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, Colorado 80401
303-275-3000 • www.nrel.gov

Technical Report
NREL/TP-7A40-58976
August 2013

Contract No. DE-AC36-08GO28308

NOTICE

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: mailto:reports@adonis.osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/help/ordermethods.aspx

Cover Photos: (left to right) photo by Pat Corkery, NREL 16416, photo from SunEdison, NREL 17423, photo by Pat Corkery, NREL 16560, photo by Dennis Schroeder, NREL 17613, photo by Dean Armstrong, NREL 17436, photo by Pat Corkery, NREL 17721.

Printed on paper containing at least 50% wastepaper, including 10% post consumer waste.

Acknowledgements

The authors thank Derek Mills and Warren Allison from Entergy New Orleans for driving this project. Also, the authors would like to acknowledge Tucker Crawford from GSREIA and Pierre Moses from Make It Right Solar, who provided valuable insight into solar PV in New Orleans.

Additionally, Dirk Jordan and Ryan Smith of NREL collected data and extracted the data for analysis in this report. Many thanks for their knowledge of solar PV data. Thank you to Andy Walker from NREL for sharing his expertise in solar on this project. Finally, special thanks to Asaf Peleg from Locus Energy who supported data collection.

List of Acronyms and Abbreviations

AC	alternating current
GSREIA	Gulf States Renewable Energy Industry Association
IMBY	In My Backyard
kW	kilowatt
kWh	kilowatt-hour
LEED	Leadership in Energy and Environmental Design
mph	miles per hour
MW	megawatt
MWh	megawatt-hour
NPV	net present value
NREL	National Renewable Energy Laboratory
O&M	operation and maintenance
PV	photovoltaic
PVDAQ	PV Data Acquisition
SAM	System Advisor Model
W	Watt

Executive Summary

As part of the Energy Smart New Orleans Plan, Entergy New Orleans, in cooperation with Gulf States Renewable Energy Industry Association (GSREIA) and Make It Right, commissioned a residential and commercial solar PV monitoring pilot project. Energy Smart is a New Orleans City Council program created to promote energy efficiency in the New Orleans area. The program is administered by Entergy New Orleans.

The pilot was a 12-month study of residential and commercial solar photovoltaic (PV) applications to gather data on the performance, costs, and benefits of PV in the New Orleans area.[1] The results and key findings from the study are intended to improve Louisiana consumers' understanding of actual solar PV production and benefits, as well as increase Entergy New Orleans's understanding of the local impact of residential and commercial PV.

The study looked at 30 residential and three commercial PV installations in New Orleans. Of the 30 residential locations, 12 residences were Make It Right residences. Make It Right residences are constructed as energy efficient and healthy homes for communities that are Leadership in Energy and Environmental Design (LEED) Platinum certified—the highest level of certification. Of the 18 typical construction New Orleans homes, 17 homes were monitored; one home did not have location information or metered data. A portion of council district C is located outside of Entergy New Orleans' electric service territory. In addition, net metering is not allowed in the French Quarter portion of district C. Therefore, the majority of the homes and facilities in the study are in council districts A, B, D and E. However, district C was the site of one of the three commercial facilities included in the study. In summary, 29 valid residences were monitored and analyzed.

The three commercial PV locations were the Joseph A. Craig Elementary School, the Warren Easton Charter High School, and the New Orleans Science and Math High School. Only Craig Elementary had valid data.

The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) served as an independent entity to gather the results from the PV monitoring systems, analyze performance, and assess the costs and benefits of PV in New Orleans.

Results

Solar PV electricity is clean, renewable, and reliable[2]. Also, distributed solar PV provides owners with fixed energy costs. Typically, grid-connected solar PV energy does not provide electricity in emergency situations; however, in certain cases, PV energy can provide emergency back-up power if coupled with batteries. This study corroborated the general understanding that

[1] *Entergy New Orleans, Inc.'s Report in Support of Application for Approval of Programs to be Included in the Energy Smart New Orleans Plan and Related Approvals Pursuant to Resolution R-09-136 and the 2009 Agreement in Principle.* Entergy New Orleans, July 2, 2009.

[2] "Photovoltaic Reliability Publications." http://www.nrel.gov/pv/performance_reliability/publications.html?print.

solar PV is a viable option to reduce net energy consumption for both residential and commercial sites.

Overall, the key findings of this study include:

- Among the 29 valid residences included in the pilot study all solar PV systems met at least 30% of the electricity consumption for the year, with an average of 62%.
- On a council district level, production, normalized by the size of the system, is effectively the same in all physical locations, with a specific production ranging from a minimum of 38 kilowatt-hours/kilowatt (kWh/kW) to a maximum 165 kWh/ kW.
- In the residential portion of the pilot study, while issues with the monitoring equipment excluded some data points, monitoring equipment enabled 90% of the total potential monthly data to be captured from the residential solar PV systems.
- Only one data set was collected for solar PV production in the commercial portion of the pilot (Craig Elementary) due to maintenance and technical equipment issues with the other pilot study sites; therefore, Craig Elementary serves as an example of a commercial system but not as a representative sample of commercial solar PV systems in New Orleans.
- Ensuring data monitoring systems are working is vital to performance monitoring of the system.
- Solar PV is continually becoming more affordable. Based on the financial analysis and assumptions presented in this report, solar PV in New Orleans is an economically viable option when considered over a 25-year time scale and when incentives are available. Without incentives, systems on both Make It Right and typical New Orleans residences are not cost-effective.

Table of Contents

List of Figures

List of Tables

1 Introduction

As part of the Energy Smart New Orleans Plan, Entergy New Orleans, in cooperation with Gulf States Renewable Energy Industry Association (GSREIA) and Make It Right, commissioned a residential and commercial solar PV monitoring pilot project. Energy Smart is a New Orleans City Council program created to promote energy efficiency in the New Orleans area. The program is administered by Entergy New Orleans.

The pilot was a 12-month study of residential and commercial solar photovoltaic (PV) applications to gather data on the performance, costs, and benefits of PV in the New Orleans area.[3] The results and key findings from the study are intended to improve New Orleans consumers' understanding of actual solar PV production and benefits, as well as increase Entergy New Orleans's understanding of the local impact of residential and commercial PV.

The study looked at 30 residential and three commercial PV installations in New Orleans. Of the 30 residential locations, 12 residences were Make It Right residences. Make It Right residences are constructed as energy efficient and healthy homes for communities that are Leadership in Energy and Environmental Design (LEED) Platinum certified—the highest level of certification. Of the 18 typical construction New Orleans homes, 17 homes were monitored; one home did not have location information or metered data. A portion of council district C is located outside of Entergy New Orleans' electric service territory. In addition, net metering is not allowed in the French Quarter portion of district C. Therefore, the majority of the homes and facilities in the study are in council districts A,B,D and E. However, district C was the site of one of the three commercial facilities included in the study. In summary, 29 valid residences were monitored and analyzed.

The three commercial PV locations were the Joseph A. Craig Elementary School, the Warren Easton Charter High School, and the New Orleans Science and Math High School. Only Craig Elementary had valid data.

The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) served as an independent entity to gather the results from the PV monitoring systems, analyze performance, and assess the costs and benefits of PV in New Orleans.

GSREIA and Make It Right coordinated procuring and deploying monitoring devices on the residential installations and provided NREL access to data. For the commercial installations, NREL worked directly with PV monitoring companies to access the data.

When making a decision about investing in a solar PV system, citizens and businesses in New Orleans will want to consider performance, costs, and benefits of PV in New Orleans. This document provides a broad overview of solar photovoltaic technology, a summary of PV performance in New Orleans based on the results of the pilot study, and discusses interconnection, permitting, incentives, net metering, emergency use, financing, and available tools.

[3] *Entergy New Orleans, Inc.'s Report in Support of Application for Approval of Programs to be Included in the Energy Smart New Orleans Plan and Related Approvals Pursuant to Resolution R-09-136 and the 2009 Agreement in Principle.* Entergy New Orleans, July 2, 2009.

Appendix A of this report provides information about how solar PV works in general and some of the key points required to implement solar PV in New Orleans. A portion of the analysis on the energy production of solar PV in New Orleans is included in Appendix A as well.

1.1 Photovoltaics in New Orleans

New Orleans had about 1,345 net metering customers at the end of 2012, equating to approximately 6.3 megawatts (MW) of installed PV solar capacity (Figure 1).[4] Residents and commercial entities in the New Orleans area may invest in solar energy for a number of reasons. Drivers may include a desire to invest in clean energy technology or a desire to hedge against rising energy prices. Some New Orleans residents and businesses may see the potential for solar energy to serve as a backup power source in the event of an outage. Solar PV may be a good choice for backup power when used with a battery bank and an inverter designed for this application. Without this configuration, a PV system will not provide backup power during a utility outage. For more information on solar energy as a backup power source, see the Section "Battery Backup and Emergency Use" in the Appendix A.

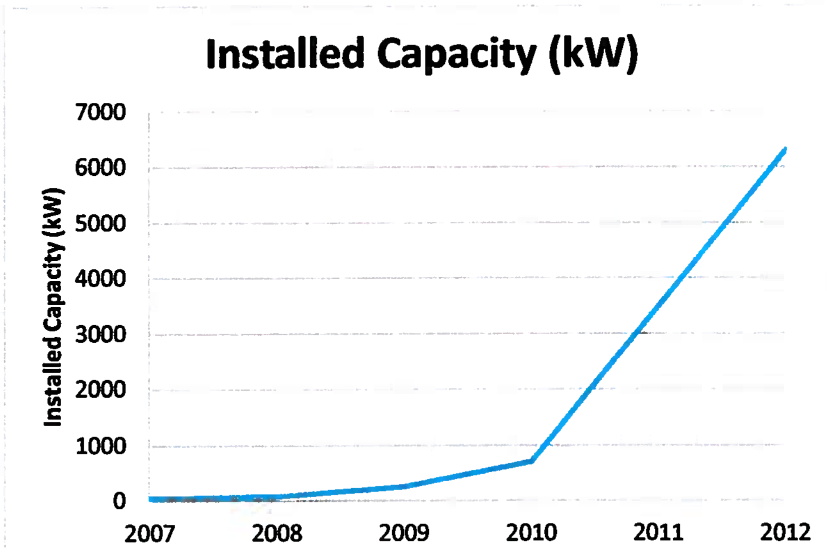


Figure 1. New Orleans installed PV capacity

Source: Energy Efficiency & Renewable Energy (http://www1.eere.energy.gov/solar/pdfs/50197_neworleans.pdf) & Entergy New Orleans

There are several incentives in place in New Orleans that residents and commercial owners can take advantage of when investing in PV. These are discussed under the section titled "Relevant Policies and Incentives" of this report. When considering a solar installation, it is wise to consult a solar installer that is familiar with local incentives, building codes, permitting, and interconnection processes. The GSREIA website provides a listing of many local area solar

[4] Data obtained from Entergy New Orleans.

contractors on their website.[5] The New Orleans Solar America City website also provides a list of contacts for purchasing solar energy systems.[6]

[5] For a list of local solar contractors, see the GSREIA website at: http://www.gsreia.org.
[6] For a list of contacts for purchasing solar energy systems, see: http://www.solarpowernola.com/where_to_buy_solar.htm.

2 Residential and Commercial Solar Photovoltaic Monitoring Pilot Study Methodology

2.1 Participating Sites—Residential

For multiple small solar systems, it is impractical and unnecessary to monitor every unit, so a sample is selected. The number of units in the sample is given by the expression:

$$\text{Sample Size N} = \frac{\{y*CV/r\}^2}{[1+\{y*CV/r\}^2/N]}$$

where

N = total population (i.e., total number of systems)

CV = coefficient of variation for population

y = "t" statistic (confidence level)

r = relative error

The assumptions made here are that the CV is 10% based on similar data output, the t statistic is 2 for a 95% confidence level, and the relative error is 5%, which takes into account error of the monitoring equipment. The required sample size is 16 residences that should be monitored to be a representative sample of the New Orleans solar market.

Thirty residential sites participated in the study as shown in Table 1. Of those sites, there were 12 Make It Right residences, which were constructed to be energy efficient, and healthy homes for communities. The other 18 sites were composed of typical New Orleans residences. One home did not have location information or metered data (NOLA #6). This home was removed from the study. Overall, all references to the residential data set include the 29 datasets that have valid data for use in this study.

The price of the installed system referred to in Table 1 may not include solar PV incentives or rebates that would reduce the total cost of the system.

With the assumptions from above, we can extend the results of our sample of the 29 valid residential PV systems to the total population of 1,345 net metered systems in New Orleans.

Table 1. PV Characteristics by Site

	District	Array Azimuth	Array Tilt	Array Power (kW)	Module Quantity	Module Make	Module Model	Inverter Make	Inverter Model
NOLA #1	A	185.9	17	3.24	12	Suntech	STP-270	Solectria	PVI 3000
NOLA #2	B	170	32	2.82	12	Conergy	235	Fronius	IG 3.0 Plus
NOLA #3	A	177	32	3.6	16	Schott	225	PV	3500

	District	Array Azimuth	Array Tilt	Array Power (kW)	Module Quantity	Module Make	Module Model	Inverter Make	Inverter Model
								Powered	
NOLA #4	B	165	28	5.06	22	Schott	230	PV Powered	4800
NOLA #5	B	175	32	13.2	60	Sanyo	220	PV Powered	4800
NOLA #6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NOLA #7	B	178	33	3.45	15	Canadian Solar	CS5P-230	Aurora PowerOne	3.6 kW
NOLA #8	A	185	25	5.98	*	Schuco	230 ESO9	Enphase	D-380
NOLA #9	B	195	33	4.625	25	Schuco	185 MPE	Enphase	D-380
NOLA #10	A	187	33	8.46	36	Canadian Solar	CS6P-235	Aurora PowerOne	4.2 kW
NOLA #11	A	185	23	9.2	40	Sunpower	230	SMA	SB5000 and SB3000
NOLA #12	D	218	30	3.36	14	Conergy	240	SMA	SB4000
NOLA #13	A	198	0	8.82	28	Sunpower	315	SMA	SB4000
NOLA #14	A	244	33.3	6.426	27	Sunpower	238	SMA	SB6000
NOLA #15	A	96	19	19.32	84	Sunpower	230	SMA	(2) SB6000 and SB5000
NOLA #16	A	200/110	30/20	5.75	25	Schuco	PS09-230	Enphase	380-5
NOLA #17	E	195	30	4.23	18	Canadian Solar	CS5P-235	PV Powered	3 kW
NOLA #18	E	195	15	4.14	18	Canadian Solar	CS5P-230	PV Powered	3.5 kW
NOLA #19	E	195	30	4.23	18	Canadian Solar	CS5P-235	PV Powered	3 kW
NOLA #20	E	195	28	4.14	18	Canadian Solar	CS6P-230	PV Powered	3.5 kW
NOLA #21	E	195	35	4.32	18	Canadian Solar	CS5P-240	PV Powered	3.5 kW
NOLA #22	E	195	30	2.7	15	Evergreen Solar	180	Xantrex	GT 3.3 kW
NOLA #23	E	195	35	2.8	14	Canadian Solar	CS6P-200	SMA	SB4000
NOLA #24	E	190	30	2.8	14	Canadian Solar	CS6P-200	SMA	SB4000
NOLA #25	E	195	28	4.14	18	Canadian Solar	CS6P-230	PV Powered	3.5 kW
NOLA #26	E	195	30	4.14	18	Canadian Solar	CS5P-230	PV Powered	3.5 kW
NOLA #27	E	195	20	2.8	14	Canadian	CS6P-200	SMA	SB4000

	District	Array Azimuth	Array Tilt	Array Power (kW)	Module Quantity	Module Make	Module Model	Inverter Make	Inverter Model
						Solar			
NOLA #28	E	195	28	4.32	18	Canadian Solar	CS5P-240	PV Powered	3.5 kW
NOLA #29	B	175	30	9.46	43	Sanyo	HIT-220A	Aurora PowerOne	4.2 kW
NOLA #30	A	225	30	5.16	24	Sanyo	HIT-215A	Aurora PowerOne	5.0 kW
NOLA #31	A	180	15	5.76	18	Sunpower	320	SMA	SB6000
Commercial	C	*	*	25.6	*	Sunpower	305	*	*

* Indicates variables that were unknown in the study

2.2 Participating Sites—Commercial

There were three commercial sites participating in the study. Of those locations, only the Joseph A. Craig Elementary School had metered data. The Warren Easton Charter High School and the New Orleans Science and Math High School installations did not produce any metered data. Therefore, Craig Elementary serves as an example of a commercial PV system but cannot be used as a representative sample of commercial PV installations in New Orleans.

2.3 Photovoltaic Data Acquisition Tool

The residential and commercial solar PV monitoring pilot study in New Orleans partnered with NREL's PV Data Acquisition (PVDAQ) program. PVDAQ is a comprehensive mapping tool to help industry and government planners study solar array efficiency. The PVDAQ project collects performance data from solar systems across the country to study trends in solar performance and degradation. Some of the solar performance data, with system owner consent, is publicly available on the PVDAQ website. In exchange for data to use in studies, NREL was providing storage and data analysis to the pilot study.

One of the purposes of monitoring data is for the owners of systems to see actual data to compare with expected production. Also, the monitoring gives owners the ability to identify malfunctions or design issues from the data. Figure 2 shows the progression of data in PVDAQ.

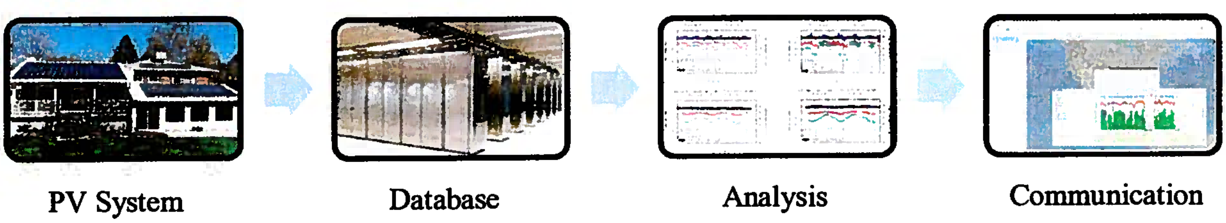


Figure 2. PVDAQ workflow of data

2.4 Photovoltaic Mapping and Photovoltaic Data Acquisition

Figure 3 shows the locations of the PV systems throughout the city in the light red bubbles with black dots. The red dots in each of the districts indicate the locations within the district that were used for public mapping via PVDAQ, the data collection tool. In all cases, this is a nonresidential public area (park, highway intersection, sports arena, etc.), which ensures privacy of the solar PV owner and their data used in the study.

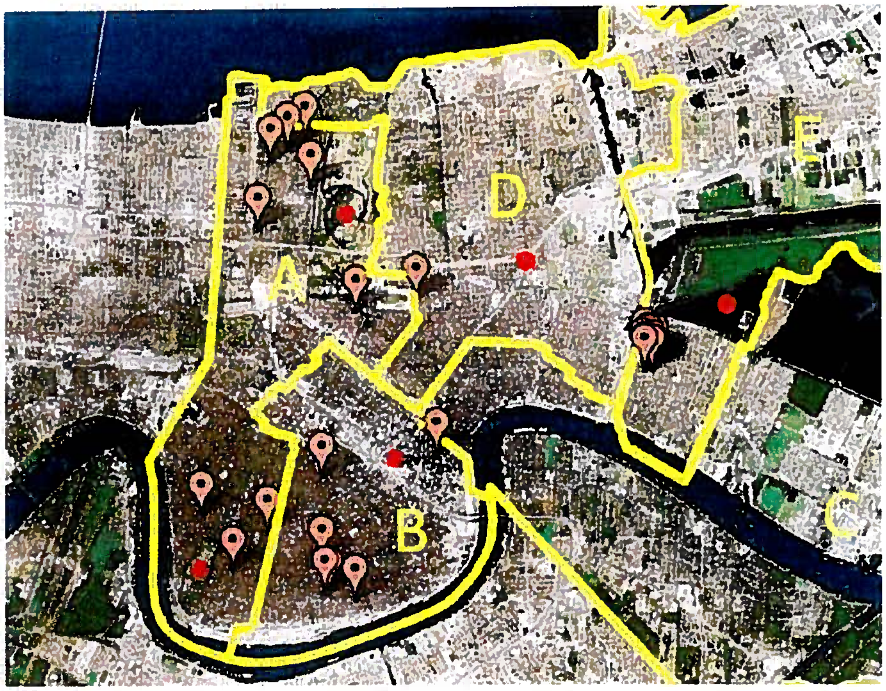


Figure 3. Locations of residential PV systems

Source: Google Maps (edited by Ryan Smith, NREL)

The commercial sites, including the two sites not included in the analysis, are displayed in Figure 4.

Figure 4. Locations of commercial PV systems

(Source: Google Maps)

Table 2 shows the distributions of residential sites among the districts.

Table 2. PV Sites by Council District

Council District	Make It Right Residence Site	Typical New Orleans Residence Site	Commercial Site
A	0	11	1
B	0	6	0
C	0	0	1
D	0	1	1
E	12	0	0
Total	**12**	**18**	**3**

2.5 Data Monitoring Technology and Data Collection

Data collection was highly dependent on the capabilities of the monitoring technology, as discussed in "Data Collection Challenges" in Section 2.5.3. Data collectors at the site recorded data every five minutes. Analyzed data looked at daily and monthly summaries of PV production.

2.5.1 Residential Data Collection

Locus Energy technology was used for data collection at the residential sites. The data stored at Locus Energy was collected manually every two months. One set of data had an unknown location and no metered data; therefore it was not included in the analysis.

Solar PV energy production and net energy consumption of the building data was collected from the residential data monitoring systems. PV energy production is the amount of electricity the PV panels produce over time and is measured in kilowatt-hours.

Net energy consumption is the total household consumption, where solar PV electricity reduces the actual consumption. The equation below demonstrates this metric:

$$\text{Net Energy Consumption} = \text{Total Energy Consumption} - \text{Solar PV Production}$$

Based on this equation and the data provided (solar PV production and net energy consumption), total energy consumption was calculated.

2.5.2 Commercial Data Collection

Deck Monitoring technology was used for the commercial sites. The data collection was automatically sent to NREL data servers each day. Data was unavailable at two sites, possibly due to poorly functioning measurement hardware. The result was valid data from a single commercial site, which is analyzed in the following section.

For the commercial system, no energy consumption data was available. Only solar PV energy production was collected and the total kilowatt-hours of production are provided in this report.

2.5.3 Data Collection Challenges

While the data provided here for both the residential and commercial solar PV systems is a comprehensive representation of the available data and is sufficient to support the findings of this report, some issues were encountered during data collection. The top reasons for not receiving data included:

- Intermittent signals. The communications radio can lose its assigned internet protocol address during an outage. The radio then requires a manual reboot to get back online.
- Lack of data storage. The particular brand of equipment only has 30 days of internal storage. At times, communications were lost for more than 30 days.
- Poorly operating equipment. One of the routers used to transmit data was periodically malfunctioning.

During the pilot study, there was a known installation issue with the current transformer clamps, which detect the flow of electricity, on a few systems; the clamps were installed exactly opposite for measuring solar PV production and net energy consumption for the buildings. This installation issue results in net metered data that was exactly opposite of the expected values. This is typically addressed by reversing the data; ten systems' values were converted to correct the data. On one system, it could not be determined if the installation issue was present; to be conservative about the quality of data, the system was removed from the net consumption analysis.

Monitoring equipment requires an Internet connection to transmit the data for storage. A finite amount of storage was available for data collection, and if the system did not connect to the internet in a timely basis, new data was recorded over previous data. Many service calls occurred during the pilot study that were specifically related to network connection issues between the internet modem and the data logger that is connected to the PV system.

Missing or inaccurate data is not uncommon. The best way to ensure quality data is to monitor for missing data on a regular basis.

2.6 Solar Photovoltaic System Reference Data

When looking at solar PV output data, comparison to benchmark data assists in understanding the potential of the system and to help see any issues with the solar PV system. The PVWatts tool,[7] which was developed by NREL, completes a PV analysis for a selected area and was used for this benchmark comparison. The tool outputs estimated alternating current (AC) energy generated and the energy value of the electricity output (Figure 5). The weather data employed here is from the Louisiana Agriclimatic Information System; Port Barre, Louisiana, had a complete year of hourly data to employ.[8]

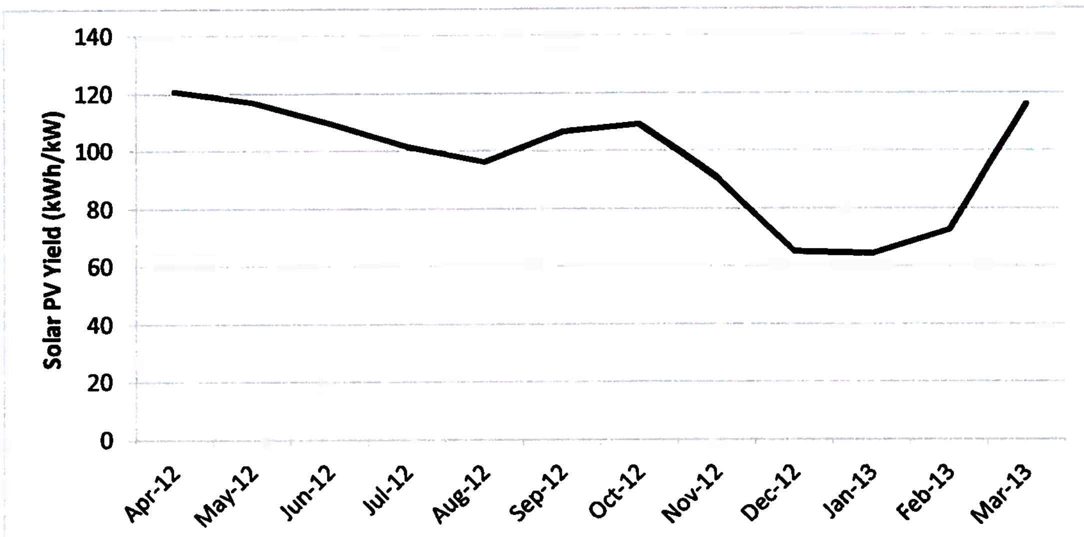


Figure 5. PVWatts solar PV production

Figure 5 shows the output of the PVWatts analysis. This data was used for comparison to the data from the pilot project. In New Orleans, the lowest electricity production by solar PV occurs in January, with peak production in the spring and fall. This data will be referred to as the reference data for the analysis.

[7] For more information about NREL's PVWatts tool, see: www.nrel.gov/rredc/pvwatts/.
[8] "Louisiana Agriclimatic Information System." LSU Ag Center, 2010. http://weather.lsuagcenter.com/Default.aspx.

2.7 Financial and Photovoltaic System Cost Data

For each site, a specific set of data was collected. This included the installed price for the system, as well as price per Watt (W). For the 29 residential systems, the average price was $4.99/W, prior to rebates and incentives. The Make It Right residences' overall average installed cost was $4.74/W, ranging from a minimum of $3.99/W to a maximum of $6.20/W. According to a study by NREL from February 2012, residential systems installed in 2010 averaged about $6/W.[9] The national average price per Watt of residential systems fell to $4.93/W in the first quarter of 2013.[10] Residential systems are typically more expensive than commercial and utility-scale systems due to reduced economy of scale.

Based on the solar PV production and the electricity rates provided in Table 3 during the study period, residents save about $11 per month on their electricity bill for every kilowatt of solar PV on the roof (Table 4). Thus, if the residence has 3 kW of PV on the roof, the owner saves $33 each month on their electricity bill.

Table 3. Electricity Rates for New Orleans

Month Year	Total ¢/kWh
April 2012	8.77
May 2012	9.84
June 2012	9.31
July 2012	10.27
August 2012	9.63
September 2012	10.03
October 2012	10.03
November 2012	10
December 2012	10
January 2013	9.59
February 2013	11
March 2013	10.6
Annual Average	**9.92**

[9] *Sunshot Vision Study*. U.S. Department of Energy, February 2012. http://www1.eere.energy.gov/solar/pdfs/47927_chapter4.pdf.
[10] Kann, S. "The Coming U.S. Distributed Solar Boom." Greentech Solar, June 14, 2013. http://www.greentechmedia.com/articles/read/the-coming-u.s.-distributed-solar-boom.

Table 4. Average Residential Electricity Savings for April 2012 to May 2013

District	Average Annual Electricity Savings per Residence	Average Monthly Electricity Savings per Residence	Average Monthly Electricity Savings/kW installed PV per Residence
A	$1,011	$86	$12
B	$781	$70	$11
D	$424	$35	$11
E	$397	$36	$10
Average across all districts	$653	$57	$11

Net present value (NPV) expresses the time value of money with the current value of all cash flows, including expenditures and payments. Here, NPV is used to show the current value of a solar PV system over its estimated 25 year life time.

The Make It Right residences' overall average installed cost was $4.74/W, ranging from a minimum of $3.99/W to a maximum of $6.20/W. The typical New Orleans residences' overall average installed cost was $5.38/W, ranging from a minimum of $3.70/W to a maximum of $6.47/W. To analyze the NPV across the range of installed costs, a sensitivity analysis was completed. The NPV analysis used the average size of the typical New Orleans residence solar PV system, which was 6.7 kW-DC and the average size of the Make It Right residence solar PV system, which was 3.7 kW-DC. Figure 6 and Figure 7 show the results of the NPV analysis of the residential solar systems, with and without incentives.

All inputs and assumptions used in the analysis presented in this report are in Appendix B including the values used for total installed costs, energy rate escalation, inverter replacement, electricity rates, etc.

Figure 6 and Figure 7 show the NPV analysis for a range of total installed costs per Watt ($/W), from $4.00 to $6.50. As seen in Figure 6, without incentives, systems on both types of residences are not cost-effective.

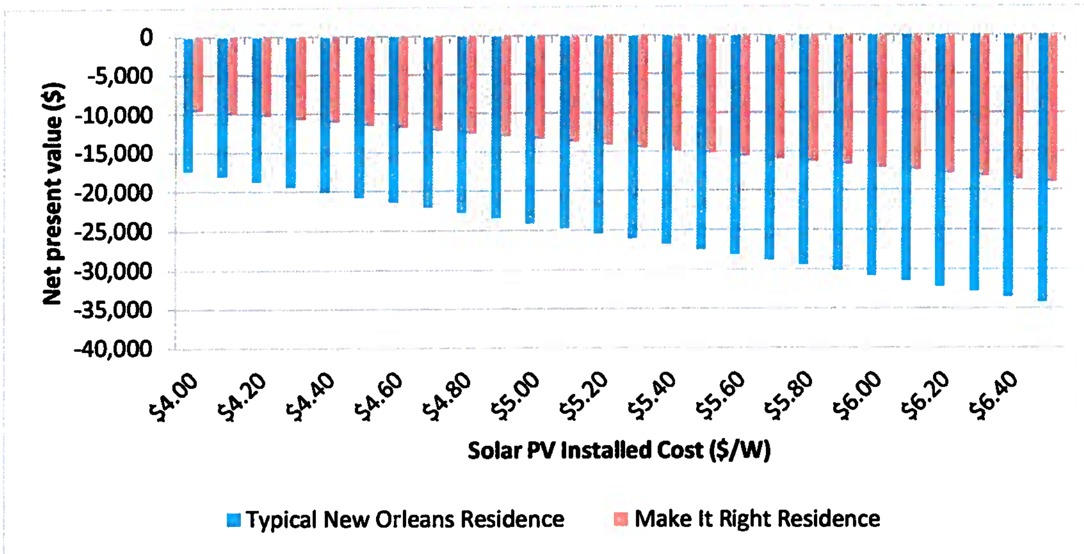


Figure 6. Net Present Value of Solar PV in New Orleans without Incentives

Under $6.10/W, the smaller Make It Right residence solar PV system has a positive net present value. Under $4.40/W, the typical New Orleans resident solar PV system has a positive net present value. These values are different because the typical New Orleans systems are so large in size that the Tax Credit for Solar Energy Systems on Residential Property (Personal), which has a limit of 50% of the first $25,000 of the cost of the system for purchased systems[11], is maxed out and the owner pays for a larger portion of the overall installed system costs. The Make It Right solar PV systems are smaller at 3.7 kW-DC (versus the 6.7 kW-DC for the typical New Orleans residence) and therefore less expensive in the first cost, which means the Make It Right system does not exceed the maximum incentive.

[11] While the credit for leased solar PV systems was revised, the credit for systems directly purchased by homeowners remains unchanged. Please see the "Relevant Policy and Incentives" section on page 28 for more details.

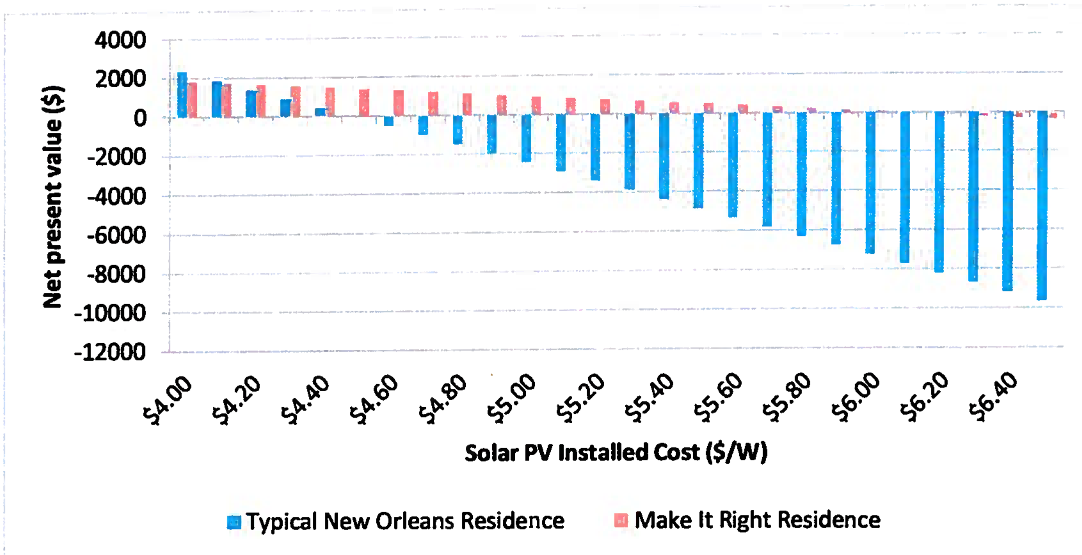


Figure 7. Net Present Value of Solar PV in New Orleans with Incentives

Compared nationally to other states, an investment in solar PV in Louisiana is worthy of further investigation, depending on the incentives and other characteristics of the site. As seen in Figure 5, Louisiana in general receives 4.5-5.0 kWh/square meter (m^2)/day in solar radiation, which is similar to other states like Florida, Georgia, and Virginia shown in Figure 6.

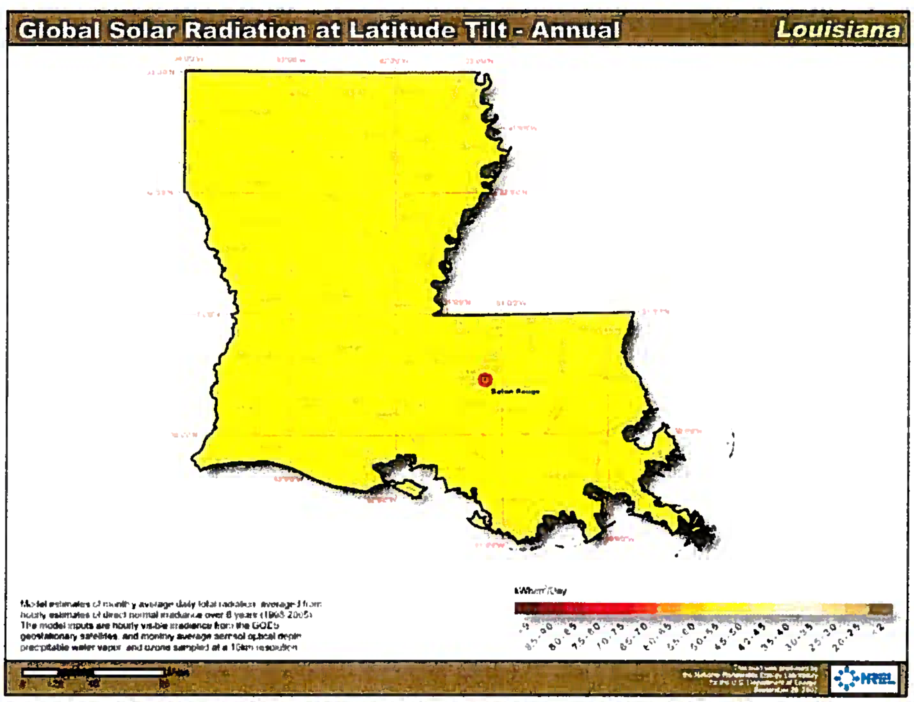


Figure 8. Louisiana solar resource

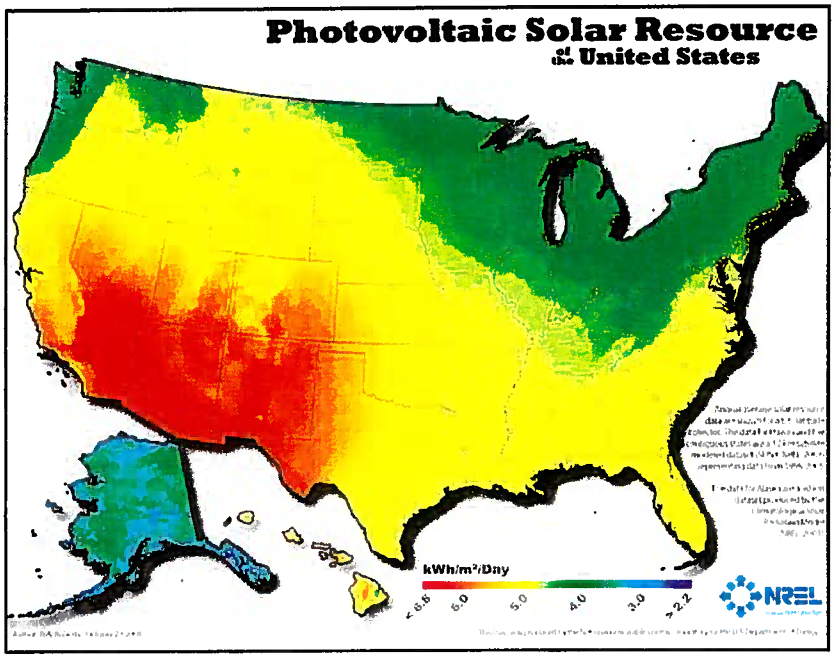


Figure 9. U.S. solar resource

With a solar resource of 4.5-5.0 kWh/square meter (m^2)/day, the value of PV energy production annually is greater than more northern regions of the U.S. and less than the highest solar resource areas such as the Southwest.

3 Results of the New Orleans Residential and Commercial Solar Photovoltaic Monitoring Pilot Study

Data collection for the systems in the pilot study started April 1, 2012. Data collected through March 31, 2013, was included in this report. All data from the 30 residential and three commercial sites was confidential and was not available for public viewing on the PVDAQ site.

3.1 Solar Photovoltaic Production at Residential Sites

Figure 10 shows the yield of the solar PV systems by council district. The graph shows the total energy output of the system in kWh, divided by the total system size in kW, which normalizes each system to the same production level. There was some variation for a variety of reasons:

- Each month does not have the same total number of days (for example, February had 29 days while March had 31 days)
- Differences in orientation of the system (tilt and azimuth)
- Variations in the weather yielded production output differences throughout the year.

Technically, the graphs show the equivalent of hours the system spent at maximum output. Another way to describe this is the total AC energy per month divided by the size of the system.

For all data analysis on residential systems, District E residences did not have data for November 15th through December 5th. For these months, values were interpolated using available data from October and January.

In Figure 10, generation in April-May 2012 was relatively high compared to the months leading into that same time of year in 2013. This could be because of weather differences between 2012 and 2013. The data was fairly consistent between months, with minimal changes between council districts.

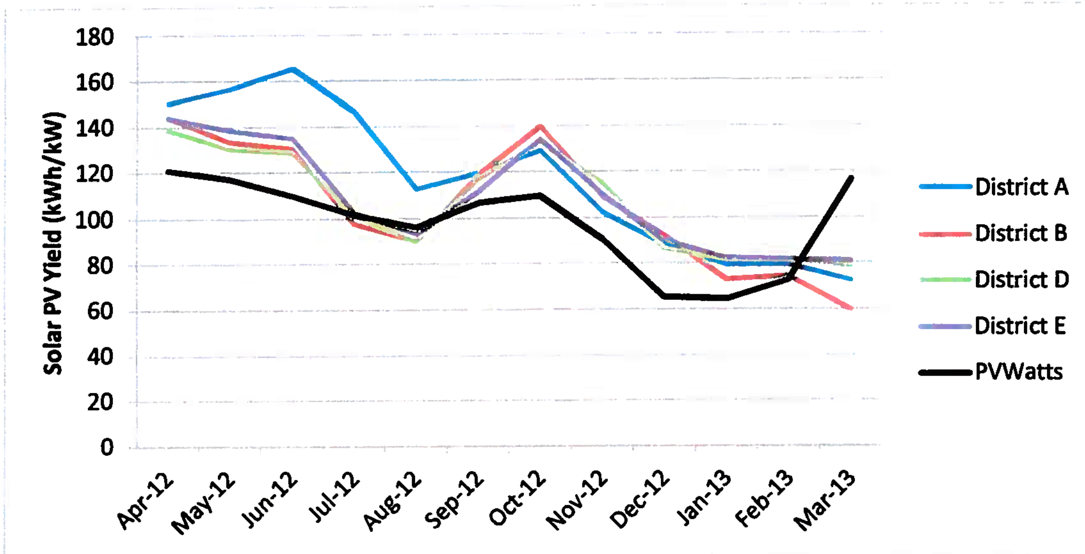


Figure 10. Residential solar PV production by council district[12,13]

The black line in Figure 10 and Figure 11 shows the expected system output for a typical solar PV system in New Orleans.

Figure 11 compiles the average output of each type of residence and compares typical New Orleans residences and Make It Right residences to reference PVWatts data, as previously described in Section 2.6. The data was fairly consistent between months, with minimal changes between council districts.

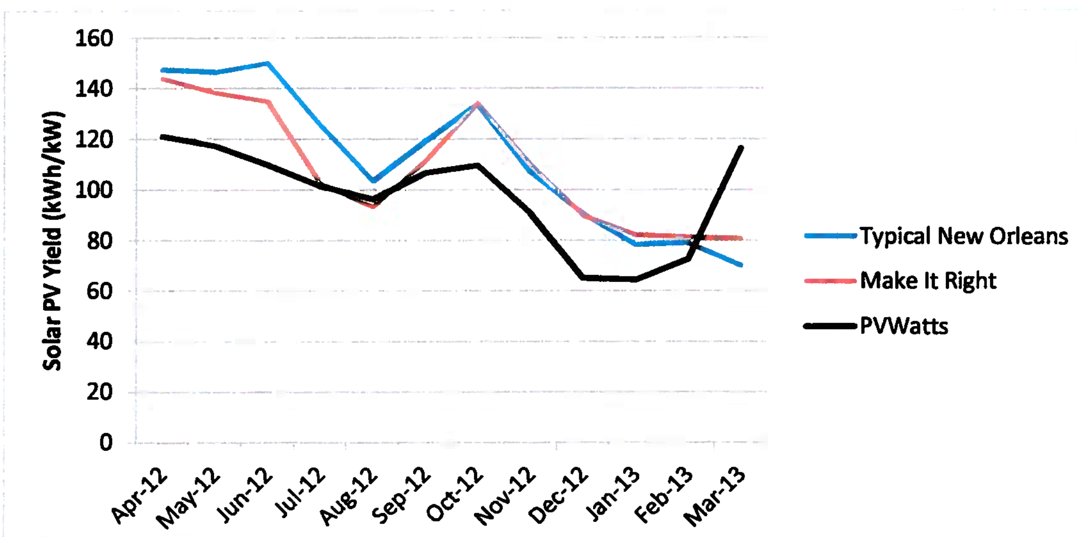


Figure 11. Residential solar PV production by residence site[14]

[12] District C did not have any residences in the monitoring study.
[13] Data for November and December of 2012 for Make It Right Residences is interpolated as described under Section 3.1.

The efficiency of the solar PV units can vary based on several factors, including:

- Conversion efficiencies. Equipment, such as PV panels, inverters, and other electronics, have a variety of conversion efficiencies.
- Panel mounting position. To maximize annual energy production, panels should be mounted at a similar angle to the latitude of the location (New Orleans is at approximately 30° North, so panels should be tilted at a 30° angle).
- Shading. PV panels shaded by nearby trees or other obstructions decreases the production of energy.
- Outdoor temperature. Solar panels function best in cooler temperatures.
- Soiled panels. Dirt on the collector decreases the energy production.
- Air circulation. Depending on the mounting system, air circulation behind the collectors cools the panels for improved production and vice versa.

3.2 Solar Photovoltaic Production Compared to Electricity Consumption at Residential Sites

Residential electricity consumption was monitored in the pilot study in addition to the solar PV production data. A known installation issue with the data collection devices caused some extreme outlier data to be removed, as discussed in "Data Collection Challenges" in Section 2.5.3. Council District D was removed due to poor net energy consumption data.[15]

Of the 18 residences with a complete year of energy consumption (eight in District A, four in District B, and six in District E), Table 5 shows the average residential electricity consumption by council district.

Table 5. Average Residential Electricity Consumption by District

	Average (kWh/yr)	Minimum (kWh/yr))	Maximum (kWh/yr)
District A	13,035	8,614	51,413
District B	11,351	3,714	42,889
District E	6,323	3,688	16,070

Table 6 shows the seasonal nature of monthly electricity consumption averaged over the district.

Table 6. Average Residential Electricity Consumption by Month and District

Date	District A	District B	District E
Apr-12	1788 kWh	1684 kWh	708 kWh
May-12	2310 kWh	2440 kWh	1112 kWh

[14] Data for November and December of 2012 for Make It Right Residences is interpolated as described under Section 3.1.

[15] See Section 2.5.1 for equation details.

Date	District A	District B	District E
Jun-12	2733 kWh	2973 kWh	1205 kWh
Jul-12	2618 kWh	2456 kWh	1156 kWh
Aug-12	2386 kWh	2224 kWh	807 kWh
Sep-12	2357 kWh	2541 kWh	771 kWh
Oct-12	1656 kWh	2458 kWh	606 kWh
Nov-12	1290 kWh	1985 kWh	146 kWh
Dec-12	1565 kWh	1900 kWh	773 kWh
Jan-13	1509 kWh	1894 kWh	940 kWh
Feb-13	1300 kWh	1646 kWh	659 kWh
Mar-13	853 kWh	1225 kWh	456 kWh

Looking at the net residential energy consumption by council district in Figure 12, District E with the 12 Make It Right residences were in the next lowest net residential energy consumers. The residences in District A may have larger building volume, resulting in higher energy use than the other council districts, which puts the net consumption higher in comparison.

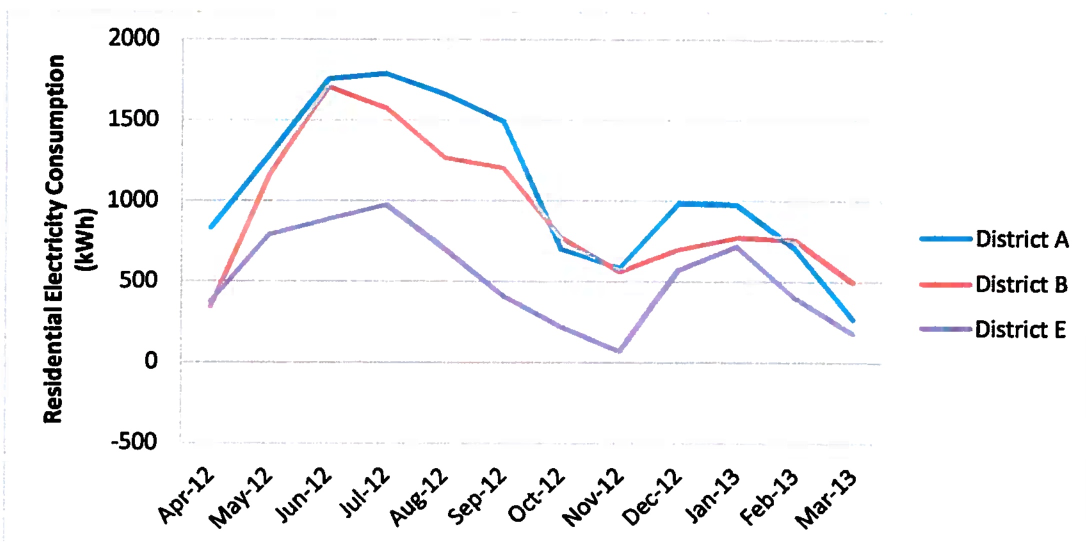


Figure 12. Residential electricity consumption by council district

Figure 13 shows the residential energy consumption by residence site. Again, Make It Right homes may have smaller building volume in this study, resulting in overall lower energy use than the other typical New Orleans residences, which puts the net consumption lower in comparison.

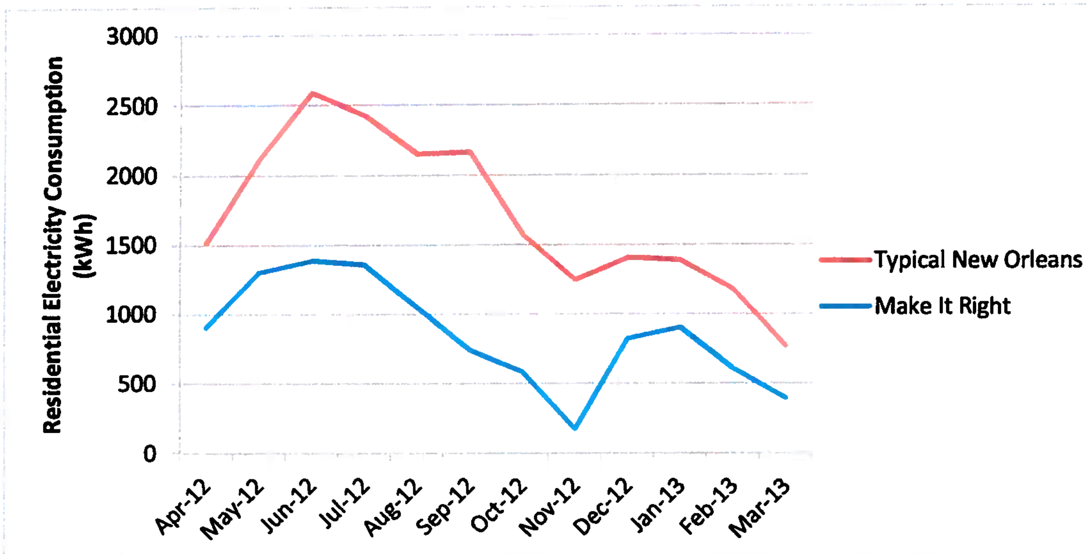


Figure 13. Residential electricity consumption by residence site[16]

The metric applied in the Figure 14 and Figure 15 is the percentage household energy consumption met by solar PV production. Since solar PV is sized to meet the demands of the residence, this metric can then be compared across the pilot study. The goal of the solar PV is to meet the electricity demand of the residence. Data for District E for the months of November and December was interpolated based on the previous and subsequent values.

As shown in Figure 14, the solar PV systems met 40% of the electricity consumption at the residences for the majority of the year. During the spring and fall seasons, the systems came closest to meeting the peak electricity consumption at the residences.

[16] Data for November and December of 2012 for Make It Right Residences is interpolated as described under Section 3.

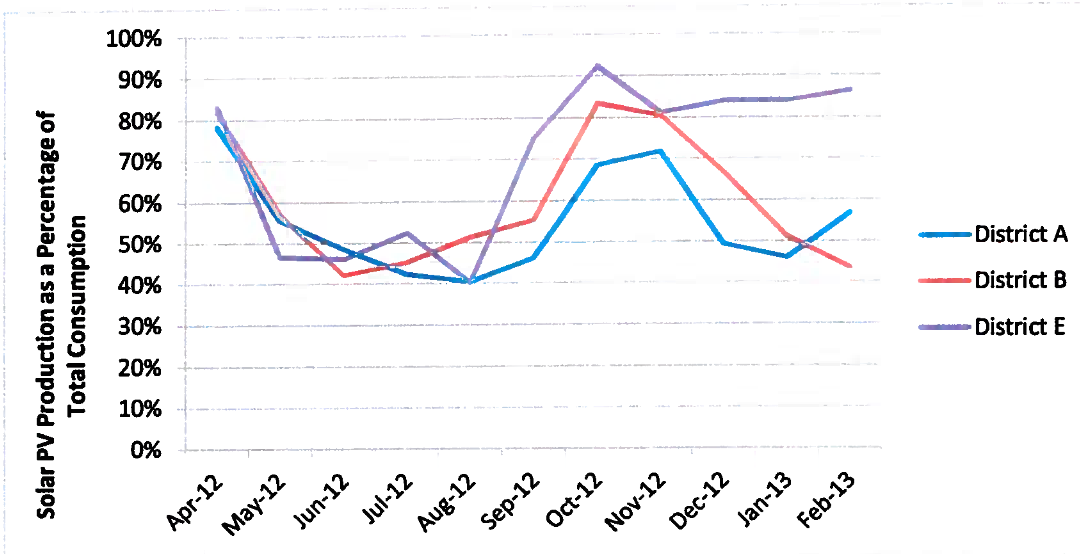


Figure 14. Solar PV production compared to residential consumption by council district[17]

Figure 15 shows that solar PV systems at both Make It Right residences and typical New Orleans residences met about the same percentage of household energy consumption. This is due to the relative size of the PV systems installed in the different locations and that the PV system is typically sized to meet the residential electricity consumption.

[17] Data for November and December of 2012 for Make It Right Residences is interpolated as described under Section 3.

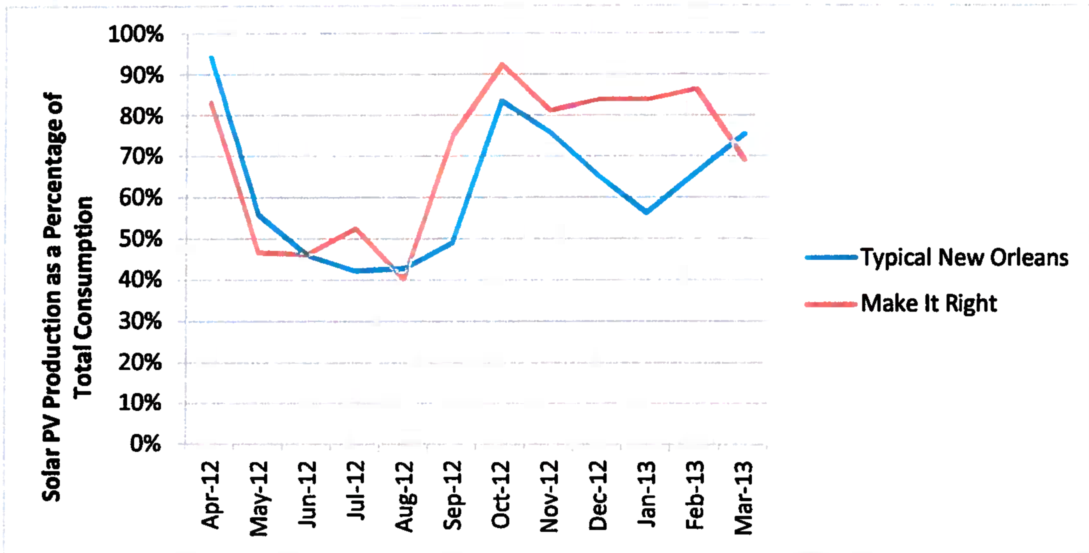


Figure 15. Percentage of energy consumption met by PV[18]

3.3 Solar Photovoltaic Production at Commercial Sites

The commercial location that had metered data was located at Craig Elementary (Figure 16). Data from the other two locations was not available.[19] The solar PV system experienced a data collection issue in April-May, when the total output of the system was very low, according to metered data. The black line in Figure 16 represents the reference data.

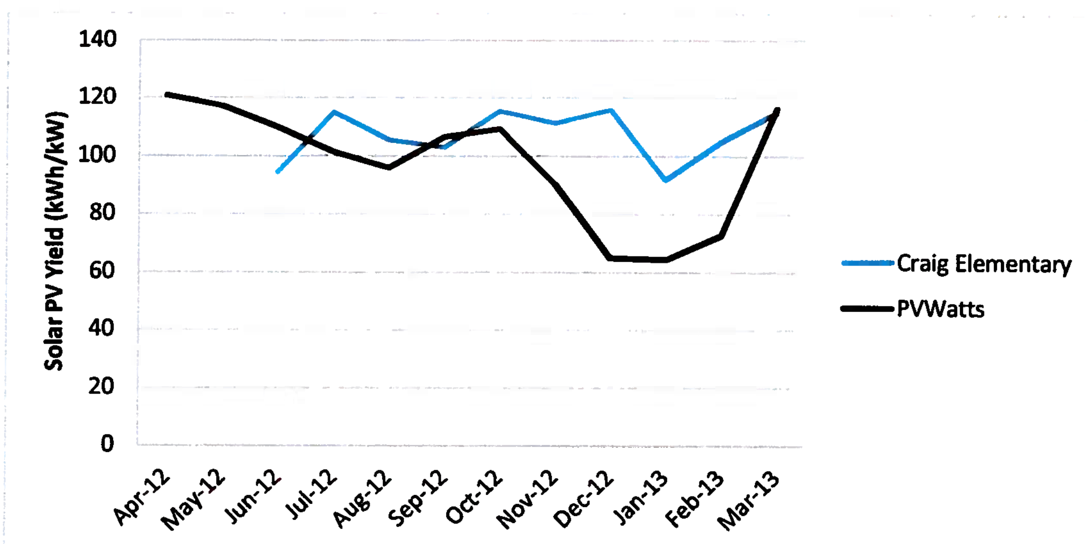


Figure 16. Commercial site solar PV production

[18] Data for November and December of 2012 for Make It Right Residences is interpolated as described under Section 3.

[19] See section 2.5.3 for additional details.

4 Conclusions and Key Findings

The one-year residential and commercial solar PV monitoring pilot project, part of the Energy Smart New Orleans Plan, successfully met the parameters outlined in the study to meter residential and commercial solar PV sites.

The pilot project aimed to gather data on the performance, costs, and benefits of PV in the New Orleans area.[20] The results and key findings from the study are intended to improve Louisiana consumers' understanding of actual solar PV production and benefits, as well as increase Entergy New Orleans's understanding of the local impact of residential and commercial PV.

One year of data collection from solar PV systems in New Orleans showed very similar outputs among the residential systems, and the data tracks closely to the expected solar PV system data from the PV Watts tool with some minor deviations.

Based on the average annual solar PV production of 1,171 kWh/kW for the sample of systems represented in this study, the New Orleans grid should expect approximately 7,600 megawatt-hours of savings per year, based on the study period year.[21]

- Overall among the 29 valid residences included in the pilot study all Solar PV systems met at least 30% of the electricity consumption for the year, with an average of 62%.
- On a council district level, production, normalized by the size of the system, is effectively the same in all physical locations, with a specific production ranging from a minimum of 38 kWh/kW to a maximum 165 kWh/kW.
- In the residential portion of the pilot study, while issues with the monitoring equipment excluded some data points, monitoring equipment enabled 90% of the total potential monthly data to be captured from the residential PV systems.
- Only one data set was collected for solar PV production in the commercial portion of the pilot (Craig Elementary) due to maintenance and technical equipment issues with the other pilot study sites; therefore, Craig Elementary serves as an example of a commercial system but not as a representative sample of commercial PV systems in New Orleans.
- Ensuring data monitoring systems are working is vital to performance monitoring of the system.
- Solar PV is continually becoming more affordable. Based on the financial analysis and assumptions presented in this report, solar PV in New Orleans is economically viable when considered over a 25-year time scale and when incentives are available.[22] Without incentives, systems on both Make It Right and typical New Orleans residences are not cost-effective.

---

[20] *Entergy New Orleans, Inc.'s Report in Support of Application for Approval of Programs to be Included in the Energy Smart New Orleans Plan and Related Approvals Pursuant to Resolution R-09-136 and the 2009 Agreement in Principle.* Entergy New Orleans, July 2, 2009.

[21] Value estimated from 6.3 MW of solar PV in New Orleans.

[22] See Appendix B for the financial analysis and assumptions.

Solar PV energy is a viable option in New Orleans for onsite electricity generation. Solar PV systems provide a good opportunity for New Orleans customers to locally generate electricity to reduce electricity bills.

Appendix A

Photovoltaics

Solar energy technologies, such as solar PV, are mature, commercially available renewable energy technologies and are widely deployed around the world. Many solar installations have been developed in New Orleans. All stakeholders involved in the adoption of this technology should understand the basics of solar electric energy production.

Solar PV technology converts energy from solar radiation directly into electricity. Solar PV cells are the electricity-generating component of a solar energy system. When sunlight (photons) strikes a PV cell, an electric current is produced by stimulating electrons (negative charges) in a layer in the cell designed to give up electrons easily. The existing electric field in the solar cell pulls these electrons to another layer. By connecting the cell to an external load, this current (movement of charges) can then be used to power the load, such as the light bulb shown in Figure A-1.

Energy Efficiency First

Before investigating the installation of solar PV on a residence, the energy efficiency of the home should be thoroughly evaluated. An energy audit will reveal areas where the home can reduce energy consumption. If the house makes more efficient use of energy, then less solar PV is required to be installed to meet the needs of the house.

According to DOE, residential buildings consumed 22% of the total energy consumed in the United States in 2010.[1] Therefore, the opportunities to save energy and money through the improved efficiency of buildings are significant.

[1] *Building Energy Data Book.* U.S. Department of Energy, 2010. http://buildingsdatabook.eren.doe.gov/ChapterIntro1.aspx

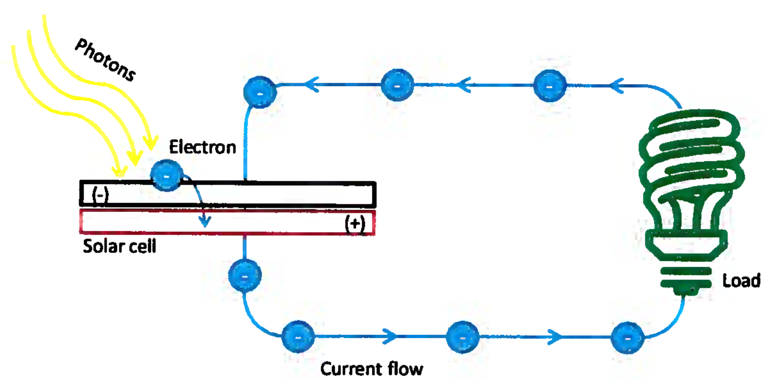


Figure A-1. Generation of electricity from a PV cell

PV cells are assembled into a PV panel or module. PV modules are then connected to create an array. When looking at solar PV panels, two metrics serve as an indication of energy output: solar PV panel rating and capacity factor. The panel rating tells the owner the rated size of the panel or the maximum output of the panel under full sun; this value is advertised by the panel manufacturer. Capacity factor is the ratio of actual output to the panel rating output at full capacity. Capacity factor is a measure of efficiency of the panel and is typically under 20% for commercially available panels.

Photovoltaic System Components

A typical PV system is made up of several key components including:

- PV modules
- Inverter
- Balance-of-system components.

A diagram of a typical ground-mounted PV system is shown in Figure A-2.

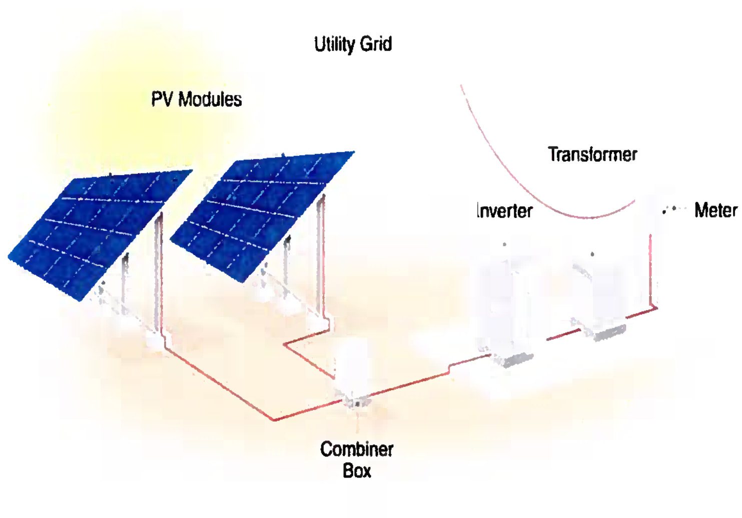


Figure A-2. Ground-mounted array diagram. ***Illustration by NREL***

Photovoltaic Module

Module technologies are differentiated by the type of PV material used, resulting in a range of conversion efficiencies from light energy to electrical energy (Figure A-3). The module efficiency is a measure of the percentage of solar energy converted into electricity. Typically, a solar installer will recommend an appropriate PV module for a proposed installation in New Orleans.

Figure A-3. Different types of solar panels. ***Photos from (left) Republic Services Inc. and (right) NREL 13823***

Inverter

Inverters convert direct current electricity from the PV array into alternating current and can connect seamlessly to the electricity grid. Inverter efficiencies can be as high as 98.5%. All systems installed in New Orleans and interconnected to the utility grid will require an inverter. Inverters also sense the utility power frequency and synchronize the PV-produced power to that frequency. When utility power is not present, the inverter will disconnect from the utility grid to prevent "islanding" or putting power into the grid while utility workers are trying to fix what they assume is a de-energized distribution system. This safety feature is built into all grid-connected inverters in the market. Without a battery backup system and a special inverter, the PV array will stop producing power altogether when the utility power fails. However, with a special inverter and a battery bank the PV array will be isolated from the utility grid and still capable of powering loads on site.

There are two primary types of inverters for grid-connected systems: string and microinverters. String inverters are most common and typically range in size from 1.5 kW to 1,000 kW(Figure A-4). These inverters tend to be cheaper on a capacity basis, are more efficient, and have lower operation and maintenance (O&M) costs. Microinverters are dedicated to the conversion of a single PV module's power output. Microinverters may be a good choice in situations where part of the PV array is likely to be shaded. The AC output from each module is connected in parallel to create the array. Inverters come with warranties, which is typically 10 years.

Figure A-4. String inverter. ***Photo by NREL 07985***

Mounting Systems

The array has to be secured and oriented optimally to maximize system output. The structure holding the modules is referred to as the mounting system. In the residential and commercial pilot study conducted in New Orleans, all installations were roof-mounted with the exception of the commercial system. However, both roof-mounted and ground-mounted systems are options in New Orleans.

Ground-Mounted Systems

For ground-mounted systems, the mounting system can be either directly anchored into the ground (via driven piers or concrete footers) or ballasted on the surface without ground penetration. Mounting systems must withstand local wind loads, which range from 90–120 miles per hour (mph) range for most areas or 140 mph or more for areas with hurricane potential. Depending on the region, snow and ice loads must also be a design consideration for the mounting system.

Typical ground-mounted systems can be categorized as fixed-tilt or tracking. Fixed-tilt mounting structures consist of panels installed at a set angle, typically based on site latitude and wind conditions, to increase exposure to solar radiation throughout the year. Fixed-tilt systems have lower maintenance costs but generate less energy (kWh) per unit power (kW) of capacity than tracking systems.

Tracking systems rotate the PV modules so they are following the sun as it moves across the sky. This increases energy output but also increases maintenance and equipment costs slightly. Tracking systems are most commonly ground-mounted systems.

The selection of mounting type is dependent on many factors, including installation size, electricity rates, government incentives, land constraints, latitude, and local weather. When considering ground-mounted PV systems, it is preferable to use brownfield or previously used land as opposed to green space that has never been developed. Contaminated land applications may raise additional design considerations due to site conditions, including differential settlement.

Roof-Mounted Systems

Installing PV on rooftops has many of the same considerations as installing ground-mounted PV systems. Factors such as available area for an array, solar resource, shading, distance to transmission lines, and distance to major roads at the site are just as important in roof-mounted systems as in ground-mounted systems. Rooftop systems can be ballasted or fixed to the roof, and it is recommended that the roof be relatively new (less than seven years old) to avoid having to move the PV system in order to repair or replace the roof.

Photovoltaic System Monitoring

Monitoring PV systems can be essential for reliable functioning and maximum yield of a system. It can be as simple as reading values, such as produced alternating current power, daily kilowatt-hours, and cumulative kilowatt-hours, locally on a liquid crystal display on the inverter. For more sophisticated monitoring and control purposes, environmental data such as module temperature, ambient temperature, solar radiation, and wind speed can be collected. Remote control and monitoring can be performed by various remote connections. Systems can send alerts and status messages to the control center or user. Data can be stored in the inverter's memory or in external data loggers for further system analysis. Collection of this basic information is standard for solar systems.

Weather stations are typically installed in large-scale systems. Weather data, such as solar radiation and temperature, can be used to predict energy production, enabling comparison of the target and actual system output, as well as performance and identification of underperforming arrays. Operators may also use this data to identify required maintenance, shade on panels, accumulating dirt on panels, etc. Monitoring system data can also be used for outreach and education. This can be achieved with publicly available, online displays; wall-mounted systems; or even smartphone applications.

Operation and Maintenance

The PV panels typically have a 25-year performance warranty. The inverters, which come standard with 10-year warranties (extended warranties available), would be expected to last 15 plus years. System performance should be verified on a vendor-provided website. Wire and rack connections should be checked annually. Annual O&M costs are estimated at $20/kW/year, based on the historical O&M costs of installed fixed-axis grid-tied PV systems. In addition, the system should expect a replacement of system inverters in year 15 at a cost of $0.25/W.

Battery Backup and Emergency Use

While PV systems do generate electricity, the generation is confined to times when the sun is shining. When a PV system is grid-connected and does not have a battery bank, it is not intended for emergency use, but rather to reduce the demand for electricity from the utility grid. In this case, if the utility power were to shut off, the PV system would shut off and not produce power, providing no backup energy. Without the proper hardware, the PV system would backfeed energy to the grid, causing additional complications within the grid system.

If backup energy is a priority, then a battery bank must be added to system. In this case, when the utility grid goes down, the inverter will isolate the PV system and battery from the utility grid. Electricity from the array will be used to charge the batteries or power loads. When the sun is not shining, the battery bank will support the emergency loads.

Battery backup systems will increase the cost and reduce the overall efficiency of the PV system. Other options, such as a natural gas or diesel generators, should be considered when choosing the appropriate backup system. These generators are noisy and require a fuel source, but may be more cost-effective than using solar for backup generation.

Relevant Policy and Incentives

Policies and incentives are constantly changing in renewable energy applications, so it is important to ensure that current ones are being used. As of August 2013, many are of particular interest for commercial and residential PV systems in Louisiana. These include:

Tax Credit for Solar Energy Systems on Residential Property (Personal) [23][24]

- Applies to solar systems on residential properties
- The credit is for up to 50% of the first $25,000 of the cost of the system, which includes installation costs, for systems directly purchased by homeowners
- From 7/1/13 to 12/31/13, the credit was for up to 50% of the first $25,000 of the cost of the system. As of 1/1/2014, the credit is for up to 38% of the first $25,000 of the cost of the system (up to 6kW), which includes installation costs, for systems leased by third-party owners, up to $4.50/Watt. Additionally, maximum systems costs have been set at:
    - Placed in service between 7/1/13 - 6/30/14: $4.50 per watt
    - Placed in service between 7/1/14 - 6/30/15: $3.50 per watt
    - Placed in service between 7/1/15 - 12/31/17: $2.50 per watt
- System should be grid connected, net metered or standalone

[23] "Tax Credit for Solar Energy Systems on Residential Property (Personal)." Database of State Incentives for Renewables & Efficiency, 2013. Accessed Nov. 6, 2012: http://www.dsireusa.org/solar/incentives/incentive.cfm?Incentive_Code=LA11F&re=1&ee=1.

[24] Federal and State Incentives are the product of legislation and therefore are subject to change.

- Tax credit may be combined with any federal tax incentive, but not other state incentives.

Solar Energy System Exemption[25]

- A solar energy system is considered to be personal property that is exempt from ad valorem
- When taxation assessments of buildings occur, the value of the solar system will not be included.

Federal Residential Renewable Energy Tax Credit[26]

- Taxpayer receives 30% of qualified expenditures for an eligible system
- Expenditures include physical property and labor costs.

Louisiana Solar Rights Act

- In June 2010, Louisiana enacted solar rights legislation that defines the right of use of solar collectors:

> A. For purposes of this section, "solar collector" means any device or combination of elements that relies on sunlight as an energy source.
>
> B. No person or entity shall unreasonably restrict the right of a property owner to install or use a solar collector.
>
> C. The provisions of this section shall not supersede zoning restrictions, servitudes as provided by Civil Code Article 697 et seq., or building restrictions, as provided by Civil Code Article 775 et seq., which require approval prior to the installation or use of solar collectors.
>
> D. The provisions of this section shall not apply to property or areas that have been identified as historic districts, historical preservations or landmarks by any historic preservation district commission, landmarks commission, or the planning or zoning commission of a governing authority.[27]

Home Energy Loan Program (HELP)[28]

- Five-year loan to help homeowners improve energy efficiency in their home

---

[25] "Solar Energy System Exemption." Database of State Incentives for Renewables & Efficiency, 2012. Accessed Nov. 6, 2012: http://www.dsireusa.org/solar/incentives/incentive.cfm?Incentive_Code=LA01F&re=1&ee=1

[26] "Residential Renewable Energy Tax Credit." Database of State Incentives for Renewables & Efficiency, 2012. Accessed Nov. 6, 2012: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US37F&re=1&ee=0.

[27] *Solar collectors, right of use.* Louisiana state legislation, Acts 2010 No. 274,§1 (June 2010). http://www.legis.state.la.us/lss/lss.asp?doc=725379.

[28] "Home Energy Loan Program (HELP)." Database of State Incentives for Renewables & Efficiency, 2013. Accessed Nov. 6, 2012: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=LA06F&re=1&ee=0.

Permitting

Governments and other authorities implement various requirements for standards compliance, safety, environmental protection, and cultural resources protection. An electrical permit is required for solar PV installation in New Orleans. A building permit is required for installations in New Orleans.

Interconnection

Interconnection is an electricity policy for consumers to interconnect energy generation systems, such as solar PV, to the utility grid. Under Louisiana's interconnection policy:[29]

- Residential facilities with a maximum capacity of 25 kW and commercial systems with a maximum capacity of 300 kW may interconnect. This is small compared to other states' policies.
- The utility provides the meter while the customer covers the installation costs.
- Customers who are interested in net-metering must submit paperwork prior to generating electricity for the grid.

Entergy New Orleans's requirements and paperwork for the interconnection agreement can be found here: http://www.entergy-louisiana.com/content/net_metering/ELL_Interconnection_Agreement_Net_Metering.pdf.

Net Metering

Once a customer has an interconnection with the utility, net metering is the electricity policy for consumers who feed energy back to the grid when a renewable energy system produces more than the building consumes. In this context, "net" is used to mean "what remains after deductions"—in this case, the deduction of any energy outflows from metered energy inflows. Under net metering, a system owner receives retail credit for at least a portion of the electricity it generates.

The State of Louisiana and Entergy net metering policy for renewable energy, including solar PV, states:

- The utility's retail rate is credited to the consumer for any net excess generation
- The credit is applied to the consumer's bill for the next period indefinitely
- For residential generation, net metering is available for up to 25 kW of capacity for customers who do not have any other generator connected to the grid.

The full description of net metering in New Orleans can be found here: http://www.entergy-neworleans.com/your_home/net_metering.aspx. Net metering rates are subject to change.

Financing Options

When looking to implement solar PV energy generation, understanding how to purchase and finance the system is key. The purchase model is where the owner purchases the system outright,

[29] "Interconnection Guidelines." Database of State Incentives for Renewables & Efficiency, 2013. http://www.dsireusa.org/solar/incentives/incentive.cfm?Incentive_Code=LA03R&re=1&ee=1.

without using any financing mechanism. With a purchase model, the homeowner retains ownership of all tax credits and electricity savings produced by the installed PV system. A system that is purchased directly by a homeowner will produce much greater savings over the life of the system compared to a system that is leased by a third party.

The third-party leasing model is another means of procuring the solar PV system. A number of innovative third-party financing structures developed in recent years have increased total deployment of residential and commercial systems, including solar lease programs. These third-party agreements allow individuals, businesses, and nonprofits to benefit from PV without requiring a high initial capital outlay or self-financing with loans. Third-party finance structures are designed to use these tax incentives in a way that benefits individuals, nonprofits, and others that would not otherwise benefit from their full theoretical value. Third-party financing also provides an option to those that are interested in consuming PV-generated electricity but unable to purchase a system outright.

For the Make It Right residences, several systems are owned by a solar leasing company. For the remaining Make It Right and typical New Orleans residential systems in New Orleans, the majority of the homeowners have purchased their systems and the system is individually owned.

Tools and Resources

When first investigating solar, there are several options to help evaluate the solar resource of the area.

The first way to evaluate solar is to look at a solar radiation map for the location of interest. As seen in Figure A-5, Louisiana in general receives 4.5-5.0 kWh/square meter/day, which is similar to other states like Florida, Georgia, and Virginia, as shown in Figure A-6.

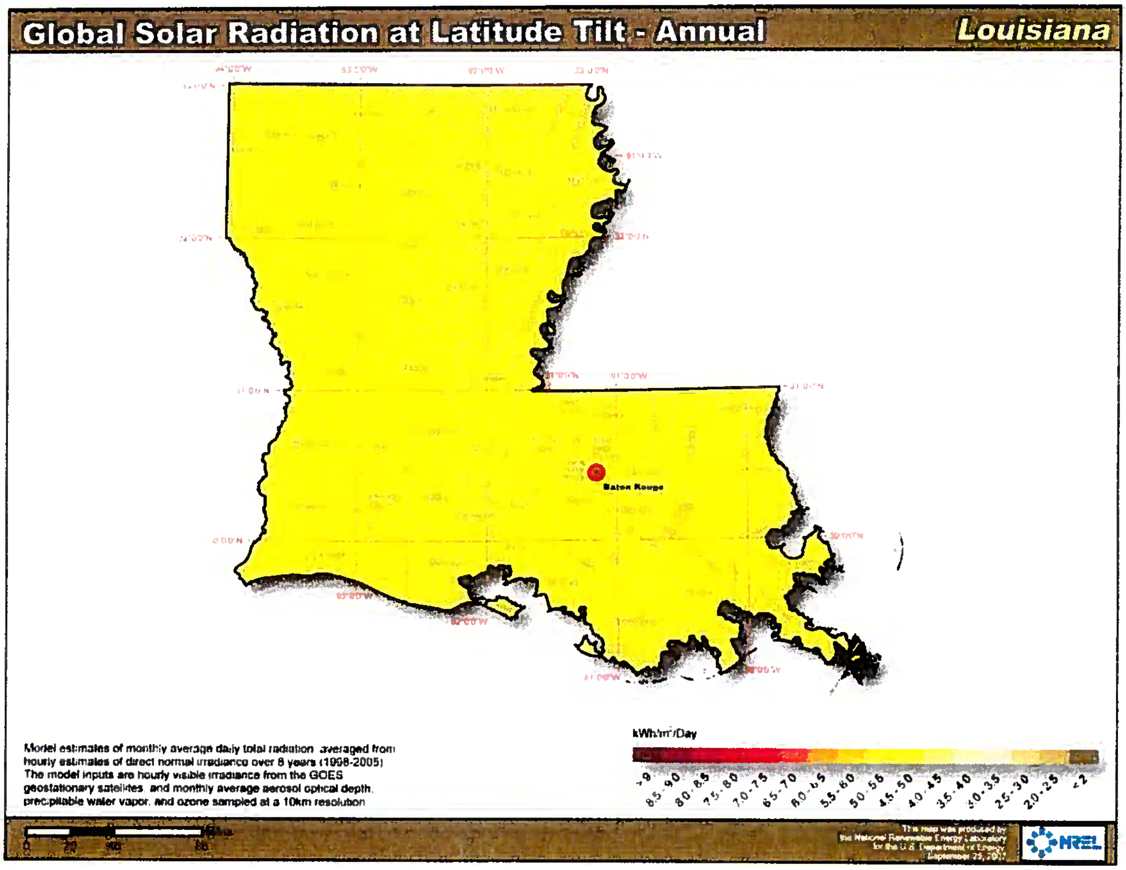


Figure A-5. Louisiana solar resource

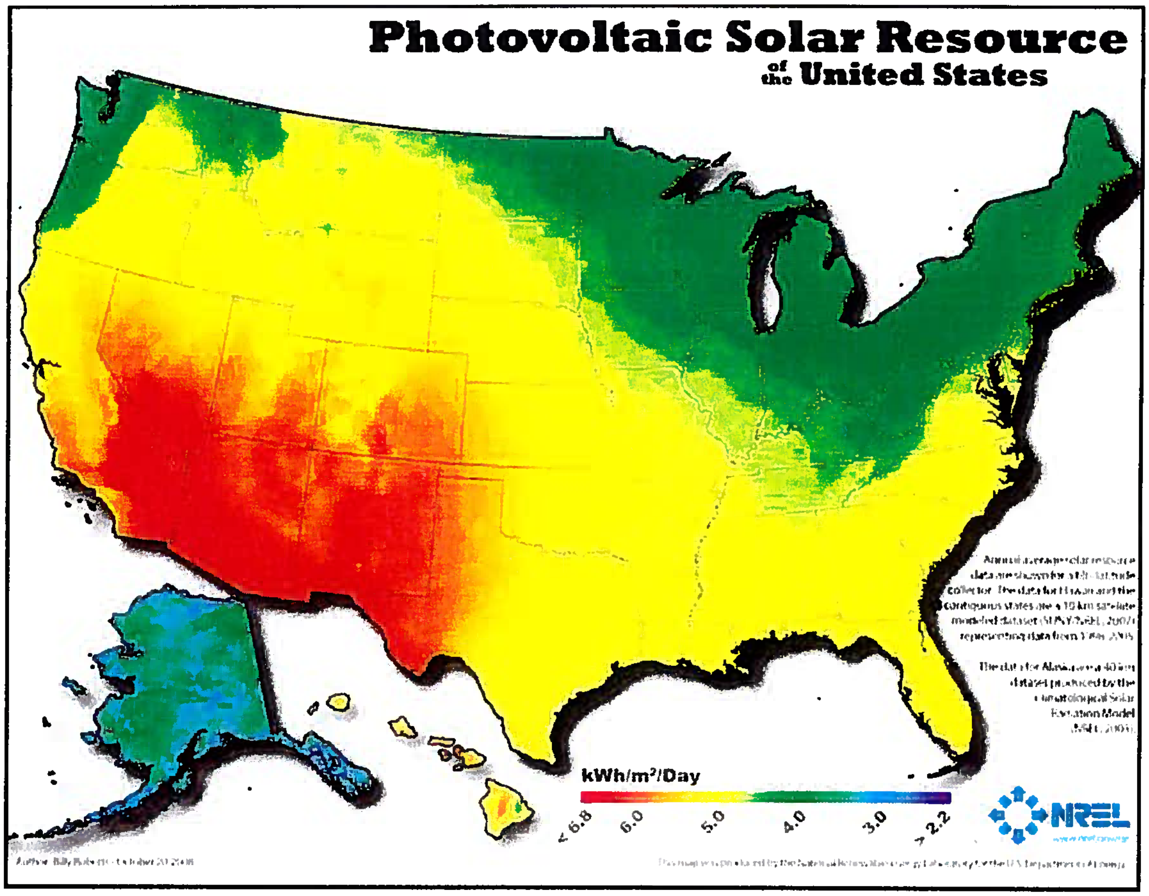


Figure A-6. U.S. solar resource

When looking to do a more detailed analysis, there are several tools that perform a closer examination into the solar resource at a particular location.

PVWatts

PVWatts,[30] which was developed by NREL, completes a PV analysis for a selected area. After choosing the location, the user can select default values or input customized system parameters for size, electric cost, array type, tilt angle, and azimuth angle. Typical meteorological year weather data for the selected location is used to calculate incident solar radiation and PV cell temperature for each hour of the year. It outputs estimated alternating current energy generated and the energy value of the electricity output. PVWatts is a quick, easy to use tool that is useful for users of all technical levels. Additionally, it is a widely accepted tool.

In My Backyard

In My Backyard (IMBY)[31] uses PVWatts data. The operator uses a cursor to outline the proposed PV system and the tool returns the feasible system size. The tool also looks up incentives, rebates, and system costs, as applicable. IMBY runs the production calculation using PVWatts

---

[30] For more information about PVWatts, see: www.nrel.gov/rredc/pvwatts/.

[31] For more information about the In My Backyard tool, see: http://www.nrel.gov/eis/imby/.

Version 1. The tool is interactive with a quick calculation run time and allows the user to modify all calculated values.

System Advisor Model

The System Advisor Model (SAM)[32] tool completes a financial analysis for various renewable energy technologies depending on a variety of input parameters. SAM includes solar PV incentives, retail electricity rate structures, and the resource data from partner sites to provide current modeling information. There are default parameters for construction, solar PV panel types, economics, and building loads. Besides solar, SAM can investigate other renewable energy technologies, including wind, biomass, and geothermal. Overall, SAM provides a comprehensive analysis of the cost-effectiveness of solar PV at the location of installation, and considers applicable incentives, as well.

[32] For more information about the System Advisor Model tool, see: https://sam.nrel.gov/.

Appendix B

Net Present Value

Net present value (NPV) expresses the time value of money with the current value of all cash flows, including expenditures and payments. Here, NPV helps to show the current value of a solar PV system over its estimated 25 year life time. NPV is given by the expression:

$$\text{NPV } i,\text{N}=t=0NRt(1+i)\text{NPV } (i, \text{N}) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

where

NPV = net present value

i = interest rate

N = number of periods

R_t = net cash flow for the period

Under the Tools and Resources section of Appendix A, the System Advisor Model (SAM) was presented as a tool for financial analysis. SAM has been used here as the NPV calculator with the PVWatts typical meteorological year data employed, so the data represents the average expected weather conditions of the system over the lifetime of the solar PV system. The production of this model falls between data collected from the typical New Orleans residences and Make It Right residences. For the analysis, the following assumptions were made:

- Analysis period of 25 years
- Net metering is in place
- Discount rate of 3.0%[33]
- Energy escalation rates for residential electricity as found in Table Cb-3 of the *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – 2013* document [32]
- Electricity rate of $0.0992/kWh[34]
- The solar PV system was purchased directly by the homeowner, rather than through alternative financing
- Performance degradation at 0.5% (compounded annually) per year over the life[35]

---

[33] *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – 2013*. National Institute of Standards and Technology. June 2013. http://www1.eere.energy.gov/femp/pdfs/ashb13.pdf.

[34] Electricity rate is the average rate over the study period from April 2012 to March 2013

- Inverter replacement at $250/kW-DC installed cost per system in year 15
- Annual operations and maintenance costs of $20/kW-DC/year
- The roof was new when the solar PV was installed and replacement is not needed over the life of the solar PV panels.

Since the total installed system costs obtained for this study did not include incentives, the analysis looks at the NPV without incentives and with incentives. The incentives that homeowners would qualify include:

Federal Residential Renewable Energy Tax Credit[36]

- Taxpayer receives 30% of qualified expenditures for an eligible system

Tax Credit for Solar Energy Systems on Residential Property (Personal) [37]

- The credit is for up to 50% of the first $25,000 of the cost of the system, which includes installation costs, for systems directly purchased by homeowners[38]

Table 7 shows the input values for the analysis for each type of residence.

Table 7. Average Array Size[39]

	Average Array Size
Typical New Orleans Residence	6.7 kW-DC
Make It Right Residence	3.7 kW-DC

[35] Jordan, Smith, Osterwald, Gelak, and Kurtz; *Outdoor PV Degradation Comparison*, NREL/CP-5200-47704, February 2011. http://www.nrel.gov/docs/fy11osti/47704.pdf.
[36] "Residential Renewable Energy Tax Credit." Database of State Incentives for Renewables & Efficiency, 2012. Accessed Nov. 6, 2012: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US37F&re=1&ee=0.
[37] "Tax Credit for Solar Energy Systems on Residential Property (Personal)." Database of State Incentives for Renewables & Efficiency, 2013. Accessed December 23, 2013: http://www.dsireusa.org/solar/incentives/incentive.cfm?Incentive_Code=LA11F&re=1&ee=1.
[38] As of July 1, 2013, the Tax Credit for Solar Energy Systems on Residential Property (Personal) was changed to reduce the credit amount for leased systems, among other changes.
[39] See Appendix B for details on computing NPV

Glossary[40]

Capacity factor	The ratio of the average load on (or power output of) an electricity generating unit or system to the capacity rating of the unit or system over a specified period of time.
Electricity	Energy resulting from the flow of charge particles, such as electrons or ions.
Energy	The capability of doing work; different forms of energy can be converted to other forms, but the total amount of energy remains the same.
Inverter	A device that converts direct current electricity to alternating current either for stand-alone systems or to supply power to an electricity grid.
Load	The demand on an energy producing system; the energy consumption or requirement of a piece or group of equipment. Usually expressed in terms of amperes or watts in reference to electricity.
Net metering[41]	For electric customers who generate their own electricity, net metering allows for the flow of electricity both to and from the customer—typically through a single, bi-directional meter. When a customer's generation exceeds the customer's use, electricity from the customer flows back to the grid, offsetting electricity consumed by the customer at a different time during the same billing cycle. In effect, the customer uses excess generation to offset electricity that the customer otherwise would have to purchase at the utility's full retail rate. Net metering is required by law in most U.S. states, but state policies vary widely.
Orientation	Placement with respect to the cardinal directions, N, S, E, W; azimuth is the measure of orientation from north.
Personal tax incentives[42]	Personal tax incentives include income tax credits and deductions. Many states offer these incentives to reduce the expense of purchasing and installing renewable energy or energy efficiency systems and equipment. The percentage of the credit or deduction varies by state, and in most cases, there is a maximum limit on the dollar amount of the credit or deduction. An allowable credit may include carryover provisions, or it may be structured so that the credit is spread out over a certain number of years. Eligible technologies vary widely by state. In recent years, the federal government has offered personal tax credits

[40] Definitions for glossary terms were obtained from http://www1.eere.energy.gov/solar/sunshot/glossary.html#photovoltaic_array, except where noted.
[41] Definition obtained from http://www.dsireusa.org/glossary/.
[42] Definition obtained from http://www.dsireusa.org/glossary/.

	for renewables and energy efficiency.
Photovoltaic(s) (PV)	Pertaining to the direct conversion of light into electricity.
Photovoltaic (PV) array	An interconnected system of PV modules that function as a single electricity-producing unit. The modules are assembled as a discrete structure, with common support or mounting. In smaller systems, an array can consist of a single module.
Photovoltaic (PV) cell	The smallest semiconductor element within a PV module to perform the immediate conversion of light into electrical energy (direct current voltage and current). Also called a solar cell.
Photovoltaic (PV) panel	Often used interchangeably with PV module (especially in one-module systems), but more accurately used to refer to a physically connected collection of modules (i.e., a laminate string of modules used to achieve a required voltage and current).
Photovoltaic (PV) system	A complete set of components for converting sunlight into electricity by the photovoltaic process, including the array and balance of system components.
Solar energy	Electromagnetic energy transmitted from the sun (solar radiation). The amount that reaches the earth is equal to one billionth of total solar energy generated, or the equivalent of about 420 trillion kilowatt-hours.
Solar resource	The amount of solar insolation a site receives, usually measured in kWh/m2/day, which is equivalent to the number of peak sun hours.
Storage battery	A device capable of transforming energy from electric to chemical form and vice versa. The reactions are almost completely reversible. During discharge, chemical energy is converted to electric energy and is consumed in an external circuit or apparatus.
Tilt angle	The angle at which a photovoltaic array is set to face the sun relative to a horizontal position. The tilt angle can be set or adjusted to maximize seasonal or annual energy collection.
Transformer	An electromagnetic device that changes the voltage of alternating current electricity.
Watt (W)	The rate of energy transfer equivalent to one ampere under an electrical pressure of one volt. One watt equals 1/746 horsepower, or one joule per second. It is the product of voltage and current (amperage).