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Why Are Residential PV Prices in Germany So Much Lower Than in the United States?

A Scoping Analysis

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Motivation, Scope, and Limitations

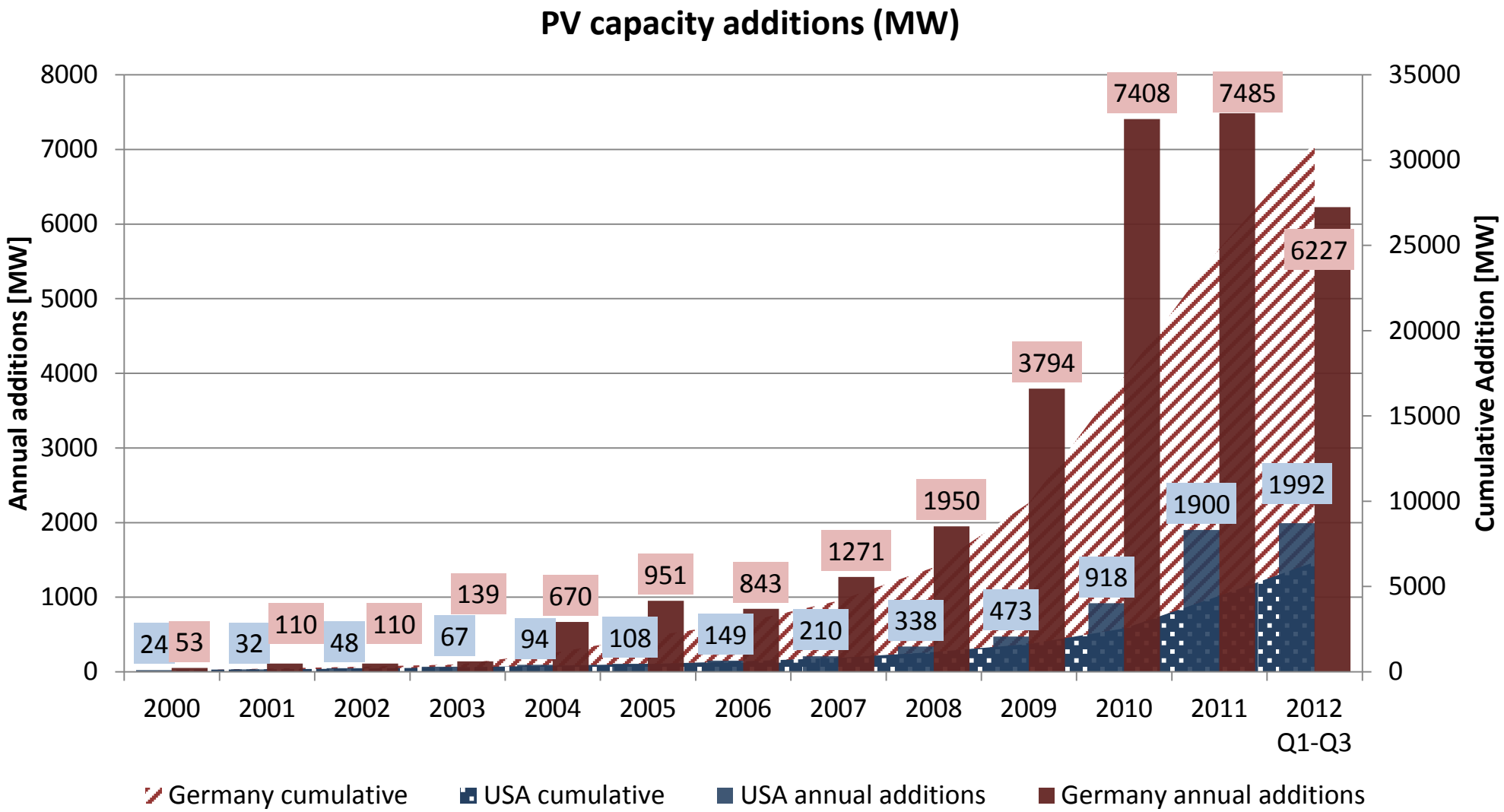
- The installed price of residential PV is significantly lower in Germany than in the U.S., due primarily to differences in "soft" costs

- In order to better characterize the nature of these differences, LBNL conducted:
  - Literature review and analysis of existing data
  - Empirical research with 2 surveys of German residential PV installers

- Focus is the pre-incentive price paid for customer-owned systems

- Analysis here is intended to be a "first cut" and serves to highlight specific areas where further research could reveal additional insights

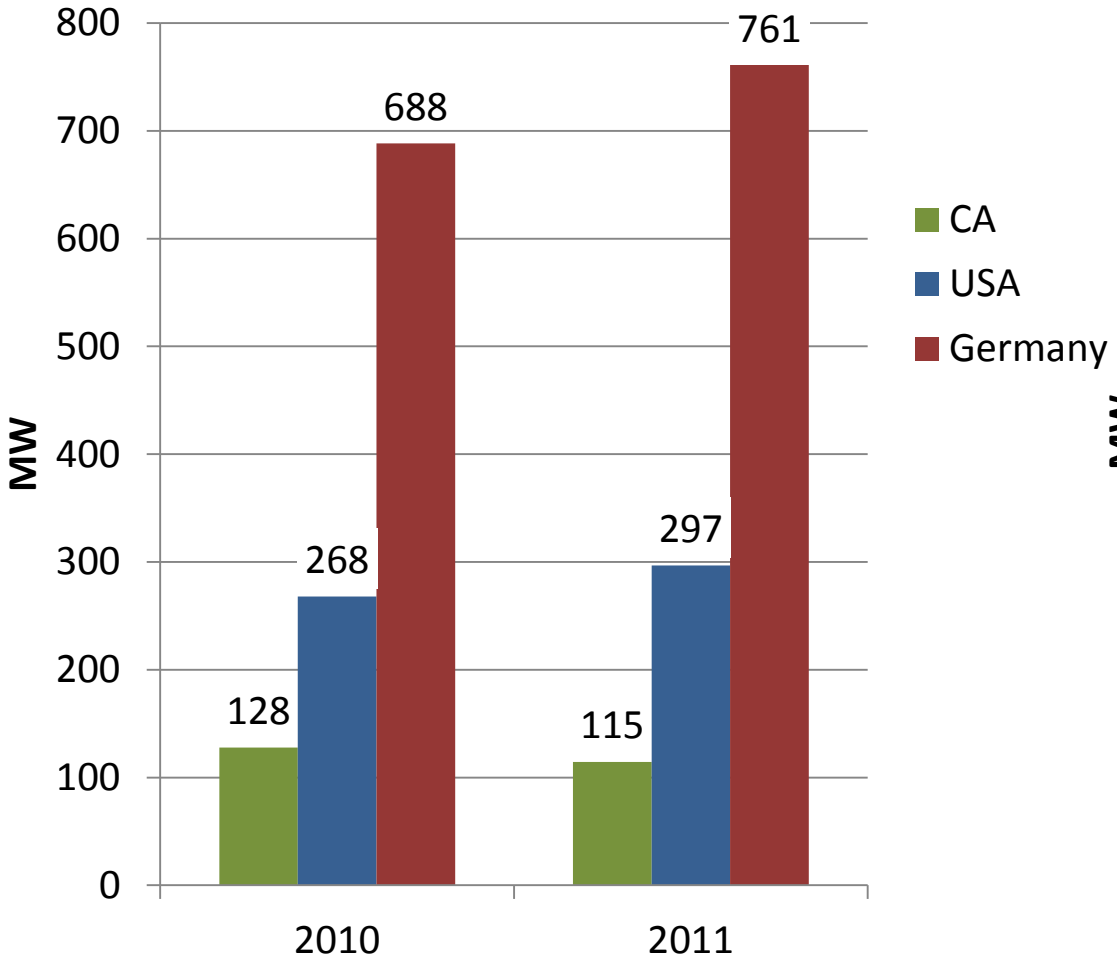
Germany's 2011 Additions ~4x Greater, and Cumulative Additions More than 5x Greater, than United States



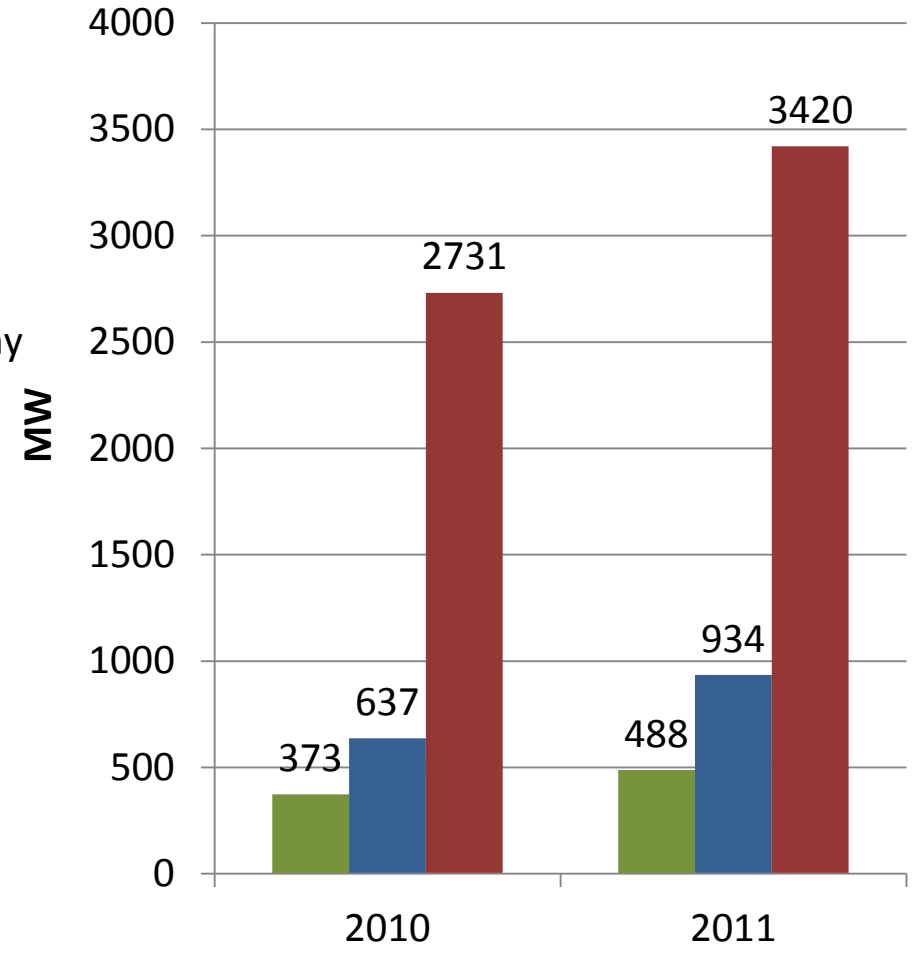
Data Sources:
US: IEA and GTM/SEIA; Germany: BNetzA (Federal Grid Agency)

Annual Residential Installations in Germany in 2011 2.5x Greater than in the United States, cumulative installations 3.6x

Annual residential PV installations



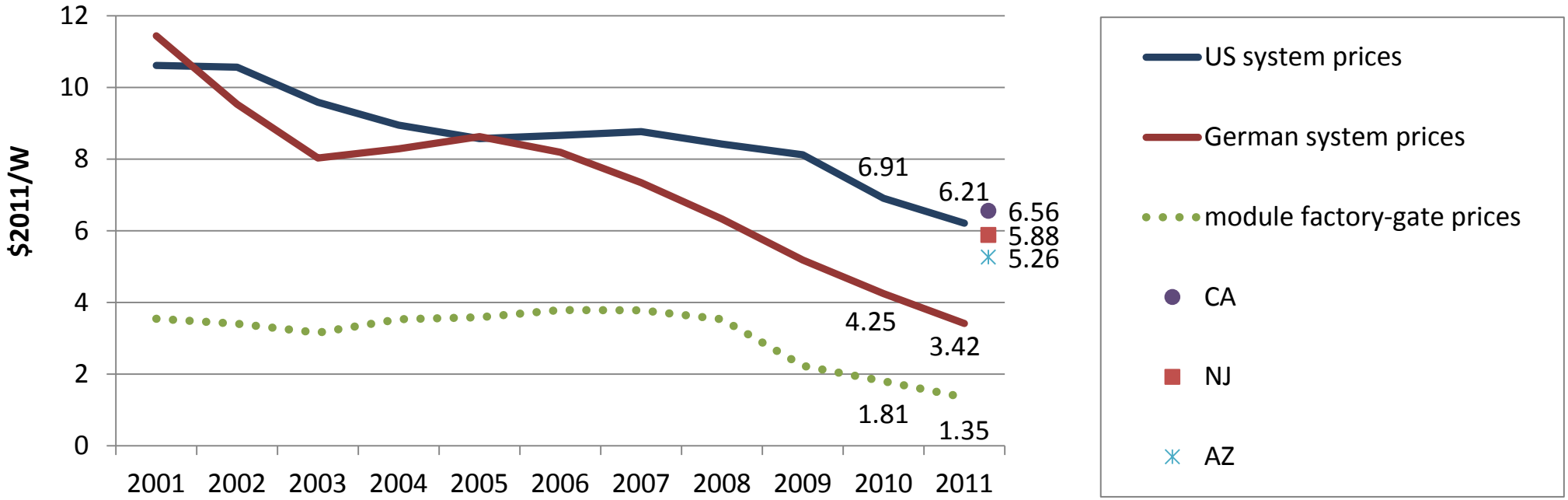
Cumulative residential PV installations



Data Sources:
US: GTM/SEIA; Germany: BNetzA (Federal Grid Agency)

Residential PV System Prices Have Often Been Higher in the U.S. Than in Germany

Median Installed Price of Customer-Owned PV Systems ≤10 kW*



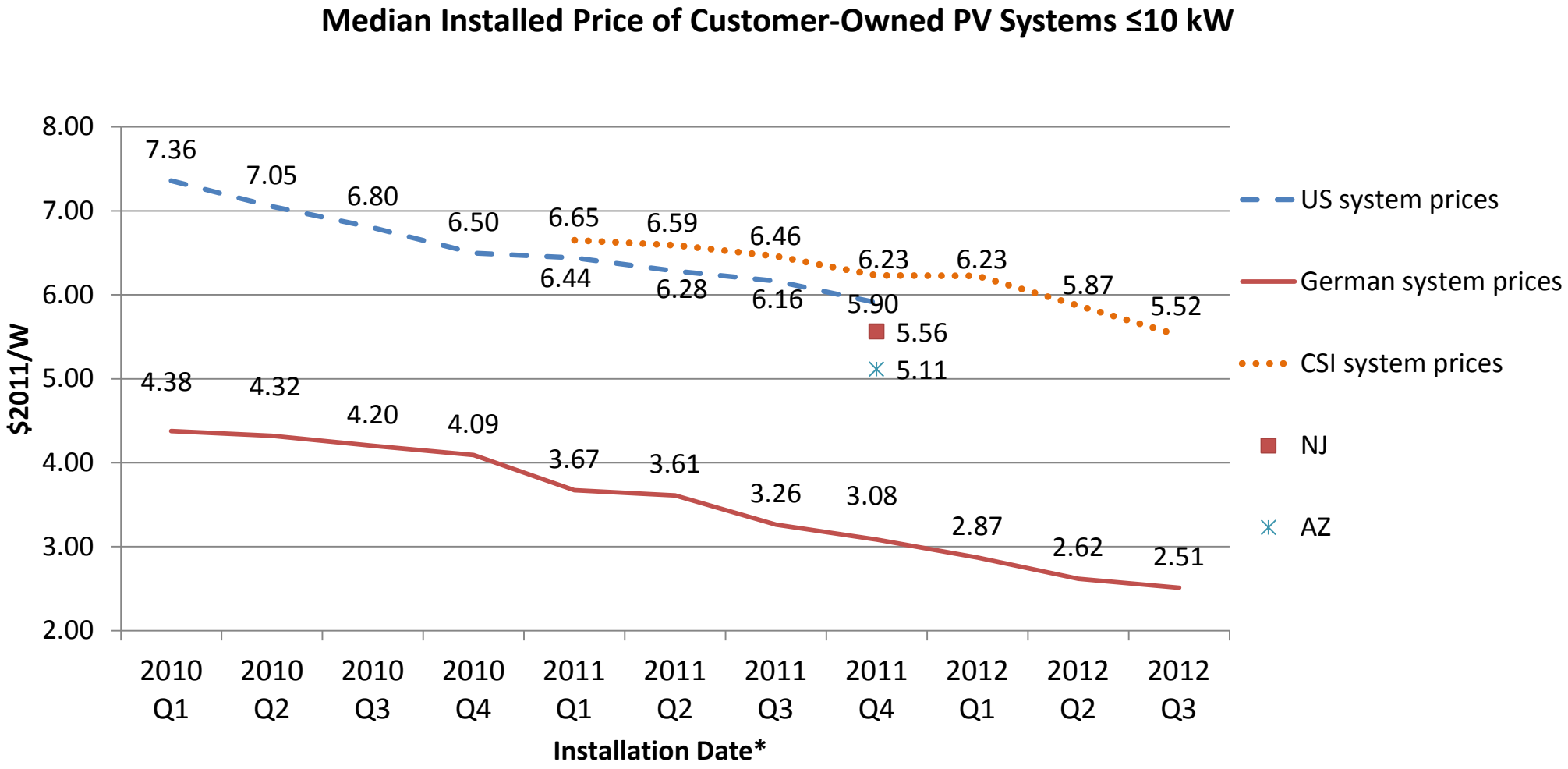
Data Sources:

U.S. System Prices are derived from LBNL's TTS dataset and are equal to the median of customer-owned systems ≤10kW installed in each year. ***German System Prices*** are the averages of individual price quotes in EuPD's dataset (2008-2011) or the average of prices reported by IEA, Photon, KfW, and Schaeffer (2001-2007).

Module Factory-Gate Prices are the average of prices reported by IEA, GTM, IRENA, Navigant, and Photon (annual currency exchange rates were used for module prices estimates)

* ***Note:*** Focusing on systems ≤10kW serves as a proxy for the residential market, as the project-level installed price data for German systems used for this figure do not include host customer type

Installed Price Gap Was $2.8/W in Q4 2011 and Differential Continued Through 2012



Data Sources: US: TTS, CSI working database of Dec 5th 2012; Germany: EuPD and BSW

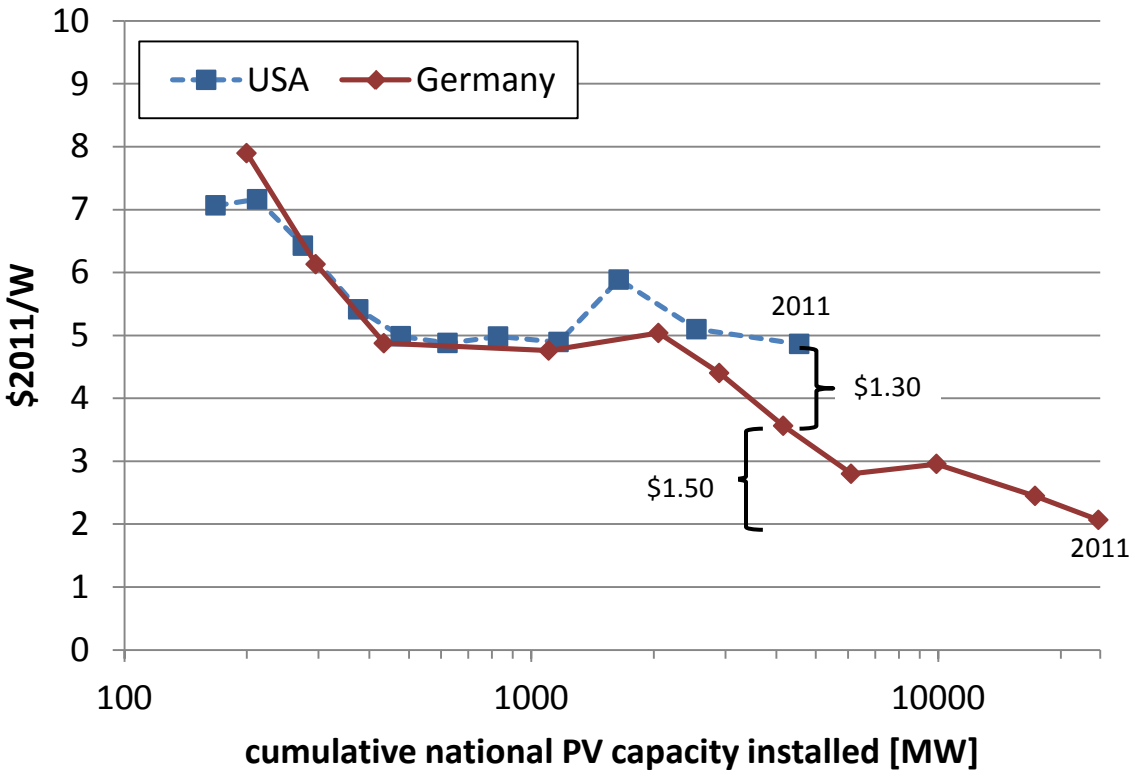
*** Note:** German system prices are available by quote date, rather than by installation date. However, the average time lag between price quote and installation date is much shorter in Germany than in the US., as described further within the secondary analysis

A Small Body of Literature Explores the German-U.S. PV Price Gap

- Few have sought to explain the underlying reasons behind the German-U.S. PV price gap or to quantify differences in specific soft costs
  - Photon 2011a, Photon 2011b, BNEF 2012, Langen 2010, Podlowski 2008, Goodrich et al. 2012
- Possible reasons for the price gap that have been postulated:
  - "Value-based pricing" in the U.S. (e.g., associated with more generous subsidies and/or less competition among installers)
  - Preference for premium products in the U.S.
  - Lower customer-acquisition costs in Germany due to simpler/more certain value proposition (FiT), critical mass of demand, and economies of scale
  - Lower installation labor costs in Germany due to greater experience and economies of scale
  - Lower permitting costs in Germany due to fewer requirements and greater standardization
  - Less onerous electrical requirements and interconnection processes in Germany

Differences in Market Size Alone *May* Explain Roughly Half of the Price Gap

Implied Average Annual Non-Module Costs* vs. Cumulative Capacity:
Customer-Owned Systems ≤10 kW, 2001-2011

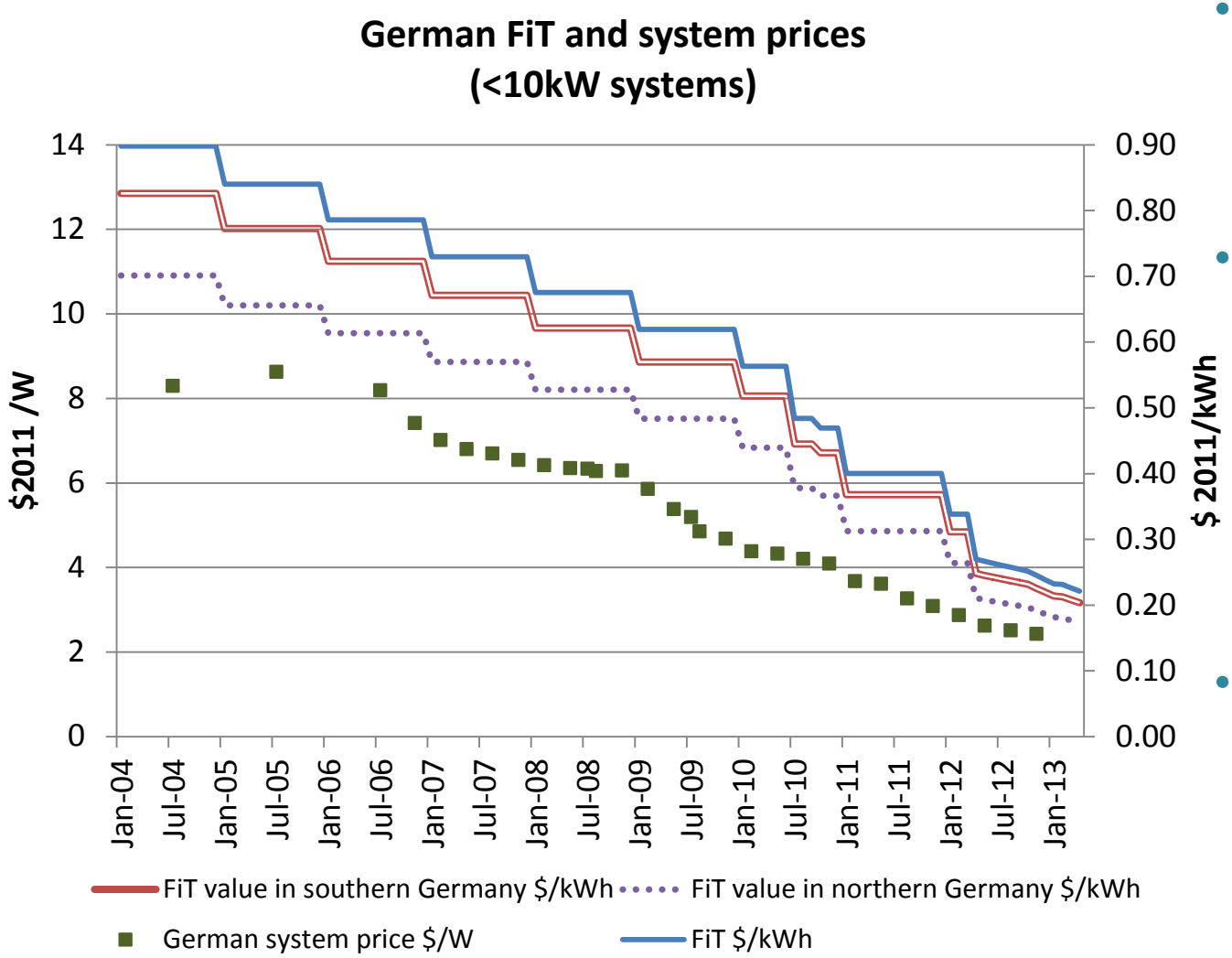


- Total non-module costs in 2011 were ~$2.8/W higher in the U.S. than in Germany
- But, at the same cumulative capacity that the U.S. had installed at the end of 2011 (4 GW), non-module costs for residential PV in Germany were only $1.3/W less than in the U.S.
- One might (crudely) infer that the remaining $1.5/W of the total gap in 2011 non-module costs may be due simply to the larger base of German experience

Data Sources: See slide 9.

***Note**: Implied average annual non-module cost = average annual system price minus global average factory gate module price

Regular FiT Adjustments Pressure German Installers to Reduce Prices



- BNEF (2012) indicates the presence of value-based pricing in both the US and Germany
- Following this hypothesis, the iterative reduction of the FiT presses German installers to lower system prices to maintain attractive investments for their customers
- Similar forces may operate less efficiently in the U.S., yielding higher "value-based" prices, even for customer-owned systems

Data Sources: EuPD (2008-2011), BSW (2012) IEA, KfW, Photon

Survey Results

Overview of Survey Methodology

- German survey focuses on standard DOE soft cost categories:
  - Customer acquisition
  - Permitting, interconnection, inspection
  - Installation labor
- Adapted from NREL survey of U.S. installers to allow comparisons
  - Average labor hours per system for PII and installation
  - Total annual expenditures on customer acquisition

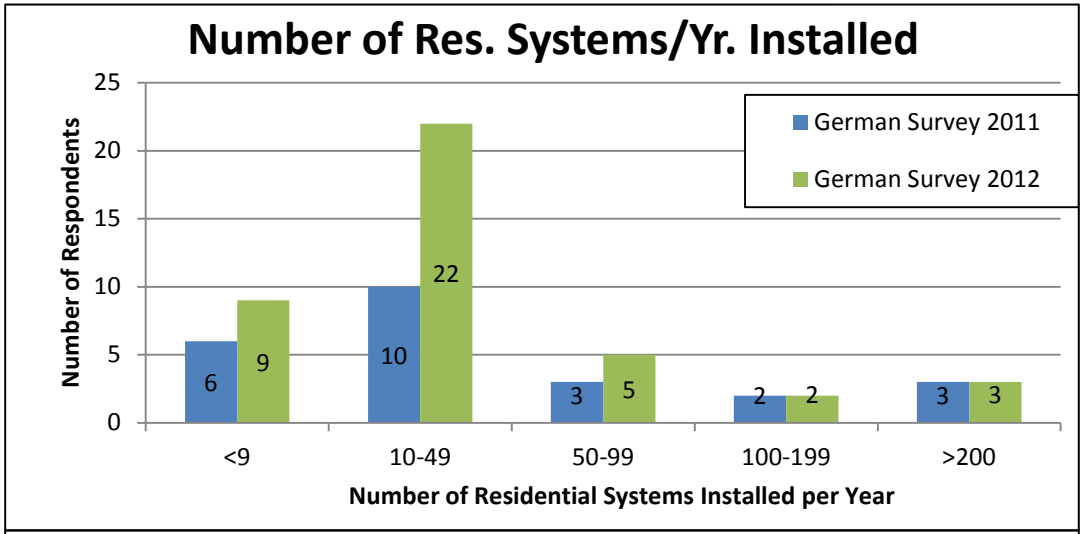
Installer Survey Sample

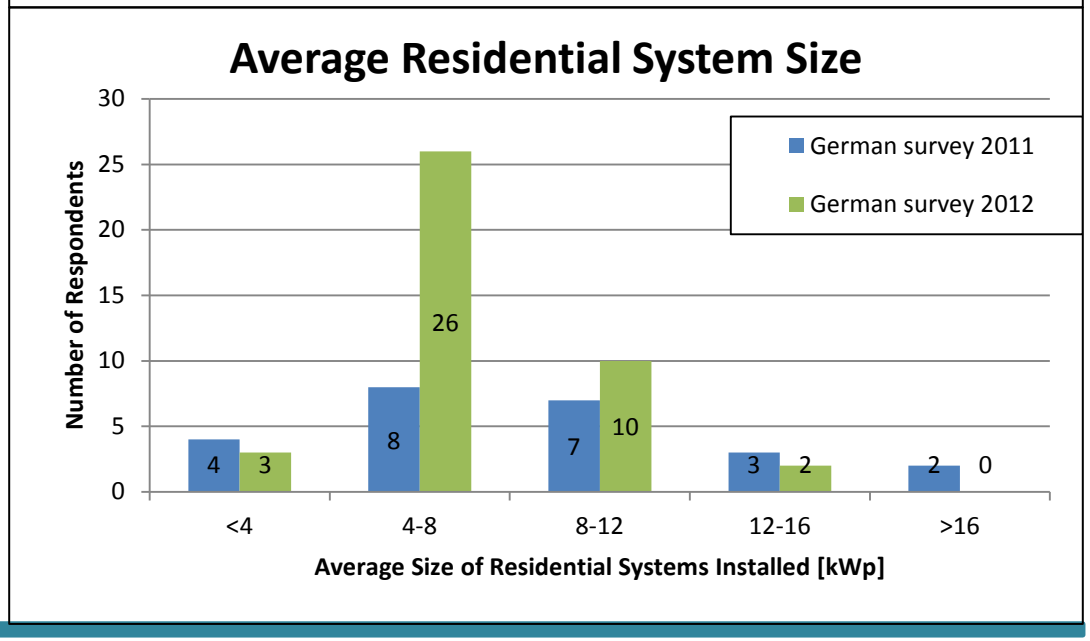
	Germany 2011	Germany 2012	U.S. 2010
Residential installers	24	41	56
Residential systems	2056	1824	6038
Residential capacity [kW]	17,819	11,924	34,396

- 1st survey asked about costs of **residential** systems **installed in 2011**, fielded in early 2012
- 2nd survey asked about installation labor of residential systems installed in preceding 12 months, fielded in October 2012
- Survey instrument, written in German, distributed by email to 300 German residential installers and fielded online via www.photovoltaikstudie.de

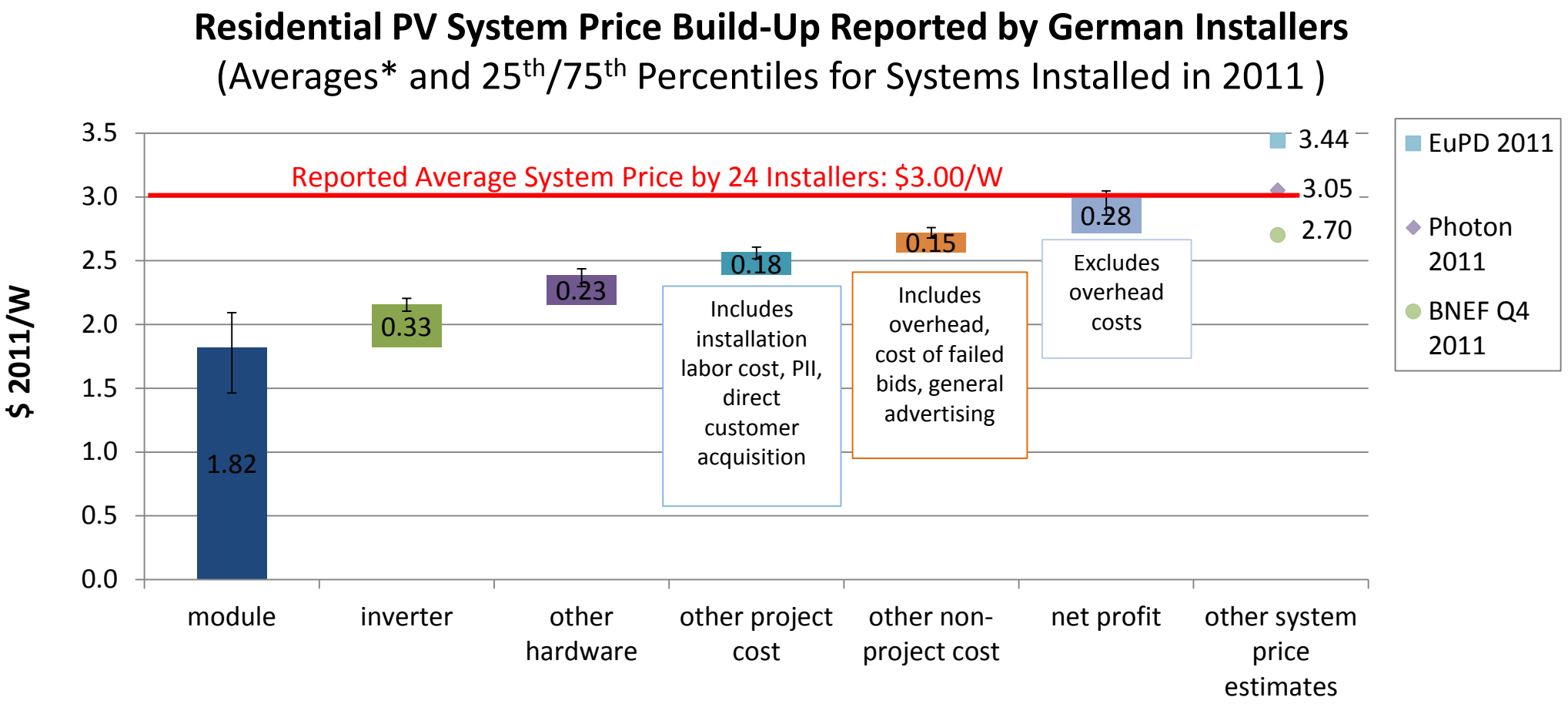
Raw Sample Characterization

- Most respondents in both surveys are small volume installers
  - Most installed <50 systems per 12-month period
  - Median installations/yr = 25 for 2011, 26 for 2012
- Average system sizes are a bit smaller in 2012 German survey
  - Average of 6 kW per system (compared to 8 kW in German 2011 survey*)
  - Less variation in average system size





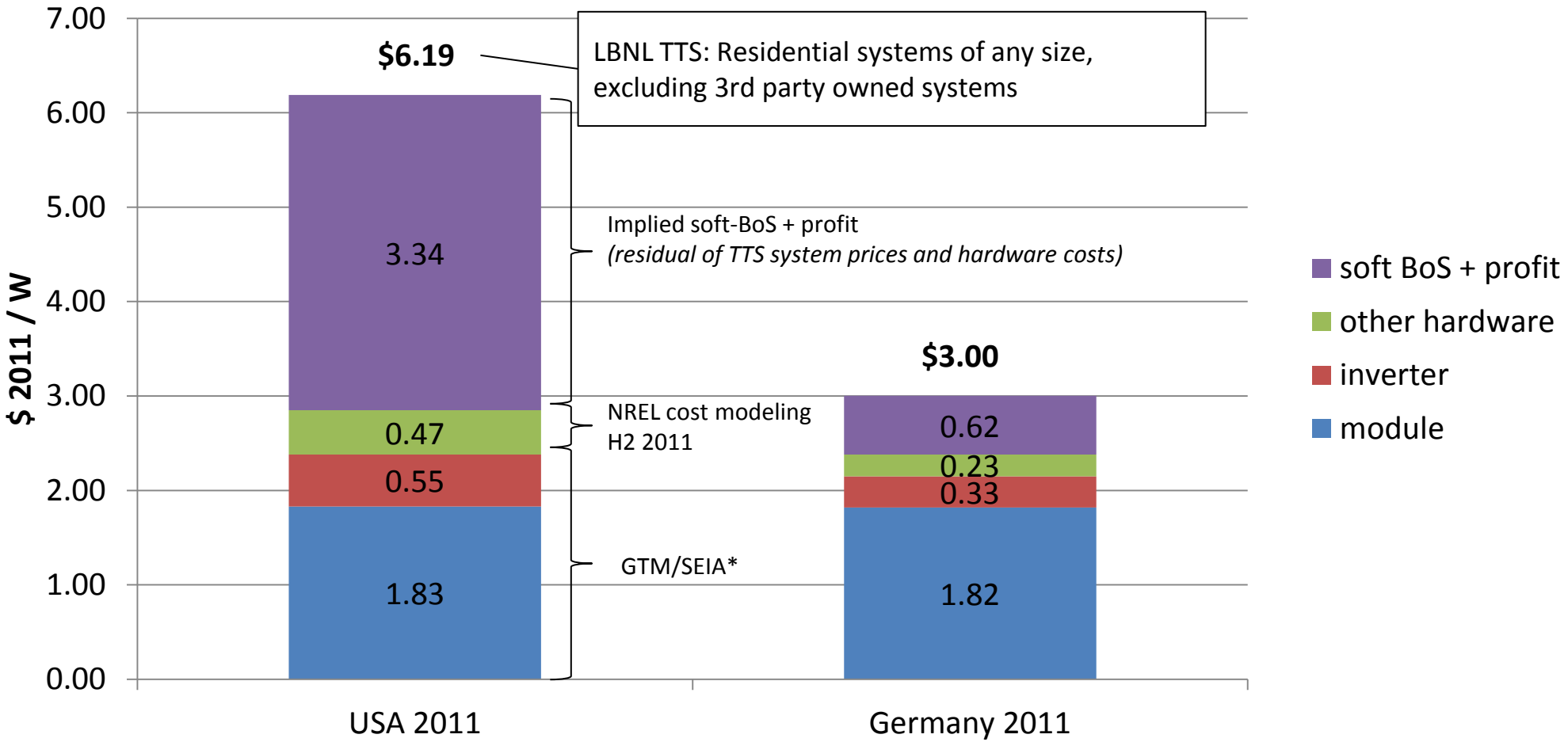
Total Soft BoS Costs + Profit Represent Roughly $0.62/W or 20% of System Price



* ***Notes:*** Survey results are summarized in terms of the average of responses across survey respondents, weighted by each respondent's reported 2011 residential capacity installed. This chart summarizes responses to the survey question asking installers to identify the average price of residential systems sold in 2011, and to allocate that price across the categories identified along the x-axis. Due to the revised installation labor cost estimates based on the second survey, there is a slight misalignment between the category "other project costs" and the sum, reported later, of PII, direct customer acquisition cost and labor installation costs.

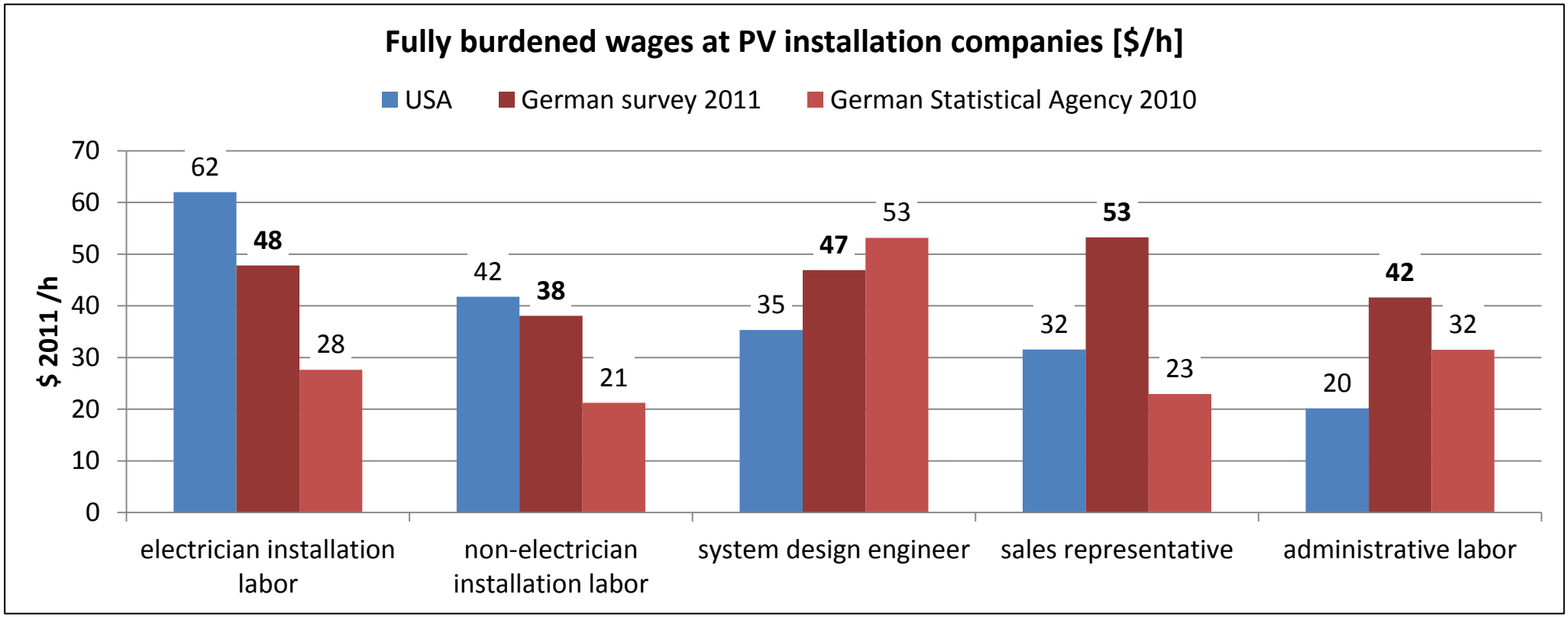
Soft Costs for Residential PV in Germany Are ~$2.7/W Lower Than in the U.S.

Total soft costs for residential PV in Germany, including margin, are just 19% of the implied soft costs for U.S. residential PV ($0.62/W vs. $3.34/W)



* ***Note:*** US module and inverter prices are based on average factory gate prices for Q4 2010-Q3 2011 as reported by GTM/SEIA with an adder of 10% to account for supply chain costs. Inverter efficiency assumed to be 85%.

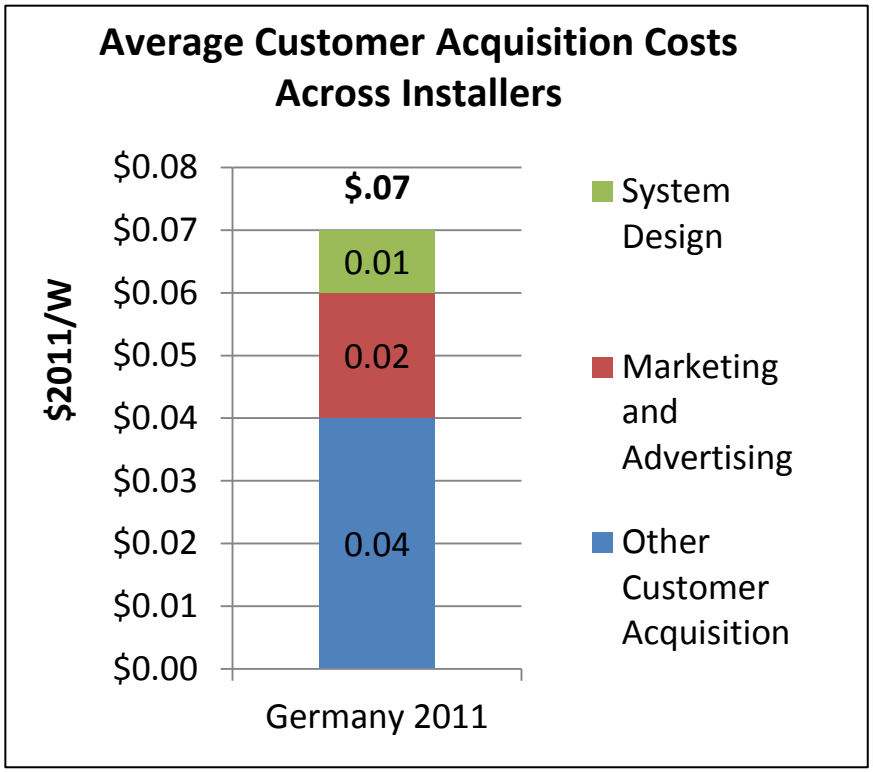
Labor Rates Are Higher in Germany Than in the U.S. for Some Functions, but Lower for Others

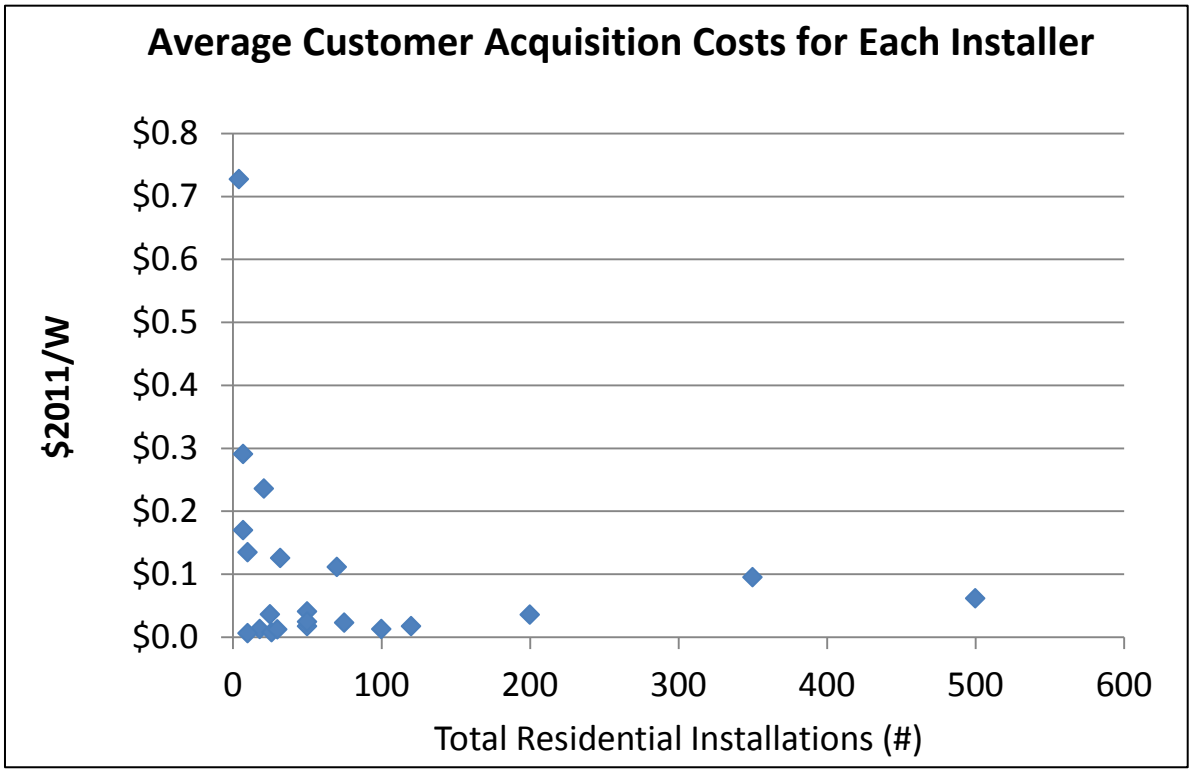


- The results that follow this slide rely on German wage rates derived from the survey
- In the above graphic, data from the German statistical agency (DeStatis) are also shown for comparison (these data cover all sectors, so are not specific to PV)
- U.S. labor rates are from RS Means (as used by NREL cost modeling team and as used in NREL BoS survey analysis for the U.S.)

Residential Customer Acquisition Costs Average $0.07/W in Germany

- Most respondents reported customer acquisition costs <$0.15/W; several small-volume installers reported somewhat higher costs
- On average, customer acquisition labor includes 3 hrs/system for sales representative and 2 hrs/system for design engineer

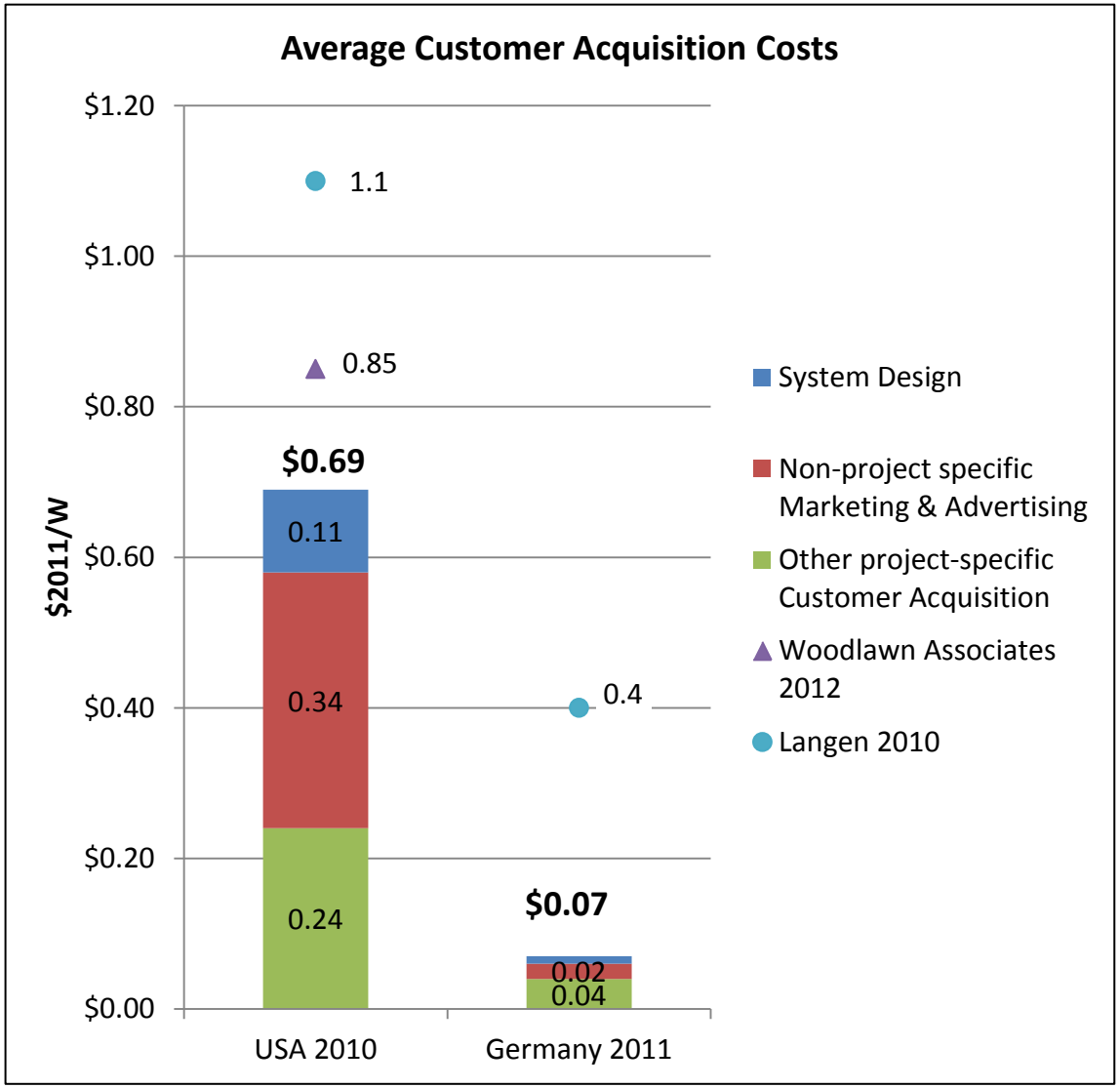




Notes: Other Customer Acquisition costs include such items as: sales calls, site visits, travel time to and from the site, contract negotiation, bid preparation. Marketing & Advertising and Other Customer Acquisition costs are based on reported annual expenditures, while System Design costs are based on reported labor hours and wages for system design engineering.

Customer Acquisition Costs in Germany Are $0.6/W Less Than in the U.S.

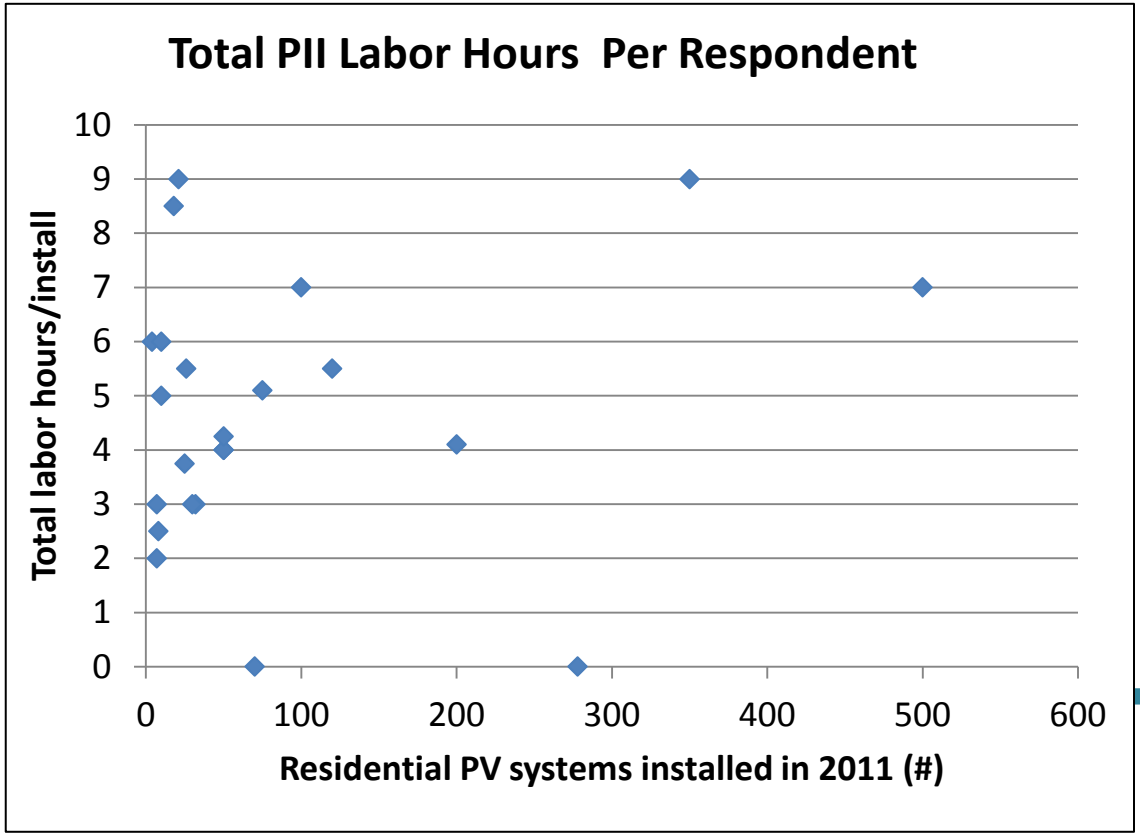
- Mean bid success rate is slightly lower in the US (30% in US vs. 40% in Germany)
- German installers leverage partnerships with equipment manufacturers
- Langen (2010) points to simpler and more certain value proposition in Germany (i.e., FiT), installer learning, and critical mass for word of mouth

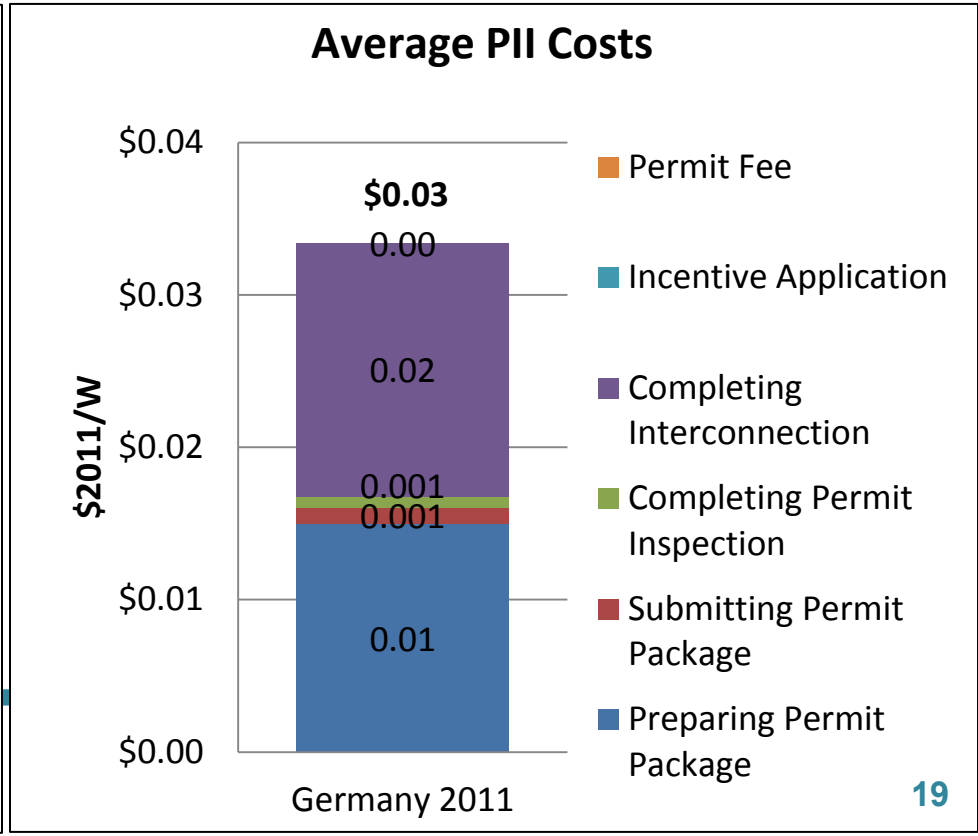


Note: Bar chart of U.S. process costs are derived from NREL survey of U.S. installers (Ardani et al. 2012).

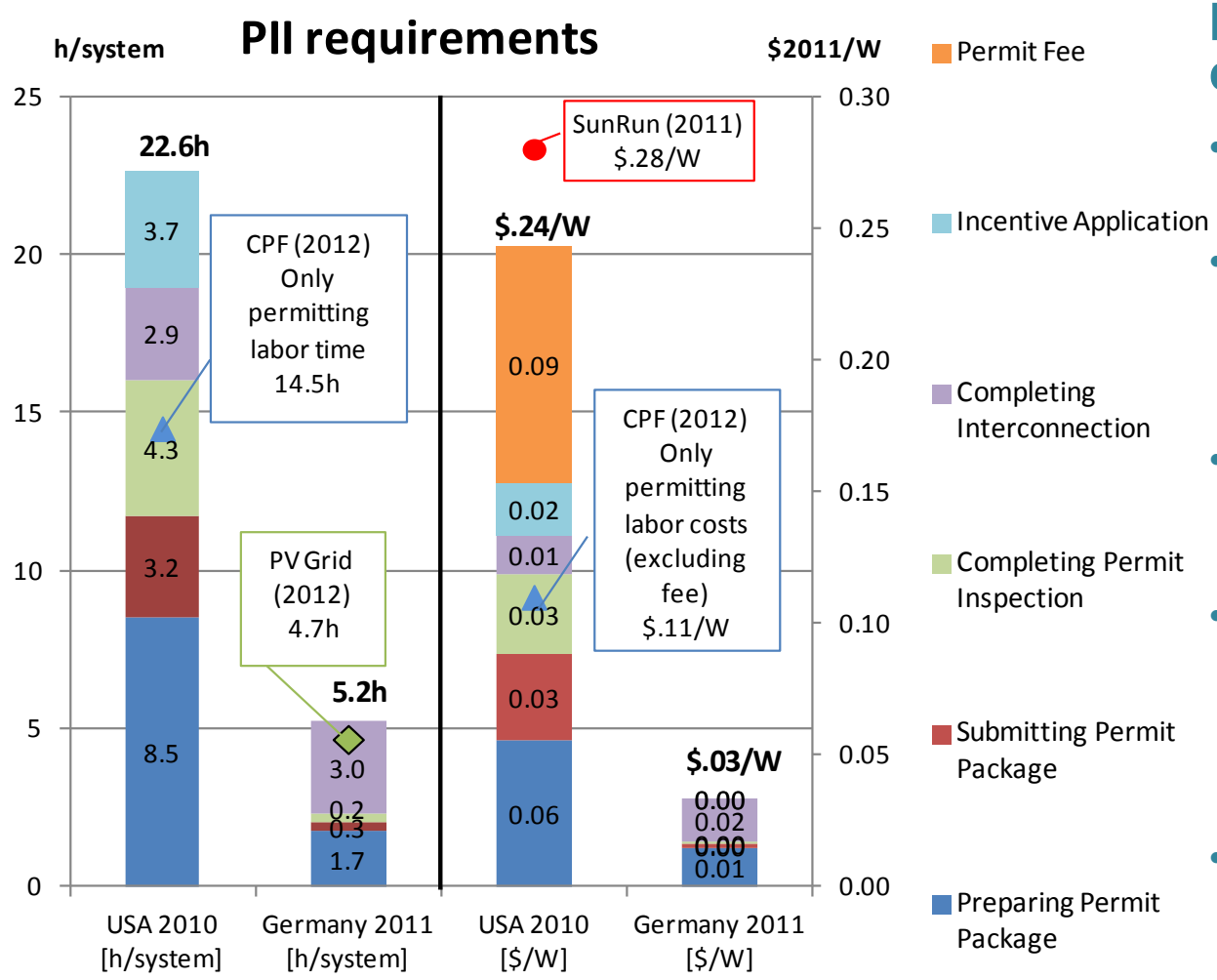
PII Costs Are Negligible for Residential PV in Germany

- Total PII costs of $0.03/W on average
- Fewer than 10 hours of labor required for all PII activities, and no fee
  - Average labor requirement of 5 hrs (confirmed by PV legal survey, lowest for all European countries)
  - Permit requests and incentive application are done online; usually no permit inspection required
- Grid upgrade costs for German residential PV systems are paid by Grid Operator (SEPA 2012)





PII Costs Account for Roughly $0.2/W of the German-U.S. PV Price Gap



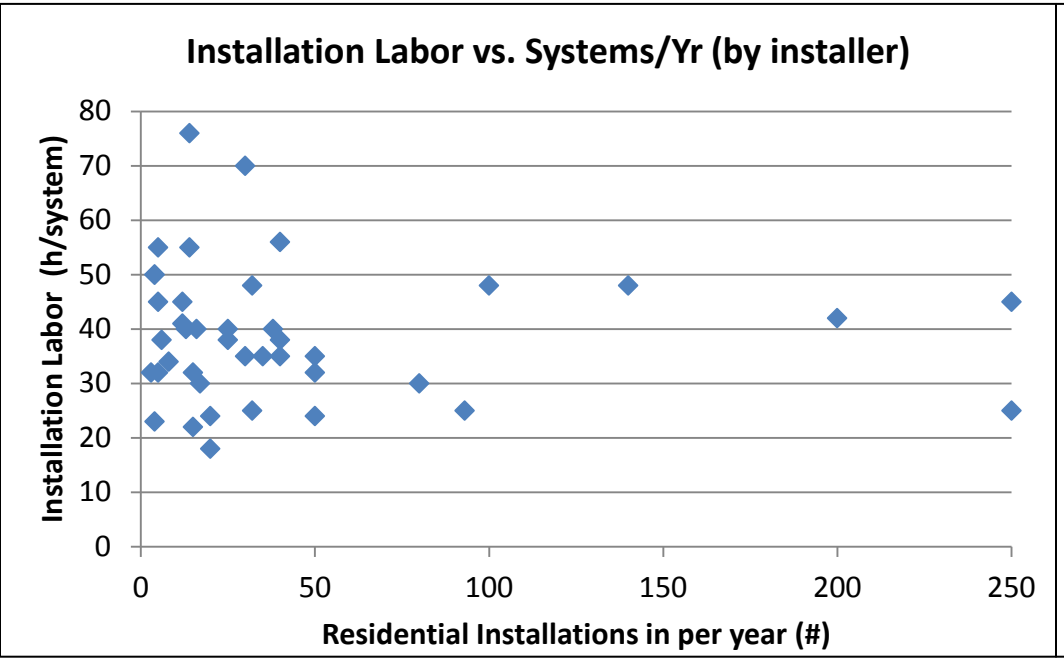
Differences due to both PII labor costs and permit fee

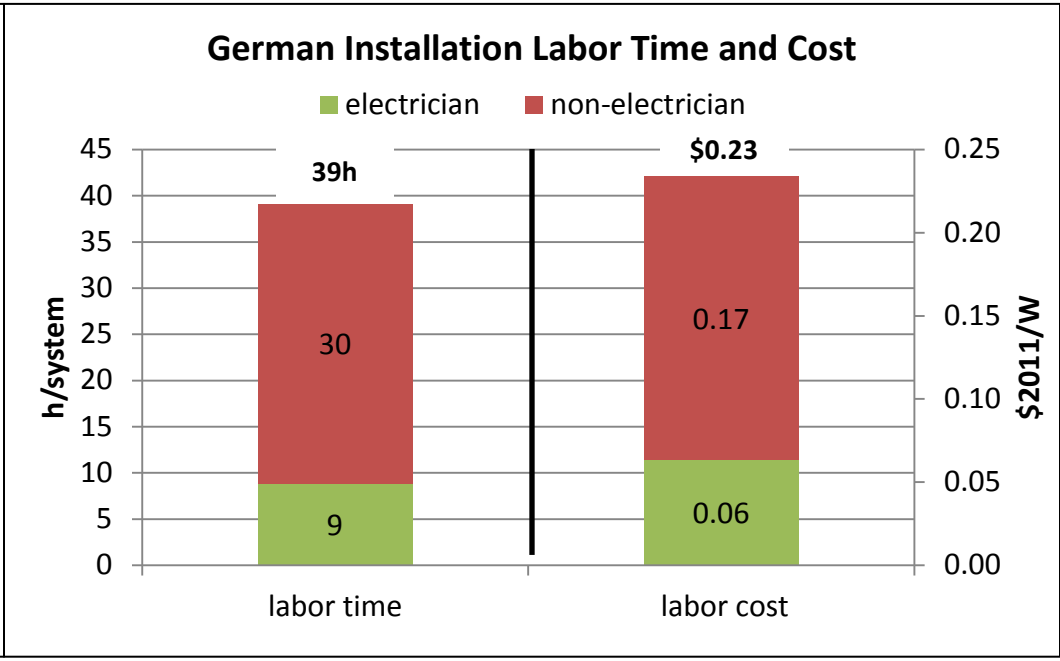
- PII labor costs are $0.12/W lower in Germany*
- Remainder of gap ($0.09/W) is associated with permit fee (assuming an average of $430 per system in the U.S.)
- Langen (2010) estimates PII costs for the US at $.80/W, and Germany at $.10/W
- PV Grid (2012) reports 2.5h for interconnection, 1.5h for interconnection permits and .7h for other legal-administrative processes in Germany
- SunRun (2011) estimate of $.50/W in the U.S. includes sales & marketing costs & variations in building requirements

* **Note:** Fully-burdened labor rates assumptions: 70% design engineer and 30% administrative labor; averaging $41/hr for Germany (based on survey questions) vs. $26/hr for the U.S. (based on RS Means data)

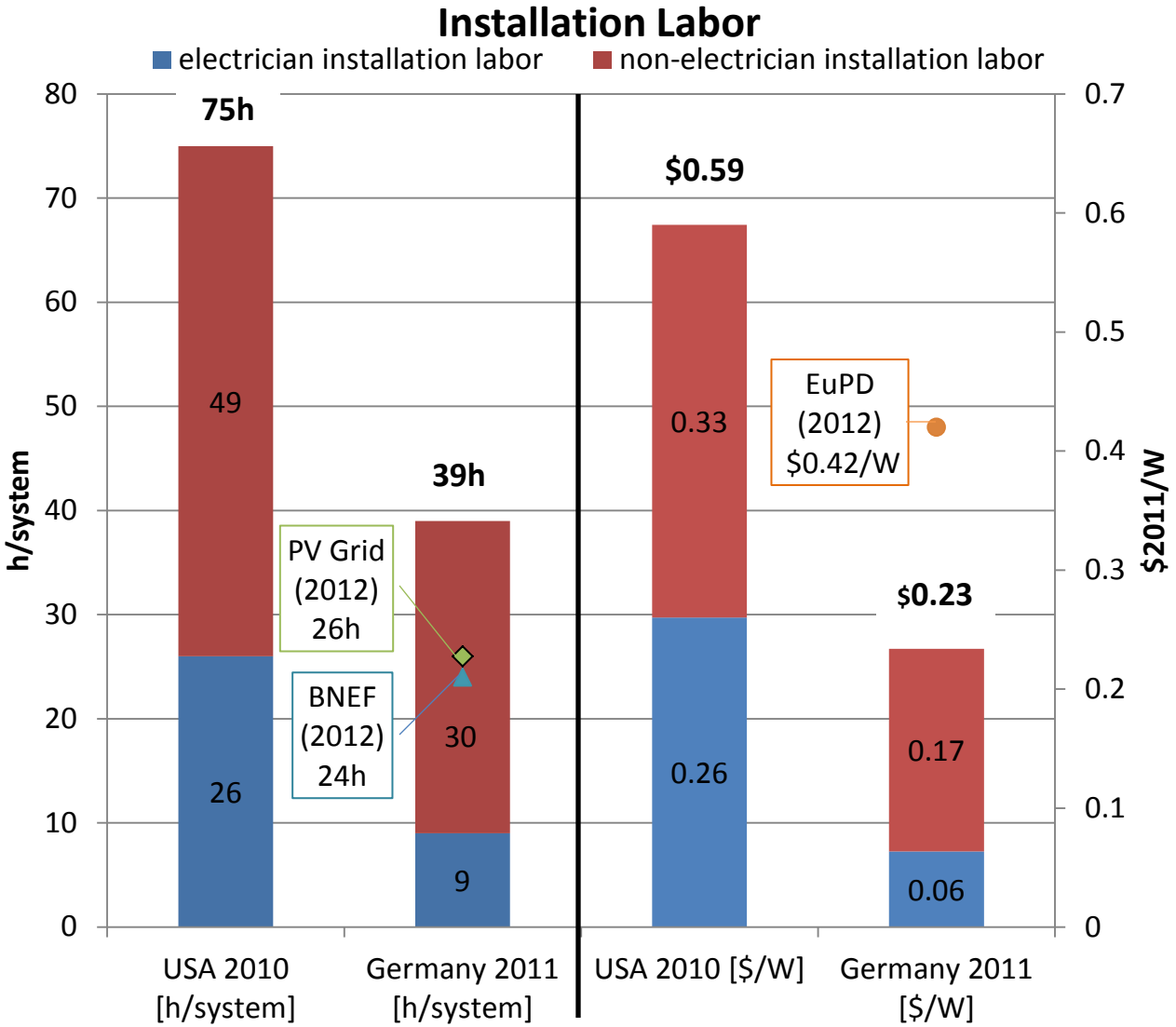
Installation Labor Costs in Germany Average $0.23/W

- German follow-up survey shows higher labor hours than original survey, more in line with expectations:
  - Mean installation labor = 39 man-hours/system (vs. 7.5 hours in original survey)
  - Responses generally ranged from 25-50 hours/system
  - Respondents to original survey likely misinterpreted the question (i.e., confusion between hours-on-site vs. man-hours)
- No obvious economies of scale with respect to installer annual sales volume





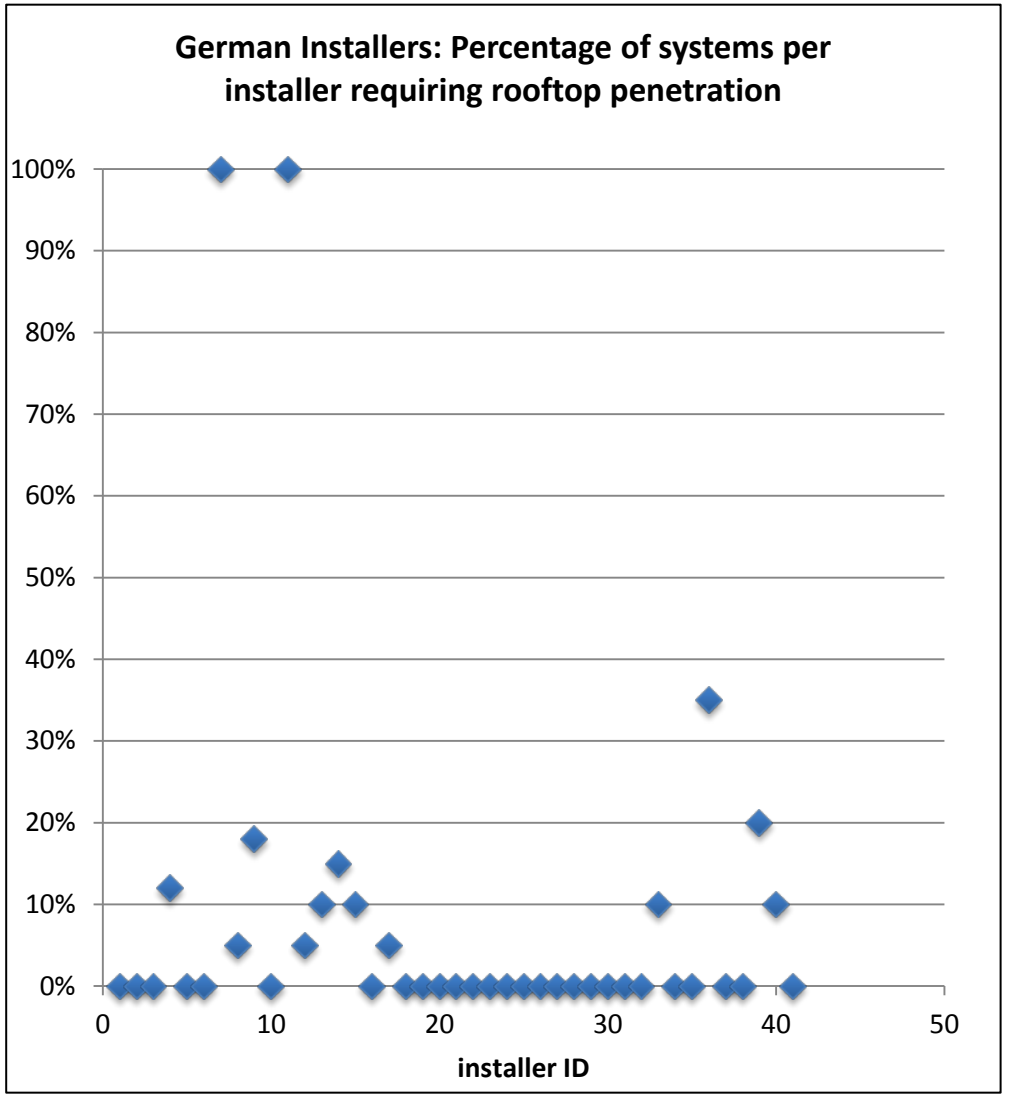
German Installations Are Faster and Cheaper than in the United States



- Updated survey results show a sizable gap between the United States and Germany in installation times (36h)
- Installers in Germany rely even more on (cheaper) non-electrician installation labor than in the US (77% vs. 65%)

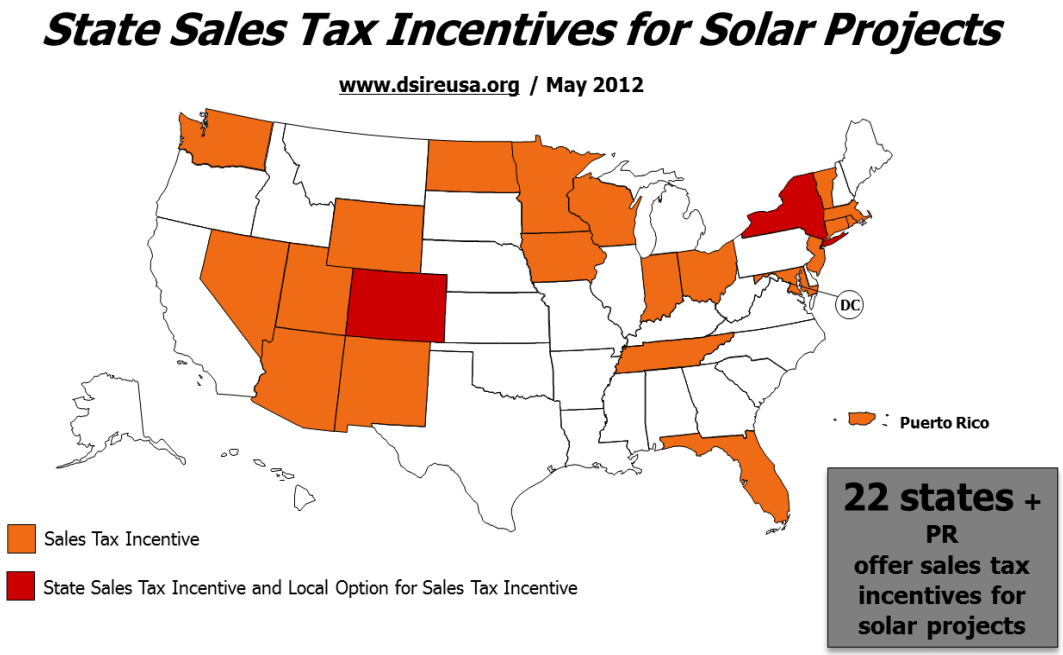
Differences in Installation Labor Partly Stem from Different Mounting Practices

- Large majority of German installers either never or rarely install systems requiring roof-penetration
- Roof penetration is much more common in the United States, due to differences in roofing materials and higher wind speeds in some regions
- Follow-up survey also asked about the usage of roof-to-inverter conduits for wiring and about the location of grounding for German residential PV
  - But no clear trend that might explain differences in labor requirements compared to U.S. systems



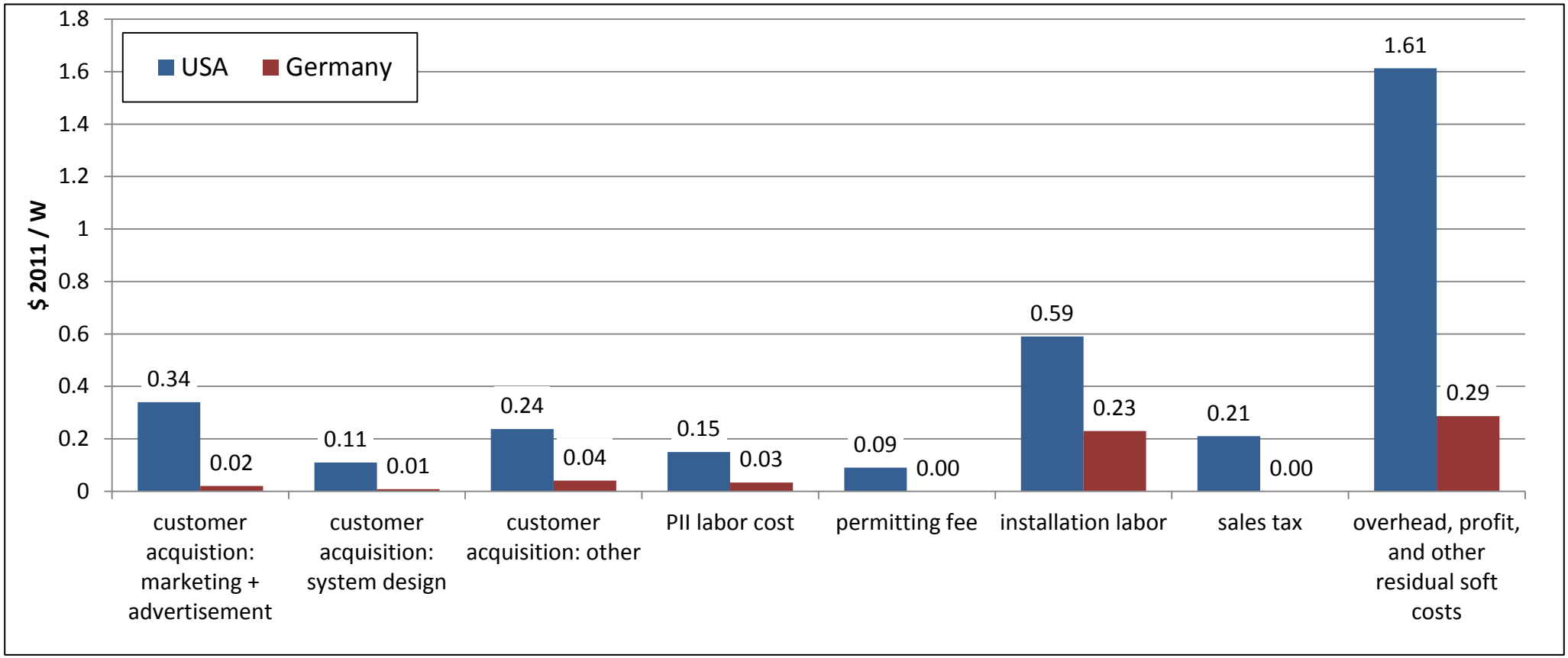
Nationwide Sales Tax Exemptions in Germany Further Reduce Soft Costs

- Survey respondents confirmed that German residential PV systems are effectively exempt from revenue taxes/ sales taxes/ value added taxes
  - Regular tax rate of 19% can be exempted either via “Kleinunternehmer” or “Vorsteuererstattungs” clause
- In the United States, 23 states assess sales tax on residential PV systems, usually 4-8% of system prices, as do many local governments
- Given the spatial distribution of PV systems, and accounting for sales tax exemptions in some states, state and local sales taxes added **$0.21/W** to the median price of US residential PV in 2011



Summary of Soft Cost Differences for Residential PV in the U.S. and Germany

Comparison of Soft Costs for Residential PV in Germany and the U.S.
(customer-owned systems)

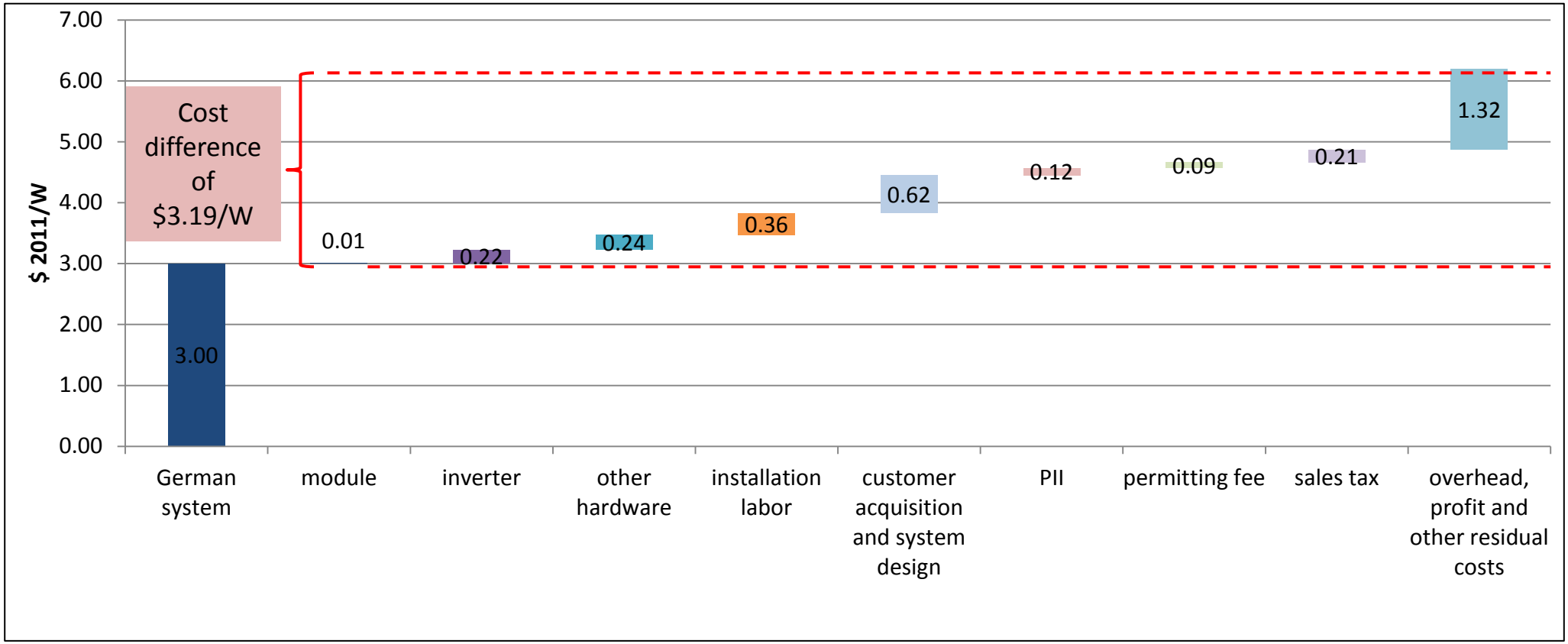


Notes: "Overhead, profit, and other residual soft costs" is calculated as the difference between total soft costs and the sum of the individual business process costs quantified through the German and U.S. installer surveys. This residual term includes such items as property-related expenses (rent, utilities, etc.), inventory-related costs, additional insurances and fees, and general administrative costs. Our estimate of $1.61/W for "overhead, profit and residual soft costs" is generally consistent with the findings of CPF (2012). Research by Woodlawn Associates (2012) suggests that profit margins for many U.S. installers are low or non-existent, implying that the differences shown for the "overhead, profit, and other residual soft costs" category is not the result of much higher profit margins in the U.S.

Summary of Soft Cost Differences for Residential PV in the U.S. and Germany

Build-Up of Cost Differential Between German and U.S. Residential PV

(customer-owned systems)



Notes: "Overhead, profit, and other residual soft costs" is calculated as the difference between total soft costs and the sum of the individual business process costs quantified through the German and U.S. installer surveys. This residual term includes such items as property-related expenses (rent, utilities, etc.), inventory-related costs, additional insurances and fees, and general administrative costs. Our estimate of $1.61/W for "overhead, profit and residual soft costs" is generally consistent with the findings of CPF (2012). Research by Woodlawn Associates (2012) suggests that profit margins for many U.S. installers are low or non-existent, implying that the differences shown for the "overhead, profit, and other residual soft costs" category is not the result of much higher profit margins in the U.S.

Possible Market Drivers for Soft Cost Differential between Germany and U.S. (1)

- Greater market-wide deployment and longevity in Germany allow for cost reductions based on installer experience
- Lower market fragmentation (one contiguous market and regulatory framework) and higher population density in Germany allow for lower overhead, transport, and supply chain costs.
  - In the US, at least 50 markets exist – many more when considering local permitting-inspection-interconnection rules.
- Larger and more concentrated markets in Germany (as well as cultural differences with the US) facilitate bandwagon effects and customer acquisition by word of mouth, leading to lower customer acquisition costs

Possible Market Drivers for Soft Cost Differential between Germany and U.S. (2)

- Less onerous permitting-inspection-interconnection processes (e.g. online registration, no permitting fee or inspection by county officials) and installation practices (e.g. easier grounding, roof penetration) in Germany
- Simpler, more certain and more lasting value proposition in Germany allow for both lower customer acquisition + overhead costs, and larger average system sizes
  - FiT guaranteed for 20 years in Germany vs. varying value of net metering + state incentives + federal tax incentives in the US
- Regular declining FiT and high competition among installers yield pressure for price reductions and lower margins in Germany, while larger incentives, opportunities for higher value-based pricing, and less installer competition allow for higher prices and margins in US

Policy Implications

Reducing residential PV prices in the United States may require policies that enable:

- A large and durable market size
- A concentrated market → minimize fragmentation
- A simple, transparent, certain incentive structure / value proposition
- Simple interconnection, permitting, and inspection requirements
- Regular incentive declines to drive & follow cost reduction

Suggestions for Further Research

- Initiate a more refined analysis of overhead costs and margins among installers
- Better understand the pricing decision of installers and competition between installers (i.e., degree of “value-based pricing”)
- Further investigate installation practices and differing regulatory requirements (usage of grounding, roof-penetration and conduits)
- Compare supply-chain margins between the two countries and average prices paid by installers for modules and inverters
- Assess the role of FIT policies in Germany in stimulating price reductions and potential implications for U.S. solar policy

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Questions?

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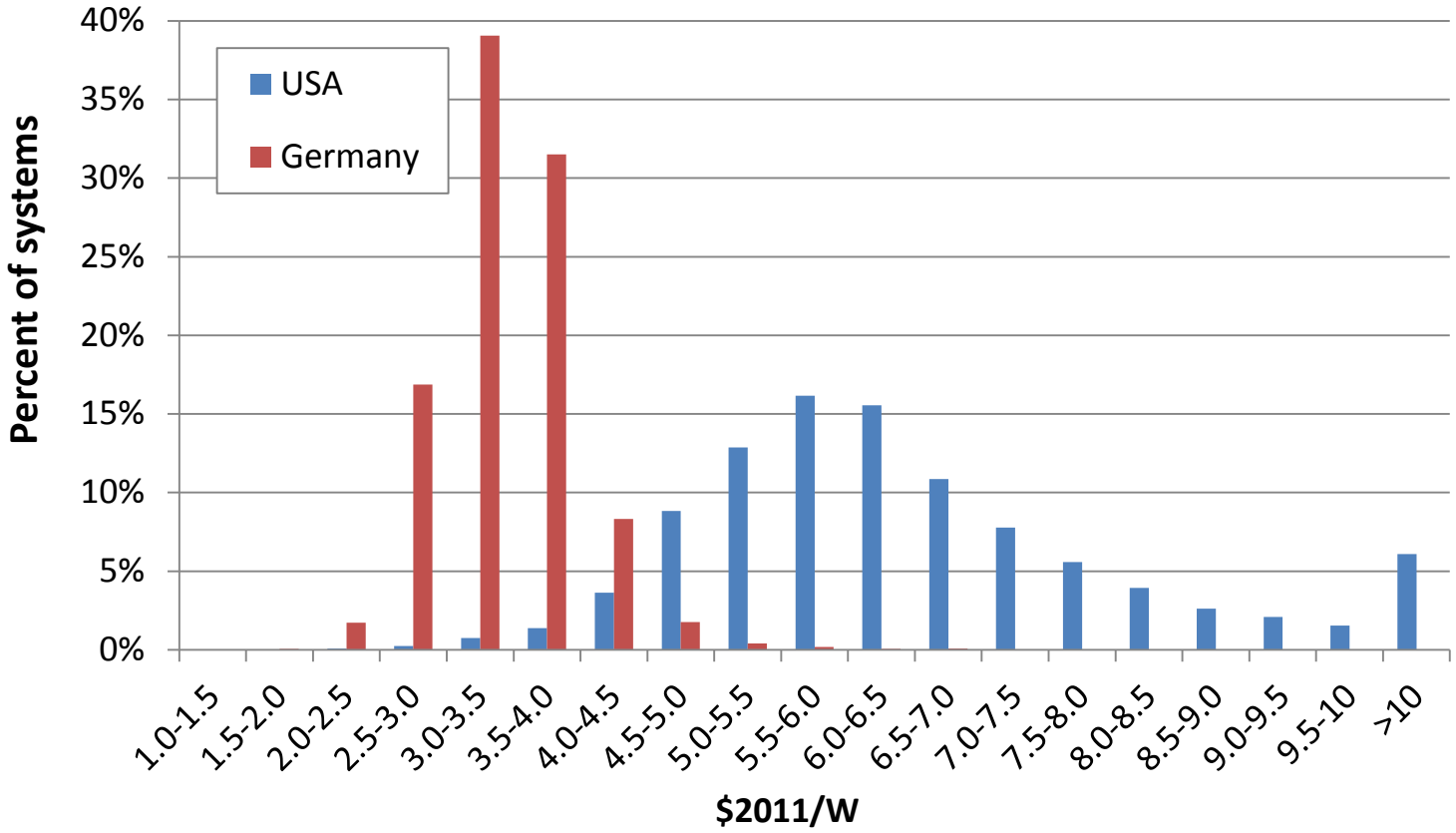
Installed Prices in the U.S. Are Also Much More Varied Than in Germany

Frequency Distribution:
Installed Price of ≤10 kW Customer-Owned Systems Installed in 2011



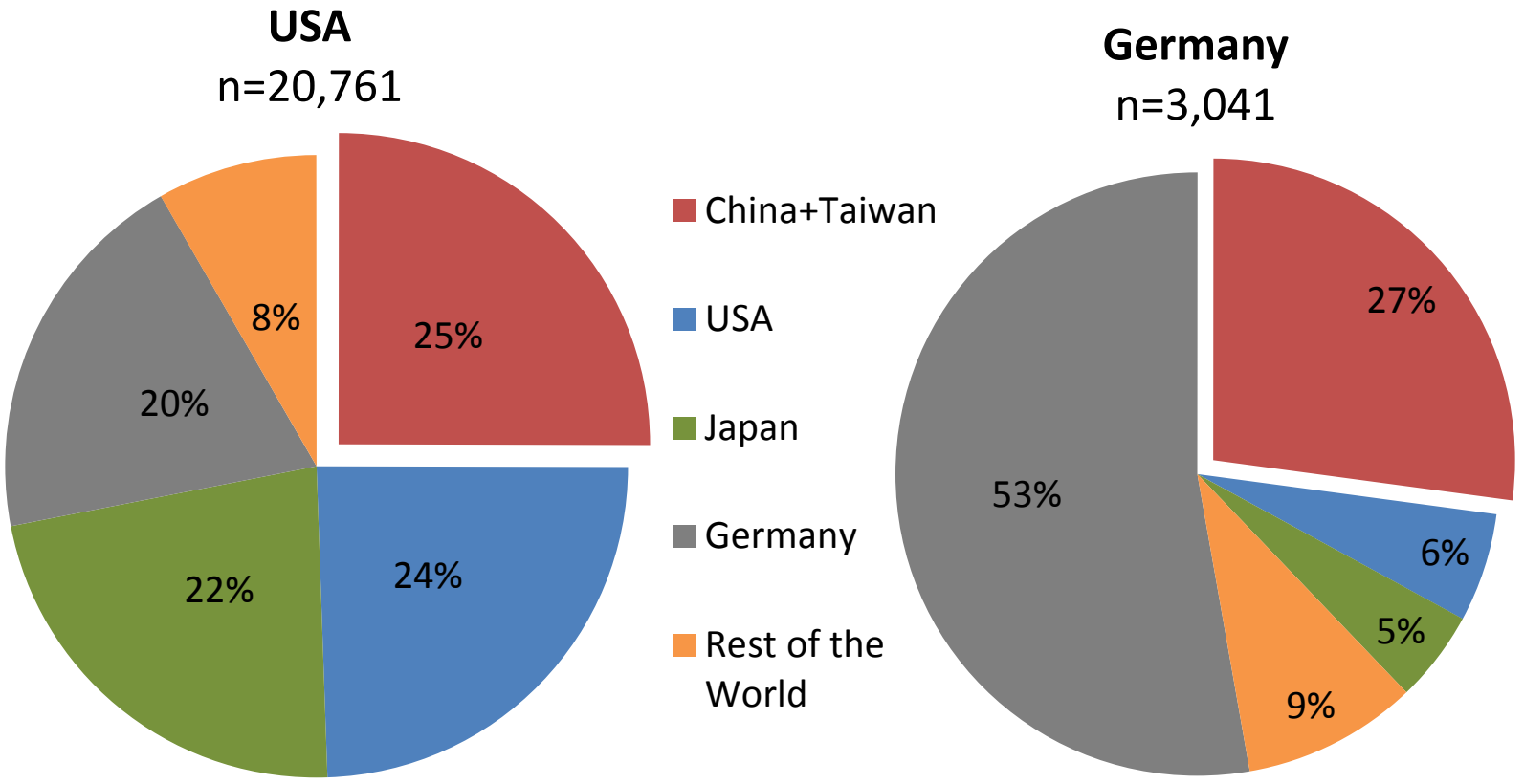
- Some U.S. systems have reached German prices already
- Greater variation in the U.S. indicative of greater market fragmentation across jurisdictions

Data Sources: US: TTS; Germany: EuPD

* ***Note***: German data come from a quarterly survey of system price quotes from roughly 100 installers, and are thus based on a much smaller sample than the US data and may not reflect the full extent of price variability in the German market.

The Price Gap Is Not Due to Differences in Chinese Module Market Share

Share of module manufacturers by country of headquarters for *customer-owned ≤10kW systems* in 2011



Data Sources: TTS, EuPD

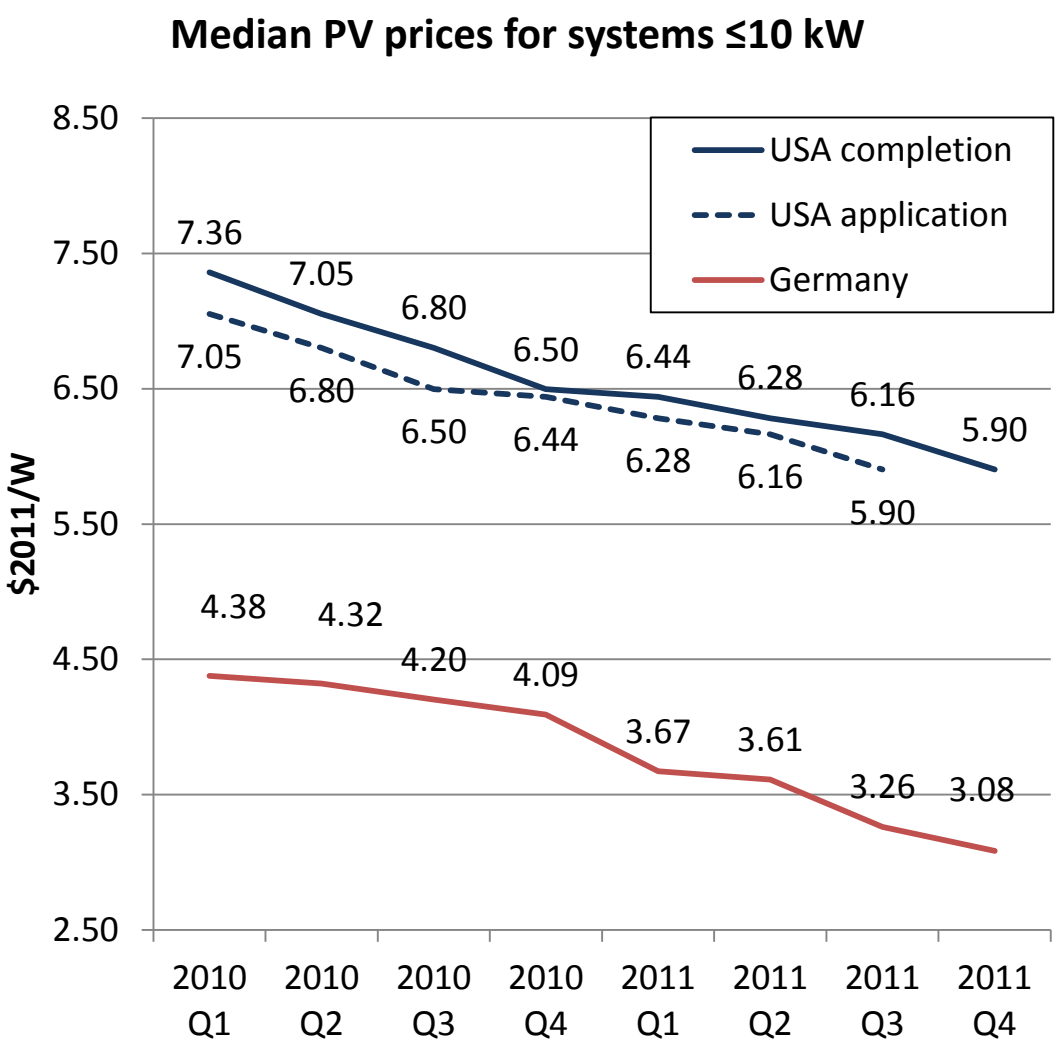
Chinese modules are cheaper ($1.61/W vs. $2.01/W in 2011), but…

Among customer owned systems ≤10 kW, the U.S. and Germany had similar shares of Chinese modules*

Thus differences in Chinese module market share do not contribute significantly to the German-U.S. price gap.

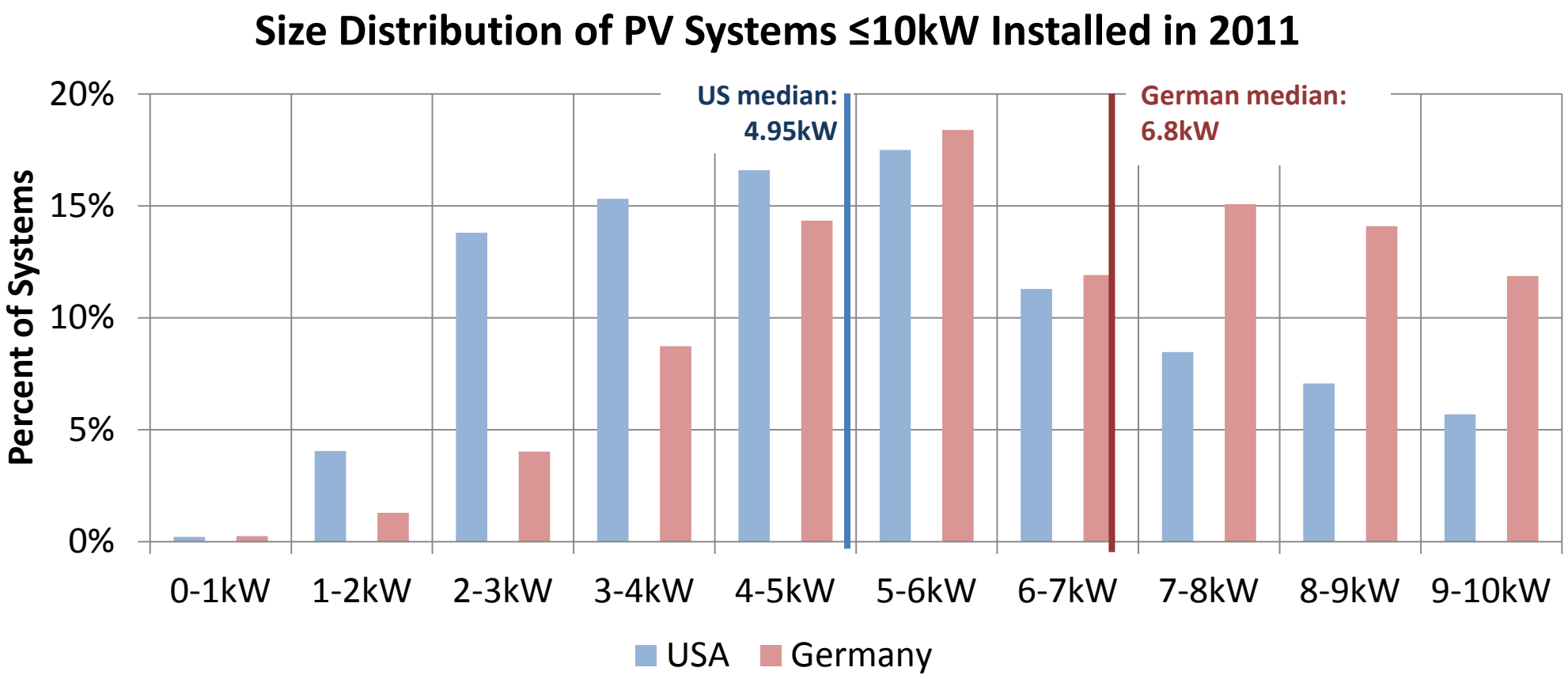
Note: Third-party owned systems in the U.S. have a higher share of Chinese modules (e.g. BNEF 2012), but for the purpose of assessing the price gap in this analysis, we focus specifically on customer-owned systems.

Longer U.S. Project Development Time Contributes to Apparent Price Gap



- Based on TTS data and German survey responses, residential projects take 126 days to develop in the U.S. vs. 35 days in Germany
- When comparing German and U.S. system prices based on installation date, some of the difference is due to the longer development time in the U.S., i.e., German system pricing is effectively "shifted" one quarter relative to the U.S.
- In Q4 2011, this effect contributes ~$0.18/W ($3.26 minus $3.08) to the apparent price gap
- Larger or smaller impacts in other quarters, depending on speed of price declines

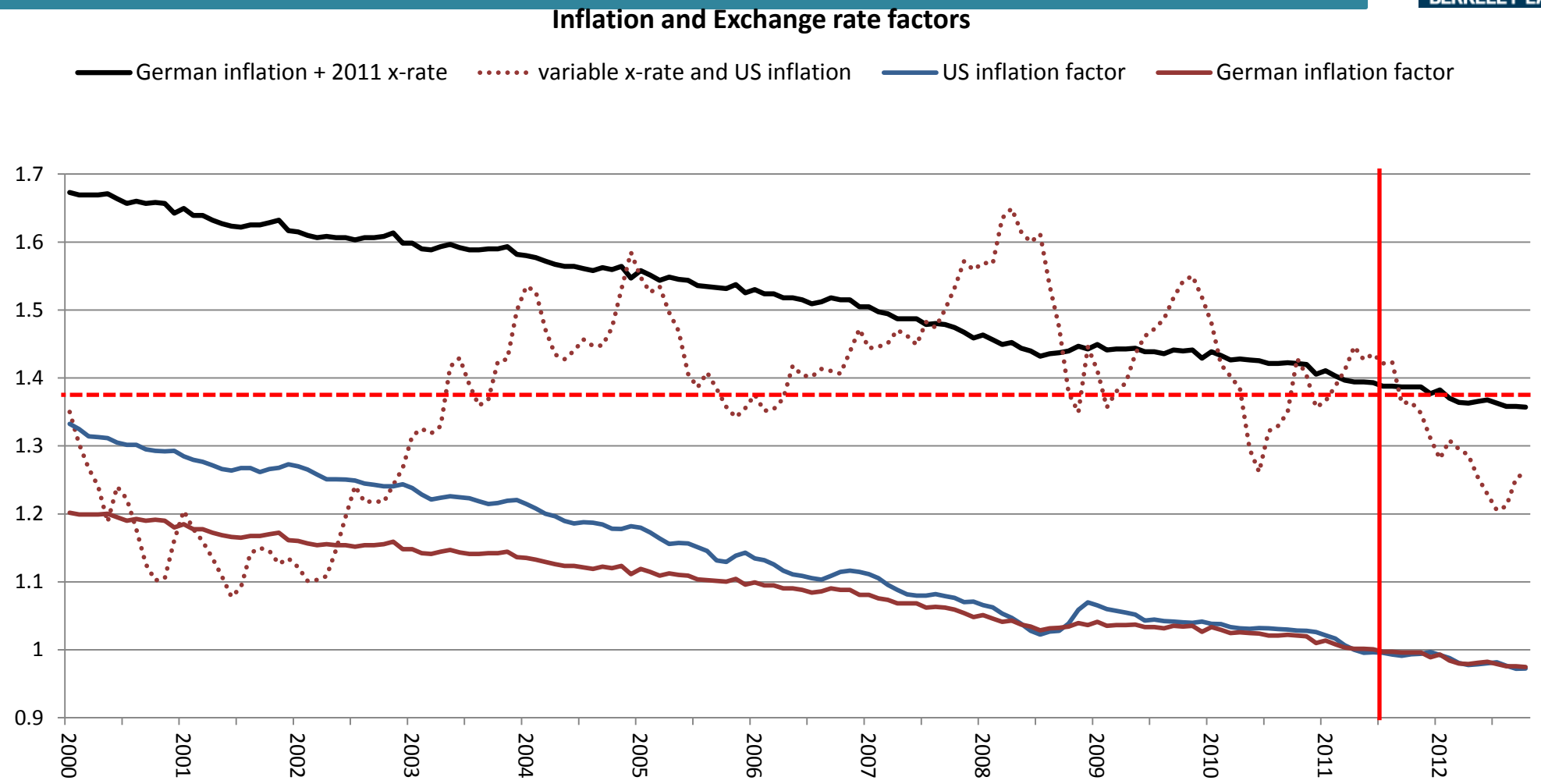
German Residential Systems Are Generally Larger Than U.S. Systems



Applying the U.S. price distribution to the system size distribution for German systems yields a median system price that is **$0.15/W lower** than the actual median price for the 2011 U.S. systems in the TTS data sample ($6.21/W)

Notes: US data based on TTS; German data reflects all grid-connected PV systems (in front + behind the meter) as collected by the Federal Grid Agency (Bundesnetzagentur, BNetzA)

Appendix: Currency Conversion



First German prices were normalizes for 2011 €, which were then converted to $ using the average exchange rate of the year 2011 of $1.39/€.

The average exchange rate in 2012 was $1.29/€, an expression of German system prices in $2012 using the 2012 average exchange rate would thus be about 7% lower than the prices expressed in $2011.

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