Solar Energy Implementation Case Study

King Orchards Fruit Co. LLC

By Jackie Thelen, Aryn Thomas, Heidi Vanderbeek and Aluel Go
Michigan Farm Energy Program

Background

King Orchards Fruit Co. LLC is a large fruit producer and processor located in Kewadin, Michigan. The farm was founded in 1980 by John and James King and their families, who started with 80 acres of land. Their operation has since expanded to close to 400 acres, on which they grow cherries, apples, peaches, pears, apricots, raspberries, plums, and nectarines. While horticulture is their core operation, King Orchards now encompasses two retail stores, a cherry juice concentrate processing facility, a farmer's market, and U-pick operations.

King Orchards has always strived to be environmentally conscious, but implementing a solar energy system had never seemed possible due to the high capital costs. Owners at King Orchards were first introduced to the possibility of installing a system on their farm when they met representatives from Harvest Energy Solutions, a solar energy equipment supplier, at the Midwest Horticulture Expo in Grand Rapids. Soon after, the energy company visited King Orchards farm and gave a presentation on the benefits and applications of solar energy. The many positive environmental and economic impacts of the technology resonated with the farm owners, especially with the high energy requirements of the farm's many operations. Installing a solar energy system seemed economically feasible once Harvest Energy Solutions explained the possible funding available for the project, and the owners of the farm welcomed the opportunity.

Four different solar energy projects at varying scales and locations were discussed between the farm owners and Harvest Energy Solutions. The project that best suited the farm owners' electrical and financial situation was selected. Initial planning was completed by the summer of 2015, but by then it was too late to incorporate a large-capital project in the budget, so the projects were tabled for future consideration. Harvest Energy Solutions returned in August 2015 with news of potential funding options, including funding from the United States Department of Agriculture (USDA) REAP and a grant from the Michigan Farm Energy Program. The owners were originally unaware of such funding opportunities, but, with assistance from Harvest Energy Solutions, they applied for and acquired $25,000 from the Michigan Farm Energy Program, financed by the Michigan Energy Office. However, to make use of this funding, the solar energy system was required to be operational by September 2015. The farm owners decided on a project, and Harvest Energy moved forward with the implementation of the new solar energy system.

Solar Energy System Implementation

The solar energy project pursued at King Orchards was a fixed, ground-mounted solar array with a vibrated I-beam structure including 208 250 W modules, for a total of 52 kW. The system was installed by Harvest Energy Solutions, implementing SolarWorld solar panels and Fronius inverters. The solar array powered Creswell Market, King Orchards' bakery and retail store, and had an overall footprint of 3,204 square feet (9 by 356 feet). Though this retail outlet was not the largest energy draw within their operation, the owners agreed that the seasonal operation of the store (which is open from the beginning of May to the end of November) would be best complemented by electricity generated by the solar array. A full specification sheet of the solar energy system as well as an aerial view of the system and surrounding property can be viewed in Attachment 1.

Following approval by the owners of King Orchards, Harvest Energy moved forward with the project implementation, completing all the paperwork and contract labor requirements. Since the existing electrical service was old and deteriorating, an electrician was brought in to upgrade it to a new, clean service so the project could proceed. King Orchards worked with Great Lakes Energy Electric Cooperative with regards to interconnectivity of their solar energy system and reported no issues from the utility perspective. Little involvement was required of the owners during the installation process, which began on September 14, 2015, and was completed by September 25, 2015. The solar arrays were positioned along a main road on the property (Figure 1), and though some land was excavated to prepare the ground for the arrays, the owners were able to easily work around the installation while in progress. The solar energy system was operational 6 short weeks after Harvest Energy's initial proposal, when the Michigan Farm Energy Grant had been awarded. The owners were very pleased with the contractor, especially with the recommendations and overall ease of the process. They emphasize that the background research and planning brought by Harvest Energy Solutions was critical in their decision making process.

Figure 1 - Photograph of the solar arrays positioned between the main road and cherry orchards.

The owners state that a vital component of the implementation of this solar energy system was site selection. While proximity to energy needs was an important aspect of this decision, location in terms of aesthetics and topography were also considered. Since the grant required immediate action on behalf of the farm owners, little time was available for determining the best site for the solar array. While the solar array is positioned close to the desired retail store, the panels are stationed along the main road, in plain sight of King Orchards customers and other passerby. While the owners report that customers have only stated positive comments regarding the observed renewable energy usage, it is a concern that the arrays may become an eyesore in the future. These solar arrays are also mounted on a slope, which negatively impacts their efficiency and structural integrity. This is a common trade-off encountered by farmers seeking to save flat ground for growing produce as opposed to using the land for ground-mounted solar arrays. Overall, while the contractor provided adequate recommendations for site selection, it is advised that farm owners spend plenty of time with their contractor to analyze the long-term benefits and drawbacks of alternative locations for a solar energy system.

Besides the challenges associated with site selection, no additional issues developed during the installation. It should be noted that, even with the Michigan Farm Energy Grant, the project still created a financial burden for King Orchards, though these were expected costs that were included in the operating budget without the use of additional loans.

System Impacts

The King Orchards solar energy system has been in operation since September 25, 2015. Since this time there have been no issues or adjustments made by either the owners or Harvest Energy Solutions. However, the King Orchards owners did contact Harvest Energy with regards to observed soil erosion around the ground mounts, another drawback from positioning the array on a slope. Monthly data of actual and predicted electricity production is shown in Figure 2, and raw data is included in Attachment 2. Predicted values are based on Harvest Energy's solar electricity production averages of previous years. The system produced less over the winter months than predicted, though this is not presumed to have a major effect on the overall annual performance of the system since the majority of energy is produced in the summer months. This deviation may have resulted from the above-normal cloud cover in Michigan due to the strong effects of El Niño, which started in December 2015 and ended in May 2016. See Attachment 3 for additional data showing the impacts of El Niño on cloud cover. In similar fashion, King Orchards experienced an underproduction in the winter months. Starting in November 2017 and ending in May 2018, the panels experienced this change because of the weather pattern, La Niña. This occurrence causes the winter months to be colder and snowier resulting in more gloomy days; therefore causing a skew in the data that affects the annual performance of the system. See Attachment 4 for data on the effects of La Niña.

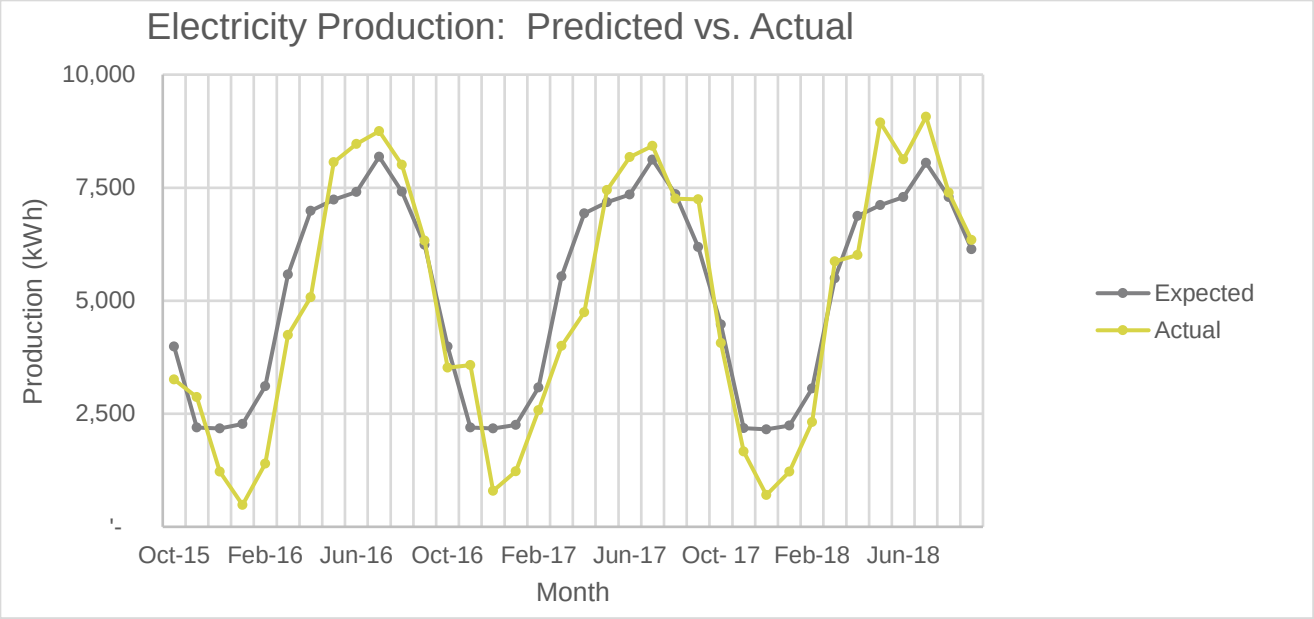

Figure 2 - Electricity produced by the King Orchards solar energy system since implementation compared to predicted values provided by Harvest Energy Solutions.

In terms of regular operations, the solar array does not inhibit the farmers' daily activities. Although, there may be minor challenges maneuvering cherry harvesting equipment around the arrays in the summer, since the system is positioned adjacent to the cherry orchard.

The solar energy system cost breakdown is shown in Table 1. The total cost predicted at the beginning of the project was $189,890, but this only considered the cost of the Harvest Energy Solutions system. The total cost including permits and utilities was $195,404. King Orchards pays $0.10488/kWh, not factoring in the monthly metering charge, so each kWh generated by their solar energy system represents energy they no longer have to buy from Great Lakes Energy. Initially, the payback period was calculated as 8.71 years, assuming a 30% renewable energy federal tax credit and no additional funding. This matches data from the Michigan Farm Energy Program, which shows an average payback period of 8.7 years from over 147 renewable energy assessments (approximately 85% solar energy projects), including the 30% tax credit and no outside grants or loans. With both the USDA REAP and Michigan Farm Energy grant, the payback period drops to 5.2 years, which demonstrates the importance of outside funding to project feasibility and implementation. No major additional costs or financial constraints emerged during or since system implementation to cause the project to deviate from the initial predicted payback period.

Table 1 – Cost breakdown for the purchase and installation of the King Orchards solar energy system.

Component	Cost

Solar energy system components and installation ($3.64/W from Harvest Energy Solutions)	$189,025
Operating agreement with utility (Great Lakes Energy)	$100
County building permit	$391
Electrical expenses to connect to the grid	$5,888
Total:	$195,404

The owners at King Orchards have received positive feedback from neighbors and customers alike regarding their pursuit of renewable energy. The owners plan to publicize their solar energy system on their website and other outlets to promote and increase awareness of renewable energy and its benefits, especially during special events and holidays such as Earth Day.

Conclusions

Overall, the owners of King Orchards are very satisfied with the outcomes of their solar energy system, and would highly recommend implementing similar systems to other farmers that have the opportunity. Juliette King, John King's daughter and Project Manager of King Orchards farm, stated, "If you can do it, why not? [This project] has immediately changed our outlook as far as everything we're thinking about with planning our infrastructure." She also discussed the importance of long-term planning for implementation of solar energy systems, including everything from new building designs, air conditioning systems, and other equipment including stoves and coolers, since these components can be compatible with energy generated from solar panels. Juliette emphasized the owners' frustration that they had not kept solar in mind from the beginning, since two major buildings with immense energy draws were recently constructed north-south oriented. Now, in order to implement a solar energy system to power these facilities, the arrays must either be positioned on the roof, and suffer from lower efficiencies, or on the ground, using up valuable land resources. Juliette King highly recommends that farmers seriously consider the potential for solar in their infrastructure planning, even if actual implementation of a system seems far in the future.

The owners at King Orchards are planning to pursue an additional solar installation to help offset energy needs for two large freezers that run continuously in their bottling

plant. These freezers are very energy intensive, and due to the success of the first project, they would like to install more solar arrays for this application within the next few years. Although, any project of this nature would be dependent on the availability of low-interest loans or other sources of funding at the time. The owners would like to see more programs and policies supporting renewable energy initiatives, especially in the form of public education campaigns and low-interest loans for green energy projects from financial institutions. The owners also expressed interest in conducting an energy audit, which could help determine additional areas of improvement in terms of renewable energy and energy efficiency.

Attachment 1

Photovoltaic System Specification Sheet King Orchards – Creswell Market	
Latitude	45.0198°N
Longitude	85.3540°W
Array Azimuth	180° True South
System Type	Fixed Array – 2 high Vibrated I-beams
System Footprint	9’ x 356’ or 3204 sq. ft
Array Orientation	Portrait
Tilt (Degrees)	33° from Horizontal
System Size (DC)	52.00 kW
System Losses	14.49%
Inverter Efficiency	96.00%
Racking System	Harvest Energy Solutions
Module Type	SolarWorld 250W
Inverter	Fronius Symo 12.0-3
Number of Sub-Arrays	3
Number of Modules per Sub-Array	78, 78, 52
Total Number of Modules	208
Number of Modules per String	13
Phase	240VAC 3-Phase
Sub-Array Current (AC)	140.00 Amps
Maximum Possible Total System Current	175.00 Amps

Below is an aerial view of property with the original schematic of the solar arrays and electrical connections.

Attachment 2

Monthly production data for King Orchards' solar energy system since implementation on September 25, 2015.

Month	Estimated Production (kWh)	Actual Production (kWh)
October, 2015	3,990	3,261
November, 2015	2,197	2,866
December, 2015	2,174	1,220
January, 2016	2,272	484
February, 2016	3,108	1,397
March, 2016	5,582	4,238
April, 2016	6,988	5,073
May, 2016	7,233	8,064
June, 2016	7,408	8,463
July, 2016	8,183	8,751
August, 2016	7,413	8,007
September, 2016	6,236	6,327
October, 2016	3,990	3,522
November, 2016	2,197	3,576
December, 2016	2,174	796
January, 2017	2,254	1,230
February, 2017	3,083	2,576
March, 2017	5,537	4,004
April, 2017	6,932	4,743
May, 2017	7,175	7,444

June, 2017	7,349	8,175
July, 2017	8,118	8,421
August, 2017	7,345	7,253
September, 2017	6,186	7,243
October, 2017	4,472	4,062
November, 2017	2,179	1,663
December, 2017	2,156	705
January, 2018	2,235	1,217
February, 2018	3,058	2,315
March, 2018	5,493	5,872
April, 2018	6,876	6,014
May, 2018	7,117	8,943
June, 2018	7,289	8,127
July, 2018	8,052	9,070
August, 2018	7,294	7,390
September, 2018	6,136	6,342

Attachment 3

The loss of solar energy production observed from December 2015 through April 2016 may be due to the effects of El Niño, which caused an increase in cloud cover compared to typical years, as seen by the 30% increase in partly cloudy days and the 86% decrease in fair days compared to historical averages. This is shown in the table below.

Month	No. of Fair Days		No. Partly Cloudy Days		No. Cloudy Days	
	Actual[1]	Avg.[2]	Actual[1]	Avg.[2]	Actual[1]	Avg.[2]
Dec-15	0	3	7	6	24	23
Jan-16	1	4	8	7	22	20
Feb-16	1	5	14	7	14	16
Mar-16	1	6	12	7	18	18
Apr-16	7	6	5	8	18	16
May-16	3	7	14	10	14	14
June-16	6	8	15	11	9	11
July-16	1	9	21	12	9	10
Aug-16	2	9	20	11	9	11
Sept-16	7	8	12	10	11	12
Oct-16	5	8	17	9	9	14
Nov-16	8	4	9	7	13	19
Dec-16	1	3	4	6	26	23
Avg. Difference	-86%		30%		-5.6%	

Attachment 4

Month	No. of Fair Days		No. Partly Cloudy Days		No. Cloudy Days	
	Actual[3]	Avg.[4]	Actual[3]	Avg.[4]	Actual[3]	Avg.[4]
Dec-16	2	3	7	6	21	9
Jan-17	1	4	10	7	20	11
Feb-17	2	5	10	7	19	12
Mar-17	2	6	5	7	21	13
Apr-17	4	6	14	8	13	14
May-17	5	7	7	10	18	17
Jun-17	2	8	12	11	17	19
Jul-17	1	9	12	12	17	21
Aug-17	5	9	17	11	9	20
Sep-17	2	8	16	10	13	18
Oct-17	2	8	11	10	18	17
Nov-17	2	4	7	7	21	11
Dec-17	1	3	10	6	20	9
Average Difference						

Starting in November and ending in late April, La Niña was observed for the 2017-2018 winter months. During this time period, there were more partly cloudy days and cloudy days observed than the expected days. This reasoning comes from the idea that La Niña affects Michigan in the way of cloud cover. Generally during this time of the pattern, Michigan experiences more partly cloudy and cloudy days. This is shown in the data below. [1]National

Weather Service Climate. (2016). *Detroit/Pontiac Observed Weather Reports.* Retrieved January 19, 2017, from http://w2.weather.gov/climate/index.php?wfo=dtx

[2]Current Results (2016). *Average Sunshine in Michigan*. Retrieved January 19, 2017 from http://www.currentresults.com/Weather/Michigan/average-sunshine-december.php.

3 National Weather Service Climate. (2017). Detroit/Pontiac Observed Weather Reports. Retrieved October 23, 2018 from http://w2.weather.gov/climate/index.php?wfo=dtx

[4]National Weather Service Climate. (2017). *Detroit/Pontiac Observed Weather Reports.* Retrieved October 26, 2018, from http://w2.weather.gov/climate/index.php?wfo=dtx