Simio May 2018 Student Competition

Improving the Delivery and Installation of Solar Panels

Simio

Forward Thinking

Sunrun's Last Mile Install

Company Background

Sunrun, Inc. is the largest dedicated residential solar company in the United States. Sunrun helps homeowners get solar energy that is perfect for their home and lifestyle, simply and quickly. Founded in 2007 by Lynn Jurich and Ed Fenster, Sunrun has over 150,000 customers across 21 U.S. states and continues to grow every year. A public company, Sunrun (NASDAQ: RUN) is a pioneer in selling home battery storage paired with solar panel systems to increase customer savings by storing power produced during the day to be used for high electrical time of use rate periods.

Lynn Jurich recently described why she founded Sunrun in a video available on YouTube. https://youtu.be/lasJs2L-Dn0

Sunrun's value proposition is a win/win for the planet and customers as Sunrun customers save money while reducing environmental impacts.

Problem Overview

Sunrun constantly optimizes operations to lower prices and improve outcomes for customers. One key driver of customer satisfaction is the time between signing a contract and turning on their solar system. Much of this process is difficult to manage as it depends on government issued permits, inspections and approval to connect to the electric grid. However, one area that can be managed directly is Sunrun's own "last mile" installation process. Sunrun wants a simulation of the last mile of the install process to evaluate a new proposed materials delivery process. Teams will then make recommendations for improving current operations and evaluate a new proposed delivery system.

Scenario One: Current Install Process

The current process begins early in the morning as the install crew shows up at an install branch warehouse, loads a box truck with pre-staged equipment and drives to the installation site. Accompanying the box truck is an equipment truck with tools and other incidentals that might be required. Most of the time, crews travel in company vehicles to the install site. On arrival, each member of the crew has specific assignments including: unloading equipment, contacting the homeowner, setting up safety equipment, starting electrical upgrades, or a final site survey.

The goal is a one-day installation process. Experienced crews can install most systems in a single day, depending on the number of panels and inverters, upgrades to the home's electrical system, potential minor repair work to the roof and, of course, the size and experience of the crew itself.

Scenario Two: Proposed Process – Containerized Materials

A change agent within the company suggested pre-packing the kit of equipment: solar panels, inverters, mounting rails, and brackets in a small shipping container to be pre-positioned at the home install site 2-3 days in advance of a scheduled install. The container can be packed and delivered at any time after the permit has been submitted. However, containers are leased and customers do not want a container sitting in their driveway longer than necessary

The shipping container transport is handled by an outside vendor who is responsible for picking up the container at the warehouse and delivery to the home install site. The cost of using containers is described in the Distance and Drive Time section. Some homes (15%) cannot use the container method because there is not enough space in the driveway or street. In this case, the current method of driving out the equipment the day of the install will have to be used. As a guideline, the container should not sit at the house for more than 5 days before installation starts. Once the installation is finished, the container should be picked up as soon as possible and the time should not exceed 3 days.

Containers can be picked up daily but it is more efficient to batch them as a single vehicle can transport and deliver multiple containers. There is enough space at the warehouse for all of the containers. The container vendor's transport vehicle can move up to 5 containers at a time in any combination of full and empty containers. Containers can only be moved during the normal work week of Monday through Friday.

Containerized shipping enables several significant changes to the usual install pattern:

- Each working day, install crews could have multiple potential install sites. If one site is blocked, then an alternate could be selected.

- Installation crews could avoid driving into the install branch at all and could report directly to the job site or to some agreed upon central location.

- The warehouse crew currently pre-positioning pallets of equipment would simply load the containers directly, cutting out the install day truck loading process entirely.

- The container delivery process can be optimized to reduce mileage which ultimately reduces cost.

Last Mile Installation Process

The volume and flow of installations is dependent on numerous factors including sales effectiveness, weather, local area electricity economics and consumer sentiment. Sunrun has provided two years of historical installation data for you to determine the frequencies, distributions and other characteristics of installation demand in the test branch location. Your model should allow for adjustments to be made to these parameters in order to accommodate work demand patterns that might be somewhat different in other markets.

Start Date and Permits

The last mile process begins when building permits are submitted. The period between submission to the city permit office and approval can vary between same day approval and several months. The install data set provides two dates: submission date and actual approval date. The permit office is not open on the weekends. No installation can proceed until one day after the date of approval.

Equipment

Solar panels, inverters, battery packs, mounting systems and other parts comprise the actual installation equipment. For the purposes of this simulation, you may assume that all equipment is available at the installation branch on the earliest of the permit approval date or the expected permit approval date. Likewise, there is no extra carrying expense for equipment in containers in the field, other than the container itself. Under the current system, the installation crew loads the box truck with the installation equipment in triangular (20,30,50) minutes.

The warehouse crew usually stages the equipment for a job 1 to 2 days before the job is started. In the case of the containerized scenario, the equipment is loaded directly into the container for transport.

Equipment also affects the length of time for installation as discussed below.

Crew Sizing and Assignment Details

The standard Sunrun crew is 5 members consisting of an install foreperson, a lead installer and three installers. In addition, most crews include a certified electrician. Generally, teams stay together and members work with the same people on a team each day. A team assigned to a build job usually stays with that job until completion. It is often the case

that a team may finish a job early and some or all members of the team are sent to another in-progress job to speed completion. For the purposes of the simulation, crew members of the same job description are interchangeable.

Electricians are required for every job, but not necessarily for the entire job duration. Electricians start their day with the installation crews and normally start their day with one crew on a job site. The final electrical tie-in must take place near the end of an installation. It does not have to be the last hours of a job but at least 65% of the expected standard work should be done before the last hour of electrical installation is started.

If available, a second electrician can be added to a single complex job such as one that includes a Brightbox® (battery storage) or a main panel upgrade.

- All installation crews must have at least one foreperson or lead installer
- All installation jobs require a certified electrician to perform final tie-in
- Install crew size minimum is four (three installers and one foreperson/lead installer)
- Install crew size maximum (not including the electrician) are as follows:

Job Panel Count	Max Crew Size
< 14 panels	6
14 – 24 panels	9
> 24 panels	13

- A lead installer can do the job of a foreperson or installer.
- Electricians can substitute as installers on a crew if not needed on another project.
- Electricians can be either Sunrun employees or independent contractors.
- Independent electricians only do final tie-in work or service panel upgrades, they do not substitute as installers.
- Electricians are only needed for Uniform(0.5,1)*Number of Inverters (hours) for the final tie-in on a job unless there is a Service Panel Upgrade. These hours are included in the Standard Install Hours.
- In the case of a service panel upgrade, you should assume that part of the Scope of Work (SOW) Additional Hours in the data table are for the panel upgrade itself and require an electrician to perform the work [Minimum(SOW Additional Hours, Uniform(9,16) hours)]. It is possible for electricians to pair on service panel upgrades as well.

Crew Member	Current Number Available
Electrician	4
Electrician – Contractor	7
Foreman	5
Lead Installer	6

Installers	17

In a similar fashion, installers, lead installers, and install foreperson can be added to other crews if available to reduce two day installations to single-day installations. These add-on crew members work supplementing the main crew until job completion that day or until the end of the workday.

It is current practice, that all crew members report each day to the install branch and commute together to the job site regardless if it is the first, second, or subsequent day of an install. This is not always the case and your recommendation can consider alternative reporting methods. However, crew members can be dispatched from the install branch or from their homes. Crew members are required to check phones for any deviation to their scheduled job assignments or work start locations early in the morning. You may assume that the dispatch system is reliable and that Sunrun's diligent employees always receive their morning assignment.

Installation Cycle Time

The gold standard is a one day install.

Small solar systems (14 panels or fewer) can usually be installed in less than a full day by a full crew. In these small jobs, crew members can be dispatched to another job site to assist another crew with a large installation.

Typical Jobs (more than 14 panels but fewer than 24 panels) are installed in a single day by a standard crew.

More complex systems such as those with a large number of panels (more than 24 panels), Brightbox (battery) installation, or requiring a main panel upgrade require a full crew day and often part of a second day to finish.

The following table illustrates the impact of equipment mix on the time required for installations for both the install crew as well as the electrician. For purposes of this problem set, you can assume that installation crew members (foreperson, leads, and installers) are substitutable. It is Sunrun policy that only certified electricians handle main panel upgrades and the final tie in to the grid. Because of this policy, electricians are required for each job. The majority of electrician specialty work is at the end of the install cycle because the final step in the process is tying all the installed panels into the electric system. However, they work with their team and work as an extra installer until electrician only work is required.

A standard day is eight hours. Jobs are scheduled Monday through Friday but Saturday is sometimes requested of the crews. No crew works on Sunday. For safety reasons, no crew member works more than 10 hours.

Overtime is approved in any case where the remaining work time is less than two hours per person onsite. Generally, it is a purely economic decision as crew overtime is less expensive than the alternative of paying for drive time to finish a job.

Crew members completing one job can be sent to assist other as long as those other home sites are less than 20 miles from their current location. New jobs are currently only started at the beginning of the day due to the need to return to the install branch for the equipment. However, some crews have installed two relatively small systems in a single day.

Crew members are compensated on an hourly basis and, if assigned, are paid for a minimum of 6 hours in a day. However, in the case that installation work is unavailable, assume that workers are paid for 4 hours that day. Please note that these pay rates are not adjusted to the actual work being done. For example, if an electrician is working as an extra installer on his team, he is still paid $21.00/hour.

Position	**Hourly rate**	**Overtime**
Electrician	21.00/hour	More than 8 hours/day or more than 40 hours / week at 1.5 times hourly basis. Limited to no more than 12 hours/day or 60 hours/week .
Contract Electrician	35.00/hour	
Team Foreperson	19.00/hour	
Lead Installer	16.00/hour	
Installer	13.25/hour	

Install Blockers

Installation is occasionally blocked due to unforeseen roof issues, wasp infestations, homeowner emergency, or other reasons and the installation cannot be done on the scheduled day. As an example, after a long rainy period, a large number of installs were delayed due to wasp nests under the eaves requiring removal. These events are only discovered after the crew has arrived at the location. When unforeseen problems occur on install day, the crew must reload the truck with equipment, drive back to the install branch, and unload the truck. Sometimes, a crew can be reassigned or split up and dispatched to help other crews in the field. Most of the time, the crew is sent home early – an entire crew day wasted.

These events are relatively random and combined occur 5% of the time. The installation crew unloads the box truck with the installation equipment back at the warehouse in triangular (20,30,50) minutes. In the case of an installation block, the job can be attempted within a few days. The distribution for possible re-start is normal with a mean of 1.75 days and a standard deviation of 0.35.

Distance and Drive Time

In practice, Sunrun uses drive time calculations rather than distance measures. However, your scenario model can use distance as an approximation of drive time. Latitude and longitude for all zip code centroids are provided for that purpose.

The following is the expense calculations for the delivery systems.

Item	**Charges**	**Crew Capacity**	**Notes**
Company equipment truck	$0.65/mile	5 crew members	All mileage to and from the install branch as well as movement between job sites.
Company box truck	$1.70/mile	2 crew members	Fully loaded for all mileage
Employee personal car	$0.55/mile	4 crew members	Only expenses for transfers between job sites during the day using a personal vehicle.

Container	$143 / first 20 miles $4.00 / each additional mile $180 / container / month	No staff	These figures are for any movement of the transport truck with any Sunrun container on board.

Crew members currently report to the warehouse and commute to the install location together each day. They are paid starting at their arrival and the morning process usually takes 10-15 minutes to check work assignments. However, crew members can be sent directly to the job site. In that case, they clock in at their arrival on site. Please note that once a crew member has reported to work, any driving time in any company vehicle or his/her personal vehicle is paid. If the crew member is driving his personal vehicle for a job reassignment, he is paid for his time as well as an additional mileage fee per the chart above.

If crew members report directly to the job site, 10-15 minutes is needed to check plans and organize the plan for the day.

Movement of any vehicle requires one person to drive. You may assume that any member of the crew is capable and authorized to drive any company vehicle. Company policy currently discourages but does not prohibit use of personal vehicles for transportation of crew members. However, this policy is not absolute and is subject to analysis and review should a better alternative arise in your analysis.

Container transportation is provided by a third-party and you can assume that they are available to transport containers on any working day.

Data

All teams should understand that Sunrun is providing data that combines information from real installations over the past two years. However, this data has been “moved” to a fictional install branch located in Norman, Oklahoma, USA. Moving or transplanting our installations was done to protect the privacy of our customers. This particular location was selected because Sunrun does not currently operate in Oklahoma and this is not any indication that Sunrun will operate in Oklahoma in the foreseeable future. Therefore, if you explore Google maps to look at the locations provided, you may not find a home with solar panels but instead nearly anything. Other than transplanting the locations, all the data is real from Sunrun’s recent operations. Distance measures between the fictional install branch and the home installation sites are preserved and the description of the systems, the permitting dates as well as the hours required to build the systems are absolutely real. Seeming inconsistencies, contradictions or other data anomalies are simply a reflection of reality.

Install Branch Location

The fictional install branch location coordinates are: 35.206069 latitude, -97.446619 longitude. This real-world location is centered on the campus of the University of Oklahoma in Norman Oklahoma, USA. It is not an actual Sunrun location.

Install Pattern

The file SIMIO_TESTBRANCH_DATA is two years of installation history for the installation branch. The fields are described below:

Field	Type: Range	Description
Install Branch	Text: "Norman"	This is merely the name for the installation branch. This field is "Norman" to indicate the fictional install branch located in Norman, Oklahoma, USA

Brightbox®	Integer: 0 or 1	Brightbox is the brand name of Sunrun's battery storage solution. It enables homeowners to store power generated during the day when they aren't home and use it at night. From an installation perspective, it takes a bit more time to mount the battery system which weighs over 250 pounds. It also requires a bit more work on the electrical wiring. All of the time associated with installing the Brightbox is included in the standard hours.
Service Panel Upgrade	Integer: blank or 1	Every home has a service panel connecting the house wiring to the electric meter and grid. In some cases, solar installation requires work on this panel in order to expand its capability for solar or bring it up to current electrical code standards. The work on these upgrades is included in the "Scope of Work" time as explained below.
Number Inverters	Integer: 1,2,3,4	An inverters main job is to convert DC power from the solar panels to AC power used in the home. Inverters are also the "brains" of a solar system providing the ability to direct power to the home, the electric grid or to the Brightbox battery system. It also provide usage and production data to the homeowner and Surnun. Every solar installation has at least one inverter. Additional inverters are designed into an installation to allow more panels or to accommodate challenging roof layouts.
Number Panels	Integer: 8 – 71	The number of solar panels installed on the roof. This number varies based on the home's electrical usage, local utility rates, homeowner preferences, usable roof space as well as local zoning regulations and several other factors. Sunrun panels are sourced from a number of different vendors but are of a standard size.
Permit Submitted Date	Date	The date when the plans and other forms are submitted to the city for review and approval. All projects require a copy of the resulting building permit to be physically available at the home installation site before construction begins.
Permit Approval Date	Date	The date that the building permit is issued. Construction can begin the moment the permit is available. You should assume that the first practical construction day is the first working day after the permit is approved.
Number Employee-Days	Integer: 1 – 45	Number of employee days on-site.
Standard Install Hours	Decimal: 2 – 280	These are the total hours recorded for construction for the solar installation itself. This work includes installing the mounting rails, the solar panels, the inverter, the Brightbox battery system and all electrical cabling. It also includes the final tie-in to the main electrical service panel.
Additional SOW Hours	Decimal: 0 – 53.6	These are the recorded hours for any work done that is not part of the solar installation itself. This is known as "Scope Of Work" from the title of the contract addendum. Scope of work covers both minor repairs to a roof (such as a broken tile that needs replacement) to any other work that should be done before the panels are installed. More than 10 SOW hours usually indicates a service panel upgrade. In some cases, the panel doesn't have room for more connections or is simply very old and no longer up to current building codes. While the work for these upgrades is performed by Sunrun, the additional costs are usually shared by Sunrun and the homeowner.

Latitude		Latitude location of the installation work site. Please note that this location data is based on zip code data so it may be possible to have multiple work sites in the same location. Consider this simply a second job site in the same neighborhood.
Longitude		Longitude location of the installation work site.

Analysis & Key Performance Indicators

Fundamentally, this problem involves trade-offs between installation time cycles, expense, and customer satisfaction. In this problem set, customer satisfaction is related to the time between the permit being available and installation completion. Faster installation is better. Senior management is interested in the key elements that drive last mile install performance. Questions concerning the proper number of crews, number of installers per crew, the use of the ready labor pool as well as the last mile install delivery method are all of interest and should be addressed.

Some metrics to consider:

- Install cost per panel
- Total installed panels
- Minimum, average, and maximum wait time for a customer from permit approval to completion

Scenario 1: Keep and improve current system

Assuming the current system is continued, are there optimizations or changes that would improve any of the following outcomes:

- Reduction of time (mean, median, and variance) between permit grant and installation complete.
- Increase in number of systems deployed
- Increase in worker utilization
- Reduction in expense
- Reduction in worst case outcomes (long delays for customers).
- What is the total transportation mileage of the system.
- What is the optimal number of crews and the optimal number of workers by specialty or assignment?

Scenario 2: Use a container pod system

The central question is whether Sunrun should continue the current two truck installation process or switch to a container based system in whole or in part. Your model should inform your recommendation to the senior executives. Your recommendation should, at a minimum, address the following issues:

- Impact on number of installations per month
- Variance of installation times
- Reduction in customer wait times (wait time starts when the permit is approved)
- Reduction in worst case performance

- Expense impacts
- What is the optimal level of containers committed to rental for any monthly period?
- When should the container be scheduled to be loaded and delivered?

Other insights are also welcome such as recommendations on the number of crews. Number of containers and scheduling heuristics should also be considered.

Further questions

Sunrun has shown historic growth of 15% year over year but this is driven by specific markets. Assuming the distribution of sales (job flow) is consistent over time, what adjustments are required for an increase of 10%, 15%, 20% or 30% of sales volume assuming a similar pattern of installation sizes and distances.

What happens to the system if Brightbox (battery) systems increase to 25% of all medium and large system builds in this market?

What happens if the percentage of Service Panel Upgrades increases by 20%? How does this impact wait time and electrician staffing?

Further Considerations

Sunrun currently operates 41 install branch locations. Each of these markets have unique installation characteristics driven by local market conditions. Ideally, your simulation model should be adaptable to repurposing to model other branch locations using different install patterns.