CSI RD&D – Solaria HQ System Performance Report

Quarters: Q1 2012

Publish Date: 05-30-2012

This report is generated as part of Solaria's performance reporting obligation outlined in "Task 5: Deliverables" of the contract between Solaria Corp. and Itron Inc.

1 Contents

2 Background 3

3 Introduction 3

4 Energy Production 4

4.1 System Layout and Module Evaluation 4

4.2 Back of module Temperatures 6

4.3 AC and DC Energy Yield 6

4.4 Actual vs. Expected Energy analysis 8

4.5 Weather data 9

5 Long Term Reliability 13

5.1 Results of visual inspection of modules on the test systems 13

5.2 Description of any reliability issues or concerns 13

5.3 Maintenance, repairs, cleaning, or system abnormalities during the month. 13

6 Conclusions 14

2 Background

This project is supported with assistance from the California Solar Initiative (CSI) Research, Development, Demonstration, and Deployment Program (RD&D). The purpose of this program is to help achieve the goal of creating a vibrant solar industry. This program makes investments to fund solar research and demonstration projects that will measurably reduce the cost and accelerate the installation of solar and other distributed technologies that could employ solar for generation, storage, or that could reduce the use of natural gas. The goal of this project is to demonstrate the financial and technical viability of Solaria's technology.

3 Introduction

Solaria, a California Corporation, has developed a photovoltaic module that uses 50-67% less silicon than the other silicon modules and are designed to not have any compromises in performance or reliability. Solaria modules are the first flat plate PV module to use optical concentration and the first low-concentration module to receive UL and IEC certification. Solaria's module is optimized for large-scale commercial and utility tracking applications.

The goal of this CSI RD&D project is to perform detailed analysis and reporting on the performance of Solaria low-concentrating photovoltaic installations that incorporate innovations to reduce costs, increase reliability, and improve system production and efficiency. Solaria is using CSI RD&D funds to support installing and operating PV test systems to demonstrate that the technology is financeable. The project will also provide performance and reliability data of Solaria's products on different tracking systems totaling 350 kWp_{dc} for two installations of which 240 kWp_{dc} will be installed at Alameda County Santa Rita Jail located in Dublin, CA and 110 kWp_{dc} will be installed at Solaria manufacturing facility located in Fremont, CA.

The purpose of this quarterly report is to demonstrate the performance and commercial viability of Solaria's technology. The cost and performance metrics covered by this report include those of operational efficiency, maintenance and repair, operating costs and electricity production. The systems covered by this report are the Horizontal and Azimuth tracking systems installed at Solaria's headquarters with a total system size of 110kW. Future reports will include the performance analysis of the 240kW_{dc} system at Santa Rita Jail. Soiling studies are excluded from this report since the regular California winter rains kept both Solaria and flat plate reference panels relatively clean.

4 Energy Production

This section includes the various energy production metrics detailed in Task 5 deliverables

4.1 System Layout and Module Evaluation

Shown below is the layout of the Solaria HQ system. The total system size is 110kWp$_{dc}$ with the Horizontal Axis tracker system being 58.1 kWp$_{dc}$ and the azimuth tracker system being 52.9kWp$_{dc}$. As shown the system comprises of 6 rows of horizontal axis trackers and 12 azimuth trackers.

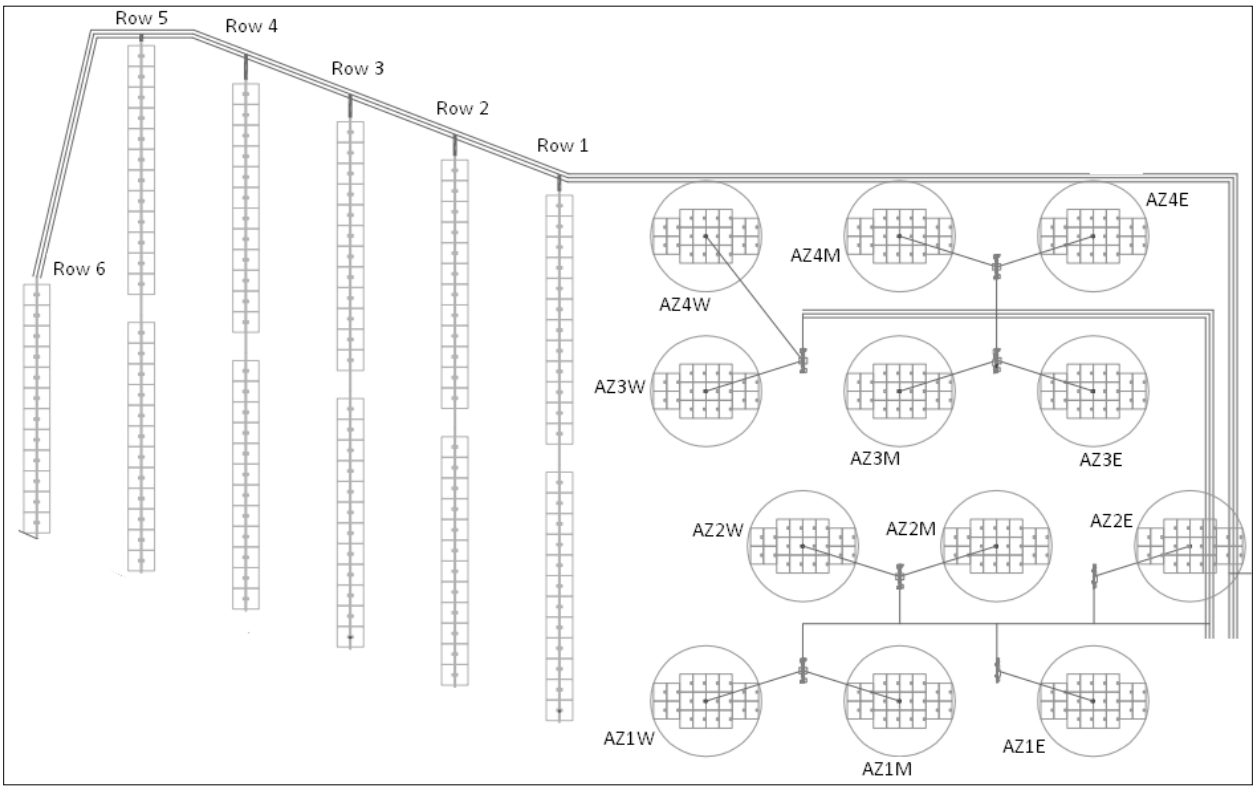

Figure 1: Solaria HQ Horizontal and Azimuth systems Layout

The individual module types and inverter types used for each string are shown in the table below. Different generations of Solaria modules that include Solaria 210W, 220W, 230W, 260W, Framed and Frameless have been used. The SMA 10kW and 5kW inverters have been used for individual strings. Shown in the Table 2.1 are the Solaria module characteristics.

System	Module	Inverter Manufacturer	Inverter Model
Row 1	Solaria 220/210 Framed	SMA Solar Technology AG	SB10000TL-US
Row 2	Solaria 230 Frameless	SMA America	SB5000US
Row 3	Solaria 230 Framed	SMA Solar Technology AG	SB10000TL-US
Row 4	Solaria 220/230 Frameless	SMA Solar Technology AG	SB10000TL-US
Row 5	Solaria 210/220/230 Frameless	SMA Solar Technology AG	SB10000TL-US
Row 6	Solaria 220/230 Frameless	SMA America	SB5000US
AZ1W	Solaria 220 Frameless	SMA America	SB5000US
AZ1M	Solaria 210 Frameless	SMA America	SB5000US
AZ1E	Solaria 210/220 Frameless	SMA America	SB5000US
AZ2W	Solaria 210 Frameless	SMA America	SB5000US
AZ2M	Solaria 210 Frameless	SMA America	SB5000US
AZ2E	Solaria 260 Frameless	SMA America	SB5000US
AZ3W	Solaria 220 Frameless	SMA America	SB5000US
AZ3M	Solaria 220 Frameless	SMA America	SB5000US
AZ3E	Solaria 220 Frameless	SMA America	SB5000US
AZ4W	Solaria 210/220 Frameless	SMA America	SB5000US
AZ4M	Solaria 230 Frameless	SMA America	SB5000US
AZ4E	Solaria 210 Frameless	SMA America	SB5000US

Table 1: Modules and Inverters used for Solaria HQ plant

Peak Power, Pmax (Watts)*	210	220	230	260
Open Circuit Voltage, Voc (V)	43.53	43.32	43.20	44.308
Short Circuit Current, Isc (A)	7.125	7.59	7.59	8.85
Voltage at Pmax (V)	37.69	35.01	34.13	35.45
Current at Pmax (A)	5.75	6.86	7.10	8.28
Max Series Fuse Rating (A)	15	15	15	15
Max System Voltage (V)	US600/IEC1000	US600/IEC1000	US600/IEC1000	US600/IEC1001

Table 2: Module Characteristics

**The different module ratings are due to cell bins.*

4.2 Back of module Temperatures

This section describes the operating temperatures of modules on azimuth trackers. The module temperature data is not available for the horizontal tracker as the monitored row was temporarily disconnected for module level flash testing. The temperature data for horizontal system is available as of 05/18/2012 which will be presented in the Q2 performance report.

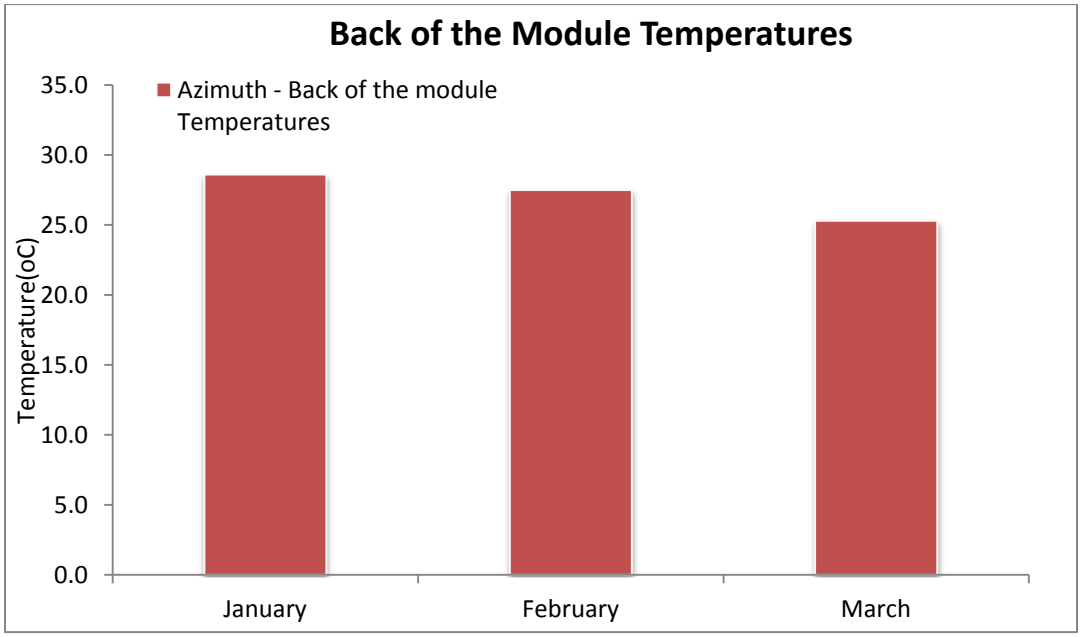

Figure 2: Back of Module Temperatures

Month	Horizontal-Module temperature [°C]	Azimuth-Module temperature [°C]
January	N/A	28.6
February	N/A	27.5
March	N/A	25.3

Table 3: Back of Module Temperatures

4.3 AC and DC Energy Yield

Shown in Figure 13 is the AC Energy yield for the months of January, February and March. As expected the Azimuth tracker outperforms the Horizontal tracker for the winter months of January and February. The energy yield differential between the two trackers is expected to narrow down over the spring and summer seasons when the sun is higher in the sky.

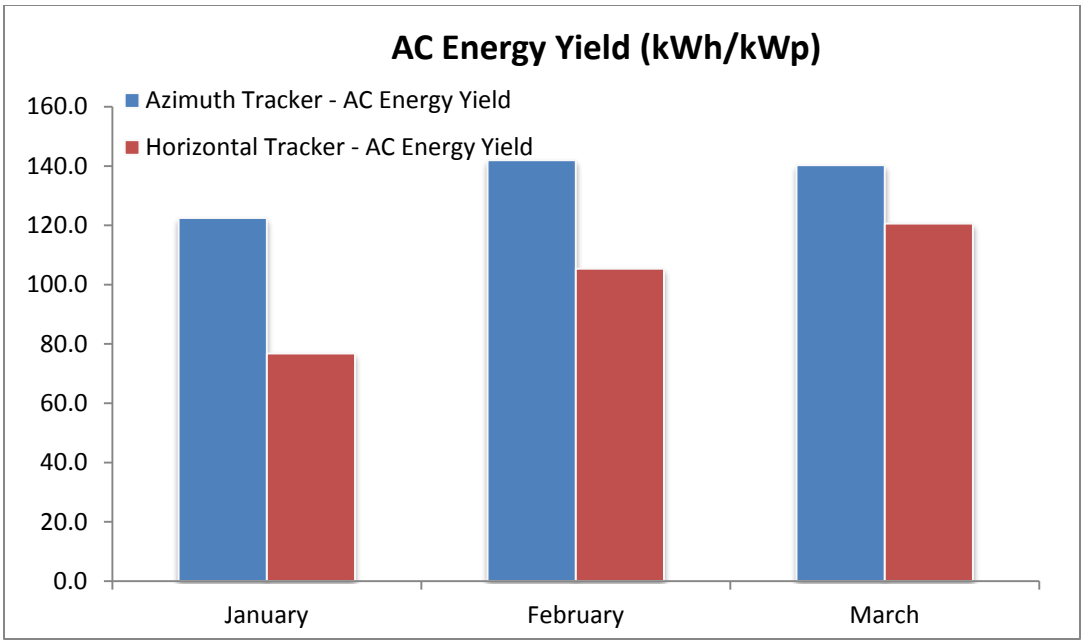

Figure 3: Q2 AC Energy Yield

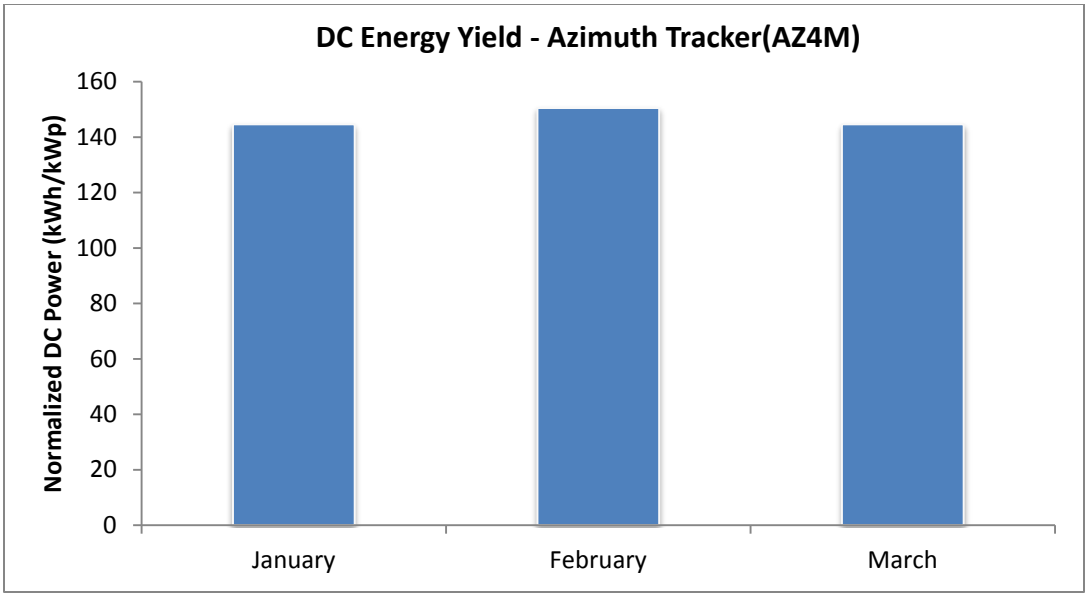

Figure 4: AZ4M DC Energy yield

Month	Horizontal - Energy Yield(kWh/kWp)	Azimuth - Energy Yield(kWh/kWp)
January	76.8	122.5
February	105.4	140.0
March	120.6	142.3

Table 4: AC Energy Yield

4.4 Actual vs. Expected Energy analysis

The simulation methodology is basically the same as what is described in section 4.4 of the Q4 2011 report with one modification. Due to the lack of module temperature measurements for the horizontal system, the ambient temperatures were used as inputs to the temperature model in PVsyst. This approach was taken for both azimuth and horizontal systems for consistency. The overall performance index (PI) for Q2 for the Azimuth tracking system was 103%. However, the range of variation of PI for the given period was 99%-106%.

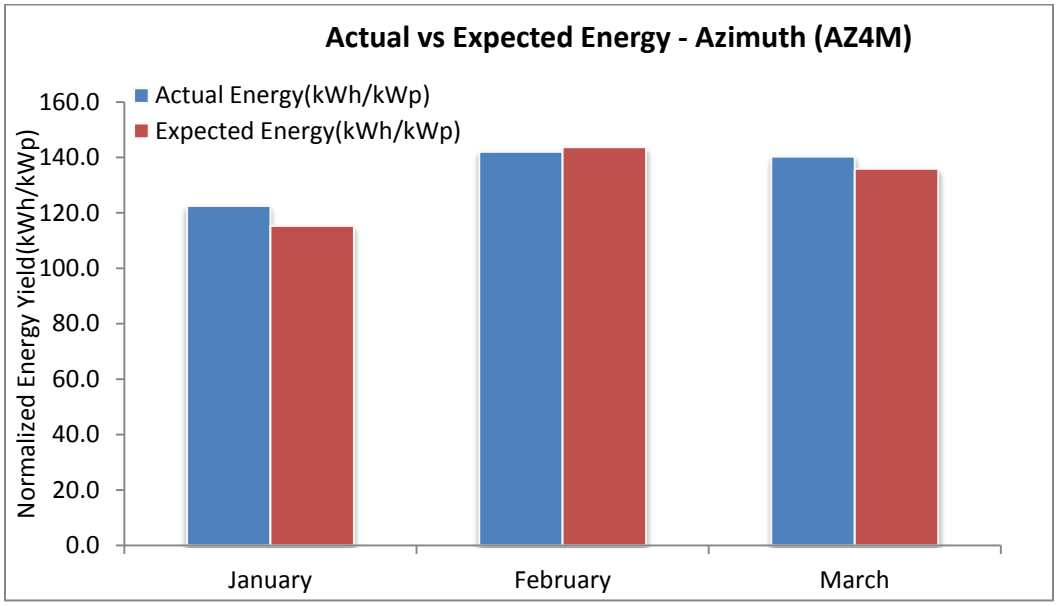

Figure 5: Azimuth - Actual vs. Expected Energy

Month	Actual Energy(kWh/kWp)	Expected Energy(kWh/kWp)	Performance Index
January	122.5	115.3	106%
February	142.0	143.7	99%
March	140.3	135.9	103%
Total	**404.8**	**394.9**	**103%**

Table 5: Azimuth - Actual vs. Expected Energy

The Performance Index for the Horizontal tracking system was found to be 100%. The range of variation of PI was 95%-102%.

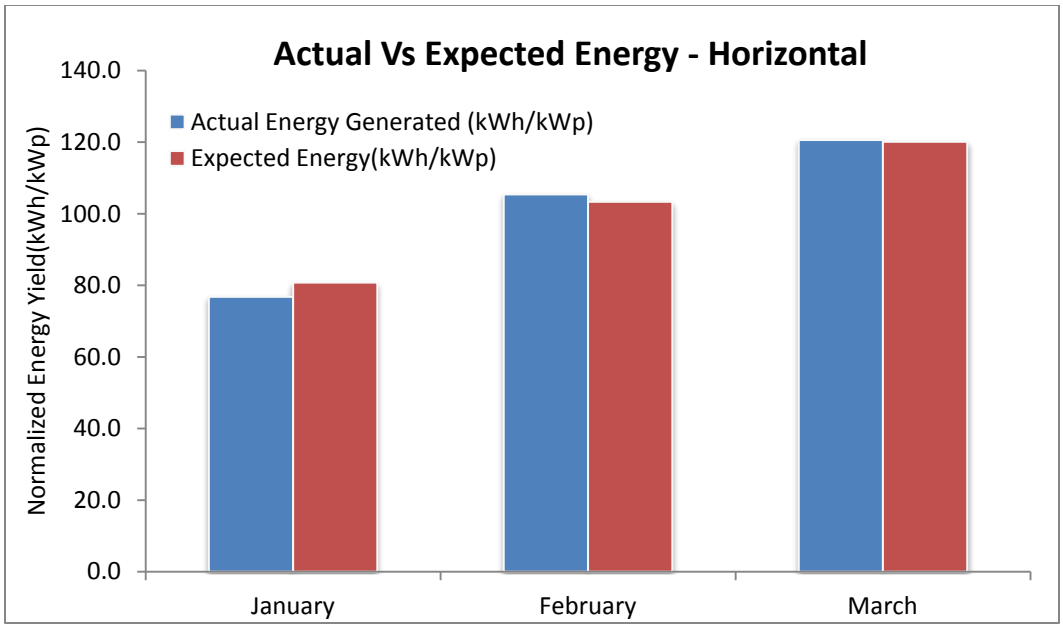

Figure 6: Horizontal - Actual vs. Expected Energy

Month	Actual Energy(kWh/kWp)	Expected Energy(kWh/kWp)	Performance Index
January	76.8	80.8	95%
February	105.4	103.3	102%
March	120.6	120.1	100%
Total	**302.8**	**304.2**	**100%**

Table 6: Horizontal - Actual vs. Expected Energy

4.5 Weather data

Shown in this section is the measured onsite weather data compared to the historical weather data for the months of January, February and March. The Perez model was used to transpose the TMY Global Horizontal Irradiance to Plane of array Irradiance for both Azimuth and Horizontal tracking planes. The POA irradiance for the months of January and February on the azimuth tracker seemed to have exceeded the historical irradiance by a total of 30%. For the horizontal tracker the POA difference between measured and historical for the months of January and February was 24%.

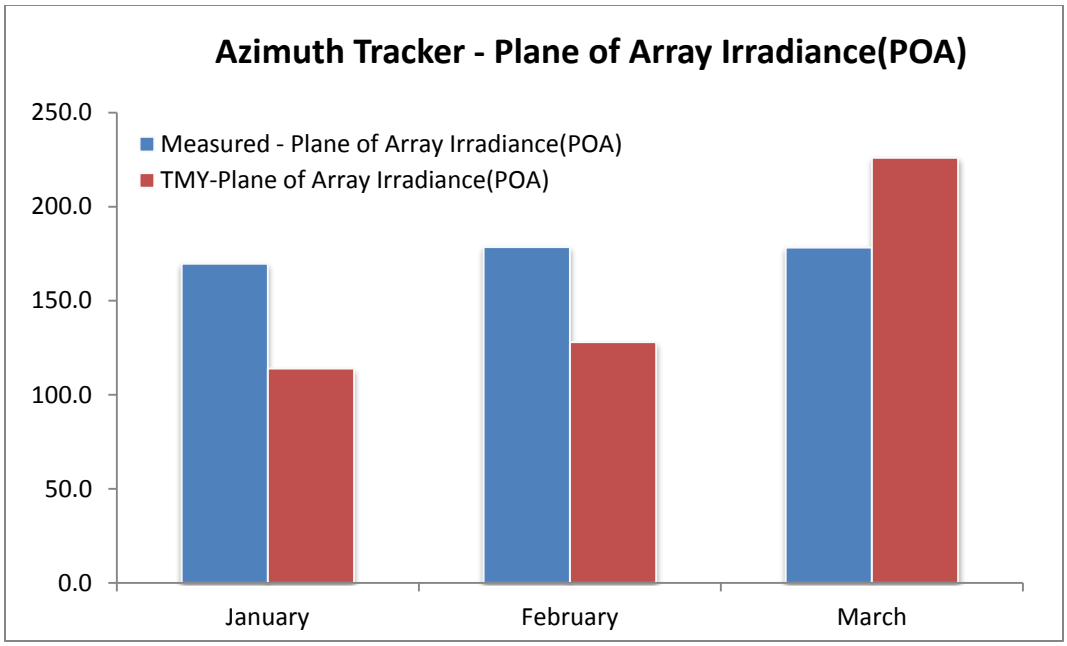

Figure 7: Azimuth Tracker-Plane of array Irradiance (POA)

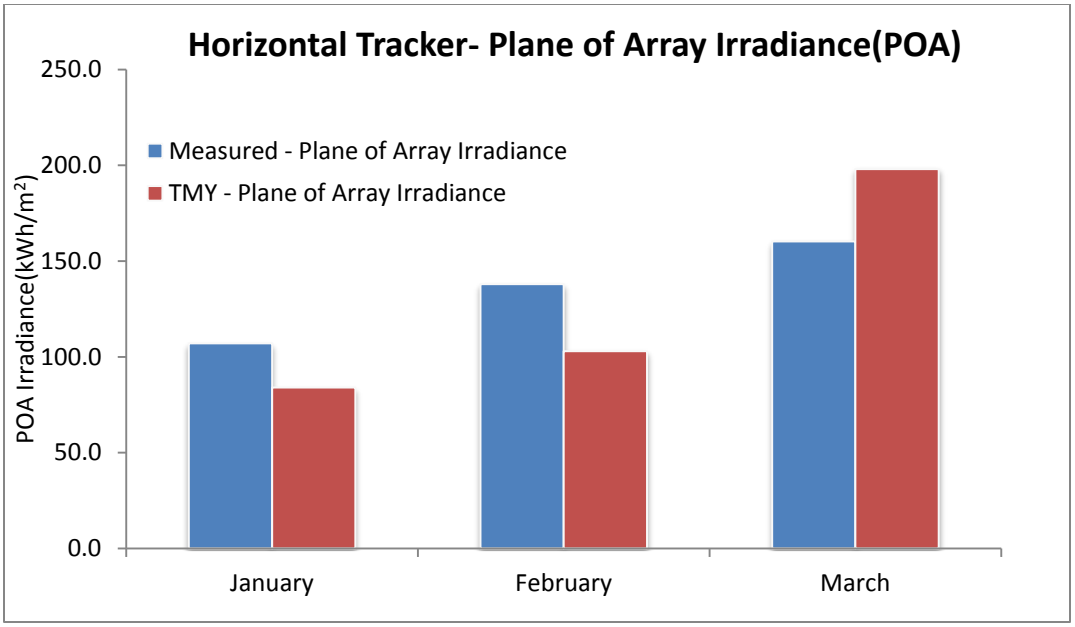

Figure 8: Horizontal Tracker - Plane of array Irradiance (POA)

Shown in figures below are the measured and historical ambient temperatures and wind speeds for Fremont, CA. The difference between the measured and historical wind speeds is much less pronounced for the period of observation as compared to Q3 and Q4 of 2011.

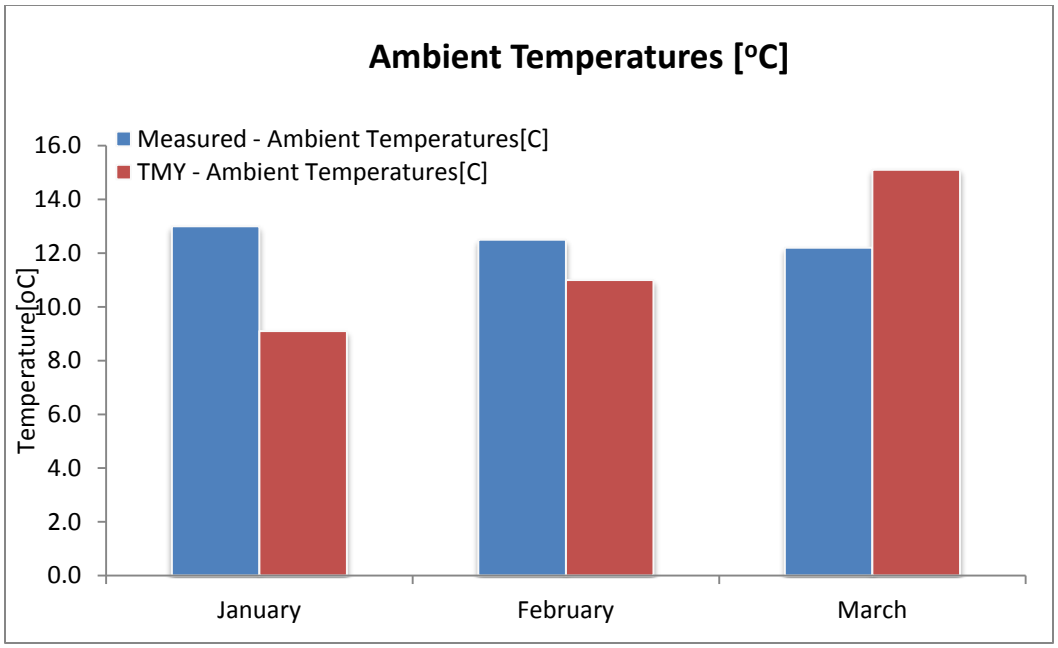

Figure 9: Ambient Temperature

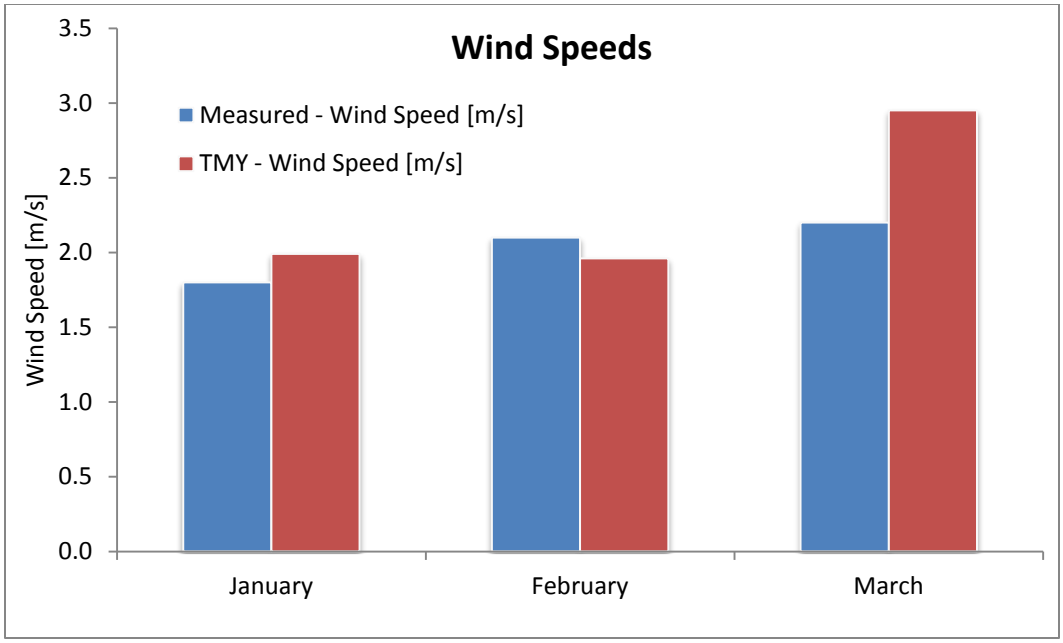

Figure 10: Wind Speeds

Month	Measured-Ambient temperature [°C]	Measured - Wind speed [m/s]	Horizontal-Measured POA[kWh/m²]	Azimuth-Measured POA [kWh/m²]
January	13.0	1.8	107.1	169.7
February	12.5	2.1	138.0	178.5
March	12.2	2.2	160.3	178.3

Table 7: Measured - Weather Summary

Month	Measured-Ambient temperature [°C]	Measured - Wind speed [m/s]	Horizontal-TMY POA[kWh/m²]	Azimuth-TMY POA [kWh/m²]
January	9.1	2.0	84	114
February	11.0	3.0	103	128
March	15.1	3.0	198	226

Table 8: TMY - Weather Summary

5 Long Term Reliability

This section documents any reliability issues observed during the period of operation. The actual vs. expected energy performance comparisons and visual inspection of modules were done to identify any anomalies and discrepancies in the module performance. The actual vs. expected energy performance analysis do not point to any reliability issues. The results of the visual inspection are presented below.

5.1 Results of visual inspection of modules on the test systems

Shown here are the results of visual inspection of some modules.

Module ID	Dimensional Check	Soiling Pattern	Cable Connection	Edge Delamination
FRDD190243510	No Change	None	None	None
FRDD190243527	No Change	None	None	None
FRDD190243551	No Change	None	None	None
FRDD190243557	No Change	None	None	None
FRDD190244831	No Change	None	None	None
FRDD190244929	No Change	None	None	None
FREA190246633	No Change	None	None	None
FREA190246685	No Change	None	None	None
FREA190248480	No Change	None	None	None
FREA190248492	No Change	None	None	None
FREA190248413	No Change	None	None	None
FREA190248448	No Change	None	None	None
FREA190250385	No Change	None	None	None
FREA190250361	No Change	None	None	None

Table 9: Results of Visual Inspection

5.2 Description of any reliability issues or concerns

Based on the visual inspection of the modules and Actual vs. Expected energy comparisons we can say that there were no reliability issues for the period of interest.

5.3 Maintenance, repairs, cleaning, or system abnormalities during the month.

Regular maintenance work is performed on the systems to ensure proper operation. A few of the activities are shown in the table below to illustrate the nature of the maintenance work done over the period of interest.

Date of Entry	System	Date of activity	Time of Activity	Comments
01/11/12	HT	1/10/2012-1/11/12	3pm-9am	Tracker to stow position to retrofit the motor with new brake motor. Tracker returned to normal operation with new motor 1/11/12 at approx 9am.
01/26/12	HT	1/18-1/20/2012	All day	New SB10000 inverter (SN: 2001587024) installed on row 3, all modules from row 3 N removed and replaced with LP modules for testing purposes. Modules on row 3N rewired into new inverter.
01/26/12	IHTR3N	01/26/12	11:00am (approx)	Installed data connection to new inverter
01/26/12	HT	01/26/12	12:00-3:00	New PLC installed on HT motor controller, took approx 3 hours to get functioning properly.
02/06/12	HT	02/06/12	11:00 - 12:00	Commissioned tracker
02/09/12	HT	02/09/12	2:00-3:00pm	Clock was off by 7 min, adjusted and calibration cycle
04/20/12	HT	04/20/12	5-6pm	replaced inclinometer on row 3M
05/02/12	HT	4/16/2012		New modules installed on row 3. Tracker was flat on 16th and 21st
05/13/12	HT1	5/11/2012	2:40-3:55pm	Inverter turned off for DC monitoring retrofit
05/13/12	HT3	5/11/2012	2:00-3:00pm	Inverter turned off for DC monitoring retrofit

Table 30: Onsite Maintenance Activities

6 Conclusions

For the given period of observation there was no measureable module degradation. Module degradation studies will be continued into the future and the results for a longer period of observation will be presented in future reports. The measured performance is compared with modeled performance and the results showed a good correlation between the measured and modeled values. No reliability issues were identified with the modules based on the visual inspection and Actual Vs Expected comparisons.