LBNL-XXXXX

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Quantifying Non-Hardware Balance of System Costs for Photovoltaic Installations in the United States Using a Combined Annual Expenditure-Labor Hour Productivity Approach

Kristen Ardani[1], Galen Barbose[2], Robert Margolis[1], and David Feldman[1]

[1] National Renewable Energy Laboratory
[2] Lawrence Berkeley National Laboratory

Environmental Energy Technologies Division

May 2012

This work was supported by the Office of Energy Efficiency and Renewable Energy, Solar Technologies Program of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

Disclaimer

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, or The Regents of the University of California.

Ernest Orlando Lawrence Berkeley National Laboratory is an equal opportunity employer.

Quantifying Non-Hardware Balance of System Costs for Photovoltaic Installations in the United States Using a Combined Annual Expenditure-Labor Hour Productivity Approach

Kristen Ardani[1], Galen Barbose[2], Robert Margolis[1], and David Feldman[1]

[1]National Renewable Energy Laboratory, Washington, DC, 20009, United States
[2]Lawerence Berkeley National Laboratory, Berkeley, CA, 94720, United States

***Abstract* — This paper presents results from the first U.S. based data collection effort to quantify non-hardware, business process costs for PV systems at the residential and commercial scales, using a bottom-up approach. Annual expenditure and labor hour productivity data are analyzed to benchmark business process costs in the specific areas of: (1) customer acquisition; (2) permitting, inspection, and interconnection; (3) installer labor costs associated with third party financing; and (4) installation labor. Annual cost and labor hour data were collected from 87 installers. After eliminating outliers, the survey sample consists of 75 installers, representing approximately 13% and 4% of 2010 added PV installations at the residential and commercial scales, respectively. Results indicate that business process costs benchmarked in this analysis (including assumed permitting fees) total $1.52/W[1] for residential systems (ranging from $0.66/W to $1.66/W between the 20th and 80th percentiles). For commercial systems, the survey results suggest business process costs of $0.99/W for systems <250 kW (ranging from $0.51/W to $1.45/W between the 20th and 80th percentiles), and $0.25/W for systems >250 kW (ranging from $0.17/W to $0.78/W between the 20th and 80th percentiles)[2]. We conclude that business process costs present significant opportunities for cost reductions.**

***Index Terms* — balance of system, non-hardware, regulatory, photovoltaics.**

I. Introduction

The global average wholesale price for PV modules fell from $4.04 per watt ($/W) in 2005 to $2.40/W in 2010, while the average installed PV system price in the U.S. declined from $7.90/W to $6.20/W over the same period [1]. Thus the reduction in module price accounted for 96% of the total decline in average installed PV system price from 2005 to 2010, and consequently non-module components have accounted for a significant, and increasing, portion of average installed PV system prices in the U.S. [1]. In order to track and analyze the rapidly evolving price structures of PV systems, a thorough understanding of non-module cost components is needed.

To date, a number of analyses have examined non-module PV system hard costs, including power electronics and hardware balance of system (BOS) [1]-[3]. However, a more thorough bottom-up examination of non-hardware BOS costs of PV installations has not been published to date. At the residential scale, total non-hardware BOS elements, such as permitting and commissioning, profit, overhead, and installation labor are estimated to contribute 47% to total installed PV system price in 2010, depending on system size, location, and other factors. For commercial PV systems, total non-hardware BOS contributes approximately 33% to total installed price [3]. The purpose of this analysis is to provide further granularity to total non-hardware BOS cost estimates and quantify certain business process costs for PV systems, previously unmeasured. Unlike hardware costs for PV systems, that can be readily benchmarked with data collected from bills of materials and equipment manufacturers, quantifying business process costs requires detailed tracking of the time required to complete the various stages of a PV installation. Inefficiencies in customer acquisition, securing financing, local permitting and inspection processes, and installation slow PV deployment, in turn, driving up the total price of PV systems. To quantify the cost of time, we examine the labor hours required, per installation, to complete discrete stages of the PV business process. We then translate labor hour requirements per installation to dollars per watt, using system size, labor class and composition assumptions, and fully burdened wages. This calculated cost of labor is aggregated with annual expenditure data for customer acquisition, to benchmark total business process costs.

We acknowledge there are non-hardware cost and end consumer price components, including profit, overhead, financing, and contracting, that are not benchmarked by this analysis using a bottom up methodology. We focus on the non-hardware BOS costs for which bottom-up data were collected, defined as *business process* costs for the purpose of this analysis.

[1] $1.52/W represents the average total business process costs, weighted by total number of installations completed per respondent, in 2010.

[2] $.99/W and $.25/W represent the median total business process costs. Median values are reported at the commercial scale on account of the small sample size and wide variation in total capacity installed, per respondent.

II. Existing Literature

Most literature on the non-hardware elements of PV installations discusses how bureaucratic hurdles and permitting paperwork requirements impede the wide scale deployment of, and add considerable cost to, PV systems in the United States, but does not explicitly quantify these additional costs [4]-[8]. Only one study that we are aware of, carried out by the Sierra Club [8], reports permitting fees across jurisdictions, gathered through an on-going survey process. While this study discusses the wide variation in fees for residential and commercial PV systems, it is limited in geographic scope to California. The non-profit organization, Vote Solar, has expanded upon this California fee data to include permitting information across approximately 20 states, and published it online through its Project Permit Initiative [9]. While the Sierra Club and Vote Solar have successfully drawn attention to the need to harmonize permitting requirements and reduce fees across jurisdictions, the literature does not benchmark non-hardware costs in a bottom-up manner.

Industry provides the single, published report to quantify non-hardware costs in detail [10]. Data for installer expenditures on the various stages of the permitting and inspection process, as well as additional marketing and advertising costs due to cancellations and reduced customer referrals, was collected from 15 residential PV installers through depth interviews. The report concludes that permitting, inspection, and marketing and advertising can add approximately $2,516/installation, or $.50/W for an assumed 5 kW system [10]. However, the literature review revealed no documentation quantifying neither the non-hardware costs for commercial scale systems, nor the costs of interconnection and arranging 3rd party financing. Our work, reported here, partially fills this gap in the literature, and presents results from a larger sample size of n= 75 installers.

While the body of work examining non-hardware costs is relatively small, a more comprehensive body of PV system price analysis exists. The Lawrence Berkeley National Laboratory (LBNL) reports aggregated price data sourced primarily from state and utility PV programs, such as the California Solar Initiative and U.S. Treasury Department's Section 1603 Grant Program [1]. Though the LBNL analysis presents variability in price attributed to a wide range of factors such as state, system size, ownership structure, technology, efficiency etc., due to the top down characteristic of the market price data used, it does not separate component costs beyond the categories of *module*, *inverter*, and *other*[3]. In contrast, Goodrich et al.[3] uses a bottom-up methodology to benchmark PV system prices and reports detailed component costs such as installation materials, electrical labor, installation labor, supply chain costs, permitting and commissioning, and installer overhead etc. While Goodrich et al.[3] provides the most granular, bottom-up PV system price analysis to date, non-hardware costs remain relatively aggregated. The aim of the analysis reported here is to further disaggregate the non-hardware costs presented throughout the extant literature.

[3] Barbose et al. uses the category of "other" to capture all costs other than module and inverter

III. Methodology

An 18 question online survey was disseminated, in collaboration with Solar Tech [11] to its network of U.S. PV installers in order to benchmark average time and cost of PV business process for systems installed in 2010. Total annual expenditure data were collected for customer acquisition costs, delineating between three cost categories- marketing and advertising, system design, and all other customer acquisition costs[4]. Annual expenditures were translated to dollars per watt, for each cost category, based on reported number of installations and PV system size.

Labor hours per installation data were collected in the areas of permitting, inspection, interconnection, installer arrangement of 3rd party financing, and installation. Reported average labor hours per installation were translated to cost per watt using system size, corresponding labor classes, proportional share of labor used, and fully burdened labor rates. Table 1 depicts the labor class, share of labor, and wage assumptions used to calculate total labor costs for each business process cost category.

TABLE I
Labor Class and Wage Assumptions [12]

Business Process Cost Category	Occupation (labor class)	Share of Labor (%)	Burdened Wage ($/hr)
Permit Preparation	Permit procurement	70	36.69
	Administrative staff	30	19.56
Permit Submission	Permit procurement	30	36.69
	Administrative staff	70	19.56
Inspection	Installer (roofer)	70	40.49
	Administrative staff	30	19.56
Interconnection	Permit procurement	30	36.69
	Administrative staff	70	19.56
Installation	Electrician	As reported by installer	60.12
	Installer (roofer)		40.49
Incentive Application Process	Installer (roofer)	30	40.49
	Administrative staff	70	19.56
Installer Labor Associated with 3rd-Party Financing	Financial analyst	100	50.75

[4] "All other customer acquisition costs" include sales calls, site visits, travel time to and from the site, contract negotiation with system host/owner, and bid/proforma preparation, but exclude marketing/advertising and system design.

III. Residential

A. Sample Market Representation and Characterization

A raw sample size of 70 residential PV installers, representing 18% of added residential installations in 2010, was cleaned for outliers on a per question basis by eliminating the highest 5% and lowest 5% of cost/W values and erroneous responses. The cleaned sample size ranges by cost category from n = 47 to n = 60 and represents between 13% and 16% of added residential PV installations in 2010. The sample is predominately comprised of small volume installers, with 18 out of 70 respondents completing more than 100 installations in 2010. Moreover, the 4 largest volume installers completed a total 4,315 installations, approximately 50% of total systems sampled.

B. Residential Results

We assume an average system size of 5 kW when calculating cost per watt for all non-hardware cost categories examined at the residential scale, except installation labor. For the category of installation labor, we calculated cost per watt using the reported average system size; we assume installation labor costs for residential systems scale with system size, while the other non-hardware costs measured do not. Average cost per watt, weighted by total annual number of installations per respondent, is reported for all cost categories at the residential scale. On average, non-hardware balance of system costs in the U.S. totaled $1.41/W at the residential scale, excluding fees.

Customer Acquisition- Customer acquisition activities can add considerable time and cost to PV installations, especially in states with less mature markets where perceived technology risk and unfamiliarity with PV increases bid failure rates. Expenses related to customer acquisition, such as lead generation, bid and pro-forma preparation, and system design, increase sunk costs to the installer in the event of project drop out, increasing the overall cost of doing business. The survey asked installers to provide their total annual expenditures on customer acquisition activities for residential PV, segmented into three cost categories: marketing and advertising, system design, and all other customer acquisition costs. Following the methodology explained above, these annual dollar amounts were translated into dollars per watt.

Installer expenditures on customer acquisition activities totaled $0.67/W for a typical 5 kW residential PV installation; $0.11/W for system design, $0.33/W for marketing and advertising, and $0.23/W for the category of all other customer acquisition costs.

Permitting, Inspection, Interconnection (PII) - The United States' regulatory requirements and permitting processes for PV installations are often burdensome and costly compared to PV market leaders, such as Germany [13]. Installers expend significant resources on paperwork completion and compliance. Additionally, the lack of standardization in permitting requirements, fees, and interconnection standards across more than 18,000 authorities having jurisdiction (AHJ) and over 5000 utilities, impedes installers' ability to rapidly deploy solar technology across numerous jurisdictions and utility service territories. Absent fees, the labor costs of completing permitting, inspection, and interconnection benchmarked by this survey totaled $0.15/W, including typical delays, wait times, and labor requirements for the financial incentive application process. Permitting and interconnection fees significantly impact total permitting costs, with total fees in the U.S. ranging from a low of $0/installation to an approximate high of $2,500/installation [3],[9]. However, typical permit fees at the residential scale in the U.S. range from $200-$450 per installation [9], [10].

When examining total PII labor hour requirements/installation, most installers reported total hours within the range of 15 to 25 hours, or $0.08/W-$0.15/W. The two largest volume installers (total # systems installed x>1,000) reported total PII labor hours ≈ 20, indicating no definitive economies of scale between PII processing times and installer volume. As such, data results indicate that total PII costs may be more dependent on jurisdictional factors than installer experience in the market place. See table 2 for the average labor costs for permitting, inspection, and interconnection[5]. In determining PII labor requirements, the following costs are included:

- Permit Preparation- determining a jurisdiction's permitting requirements, travel time to site/verification, drawing system plans, structural calculations, zoning application, and delays
- Submit Permit Package- travel time to and from the permitting office and wait time at the permitting office
- Permitting Inspection - paperwork, travel time to and from the site, wait time for inspector, and physical inspection
- Interconnection Process- paperwork, travel time to and from the site, wait time for representative from utility, and physical interconnection
- Financial Incentive Application Process- determining eligibility, paperwork, travel time to and from the site, wait time for inspector, and physical inspection.

TABLE II
PERMITTING. INSPECTION. INTERCONNECTION LABOR COSTS

PII Cost Component	Cost ($/W)
Permit Preparation	.05
Permit Submittal	.03
Inspection	.03
Interconnection	.01
Financial Incentive Application Process	.02
Total	.15

[5] Average cost weighted by the total number of installations completed in 2010.

Installation Labor- Survey results indicate that installation labor costs total $0.59/W: $0.33/W for installer (roofer) labor and $0.26/W for electrician labor. Despite a lower assumed roofer labor wage ($40.49/hr), compared to electrician labor ($60.12/hr), higher average roofer labor requirements (49 hours/installation) compared to electrician labor (26 hours/installation) lead to overall higher roofer labor costs than electrician. Goodrich et al.[3] labor class and wage assumptions were used to arrive at a total installation labor cost of $0.59/W, which closely tracks the Goodrich et al. [3] benchmark of $0.63/W.

In general, installers with higher average system sizes exhibit greater installation labor requirements, indicating that gains in module efficiency and decreases in hardware requirements have potential to significantly decrease installation labor costs per watt (see figure 1).

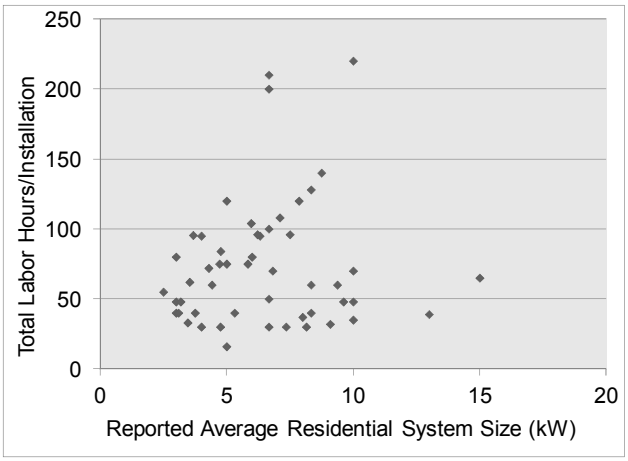

Fig. 1. Total installation labor requirements and system size.

Installer Labor Costs of 3rd Party Financing- To benchmark the additional installer labor costs of arranging 3rd party financing, the survey asked installers to report the average number of labor hours spent working with fund providers of 3rd party leases, PPAs, and other financing arrangements (including commercial bank financing and government loan programs). Based on the results of the survey, it took 2.4 labor hours on average to work with fund providers for third-party systems, translating into $0.02/W for a 5 kW system. Of the 66 respondents, 43 installers worked with fund providers,18 assisted third-party leases while 7 assisted third-party PPA's; Moreover, PV systems completed by smaller volume installers were more likely to be financed through direct cash purchase compared to large installers, with 46% of all installations in the sample financed through 3rd party schemes.

While the benchmarked $0.02/W installer labor associated with working with fund providers is a very small portion of the total cost of a 5 kW residential system, there are many more potential financing costs that still need to be benchmarked in order to understand the full impact of 3rd-party financing on PV system price. Potential additional costs include, but are not limited to,: any additional installer labor and overhead associated with internally vetting the creditworthiness of a system host; legal, accounting and independent engineering fees associated with reviewing financing contracts; fees associated with setting up tax equity and debt facilities, including billing and collection costs, audits, and working capital reserve.

IV. Commercial

A. Sample Market Representation and Characterization

A total of 17 commercial PV installers responded to the survey. These installers reported completing 247 commercial PV systems in 2010, totaling 85 MW and representing roughly 5% of all commercial PV systems and 23% of all commercial PV capacity installed in the U.S., in 2010. As with the residential survey, the data were cleaned for outliers, with 13-15 valid responses remaining per question. Given the small sample size for the commercial survey results, a certain degree of caution is warranted in generalizing from these findings.

The sample primarily consists of relatively small-volume commercial installers, with only two survey respondents having completed more than 20 commercial systems in 2010. The large majority (12 out of 17) of respondents completed fewer than 10 systems in 2010, reflecting the fact that some have a broader scope of business (e.g., electrical contractors or engineering firms) and may not exclusively focus on PV or solar installations or may serve both residential and commercial PV markets.

Commercial PV systems vary considerably in size, and the survey respondents correspondingly include installers specializing in both small and large commercial systems. Of the 17 installers surveyed, 6 installed systems averaging <100 kW in 2010, while 5 reported an average system size >500 kW (with the remainder falling in between those average system sizes). In order to illustrate how business process costs for commercial PV may differ depending on the size of the system installed, we separately report median values for the group as a whole, as well as for installers with average system size <250 kW and those with an average system size >250 kW.

B. Commercial Results

For each installer surveyed, reported labor hours per installation were translated to units of dollars per watt based on the average system size of that particular installer and assumed labor rates (see table 2). These survey responses were translated to dollars per watt for each installer based on their total capacity of commercial systems installed in 2010.

Survey responses for commercial installers are summarized here in terms of the median value across respondents. Given the relatively small sample size of commercial installers surveyed, this statistical metric was deemed more meaningful

than a simple or weighted average (as was used for residential PV).

Customer Acquisition - Across all commercial PV installers surveyed, median customer acquisition costs totaled $0.10/W, with almost all respondents reporting total customer acquisition costs of less than $0.20/W, on average. System design constitutes the largest component of total customer acquisition costs ($0.07/W in the median case), while advertising and marketing comprise just $0.01/W, and "all other" customer acquisition costs make up the remainder. These costs appear to exhibit strong economies of scale, with median total customer acquisition costs of $0.19/W for installers with average system size <250 kW, compared to roughly $0.03/W for commercial installers with an average system size >250 kW.

Permitting, Inspection, Interconnection- The reported average number of labor hours for all five PII activities varied widely across installers, ranging from roughly 20 hours to almost 500 hours per system, with a median response of 67 hours. Based on assumed labor rates and each installer's average system size, PII labor costs amount to less than $0.01/W across the full set of commercial installers surveyed, with permit preparation constituting the largest underlying labor cost (see figure 2). Reported PII labor requirements were typically higher for larger systems; installers with average system size <250 kW reported 41 hours/system in the median case, compared to 72 hours/system for installers with average system size >250 kW. This difference is to be expected, given the generally greater complexity of permit application processes for larger systems. However, although labor requirements are greater for larger commercial PV systems in terms of the number of labor hours per installation, the associated costs on a per-watt are lower, as the absolute dollar costs are spread across a larger number of installed watts. For installers with a reported average system <250 kW median PII costs totaled $.02/W, while median PII costs for installers with average system size>250 kW totaled $.0025/W.

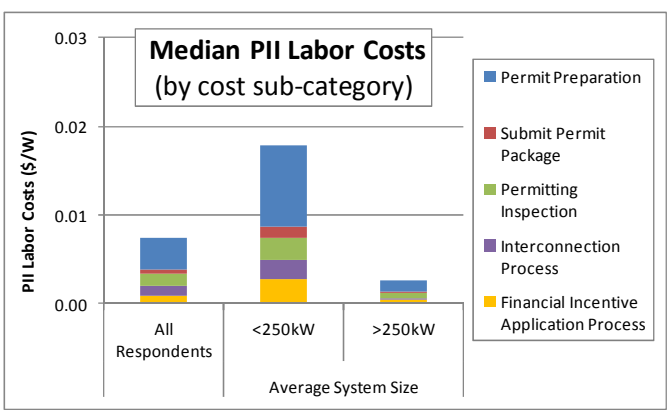

Fig. 2. Median permitting, inspection, and interconnection labor costs for commercial PV installers (excludes fees)

Total Business Process – Excluding fees, across all commercial PV installers surveyed, median business process costs totaled $.33/W. For installers with a reported average system <250 kW, median business process costs totaled $.64/W. Customer acquisition costs contributed $.09/W, system design $.10/W, permitting, inspection, and interconnection labor $.02/W, and installation labor $.41/W. The installer labor costs of arranging 3rd party ownership contributed an additional $.02/W, for a total of $.64/W. Based on a total installed PV system price of $4.59/W for a 217 kW system in 2010 [2] these non-hardware costs represented approximately 14% of installed commercial PV system price in 2010.

For installers with a reported average system size >250 kW, customer acquisition costs contributed $.02/W, system design $.01/W, permitting, inspection, and interconnection labor $.0025/W, and installation labor $.19/W. The labor costs of arranging 3rd party ownership contributed an additional $.0025/W, for a total of $.23/W.

V. Limitations

Certain limitations to the analysis reported here exist. First, after eliminating the top and bottom 5% of responses, the sample size of installers across the United States is small (n=60 residential; n=17 commercial), potentially magnifying the effect of response error. Secondly, when assessing bottom-up cost structures, the inability to identify whether some questions may be inapplicable or only marginally applicable to respondents that serve primarily as subcontractors to engineering procurement and construction firms may result in an underestimation of costs. Thirdly, while this soft cost data collection is the most granular to date, further data collection is necessary to capture certain costs not explicitly addressed by the survey design. For instance, while the analysis benchmarks the installer labor costs of arranging 3rd party ownership and the financial incentive application process, there are additional financing related costs to be considered Lastly, the data set could be enhanced with increased geographic variability, for the sample representation is heavily weighted by installers based in California, with the exception of a few large scale installers from the east coast. This lack of geographic representation has the potential to misrepresent costs on a national basis, given the differences in market maturity across states.

VI. Summary of Key Findings

A. Residential

The results of the residential installer survey suggest that business process costs compose a significant portion of the total non-hardware cost of residential PV (see figure 3). For residential systems, business process costs (including assumed permitting fees) total $1.52/W, equivalent to 46% of total PV

non-hardware costs ($3.33/W) and 23% of total PV system price in 2010 ($6.60/W). Customer acquisition and installation labor costs are the greatest of those benchmarked in this analysis, suggesting considerable cost reductions can be made in these areas. However, the importance of streamlining permitting, inspection, and interconnection requirements should not be disregarded. Given that PII accounts for an estimated 25-35% of the price difference between the U.S. and Germany, the U.S. permitting, inspection, and interconnection processes present opportunities for cost reductions as well.

B. Commercial

As indicated in figure 3, business process costs can also constitute a significant portion of the non-hardware cost of commercial PV, though the impact depends significantly on system size. For commercial systems <250 kW, business process costs (including assumed permitting fees) total $0.99/W, equivalent to roughly 37% of all non-hardware costs ($2.64/W) and roughly 17% of total system price in 2010 ($5.96/W). In contrast, business process costs are just $0.25/W for systems >250 kW, or 12% of all non-hardware costs ($2.16/W) and 5% of the total system price in 2010 ($5.33/W). Of the various labor-related business process costs, installation labor is by far the most significant. System design and customer acquisition add moderately to the cost of small commercial systems, but are negligible for large (>250 kW) systems on a dollar-per-watt basis, given economies of scale and the ability to spread those (relatively) fixed costs out over a larger number of installed watts. Labor costs associated with PII as well as labor costs associated with 3rd party financing, are generally negligible for commercial PV.

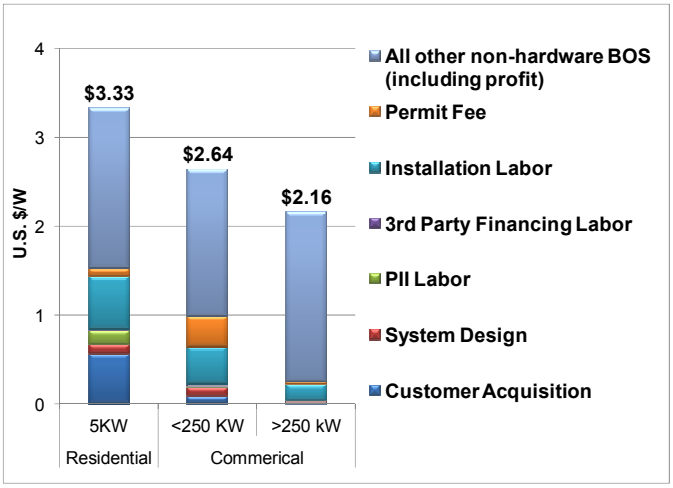

Fig. 3. Total non-hardware BOS costs, by system size

ACKNOWLEDGEMENTS

The authors would like to thank the following individuals and organizations for their support and review of this work: David Arfin (SETP), Jennifer DeCesaro (SETP), Alan Goodrich (NREL), Sean Ong (NREL), Rachel Tronstein (SETP), and Ryan Wiser (LBNL). The authors would also like to thank Solar Tech for their support in industry outreach and data collection.

REFERENCES

[1] G. Barbose, N. Darghouth, R. Wiser, and J. Seel, *Tracking the sun IV: An historical summary of the installed cost of photovoltaics in the United States from 1998 to 2010*, Berkeley, California: Lawrence Berkeley National Laboratory, 2011.

[2] Solar Energy Industries Association. *U.S. Solar Market Insight: 2011 Year in Review.* SEIA-GTM Research, 2012.

[3] A. Goodrich, T. James, and M. Woodhouse, *Residential, Commercial, and Utility-Scale Photovoltaic System Prices in the United States: Current Drivers and Cost Reduction Opportunities*, NREL/TP-6A20-53347, 2011.

[4] B. Brooks, *Expedited Permit Process for PV Systems. A Standardized Process for the Review of Small-Scale PV Systems.* Solar America Board for Codes and Standards Report, <http://www.solarabcs.org/permitting>, 2011.

[5] J. Rose, S. Chapman, G. Rose, R. Jackson, J. Weidman, K. Christopher, T. Culley, J. Keyes, K. Fox, and L. Varnado, *Freeing the Grid: Best Practices in State Net Metering Policies and Interconnection Procedures*. New York, New York: Network for New Energy Choices, 2011.

[6] L. Varnado and M. Sheehan, *Connecting to the Grid Guide: 6th Edition*. Interstate Renewable Energy Council (IREC), 2009.

[7] D. Pitt, *Taking the Red Tape Out of Green Power: How to Overcome the Permitting Obstacles to Small Scale Distributed Renewable Energy*. New York, New York: Network for New Energy Choices, 2008.

[8] C. Mills and K. Newick, *Solar Electric Permit Fees in Northern California: A Comparative Study*. San Francisco, California: Sierra Club, 2011 (first published in 2005).

[9] Vote Solar, "Project permit interactive permitting map," http://votesolar.org/city-initiatives/project-permit/2011, 2011.

[10] Sun Run, *The Impact of Local Permitting on Solar Cost*, 2011.

[11] See Solar Tech website at <http://www.solartech.org>

[12] United States Bureau of Labor Statistics, Occupational Employment Statistics: National Occupational Wage Estimates,<http://www.bls.gov/oes/current/oes_nat.htm#13-0000>, 2011

[13] C. Langen, "Complexity cost and economies of scale: Why tesidential customers in Germany pay 25% less for a PV system that U.S. customers," *Proceedings of Solar Power* International, Solar Energy Industries Association, 2010.