Building A Solar Farm On A Rolling Landscape: A Case Study

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The well-being of the environment in the United States is becoming dependent on a change from unreliable and scarce resources such as coal as a means to generate electricity to a more eco-friendly and abundant source. Solar farms provide the opportunity to generate electricity with no effect on global warming, no environmentally hazardous emissions, and are not affected by the fluctuating costs of fuel. One construction company in particular has noticed this as not only a terrific opportunity to improve the nations' environmental footprint, but also as a tremendous business opportunity; Swinerton. Swinerton recently developed a renewable energy division that focuses on the creation and maintenance of solar farms. The division, now known as Swinerton Renewable Energy, was created in 2010 and has since then built themselves into the number 1 solar energy contractor in the entire world. This case study will examine one of their first solar farm projects, a 9.4MW site in Sacramento County, CA. Furthermore, this paper will examine the current industry trends, the project specifics, the challenges encountered, the benefits of this project, and the lessons learned to be applied to the industry.

Key Words: Solar Power, Photovoltaic, Renewable Energy, Modules

Introduction

Swinerton was established over 125 years ago; they are a completely employee-owned company that has a wealth of experience in the construction industry and have been one of the top contractors in California for several years. They are constantly innovating ways to stay competitive in the rapidly advancing industry of construction. Recently, they made a business decision that was arguably one of the best they've made.

Swinerton Renewable Energy (SRE) is a division of Swinerton that was created in 2011 with the completion of three solar sites in Sacramento County. Referred to as the "BKD" sites, representing the names of each project (Bruceville, Kammerer, Dillard), this paper will focus on the Dillard site, named as such due to its' location off of Dillard Street. Since the completion of the BKD sites, SRE has amounted to the number one solar farm contractor in the world. The success of these three projects translated into a long-term success for SRE and paved the way for Swinerton's Renewable Energy division to compete at such a prominent level.

In 2011, Recurrent Energy, the land-developer on the Dillard site, had a 90-acre parcel of land in Sacramento county that they wanted to build a solar farm on. However, their typical solar contractors did not want to build on that land as it was on a rolling landscape covered with hills. They claimed the landscape was too difficult for them to work with and they did not want to take on that risk. As a result, Recurrent Energy reached out to Swinerton to ask if they wanted to build the solar farm. Swinerton had done work for Recurrent Energy in the past, and the two companies had a good relationship. George Hershman, now the head of the SRE decided to take on the challenge, having confidence in Swinerton's ability to complete the job.

This job was by no means straight-forward. Recurrent Energy presented SRE with a challenging schedule to meet. In order to achieve levels of completion that Recurrent Energy required for Federal Tax incentives, the entire 9.4 MW site needed to be completed and fully operational by the end of the year, December 31st, 2011. This included the complete start-up of the 69kVA electrical substation that delivers the AC power to the utility grid, in addition to all necessary coordination with Sacramento Municipal Utility Department (SMUD) and a functional tie-in to the utility grid. With a Notice to Proceed given to SRE on August 25th, 2011, that left only four months for this project to reach an acceptable level of operation for the incentives that Recurrent Energy required (See Figure 1). A typical schedule to finish a project of this magnitude would be approximately nine months. With limited Notices to Proceed for design and procurement previously provided by Recurrent Energy on June 7th and June 23rd of 2011, SRE had majority of the long-lead-time procurement items in order, which allowed the project to progress smoothly towards the required end of year completion.

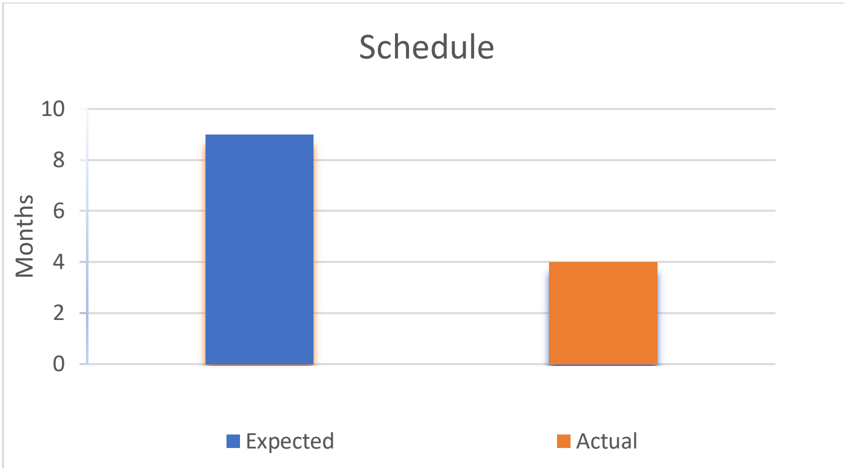


Figure 1: Schedule of the Dillard Solar Farm

Apart from the schedule, there were several other challenges presented by this project. The site was uniquely shaped, which added complications to getting the arrays laid out properly and maximizing energy production. The strange shape was due to with multiple 250-foot setbacks from existing wetlands and emergent marshes where no work or disturbance could occur. This environment housed a copious amount of wildlife, including fairy shrimp and other fauna. Many of the organisms in this community made up a substantial portion of lower food chain and were therefore considered vital for native species' survival. In order to not disturb these creatures, great care was taken to keep the site clear from these areas, ensuring no disruptions to the local habitat.

Not only that, but the rolling landscape made it difficult to arrange the arrays in a way where there would be no shading from one string onto another. A string is simply a number of modules, or solar panels, in line with each other. One of the most important items to consider when designing a solar farm is the spacing from one string to another. Depending on the height of each string and the orientation of the site in relation to the sun, there are very specific ways to line up each string. If the arrays, which are composed of a group of strings, are laid out with a poor design, the modules could potentially be exposed to less sunlight than the optimal amount, which runs the risk of losing the owner money.

This paper is a case study that will discuss the ways in which SRE was able to tackle each obstacle presented to them and make the project into a success. As one of their first renewable energy projects, the lessons learned and the innovation to find ways to solve each problem set them up to be the now industry-leading contractor in renewable energy.

Solar Power in the Industry

Solar power first emerged in the industry as a clean way to generate electricity, therefore assuring no effects to global warming and reducing damage to the environment. Although slow at first, the implementation of solar as a means to provide energy has increased over time. As climate change becomes a more prevalent issue to society, people have been made aware of the damaging effects that other methods of energy production have on the environment. As a result, recent technological advancements have been made to make photovoltaic (PV) systems more efficient. For example, SRE uses axis-tilting strings, a system that adjusts the angle of the modules to follow the sun as it moves across the sky throughout the day. This advancement maximizes the sunlight collected by an array resulting in an increase of net energy produced. By doing so, a common concern that client's have about upfront costs and return on investments is eased.

Due to the increased attention solar has been getting in recent years, there has been an increase in the demand for solar systems (See Figure 2). The amount of solar PV systems installed in the United States grew 483% from 2010 to 2013, and has not slowed down since. This is a result of private owners, land developers, and contractors realizing the numerous benefits solar systems provide. From 2011 to the end of 2012, solar accounted for about 16% of the electricity generation installed annually, and jumped up to 30% in 2013. SRE has more revenue than the year prior since its' creation in 2010, along with more jobs awarded and more jobs managed.

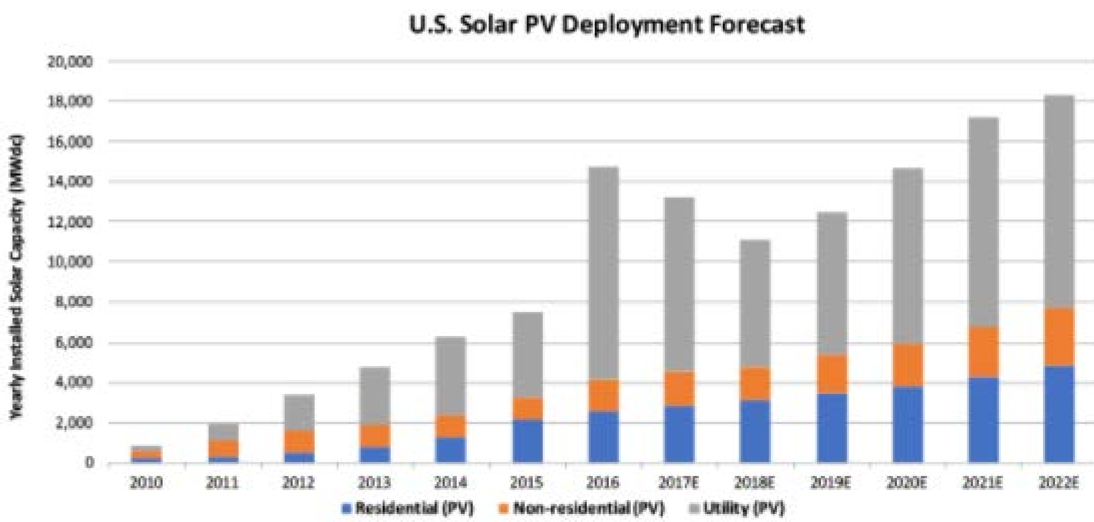


Figure 2: Trends of the 3 Solar Markets in Terms of Mega-Watts Installed

Solar power has also experienced a drastic decrease in costs (See Figure 3). The main 3 markets for solar energy are residential, commercial, and large-scale solar farms. Residential systems typically are installed on a rooftop of a home, whereas commercial systems are usually installed on a rooftop of an office building or a parking structure. These two markets encompass the majority of the systems that are installed; however large-scale solar farms that are typically built on unused land, produce the most energy and can be tied into a city grid. There has been an estimated 29% drop in the price of rooftop PV systems from 2010 to 2013. Similarly, the cost for installing a large-scale PV system is an estimated 60% cheaper than a residential system.

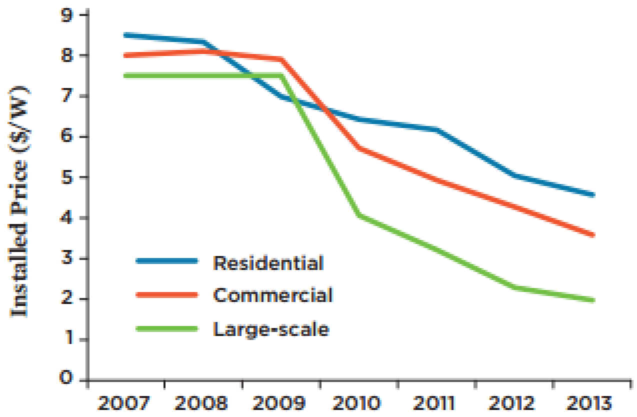


Figure 3: Trends of the 3 Solar Markets in Terms of Price per Watt Installed

Methodology

The objectives for this case study are as follows:

- To analyze how SRE dealt with the challenges encountered on this site
- To discuss the lessons learned from this project
- To determine whether the project goals were met
- To show the construction industry a risky project that led to immense success

The methodology used for this case study was mainly qualitative. The qualitative study was done through a number of interviews of two knowledgeable members of SRE who were familiar with the Dillard site. The first interview was with a man who was on site during the construction of the solar farm. He was able to shed some light on the process from the beginning of the project to the end, and could answer question that were specific to that site. The second interview was with another man who works for SRE's technical division, and was able to provide answers the first man could not. There was also a string of emails from numerous members of the SRE team that provided quantitative data for the Dillard site. The interviews and emails were then analyzed by the researcher and separated into distinct categories: obstacles, benefits, and lessons learned.

Case Study

Swinerton Renewable Energy (SRE) is a solar power contractor based out of San Diego, California. They are a division of Swinerton Builders created in 2010 and have since then grown to the top solar power contractor on the globe. SRE is comprised of two major departments; the EPC team and the SOLV team. EPC stands for engineer, procure, and construct. Their EPC team is the group that physically builds the solar sites. In order to avoid third-party delays, they like to keep everything in house, from the engineering/design stage, to the purchasing of materials and managing the lead times, to the constructing of the project, hence the name of the department EPC. They are out on the site doing the construction, while the SOLV team instead is monitoring the performance of completed sites. SOLV, unlike EPC, is not an acronym, but is the Operations and Maintenance (O&M) group. They are in charge of monitoring the well-being of sites the EPC team builds. In order to do so, they developed a software, called SOLV. Not only can the SOLV software monitor each site built, but it has the ability to receive very specific information from each site. For example, if a rodent chewed up a low-hanging wire and damaged it, causing the need for it to be replaced, on a 50 MW site in Utah, the SOLV software would be able to tell the team which string the damaged wire was on, in which array, and what combiner box was affected by it, all the way from San Diego. The software has become so elite, private owners who possess already-completed solar farms are now hiring the SOLV team to monitor their sites. Today the SOLV team monitors over 3.65GW of energy. This paper will focus on one of their first sites that led them to where they are today.

Figure 4: The Nock, SOLVs' Main O&M Center

Project Specifics

The Dillard solar project is located in an agricultural area of Sacramento County, California on a 90-acre parcel. This privately funded job was backed by the land-developer Recurrent Energy, while it was designed and constructed by SRE and its' consultants. The project consisted of 40,445 Suntech 285 watt modules on a 9 megawatt (MW) single-axis tracker system and 1,755 modules on a 400 kilowatt (kW) fixed-tile system, combining for the potential to produce 9.4MW of AC energy directly to the utility grid. Notably, this is the first facility in the Sacramento Municipal Utility District (SMUD) area that was reviewed, approved, and installed as a 1000v grid-tied system, as opposed to the previous standard of 600v.

The total project had a valuation of about $34,560,000, including modules that were supplied by the owner. A large portion of the Swinerton contract value can be attributed to the negotiation and purchase of the single-axis tracker assembly and the DC to AC inverters. Provided by ATI and Advanced Energy, respectively, the Dura-Track racking assembly and the advanced Solaron inverters define the industry standard for quality of manufacture, efficiency and longevity. With preferred pricing dictated by Swinerton's relationship with these vendors, Recurrent Energy found it to be effective to procure this material and equipment through Swinerton to reduce the overall project costs.

Recurrent Energy presented SRE with a challenging schedule to meet on this project. Recurrent Energy required an accelerated schedule for Federal tax incentives, meaning the entire 9.4MW project needed to be installed and operational in just over 4 months. Typically, it would take near 9 months to complete a project of this magnitude. This included the complete installation, testing, and start-up of the 69kVA electrical substation.

Figure 5: Dillard Solar Farm Under Construction in 2011

Challenges

This site was interestingly shaped, adding complications to getting the arrays laid out properly and maximizing energy production. The strange shape was partly due to the multiple 250-foot setbacks from existing wetlands and emergent marshes where no work or disturbance could occur. These habitats for fairy shrimp and other organisms that represented a broad spectrum of the lower food chain are considered vital for native species' survival and great care was taken to keep our site clear from these areas. Another aspect to the weird shape was the landscape itself. This site was located on a rolling hill landscape and provided many design complications. Designing a solar site on a rolling landscape needs to be very carefully thought out in order to avoid any potential shading from one string to another. In order to mitigate any potential energy-loss, SRE opted instead to cut and fill a total of 130,000 cubic yards (CY) of soil, a massive undertaking that disturbed a large amount of soil that needed to be re-stabilized (Figure 5). By doing so they were able to lay out the arrays properly and it allowed them to maximize the energy capacity of each module without worrying about any shading.

Given the adjacent wetlands, storm water management was a major concern with county inspectors actively monitoring the site to ensure no dirt or clay-bearing water ran off the site into surrounding protected areas. The solution to this was to construct a 3-foot deep trench around portions of the site to catch and direct water, in addition to multiple DI locations where water could be directed to and then drained to retention ponds. The site had three retention areas where water was collected and then was pumped to holding tanks to allow the sediments to settle to the bottom. This water was then pumped through filtration tanks, tested, and then reintroduced into the wetland areas without any harmful solids or contaminants.

Since this was an agriculturally zoned site, the county required it to retain a resemblance of its zoning once the photovoltaic aspect of the site was operational. To do this, SRE used a hydro seeding mix that would make the wildlife plants grow back. This hydro seed mix was a "sheep" mix that works well with ovine diets. As part of the O&M for the site, sheep were used to keep plant growth around the modules down to a minimum. This agreed with the county's demand to keep the site zoned agriculturally and provided a way to keep weeds and other growth from shading the modules and reducing energy production.

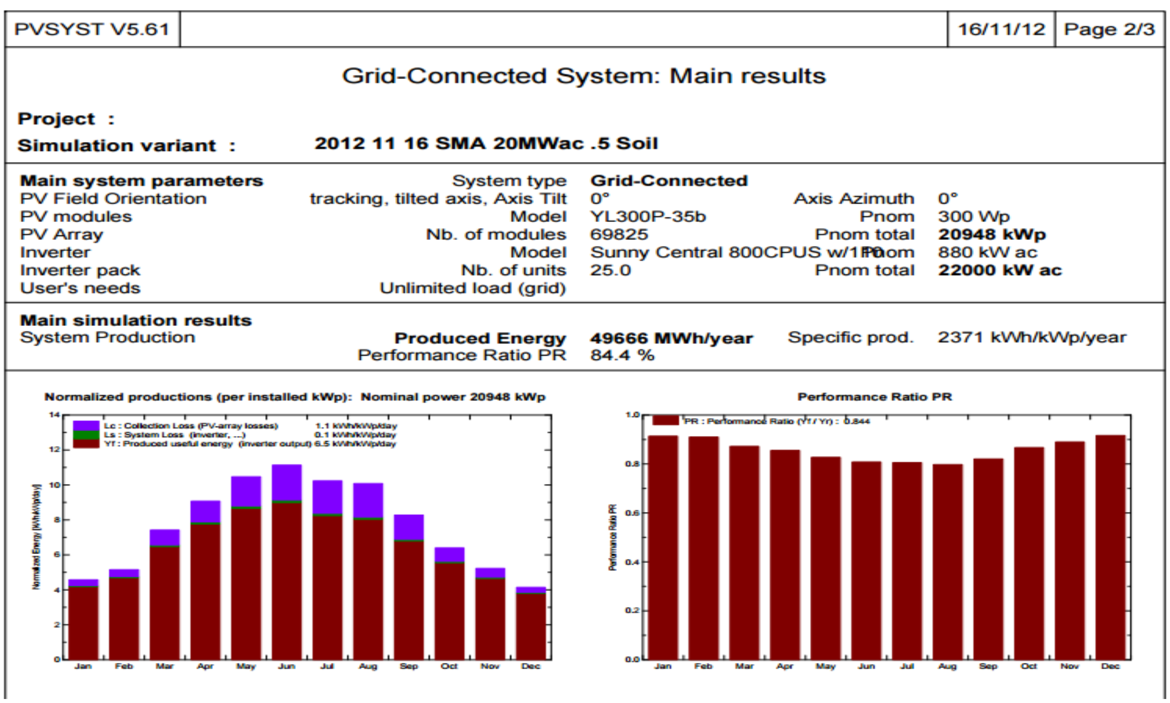
Recurrent Energy contracted their own SCADA (Supervisory Control and Data Acquisition) company for this site, which created some unforeseen challenges. Their system needed to be fully installed and operational before SMUD could see the revenue and production meter. Before SMUD would allow the interconnection to take place, they needed to be able to remotely read and acquire data from the SCADA system. Lacking the contractual pull with the SCADA contractor that SRE had gave them little leverage to push them toward completion. Much of their time was spent coordinating and cajoling the SCADA contractor to get the levels of monitoring in place so that SMUD would allow interconnection. Without this delay, the project could have been completed earlier than the 4-month target date.

Benefits

SRE experienced great success on this project that has translated into a number of benefits. One major benefit from this project was the relationship they gained with Recurrent Energy. Although prior to this project, Swinerton and Recurrent Energy had a positive relationship, SRE really gained their trust with the completion of this project. They were able to take a scope of work that was unfamiliar to them, innovate the site in a way that met the schedule requirement of 4 months, and still make a profit on the job. Their ability to think quickly and work even faster impressed Recurrent Energy, and has led to numerous other projects for them.

Since SRE completed this project in such a remarkable fashion, other land-developers and private owners heard about it and wanted them to do the same thing for them. By succeeding in an extremely risky project, SRE gained exposure to many other opportunities and have not slowed down their intensity. It is possible that without such incredible success on this project, SRE would not be the number one solar contractor in the world and they may not even have stayed in the market, potentially due to them being discouraged by their lack of success.

As this was one of their first projects, there were many lessons learned, which will be touched on in the next section. However, without some of these lessons learned, SRE would not be as competitive as they are today. One major benefit that came as a result from the lessons learned on this project was the brainstorming and implementation of an Energy Model (Figure 6). Apart from their track record on seemingly risky projects, these energy models are a huge tool used to help SRE gain more clients. To put it simply, PVsyst is a software that takes historical weather files of the area that a client wants to build a solar farm, runs it through a simulation, considering weather conditions, the number of arrays, whether the modules are tracking or not, etc. and it gives the client a diagram, showing how much energy is stored into the grid. The ability to show a client how much energy they can save or generate is a really good selling point for most people.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Grid-Connected System: Main results

Project :
Simulation variant : **2012 11 16 SMA 20MWac .5 Soil**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tracking, tilted axis, Axis Tilt	0°	Axis Azimuth	0°
PV modules	Model	YL300P-35b	Pnom	300 Wp
PV Array	Nb. of modules	69825	Pnom total	**20948 kWp**
Inverter	Model	Sunny Central 800CPUS w/1PO	Pnom	880 kW ac
Inverter pack	Nb. of units	25.0	Pnom total	**22000 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**49666 MWh/year**	Specific prod.	2371 kWh/kWp/year
	Performance Ratio PR	84.4 %		

Figure 6: An Example of a PVsyst Energy Model

Lessons Learned

This project provided SRE a valuable information they can implement on future jobs, such as:

1. Do not underestimate the weather. When working outside, dealing with electrical wires everywhere and diverse types of soil, the slightest bit of rain can cause a huge delay. The run-off from the site was an unanticipated challenge, due to its proximity to wildlife, so it is important to have a site run-off plan figured out early on to mitigate any problems caused by hazardous run-off.

2. When dealing with excessive amounts of earthwork like this project, 130,000 CY, it is easy to cause a disturbance in the soil you plan on piling the arrays onto. It is important to make sure the soil is both adequate to hold the load, and stabilized after all the earthwork is done.

3. As crews work longer and longer on the job, the more proficient they will become. SRE's self-performed crews were motivated to get the project done within the 4-month window. They went from installing approximately 750 modules a day at the beginning of the project to slightly over 2,000 modules a day a mere month later. This increase in production was unforeseen and was what enabled the project to be completed on time.

4. One huge lesson learned from this project was how to install the SCADA system. SRE had a tough time cooperating with the 3rd party SCADA team, as the two had never worked together before and each team wanted to take the lead on the work. The constant lack of being on the same page led to multiple delays that could have been costly to the project's success. As a result, SRE developed their own in-house SCADA team that fully designs and installs all monitoring equipment for their sites. With no 3rd party to rely on for this scope and their ability to keep it under their umbrella of influence, the monitoring and interconnection process has been much smoother and controllable.

Conclusion

Since SRE's entrance to the solar power industry they have since emerged as the top solar power contractor in the world, constantly finding new ideas to implement and new innovations to incorporate to their project. In such a constantly advancing field and high-in-demand market, solar power has the capability to be something truly remarkable. This project can help the industry realize what accomplishments can be made by a focused and determined group, regardless of their knowledge of a particular type of scope. It can help identify what challenges to expect, what benefits can be reaped, and can serve as a template for lessons learned that others can apply to achieve success. This case study serves the purpose of promoting the creation of solar farms, even if it is something that is new and unfamiliar. Understand that SRE does not achieve this level of performance on every job they complete, cutting the schedule in half every time is an unrealistic goal. However, it does go to show that through smart thinking, innovation, and hard work, unrealistic goals can be achieved. As solar gains more and more traction in the United States, there is no limit to the possible new technologies than can make solar go from "a hot trend" to the nation's leading source of energy production.

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