Spring 2014

Analyzing the Economic and Energetic Sustainability of Pursuing Solar Energy in New Orleans, Louisiana

Jacob Gaskill

Analyzing the Economic and Energetic Sustainability of Pursuing Solar Energy in New Orleans, Louisiana

Jacob Gaskill

Introduction

Natural disasters are horrible events. They destroy infrastructure, displace residents, and lead to the expensive and time-consuming process of re-building. However, they also create a very unique opportunity for the municipality that oversees this rebuilding. A large influx of federal aid and the pressing need for large-scale infrastructure construction creates this opportunity by asking questions about how the municipality will invest its resources. Is it a better use of resources to try and re-create what was in place previously in the cheapest way possible, especially considering the very real possibility of another natural disaster? Or should efforts be made to improve living conditions, take steps toward "sustainability," and create a better version of what was in place before, even if it means that initial building costs will be higher? Quantifying some of the pros and cons to these resource allocation strategies can provide some insight to how these questions can be answered. Only through a holistic approach that takes into account both economics and energy can we begin to answer the "sustainability" aspect of this question.

There are many definitions for "sustainability," but one of the most commonly referenced ones was developed by the Bruntland Report and is the definition used by the United States Environmental Protection Agency (EPA). This definition claims that sustainability is: "Development that meets the needs of the present without compromising the ability of future generations to meet their needs" ("Definition of Sustainability," n.d.). To accomplish this, a very measureable, quantifiable approach must be taken. Too often are "green" practices utilized without fully being analyzed. Companies, governments, and colleges implement these green practices to improve their image, take advantage of federal or state incentives, or increase sales. We are at a point now where the "green label" is fashionable and is used to sell products and gain publicity. Called green-washing, this process often does not contribute to achieving sustainability and might even be counterproductive. This is why it is important to quantify benefits of green practices so that they can be compared to costs, both from an economic and energetic perspective.

This is especially true when dealing with energy systems. If a particular system costs more energy to install than it will produce over its lifetime, it cannot be considered sustainable, even if the energy it produces does not release many pollutants. However, since it is impossible to know the exact lifespan of a particular system, these estimations contain some degree of error. In a controlled setting, the lifespan of many of our current energy systems are well known, but uncertainty exists concerning the lifespan of these systems when they are actually functioning. Most energy systems are outside, exposed to the elements and environmental extremes. This can make it difficult to predict the actual lifespan of a particular energy system, and mistakes are made often. Off-shore wind farms were considered to have great potential and were built in several different locations. However once in operation, the turbines were corroded by the salt water, causing them to need to be repaired several years before predicted. In The Netherlands, an unexpected sinking of offshore wind turbines due to the shifting seabed caused a dramatic decrease in efficiency (Aardvark, 2012). Repairs are energy intensive, and detract from the total energy produced by the turbines. However, despite the uncertainty in predictions, there is no better way to quantify the potential of new energy technologies. Predictions are the best thing available to us and so we must rely on predictions to guide our implementation of green technologies, including solar panels.

In certain parts of the world, environmental variability is of greater concern than others. From a solar energy perspective, hurricanes, hailstones, and flying debris have all been known to damage or destroy panels. This creates the need for costly repairs that decrease the overall energetic and economic benefits originally provided by the solar panels. Certain regions of the country are more prone to these types of conditions than others. It is important to use quantification analyses to determine if installing solar panels in these disaster prone areas is a worthwhile use of resources and actually contributes to the overall goal of achieving sustainability, or is just another form of green washing. If a solar PV (photovoltaic) array has a likely chance of being damaged or destroyed before it can payback its costs (both from an economic and energetic perspective), it is senseless to install the panels.

New Orleans is one such disaster prone area that has experienced very damaging weather in the past decade, most notably from Hurricane Katrina in 2005. Rebuilding efforts focused on constructing homes for the thousands of displaced persons. One of the most publicized groups to build these homes was the "Make it Right 9" organization. Known as the "Brad Pitt Houses" (it was Brad Pitt that created this group in the aftermath of Hurricane Katrina), these progressive homes were designed to incorporate many green technologies, including solar panels. They received very mixed responses from the public. Many felt that the homes were not consistent with the traditional themes of other homes in the neighborhood and were a frivolous waste of resources that were in short supply (Bernstein, 2009). While the traditional neighborhood themes may be difficult to measure, it is possible to gain some insight into the frivolousness of building these homes with "green" infrastructure. The benefits to these green building techniques are often quantifiable, though there will always be some degree of error associated with these calculations due to assumptions. However, no public analysis exists that examines the sensibility of installing these green building techniques into a disaster prone area like New Orleans.

Purpose

This study attempts to answer the question of whether or not it make sense to build new structures in a way that conserves and uses energy more efficiently if these structures have long payback periods and are situated in disaster prone regions. Specifically, I will quantify the sustainable potential of installing solar panels in New Orleans, Louisiana. This will be done by comparing the average time between severe hurricanes with the economic and energetic payback periods of solar PV arrays.

Methods

In these types of quantification analyses, several assumptions must be made. For example, this study assumes that the installation of solar panels is done in the most effective way possible and that the workers installing the panels made sure to angle them properly and install them in places of minimal shade. Several other assumptions more specific to the calculations are iterated below along with the steps taken to perform this analysis and the sources for the utilized data. Three different sized solar arrays were used for this study: 3kw, 4kw, and 5kw. All analyses were ran for each of these ratings because this is a typical range for residential buildings ("Clean Power Estimator," n.d.). For a frame of reference, one of the residents of a recently constructed Make It Right 9 home owns a solar array rated at 3kw (Lavelle, 2010).

Economic Analysis

For this study, the PVWatts v.1 solar calculator was used to determine the savings that different sized PV arrays produced ("A Performance Calculator for Grid-Connected PV Systems," (n.d.). This calculator is applicable to many of the major cities located within the United States, so "New Orleans" was used to calculate savings in New Orleans. For this analyses, I used the "recommended" settings given by the solar calculator: 8.1 cents per kwh (the state average for electricity prices), a fixed tilt with panels facing south, and a DC to AC derate factor of 0.77. Based on these parameters and the size of the system selected (either 3kw, 4kw, or 5kw for the purposes of this study), the solar calculator produces a yearly savings in dollars. This savings amount is compared to the total costs of the solar panel, after federal and state incentives and tax credits. The "Clean Power Estimator" (n.d.) on the NYSERDA website lists $5,000 per kw as the default cost for PV systems (for example a 4kw PV array would cost $20,000), so this number was used in my study as well. The cost of panels has been known to fluctuate in the past, as it is affected by supply, demand, overproduction, and economies of scale (Hall and Klitgaard, 2013). How these factors affect the market for solar panels is very important in determining the overall costs to consumers and are explored in greater detail in the Discussion section, below. Economic sustainability was calculated at a household level, so the costs used for this analysis were the costs of the PV system to the homeowner after federal and state incentives and tax credits were accounted for. The federal government currently discounts solar PV systems by 30% and the state of Louisiana discounts solar PV systems by an additional 50% (Lavelle, 2010), so the cost to homeowners in this study was found by multiplying the total cost of each PV system by 0.8 (a total of 80% of the PV system is discounted by federal and state incentives). The amount of time it took for the PV system to pay for itself through net metering and energy savings, or Payback Period, was found by dividing the cost for the homeowner by the yearly savings (in dollars) determined by the solar power calculator. This number was compared with hurricane data to evaluate the economic sustainability of installing solar panels in New Orleans.

Weather Analysis

"Ethical Solar FAQ" (n.d.) is a not-for-profit organization that attempts to educated the public about solar energy. They provide ratings for commercial solar panels, including resistance to wind speed. They rate commercial grade solar panels as being resistant to winds of up to 122 mph. Ross (2010) has compiled a list of all the hurricanes in Louisiana since 1852 and provides all of their maximum recorded wind speeds in increments of 5 mph. For this study, I took two approaches. The conservative approach found the average time between all hurricanes with wind speeds of at least 100 mph. It is impossible to know whether or not the highest *recorded* speed was the *actual* highest wind speed during any given hurricane, especially for the older storms that occurred when instrumentation was not as fine as it is today. The conservative approach allows for a small cushion to account for this. The best-case approach looked at all hurricanes with wind speeds of at least 120 mph. This analysis assumes that the highest *recorded* wind speed was the *actual* highest wind speed that occurred during the hurricane and that solar panels would not be damaged in storms that did not have as fast of winds. Once the average time in between storms was found for both approaches, it was compared with the economic and energetic payback periods in order to evaluate the sustainability of each.

Energetic Analysis

For the energetic analysis, I used a conversion factor that accounts for the energy used per dollar spent. This made it possible to estimate the energy required to build, transport, and install each solar PV system. The conversion factor I used was 7.65 MJ per 2005 dollar and was obtained from Hall et al. (in press). Basically, this means that for every 2005 US dollar spent, 7.65 MJ of energy are used in a combination of production, transportation, and resource extraction. For this conversion, the total costs (in dollars) of each rated PV system before any of the federal or state tax credits or incentives was used, since these incentives do not reduce the energy that goes into producing a solar panel.

After converting the dollar costs of each PV array into energetic costs using the 7.65 MJ per dollar conversion factor, I found the energetic production of each system. The solar PV calculator on "PVWatts v. 1" (n.d.) takes into account latitude and past solar trends to estimation the production of each PV system in AC kwh/year. Each production estimate was converted into MJ using the conversion factor of 1 kwh = 3.6 MJ. Once conversion to a common unit had taken place, the energetic costs (in MJ) were subtracted from the PV array production (in MJ). This number was then multiplied by 25 years to find the production over the systems lifespan (in MJ). The expected lifetime of each PV array is 25 years, according to "Ethical Solar FAQ" (n.d.). Net production (in MJ) was found by subtracting the energetic costs (MJ) from the Production over Lifespan (MJ). Economic Payback Time Production is the energetic production (in MJ) that each PV array will generate over the number of years that it must function to recoup the original costs of the solar PV array paid for by the homeowner. The Energetic Payback Period was found by dividing the energetic costs of installing the array by the yearly production.

EROI (energy returned on energy invested) is calculated by dividing the energy output of a system by the energy that goes into creating that system (Hall and Klitgaard, 2012). This is useful when evaluating a particular systems worth, but in this case it was used as a rough check. The crude EROI I calculated for this study was only slightly lower than the EROI calculated for solar PV systems in more thorough EROI analyses (Prieto and Hall, 2013), indicating that the calculations of this study are sound.

Results

It takes 9.7 years for a 3kw, 4kw, or 5kw solar PV array to pay for itself (Table 1). The average time between hurricanes with wind speeds great enough to damage or remove solar panels is 8.4 years, but a more conservative estimate that takes into account slower wind speeds (of at least 100mph) finds the time between storms to be 3.6 years (Table 2). From an energetic perspective, it takes 8.3 years for PV arrays of 3kw, 4kw, and 5kw to pay for themselves (Table 3).

Economic Analysis

Table 1: The economic savings and costs of installing three different sized PV arrays from a home owners perspective.

	3 kw	**4 kw**	**5 kw**
Savings ($/yr)	$310.31	$413.83	$517.27
Costs (before rebates)	$15,000	$20,000	$25,000
Costs (after rebates)	$4,500	$6,000	$7,500
Payback time (yrs)	9.7	9.7	9.7

Weather Analysis

Table 2: A summary of all hurricanes occurring in Louisiana since 1852 with wind speeds of at least 100mph. For a complete list of all hurricanes that meet these criteria, refer to the Appendix.

# of Hurricanes w/ Wind Speeds at Least 100mph at Mouth of Mississippi R. Since 1852	**5**
Average Time Between LA Hurricanes with Wind Speeds at Least 100mph	**3.6 years**
Average Time Between LA Hurricanes with Wind Speeds at Least 120mph	**8.4 years**

Energetic Analysis

Table 3: The energetic savings and costs of installing three different sized PV arrays from a homeowners perspective.

	3 kw	**4 kw**	**5 kw**
Costs (before rebates)	$15,000	$20,000	$25,000
Energetic costs (MJ)	114750	153000	191250
Production (MJ/yr)	13791.0	18392.4	22989.6
Energetic Payback Period (yrs)	8.3	8.3	8.3
Expected Lifespan (yrs)	25	25	25
Production over Lifespan (MJ)	344775	459810	574740
Net Production (MJ)	230025	306810	383490
Economic Payback Time Prod. (MJ)	19022.7	25406.3	31749.1
EROI	3.00	3.00	2.00

Discussion

Initially, my study indicates that installing solar panels in Louisiana might be energetically sustainable, but not economically sustainable. I found that the average time between Louisiana hurricanes with wind speeds of at least 120 mph is 8.4 years (Table 2). This is an important benchmark for wind speed because "Ethical Solar FAQ" (n.d.) believes that any faster winds can damage or destroy solar panels. I also calculated the energetic payback period to be 8.3 years (Table 3). That is to say, after 8.3 years the PV array is predicted to have produced more energy than went into its construction. The energetic payback is slightly less than the average time between Louisiana hurricanes with wind speeds of at least 120 mph. Economically, it takes 9.4 years for a PV array of between 3 and 5 kw to pay for itself through energy bill savings (Table 1). This is one year more than the average time between Louisiana hurricanes with wind speeds of at least 120 mph. It should also be noted that both the energetic and economic paybacks are roughly three years higher than the conservative wind speed approach of 3.6 years (Table 2). The National Oceanic and Atmospheric Administration (NOAA) records the highest maximum wind speeds in 5 mph increments (Ross, 2010), but that does not mean these were the actual highest wind speeds that happened in the storm. For this reason, I conducted a conservative analysis where the average time between hurricanes with at least wind speeds of 100 mph was calculated. This yielded an average time between storms of 3.6 years (Table 2), much lower than both the economic and energetic payback times.

The most erroneous assumption of this study is that all hurricanes in Louisiana are included in calculations. In reality, a proper analysis should take into account only the hurricanes that happened in New Orleans. The problem with this approach is that there are only five hurricanes with storms of at least 100mph that occurred in New Orleans since 1852, a much too small sample size to gleam any realistic insight about hurricane patterns. Also, the variability of time between these five storms is very large. Katrina and Gustav happened three years apart, while Number 4 (1860) and Number 10 (1893) happened over 33 years apart. With such a small number of severe storms, calculating the average time in between storms would not account for such dramatic variability and would oversimplify the complexity of these weather systems or analyses. For these reasons, all Louisiana storms were included in this study. In reality, installing PV arrays can probably be considered sustainable from both an economic and energetic perspective, based on the fact that only five hurricanes since 1852 had wind speeds greater than 100 mph. Furthermore, the economic and energetic payback times of 3kw to 5kw PV arrays in Louisiana are both very close to the average time between all Louisiana storms of wind speeds of at least 120 mph. Ross (2010) indicates that hurricanes occurring in New Orleans are relatively rare, though do occur. This rarity probably means that the installation of solar panels in New Orleans is sustainable, both from an economic and energetic point of view.

If this study were to be continued, it would examine how climate change will affect the economic and energetic sustainability of installing solar panels in New Orleans. Many climatologists believe that as average global temperatures continue to warm, the frequency and severity of hurricanes will increases (Eichorn, pers. com., 2014). While the magnitude of these increases are unknown, many models exist that predict how hurricanes will be affected by climate change. However, these models cover a wide range of potential scenarios. Future work on the topic of solar sustainability in New Orleans should analyze several of these models to see how they might potentially affect the economic and energetic sustainability of installing PV arrays in New Orleans.

Currently, very progressive legislation is in place in Louisiana that encourages solar development. The federal government covers 30% of the total costs to homeowners and the state covers an additional 50%. While these incentives are significant, confidence in their continuation is just as important. Since many renewable energies are not as cost competitive as fossil fuels, government subsidies are required to promote adoption by quantifying the externalities of fossil fuels and "leveling" the market. In the United States, these subsidies are often not guaranteed over the long term and must therefore be renewed after every *x* number of years (this number varies depending on the technology and type of incentive). In the case of solar energy, this uncertainty largely effects the production of PV panels. The number of panels a company produces is determinant on how many they think they will sell each year, which is strongly dependant on government incentives. Often this is not a problem, but when these incentives are due to expire, many homeowners do not buy solar panels. The process of getting them installed is a long one, and many homeowners do not want to risk beginning the process, having the incentives fail to get renewed before the panels are installed, and getting stuck with paying for all of the costs of the panels out of pocket. This happened soon after 2000 when solar panel manufacturers ended up overestimating the amount of panels they would sell and produced too many. This was exacerbated by a decline in world silica prices, as more companies produced a usable form of the substance to meet the increasing demands of increased panel production (Kelleher, pers. com., 2013). Ultimately, this resulted in a surplus of panels and a dramatic decrease in panel prices.

This is important from the standpoint of this study because any over or underproduction of solar panels will affect prices. The MJ/dollar conversion factor I used in this study assumes that the price of a product accurately represents the energy that goes into producing it. Often, when market prices remain relatively stable for a certain commodity, this is an accurate assumption. However, prices experiencing significant shifts due to changes in demand do not accurately reflect the energy that goes into production. The same amount of energy goes into creating a solar panel, no matter what the demand for that panel is. Unfortunately, it is almost impossible to account for this and it is important to keep it in mind when using this conversion factor to help explain any drastic fluctuations.

Conclusion

It is very important to quantify green practices so that their value of contributing to sustainability can be determined. This study attempted to do this by calculating the economic and energetic payback periods of PV arrays in New Orleans and comparing them to the average time between severe hurricanes. Initial calculations indicated that economically, this might not be a sustainable practice, but that it is sustainable from an energetic standpoint. However, hurricane data from the whole state of Louisiana was used due to a large amount of variability and small sample size of severe hurricanes that struck New Orleans. If the scarcity of these storms is taken into account, then solar energy can almost certainly be considered sustainable in New Orleans. However, future analyses must take into account the increases in frequency and magnitude of hurricanes that are expected to result from increasing global temperatures.

Citations

Aardvark, Tory. "Green Energy Fails Again Offshore Wind Farms Are Sinking."*Tory Aardvark*. Word Press, 20 June 2012. Web. 23 Apr. 2014.

"A Performance Calculator for Grid-Connected PV Systems." *PVWATTS v. 1*. PVWATTS v. 1, n.d. Web. 17 Apr. 2014.

Bernstein, Fred A. 2009. Brad Pitt's Gifts to New Orleans. *The New York Times.* November 25.

"Clean Power Estimator." *Solar Technologies - NYSERDA*. New York State Energy Research and Development Authority (NYSERDA), n.d. Web. 19 Apr. 2014.

"Ethical Solar FAQ." *Frequently Asked Questions*. Ethicalsolar.org, n.d. Web. 19 Apr. 2014. <http://www.ethicalsolar.org/faq.php#weather>.

Eichorn, David. "Hurricanes." Meteorology. Illick Hall, Syracuse. Apr. 2014. Lecture.

Hall, Charles A. S., and Kent A. Klitgaard. *Energy and the Wealth of Nations: Understanding the Biophysical Economy*. New York, NY: Springer Verlag, 2012. Print.

Hall, Myrna, Ning Sun, Steve Balogh, Catherine Foley, and Ruiqi Li. "Assesing the Tradeoffs for an Urban Green Economy." *In Press*. Print.

Kelleher, Michael. Energy Markets and Regulations. Baker Laboratory, Syracuse. Mar. 2013. Lecture.

Lavelle, Marianne. "For Hurricane Katrina Victims, A Solar Restart." *National Geographic*. National Geographic, 26 Aug. 2010. Web. 18 Apr. 2014.

Prieto, Pedro A., and Charles A. S. Hall. *Spain's Photovoltaic Revolution: The Energy Return on Investment*. New York: Springer, 2013. Print.

USA. Environmental Protection Agency (EPA). *Definitions of Sustainability*. EPA, n.d. Web. 22 Apr. 2014.

USA. National Oceanic and Atmospheric Administration (NOAA). National Weather Service. *Louisiana Hurricane History*. By David Ross. Camp Springs: NOAA, 2010. Print.

Appendix

Table 1: Louisiana state hurricane data. Covered here are hurricanes with wind speeds of at least 100 mph. Italicized hurricanes occurred at the Mouth of the Mississippi River (which is where New Orleans is located). Bold hurricanes are those with wind speeds of at least 120 mph. This table only covers hurricanes until 2009.

Date	**Hurricane Name**	**Highest Recorded Wind Speed (mph)**	**Months since Last Storm of at Least 100mph**	**Months Since Last Storm of at Least 120mph**
1852, 8/26	Number 1	115	n/a	n/a
1855, 9/15-16	***Number 5***	***125***	***37***	***37***

1856, 8/10-12	**Isle Dernieres**	**150**	**11**	**11**
1860, 8/11	**Number 1**	**125**	**48**	**48**
1860, 9/14-15	*Number 4*	*105*	*1*	-
1860, 10/2-3	Number 6	105	1	-
1865, 9/12-13	Number 4	105	59	-
1866, 7/12-13	Number 1	105	10	-
1867, 10/3-4	Number 7	105	15	-
1879, 8/22-23	Number 3	105	142	-
1879, 9/1	**Number 4**	**120**	**1**	**229**
1882, 9/14	Number 3	105	36	-
1886, 6/13-14	Number 1	100	45	-
1886, 10/12	**Number 10**	**120**	**4**	**85**
1888, 8/18-20	Number 3	110	22	-
1893, 9/9-8	Number 8	100	61	-
1893, 10/1-2	***Number 10***	***130***	***1***	***84***
1900, 9/7-8	**Galveston HU**	**145**	**83**	**83**
1906, 9/26	Number 6	110	72	-
1909, 7/21	Number 4	115	34	-
1909, 9/20	**Number 8**	**120**	**2**	**108**
1915, 8/15-17	**Number 2**	**130**	**71**	**71**
1915, 9/29	**Number 6**	**130**	**1**	**1**
1916, 10/18	Number 14	110	13	-
1918, 8/06	**Number 1**	**120**	**22**	**35**
1920, 9/21-22	Number 2	100	25	-
1926, 8/25-27	Number 3	115	71	-
1941, 9/22-24	**Number 2**	**120**	**181**	**277**
1943, 7/26-27	Number 1	100	22	-
1956, 9/24	Flossy	100	159	-
1957, 6/27	**Audrey**	**145**	**9**	**193**
1961, 9/11	**Carla**	**145**	**51**	**51**
1964, 10/3	Hilda	115	37	-
1965, 9/10	**Betsy**	**125**	**11**	**48**
1969, 8/17-18	**Camille**	**190**	**47**	**47**
1971, 9/16	Edith	100	25	-
1974, 9/7-8	**Carmen**	**120**	**36**	**61**
1985, 9/02	Elna	115	132	-
1992, 8/26	Andrew	115	83	-
1995, 10/04	Opal	115	38	-
1998, 9/27-28	Georges	110	35	-
2005, 8/29	***Katrina***	***125***	***83***	***371***
2005, 9/24	Rita	115	1	-
2008, 9/1	*Gustav*	*100*	*36*	-
		Average:	**43.1 months (3.6 yrs)**	**101.7 months (8.4 yrs)**