ASSET MANAGEMENT WEBINAR SERIES

Local Government SUSTAINABLE ENERGY Coalition

TerraVerde ENERGY

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TerraVerde ENERGY

INTRODUCTIONS

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

TerraVerde ENERGY | WEBINAR SERIES

THE “WHY”

SOLAR ASSET MANAGEMENT

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Properly managed systems perform better and last longer, yielding the maximum financial benefit

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THE “WHY” OF ASSET MANAGEMENT

Conversely, poorly managed systems will result in cost overruns, reduced performance, and decreased longevity

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THE “WHY” OF ASSET MANAGEMENT

BEST PRACTICES

SOLAR ASSET MANAGEMENT

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1. Performance Monitoring
2. Preventive Maintenance
3. Reactive Maintenance
4. Reporting & Forecasting

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FOUR MAJOR CONSIDERATIONS

PERFORMANCE MONITORING

SOLAR ASSET MANAGEMENT

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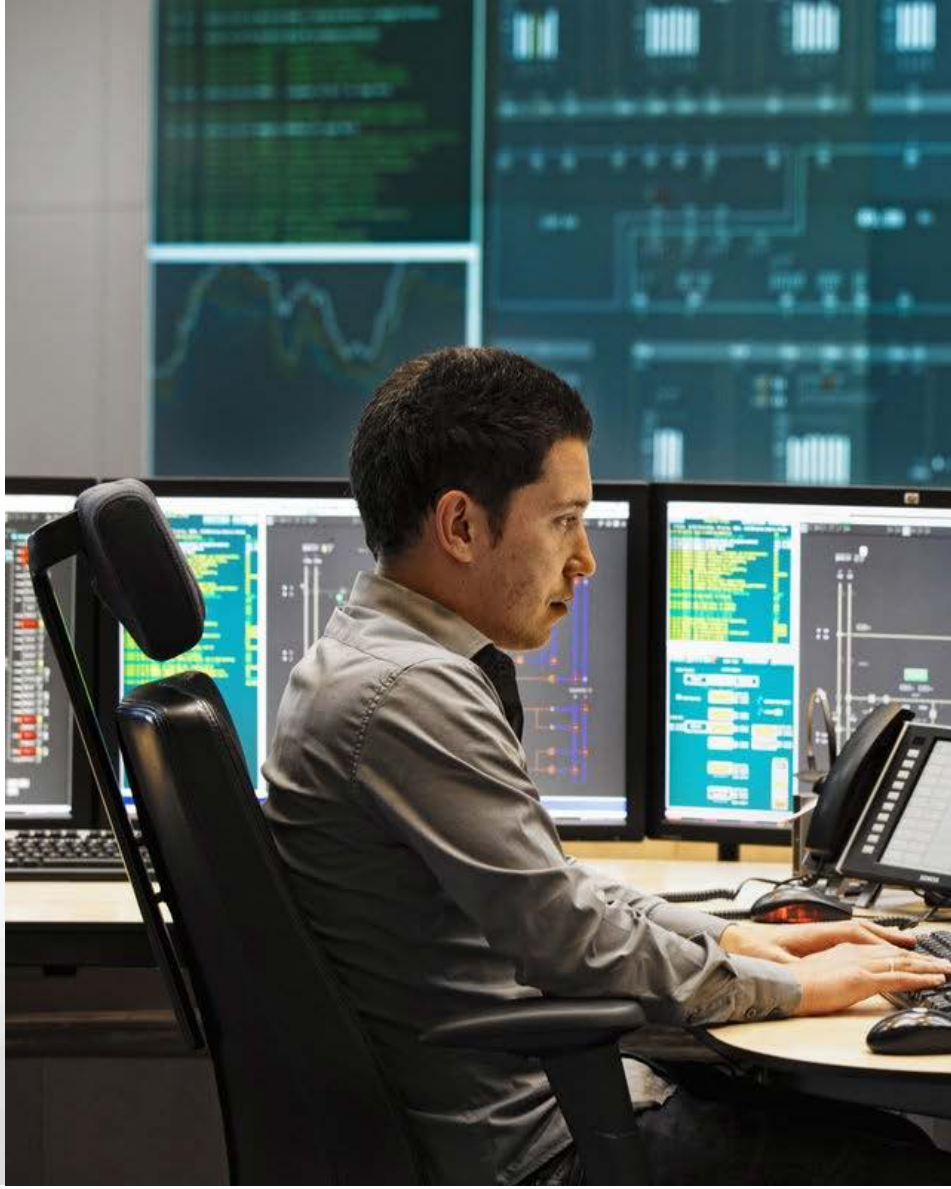
- Daily reviews of prior day's performance with actual, expected, & weather adjusted data
- Daily review of open alerts
- Early detection of outages / underperformance
- Validate accuracy of metering and monitoring hardware / software
- Establish accurate baselines



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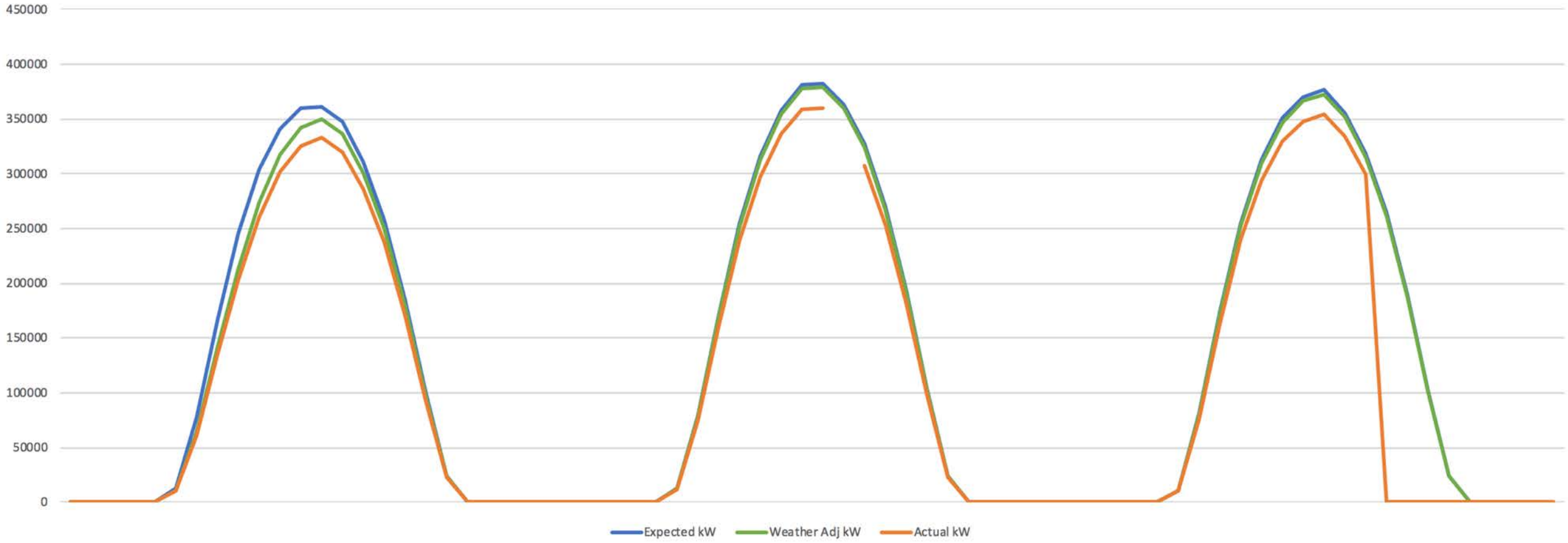
EXAMPLE | Understanding Solar Monitoring



Day 1	Day 2	Day 3
5% Soiling Loss, Cloudy Morning	5% Soiling Loss, Communication Interruption	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
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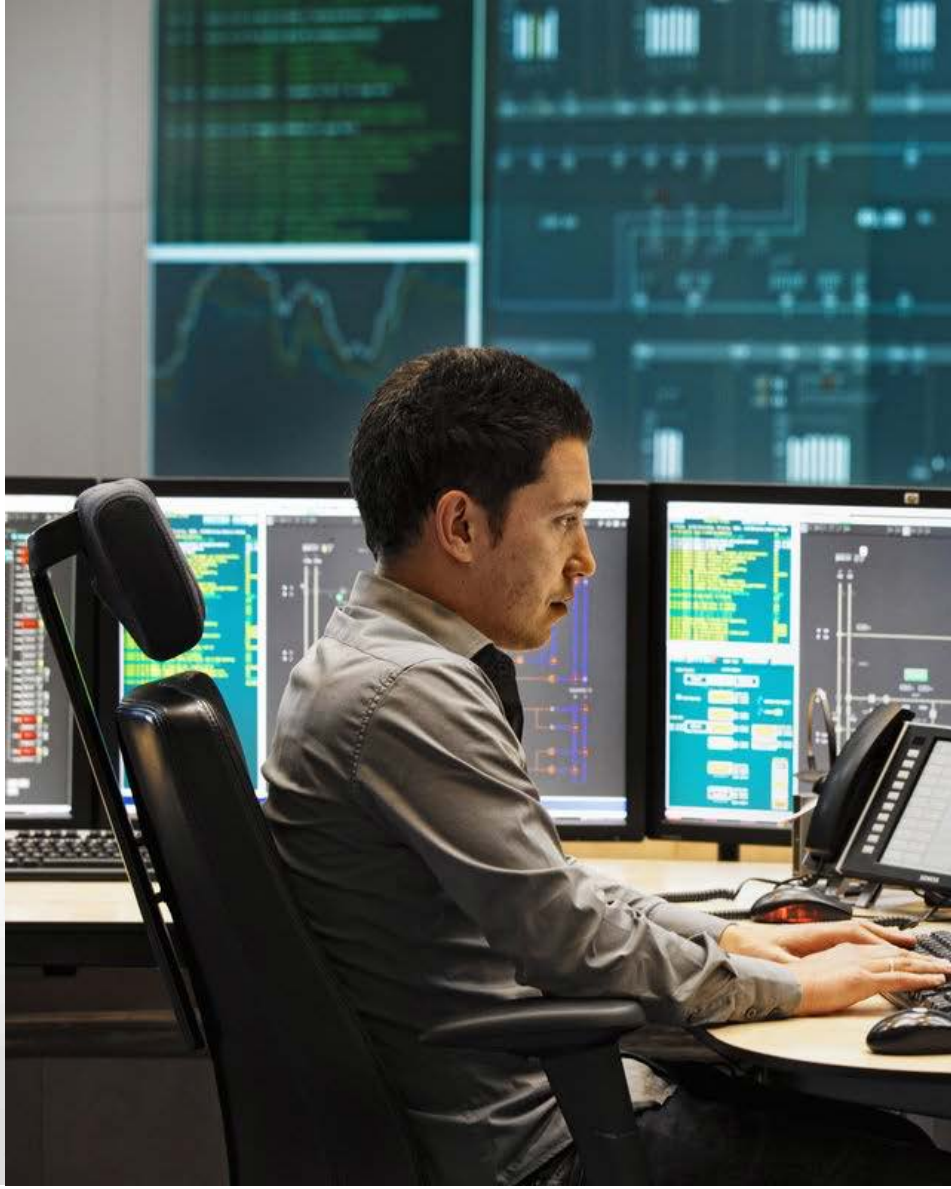

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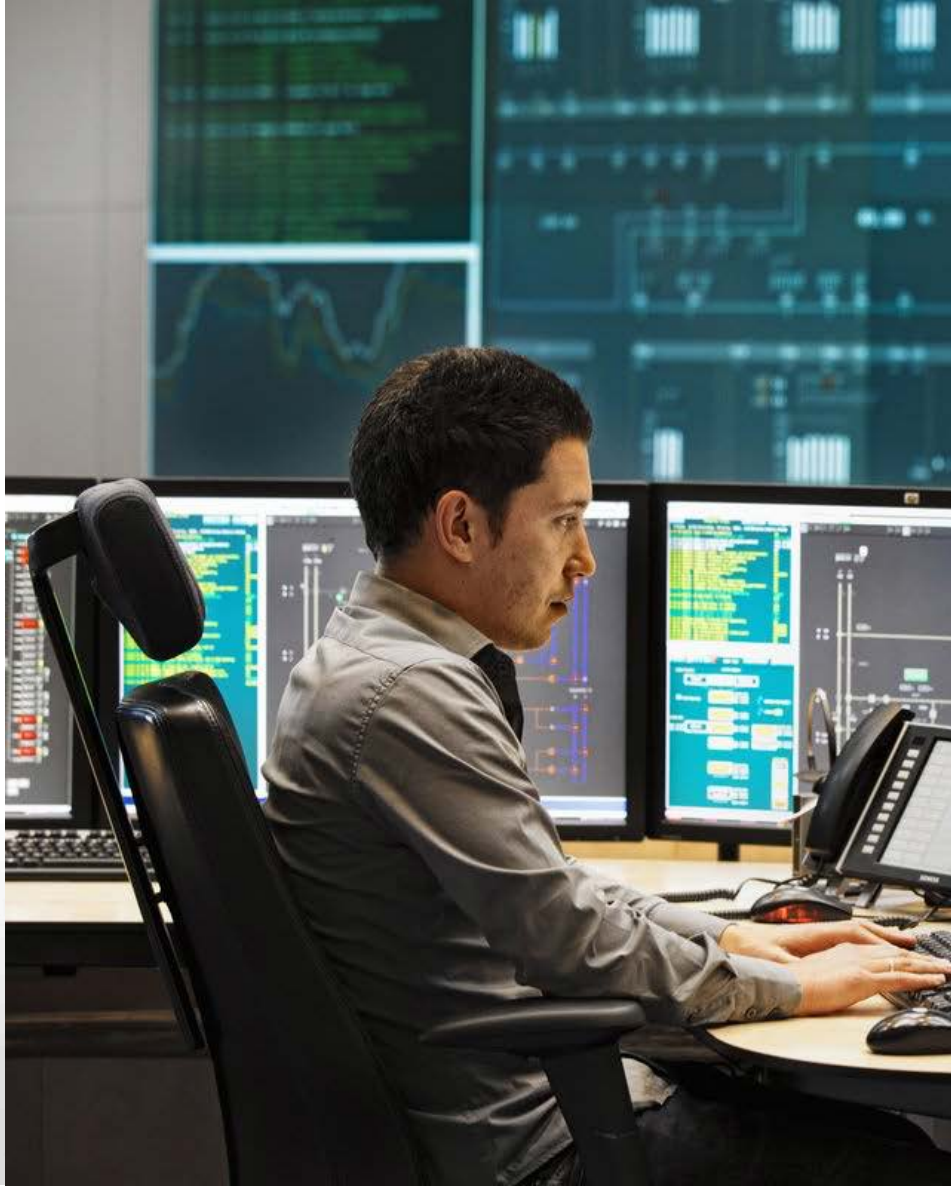

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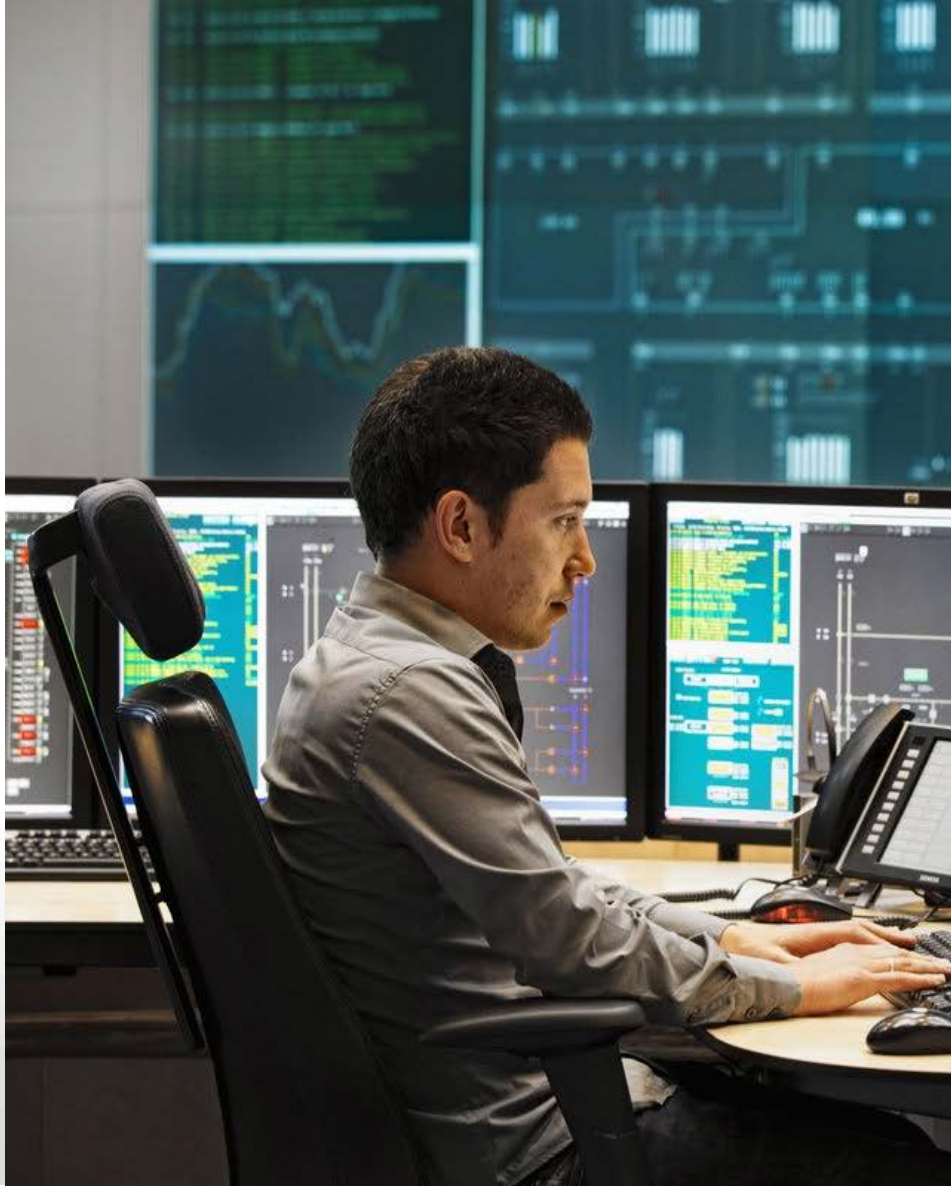

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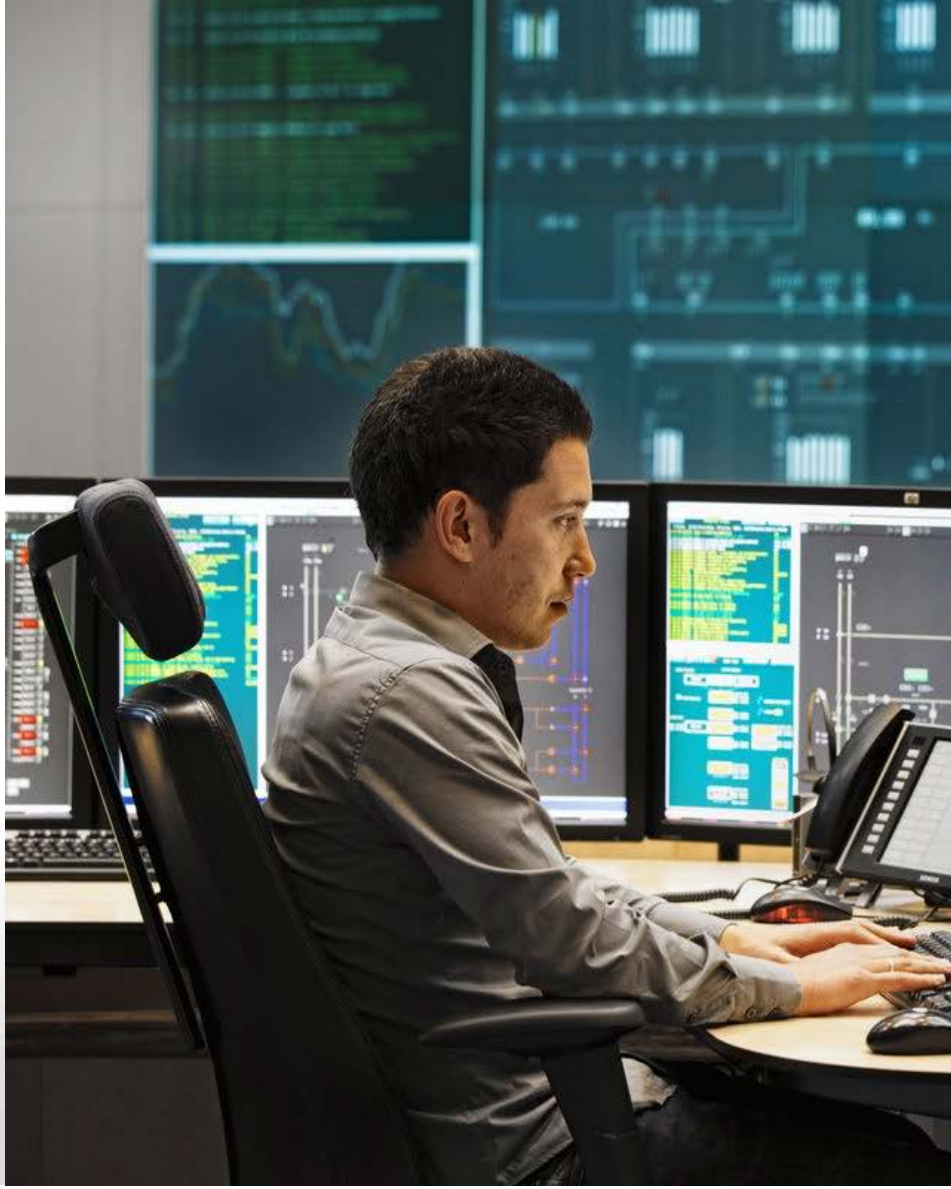

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PREVENTIVE MAINTENANCE

SOLAR ASSET MANAGEMENT

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- Create a documented facility operations plan
- Thoroughly inspect the systems annually
- Perform regular inverter maintenance as required by the manufacturer (important warranty condition)

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PREVENTIVE MAINTENANCE

- Description of each system including: equipment & manufacturer lists, site plans, as-built drawings
- Contacts, roles and responsibilities
- Installer's Operations and Maintenance (O&M) guide
- Monitoring System Guide
- Emergency shutdown / restart procedures (contact list / location of keys)

- Create a documented facility operations plan
- Thoroughly inspect the systems annually
- Perform regular inverter maintenance as required by the manufacturer (important warranty condition)

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PREVENTIVE MAINTENANCE

- 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

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ANNUAL INSPECTION CONSIDERATIONS

- Create a documented facility operations plan
- Thoroughly inspect the systems annually
- Perform regular inverter maintenance as required by the manufacturer (important warranty condition)

TerraVerde ENERGY | PREVENTIVE MAINTENANCE

EXAMPLE | Inverter Warranty Conditions

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.

EXAMPLE | Inverter Maintenance Guidelines

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

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- Soiling – ROI analysis, methods
- Outages, underperformance, and communication issues
- Clarify who is financially responsible for corrective maintenance

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CORRECTIVE MAINTENANCE

REPORTING & FORECASTING

SOLAR ASSET MANAGEMENT

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- 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

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REPORTING & FORECASTING

QUARTERLY MEMOS

Summary Analysis

TO: Client Name
SUBJECT: Example Quarterly Electricity Usage & PV Production Report
DATE: April 2018

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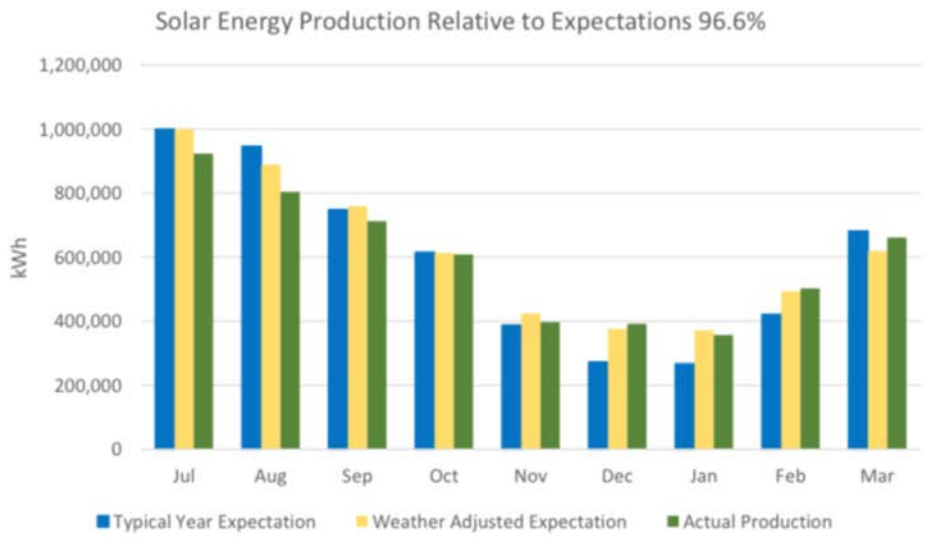
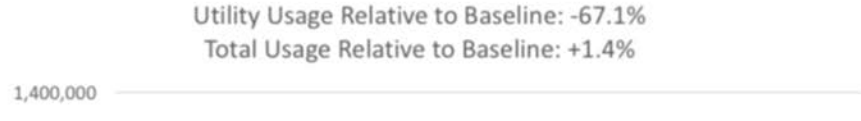
1. EXECUTIVE SUMMARY

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.

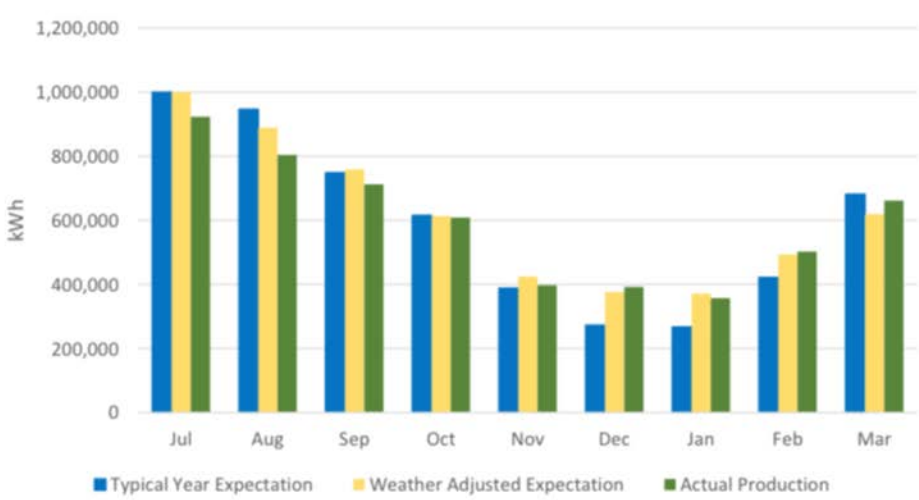


As it is shown below, the **electricity usage from PG&E has been reduced by 67%** over this period as compared to the baseline year. This is a result of utility electricity being offset by solar electricity. The client has used approximately **1% more total electricity** compared to the baseline year.



QUARTERLY MEMOS

Summary Analysis



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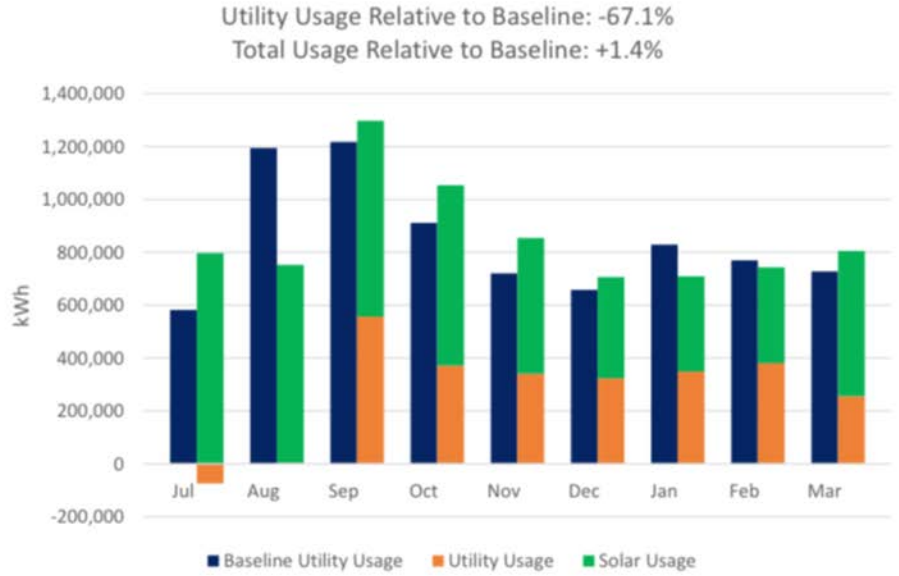


QUARTERLY MEMOS

Maintenance Records

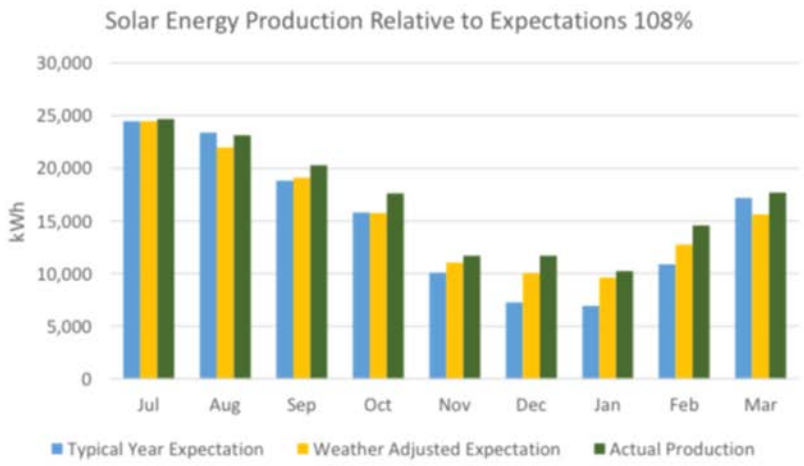
2. CORRECTIVE MAINTENANCE

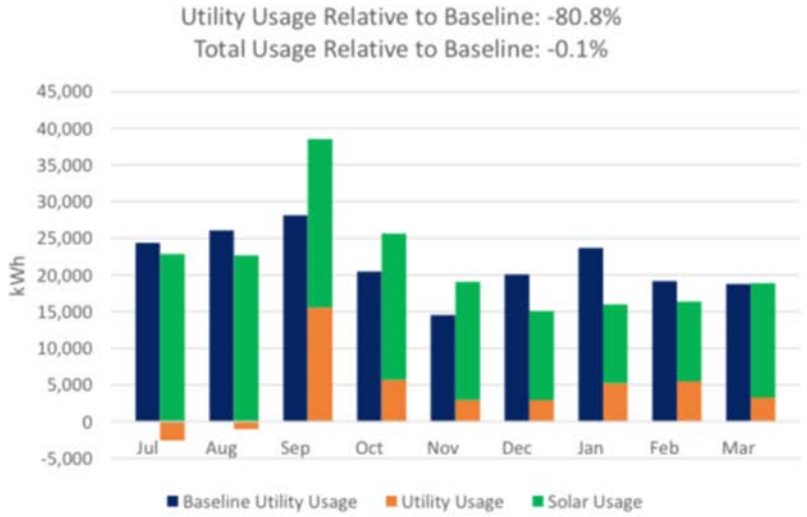
Date opened	Date Resolved	Duration (Days)	Type	Site Name	Issue	Status
1/4/2018	1/10/2018	6	Inverter Outage	Site 1	Inverter A stopped producing power at 10:30am on 1/4.	1/10/2018 Installer tech visited site to troubleshoot the inverter. From Installer: "What was discovered is that this inverter had experienced the same issue as Inverter C did 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 DAS system, however there will be no data or information visible on the display of the inverter. I am working with Solectria 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." 1/9/2018 Inverter did not resumed producing power this morning. Installer can have someone look at the inverter on 1/10. Most likely in the morning. 1/8/2018 Client staff visited site and power cycled the inverter. Production resumed. 1/5/2018 Sent message to client staff requesting a visit to restart inverter.
1/8/2018	1/8/2018	0	Site Communication Outage	Site 2	Site stopped transmitting data at 12pm on 1/7.	1/8/2018 Sent message to client staff requesting that they visit the site. Client electrician 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.
1/10/2018	2/8/2018	29	Other/Not production related	Site 1	Inverter A display screen needs to be replaced.	2/14/2018 Installer technicians visited site and installed new inverter screens on 2/8. 2/6/2018 visit delayed to take care of more pressing issues at other client sites. 1/30/2018 Now scheduled for Monday 2/5. 1/23/2018 Installer has the display and will dispatch technician to install next week. 1/16/2018 From Installer: "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." 1/10/2018 Installer has reached out to manufacturer about a replacement screen. Also asking about pro-actively replacing screen on third inverter.
1/29/2018	3/5/2018	35	Inverter Communication Outage	Site 3	Inverter B stopped transmitting data a day after showing 0 production. Gen meter is still showing normal production from the inverter.	3/5/2018 Manufacturer visited the site and successfully completed the repairs. Both inverters are communicating. 2/27/2018 Manufacturer visit new confirmed for 3/5 at 1pm. 2/26/2018 Manufacturer tentatively scheduled to visit on 3/6. 2/14/2018 Installer to follow up with Manufacturer. 2/6/2018 Installer will follow up with Manufacturer on details and schedule. 2/1/2018 Installer technician 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." 1/30/2018 Informed installer during phone call. Technician who visits site will also stop at this site to troubleshoot.
1/31/2018	2/13/2018	13	Inverter Underperformance	Site 4	Inverter BCD is showing derated production.	2/13/2018 Technicians found the exhaust fans to be clogged. Fence was blocking access to exhaust screen louvre. 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 2/13/2018 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 de-energized and left de-energized until the fan is replaced. I am working with manufacturer on scheduling the repair as soon as possible." 1/31/2018 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."
2/26/2018	2/27/2018	1	System Outage	Site 2	Site stopped transmitting data at 9pm on 2/24. Inverter data stopped at 6pm.	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.
2/27/2018	2/27/2018	0	Inverter Outage	Site 1	Inverter B stopped producing power at 10:30am on 2/27.	2/27/2018 Sent text to client facilities staff to send someone to view inverter and try a restart. Site resumed producing power at 2:45pm.

QUARTERLY MEMOS

Site Summaries

Site: Site 4
SAID: ##########





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- Annual reviews of energy and financial performance, inspection results and recommendations
- Forward looking considerations: PPA buyouts, inverter replacements, additional energy resources

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Financial Performance

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2016-2017 Fiscal Year Solar Performance Executive Summary

I. Financial Performance

Metric (Phase I)	Projection	Actual	Percentage
Avoided Cost of Electricity	$549,035	$508,283	93%[1]
CSI Rebate Payments	$428,117	$916,856	214%[2]
REC Sales	$6,517	---	---[3]
O&M Costs	($84,394)	($73,106)	86%
Financing Costs	($566,544)	($566,544)	100%
Net Savings	$332,731	$785,489	236%

Metric (Phase II)[4]	Projection	Actual	Percentage
Avoided Cost of Electricity	$163,410	$147,807	90%[5]
CSI Rebate Payments	$128,178	$106,040	78%[6]
REC Sales	$1,053	---	---
O&M Costs	($31,953)	($24,969)	78%
Prop 39 Grant	$462,898	$462,898	100%
Solectria Outage Payment	---	$15,600	---
Net Savings	$723,586	$707,376	98%

II. Technical Performance

Metric	Projection (kWh)	Actual (kWh)	Percentage
Solar Energy Production I	3,142,545	3,322,565	106%
Solar Energy Production II	937,626	830,638	89%
Client Energy Usage I	3,429,614	2,861,165	83%
Client Energy Usage II	1,045,939	970,266	93%

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Energy Performance

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Annual Inspection

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

Site	Finding	Recommended Action	Status
Site 1	Bird nests found in the back of the inverter and under the array.	Client should remove bird nests when possible.	Open
Site 2	No maintenance issues found during the annual inspection.		
Site 3	I-V Curve showed string anomaly. Likely broken module or wire connection issue.	TerraVerde will work with our maintenance team to determine the best solution.	Open
Site 4	Inverter 1 has a blown fan capacitor.	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.	Open
	Bird nests found in the array racking.	Maintenance technician cleared the bird nests from the array.	Complete
Site 5	No maintenance issues found		
Site 6	There is tree overgrowth near the inverter and disconnects.	Client should trim tree near the inverter equipment pad.	Open
	Inverter equipment pad gate can be opened without opening the	Client should address issue with gate lock	Open

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Maintenance Record

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.

Site	Issue and Resolution	Status
Site 1	In December, TerraVerde alerted installer that production was lower than normal. Installer dispatched a technician who initiated a replacement of one inverter under warranty.	Complete
	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.	Complete
Site 2	No issues identified from July 2016 through June 2017.	
Site 3	In January, the PV system stopped transmitting data. TerraVerde identified the issue and worked with district IT to restore data communication.	Complete
	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.	Complete
	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 the monitoring equipment.	Complete
Site 4	No issues identified from July 2016 through June 2017.	
Site 5	No issues identified from July 2016 through June 2017.	
Site 6	No issues identified from July 2016 through June 2017.	

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Site Summaries

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Pro Forma

Project Qualification Model

Project Name: Client Phase I
Scenario #1: Installer Pre-Final (Phase I)

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Electricity Assumptions					Avoided Cost & Revenue				O&M						Financing Outflows		Results	
Year	Period Ending	Annual Solar Production (kWh)	Utility Escalator	Avoided Cost of Utility Power ($/kWh)	Avoided Cost from Solar Generation	Production Based Incentive (PBI)	Renewable Energy Certificates (RECs)	**Subtotal: Annual Solar Benefit**	Asset Management Services	Contingency Reserve Fund	Module Washing	Inverter Replacement	Insurance	**Subtotal: Annual Operating Expenses**	Fund 200 Loan	**Subtotal: Financing Outflows**	Annual Net Savings / Avoided Cost	**Cumulative Net Savings / Avoided Cost**
1	12/31/14	3,150,329	n/a	$0.1573	$495,656	$312,059	$0	$807,715	$0	$0	$0	$0	$0	$0	($180,755)	($180,755)	$626,960	**$626,960**
2	12/31/15	3,126,702	4.25%	$0.1640	$512,846	$434,612	$6,301	$953,758	($71,366)	($18,288)	($9,753)	$0	($6,096)	($105,503)	($180,755)	($180,755)	$667,500	**$1,294,460**
3	12/31/16	3,103,251	4.25%	$0.1710	$530,632	$431,352	$6,253	$968,238	($60,661)	($18,745)	($9,997)	$0	($6,248)	($95,652)	($566,544)	($566,544)	$306,042	**$1,600,502**
4	12/31/17	3,079,977	4.25%	$0.1783	$549,035	$428,117	$6,517	$983,669	($48,529)	($19,213)	($10,247)	$0	($6,404)	($84,394)	($566,544)	($566,544)	$332,730	**$1,933,232**
5	12/31/18	3,056,877	4.25%	$0.1858	$568,077	$424,906	$7,700	$1,000,683	($38,823)	($19,694)	($10,503)	$0	($6,565)	($75,585)	($566,544)	($566,544)	$358,553	**$2,291,785**
6	12/31/19	3,033,950	4.25%	$0.1937	$587,778	$121,188	$8,254	$717,220	($34,941)	($20,186)	($10,766)	$0	($6,729)	($72,622)	($566,544)	($566,544)	$78,054	**$2,369,839**
7	12/31/20	3,011,196	4.25%	$0.2020	$608,163	$0	$21,238	$629,401	($34,941)	($20,691)	($11,035)	$0	($6,897)	($73,564)	($566,544)	($566,544)	($10,707)	**$2,359,132**
8	12/31/21	2,988,612	4.25%	$0.2106	$629,255	$0	$21,078	$650,333	($34,941)	($21,208)	($11,311)	$0	($7,069)	($74,529)	($566,544)	($566,544)	$9,260	**$2,368,391**
9	12/31/22	2,966,197	4.25%	$0.2195	$651,078	$0	$20,920	$671,999	($34,941)	($21,738)	($11,594)	$0	($7,246)	($75,519)	($566,544)	($566,544)	$29,935	**$2,398,327**
10	12/31/23	2,943,951	4.25%	$0.2288	$673,659	$0	$29,662	$703,321	($34,941)	($22,282)	($11,884)	$0	($7,427)	($76,534)	($566,544)	($566,544)	$60,243	**$2,458,569**
11	12/31/24	2,921,871	4.25%	$0.2386	$697,022	$0	$29,440	$726,461	($36,164)	($22,839)	($12,181)	$0	($7,613)	($78,796)	($566,544)	($566,544)	$81,121	**$2,539,690**
12	12/31/25	2,899,957	4.25%	$0.2487	$721,196	$0	$29,219	$750,414	($37,430)	($23,410)	($12,485)	$0	($7,803)	($81,128)	($566,544)	($566,544)	$102,742	**$2,642,432**
13	12/31/26	2,878,207	4.25%	$0.2593	$746,207	$0	$29,000	$775,207	($38,740)	($23,995)	($12,797)	$0	($7,998)	($83,530)	($566,544)	($566,544)	$125,132	**$2,767,564**
14	12/31/27	2,856,621	4.25%	$0.2703	$772,087	$0	$43,173	$815,260	($40,096)	($24,595)	($13,117)	$0	($8,198)	($86,006)	($566,544)	($566,544)	$162,710	**$2,930,274**
15	12/31/28	2,835,196	4.25%	$0.2818	$798,864	$0	$42,849	$841,713	($41,499)	($25,210)	($13,445)	$0	($8,403)	($88,557)	($566,544)	($566,544)	$186,612	**$3,116,886**
16	12/31/29	2,813,932	4.25%	$0.2937	$826,569	$0	$42,528	$869,097	($42,951)	($25,840)	($13,781)	$0	($8,613)	($91,186)	$0	$0	$777,911	**$3,894,797**
17	12/31/30	2,792,828	4.25%	$0.3062	$855,236	$0	$42,209	$897,445	($44,455)	($26,486)	($14,126)	$0	($8,829)	($93,895)	$0	$0	$803,550	**$4,698,347**
18	12/31/31	2,771,882	4.25%	$0.3192	$884,897	$0	$41,892	$926,789	($46,011)	($27,148)	($14,479)	$0	($9,049)	($96,687)	$0	$0	$830,102	**$5,528,449**
19	12/31/32	2,751,092	4.25%	$0.3328	$915,586	$0	$41,578	$957,164	($47,621)	($27,827)	($14,841)	$0	($9,276)	($99,564)	$0	$0	$857,600	**$6,386,048**
20	12/31/33	2,730,459	4.25%	$0.3470	$947,339	$0	$41,266	$988,606	($49,288)	($28,522)	($15,212)	$0	($9,507)	($102,530)	$0	$0	$886,076	**$7,272,125**
21	12/31/34	2,709,981	4.25%	$0.3617	$980,194	$0	$40,957	$1,021,151	($51,013)	($29,236)	($15,592)	($162,567)	($9,745)	($268,152)	$0	$0	$752,999	**$8,025,123**
22	12/31/35	2,689,656	4.25%	$0.3771	$1,014,189	$0	$40,650	$1,054,838	($52,798)	($29,966)	($15,982)	($162,567)	($9,989)	($271,302)	$0	$0	$783,536	**$8,808,660**
23	12/31/36	2,669,484	4.25%	$0.3931	$1,049,362	$0	$40,345	$1,089,707	($54,646)	($30,716)	($16,382)	($162,567)	($10,239)	($274,549)	$0	$0	$815,158	**$9,623,818**
24	12/31/37	2,649,462	4.25%	$0.4098	$1,085,755	$0	$40,042	$1,125,798	($56,559)	($31,483)	($16,791)	($162,567)	($10,494)	($277,895)	$0	$0	$847,903	**$10,471,721**

- 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

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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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