Review of SunPower Fleet-Wide System Degradation Study using Year-over-Year Performance Index Analysis

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Review of SunPower Fleet-Wide System Degradation Study using Year-over-Year Performance Index Analysis

Black & Veatch reviewed the study entitled "A SunPower Fleet-Wide System Degradation Study using Year-over-Year Performance Index Analysis" by Mike Anderson and Zoe Defreitas dated as of October 23, 2012 (Degradation Report).

The Degradation Report is an analysis of data taken from 266 systems comprised of SunPower modules located at 70 sites (86MW) and 179 systems located at 74 sites (42MW) comprised of non-SunPower modules. All of the sites are located in the United States. Black & Veatch's review is limited to the systems that use SunPower modules. These SunPower systems were commissioned between September 20, 2007 and December 23, 2010.

The purpose of the Degradation Report is to determine the rate of degradation of the output power of the systems. Black & Veatch believes that accurate determination of PV system degradation is inherently difficult because the system power generally degrades slowly, thus requiring power measurements over an extended period of time. Furthermore, power degradation calculations are often affected by module soiling, seasonal effects, weather station sensor errors, shading and missing or erroneous data.

The Degradation Report incorporates a number of techniques and procedures into the analysis to minimize the impact of these factors. The Degradation Report states that these techniques, combined with the very large sample size, allow for an accurate estimate of the overall site degradation rate. Black & Veatch believes that this is a proper conclusion.

The output power, irradiance and meteorological conditions for each system were reported every fifteen minutes. A minimum of filtering of the data was performed in order to remove clearly faulty data associated with communication problems or clearly erroneous weather or irradiance conditions.

The Degradation Report accounts for changes in system power due to light level variations and weather conditions by means of a calculated quantity called the performance index which is the ratio of measured system power to calculated expected power. The expected power is calculated by using a SunPower performance model called PVSim. Black & Veatch was informed that this model was developed on the basis of a performance model developed by Sandia National Labs. The expected power calculations use meteorological and irradiance conditions to derive the power that the system could produce in those conditions.

The use of the performance index is intended to decrease the effects of varying irradiance, temperature and wind speed in the system power output calculation. Black & Veatch understands that, ideally, the performance index should be constant in time, except for module power degradation effects. A performance index value is calculated every fifteen minutes from irradiance, weather, and system power measurements.

The results of the Degradation Report show that there is a distribution in the values of the performance index. Black & Veatch believes that this is due to the fact that changes in irradiance and weather cannot be completely accounted for in the calculation model. It is difficult to determine whether the more extreme values of performance index are reliable or not. Because the extreme performance index values can, in aggregate, have a significant effect on the calculated mean daily performance index values, the Degradation Report uses median daily values, rather than mean daily values. The authors believe that the use of medians in large data sets eliminates the need to do additional data filtering. Black & Veatch understands that median statistical values are more tolerant of the presence of data in the extremes than mean statistical values.

Black & Veatch understands that there are also a variety of seasonal effects on the systems. The variation in system power output between seasons can be much larger than the change in power due to system component degradation. Some seasonal effects, including module soiling, depend on the environment where the system is located. There can also be seasonal influences on the irradiance monitoring instrumentation.

In order to minimize these effects, Sunpower developed the year over year (YOY) analysis. The change in daily median performance indices between successive years is calculated for each day of the year that the system has been in operation. For instance, a system operating in 2009 and 2010 would have a YOY degradation rate calculated by comparing the performance index for every day of the year, i.e. January 1, 2009 to January 1, 2010; January 2, 2009 to January 2, 2010, and so on. If no data is lost by filtering, each system could have 365 YOY degradation rates for each year in operation. Black & Veatch believes that this is a reasonable approach for analyzing the data.

A final consideration is that some sites have multiple systems. A system consists of an inverter and all the modules attached to it. Other sites have only a single system. Most sites, however, have only a single meteorological station. Imperfections of the site meteorological station can bias the calculated performance indices for all systems at that site. Consequently, at sites where there are multiple systems, the data for all the systems is combined to generate a single set of site YOY degradation rates. Black & Veatch is of the opinion that this technique will help ameliorate potential calculation biases introduced by specific meteorological measurements

The data array used by SunPower to calculate the median degradation value of the 70 sites analyzed in the Degradation Report consists of all of the daily YOY degradation rates for each site. The Degradation Report also calculates the uncertainty of the median value using the median of absolute deviations.

The analysis concludes that the median annual system power degradation rate for these sites is 0.32 ±0.05 percent per year. The analysis also indicates that the degradation is linear over the period of time of over three years that was measured.

Black & Veatch reviewed the calculation techniques and the data used to obtain the degradation rates for the systems using SunPower modules and believes that the system power degradation results appear to be derived from the data reviewed, and are based on appropriate statistical analysis.

Addendum
A SunPower Fleet-Wide System Degradation Study using Year-over-Year Performance Index Analysis

A SunPower Fleet-Wide System Degradation Study using Year-over-Year Performance Index Analysis

Mike Anderson (Ph.D., P.E) and Zoe Defreitas (MEng)

SunPower Corporation

10/23/2012

1.0 Executive Summary

A fleet-wide system level degradation study of 445 systems within the SunPower operating fleet has been conducted. The study includes 266 systems (86MW) using SunPower modules as old as 5.5 years, and 179 systems (42MW) using non-SunPower modules as old as 11.5 years. Data spanning back to the site commissioning date were used to determine fleet-wide degradation rates, representing 3.2 million module-years of monitored data. The annual system power degradation rate (AC side of the inverter) for SunPower systems was - 0.32 ± 0.05% (95% confidence) per year, and for non-SunPower conventional silicon solar panel systems was - 1.25 ± 0.05% (95% confidence) per year, and in both cases was shown to be constant with time.

2.0 Introduction

Degradation calculations were carried out using 445 systems (inverters), consisting of both SunPower (266 systems at 70 sites) and non-SunPower (179 systems at 74 sites) modules. These sites represent the US fleet of commercial and power plant sites for which SunPower had at least 18 months of performance monitored AC power and weather data, with at least 100 days of valid data. No sites were omitted from the study for any other reason.

This study used broad filtering to remove clearly erroneous data, and a performance model developed at Sandia to normalize power output for factors such as wind, temperature, and irradiance. A Year-Over-Year (YOY) degradation rate method was employed to minimize the effect of seasonal variation not otherwise accounted for, and to eliminate any biases associated with power output prediction. Annual fleet degradation rates were obtained using statistical methods which convert a large number of high-uncertainty degradation rate data points into a low-uncertainty fleet-wide degradation rate, utilizing an extremely large sample size and the fact that the sources of uncertainty are unbiased noise. An integration approach was used to determine that the fleet-wide degradation over time for each group is highly linear.

3.0 Analysis

3.1 Data

Fifteen minute sampled meteorological data (irradiance, ambient temperature and wind-speed) and power data were retrieved from SunPower's OSI-PI data archiving system for each PV system as far back in time as available, generally from the site commissioning date or soon after. Plane-Of-Array (POA) irradiance was used when available (approximately 80% of the systems), and Global Horizontal (GH) irradiance was used for the others.

3.2 Filter

Minimal data processing was done to remove only clearly erroneous data points. Filtering was applied as follows: irradiance ($400<W/m^2<2000$), ambient temperature ($-40<{}^{\circ}C<65$), and wind speed ($0<m/s<50$). In addition, flat-line/straight-line data, which is a consequence of the OSI-PI archive returning interpolated values between data points with significant periods of missing data, often due to communication problems, were filtered out, i.e. if irradiance, temperature, wind-speed or power were flat-lined or straight-lined, within machine tolerance, for more than 1 hour, then these points were removed.

If any data point was filtered, then the entire time record associated with that point was removed for this system. The exception was wind-speed. Bad wind-speed sensors are very common, and removing this data would have significantly reduced the amount of data available. Instead of removing points with filtered wind speed, the wind-speed was replaced with a nominal 2m/s value; this approximation has a negligible effect on relative degradation calculations.

No other filtering was used in this analysis. Following best practice, this analysis used median values rather than average values, to minimize the effect of outliers, and provide a more robust representation of the population.

3.3 Expected power

The expected power at each timestamp for each system (inverter) was calculated using the performance model, called PVSim, with measured values of irradiance, ambient temperature and wind-speed, along with system specific information (i.e. system-type and module type). PVSim is SunPower's publicly available, state-of-the-art PV system simulator, originally developed based on Sandia's model for a PV panel. All calculations assumed that the irradiance was POA, (i.e. conversion from Global Horizontal to Plane-of-Array was not performed for the systems that did not have Plane-of-Array measurements). The conversion was not done because precise installed system information was not always available or reliable, (e.g. azimuth and slope), and because the Year-Over-Year (YOY) analysis technique, to be discussed shortly, made this unnecessary.

3.4 Performance Index

Performance Index (PI), the ratio of measured to expected power, was calculated for each system at every timestamp. The daily PI was taken as the median of all PI values for that day.

3.5 Year-Over-Year Analysis

If the actual system were performing in a new and clean state at all times, and if the measured atmospheric parameters were always perfectly accurate, and if the performance model were perfectly accurate under varying conditions, then the ratio of measured to expected power, PI, would gradually reduce below unity as the system degrades with time. Measurements, however, especially at multi-year operational installations, have very significant noise and anomalies, and even the best models do not predict all operating conditions perfectly. Primary sources of uncertainty in PI come from soiling, weather station sensor calibration drift (irradiance, wind speed, temperature), site anomalies (shadows, equipment outages, characterization errors), and missing or miss-time-stamped data. These sources of uncertainty make it difficult to estimate sub-1% yearly degradation rates at individual sites over a period of time that is less than decades with high accuracy.

To detect a low degradation rate in a sea of noisy data, a Year-Over-Year (YOY) analysis was performed. The YOY analysis estimates a daily degradation rate by taking the percent change in Performance Index between the same calendar days of subsequent years. In this approach the YOY degradation rate at each day over the life of the system is determined by this central difference method, evaluated from ½ year after COD to ½ year before the end of the dataset:

$$DegRate_{n+365/2} = PI_{n+365} - PI_n.$$

For example, the YOY degradation rate for a given site on September 1st, 2009 = [(median of (actual power/expected power) on March 1st 2009) – (median of (actual power/expected power) on March 1st 2010)]. If PI on either of the two days used for a YOY calculation was missing, then a YOY value was not calculated for that day.

This method bypasses seasonal effects, modeling uncertainty in the expected power calculation, and site characterization errors. For example, one specific issue that YOY analysis overcomes is instances where fixed-tilt or tracker systems are instrumented with Global Horizontal irradiance measurement rather than Plane-of-Array irradiance measurement; the seasonal absolute error in modeling the wrong type of irradiance sensor would be significant, but the YOY slopes approach is robust against this variation.

All of these sources of error create white noise in the power output data which is impossible to correct for at the accuracy needed to determine low degradation rates, so this YOY analysis explicitly keeps all the noisy data uncorrected, and utilizes the PI ratio, YOY slopes, and statistics of extremely large sample sets to determine a fleet-wide degradation rate with low uncertainty.

Figure 1 shows YOY lines for two representative sites. Each black dot represents the median Performance Index for each day where there is data. A uniquely colored line connects the Performance Index black dot values on the same calendar day of subsequent years. The slopes of these lines are the daily YOY degradation rates. A site with 11 years of data could have as many as 3650 YOY deg rates (10 years x 365 days per year, since 6 months is lost on either side of the estimates due to central differencing).

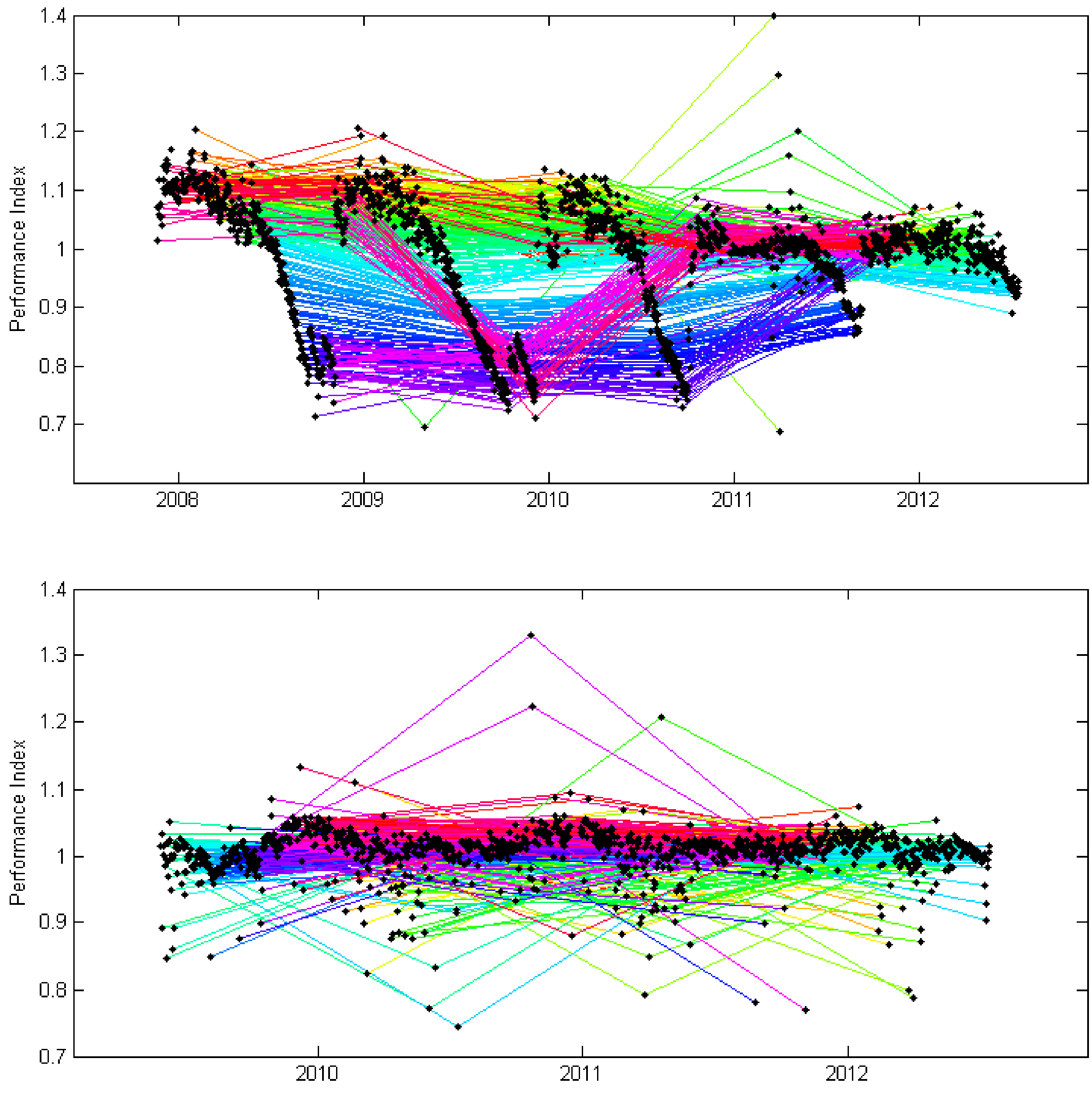

Figure 1 Examples of YOY lines applied to Performance Index for two systems

The top figure underlines the seasonal nature of some of the data sets, and how well the YOY method does at overcoming this and providing reasonable degradation rates; the linear drops in performance are due to annual soiling. This is fairly common, particularly with sites that have seasonal soiling (e.g. no rain all summer), and makes finding the degradation rate from a small sample of year-over-year slopes impossible, although it can be seen in the overall trend. The bottom figure shows a data set that does not contain significant seasonal effects, but does contain random noise along with outlier points.

3.6 Fleet Degradation

Some sites have one system (inverter) and some sites have many systems (the largest here has 38). To avoid common mode bias due to a site level bias, e.g. a single site irradiance sensor, the systems at each site were combined into a single site level time series of YOY degradation rates by taking the median daily YOY degradation rate of all inverters. This gives each site equal weight in the analysis, regardless of the number of inverters.

Figure 2 shows histograms of all daily site level degradation rates for both SunPower and non-SunPower systems. This is comprised of 45,636 and 73,829 year-over-year degradation rate estimates for SunPower and non-SunPower systems respectively. This plot illustrates the significant variation in degradation rates present, for example greater than 20%/year (both positive and negative) in some cases, which is an indication of the noise inherent in this type of data. An example of a cause for such a large degradation rate on a particular day is soiling that causes a 20% reduction in power output relative to the expected power output on a particular day one year, but not the previous (or following) year due to rain that cleans the panels.

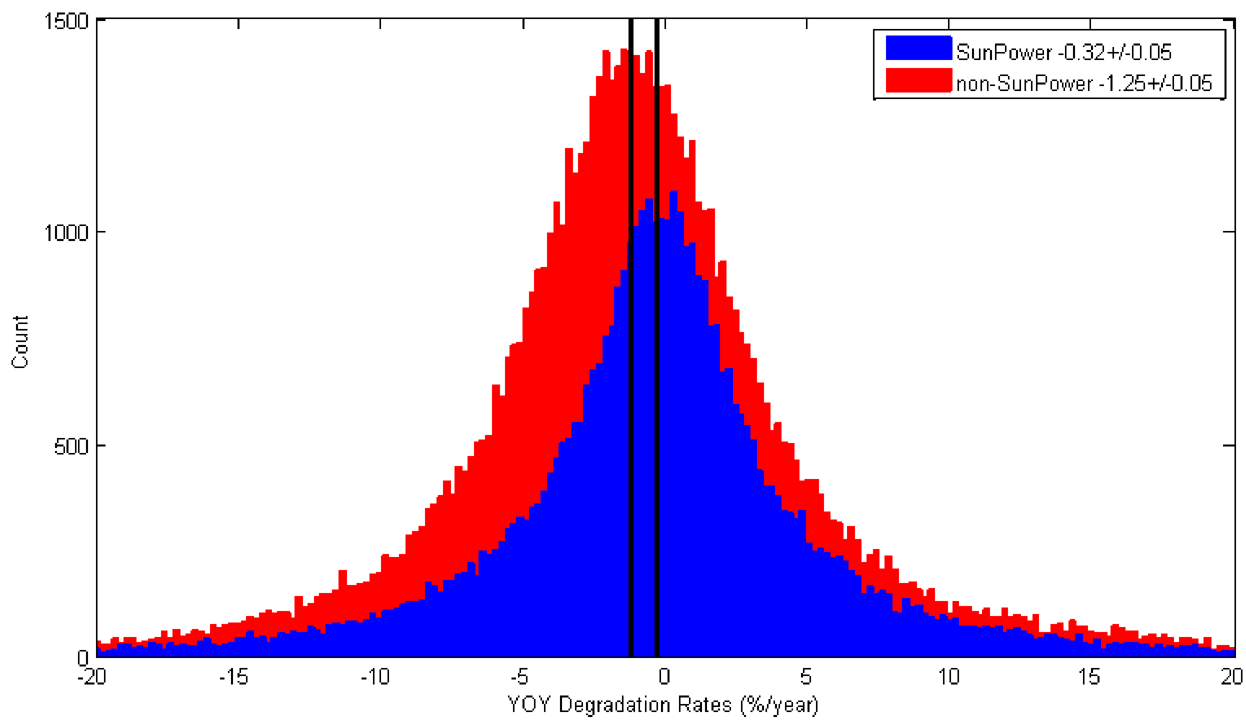

Figure 2 Histograms of all site level YOY degradation rate data for SunPower and non-SunPower systems

The median of these two distributions, shown in **Table 1**, represents the most accurate estimate of the degradation rates for installed SunPower and non-SunPower systems. (See Appendix A for further details.)

Table 1 Yearly Degradation Rates (95% Confidence)

Yearly Degradation Rate	
SunPower Systems	- 0.32 ± 0.05%
Non-SunPower Systems	- 1.25 ± 0.05%

The SunPower degradation rate is noticeably smaller in magnitude than the non-SunPower degradation rate. Since such large data sets, with large varieties of (years, locations, systems etc.) are being used, even though there is a large spread in the samples, there is low uncertainty in the results. This plot also shows that the degradation rates for both SunPower and non-SunPower systems have relatively normal distributions, which is expected given the white-noise nature of the sources of uncertainty in the data.

3.7 Behavior over Time

While the above estimate indicates how a normal site will perform over this time period, it does not indicate whether the degradation is getting better or worse or staying constant with time. To investigate the behavior of degradation over time, a daily fleet degradation rate was constructed from the site YOY degradation rates aligned according to the age of the site, and then this was integrated to obtain the shape of the degradation profile over time.

The YOY degradation rates for all SunPower sites (recall that YOY degradation rate values for a site represent all inverters from that site) as a function of years from each site's respective Commercial Operation Date (COD) are shown in **Figure 3**. Each colorful high frequency trend indicates the daily YOY degradation rate for a particular site, although it is not possible to distinguish all of the different sites in this figure. The data are aligned so that the starting time is COD (recall that the first YOY value would occur halfway between COD and COD+1 year), and each black dot represents the median of the degradation rates across the fleet when each site has been operating for the same length of time. The median daily fleet values are better behaved in the earlier years, and are more volatile in the later years, because most all of the sites have daily values for the first several years from COD, but the number of sites decreases in later years (see **Figure 4**), since there are fewer older sites.

The camel-hump behavior in the number of valid YOY degradation rates seen in **Figure 4** is due to the fact that a large number of sites happened to be commissioned around the same time-frame, and therefore hit winter months around the same time after COD. In winter months, it is more common for a site to not produce a valid Performance Index value, and therefore not produce valid YOY degradations rates 6 months prior, or 6 months after this date.

Figure 5 and **Figure 6** shows a similar representation for the non-SunPower fleet.

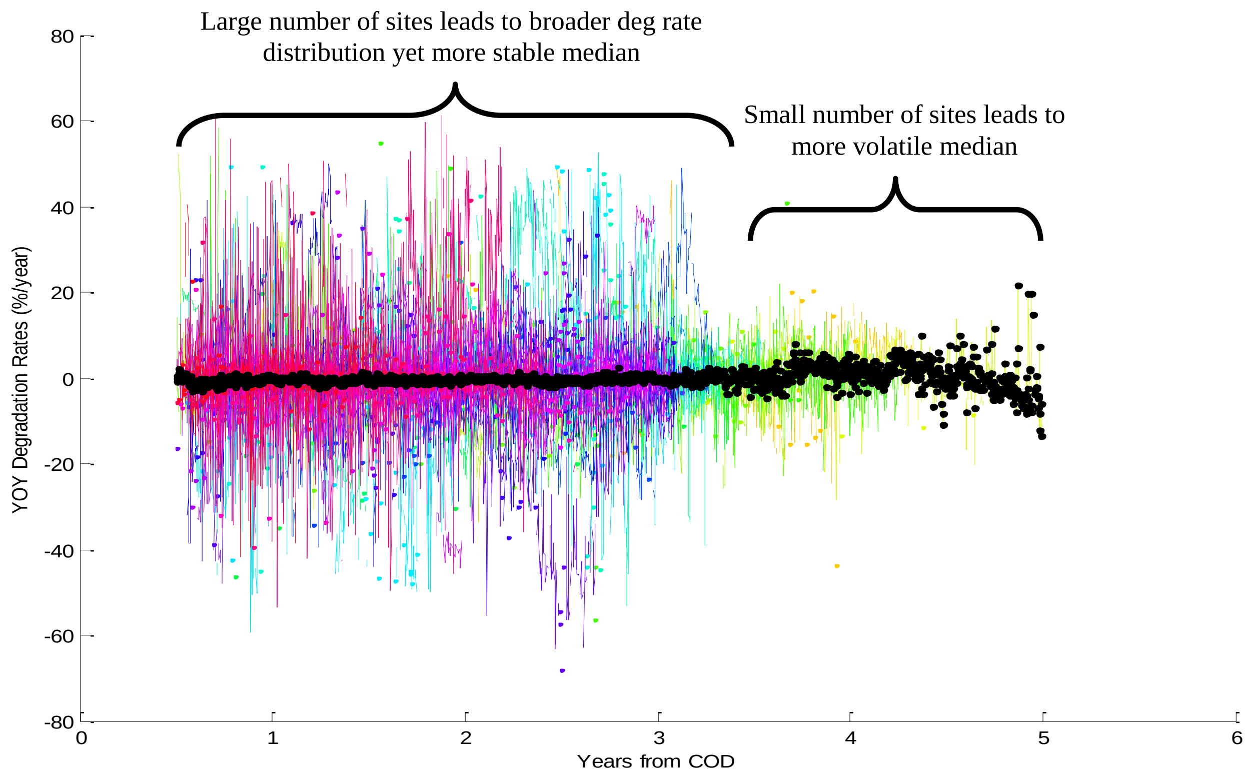

Figure 3 Daily YOY degradation rates for all SunPower sites (colored lines), along with daily medians (black points)

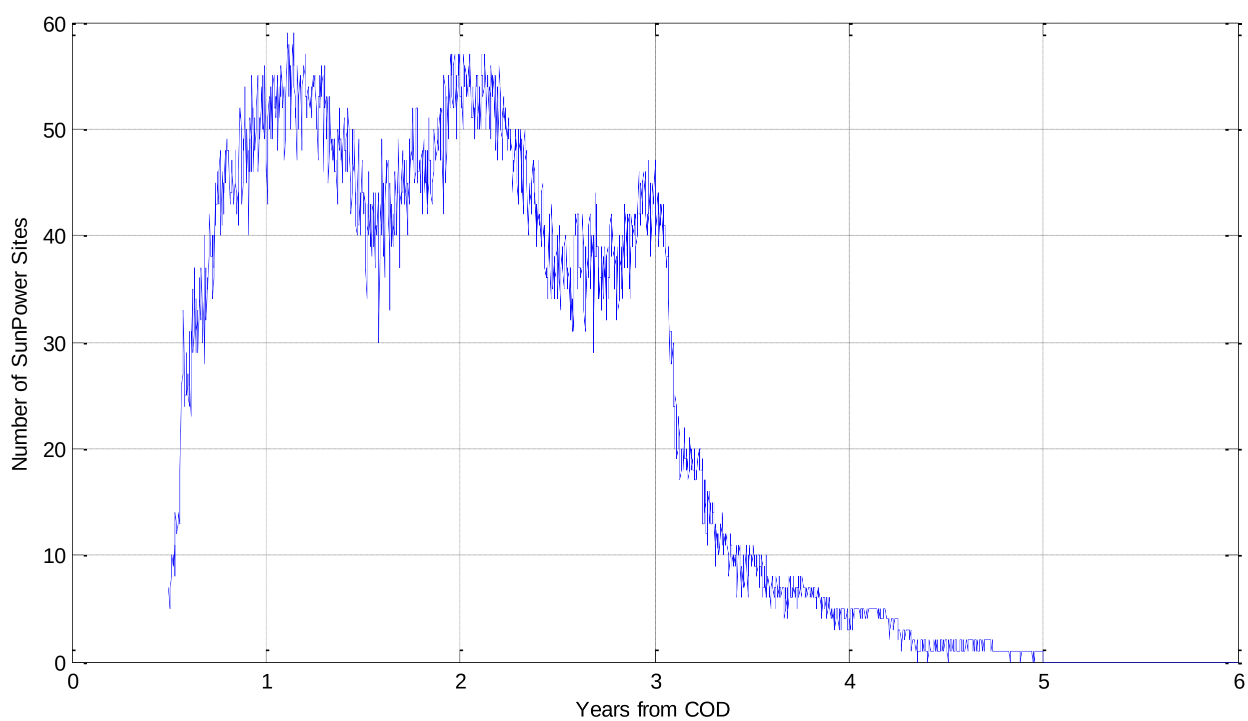

Figure 4 Number of SunPower sites with valid YOY degradation rates on each day

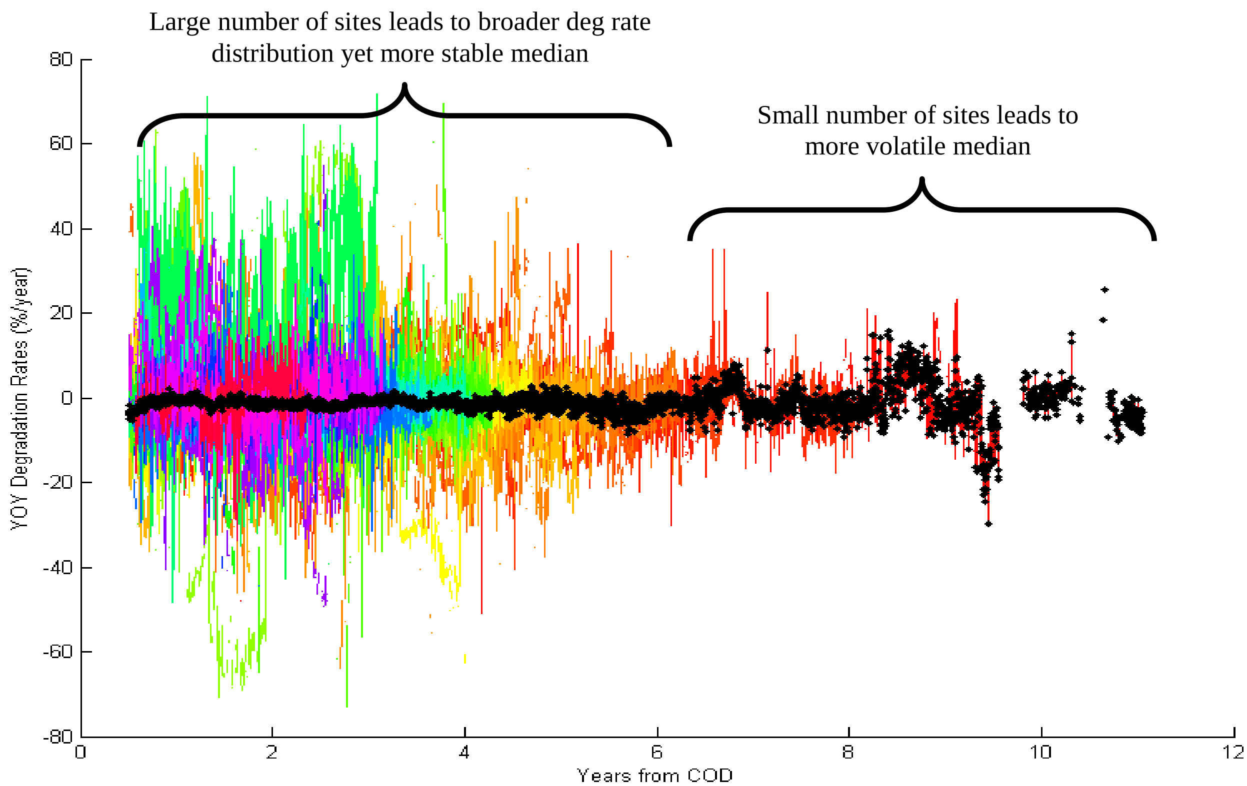

Figure 5 Daily YOY degradation rates for all non-SunPower sites (colored lines), along with daily medians (black points)

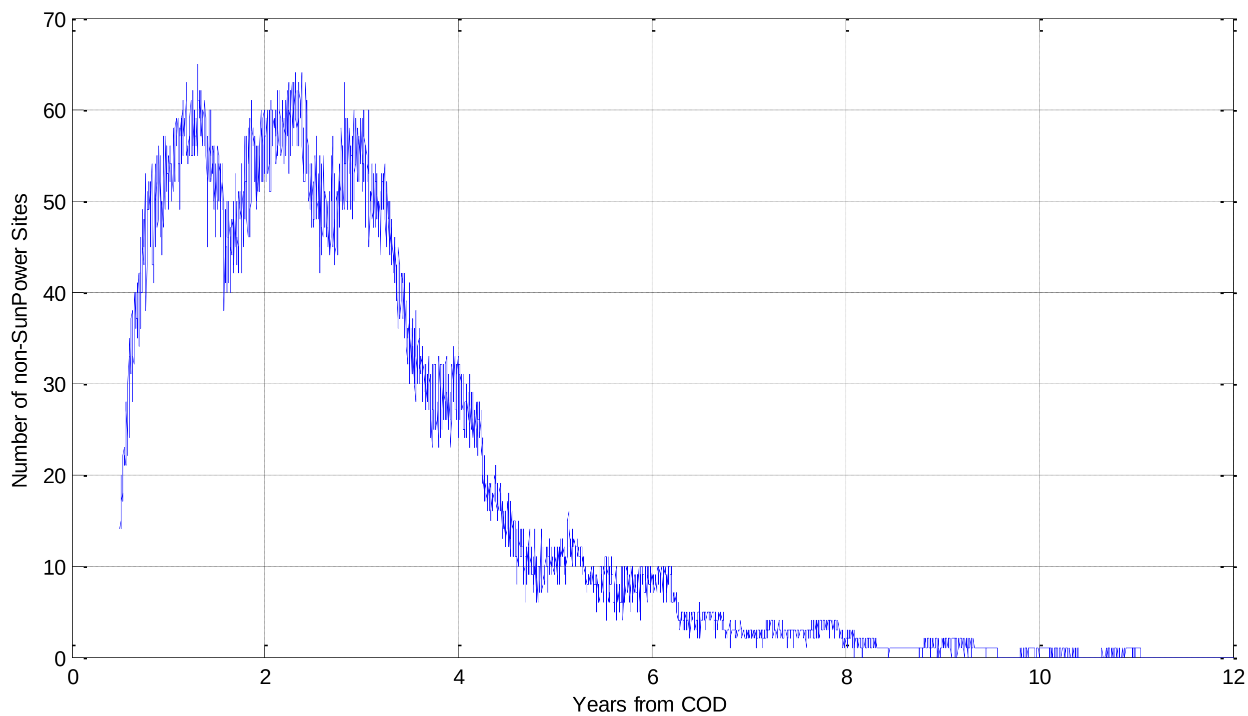

Figure 6 Number of non-SunPower sites with valid YOY degradation rates on each day

The daily median degradation rates, for both SunPower and non-SunPower fleets, were integrated (trapezoid method) to obtain the shape of the degradation vs. time. This approach does not make any assumption regarding how the degradation varies with time, e.g. it does not assume that degradation is linear. The results of these integrations are shown in **Figure 7**. Days with less than 10 sites of daily YOY degradation rate values were excluded from this integration due to the volatility seen in the figures above (i.e. at about 3.5 years for SunPower and 6.1 years for non-SunPower). Superimposed on **Figure 7** are the fleet degradation rates determined previously. The degradation indicates a surprisingly linear behavior over time, and aligns well with the degradation rates calculated previously. It is worth noting in Figure 9 that the method used to create these lines indicates only the slopes of the lines, and not the y-intercept, so the intercept has been arbitrarily set to zero. (For non-SunPower systems the intercept is generally presumed to be between -1% and -2% due to immediate Light-Induced degradation, but that is not part of this study.)

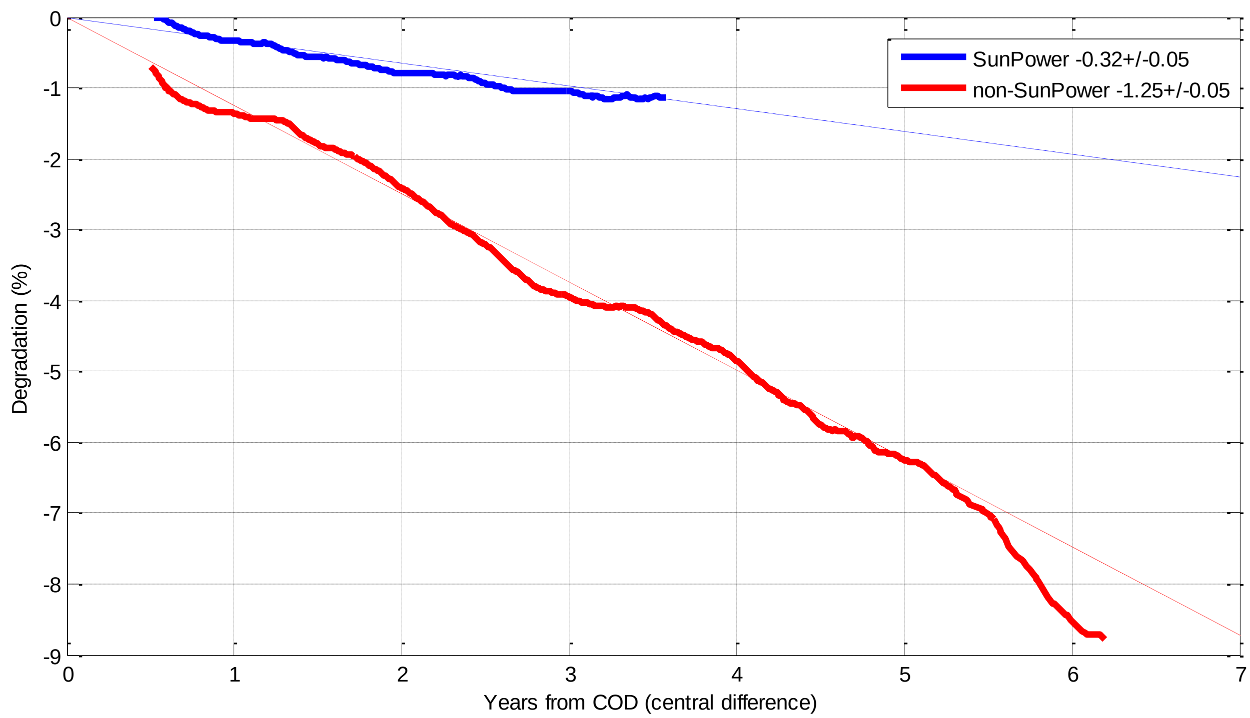

Figure 7 Fleet degradation over time from median of all SunPower sites, and Non-SunPower sites, when more than 10 sites

3.8 Uncertainty

The uncertainty in the median YOY degradation rate was determined using the method outlined in [1]. The standard deviation, s, of the median, $\tilde{m}$, of n values is given by

$$s(\tilde{m}) = \frac{1.9}{\sqrt{(n-1)}} \text{ MAD},$$

where MAD is the Median of the Absolute Deviations and is defined by

$$\text{MAD} = \text{med}\{|x_i - \tilde{m}|\}, \text{ for } i = 1,2,\ldots,n,$$

Where x_i is the value of the ith degradation rate.

A coverage factor of k=2 is applied for a 95% level of confidence [3] in the Extended Uncertainty.

4.0 Conclusions

The degradation rates for installed SunPower and non-SunPower systems were found to be significantly different from one another. The annual degradation rate of SunPower systems was determined to be - 0.32 ± 0.05% per year and the degradation rate of non-SunPower systems was determined to be - 1.25 ± 0.05% per year, with 95% confidence. Median values were found to result in more stable and robust results than average values. Daily fleet degradation rates were integrated to obtain the degradation over time for the two fleets, indicating highly linear degradation with time for each.

5.0 References

[1] Müler, J. W., “Possible Advantages of a Robust Evaluation of Comparisons”. Journal of Research of the National Institute of Standards and Technology, 105, 551-555, 2000.

[2] "Measures of Central Tendency" *Mean, Mode and Median*. N.p., n.d. Web. 16 Oct. 2012. <https://statistics.laerd.com/statistical-guides/measures-central-tendency-mean-mode-median.php>.

[3] BIPM, IEC, IFCC, ILAC, ISO, IUPAC, IUPAP, and OIML. *Evaluation of measurement data - Guide to the expression of uncertainty in measurement*. Joint Committee for Guides in Metrology, JCGM 100:2008.

Appendix A

Statistical Soundness

Using the median to represent the central tendency is more robust than using the average [1] [2]. If the data were symmetrically distributed with no outliers, then the median and average would have the same value. However, operating sites inherently exhibit anomalous behavior, as seen in **Figure 1** for example. Virtually every site has some amount of anomalous behavior; some are more obviously erroneous and some are less so. The approach taken here was to not attempt to use subjective means to filter the dataset but to overcome anomalous data through the use of ratios, year-over-year slopes, very large data sets, and characterization by medians.

The validity of this approach was investigated by looking at the median and the average calculated after filtering out the largest YOY degradation rates (both positive and negative). For example, if we assume that any degradation rate above 40%/year is unreasonable, and remove these values, and then calculate the median and average from the remaining data (i.e. -40<DegRate<40) we will get a result that might be different due to elimination of outlier points. To avoid an artificial bias from filtering unevenly on each side of the distributions, the filtering was centered around the distribution medians, rather than zero. Filters covering ranges -1<(DegRate-Median)<1 to -80<(DegRate-Median)<80 were applied and the resulting median and average values for both the SunPower and non-SunPower data sets are shown in **Figure 8**. As expected, the median values are more stable than the average values. Simply taking the average of the populations results in degradation rates of -0.21%/year and -0.96%/year, but this is a consequence of outliers and not as predictive as medians.

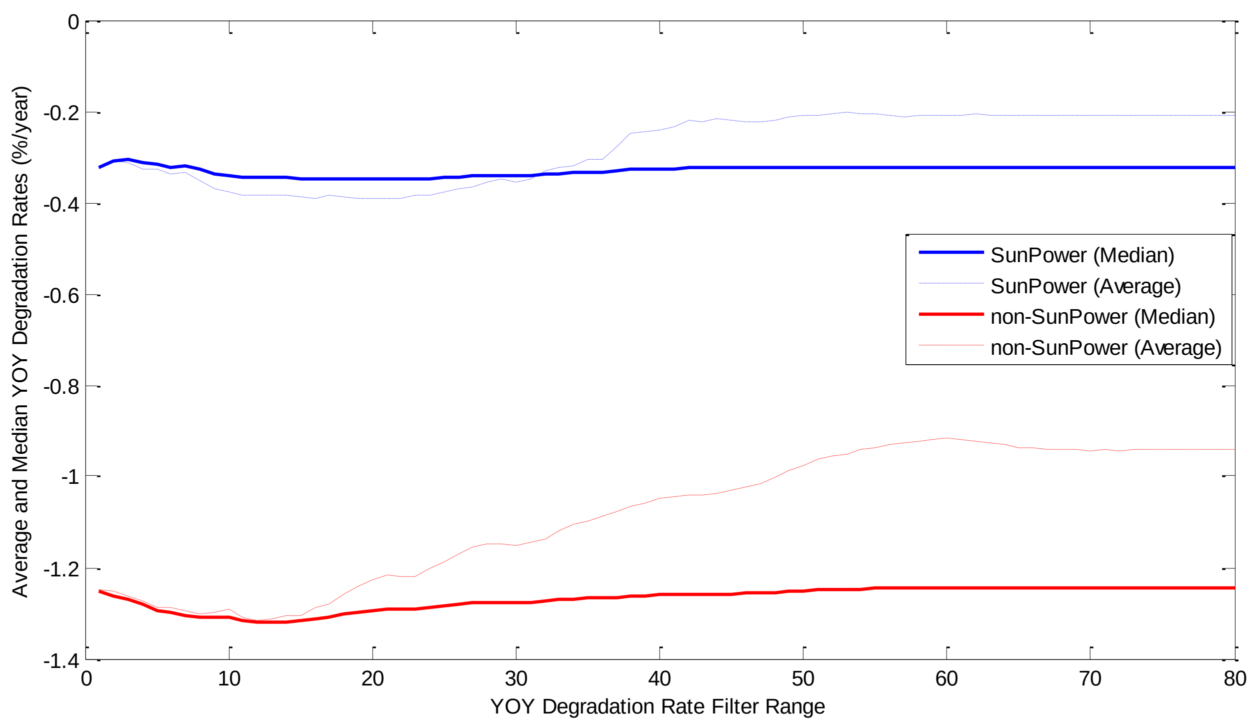

Figure 8 Median and average values after applying various filters ranges

Figure 9 shows the associated skewness and kurtosis of the data sets as a function of the filter range applied, which helps to explain the cause for the variation in the average seen in **Figure 8**. Skewness is a measure of asymmetry of the data around the average. If skewness is positive, the data are spread out more to the right. The skewness of the normal distribution (or any perfectly symmetric distribution) is zero. As the filter range gets larger, the skewness of these two datasets both become more positive, which result in the averages becoming more positive.

Kurtosis is a measure of how outlier-prone a distribution is. The kurtosis of the normal distribution is 3. Distributions that are more outlier-prone than the normal distribution have kurtosis greater than 3; distributions that are less outlier-prone have kurtosis less than 3. At YOY degradation rates larger than about 15-20, the kurtosis begins to exceed 3 indicating that outliers are more prominent. The prominence of these outliers can be seen in **Figure 10** which shows a zoomed in detail of the histogram from **Figure 2**. The best predictor of site performance for this dataset is the median.

References 1 and 2 do an excellent job with the theoretical foundation for using medians rather than averages for more stable "best" choice for robust prediction.

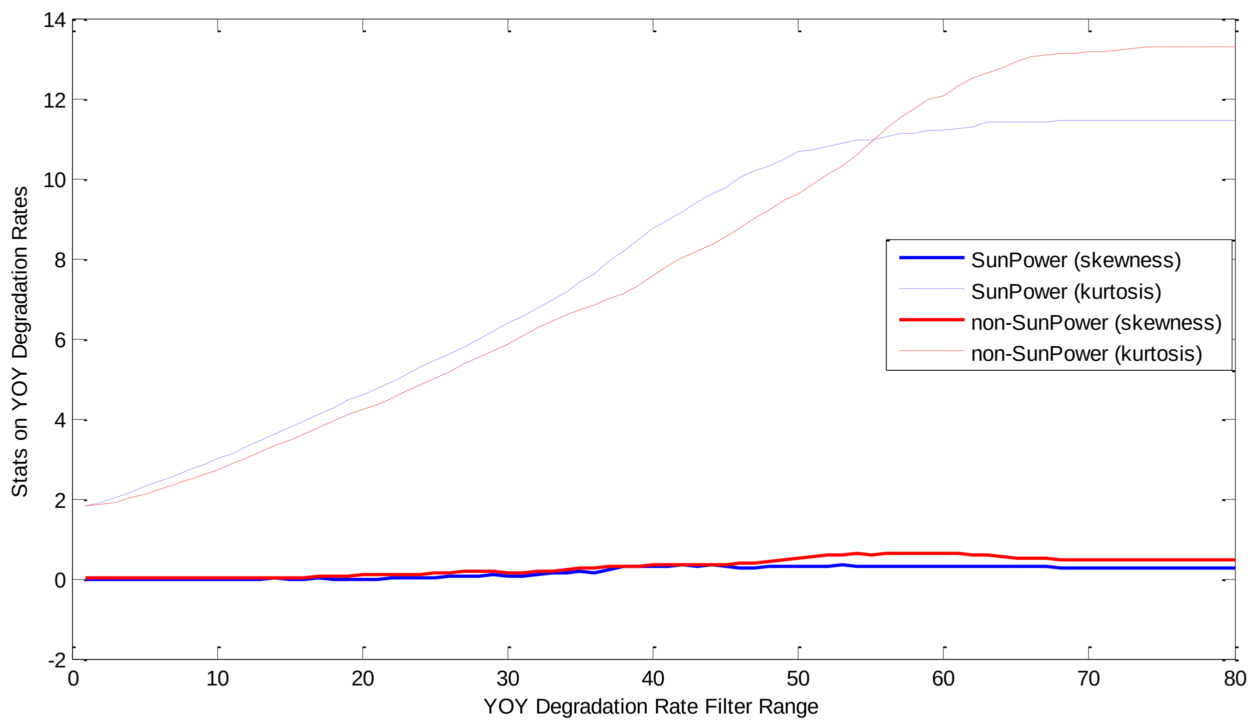

Figure 9 Skewness and kurtosis values after applying various filters ranges

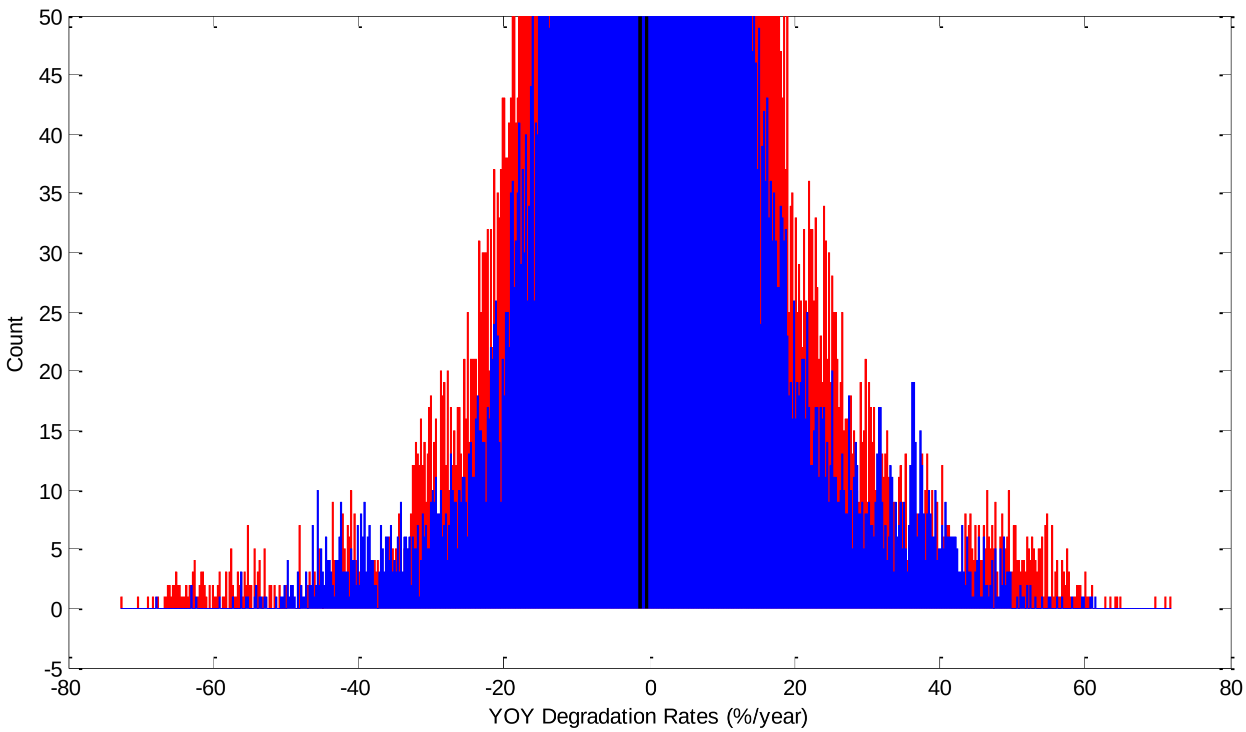

Figure 10 Histograms from Figure 2 zoomed in to show prominence of data in the tails of the distribution

Appendix B

Site Information

Table 2 Site information used in this study

#	Country	State	City	COD	PV Manufacturer	Number of Systems (Inverters)	Rated Power (kW)	Mount Type*
1	US	NY	ITHACA	12/28/00	NON-SUNPOWER	1	186	PG
2	US	CA	DUBLIN	6/25/02	NON-SUNPOWER	3	902.7	PG
3	US	NY	BROOKLYN	10/3/05	NON-SUNPOWER	1	64.4	PG
4	US	CA	SAN FRANCISCO	3/30/04	NON-SUNPOWER	3	676	PG
5	US	CA	WEST HILLS	10/19/03	NON-SUNPOWER	2	372.5	PG
6	US	CA	LOS ANGELES	2/12/04	NON-SUNPOWER	2	378.2	PG
7	US	CA	PACOIMA	1/1/04	NON-SUNPOWER	2	384.4	PG
8	US	CA	CLOVIS	7/18/05	NON-SUNPOWER	4	1130.8	PG
9	US	CA	OAKLAND	11/10/05	NON-SUNPOWER	4	760.5	PG
10	US	CA	OAKLAND	11/10/05	NON-SUNPOWER	2	372.4	MR
11	US	CA	SAN FRANCISCO	10/13/05	NON-SUNPOWER	1	255.4	PG
12	US	CA	NAPA	11/1/05	NON-SUNPOWER	1	166	T10
13	US	CA	SAINT HELENA	11/1/05	NON-SUNPOWER	1	261.4	T10
14	US	NJ	TOMS RIVER	11/22/06	NON-SUNPOWER	1	147	T10
15	US	NJ	TOMS RIVER	11/22/06	NON-SUNPOWER	1	106	T10
16	US	CA	AMERICAN CANYON	9/20/06	NON-SUNPOWER	2	159.1	T10
17	US	HI	WAIKALOA-HAWAII	8/24/06	NON-SUNPOWER	2	96.7	MR
18	US	CA	SAN FRANCISCO	1/2/07	NON-SUNPOWER	1	245.5	MR
19	US	CA	HOPLAND	11/8/06	NON-SUNPOWER	4	898.5	MR
20	US	CA	CHICO	9/20/07	SUNPOWER	1	503	T0
21	US	CA	SONOMA	5/12/07	NON-SUNPOWER	4	1042	T0
22	US	CA	WALNUT CREEK	7/10/07	NON-SUNPOWER	1	368	T10
23	US	CA	FREMONT	6/21/07	NON-SUNPOWER	2	377.88	T10
24	US	CA	ANTIOCH	4/19/07	NON-SUNPOWER	2	381	T10
25	US	CA	HAYWARD	7/25/07	NON-SUNPOWER	1	368	T10
26	US	CA	GILROY	5/23/07	NON-SUNPOWER	2	381	T10
27	US	CA	STOCKTON	6/6/07	NON-SUNPOWER	2	370	T10
28	US	CA	EL SOBRANTE	1/16/07	SUNPOWER	2	501.27	MR
29	US	CA	YUBA CITY	1/10/08	NON-SUNPOWER	2	774	T0
30	US	CA	CAMARILLO	4/20/07	SUNPOWER	3	584	T0
31	US	CA	BAKERSFIELD	4/2/08	SUNPOWER	2	385.77	T10
32	US	CA	SAN LEANDRO	10/25/07	NON-SUNPOWER	1	392	T10
33	US	CA	MANTECA	2/20/08	SUNPOWER	2	386	T10
34	US	CA	SAN JOSE	10/17/07	NON-SUNPOWER	1	387	T10
35	US	CA	CLOVIS	11/30/07	NON-SUNPOWER	1	387	T10
36	US	CA	SAN JOSE	3/6/08	SUNPOWER	2	386	T10

#	Country	State	City	COD	PV Manufacturer	Number of Systems (Inverters)	Rated Power (kW)	Mount Type*
37	US	CA	HAYWARD	10/18/07	NON-SUNPOWER	1	387	T10
38	US	CA	LINCOLN	4/2/08	SUNPOWER	2	386	T10
39	US	CA	PLEASANTON	8/22/07	NON-SUNPOWER	1	201	T10
40	US	NJ	BRANCHBURG	10/2/07	NON-SUNPOWER	2	413.38	T10
41	US	NJ	BRANCHBURG	10/2/07	NON-SUNPOWER	2	500.56	T10
42	US	NV	LAS VEGAS	10/15/07	NON-SUNPOWER	7	1666	T0
43	US	NV	LAS VEGAS	10/15/07	NON-SUNPOWER	10	2380	T0
44	US	NV	LAS VEGAS	10/15/07	SUNPOWER	19	4636	T20
45	US	NV	LAS VEGAS	10/15/07	NON-SUNPOWER	18	4284	T20
46	US	FL	SARASOTA	10/22/07	NON-SUNPOWER	1	250	PG
47	US	CA	SUNNYVALE	11/7/07	SUNPOWER	3	959	PG
48	US	CA	RICHMOND	4/22/08	NON-SUNPOWER	1	252.32	PG
49	US	CA	WESTMINSTER	11/1/07	NON-SUNPOWER	2	348.41	PG
50	US	CA	CULVER CITY	9/15/08	NON-SUNPOWER	1	259	PG
51	US	CA	NEWPORT BEACH	10/1/08	NON-SUNPOWER	1	227.52	PG
52	US	CA	THOUSAND OAKS	4/8/08	NON-SUNPOWER	1	242	PG
53	US	CA	THOUSAND OAKS	9/15/08	NON-SUNPOWER	1	255.84	PG
54	US	CA	DOWNEY	9/15/08	NON-SUNPOWER	2	368	PG
55	US	CA	MORENO VALLEY	12/7/07	NON-SUNPOWER	1	259	PG
56	US	CA	ARCADIA	5/2/08	NON-SUNPOWER	1	293.76	PG
57	US	CA	TEMECULA	3/18/08	NON-SUNPOWER	2	388.8	PG
58	US	CA	SUNNYVALE	8/5/08	SUNPOWER	4	1019.92	T0
59	US	HI	LANAI CITY	12/12/08	NON-SUNPOWER	12	1440	T0
60	US	CA	LAKEWOOD	9/22/08	SUNPOWER	2	364	T10
61	US	CA	SIMI VALLEY	6/18/08	SUNPOWER	2	488	T10
62	US	CA	PALMDALE	12/30/08	SUNPOWER	2	585.6	T10
63	US	CA	BREA	8/18/08	NON-SUNPOWER	2	542.12	T10
64	US	CA	ORANGE	9/22/08	SUNPOWER	3	717.36	T10
65	US	CA	TEMECULA	12/28/07	NON-SUNPOWER	2	403.2	PG
66	US	CA	CITY OF INDUSTRY	2/6/08	NON-SUNPOWER	1	130.72	PG
67	US	CA	NEWPARK	12/27/07	NON-SUNPOWER	1	185.44	PG
68	US	CA	SIMI VALLEY	12/31/07	NON-SUNPOWER	1	246.24	PG
69	US	CO	LAKEWOOD	10/15/08	SUNPOWER	2	785	FT
70	US	CO	LAKEWOOD	10/15/08	SUNPOWER	1	199	FT
71	US	CO	LAKEWOOD	10/15/08	SUNPOWER	2	761.5	FT
72	US	CA	SANTA ROSA	8/28/08	SUNPOWER	2	1088	T0
73	US	CA	ONTARIO	7/1/08	SUNPOWER	8	2249.99	T10
74	US	CA	MURRIETA	12/24/08	SUNPOWER	4	1120.1	T20
75	US	CA	SAN DIEGO	9/19/08	NON-SUNPOWER	4	1171.68	T10
76	US	CA	LAKEPORT	12/26/08	SUNPOWER	3	602.14	T0
77	US	CA	LAKEPORT	12/26/08	SUNPOWER	1	280.6	T20
78	US	CA	LAKEPORT	12/26/08	SUNPOWER	3	764.06	T0

#	Country	State	City	COD	PV Manufacturer	Number of Systems (Inverters)	Rated Power (kW)	Mount Type*
79	US	CA	RICHMOND	12/23/08	SUNPOWER	4	966.24	MR
80	US	CA	SANTA CLARA	5/28/08	NON-SUNPOWER	2	481.76	PG
81	US	CA	CUPERTINO	7/10/08	NON-SUNPOWER	1	191.52	PG
82	US	CA	SUNNYVALE	7/31/08	NON-SUNPOWER	1	246.24	PG
83	US	CA	FRESNO	9/2/08	NON-SUNPOWER	1	161.12	PG
84	US	HI	KAILUA KONA	1/1/09	NON-SUNPOWER	3	392.16	PG
85	US	CA	FRESNO	9/24/08	SUNPOWER	4	1055.01	T0
86	US	CA	DALY CITY	9/30/08	NON-SUNPOWER	1	331.36	PG
87	US	CA	SAN JOSE	5/21/08	NON-SUNPOWER	1	307.04	PG
88	US	CA	CONCORD	7/8/08	NON-SUNPOWER	1	230.4	PG
89	US	CA	SANTA MARIA	9/25/08	NON-SUNPOWER	2	355.68	PG
90	US	CA	IRVINE	10/16/08	NON-SUNPOWER	2	480.32	PG
91	US	DC	WASHINGTON	9/1/08	SUNPOWER	1	204	PG
92	US	CA	HUGHSON	9/30/08	SUNPOWER	2	581.9	MR
93	US	NJ	WHITEHOUSE STATION	2/9/09	SUNPOWER	6	1599	T0
94	US	CA	SUNNYVALE	12/2/08	SUNPOWER	4	902.8	PG
95	US	CA	VALLEJO	10/28/08	NON-SUNPOWER	1	556.32	MR
96	US	NC	CARY	12/17/08	NON-SUNPOWER	2	1001.53	T0
97	US	HI	KIHEI-MAUI	12/4/08	SUNPOWER	1	80.41	PG
98	US	HI	MAKAWAO	12/12/08	SUNPOWER	1	85.14	PG
99	US	CA	PALMDALE	12/10/08	SUNPOWER	3	593.62	T10
100	US	CA	REDLANDS	12/9/08	SUNPOWER	2	454.09	T10
101	US	CA	SANTA CLARITA	12/11/08	SUNPOWER	1	271.98	T10
102	US	CA	EL CAJON	12/8/08	SUNPOWER	2	392.59	T10
103	US	NJ	WAYNE	12/8/08	SUNPOWER	2	602.7	T10
104	US	NJ	WOODBRIDGE	12/5/08	SUNPOWER	1	273.28	T10
105	US	NJ	CHERRY HILL	12/15/08	SUNPOWER	1	300.12	T10
106	US	NJ	DEPTFORD	12/17/08	SUNPOWER	1	258.64	T10
107	US	NJ	EAST BRUNSWICK	12/18/08	SUNPOWER	2	517.2	T10
108	US	CA	RANCHO CUCAMONGA	12/23/08	NON-SUNPOWER	3	1160.96	T10
109	US	CA	CHINO	12/12/08	SUNPOWER	3	700.81	T10
110	US	CA	CHINO	11/28/08	SUNPOWER	4	1122.4	T20
111	US	CA	ONTARIO	12/30/08	SUNPOWER	3	779.24	T0
112	US	NJ	MONROE TOWNSHIP	12/31/08	NON-SUNPOWER	1	633.6	T10
113	US	NC	ROCKY MOUNT	11/20/08	NON-SUNPOWER	5	1063.1	T0
114	US	CA	PORTERVILLE	12/18/08	NON-SUNPOWER	1	598.88	MR
115	US	CA	HANFORD	12/18/08	SUNPOWER	1	554.07	T10
116	US	CA	KINGSBURG	12/18/08	SUNPOWER	3	634.4	T10
117	US	CA	HANFORD	12/20/08	NON-SUNPOWER	5	1172.48	MR
118	US	NJ	SECAUCUS	2/19/09	SUNPOWER	2	412.4	T10
119	US	HI	HONOLULU-OAHU	1/6/09	SUNPOWER	6	663.68	PG
120	US	CA	SAN JOSE	11/14/08	SUNPOWER	1	185	T10

#	Country	State	City	COD	PV Manufacturer	Number of Systems (Inverters)	Rated Power (kW)	Mount Type*
121	US	CA	KINGSBURG	11/15/08	NON-SUNPOWER	1	124.8	MR
122	US	CA	BALDWIN HILLS	12/3/09	SUNPOWER	1	216.2	T10
123	US	HI	KAHULUI-MAUI	1/13/09	SUNPOWER	1	139.15	PG
124	US	CA	WINCHESTER	5/15/09	SUNPOWER	4	1062.6	T20
125	US	CA	SAN RAMON	12/16/08	SUNPOWER	2	1124.84	T10
126	US	CA	PICO RIVERA	12/24/08	NON-SUNPOWER	3	1160	T10
127	US	CA	FRESNO	12/19/08	SUNPOWER	4	1102.1	T0
128	US	FL	ARCADIA	9/15/09	SUNPOWER	17	7310	T0
129	US	NJ	NEW BRUNSWICK	3/27/09	SUNPOWER	2	420.97	PG
130	US	NJ	STAFFORD TOWNSHIP	8/12/09	SUNPOWER	2	451.4	MR
131	US	FL	TITUSVILLE	9/30/09	SUNPOWER	2	988.2	FT
132	US	CA	LIVERMORE	8/19/09	SUNPOWER	3	701.84	MR
133	US	FL	KENNEDY SPACE CENTER	9/28/10	SUNPOWER	7	2100	FT
134	US	NJ	HAMILTON	8/5/09	SUNPOWER	5	1174	MR
135	US	CA	REDLANDS	8/14/09	SUNPOWER	1	100	T5
136	US	HI	KAILUA-KONA	10/31/09	SUNPOWER	2	91	MR
137	US	NJ	VINELAND	8/25/09	SUNPOWER	4	2339.96	FT
138	US	CA	SAN LUIS OBISPO	7/27/09	SUNPOWER	2	539.22	T0
139	US	CA	REEDLEY	10/19/09	SUNPOWER	4	1108.6	T20
140	US	IL	CHICAGO	3/23/10	SUNPOWER	18	5400	T0
141	US	CA	SAN MIGUEL	9/3/09	NON-SUNPOWER	4	1110.2	T10
142	US	CA	REDDING	4/30/10	NON-SUNPOWER	3	1174.08	T20
143	US	NJ	TITUSVILLE	9/19/10	SUNPOWER	7	4116	T0
144	US	NJ	ROBBINSVILLE	6/30/10	SUNPOWER	2	1200	T10
145	US	CO	MOSCA	9/23/10	SUNPOWER	38	20064	T20
146	US	NJ	FLORENCE	12/23/10	SUNPOWER	2	1000	T5

*Mount Type

PG	PowerGuard - fixed roof
MR	Metal Roof - fixed roof
T5	5 degree tilt - fixed roof
T10	10 degree tilt - fixed roof
FT	Fixed tilt
T0	0 degree tilt - tracker
T20	20 degree tilt - tracker