ASSET MANAGEMENT WEBINAR SERIES
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TerraVerde Energy

- An independent energy advisory firm
- Feasibility, project development, and asset management services
- Solar, battery storage, and energy efficiency
- 10 years: $390 Million in projects
- Solar: 70 MWs, Battery: 13 MWs, Energy Efficiency: 300+ buildings
- CEC & NREL Projects, working with CCAs developing software and programs to incentivize implementation of DERs
Today’s Session:
BEST PRACTICES IN MANAGING SOLAR ASSETS

Join Us for Part 2:
HOW TO ASSESS & EXECUTE A PPA BUYOUT
August 22 | 10 AM | Register at lgsec.org/events
THE “WHY”

SOLAR ASSET MANAGEMENT
Properly managed systems perform better and last longer, yielding the maximum financial benefit.
Conversely, poorly managed systems will result in cost overruns, reduced performance, and decreased longevity.
BEST PRACTICES

SOLAR ASSET MANAGEMENT
FOUR MAJOR CONSIDERATIONS

1. Performance Monitoring
2. Preventive Maintenance
3. Reactive Maintenance
4. Reporting & Forecasting
Perform daily reviews of prior day’s performance with actual, expected, & weather adjusted data.

- Daily review of open alerts
- Early detection of outages / underperformance
- Validate accuracy of metering and monitoring hardware / software
- Establish accurate baselines
EXAMPLE | Understanding Solar Monitoring

Day 1
5% Soiling Loss, Cloudy Morning

Day 2
5% Soiling Loss, Communication Interruption

Day 3
5% Soiling Loss, Critical Outage
• Daily reviews of prior day’s performance with actual, expected, & weather adjusted data
• Daily review of open alerts
• Early detection of outages / underperformance is key
• Validate accuracy of metering and monitoring hardware / software
• Establish accurate baselines
Daily reviews of prior day’s performance with actual, expected, & weather adjusted data

- Daily review of open alerts
- Early detection of outages / underperformance is key
- Validate accuracy of metering and monitoring hardware / software
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- Daily reviews of prior day’s performance with actual, expected, & weather adjusted data
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- Validate accuracy of metering and monitoring hardware / software
- Establish accurate baselines
PREVENTIVE MAINTENANCE

SOLAR ASSET MANAGEMENT
› Create a documented facility operations plan
› Thoroughly inspect the systems annually
› Perform regular inverter maintenance as required by the manufacturer (important warranty condition)
 racialized. However, it is important to note that the data on topographical features in the area is limited. Therefore, the construction process will likely require additional survey work to ensure that the foundation is properly laid.

3. Conduit and Cable: In addition to the underground utility lines, there will be conduit and cable required for the building's electrical system. This includes the installation of conduits for electrical wiring and overhead cables for communication and security systems. Special considerations may need to be made for the installation of these systems to ensure they are properly integrated with the building's structural elements.

4. Plumbing: The plumbing system will play a critical role in the building's operation. It is essential that the system is designed to meet both the aesthetic and functional requirements of the building, as well as the environmental standards. This includes the installation of water supply lines, waste disposal systems, and other related components. Efficient water management and conservation practices should also be incorporated to minimize water consumption and reduce energy usage.

5. Insulation: Insulation is crucial for maintaining a comfortable indoor environment and improving energy efficiency. Proper insulation of the building envelope, including walls, floors, and roofs, will help to regulate temperature and reduce energy consumption. The selection of appropriate insulation materials and the correct installation techniques are critical to achieving optimal performance.

6. HVAC: The heating, ventilation, and air conditioning system is a vital component of the building's operation. It is essential to ensure that the system is designed to meet the heating and cooling needs of the building while minimizing energy consumption. Special considerations may need to be made for the installation of HVAC systems in areas with extreme temperatures or high humidity levels.

7. Security: The building's security system will be critical for ensuring the safety and security of the occupants. This includes the installation of security cameras, access control systems, and other related components. The design and installation of the security system should be carefully planned to ensure that it meets the specific needs of the building and its occupants.

8. Fire Protection: The building's fire protection system will play a critical role in ensuring the safety of the occupants in the event of a fire. This includes the installation of smoke detectors, fire alarms, and fire extinguishers. Special considerations may need to be made for the installation of fire protection systems in areas with high fire hazards or in buildings with specific fire codes.
- Create a documented facility operations plan
- Thoroughly inspect the systems annually
- Perform regular inverter maintenance as required by the manufacturer (important warranty condition)
- Visual inspection of panels, racking, inverters, balance of system components, point of interconnection
- Voc testing / I-V curve tracing
- Validate continuity and torque marks
- Verifying accuracy of meters & weather sensors
› Create a documented facility operations plan
› Thoroughly inspect the systems annually
› Perform regular inverter maintenance as required by the manufacturer (important warranty condition)
EXAMPLE | Inverter Warranty Conditions

Warranty Policy (Rev. L)  Grid-Tied Photovoltaic Inverters & Accessories

maximum or minimum limits listed in the Yaskawa Solectria Solar product specifications including high input voltage from generators or lightning strikes;
c) The product, if repairs have been made to it other than by Yaskawa Solectria Solar or its authorized, trained service personnel;
d) The product, if it is used as a component part of a product expressly warranted by another manufacturer;
e) The product, if its original identification (trademark, serial number) markings have been defaced, altered, or removed;
f) The product, if it has been damaged in shipping (unless approved in writing by Yaskawa Solectria Solar);
g) The product, if damaged by customer connections or any items installed by customer or installation company including third party monitoring;
h) Any installation and operation beyond the scope covered by relevant safety regulations (UL1741, NFPA 70, etc.);
i) Third party monitoring equipment;
j) Failure to perform Preventative Maintenance may void the warranty;
k) External transformers for the XTM product are excluded from the Yaskawa Solectria Solar warranty as they are warranted by the transformer manufacturer.
6.2 Product Maintenance
6.2.1 Check the Electrical Connection
Check all the cable connections as a regular maintenance inspection every 6 months or every year.
1.) Check the cable connections. If loose, tighten all the cables according to “2.3 Electrical Installation”.
2.) Check for cable damage, especially whether the cable surface is scratched or smooth. Repair or replace the cables if necessary.

6.2.2 Clean the Air Vent Filter
The inverter can become hot during normal operation. It uses built in cooling fans to provide sufficient air flow to help in heat dissipation.
Check the air vent regularly to make sure it is not blocked and clean the vent with a soft brush or vacuum if necessary.

6.2.3 Replace Cooling Fans
If the internal temperature of the inverter is too high or abnormal noise is heard assuming the air vent is not blocked and is clean, it may be necessary to replace the external fans. Please refer to Figure 6.1 for replacing the cooling fans.
(1) Use a No.2 Phillips head screwdriver to take off the 10 screws on the fan tray (6 screws on the upper fan tray, and 4 screws on the lower fan tray).
(2) Disconnect the waterproof cable connector from the cooling fan.
(3) Use a No.2 Phillips head screwdriver to take off the screws.
(4) Fix the new cooling fan on the fan tray, and fasten the cable on the fan tray with cable ties
   Torque value: 8 in-lbs (0.8-1N.m)
(5) Install the assembled fans back to the inverter.
   Torque value: 10 in-lbs (1.2N.m)
CORRECTIVE MAINTENANCE

SOLAR ASSET MANAGEMENT
- Soiling – ROI analysis, methods
- Outages, underperformance, and communication issues
- Clarify who is financially responsible for corrective maintenance
REPORTING & FORECASTING

SOLAR ASSET MANAGEMENT
› Monthly or quarterly reviews of actual vs. expected production and energy usage, corrective maintenance

› Annual reviews of energy and financial performance, inspection results and recommendations

› Forward looking considerations: PPA buyouts, inverter replacements, additional energy resources
1. EXECUTIVE SUMMARY

This memo is prepared to present a monthly performance review of the Photovoltaic (PV) systems and the electricity usage at each site from July 2017 through March 2018. Individual site production and usage is found in Section 4. A guide to understanding the data in this memo can be found in Section 5.

An analysis of the PV system production shows that over the course of the first three quarters the PV systems produced 97% of what would be expected in a weather adjusted typical year.

As it is shown below, the electricity usage from PG&E has been reduced by 67% over this period as compared to the baseline year. This is a result of utility electricity being offset by solar electricity. The client has used approximately 1% more total electricity compared to the baseline year.

Utility Usage Relative to Baseline: -67.1%
Total Usage Relative to Baseline: +1.4%
As it is shown below, the electricity usage from PG&E has been reduced by 67% over this period as compared to the baseline year. This is a result of utility electricity being offset by solar electricity. The client has used approximately 1% more total electricity compared to the baseline year.
## 2. CORRECTIVE MAINTENANCE

<table>
<thead>
<tr>
<th>Date</th>
<th>Site Name</th>
<th>Issue</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/4/2018</td>
<td>Inverter Outage</td>
<td>Site 1</td>
<td>1/10/2018 Installer visited site to troubleshoot the inverter. From installer: “What was discovered is that the inverter had experienced the same issue as Inverter C last year, basically the screen was experiencing a failure that acted like a button was stuck which caused erroneous commands to the unit. The screen was disconnected and the inverter restarted. Normal operations have resumed and the inverter is reporting via the EMS system, however there will be no data or information visible on the display of the inverter. I am working with Selectria regarding the installation of a replacement screen. Additionally, I have asked them to replace the screen on the third and final inverter at this site in the hopes of not having to deal with this particular issue at this location again.” 1/19/2018 Inverter did not resume producing power this morning. Installer can have someone look at the inverter on 1/20. Most likely in the morning.</td>
</tr>
<tr>
<td>1/8/2018</td>
<td>Site Communication Outage</td>
<td>Site 2</td>
<td>1/8/2018 Sent message to client staff requesting that they visit the site. Client technician visited site and found that main AC disconnect had been opened (vandalism). He closed the switch and powered on the inverter. System resumed producing power.</td>
</tr>
<tr>
<td>1/10/2018</td>
<td>Inverter Outage</td>
<td>Site 1</td>
<td>2/14/2018 Installer technicians visited site and installed new inverter screens on 2/9. 2/16/2018 visit delayed to take care of more pressing issues at other client sites. 3/10/2018 New schedule for Monday 2/7. 1/13/2018 Installer has the display and will dispatch technician to install next week. 1/16/2018 From installer: &quot;Manufacturer has agreed to provide replacement screens for both the inverter that is currently experiencing a problem as well as the third inverter on the site that has yet to have this issue. The screens have shipped and I am expecting to receive them next week. Once they are in hand I will proceed with scheduling their installation.&quot; 1/15/2018 Installer has reached out to manufacturer about a replacement screen. Also asking about pro-actively replacing screen on third site.</td>
</tr>
<tr>
<td>2/29/2018</td>
<td>Inverter Communication Outage</td>
<td>Site 3</td>
<td>2/7/2018 Manufacturer visited the site and successfully completed the repairs. Both inverters are communicating.</td>
</tr>
<tr>
<td>2/7/2018</td>
<td>Inverter communication Outage</td>
<td>Site 1</td>
<td>2/27/2018 Manufacturer visit confirmed for 3/5 at 9pm.</td>
</tr>
<tr>
<td>2/4/2018</td>
<td>Inverter Communication Outage</td>
<td>Site 1</td>
<td>2/13/2018 Installer visited site to troubleshoot issue. From installer: “the inverter requires a new board in order to restore communications. I am working with Manufacturer regarding scheduling.” 3/10/2018 Informed installer during phone call. Technician who visits site will also stop at this site to troubleshoot.</td>
</tr>
<tr>
<td>1/10/2018</td>
<td>Inverter Communication Outage</td>
<td>Site 1</td>
<td>2/13/2018 Technicians found the exhaust fans to be clogged. Fence was blocking access to exhaust screen louvers. Client removed fence to clean and power cycle the inverter. Resumed normal operation. Client will move fence to allow access to back of inverter. 2/6/2018 Manufacturer technician plans to be onsite at 8am on 2/15/2018 to repair the inverter. 2/1/2018 Installer technician visited site for troubleshooting. From installer: “the inverter has a fan that is failing and requires replacing. Manufacturer has stated that due to overheating the unit needs to be energized and left de-energized until the fan is replaced. I am working with manufacturer on scheduling the repair as soon as possible.” 1/15/2018 Sent email to installer informing them of issue and requesting troubleshooting while in area to visit other sites. From installer: “I will add this to the list of sites to visit. There is a possibility that I may be able to pull up the client visits to tomorrow or Friday.”</td>
</tr>
<tr>
<td>2/26/2018</td>
<td>System Outage</td>
<td>Site 2</td>
<td>2/27/2018 Site still not transmitting. Sent reminder by text to facilities staff. Client electrician visited site and found main AC disconnect turned off. Possibly vandalism or a contractor. Disconnect closed and system production resumed. 2/26/2018 Sent email to Client IT and facilities staff to check on site network status and requesting a check on the inverters. Received email from Adam B. that they have an electrician looking into it.</td>
</tr>
<tr>
<td>2/27/2018</td>
<td>Inverter Outage</td>
<td>Site 1</td>
<td>2/27/2018 Sent test to client facilities staff to send someone to view inverter and try a restart. Site resumed producing power at 2:45pm.</td>
</tr>
</tbody>
</table>
QUARTERLY MEMOS

Site Summaries

Solar Energy Production Relative to Expectations 108%

Utility Usage Relative to Baseline: -80.8%
Total Usage Relative to Baseline: -0.1%
¬ Monthly or quarterly reviews of actual vs. expected production and energy usage, corrective maintenance
¬ Annual reviews of energy and financial performance, inspection results and recommendations
¬ Forward looking considerations: PPA buyouts, inverter replacements, additional energy resources
## 2016-2017 Fiscal Year Solar Performance Executive Summary

### I. Financial Performance

<table>
<thead>
<tr>
<th>Metric (Phase I)</th>
<th>Projection</th>
<th>Actual</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided Cost of Electricity</td>
<td>$549,035</td>
<td>$508,283</td>
<td>93%</td>
</tr>
<tr>
<td>CSI Rebate Payments</td>
<td>$428,117</td>
<td>$916,856</td>
<td>214%</td>
</tr>
<tr>
<td>REC Sales</td>
<td>$6,517</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>O&amp;M Costs</td>
<td>($84,394)</td>
<td>($73,106)</td>
<td>86%</td>
</tr>
<tr>
<td>Financing Costs</td>
<td>($566,544)</td>
<td>($566,544)</td>
<td>100%</td>
</tr>
<tr>
<td>Net Savings</td>
<td>$332,731</td>
<td>$785,489</td>
<td>236%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metric (Phase II)</th>
<th>Projection</th>
<th>Actual</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided Cost of Electricity</td>
<td>$163,410</td>
<td>$147,807</td>
<td>90%</td>
</tr>
<tr>
<td>CSI Rebate Payments</td>
<td>$128,178</td>
<td>$106,040</td>
<td>78%</td>
</tr>
<tr>
<td>REC Sales</td>
<td>$1,053</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>O&amp;M Costs</td>
<td>($31,953)</td>
<td>($24,969)</td>
<td>78%</td>
</tr>
<tr>
<td>Prop 39 Grant</td>
<td>$462,898</td>
<td>$462,898</td>
<td>100%</td>
</tr>
<tr>
<td>Solectria Outage Payment</td>
<td>---</td>
<td>$15,600</td>
<td>---</td>
</tr>
<tr>
<td>Net Savings</td>
<td>$723,586</td>
<td>$707,376</td>
<td>98%</td>
</tr>
</tbody>
</table>

### II. Technical Performance

<table>
<thead>
<tr>
<th>Metric</th>
<th>Projection (kWh)</th>
<th>Actual (kWh)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Energy Production I</td>
<td>3,142,545</td>
<td>3,322,565</td>
<td>106%</td>
</tr>
<tr>
<td>Solar Energy Production II</td>
<td>937,626</td>
<td>830,638</td>
<td>89%</td>
</tr>
<tr>
<td>Client Energy Usage I</td>
<td>3,429,614</td>
<td>2,861,165</td>
<td>83%</td>
</tr>
<tr>
<td>Client Energy Usage II</td>
<td>1,045,939</td>
<td>970,266</td>
<td>93%</td>
</tr>
</tbody>
</table>
Energy Performance

Client Phase I Total

Solar Energy Production Relative to Expectations 105.7%

Utility Usage Relative to Baseline: -113.5%
Total Usage Relative to Baseline: -16.6%
Preventative Maintenance Summary

Preventative maintenance and inspection was performed at each site. This preventative maintenance is necessary to maintain inverter warranties and to ensure the long term functionality of the systems. The preventative maintenance includes:

- I-V Curve Tracing
- Checking for burned fuses
- Checking for electrical hot spots
- Validating torque marks
- Visually inspecting inverters, disconnect switches, combiner boxes, pyranometers, and array racking
- Performing inverter maintenance according to manufacturer’s specifications
- Testing ground fault values at the inverters

<table>
<thead>
<tr>
<th>Site</th>
<th>Finding</th>
<th>Recommended Action</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>Bird nests found in the back of the inverter and under the array.</td>
<td>Client should remove bird nests when possible.</td>
<td>Open</td>
</tr>
<tr>
<td>Site 2</td>
<td>No maintenance issues found during the annual inspection.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 3</td>
<td>I-V Curve showed string anomaly. Like broken module or wire connection issue.</td>
<td>TerraVerde will work with our maintenance team to determine the best solution.</td>
<td>Open</td>
</tr>
<tr>
<td>Site 4</td>
<td>Inverter 1 has a blown fan capacitor.</td>
<td>TerraVerde has provided a work order to replace the damaged fan. At the time of writing our maintenance team is preparing to schedule the visit once the fan parts are delivered.</td>
<td>Open</td>
</tr>
<tr>
<td>Site 5</td>
<td>No maintenance issues found</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 6</td>
<td>There is tree overgrowth near the inverter and disconnects.</td>
<td>Client should trim near the inverter equipment pad.</td>
<td>Open</td>
</tr>
<tr>
<td>Site 6</td>
<td>Inverter equipment pad gate can be opened without opening the lock.</td>
<td>Client should address issue with gate lock.</td>
<td>Open</td>
</tr>
</tbody>
</table>
Corrective Maintenance Summary

TerraVerde monitors the system production and alarms in 15 minute increments every day of the year. TerraVerde determined many of these alarms to be false positives and did not escalate those issues. Of the remaining alarms, several issues were related to site connectivity and were resolved through contact with the District IT team. The remaining alarms required corrective action. In general, TerraVerde detects an issue through the online portal and then works with client personnel to fully diagnose the situation on site. TerraVerde works with the client to ensure that installers and manufacturers are held to their warranties, minimizing the cost of corrective maintenance work. The following table is a list of the detected alarm events, the corrective action taken, and the result of the corrective action.

<table>
<thead>
<tr>
<th>Site</th>
<th>Issue and Resolution</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>In December, TerraVerde alerted installer that production was lower than normal. Installer dispatched a technician who initiated a replacement of one inverter under warranty. In January, the installer monitoring system stopped transmitting data. TerraVerde alerted installer who confirmed that a case had been created and a technician scheduled to visit the site.</td>
<td>Complete</td>
</tr>
<tr>
<td>Site 2</td>
<td>No issues identified from July 2016 through June 2017.</td>
<td></td>
</tr>
<tr>
<td>Site 3</td>
<td>In January, the PV system stopped transmitting data. TerraVerde identified the issue and worked with district IT to restore data communication. In April, the inverter began intermittently derating or shutting off. TerraVerde identified the issue and after initially working with the client to power cycle the inverter, we dispatched installer under a client signed work order to repair the inverter. In June, the PV system stopped transmitting data. TerraVerde identified the issue and worked with our maintenance team during the site’s annual inspection visit to restore power to the monitoring equipment.</td>
<td>Complete</td>
</tr>
<tr>
<td>Site 4</td>
<td>No issues identified from July 2016 through June 2017.</td>
<td></td>
</tr>
<tr>
<td>Site 5</td>
<td>No issues identified from July 2016 through June 2017.</td>
<td></td>
</tr>
<tr>
<td>Site 6</td>
<td>No issues identified from July 2016 through June 2017.</td>
<td></td>
</tr>
</tbody>
</table>
ANNUAL REPORTS

Site Summaries

Solar Energy Production Relative to Expectations:
106.9%

Utility Usage Relative to Baseline: -103.1%
Total Usage Relative to Baseline: -7.3%
<table>
<thead>
<tr>
<th>Period Ending</th>
<th>Annual Production (kWh)</th>
<th>Utility Power (S/kW)</th>
<th>Avoided Cost of</th>
<th>Avoided Cost of</th>
<th>Renewable</th>
<th>Subtotal:</th>
<th>Annual Solar</th>
<th>Operations Expenses</th>
<th>Financial Outflows</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/31/13</td>
<td>3,150,329</td>
<td>0.0</td>
<td>$495,656</td>
<td>$312,059</td>
<td>$0</td>
<td>$807,715</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/31/12</td>
<td>1,324,500</td>
<td>0.0</td>
<td>$430,875</td>
<td>$205,600</td>
<td>$0</td>
<td>$636,475</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/31/11</td>
<td>3,150,329</td>
<td>0.0</td>
<td>$495,656</td>
<td>$312,059</td>
<td>$0</td>
<td>$807,715</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/31/10</td>
<td>1,324,500</td>
<td>0.0</td>
<td>$430,875</td>
<td>$205,600</td>
<td>$0</td>
<td>$636,475</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/31/09</td>
<td>3,150,329</td>
<td>0.0</td>
<td>$495,656</td>
<td>$312,059</td>
<td>$0</td>
<td>$807,715</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/31/08</td>
<td>1,324,500</td>
<td>0.0</td>
<td>$430,875</td>
<td>$205,600</td>
<td>$0</td>
<td>$636,475</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Pro Forma*
Monthly or quarterly reviews of actual vs. expected production and energy usage, corrective maintenance

Annual reviews of energy and financial performance, inspection results and recommendations

Forward looking considerations: PPA buyouts, inverter replacements, additional energy resources
Thank You! If you’re interested in...

‣ Copies of this presentation
‣ Copies of example reports
‣ Article: “Top 5 Ways Solar Owners Lose Money”
‣ Continuing This Conversation

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