SALVAGE VALUE OF PHOTOVOLTAIC SYSTEMS

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ABSTRACT

As photovoltaic (PV) system prices become less expensive, the salvage value can be increasingly important in life cycle economic calculations. This report examines data from historic utility salvage sales, reliability perspectives, and an actual 2011 salvage operation. From 2005 to 2010, large volume PV modules sold at salvage for a variety of pricing dependent upon strength of glass, amount of easily recycled aluminum, industry reduced average selling price (ASP) of new modules and expectations for future energy production. Reliability of product, both real and perceived, are important factors in resale valuations.

1. INTRODUCTION

Used PV modules have been selling for decades. In 1994 the author purchased slightly brown, nine year old Siemens M-55's pulled from the Carissa Plains California project; they worked well. These modules were re-sold again on E-bay six years later. The value of large scale salvage PV bids have been tracked since 2005 – 2010 and in 2011 we performed a salvage value analysis on one of these bids.

2. LARGE SCALE SALVAGE SALES

The Sacramento Municipal Utility District (SMUD) has been re-selling salvaged PV equipment since 2005. The table presented includes the technology based dollar per nameplate watt prices. Over 0.9 megawatts of nameplate modules were sold during this period.

Winning bids ranged from $0.04 to $1.26 / watt. The table shows minimum, maximum, average $/watt winning price for individual lots and approximate nameplate wattage sold that year. Modules sold included tandem amorphous silicon (a-Si), single crystal (Single) and polycrystal (Poly) PV. Model numbers included: Solarex MST 43 and MSX 60, Shell SQ 75/80, Solec SP-102 and SQ-80, and Siemens M55's. Some modules had been panelized, as shown in Photo #1 demonstrating well handled, nicely stacked and high resale valued of crystalline PV modules.

3. ECONOMICS

Most engineering students are required to learn present value calculations for comparing the life cycle economics of different systems solutions. These calculations include capitol costs, maintenance costs, any gradually increasing costs or escalating costs (like an increasing electrical utility bill) and salvage values. In the past, PV systems typically didn't include salvage value because there wasn't a recognized resale market. In addition, the life expectancy of PV systems is 20 years or more, thus present value salvage values were considered minimal in comparison to yesteryear's high capital costs. Removal costs should be factored into the economic calculations.

Working modules have some value, based on the electricity they can generate for the remainder of their useful life. It is possible that high value, non-breakable glass modules can consistently obtain half the going retail rate per watt.

A module selling for $0.20 / watt salvage value at the end of 20 years, using a 6% discount rate has a present value of $0.06; however at $1.26 / watt the salvage value is $0.39 today. Present value salvage values can now be subtracted from today's installed systems costs with confidence that they will be resold.

4. BANK ESTIMATION OF VALUE

An investigation into large scale bank financed PV projects indicates that banks use residual values ranging from 15-25%. Banks base this on 3rd party appraisals,

TABLE 1: SMUD WINNING BIDS, 2005 TO 2010 SALVAGE SALES

Winning Bids from 6 Years of Surplus Photovoltaic Sales at SMUD												
	2005		2006		2007		2008		2009		2010	
Bid Lot	Type	Price Per watt	Type	Price Per watt	Type	Price Per watt	Type	Price Per watt	Type	Price Per watt	Type	Price Per watt
1	a-Si	$0.46	a-Si	$0.46	Single	$0.78	a-Si	$0.53	a-Si	$0.07	a-Si	$0.09
2	a-Si	$0.46	a-Si	$0.31	Single	$0.66	a-Si	$0.50	a-Si	$0.06	a-Si	$0.13
3	a-Si	$0.46	a-Si	$0.20	Single	$0.77	a-Si	$0.97	a-Si	$0.04	a-Si	$0.07
4	Poly	$0.98	a-Si	$0.22	Single	$0.82	Poly	$0.44	a-Si	$0.06	Poly	$0.23
5	Poly	$0.75	a-Si	$0.24	Single	$0.73	Poly	$1.15	a-Si	$0.04	Single	$0.13
6	Single	$0.51	Single	$0.66	Single	$0.82	Single	$0.54	a-Si	$0.04	Single	$0.13
7	Single	$0.51	Single	$1.04	Single	$0.72	Single	$0.83	Poly	$0.17	Single	$0.18
8	Single	$0.61	Single	$1.26	Single	$0.48	Single	$0.88	Poly	$0.48	Single	$0.19
9	Single	$0.61	Single	$0.77	Single	$0.66	Single	$0.76	Poly	$0.24	Single	$0.33
10	Single	$0.61	Single	$0.77	Single	$0.82	Single	$0.88	Poly	$0.29	Single	$0.04
11			Single	$0.92	Single	$0.78	Single	$0.91	Poly	$0.21	Single	$0.24
12					Single	$0.82	Single	$0.72	Poly	$0.17		
13					Single	$0.52	Single	$0.56	Poly	$0.23		
14							Single	$0.72	Single	$0.25		
15							Single	$0.65	Single	$0.24		
16									Single	$0.17		
17									Single	$0.30		
18									Single	$0.16		
Min		$0.46		$0.20		$0.48		$0.44		$0.04		$0.04
Max		$0.98		$1.26		$0.82		$1.15		$0.48		$0.33
Total kW	150		69		177		136		212		160	

Photo 1: Stacked single crystal silicon salvage sales PV panels.

which the banks then reduced by 50 to 70%. Two reported appraisals approaches used by banks include:

1) An income approach. Banks assumed a useful life of 35 years for both crystalline and a-Si, then discounted back the future energy revenues from years 21-35, back to year 20. Because of an anticipated rise in value of the electricity PV module would generate after 20 years, the 15 years of energy revenue (at year 20) results in very high residual values (in the 50-70% range). This income approach recognizes that functioning modules will always have an energy revenue value based on life expectancy and in comparison to future alternative electric generation costs.

2) A replacement value approach. What might PV modules cost down the road, for a new buyer that had the choice of buying used modules, or the same power generation capability of new modules? A bank might assume a 5% decline in the cost of a module every year, and a 5% gain in energy value every year. When you factor in what a PV module should cost (without regards to oversupply / undersupply), based on these historical trends, you get a value of what a person should be willing to pay per watt for a used PV module at any given year, vs. the alternative of purchasing a new PV module.

5. RESALE MARKETS

Used or salvaged modules are bought and sold in a number of ways. In some cases, they can be installed into non-incentivized systems like off grid markets. Or they might be showing up in resale channels like on E-Bay, Craigslist or classified section of Home Power Magazine. We were able to sell 15 year old modules for approximately $0.50 / watt in 2011.

It is possible individual modules are being sold into existing systems where a component has broken. All modules in a system should perform at exactly the same level, thus avoiding miss match conditions that reduce overall system performance. Similar to a fine china dinner set that has a broken plate; specific modules have a high replacement value, even if they are a used module. If an existing PV system has a problem with an individual module, replacing that module could have a very high system level value.

Used modules could be sold into a wholesale green power generator; however a tax credit or renewable energy credits (RECs) for the installation would not be allowable because the PV materials are not new.

Scrap markets can utilize crystalline cells, as well as the aluminum frames, thus non-working crystalline modules can have an attractive scrap value. Various PV recycling programs have begun around the world including PV ReCycling with headquarters in Tucson Arizona and additional collection point in San Jose CA.

6. ENERGY and GLASS

Most PV technologies lose 1% per year in performance consistent with typical 20 year, 80% power warranties. A module with an original standard test condition (STC) power output rating of 100 watts will probably be producing 90 watts at STC after ten years, 80 watts after 20 years. Used modules can be tested for their performance using a max power point current / voltage meter, correcting for module temperature and actual solar radiation normalized to the STC conditions of 1,000 watts per square meter and 25 degrees centigrade cell temperature.

It is important to note that the SMUD salvage sales illustrates a-Si on breakable float glass has considerable less salvage value than single or poly silicon technologies using tempered glass (see Photo #2). CdTe might have similar issues with removability and transportability of the more fragile glass compared with tempered glass of crystalline PV. Even tempered glass is subject to breakage during decommissioning, removal transportation and storage activities (see Photo #4) . If flexible PV like United Solar or other newer flexible PV players in the market were designed for removability, it is possible the salvage value would be even higher than glass based PV.

Photo 2: Poorly handled float glass a-Si for bid 2005

Visual factors including browning of EVA was an important factor for resale, with large amounts of browning, as shown in the 15 year old single crystals cells of Photo 5, dramatically reducing the resale value.

7. SALVAGE OPERATION

In 2011 we examined the 144 Solec SP-102's 24 volt modules shown in photo #3 for the actual resale value. Operating modules produced approximately 85 watts in full sun, consistent with a 1%/year degradation. Performance was measured with a 100 watt variable resistor providing

voltage open circuit, short circuit current and an approximation of voltage and current at max power in full sunlight. Good modules with junction boxes sold on a roadside in Grass Valley CA for between $30 and $50 each. Modules without junction boxes sold in bulk for $20 each. Approximately 15% of the modules were discarded because of glass breakage, delamination, serious browning of EVA, obvious burn marks on interconnections or damaged backsheets. Angle aluminum used to panelize the modules was salvaged at a high value.

The time needed to transport, warehouse, clean, examine, sort, inventory, and sell the surplus modules considerably reduced the value of the salvage operation. Ideally modules are taken out of service and immediately installed in a new location.

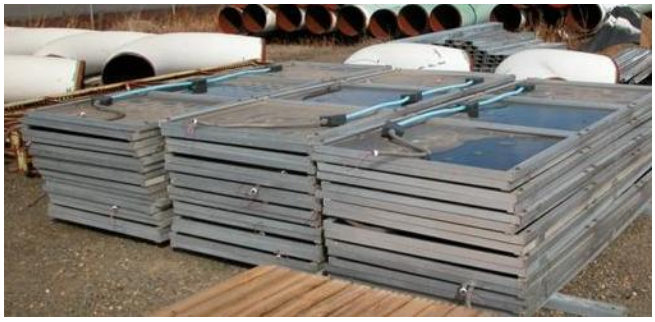

Photo 3: 1995 Solec SP-102's piled up in 2010.

Photo 4: Side by side broken and good quality modules.

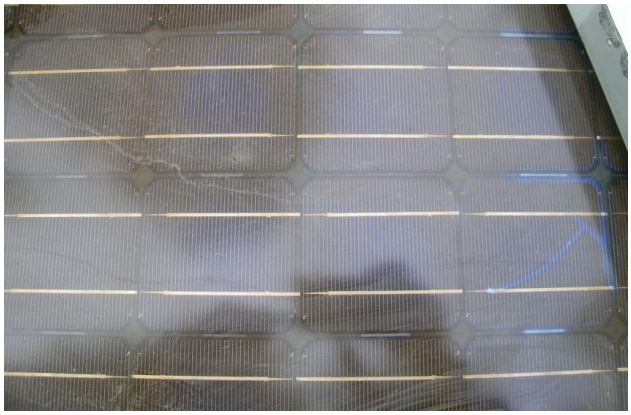

Photo 5: EVA discoloration.

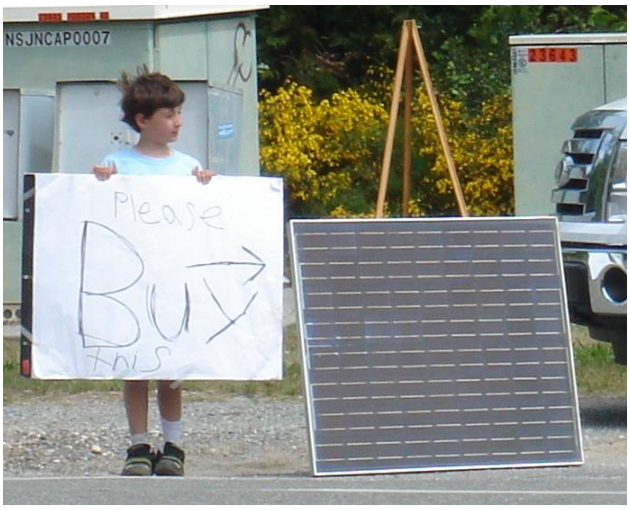

Photo 6: Selling PV in northern CA 2011.

8. CONCLUSION

There is a healthy resale market for PV modules that should be recognized in project level economic calculations. As systems costs become lower and lower, salvage value have more significant ramifications. Functioning modules will have a revenue value based on life/performance expectations considering the additional shipping and handling costs in comparison to other alternatives to electric generation. The fragility due to glass used in PV modules has important resale value ramifications. Non-glass modules should have greater resale values because of no potential breakage during removal, and resale. Over time, bank residual values can be compared with actual salvage sales for accuracy in future assumptions. Safety and performance standards for used modules will become more important as salvaged modules show up in greater numbers in future years.

9. ACKNOWLEDGEMENTS

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10 REFERENCES

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