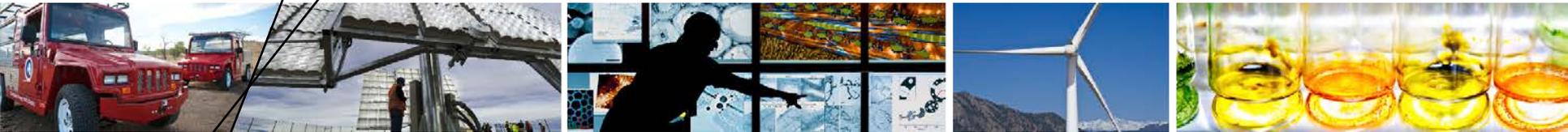


Japan's Solar Photovoltaic (PV) Market: An Analysis of Residential System Prices



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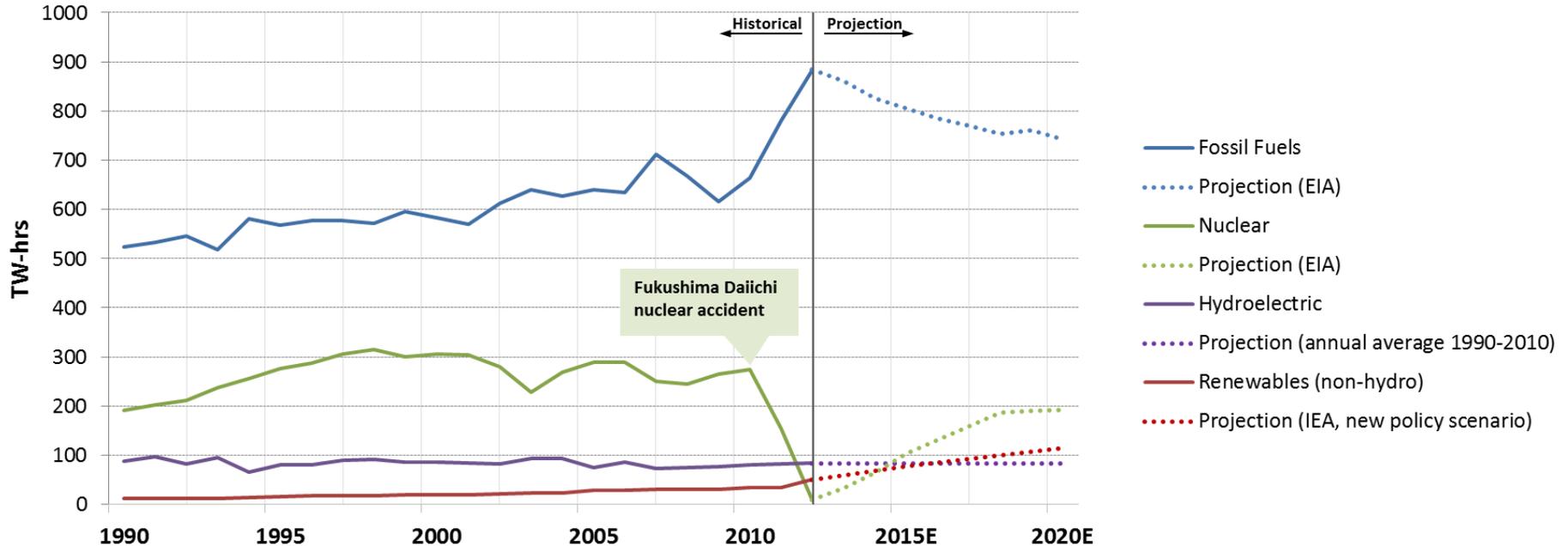
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Japan's Electricity Generation Portfolio Continues to Change, and Stronger Growth in Renewable Energy is Anticipated

Electricity Generation in Japan

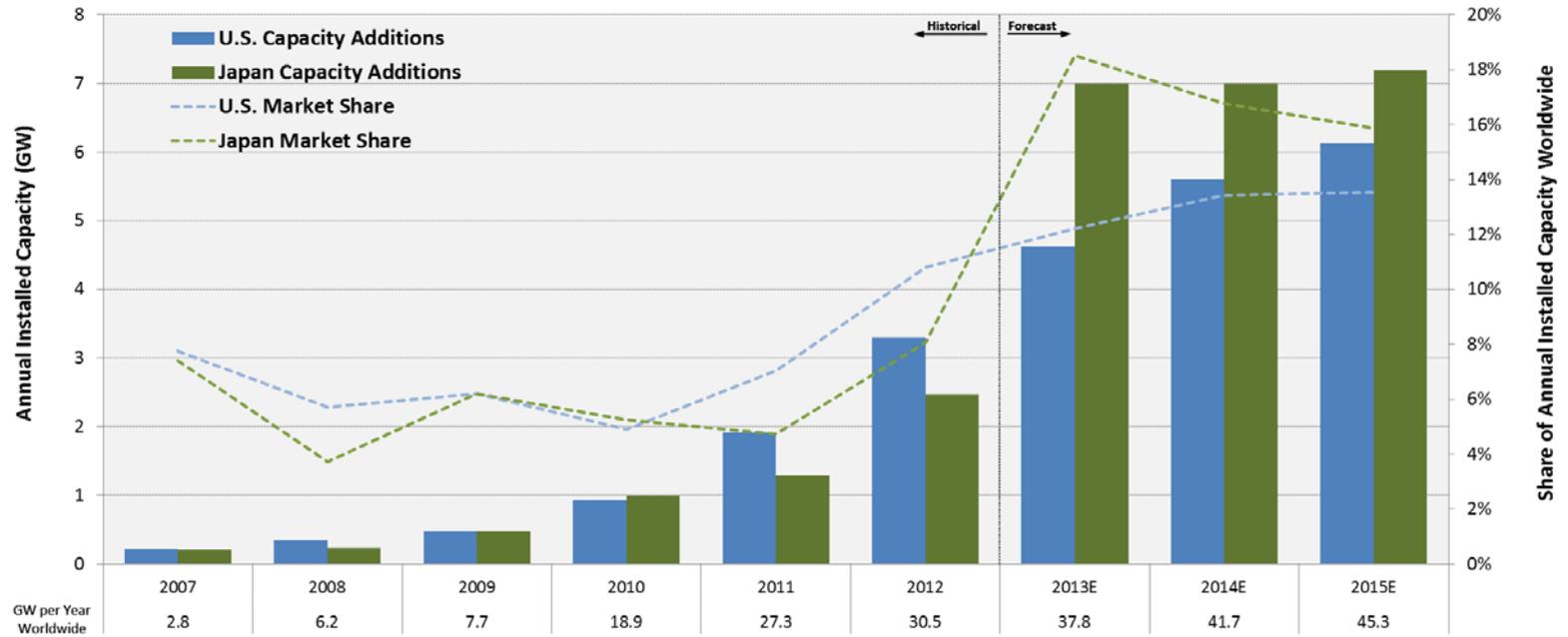


- **The future of nuclear energy in Japan is uncertain, and national policy is evolving.**
 - The figure only illustrates one nuclear projection by the U.S. Energy Information Agency (EIA).
- **Renewable energy and fossil fuels are expected to replace some permanently retired nuclear plants.**
 - Japan's national solar energy goal is to deploy 63 GW by 2030 (cumulative installed capacity).

Sources: U.S. Energy Information Agency (EIA). (2013). "International Energy Statistics." Accessed on September 12, 2013: <http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=27&aid=12&cid=r1,&syid=1990&eyid=2011&unit=BKWH>.
 U.S. Energy Information Agency (EIA). "International Energy Outlook 2013." July 25, 2013.
 International Energy Agency (IEA). (2012). "World Energy Outlook 2012: Renewable Energy Outlook." Chapter 7. Page 218.

Historical Solar Deployment in Japan is Similar to the United States, but Japan's Demand Will Likely Exceed U.S. Demand in the Near-term

U.S. and Japan's Annual Solar PV Deployments and Market Share of Global Installations

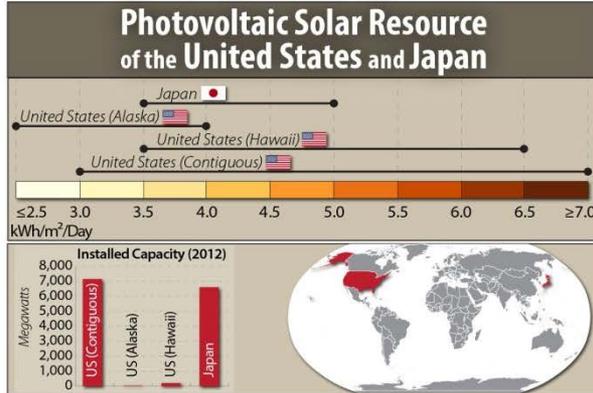
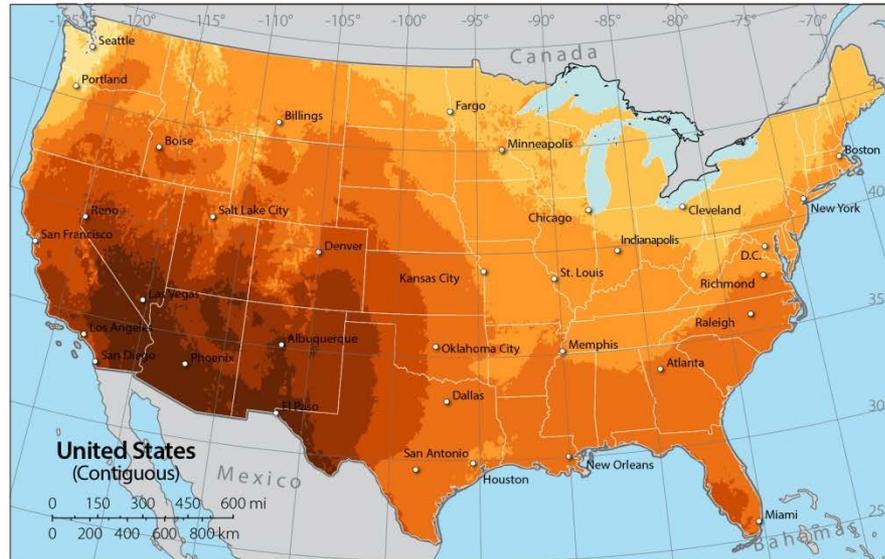
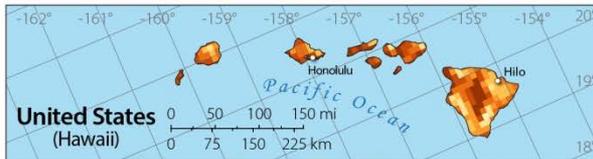


Note: This chart illustrates median data from a number of market forecasts listed below. In addition to the illustrated policies, net-metering in Japan was available from the early 1990s until the start of the feed-in-tariff in mid-2012.

- **Historical installed capacity (2012): 2.5 GW in Japan and 3.3 GW in the United States.**
- **Near-term forecasts (2015): 7.2 GW in Japan and 6.1 GW in the United States.**
- **By 2015, deployments in Japan, China, and India will likely account for about 50% of global demand.**

Source: Photon Consulting 1Q2013; BNEF 1Q2013; GTM Research January 2013; Deutsche Bank 1Q2013; Stifel Nicolaus January 2013; Goldman Sachs January 2013. Policy details from RTS Corporation. PVTech. "Japan to exclude net-metering from new FiT." May 2, 2012. PV-tech.org. Accessed September 3, 2013.

Solar Resources in Japan are Similar to Some Northern Areas of the Contiguous United States



Annual average solar resource data are shown for a tilt = latitude collector. The data for Hawaii and the 48 contiguous states are a 10km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2009. The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003). Solar data for Japan were obtained from the NASA Langley Research Center Atmospheric Science Data Center Surface meteorological and Solar Energy (SSE) web portal supported by the NASA LaRC POWER Project. Capacity value source for Japan is REN21, and for the US, IREC/Larry Sherwood, US Solar Market Trends 2012.

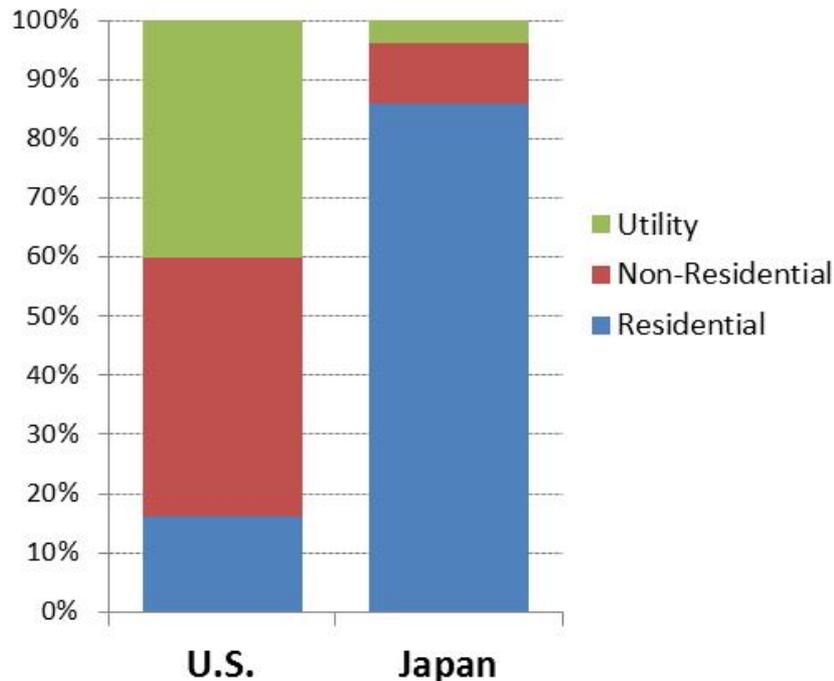
This map was produced by the National Renewable Energy Laboratory for the US Department of Energy, August 27, 2013



Note: Factors that impact the economic viability of solar PV systems include: solar resources, installed PV system costs, system performance, retail electricity prices, policy incentives, and financing considerations.

Today, Japan Represents the World's Largest Residential Solar Market; Other Market Segments are Growing Rapidly

Shares of Installed Capacity by Market Segment (2011)



This chart illustrates Japan's historical focus on distributed generation solar applications. Non-residential and utility sectors have gained significant market share in Japan since 2011.

Residential Market Considerations

- Average residential electricity usage in Japan is 1/3 of U.S. household usage.
- 90% of modules installed on homes in Japan are composed of domestic brands.
 - Manufacturers' channel strategies may create barriers for new entrants
 - Country-specific certification requirements represent short-term barriers (many solar firms headquartered overseas have now passed certifications)
- Third-party ownership models are uncommon in Japan's residential sector, though developments in leasing and power purchase agreements are occurring.

Note: Typical household electricity consumption in Japan is about 300 kWh/month (Federation of Electric Power Companies 2013); typical usage in the U.S. is 940 kWh/month (EIA 2013). Source: Dialogue with Japanese installers and market analysts. Deutsche Bank's Industry Update Report (May 2013). Data from RTS Corporation and GTM/SEIA (2013). Japan Electrical Safety & Environment Technology Laboratories (JET). "Certification of Photovoltaic Modules." (2011). Accessed September 15, 2013: <http://www.jet.or.jp/en/products/solar/>. Bloomberg interview with Travis Woodward. "Japan's Solar Imports Up 9 Times." September 12, 2013.

Japan's National Policy Considers PV Pricing and Technology Performance

Residential Solar PV Systems in Japan (as of 1H 2013)

- **National cash subsidy program**
 - *Cash subsidy*: residential incentive of \$0.20/W for systems priced below \$4.10/W; a lower subsidy of \$0.15/W is available for systems priced between \$4.10/W and \$5.00/W.
 - *Price ceiling* : systems sold for greater than \$5.00/W cannot receive the subsidy.
 - *Certification*: residential PV systems must obtain domestic certifications from the Japan Electrical Safety & Environment Technology Laboratories (JET).
 - *Technology requirements*: module efficiencies must exceed 16% for mono-crystalline Si, 15% for multi crystalline Si, 8.5% for a-Si, and 12% for CIGS and CdTe.
- **National feed-in-tariff (FIT)**
 - *Residential FIT details*:
 - Residential FIT of \$0.40/kWh is for surplus power generation (i.e., power not consumed by the home).
 - The government targets a 3.2% annual return for system owners (10 year purchase period).
 - The government's installed PV system price assumption is \$4.44/W.
 - *Technology requirements*: module efficiencies must exceed 13.5% for c-Si, 7.0% for a-silicon, and 8.0% for other thin films. Requirements apply to BIPV, but flexible and concentrator devices are excluded.
- **Local incentives**
 - No penalties for combining national and local incentives; more than 900 local authorities offer incentives.
 - Some prefecture and municipal governments provide cash incentives (e.g., \$500/system).
- **Strikingly low cost of capital**
 - 10-year Japanese government bond is about 0.7%; this enhances the attractiveness of PV as an investment option.

Note: Japan's residential electricity prices range from \$0.19/kWh to \$0.29/kWh in the Tokyo region (TEPCO 2013) and are similar in other parts of the country.

Sources: Kazuhiko, O.; Izumi, K.; Yuzuru, U.; Takashi, O. (March/April 2013). "A Good Fit – Japan's Solar Power Program and Prospects for the New Power System." IEEE Power & Energy Magazine. "Certification of Photovoltaic Modules." (2011). Japan Electrical Safety & Environment Technology Laboratories (JET). Accessed September 15, 2013: <http://www.jet.or.jp/en/products/solar/>. RTS Corporation (2013). Trading Economics website. Accessed September 10, 2013: <http://tradingeconomics.com>.

Residential PV System Price Drivers in Japan Differ from Other Regions

Factors affecting residential PV system prices in Japan include:

- Relatively small rooftop spaces compared to the United States.
- Higher equipment prices and channel costs.
- Labor costs are relatively high compared to some countries.
- The market is driven by host-owned systems.
- National policies incentivize the deployment of large solar PV systems (in terms of capacity).

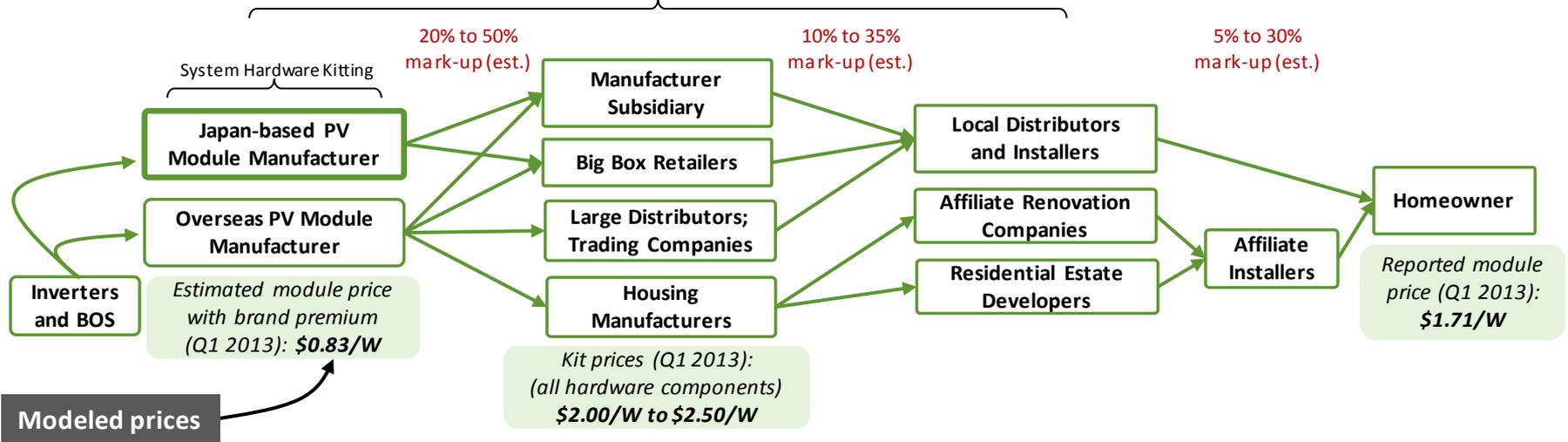
Selected Residential PV System Installation Cost Factors		
Factor	Japan	United States
PV system hardware	Generally higher PV equipment prices (supplier power).	Generally lower PV equipment prices (buyer power).
Other equipment	Some installers use scaffolding as opposed to ladders. Installers often add materials to satisfy customers' aesthetic preferences (e.g., smoothing the corners of arrays).	Most installers use ladders; additional materials to protect panels from animals like squirrels are common in some regions.
Taxes	Tax of 5% on all systems.	Taxes often range from 0% to more than 7%.
Installation labor	4-6 people in a crew; electrician(s) may operate independently from construction crew; systems are often installed in less than 1 or 2 days.	3-8 people in a crew; total time to install systems range from less than 1 day to more than 4 days depending on system and site characteristics.
System design	Installers use design software provided by equipment suppliers; typically takes 15 to 30 minutes to design a residential system.	Installers often use in-house engineering expertise and design software; typically takes 2 to 7 hours to design rooftop systems.
Permitting and grid interconnection	Utilities often require both a pre-inspection and final inspection; this may occur independently of work by PV installation crew; structural and rough inspections are rare.	Types of inspections vary by location; may include structural, rough, and final inspections, in addition to interconnection approval by the utility.
Applications for subsidies	Generally takes 2-3 hours to complete paperwork; cannot file all forms electronically, but most are available online. Approval often takes 1-2 months.	Time to complete and file paperwork varies, but often takes 3-10 hours; not all forms are available online; some forms cannot be filed electronically.
Ownership structure	Majority of systems are customer-owned.	Majority of systems sold in 2012 and 2013 are third-party owned.
Operations and maintenance	Installers prioritize building strong relationships with homeowners; O&M plans vary (e.g., \$100/cleaning or multi-year service contracts).	Third-party companies are responsible for the operations of their systems; with customer-owned systems, service plans vary.

Sources: Dialogue with installers, RTS Corporation, municipal government officials, the Japanese Photovoltaic Industries Association (JPEA), and Photon Consulting. The U.S. Bureau of Labor Statistics . (December 2012). "Economic News Release –Hourly Compensation Costs." Accessed on September 10, 2013: <http://www.bls.gov/news.release/ichcc.t01.htm>.

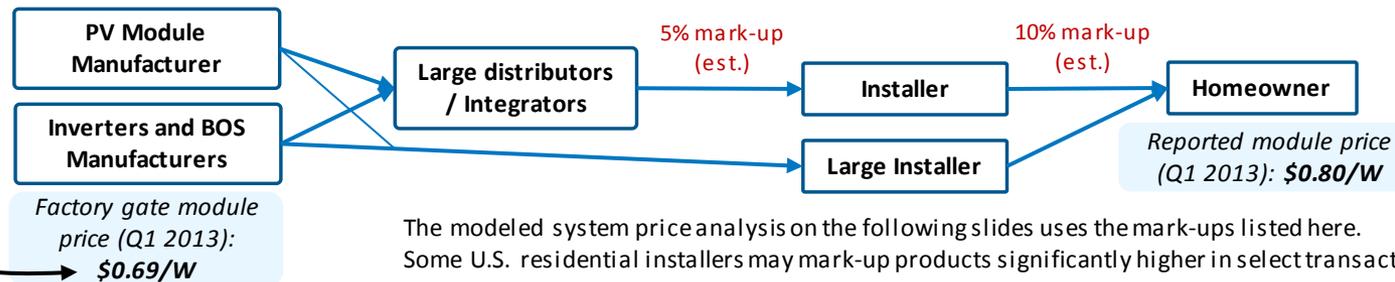
PV System Hardware: Channel Structures Affect Installers' Equipment Costs, and the Structures in Japan are Distinct from Those in the United States

Japan: two-tier wholesale system; relatively high supplier power

- Installers must have “manufacturer IDs” to buy hardware.
- Installers use system design software provided by OEMs.



United States: hardware pricing driven by large integrators; high buyer power



The modeled system price analysis on the following slides uses the mark-ups listed here. Some U.S. residential installers may mark-up products significantly higher in select transactions.

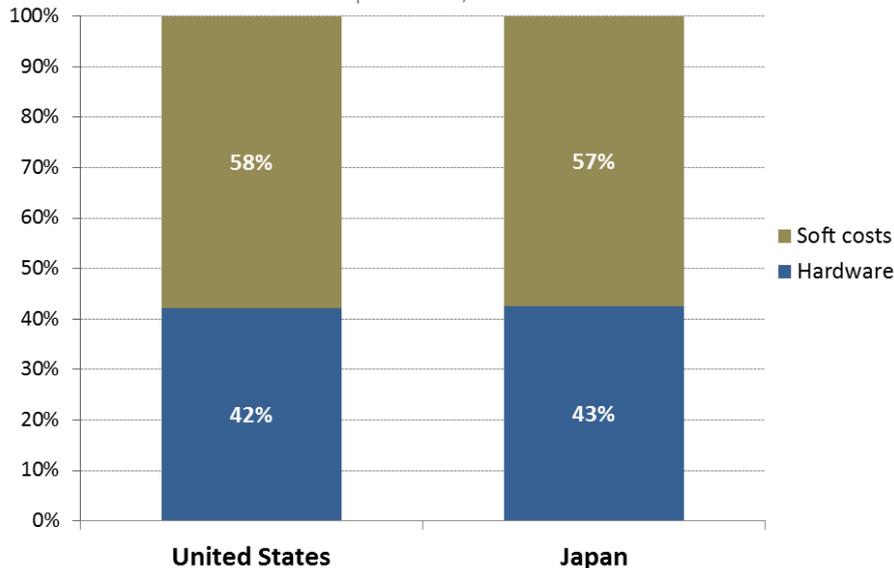
Source: Dialogue with Japanese and U.S. solar PV installers, and RTS Corporation. “Global Clean Tech Weekly.” (March 5, 2012). Piper Jaffray. “GTM Research Solar Quarterly Executive Briefing, Q4 2012.” (2013). GTM Research. Boston, MA: Greentech Media.

Modeled PV System Cash Purchase Prices in Japan are Higher than U.S. Prices

- Key factors influencing price differences: hardware and channel costs, customer acquisition costs, and labor costs.
- Modeled cases do not necessarily reflect transaction prices in each market. For more information on reported transaction prices in the United States, see: Feldman, D. et al. (July 2013). "Photovoltaic System Pricing Trends." NREL/PR-6A20-60207; and, Goodrich, A., et al. (2013). "U.S. Residential PV System Prices: Drivers of Cash Purchase, Fair Market Value, and Transaction Prices." NREL/TR. Forthcoming.
- Limited data is available about PV system technology differences between the United States and Japan. In Q1 2013, 600 MW of mono-crystalline silicon modules and 900 MW of multi-crystalline modules were shipped within Japan.

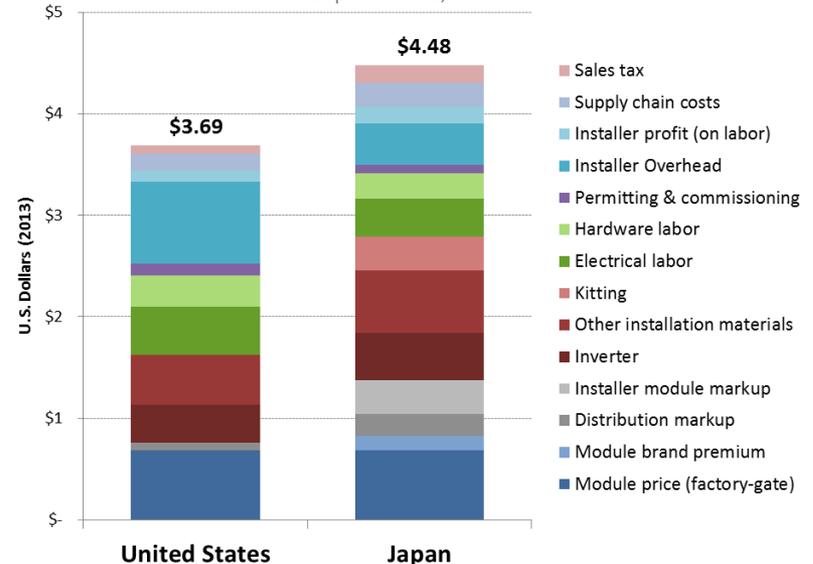
Share of PV System Prices from Hardware and Soft Costs
Modeled Cases in the United States and Japan

September 18, 2013



Modeled PV System Prices in the United States and Japan
Detailed Breakdown of Major Pricing Elements

September 18, 2013



Note: These modeled prices assume residential rooftop system sizes of 6 kW using 15% efficient modules. In the figure on the right, customer acquisition costs are considered as part of installer overhead expenses. Additional details are available on the following slide. We assume equivalent technologies in the modeled cases.

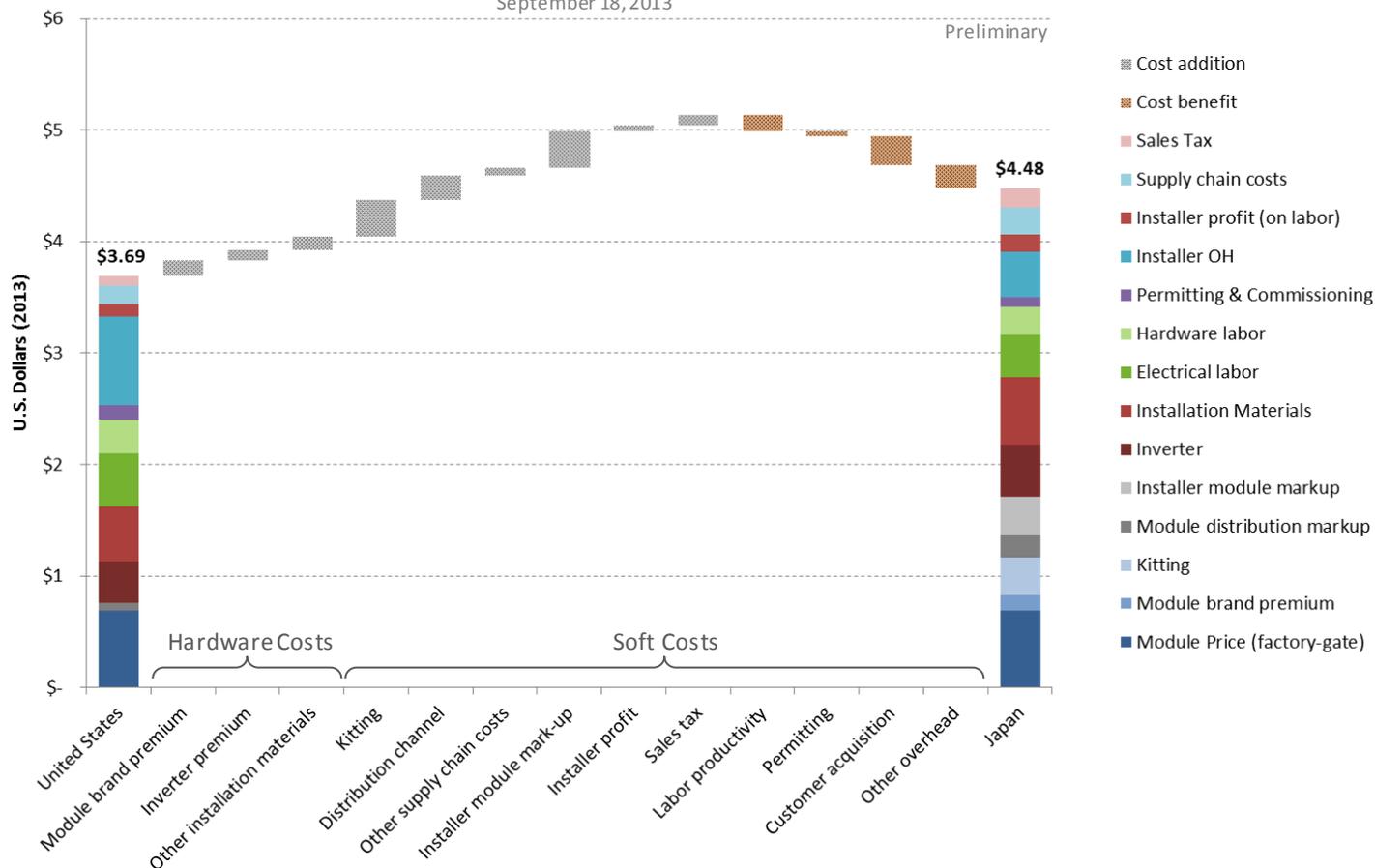
Source: Dialogue with Japanese and U.S. installers, the Japanese Photovoltaic Energy Association, Photon Consulting, and the RTS Corporation.

While Japan's Equipment and Channel Prices are Higher Than U.S. Prices, Installation and Overhead Costs are Lower in Some Markets

Residential PV System Prices in the United States and Japan

Key Factors Differentiating the Modeled Cases

September 18, 2013



Note: These modeled prices assume residential rooftop system sizes of 6 kW using 15% efficient modules. "Installer profit" represents profits on labor, and a 25% margin was assumed for both cases. Installers' profit on materials is represented as "supply chain costs." Customer acquisition costs are a combination of sales and marketing expenses, system design costs, sales commissions, and travel expenses. With the FIT policy in Japan, customer acquisition costs, which we consider as part of installer overhead, are significantly lower than in the United States. Information about the analysis methodology is available in the following reports: Goodrich, A.; James, T.; Woodhouse, M. (2012). "Residential, Commercial, and Utility-scale Photovoltaic System Prices in the United States: Current Drivers and Cost-Reduction Opportunities." NREL/TR-6A20-53347. Golden, CO: National Renewable Energy Laboratory; and, Goodrich, A.; Davidson, C.; James, T.; Feldman, D. (2013). "U.S. Residential PV System Prices: Drivers of Cash Purchase, Fair Market Value, and Transaction Prices." NREL/TR. Forthcoming. Golden, CO: National Renewable Energy Laboratory.

Source: Dialogue with Japanese and U.S. installers, RTS Corporation, and Photon Consulting.

Summary

- **Solar PV deployments are increasing rapidly in Japan—the residential market is the largest in the world, and the share of installed capacity from other market segments is growing as a result of the FIT.**
- **Solar energy resources in Japan, which impact project economics, are lower than many areas of the United States.**
 - Solar resources in Japan are similar to some northern areas of the contiguous United States.
- **Japan’s installers currently acquire some PV system equipment (e.g., modules, inverters, racking) at higher prices than U.S. installers, due in part to their supply-chain structures and a strong consumer preference for Japanese brand products.**
- **In our modeled case, residential PV system prices in Japan are higher than in the United States.**
 - Pricing differences between Japan and the United States are mostly driven by differences in hardware and channel costs; select elements of installation soft costs in Japan are lower than comparable U.S. installations.