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Independent Engineering Review for Solar PV System at

Hanford Mall – Hanford, CA

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Disclaimer:

The intent of this Engineering Review is to perform rough order of magnitude checks on "reasonableness" of quoted financials, design, equipment integrity and estimated energy production from photovoltaic systems. This report is not intended to be a detailed engineering document. Data was provided electronically that included project scopes, as-built drawings, equipment details, inspection documents, financial spreadsheets and energy production estimates. An actual site visit was not performed by this reviewer and data was limited to the documentation provided. Rough calculations and rules of thumb were utilized in checking the cost and savings values with no guarantee expressed or implied in the savings estimates.

In no event will the author be liable to the customer for the inability to achieve the estimated results. Nor shall the author be liable for any incidental or consequential damages of any kind in connection with this report or the project.

Prepared by:

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1. Executive Summary

This is an Independent Engineering Review (IER) for a planned, 1,637 kW, solar photovoltaic (PV) installation at 1675 W Lacey Blvd, Hanford, California. The purpose of the review is to perform a rough order of magnitude check of project designs, economics, energy production, planned revenues from the energy production and equipment quality and warranties.

Conclusions:

There are discrepancies in the system configuration. The building permits, drawings, O&M contract and EPC contract all list a 1,587 kW DC system. The PVSyst production output and provided project costs list a 1,637 kW DC system. This is a significant difference that would require revisions to the calculations for compliance to building codes and may require revisions to the O&M contract price. *It is necessary to provide updated drawings and building permits that reflect the current system size and configuration.*

Energy output was modeled using industry standard software (PVSyst). Energy production is estimated at 3,156,300 kWh the first year, with a 0.5% annual reduction, which is accurately included in the cash flow model.

PV production revenues are $0.1628 per kWh. This is an average from utility rate structures as the cost of electricity purchased based on the rate structures at the site. This was estimated as an acceptable value. A 5% fee on production revenues are to be paid to the property owner. This is reflected as a 5% discount rate in the cash flow model.

The system has an O&M contract in place for $14,600 per year that includes one panel washing. Additional panel washings can be purchased for $11,900 each. The cash flow model includes O&M charges of $24,633 per year with a 2% annual escalation. This is close to an expected average cost.

An additional O&M expense is required to cover insurance for roof damage (included in the site lease contract). This expense is estimated at approximately $2,000 per year and is not currently included in the cash flow model. *It is recommended to include the roof insurance in the cash flow model once the insurance quote is received.*

The cash flow model includes operational insurance at $18,089. This was verified through a quote provided via e-mail of $12,000 per year.

The site lease contract is for $45,000 per year - verified through the site lease contract.

Both the PV modules and inverters are certified to industry accepted quality/durability standards. The PV modules have a 25 year output warranty, meaning they are warranted to produce over 80% of their rated output after 25 years. The inverters have a 10 year limited warranty. The project also includes equipment replacement costs in the cash flow at $8,348 per year with a 2% annual escalation rate. This is determined to be an adequate value based on likely replacement costs when the inverters exceed their warranty period.

Other expenses are either minor or internal to Blue Sky Utility and include: Management Fee, Gross Receipt Tax and a WREGIS[1] Fee.

[1] WREGIS is the Western Renewable Energy Generation Information System. From their website: ". . .an independent, renewable energy tracking system for the region covered by the Western Electricity Coordinating Council (WECC). WREGIS tracks renewable energy generation from units that register in the system by using verifiable data and creating renewable energy certificates (REC) for this generation."

2. Photovoltaic Systems Descriptions and Energy Output

The site has PV arrays mounted on both flat and sloped metal roofs. PV modules are manufactured by Sunpreme and inverters are manufactured by Sungrow. Flat roof mounted modules are mounted at a 15° tilt, oriented 47° toward west, relative to direct south (47° azimuth). The metal roof mounted modules have a 30° tilt, with some mounted 47° toward west and some mounted 43° toward east (-43° azimuth).

Description	Array 1					Array 2					Total
Module	SNPM-GxB 360	SNPM-GxB 360	SNPM-GxB 360	SNPM-GxB 360	SNPM-GxB 360	SNPM-GxB 360	SNPM-GxB 360	SNPM-GxB 360	SNPM-GxB 360	SNPM-GxB 360	
Rated Output EA (W)	360	360	360	360	360	360	360	360	360	360	
Quantity	1,980	51	90	75	51	1,815	195	51	102	136	**4,546**
Total Output (kW)	712.8	18.36	32.4	27	18.36	653.4	70.2	18.36	36.72	48.96	**1,637**
Tilt/Azimuth	15°/47°	15°/47°	30°/47°	30°/-43°	30°/-43°	15°/47°	15°/47° & 30°/47°	30°/47°	30°/-43°	15°/47° & 30°/47°	
Inverter	SG60KU	SG36KU	SG30KTL-M	SG30KTL-M	SG36KU	SG60KU	SG60KU	SG60KU-M	SG60KU-M	SG49K5J	
Rated Output EA (kW)	60	36	30	30	36	60	60	60	60	49	
Quantity	11	1	2	2	1	10	1	1	2	4	**35**
Total Output (kW)	660	36	60	60	36	600	60	60	120	196	**1,888**

Table 2-1 PV System Summaries

One issue with the system configuration is it doesn't match the engineering drawings or the building permits. The drawings and permits show a significantly different design, with a smaller array (1,587 kW) and different inverters and modules being used.

The current system includes Sunpreme bi-facial modules – meaning the back of the modules produce additional power through collecting the solar radiation that reflects from the roof top to the back of the modules.

System Energy Output

Predicted output was determined using a PVSyst software. PVSyst is an energy modeling tool used by the solar industry to simulate the energy harvest of a potential site. The software includes technical characteristics of most (if not all) of the PV modules and inverters that have been on the market over the past several years.

Total combined predicted output for both metal and flat roof installations is 3,156,300 kWh/yr. This is well below the current site consumption of 4.8 million kWh/yr. Therefore the system does not present a

risk of being a net exporter of energy to the grid. It is typically a requirement by the utility to not export more power than consumed for PV installations.

Month	Array 1 (kWh/yr)	Array 2 (kWh/yr)	Total Output (kWh/yr)
January	54,100	55,700	109,800
February	84,200	86,600	170,800
March	129,100	132,300	261,400
April	161,700	165,300	327,000
May	176,400	180,100	356,500
June	184,200	188,100	372,300
July	183,200	187,300	370,500
August	178,300	182,300	360,600
September	144,200	147,600	291,800
October	122,600	125,800	248,400
November	81,300	83,900	165,200
December	60,000	62,000	122,000
Total	**1,559,300**	**1,597,000**	**3,156,300**

Table 2-2 Predicted Output

The cash flow model shows predicted output during the first year of 3,168,840 kWh/yr, a negligible difference. The cash flow includes a 0.5% degradation in energy production each year, which is a typical characteristic of PV modules.

Conclusion: *Cash flow model PV output is an acceptable prediction for this installation.*

Recommendation: *Update engineering drawings to show the current configuration of the system and obtain a new set of building permits.*

Revenue:

The cash flow model shows a PV production revenue of $0.1628 per kWh, with an annual discount rate of 5% and an annual escalation of 3%. The 5% discount rate is paid directly to the property owner as part of the lease agreement.

An analysis was performed, by BSU, of the PV system hourly output compared to the utility electric rates during the month of the year and time of day. The blended average determines the annual average production revenue of $0.1628 per kWh.

Conclusion: *Production revenue of $0.1628 per kWh is acceptable based on the current utility rate structures at the site.*

Operations and Maintenance:

The site has an O&M contract in place. There is no performance guarantee, however the O&M elements are in place to ensure peak output. The contract includes one panel washing per year (in spring time) with additional panel washings as required based on monitoring of output.

Conclusion: *There are adequate O&M services planned for this project.*

3. Expenses

Below are shown the annual operating expenses included in the cash flow model and the amounts verified through additional documentation and analysis. Some expenses are internal to BSU or are considered minor, with no verification performed.

Expense Amounts:

Operating Expenses & Capital Reserves				
		Cash Flow Amount	Annual Increase	Verified Amount
	Insurance Coverage	$ 18,089	None	$ 12,000
	Lease Costs	$ 45,000	2%	$ 45,000
	Management Fee	$ 3,000	2%	Minor
	WREGIS Fee	$ 100	None	Minor
	Gross Receipt Tax ($/yr)	$ 1,700	None	Minor
	Replacement Costs ($/yr)	$ 8,211	2%	Acceptable
Maintenance				
	O&M Charge	$ 24,633	2%	$ 14,600
	Panel Cleaning	None	NA	$ 11,950

Table 3-1 Expenses Comparison

Insurance:

The cash flow includes a General Commercial Liability expense of 0.39% of the capital expenditure (less contingency), with no annual escalation. This totals $18,089 per year.

An e-mail from the insurance broker gives an estimate of 0.24% of the capital expenditure, which totals approximately $12,000 per year.

Conclusion: *Adequate insurance costs are included in the cash flow model.*

Lease Costs:

The cash flow includes lease costs $45,000 per year with a 2% annual escalation. This was verified through the lease agreement provided.

Conclusion: *Adequate lease costs are included in the cash flow model.*

Operations & Maintenance:

There are a large number of maintenance tasks included with each project. They basically consist of monitoring the system and troubleshooting any deficiencies, equipment inspection and service of major equipment, weather monitoring station, and electrical connections, and calibration of sensors as required.

The O&M contract price includes one panel washing per year. Further panel washings can be included for an additional fee. Studies performed at the Photovoltaic for Utility Scale Applications (PVUSA) site in Davis, CA, recommends an annual average soiling factor of 93% - meaning 7% loss due to dirt build-up.[2] This is due to California having a dry season and a rainy season. Hanford is near farming communities, where significant amounts of dust build-up can occur.

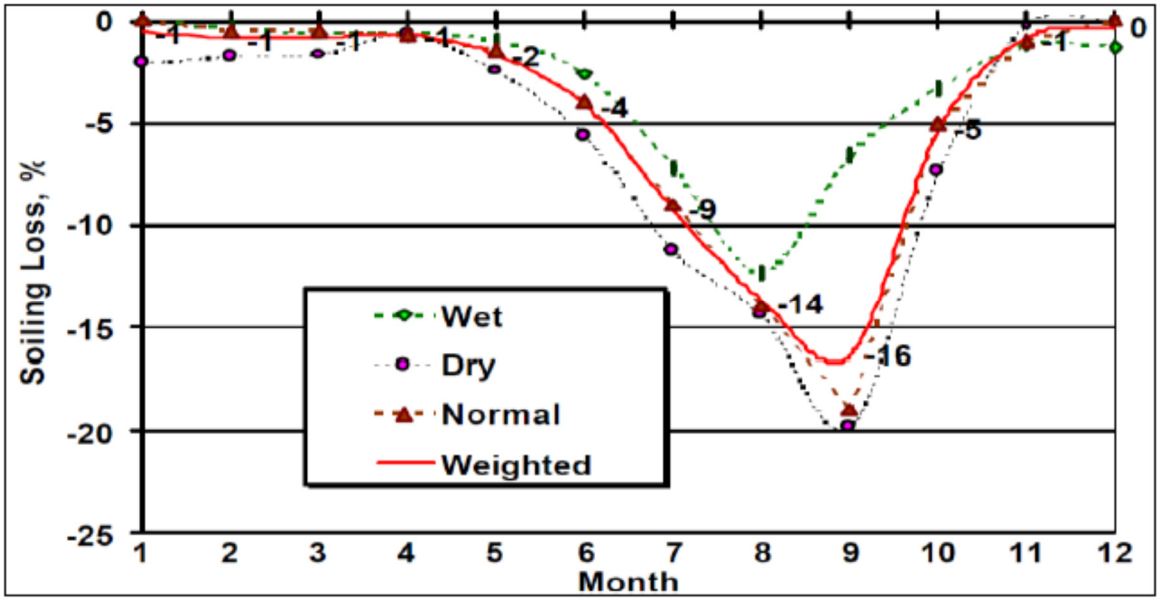

Figure 3-1 Recommended monthly soiling loss profiles for "wet", "dry" and "normal" years at the PVUSA site in Davis, CA[3]

Per the O&M contract, the annual cost quote is $14,600, with optional panel washings at $11,950 each. The base contract includes one panel washing in the spring. Therefore assuming one additional panel

[2] A Guide to Photovoltaic (PV) System Design and Installation, Endecon Engineering for the California Energy Commission, Report 500-01-020, June 2001, http://www.energy.ca.gov/reports/2001-09-04_500-01-020.PDF

[3] The Effects of Soiling on PV Performance – A Brief Literature Survey, Atonometrics, Inc., Document Number 880027 Revision B, 2012

washing per year, the cost is $26,550. The cash flow model shows a lower value of $24,633 per year with a 2% annual escalation.

Additional O&M costs will include insurance on potential damage to the roof, which is included in the site lease agreement. A quote has not been obtained for this cost, however it is estimated to be roughly $2,000 per year, per a phone conversation with the installing contractor.

Conclusions: *Adequate O&M costs are captured in the cash flow model – except for the additional roof insurance provided. Assuming two panel washings per year, the cash flow costs are within 8% of the quoted O&M price. If no additional panel washings are required, the O&M costs in the cash flow model are $10,000 greater than the actual O&M costs.*

It is recommended to update the cash flow model to include the roof insurance when that quote is available.

Replacement Costs:

The cash flow spreadsheet provides a reserve amount for replacement costs at $5 per system rated kW each year, with a 2% annual escalation. Inverters are typically the largest replacement expense that will be seen in PV systems. The inverters have a standard 10 year limited warranty, but they may actually last longer.

It is very difficult to predict the actual timeline of inverter failure, or future replacement costs. Several different types of documentation were reviewed to determine an estimate:

1. String inverters are very modular. Meaning individual components may fail, that can be replaced individually, without the need to replace the entire inverter.
2. Three general reports were found that state, for planning purposes, an inverter should be planned for replacement between 12 and 18 years of service, or an average of 15 years.[4],[5],[6]

Since this system has 10 inverters, it is assumed that when they do fail, it won't be all at one time. Therefore as an estimate, one can expect them to fail between year 12 and 18. Inverter costs have been declining over the past several years and it's difficult to predict how low they will go. As an estimate, 75% of current costs are assumed at around year 12 to 18. Current installed costs for the 35 inverters is $235,705. At 75%, this gives $176,778. Labor to install each inverter replacement is assumed to be a crew of two, at $100/hr each, working for 4 hours. This results in $800 labor each or $28,000 total for 35 inverters. Therefore the total estimated replacement cost is $205,000.

[4] Solar Valuation – An Appraiser's Guide to Solar, Sun Power, https://us.sunpower.com/sites/sunpower/files/media-library/white-papers/wp-residential-real-estate-appraisers-guide-accurately-valuate-residential-rooftop-solar-electric-pv.pdf

[5] "Economics of Solar Electric Systems for Consumers: Payback and other Financial Tests", Black, July 2009, http://www.ongrid.net/papers/PaybackOnSolarSERG.pdf

[6] Separating Myths from Reality in PV Inverter Reliability, Peshek, April 2012, http://engineering.case.edu/centers/sdle/sites/engineering.case.edu.centers.sdle/files/peshek.pdf

The cash flow model, when replacement costs are added for 18 years, gives $178,750. This is within 13% of the estimated replacement costs.

Conclusion: *Equipment replacement cost reserve in the cash flow model is $5 per rated Watt with a 2% annual escalation. This is an acceptable value.*

Other Expenses:

Additional expenses are included in the project cash flow that are considered internal to BSU and necessary for their business model, or minor expenses, with no verification of costs performed.

- Management Fee: $3,000 per year with a 2% annual escalation.
- WREGIS Fee: $100 per year with no escalation.
- Gross Receipt Tax: $1,700 per year with no escalation.

4. System Equipment Quality

Equipment quality for each site was evaluated.

PV Modules:

The modules are certified to UL 1703, which is the typical US standard for PV module quality/durability. Spec sheets show certification performed by CSA, who is authorized to certify products to this standard. Certification was verified through the CSA online database, with certification file number 255419.

The modules are warranted to produce 95% of their rated output after the first five years in service and with output degradation of no more than 0.6% each year thereafter for 20 years. They also carry a 10 year material and workmanship warranty.

Inverters:

The inverters are certified to UL 1741, which is the typical US standard for inverter quality/durability. Spec sheets show certification performed by CSA, who is authorized to certify products to this standard. Certification was verified through the CSA online database, with certification file number 253758.

They include a standard 10 year standard warranty, per their data sheet.

Mounting System:

The installation includes a Renusol mounting system, which carries a 10 year limited warranty on any defects in materials and workmanship.

Conclusions:

Equipment quality: *Adequate product certifications and warranties for inverters, PV modules and mounting system.*

5. Permits, Inspections and Contractor/Engineering Qualifications

The installation contractor is Bright Power, Inc (dba BPI), a licensed contractor in the state of California, license # 930054. They have both general and electrical contractors licenses, current and active. They are bonded with workers compensation insurance, according to California's Department of Consumer Affairs Contractors State License Board.

The electrical engineer is Himanshu Bhartiya, license 16945. The structural engineer is Jessyca Cochran, license 73092. The electrical engineer who stamped and signed the drawings is Rickert Hendriksen, license 10629. All licenses are current and active with no Public Record Actions.

Permit and inspection numbers are FY16-1830 and 1831 issued by the City of Hanford Building Division.

One issue is the engineering drawings don't match the design configuration used to determine energy output. Also the permits don't match the system configuration.

Recommendation: *It is necessary to update the installation drawings and obtain new building permits for this job.*