EPRI 2013 PV Systems O&M Symposium

Joseph Frani

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PV O&M

- Overview
- Tools and Tactics
- Measureable Impacts
- Component Reliability
- O&M Challenges
- Strategies for Boosting ROI

San Diego Gas & Electric

SDG&E - Service territory 4,000 square miles, 25 cities

Serve 1.4M electric accounts:

- 700k gas, 3.4M customers

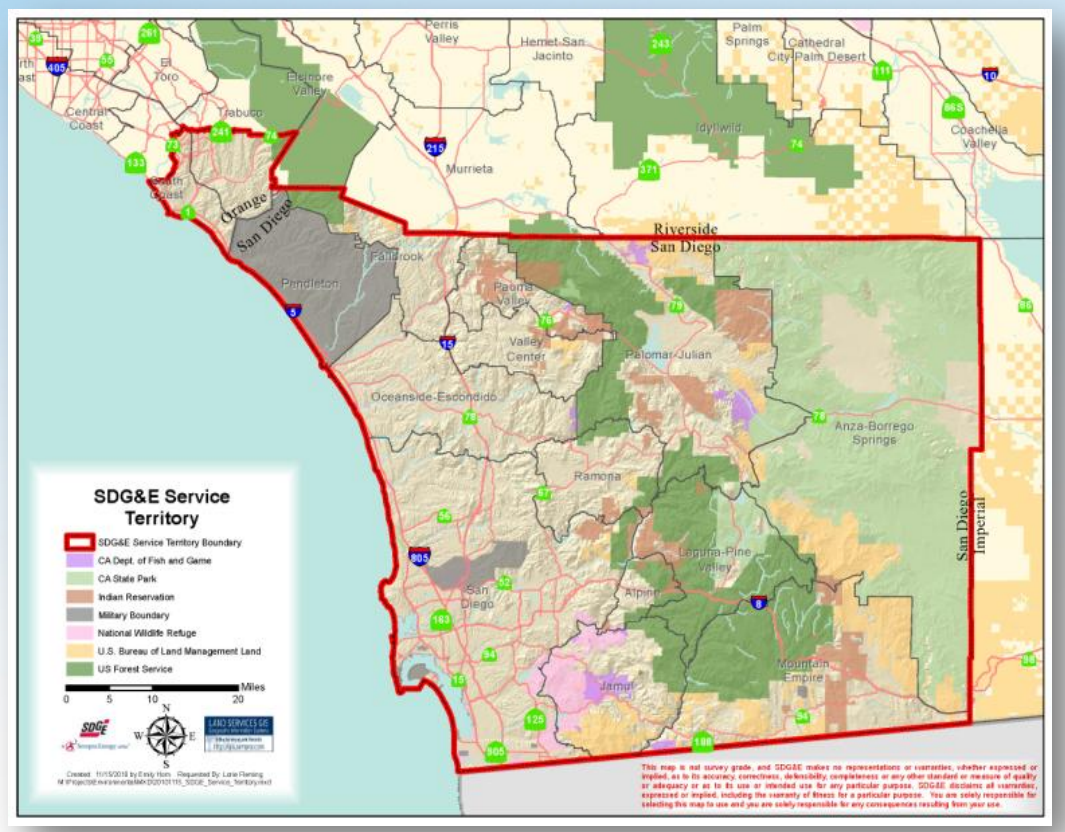
Operate over 2,000 miles transmission lines and 22,000 miles distribution lines

4,500 employees

Sempra Utilities

- SDG&E
- SoCal Gas
- Sempra International
- Sempra US Gas & Power

31 million consumers worldwide
17,000 employees



Overview

- SDG&E Solar Experience
  - Customer installs
    - 23,000 NEM systems / 170 MW
  - Sustainable Communities Program
    - Integrate utility owned renewable generation within “sustainable commercial/community sites
    - Participants “host” site in exchange for lease payments or “LEED” points
    - 36 sites/ 4.4 MW; first system installed 2004
  - Utility Scale
    - 26 MW authorized
    - Ground mount systems in San Diego County
    - In design phase

Tools and Tactics

- Design
- Project Documentation
- Commissioning
- Annual Maintenance
- Monitoring/Evaluation
- Spare Parts
- Software

Project Documentation

Project						
#	Item	C	P	N/A	Elec.	Hard Copy
1	System description and overview with photos, including principles of operation and safety considerations.				x	x
2	Procedures for operating, disconnecting, servicing, and maintaining complete system and components				x	x
3	Complete parts list and equipment specifications					
4	As-Built Drawings (PDF and DWG), including the following details:				x	x
a	Location of all equipment on property or building				x	x
b	Diagram indicating overall layout of entire system, including location of PV array, individual strings, BOS hardware, and inverter				x	x
c	All electrical details				x	x
d	All mechanical details				x	x
e	Communication and DAS wiring and equipment locations				x	x
5	DAS communication/configuration documentation including IP addresses, Modbus addresses, MAC addresses				x	x
6	Documentation of serial numbers for inverters and other major equipment				x	x

Project Documentation Cont'd

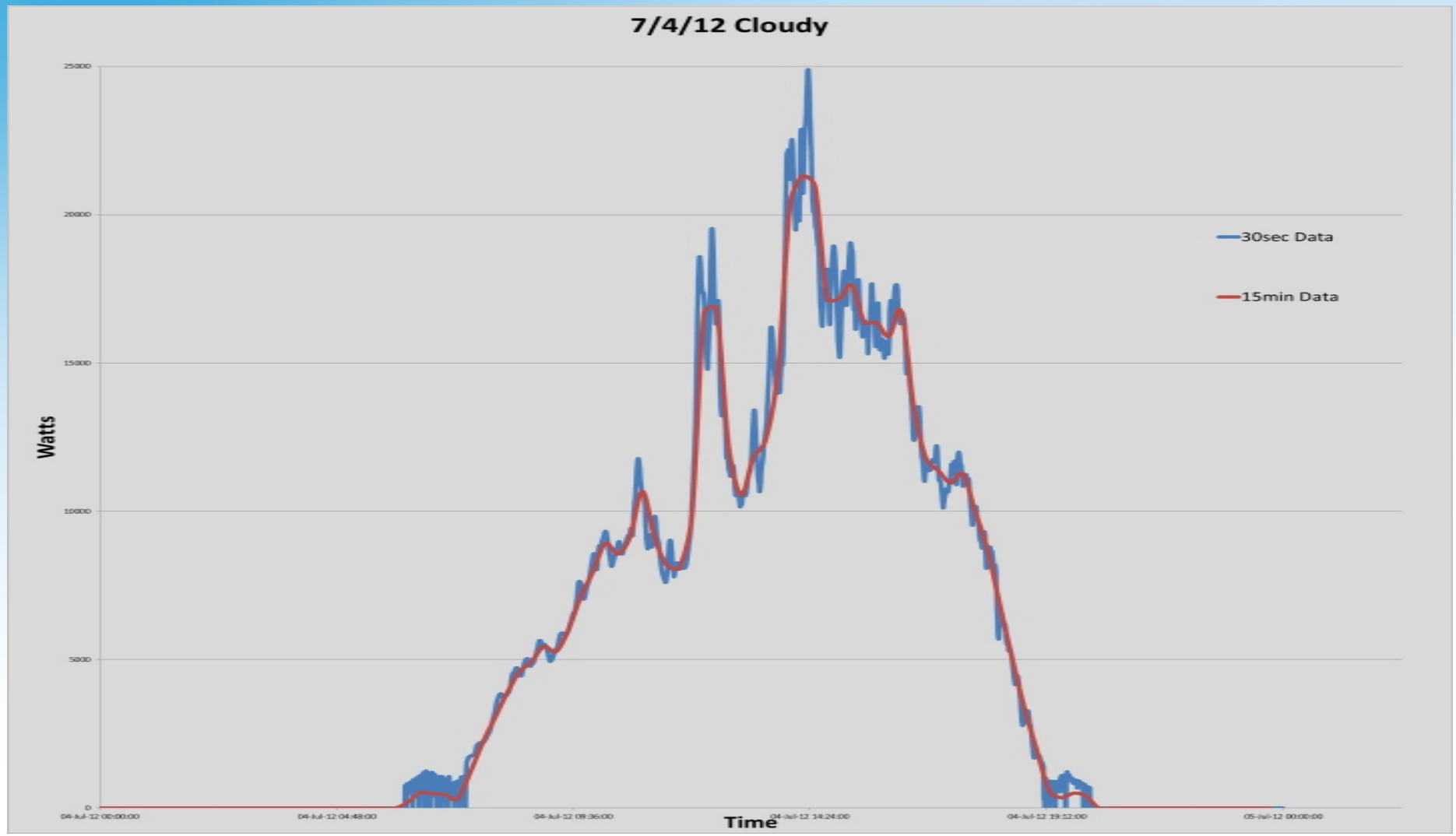
Project #	Item	C	P	N/A	Elec.	Hard Copy
7	Structural Calculations				x	x
8	Shop Drawings				x	x
9	Tap Drawing with SDG&E approval and signatures				x	x
10	Permits				x	x
11	Signed Inspection Cards				x	x
12	Equipment Data Sheets				x	x
13	Equipment Manuals				x	x
14	PV Watts Estimate Sheet(s)				x	x
15	Commissioning Documents (including megger readings for all conductors and torque test results)				x	x
16	Equipment Warranty Documents				x	x
17	Contractor Warranty Documents				x	x
18	Roof Warranty Documents				x	x
19	Documentation of 10-year maintenance agreement				x	x
20	SDG&E Interconnection Application				x	
21	SDG&E Authorization to Operate				x	x
22	AHJ Approved Plan Set (separate from O&M Manual)				x	

Annual Maintenance Reports

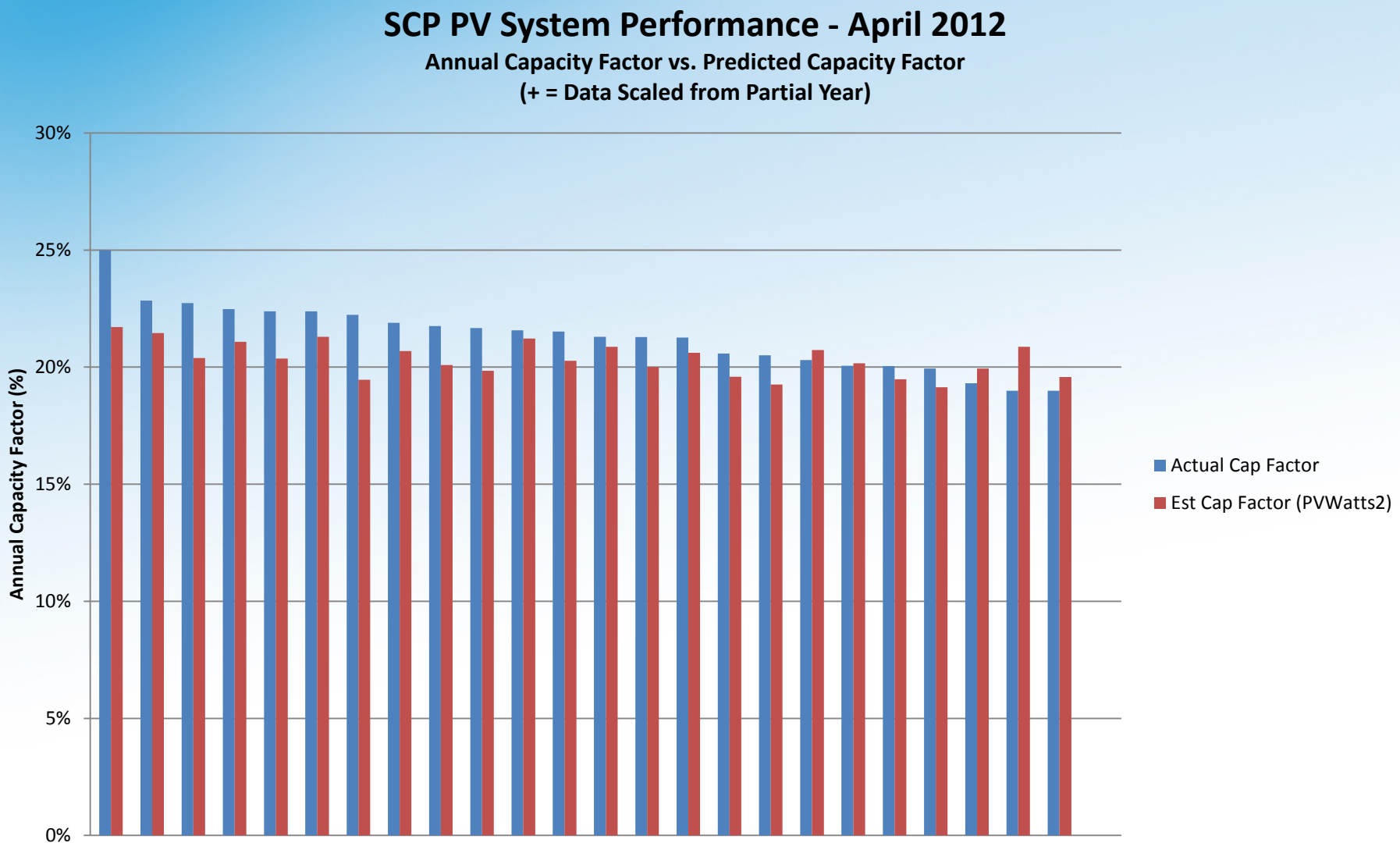
	* System shut down and lock out/tag out procedures					
Check-List Instructions						
Perform all inspections and tests as specified below. Record results and comments in the space provided. If additional notes are required, place an "X" in the Add'l Notes column and provide details on the attached sheet.						
Soledad		Address:		5465 Nancy Ridge Rd, San Diego	92121	
Inspection Date/Time:		Contact:		Rebecca Gallegos		
Technician Signature:		Phone #:		858-704-1968		
Weather Observations:		Cell #:		760-484-3419		
Step	**Description**	**Pass**	**Fail**	**Comments/Readings**	**Initials**	**Add'l Notes**
1.0	**PRE-INSPECTION SYSTEM PERFORMANCE CHECK**					
1.0.1	Generate, review, and attach 7-day and 12-month Performance Ratio test reports.					
2.0	**GENERAL CONDITION AND PHYSICAL INSPECTION**					
2.0.1	Verify new and/or existing shade concerns for the photovoltaic array.					
2.0.2	Inspect panels for defects or damage.					
2.0.3	Verify panel cleanliness and/or soiling issues - note if cleaning required.					
2.0.4	Remove debris, weeds, and leaves from array and immediate vicinity.					
2.0.5	Verify that all placards are firmly attached and legible.					
2.0.6	Note any potential safety concerns or fire hazards.					
2.0.7	Other:					
3.0	**INTERMODULE WIRING AND CONNECTIONS**					
3.0.1	Verify condition of inter-module array wiring for aging & corrosion.					
3.0.2	Inspect all array wiring connections to make sure quick connect leads are fully seated into one another.					
3.0.3	Inspect all array wiring to make sure it is secured/dressed properly to the module frame &/or array racking so as to not be laying on the roof deck or hanging from the underside of the array.					
3.0.4	Other:					
4.0	**RACKING AND ROOF CONDITION**					
4.0.1	Verify secure module attachment by random torque test of 10 module attachments.					
4.0.2	Verify condition of racking for corrosion, sagging of rails, etc.					
4.0.3	Verify condition of racking hardware connections, splices, etc.					
4.0.4	Randomly torque test racking hardware to confirm.					
4.0.5	Verify connection/attachment/anchoring to building/superstructure.					
4.0.6	Verify condition of roof under and around solar photovoltaic array.					
4.0.7	Verify condition of sacrificial sheets under rack feet (if present - ballasted systems)					
4.0.8	Verify condition and placement of wind deflectors (if present).					
4.0.9	Other:					
5.0	**BOS COMPONENTS**					
5.0.1	Verify condition (if present) of wire transition j-box for weatherproofing, corrosion & security of internal wiring connections.					

- Pre-inspection system check
- General condition/physical inspection
- Inter module wiring/connections
- Racking/roof connections
- BOS components
- Weather Station
- Electrical connections/torque
- Inverter
- Infrared check
- Electrical tests and measurements
- Miscellaneous
- Final checks

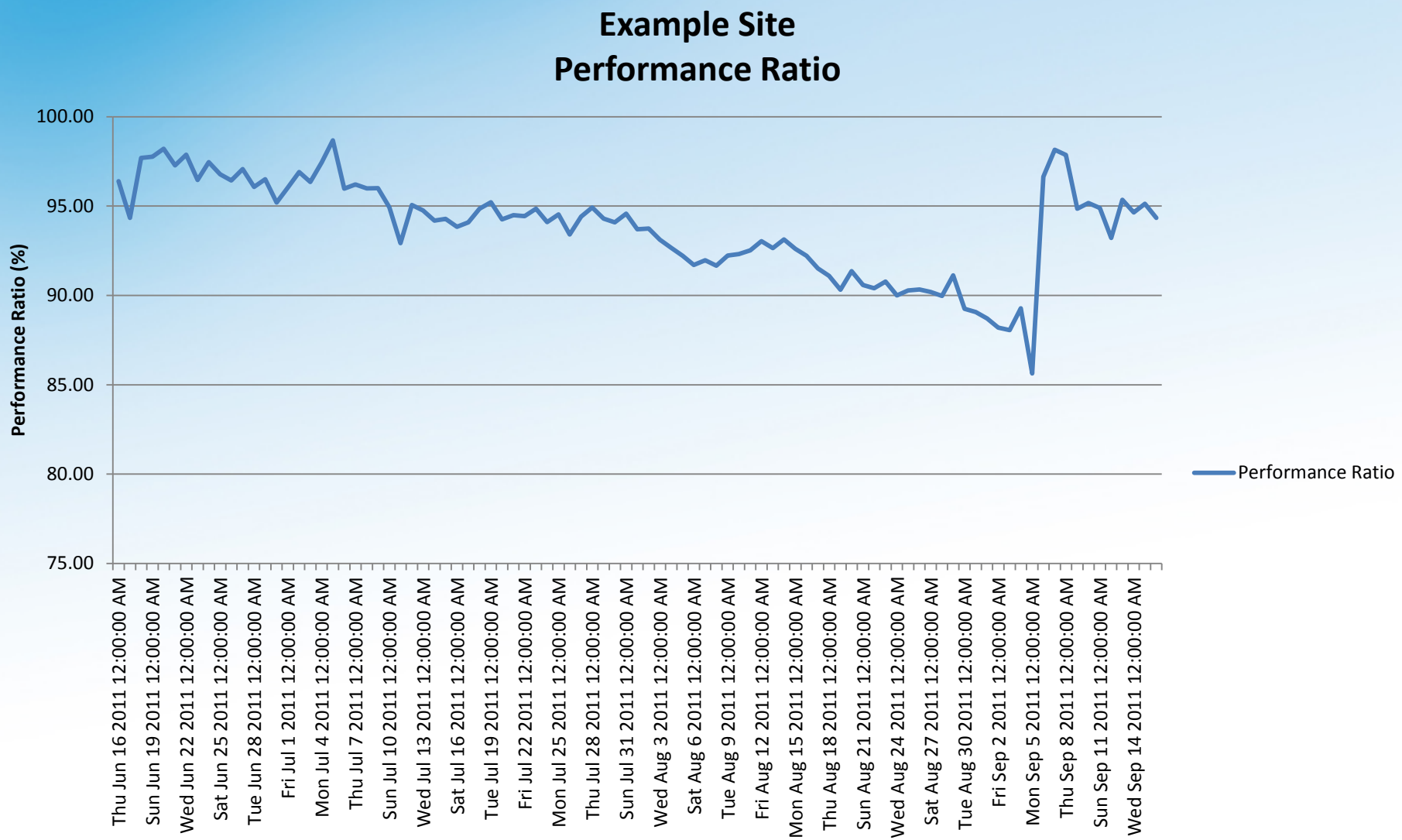
Monitoring



Performance Evaluation



Module Cleaning: Measureable Impacts



Module Cleaning ROI: Panel Washing Payback

Parameter	Units	Value	Comments
San Diego CC Skills Center			Select site from pull down list
Site ID		11	
Electricity Value	$/kWh	$0.10	
Performance Multiplier		1.00	
Daily Sun Hours	hrs/day	6.0	
Site			
System Size	kW	80.4	Automatically pulled from database
Panel Washing Cost	$/event	$395	Automatically pulled from database
Panel Washing Cost	$/kW	$4.91	
Payback Calculations			Does it pay back to wash panels given current soiling and forecast to next rain
Performance Decrease from "Clean" Condition	%	10%	Estimate from Aurora Vision Trend (average is 6% in 120 days)
Time for Performance Delta	days	60	Estimate from Aurora Vision Trend. Not used specifically in payback calculation.
Time to Next Washing or Next Rain	days	60	Forecast to next significant rain
Daily Performance Delta	%/day	0.17%	Calculated assuming linear decrease in performance over time
Avg Performance Improvement	%	10%	
Savings	kWh/day	48.24	
Savings	$/day	$4.82	
Total Gross Savings	$	$289	
Total Net Savings (Loss)	$	($106)	
Savings/Cost Ratio	Ratio	0.73	
Panel Washing Cost Effective?	Yes/No	**NO**	

Panel Washing Payback Cont'd

Parameter	Units	Value	Comments
Break Even Calculations			Assumes starting with clean panels and calculates the number of days until cleaning at an assumed soiling rate
Daily performance deterioration	%/day	0.05%	
Break Even Period	**days**	**128**	If time from last cleaning or rain (full performance) to next predicted rain is not greater than 2X Break Even Period, then it will not be cost effective to clean panels.
Optimal Summer Cleaning			
Days between cleaning and next rain	days	120	
Daily performance deterioration	%/day	0.05%	
Days to scheduled cleaning (optimum)		56	
Savings	$	86	

Component Reliability

Site	Start	End	Duration (days)	kWh Lost	Cause
XXXX	4/24/2011 0:00	5/25/2011 15:00	31.6	79,063	Inverter failure. Blown capacitor due to faulty bus design.
XXXX	3/5/2013	3/29/2013	24.0	12,000	Inverter failure. Control board.
XXXX	5/29/2010 12:00	6/3/2010 22:00	5.4	8,125	Blown fuse
XXXX	2/24/2013	3/12/2013	16.0	6,400	Intermittent faulty connection at array. Ground fault.
XXXX	1/1/2011	1/31/2011	30.0	6,000	Inverter failure. Fan problem.
XXXX	6/20/2010 12:00	6/24/2010 12:00	4.0	6,000	Blown fuse
XXXX	2/9/2013	2/21/2013	12.0	3,000	Control board failure
XXXX	5/1/2011 12:00	5/3/2011 12:00	2.0	3,000	Blown fuse. Shade structure to be added.
XXXX	1/27/2013	2/3/2013	7.0	2,800	Faulty connection at array. Ground fault.
XXXX	12/15/2011	12/19/2011	4.0	2,800	Inverter internal AC disconnect would not close (Eaton device inside inverter).
XXXX	12/12/2012	12/27/2012	15.0	2,250	Inverter fault. RDC board failure.
XXXX	6/29/2011 0:00	7/9/2011 0:00	10.0	2,000	Inverter failure. Blown fuse/defective design.
XXXX	4/5/2013	4/8/2013	3.0	1,800	Inverter blown fuse.
XXXX	8/17/2011	8/23/2011	6.0	960	Inverter blown fuse. Known problem, redesigned.
XXXX	5/14/2011 0:00	5/16/2011 0:00	2.0	400	Inverter failure. Software updated.
XXXX	1/31/2013	2/5/2013	5.0	250	Intermittent ground fault wet weather
XXXX	4/5/2011 0:00	4/6/2011 0:00	1.0	200	Inverter failure.
XXXX	4/27/2011 0:00	4/28/2011 0:00	1.0	200	Inverter failure.
XXXX	6/2/2011 0:00	6/3/2011 0:00	1.0	200	Inverter failure.
XXXX	6/7/2011 0:00	6/8/2011 0:00	1.0	200	Inverter failure. DC Contactor
XXXX	?				Module. One failed module found during annual inspection. Failed module was pulling down entire string. Start date for failure unknown.
			Total	137,647	

Most Common Problems Seen

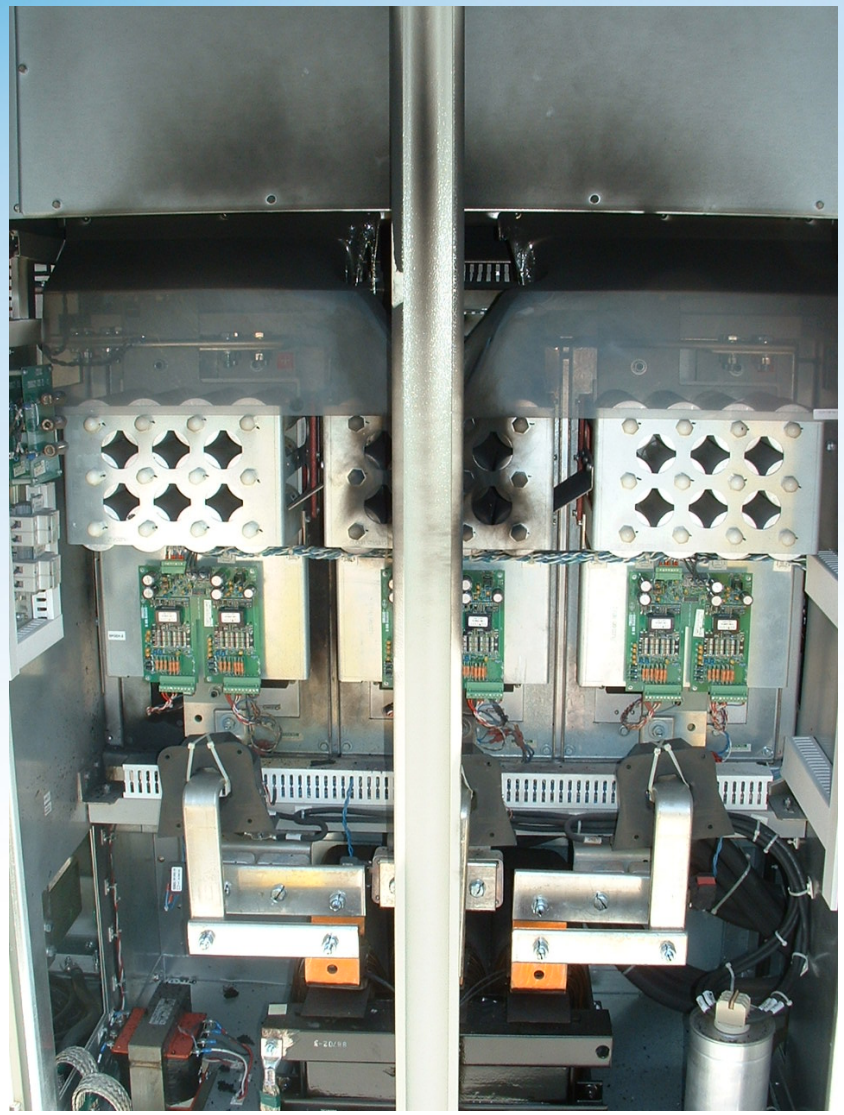
- Inverter
  - Unexpected trip
  - Blown fuse
  - Control board
  - Software issue
  - Incipient ground fault
- Weather station
  - Board failure
  - Communication loss
- Racking
  - Surface contact wear

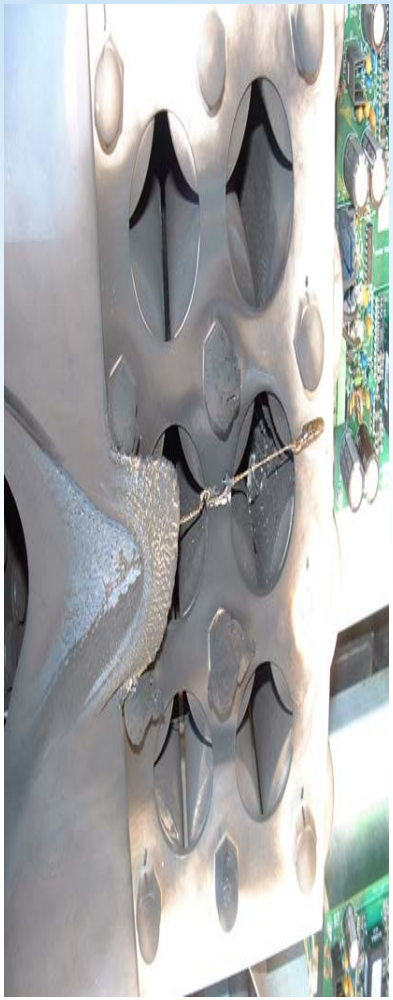
Maintenance Issues

Fuse Pull Out Problem

Inverter Capacitor Failure
DPCB, Fiber, AC contactor

SDGE connected
A Sempra Energy utility™





O&M Challenges

- Constant Change
  - Especially in Module and Inverter stock
  - In manufacturer support and viability
  - In maintenance support, training, and personnel
- Data reliability and accuracy
- Balance = Goals and Support/Time and Finance

Boosting ROI

↑ Production

↓ Maintenance

Start with Good Design

Use Quality Components

Thorough Commissioning

Balanced maintenance

Monitor to Detect Problems

Thank you