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**Independent Engineering Review for Solar PV System at  
BSU – Winery Square, Fairfield, CA  
February 10, 2017**

**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, 293 kW, solar photovoltaic (PV) installation at 1955 W. Texas St, Fairfield, 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:

Energy output was modeled using industry standard software (PVsyst). Energy production is estimated at approximately 475,000 kWh per year, which is accurately included in the cash flow model.

PV production revenues are \$0.23 per kWh. This is an average from PG&E rate structures as the cost of electricity purchased based on the rate structures at the site. This was verified as an acceptable value.

The system has an O&M contract planned to ensure peak system operation over time.

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 \$1,472 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 major operational costs include insurance (\$3,500 per year) and the O&M agreement (\$5,880 per year), which have been verified through vendor documentation as valid amounts to use in the cash flow.

One discrepancy in operational costs is the site lease. The cash flow model shows \$13,909 per year and the site lease agreement shows \$19,473 per year, with an additional fee of 5% PV production revenue. Through an e-mail exchange with BSU, the net annual rent negotiated with the property owner is \$13,900; however no written agreement has been provided for review. *It is recommended to obtain written agreement regarding final lease costs.*

Other expenses are either minor or internal to Blue Sky Utility and include: Management Fee, Gross Receipt Tax, Bad Debt and a WREGIS<sup>1</sup> Fee.

The project includes adequate contractor and engineering qualifications and building permits.

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<sup>1</sup> 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 rooftop mounted PV systems, comprised of the following equipment. All modules are to be mounted south facing, with a 10° tilt.

**Table 2-1** PV Module Summary

Module Manufacturer	Module Model Number	Rated Power Each (W)	Quantity	Total Rated Power (kW)
Hanwha Q Cells	Q.PEAK-G4.1 300	300	978	293

**Table 2-2** Inverter Summaries

Inverter Manufacturer	Inverter Model Number	Rated Power Each (kW)	Quantity	Total Rated Power (kW)
Sungrow	SG30KU	30	2	60
	SG60KU	60	4	240
<b>Total</b>			<b>6</b>	<b>300</b>

### **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 predicted output is 474,450 kWh/yr. Total electric usage at the site last year was 584,886 kWh. Therefore the PV system will not be a “net exporter”. This is significant since PG&E will no pay for PV power generation that exceeds consumption at the site.

**Table 2-3** Predicted Output

Month	PVSyst Output
January	19,637
February	24,475
March	40,108
April	48,708
May	57,819
June	57,685
July	56,483
August	54,038
September	44,376
October	32,229
November	22,592
December	16,300
<b>Total</b>	<b>474,450</b>

The cash flow model shows a higher value for predicted output - 475,000 kWh/yr. The cash flow includes a 0.5% degradation in energy production each year, which is a typical characteristic of PV modules.

Conclusion: *Expected energy output matches cash flow model.*

**Revenue:**

The cash flow model shows a PV production revenue of \$0.230 per kWh. This is utilized in the model with a 10% discount rate (which reduces the production revenue amount each year) and a 3% annual escalation rate (which increases the production revenue amount each year).

An analysis was performed of the PV system hourly output compared to the PG&E electric rates during the month of the year and time of day. The blended average determines the annual average production revenue of \$0.230 per kWh.

Conclusion: *Production revenue of \$0.230 per kWh is acceptable based on the current PG&E rate structures at the site.*

**Operations and Maintenance:**

An O&M contract is included with the project in order to ensure system output is maintained. Included with the installation is a monitoring package to aid the O&M contractor in performing their functions efficiently.

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

### **3. 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. This was verified through the California Solar Initiative web listing of eligible equipment. In order to be on that listing, the UL 1703 certification would have been submitted.

The modules carry a 25 year linear power output warranty. They are warranted to produce at least 83.6% of their rated power after being in service for 25 years. This means their output is expected to degrade by no more than 0.6% each year. They also carry a 12 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. For the 60 kW inverter, this was verified through the CSA certification document, found online. The actual certification document for the 30 kW model was not located. It is assumed the 30 kW model is also certified, since the 60 kW model was certified.

They include a standard 10 year limited warranty, which includes cost of material, service reimbursements and replacement, as required.

#### Conclusions:

Equipment quality: *Adequate product certifications and warranties*

#### **4. Expenses**

The main factors associated with the submitted expenses are:

Operating Expenses and Capital Reserves:

- Replacement Costs
- Insurance
- Management Fee
- Gross Receipt Tax
- Bad Debt
- WREGIS Fee

Maintenance:

- O&M Charge
- Panel Cleaning

#### **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.<sup>2, 3, 4</sup>

Since this system has six 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 six inverters is \$39,120. At 75%, this gives \$29,340. Labor to install each inverter replacement is assumed to be a crew

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<sup>2</sup> 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>

<sup>3</sup> "Economics of Solar Electric Systems for Consumers: Payback and other Financial Tests", Black, July 2009,  
<http://www.ongrid.net/papers/PaybackOnSolarSERG.pdf>

<sup>4</sup> 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>

of two, at \$100/hr each, working for 4 hours. This results in \$800 labor each or \$4,800 total for six inverters. Therefore the total estimated replacement cost is \$34,140.

The cash flow model, when replacement costs are added for 18 years, gives \$31,500. This is within 10% 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.*

**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 \$3,456 per year. An insurance quote, provided via e-mail from the insurance provider, gives an estimate of \$3,500 per year.

Conclusions: *Adequate proof of insurance is provided to substantiate the value in the cash flow model.*

**Lease Costs:**

These are quantified in the cash flow as \$13,909 per year, plus an annual escalation of 2%. The license fee provided in the Winery Square License Agreement gives \$19,473 per annum, with a 2% escalation rate. Additionally a fee of 5% PV production revenue is required.

Through an e-mail with BSU, the rent will be prorated based on system size through an agreement with the property owner. The net cost will be \$13,900, however a written agreement has not been provided.

Recommendation: *Obtain written agreement regarding final lease costs.*

**Operations & Maintenance:**

An O&M cost of \$20 per rated Watt, plus a 2% annual escalation, is included in the cash flow. This totals \$5,880 the first year. An O&M agreement was provided for \$4,288 per year, which includes one panel washing. Additional panel washings cost \$2,955 each. It is expected that during California's dry season, that one or two panel washings will be desired to maintain system output.

Conclusions: *O&M costs included in the cash flow model of \$20 per rated Watt, are in an acceptable range.*

**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 required.

- Management Fee: \$1,000 per year plus a 2% annual escalation
- Gross Receipt Tax: \$1,000 per year plus a 2% annual escalation
- Bad Debt: 2% of total annual revenue or \$1,947 the first year.
- WREGIS Fee: \$100 per year with no escalation.

## **5. Permits and Contractor Qualifications**

A building permit was issued by the City of Fairfield - Permit No: BLD16-01649.

Installing contractor is Bright Power, Inc, DBA BPI. They hold A & C-10 contractor licenses, No. 930054, Exp. 3/31/17. This license is current and active per the California Department of Consumer Affairs, Contractors State License Board.

The professional engineer who signed and stamped the drawings is Rickert C. Hendriksen, No E10629, Exp. 6-30-17. This license is active and clear, with no actions, per the California Department of Consumer Affairs, Board for Professional Engineers.

Conclusion: *This project includes adequate permits and contractor/engineering qualifications.*