INTERNATIONAL ENERGY AGENCY

CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS

Task 1

Exchange and dissemination of information on PV power systems

National Survey Report of PV Power Applications in the United States 2012

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Definitions, Symbols and Abbreviations

For the purposes of this and all IEA PVPS National Survey Reports, the following definitions apply:

PV power system market: The market for all nationally installed (terrestrial) PV applications with a PV power capacity of 40 W or more.

Installed PV power: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m^2, cell junction temperature of 25°C, AM 1,5 solar spectrum – (also see 'Rated power').

Rated power: Amount of power produced by a PV module or array under STC, written as W.

PV system: Set of interconnected elements such as PV modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a PV power capacity of 40 W or more.

CPV: Concentrating PV

Hybrid system: A system combining PV generation with another generation source, such as diesel, hydro, wind.

Module manufacturer: An organisation carrying out the encapsulation in the process of the production of PV modules.

Off-grid domestic PV power system: System installed to provide power mainly to a household or village not connected to the (main) utility grid(s). Often a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'. Can also provide power to domestic and community users (plus some other applications) via a 'mini-grid', often as a hybrid with another source of power.

Off-grid non-domestic PV power system: System used for a variety of industrial and agricultural applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc. that are not connected to the utility grid. Usually a means to store electricity is used. Also referred to as 'stand-alone PV power system'.

Grid-connected distributed PV power system: System installed to provide power to a grid-connected customer or directly to the electricity grid (specifically where that part of the electricity grid is configured to supply power to a number of customers rather than to provide a bulk transport function). Such systems may be on or integrated into the customer's premises often on the demand side of the electricity meter, on public and commercial buildings, or simply in the built environment on motorway sound barriers etc. They may be specifically designed for support of the utility distribution grid. Size is not a determining feature – while a 1 MW PV system on a rooftop may be large by PV standards, this is not the case for other forms of distributed generation.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station. The power supplied by such a system is not associated with a particular electricity customer, and the system is not located to specifically perform functions on the electricity grid other than the supply of bulk power. Typically ground mounted and functioning independently of any nearby development.

Turnkey price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid PV system, the prices associated with storage battery maintenance/replacement are excluded. If additional costs are incurred for reasons not directly related to the PV system, these should be excluded. (E.g. If extra costs are incurred fitting PV modules to a factory roof because special precautions are required to avoid disrupting production, these extra costs should not be included. Equally the additional transport costs of installing a telecommunication system in a remote area are excluded).

Field Test Programme: A programme to test the performance of PV systems/components in real conditions.

Demonstration Programme: A programme to demonstrate the operation of PV systems and their application to potential users/owners.

Market deployment initiative: Initiatives to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives etc. These may be implemented by government, the finance industry, electricity utility businesses etc.

Final annual yield: Total PV energy delivered to the load during the year per kW of power installed.

Performance ratio: Ratio of the final annual (monthly, daily) yield to the reference annual (monthly, daily) yield, where the reference annual (monthly, daily) yield is the theoretical annual (monthly, daily) available energy per kW of installed PV power.

Currency: The currency unit used throughout this report is United States dollars (USD).

PV support measures:

Enhanced feed-in tariff	an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh somewhat higher than the retail electricity rates being paid by the customer
Capital subsidies	direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed PV system cost
Green electricity schemes	allows customers to purchase green electricity based on renewable energy from the electricity utility business, usually at a premium price
PV-specific green electricity schemes	allows customers to purchase green electricity based on PV electricity from the electricity utility business, usually at a premium price
Renewable portfolio standards (RPS)	a mandated requirement that the electricity utility business (often the electricity retailer) source a portion of their electricity supplies from renewable

	energies
PV requirement in RPS	a mandated requirement that a portion of the RPS be met by PV electricity supplies (often called a set-aside)
Investment funds for PV	share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends
Income tax credits	allows some or all expenses associated with PV installation to be deducted from taxable income streams
Net metering	allows PV customers to incur a zero charge when their electricity consumption is balanced by their PV generation, to be charged the applicable retail tariff when electricity is imported from the grid and to receive some remuneration for PV electricity exported to the grid
Net billing	the electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity account is reconciled over a billing cycle
Commercial bank activities	includes activities such as preferential home mortgage terms for houses including PV systems and preferential green loans for the installation of PV systems
Activities of electricity utility businesses	includes 'green power' schemes allowing customers to purchase green electricity, operation of large-scale (utility-scale) PV plants, various PV ownership and financing options with select customers and PV electricity power purchase models
Sustainable building requirements	includes requirements on new building developments (residential and commercial) and also in some cases on properties for sale, where the PV may be included as one option for reducing the building's energy foot print or may be specifically mandated as an inclusion in the building development

Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Co-operation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency. The IEA Photovoltaic Power Systems Programme (IEA-PVPS) is one of the collaborative R & D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The 23 participating countries are Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), China (CHN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia (MYS), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). The European Commission, the European Photovoltaic Industry Association, the US Solar Electric Power Association, the US Solar Energy Industries Association and the Copper Alliance are also members. Thailand is a pending member.

The overall programme is headed by an Executive Committee composed of one representative from each participating country or organization, while the management of individual Tasks (research projects / activity areas) is the responsibility of Operating Agents. Information about the active and completed tasks can be found on the IEA-PVPS website www.iea-pvps.org.

Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. An important deliverable of Task 1 is the annual Trends in photovoltaic applications report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the U.S. National Survey Report for the year 2012. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

The PVPS website www.iea-pvps.org also plays an important role in disseminating information arising from the programme, including national information.

1 EXECUTIVE SUMMARY

1.1 Installed PV power

The United States added approximately 3 366 MW of PV (including CPV) grid-connected generating capacity in 2012, bringing cumulative installed capacity to 7 273 GW. This represents an 86 % growth in cumulative capacity over 2011. The nation added 1 803 MW of utility-scale generation capacity in 2012, a 130% increase over 2011 annual installations.

By the end of 2012, there were approximately 303 000 distributed, grid-connected solar electric systems installed in the United States. More than 90 000 PV systems were connected in 2012, compared to 60 000 in 2011, for a 50 % growth in the number of grid-connected systems installed annually. At the state level, California represents 27 % of new capacity in 2012 compared to 29 % in 2011, indicating stronger growth in other states.

1.2 Costs & prices

From Q1 2012 to Q4 2012, national weighted average system prices fell by 32 %, from a high of 4,45 USD/W_{DC} to 3,04 USD/W_{DC}. However, when examining system prices on a per-watt basis, it is important to highlight that some of this decline is attributed to an increased share of large-scale, utility PV installations in 2012.

The United States continues to be a leader in the production of polysilicon feedstock. Due to increased supply globally, the spot price for polysilicon decreased from 32 USD/kg to 19 USD/kg, from Q1 2012 to Q4 2012. Meanwhile, the price of modules declined from 0,94 USD/W_{DC} to 0,68 USD/W_{DC} for the same period.

1.3 PV Production

In 2012, the United States produced approximately 949 MWp of PV modules. A breakdown of module production, by technology, is provided below.

Technology	2012 Annual Capacity (MW_{DC})	2012 Annual Production (MW_{DC})
Crystalline silicon	1 255	670
Thin film	785	279
Total	2 040	949

1.4 Budgets for PV

The U.S. Department of Energy (DOE) allocated a research, development, demonstration, and deployment (R D & D) budget of 262 MUSD to the Solar Energy Technologies Office (SETO) in fiscal year (FY) 2012 (October 2011 to September 2012).These funds financed RD&D activities in partnership with national laboratories, universities, private industry, sub-national governments, and non-governmental organizations. To obtain SETO R&D funding, industry partners are required to provide 20 % to 50 % matching cost share and university partners a 0 % to 20 % matching cost share. In addition, the U.S. Department of Treasury dispersed 1,9 BUSD in grants in lieu of the Investment Tax Credit under Section 1603 to PV projects in calendar year 2012.

2 The Implementation of PV Systems

2.1 Applications for photovoltaics

Growth in the United States' PV market has been propelled by grid-connected PV installations, with approximately 3 366 MW_{DC} of new grid-connected PV capacity added in 2012. Because a reliable data source for off-grid systems is no longer available, new data presented here is for grid-connected systems only.

Grid-Connected PV: For the purposes of this report, distributed grid-connected PV systems are defined as residential and commercial applications, while centralized grid-connected PV systems are defined as utility applications. Distributed PV systems can be mounted on the ground near the facility, on the building roof, or integrated into the building roof, walls, or windows. Distributed generation is connected to the grid on the consumer side of the meter, usually at a facility or building that uses electricity and owns or leases the PV generation. By the end of 2012, there were nearly 303 000 distributed PV systems interconnected across the United States.

Centralized PV systems (utility applications) generate electricity that is fed directly to the grid, without serving an on-site load. This sector expanded from 784 MW_{DC} installed in 2011 to 1 803 MW_{DC} installed in 2012.

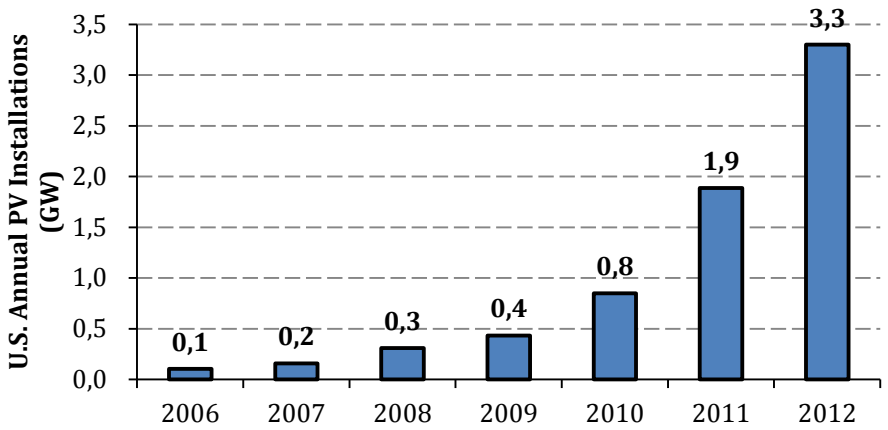
Several utilities in the U.S. lease customer roof space for PV generation that is fed directly back to the grid, often with the goal of placing systems "strategically" on the grid for grid support benefits. This emerging utility business now blurs the line between utility-scale and distributed PV. One of the largest utility rooftop programs is in California and has a target capacity of 250 MW, all in 1 MW to 5 MW segments.

Off-Grid PV: Off-grid systems have storage (usually deep-cycle, lead-acid batteries) and charge controllers that extend battery life and prevent the load from exceeding the battery discharge levels. Some off-grid systems are hybrids, with diesel or gasoline generators. Off-grid PV installations serve both the domestic and non-domestic market. Off-grid domestic PV systems are often used where utility-generated power is unavailable, or the customer requires back-up power and a second utility service is too costly. Applications also occur when the price of extending power lines costs more than a PV system. Off-grid domestic systems are ideal when only small amounts of power are needed, such as in residential applications in rural areas, boats, motor homes, travel trailers, vacation cottages, and farms. Most systems are rated at less than 1 kW, have several days of battery storage, and usually serve direct current (DC) loads. Some larger systems use stand-alone inverters to power alternating current (AC) loads and may include a diesel generator as backup.

Off-grid non-domestic PV systems are used in commercial, industrial, agricultural, and government activities. These include large PV and diesel hybrid power stations where grid connections are impractical. Telecommunications are often powered by PV for telephone, television, and secure communications, including remote repeaters and amplifiers for fibre optics. Additionally, off-grid PV systems supply power for data communication for weather and storm warnings and security phones on highways. In the United States, PV-powered lighting and signals are numerous along highways and in cities; they are used at bus stops, shelters, and traffic signals. Off-grid non-domestic PV is also used for pumping water into stock ponds and for irrigation control.

2.2 Total photovoltaic power installed

Figure 1 displays annual U.S. PV capacity additions from 2006 to 2012. In 2012, the U.S. added 3 366 MW of capacity, more than ten times the capacity added in 2008.



Sources: 2006-09 (IREC "Solar Market Trends" 2006-09); 2010-12 (GTM/SEIA "U.S. Solar Market Insight Q4 '12")

Figure 1: New U.S. PV Installations

Table 1 displays annual installed, grid-connected PV capacity for 2012 across two sub-markets. Annual installed PV capacity totals 3 366 MW in 2012, with grid-connected distributed capacity of 1 563 MW and grid-connected centralized capacity of 1 803 MW. For off-grid installations, domestic and non-domestic segmented data is unavailable for 2012.

Table 1: PV power installed during calendar year 2012 in 4 sub-markets.

Sub-market/ application	off-grid domestic	off-grid non-domestic	grid-connected distributed	grid-connected centralized	Total
PV power installed in 2012 (MW)	-	-	**1 563 MW**	**1 803 MW**	**3 366 MW**
Amount of CPV in the above (MW)		-	-	**(38 MW)**	
Amount of PV in hybrid systems (MW)	(…)				

Table 2 provides an estimate of cumulative PV capacity and annual installed PV capacity as percentages of cumulative and annual installed electricity generation capacity. Table 2 also depicts total PV energy production as a percentage of total electricity consumption.

Table 2: PV power and the broader national energy market.

Total national (or regional) PV capacity (from Table 1) as a % of total national (or regional) electricity generation capacity	New (2012) PV capacity (from Table 1) as a % of new electricity generation capacity	Total PV electricity production as a % of total electricity consumption
0,50 %	**9,87 %**	**0,23 % (in 2012)**

A summary of the cumulative installed PV Power, from 2003-2012, broken down into four sub-markets is shown in Table 3. While domestic and non-domestic segmented data for off-grid installations is unavailable for 2009 and 2010, the cumulative off-grid PV capacity installed in the United States at the end of 2010 is approximately 440 MW. In 2011-2012, data for off grid installed capacity is unavailable. (Data may differ from data reported in previous years because of the discovery of additional capacity and because of improved data collection methodology.)

Table 3: The cumulative installed PV power in 4 sub-markets.

Cumulative installed capacity as at 31 December										
Sub-market	2003 MW	2004 MW	2005 MW	2006 MW	2007 MW	2008 MW	2009 MW	2010 MW	2011 MW	2012 MW
Stand-alone domestic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stand-alone non-domestic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grid-connected distributed	59	115	193	298	449	731	1 108	1 731	2 781	4 344
Grid-connected centralized	14	16	17	17	26	42	100	340	1 124	2 927
TOTAL (MW)	73	131	201	315	475	773	1 208	2 071	3 907	7 273

Market Drivers

The United States PV market development is supported by financial incentives at both the federal and state levels, though policy drivers for renewable energy deployment remain at the state and local levels.

Federal Over the course of 2012, the federal government outlined the potential for a federal-level clean energy standard that would mandate a certain percentage of the nation's

energy portfolio be derived from "clean" sources. However, to date, a federal level mandate has yet to be implemented. Despite this lack of a national renewable energy policy framework, PV continues to grow rapidly in the United States as a result of local and state initiatives.

The United States supports the domestic installation and manufacturing of PV generating assets. Historically, federal incentives have been provided primarily through the U.S. tax code, in the form of an Investment Tax Credit (ITC) (which applies to residential, commercial, and utility-scale installations) and an accelerated 5-year tax depreciation (which applies only to systems owned by a business, including residential systems deployed under a lease or power purchase agreement). For commercial installations, the present value to an investor of the combination of these two incentives—which can be used only by tax-paying entities—amounts to about 56 % of the installed cost of a solar project.

In 2011, two additional federal programs supporting PV expired. They included the grant in lieu of tax credit through Section 1603 of the American Recovery and Reinvestment Act of 2009 (ARRA), as well as the temporary loan guarantee program through the Department of Energy (DOE), which provides loan guarantees for renewable energy installations and manufacturing facilities for renewable energy components. Because the Section 1603 grants allow businesses to receive a grant for projects which began construction in 2011, but are completed before the end of 2016, this program continued to fund the deployment of solar assets in 2012. The U.S. Department of Treasury dispersed 1,9 BUSD in grants in lieu of the Investment Tax Credit under Section 1603 to PV projects in calendar year 2012. In addition, many of the manufacturing and solar installations which received loan guarantees in 2011 or earlier, continued construction or operation of those assets in 2012. The three largest PV electric generation installations in 2012 each received loan guarantees for at least a portion of the project's capital cost.[1]

State, Local, and Utility State incentives in the United States have been driven in large part by the passage of Renewable Portfolio Standards (RPSs). An RPS, also called a renewable electricity standard (RES), requires electricity suppliers to purchase or generate a targeted amount of renewable energy by a certain date. Although design details can vary considerably, RPS policies typically enforce compliance through penalties, and many include the trading of renewable energy certificates (RECs). A clean energy standard (CES) is similar to an RPS, but allows a broader range of electricity generation resources to qualify for the target. As of December 31, 2012, sixteen states and Washington D.C. had RPS policies with specific solar provisions. Of the 14 states in 2012 with more than 10 MW of utility sector installations, 12 had an RPS, usually with a solar requirement.

In 2012, nine of the top ten state PV markets in the U.S. have state or utility rebate programs available for at least some of the installations. However, the importance of rebates is declining as their amount per watt has decreases over time. The largest rebate program in the country, the California Solar Initiative (CSI), has been reducing rebates in a planned manner for years and the rebates are planned to end in 2013.[2]

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[1] Sherwood, L. (July 2013). "U.S. Solar Market Trends 2012." Latham, NY: Interstate Renewable Energy Council (IREC).

[2] IBID.

2.3 PV implementation highlights, major projects, demonstration and field test programmes

The utility sector's share of all U.S. grid-connected PV installations grew from 5% in 2007 to 53 percent in 2012. Of the 10 largest PV installations in the United States, eight were completely or partially installed in 2012 (Figure 2). The five largest installations provide electricity for PG&E and are located in Arizona, California and Nevada.[3]

	Plant Name	Location	Size (MWDC)	Year Built	Utility Purchaser
1	Agua Caliente	Yuma, AZ	289	2012	PG&E
2	Mesquite Solar 1	Arlington, AZ	207	2011-12	PG&E
3	Copper Mountain Solar 1 & 2	Boulder City, NV	192	2010 & 2012	PG&E
4	California Valley Solar Ranch	San Luis Obispo County, CA	130	2012	PG&E
5	Alpaugh	Alpaugh, CA	66	2012	PG&E
6	Silver State Nevada	Primm, NV	58	2012	NV Energy
7	Kammerer	Sacramento, CA	38	2012	SMUD
8	San Luis Valley Solar Ranch	Mosca, CO	35	2012	Xcel
9	Cimarron	Cimarron, NM	35	2010	Tri-State
10	Webberville	Webberville, TX	35	2011	Austin Energy

Figure 2: Ten Largest U.S. PV Installations, as of 2012

2.4 Highlights of R&D

The DOE is one of the primary bodies that support research, development, and demonstration (R D & D) of solar energy technologies. In February 2011, the Secretary of Energy launched the SunShot Initiative, a program focused on driving innovation to make solar energy systems cost-competitive with other forms of unsubsidized energy. To accomplish this, the DOE is supporting efforts by private companies, academia, and national laboratories to drive down the cost of solar electricity to about $0,06 per kilowatt-hour. This, in turn, would enable solar-generated power to account for 15 % to 18 % of America's electricity generation by 2030. By funding selective RD&D concepts, the SunShot Initiative promotes a genuine transformation in the ways the United States generates, stores, and utilizes solar energy.

Examples of SETO-funded research and development activities include those that:

[3] IREC, 2013.

- Demonstrate and prove new concepts in materials, processes, and device designs to feed into component development at the laboratory scale, with subsequent component integration, engineering scale-up, and eventual commercial production.
- Research, development, and demonstration of new balance of system components including power electronics and building-integrated photovoltaics as well as investments in smart grid technologies that will enable higher penetrations of photovoltaic systems on the grid.
- Conduct applied scientific research that provides the technical foundation for significant increases in solar photovoltaic (PV) cell efficiency, to enable commercial and near-commercial PV technologies to achieve $1 per watt direct current installed system cost targets by the end of the decade.
- Provide $21M in funding to advance the development of a commercial "plug-and-play" PV system – an off-the-shelf product that is fully inclusive with little need for customization. The homeowner simply plugs the system into a PV-ready circuit, and an automatic PV discovery process initiates communication between the system and the utility.
- Provide $8M to fund projects that are helping utilities and grid operators better forecast when, where, and how much solar power will be produced at U.S. solar energy plants. Part of the SunShot Systems Integration efforts, the Solar Forecasting projects will allow power system operators to integrate more solar energy into the electricity grid, and ensure the economic and reliable delivery of renewable energy to American families and businesses.
- Implemented awards totaling $12M for the Rooftop Solar Challenge, an initiative in which cities, states, and regions were awarded funding to develop innovative ways to drive measurable improvements in market conditions for rooftop photovoltaic across the United States, with an emphasis on streamlined and standardized permitting and interconnection processes.

2.5 Public budgets for market stimulation, demonstration / field test programmes and R&D

Table 4: Public budgets for R&D, demonstration/field test programmes and market incentives.

	Total	R&D[4]	Demo/ Field test	Market incentives[5]
National/federal ($)	**261 556 771**	DOE: 194 476 277	DOE: 67 080 494	Sec 1603: 1,9 BUSD*
State/regional	Not Available			

[4] DOE is the Department of Energy Solar Energy Technology Program. This does not include funding from ARPA-E or the Office of Science within DOE.

[5] *Sec 1603 is the 30 % grant in lieu of the Investment Tax Credit. Only a portion of U.S. PV installations received Sec 1603 grants. It is estimated that an additional 1,6 BUSD in income tax credits were awarded to solar installation owners.

Table 4a Breakdown of Solar Energy Technologies Program FY 12 R&D Activities[6]

Activity	**USD**
Research	61 722 772
Development	132 753 505
Demonstration	54 296 297
Deployment	12 784 197
Total	**261 556 771**

3 INDUSTRY AND GROWTH

In the United States there are three companies that produce silicon feedstock: Hemlock Semiconductor Group, MEMC Electronics, and Renewable Energy Corp. Together, these companies produced 44 673[7] metric tons of polysilicon feedstock in 2012, representing approximately 25 % of the global market.[8] The United States has been able to remain competitive in raw materials for crystalline silicon (c-SI) photovoltaics by its experienced workforce and national advancements in feedstock refinement. China announced in July 2012 that it would launch anti-dumping and anti-subsidy probes on solar grade polysilicon products imported from the U.S. (along with South Korea and the European Union) in what many believed to be retaliatory measures against U.S. investigations into Chinese cell manufacturing. Preliminary measures have been instituted in 2013; however they only apply to polysilicon used for the Chinese domestic PV market.

Wafer manufacturing in the United States decreased 47 %, from 399 MW in 2011 to 211 MW in 2012, returning to the average production levels achieved in 2007-09[9]. There were four companies engaged in wafer manufacturing: Solar World America, Sanyo/Panasonic, Solar Power Industries, and SunEdison; however, Sanyo/Panasonic and Solar Power Industries each produced less than 10 MW in 2012.

Table 5 depicts production and capacity for U.S. polysilicon feedstock and wafers. In 2012, the spot price for polysilicon decreased from 32 USD/kg to 19 USD/kg.

[6] A portion of these funds was directed towards RD&D of concentrating solar power (CSP) technology, not photovoltaic technology.

[7] GTM/SEIA: U.S. Solar Market Insight Q2 2013.

[8] Chin, S. "UBS Investment Research Global Solar Industry Update." October 24, 2013.

[9] GTM Research, Wafer-Cell-Module Database, 2013.

3.1 Production of feedstocks, ingots, and wafers

Table 5: Production information for 2012 for silicon feedstock, ingot, and wafer producers[10]

Manufacturers (or total national production)	Process & technology	Total production	Maximum production capacity
Total	Silicon feedstock	44 673 tonnes	53 800 tonnes
Solar World America	Si wafers	150 MW	250 MW
SunEdison	Si wafers	54 MW	180 MW
Solar Power Industries	Si wafers	2 MW	-
Sanyo/Panasonic	Si wafers	5 MW	-
Total	Si wafers	211 MW	430 MW

3.2 Production of photovoltaic cells and modules

According to GTM Research, the United States produced 522 MW_{DC} of c-Si cells and 670 MW_{DC} of c-Si modules in 2012. With thin-film cell and module production totalling 279 MW_{DC}, U.S. production of c-Si continues to outpace U.S. production of thin films.

Total PV cell and module manufacture, together with production capacity information, is summarised in Table 6, below.

Table 6: Production and production capacity information for 2012[11]

Company	Technology	Total Production (MW/yr)		Production Capacity (MW/yr)	
Crystalline Silicon Manufacturers		Cell	Module	Cell	Module
1SolTech	Mono/Multi c-Si	-	14	-	35
Advanced Solar Photonics	Mono/Multi c-Si	-	40	-	100
Helios USA	Mono/Multi c-Si	-	16	-	40
Kyocera	Mono/Multi c-Si	-	10	-	30
Mage Solar	Mono/Multi c-Si	-	16	-	40

[10] GTM/SEIA: U.S. Solar Market Insight Q2 2013; GTM Research, Wafer-Cell-Module Database, 2013.

[11] GTM Research, Wafer-Cell-Module Database, 2013.

Motech	Mono/Multi c-Si	-	16	-	40
MX Solar	Mono/Multi c-Si	-	26	-	65
Pevafersa	Mono/Multi c-Si	-	8	-	20
Schott Solar	Mono/Multi c-Si	-	9	-	-
Sharp	Mono/Multi c-Si	-	116	-	210
Silicor Materials (CaliSolar)	Mono/Multi c-Si	6	-	-	-
Solar Power Industries	Mono/Multi c-Si	2	1	-	-
SolarWorld	Mono/Multi c-Si	412	243	500	350
Suniva	Mono/Multi c-Si	102	63	170	140
SunPower	Mono/Multi c-Si	-	61	-	75
Suntech Power	Mono/Multi c-Si	-	16	-	50
tenKSolar	Mono/Multi c-Si	-	2	-	20
Wanxiang	Mono/Multi c-Si	-	14	-	40
Sub-Total	**Mono/Multi c-Si**	**522**	**670**	**670**	**1,255**
Thin-Film Manufacturers					
Sencera	a-Si	-	1	-	-
Sunlogics (EPV/New Millenium)	a-Si	-	1	-	-
Xunlight	a-Si	-	3	-	25
First Solar	CdTe	-	229	-	280
GE	CdTe	-	3	-	30
WK Solar	CdTe	-	5	-	-
Ascent Solar	CIGS	-	2	-	20
Dow Solar	CIGS	-	2	-	25
Heliovolt	CIGS	-	2	-	20
ISET	CIGS	-	1	-	10
Miasole	CIGS	-	-	-	150
Nanosolar	CIGS	-	16	-	40
SoloPower	CIGS	-	4	-	50
Stion	CIGS	-	10	-	135
Sub-Total	**Thin-Film**		**279**		**785**
Grant-Total		**522**	**949**	**670**	**2,040**

As shown in Table 6, First Solar was the largest U.S. producer of thin-film modules in 2012. However, 88 % of its manufacturing occurred overseas with factories in Germany and

Malaysia. SunPower, another large U.S. solar manufacturer, produces all of its cells and 93 % of its modules in the Philippines.

3.3 Module prices

The average price of PV modules decreased 45 % from 2011 to 2012; 79% below its 10-year peak in 2007.

Table 7: Typical module prices for a number of years[12]

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Module ASP ($/W)	$2,65	$2,90	$3,03	$3,39	$3,50	$3,25	$2,18	$1,48	$1,37	$0,75

3.4 Manufacturers and suppliers of other components

Inverter manufacturing is one of the few sectors to grow, by production, in the U.S. solar supply chain. In 2012, the U.S. produced 2,7 GW of inverters—a growth from 2011 of 67 %—while its year-end capacity of 6,4 GW represents a reduction of 5% from year-end capacity in 2011. There continues to be a large amount of excess capacity; however the additional cost of that excess capacity is relatively low, and is made up for by the flexibility to respond to changes in demand. Within the residential U.S. market micro-inverters continued to increase their market-share—38% of California residential projects. "But bankability and reliability concerns continue to hinder their progress in third-party-ownership projects. Micro-inverters account for only 12% of the residential third party-ownership market in California."[13]

2012 factory-gate inverter prices ranged from 0,30 USD/W_{AC} to 0,34 USD/W_{AC} for residential (excluding micro-inverters which ranged from 0,61 USD/W_{AC} to 0,68 USD/W_{AC}); 0,24 USD/W_{AC} to 0,25 USD/W_{AC} for commercial; and 0,16 USD/W_{AC} to 0,19 USD/W_{AC} for utility-scale projects.[14]

3.5 System prices

Installed system prices continue to fall in the United States, driven by three primary factors: 1) falling module prices 2) the shift toward larger systems and 3) improved installation practices. While average system prices are still higher than those seen in Germany, the trend is clearly downward and hundreds of individual systems have been installed for less than 2,5 USD/W_{DC}. This downward trend is somewhat masked by the increasing popularity of third-party ownership of PV systems in the U.S. systems deployed under these lease or power purchase agreement structures tend to have higher installed prices that reflect higher financing transaction costs, as well as more substantial performance requirements. In total, the capacity-weighted average installed price fell from 4,55 USD/W in 2011 to 3,47 USD/W in 2012.

A summary of typical system prices is provided in tables 8 and 8a, below.

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[12] Mints, Paula. "The Solar Pricing Struggle." SPV Market Research. August 28, 2013. Accessed 10/28/13: http://www.renewableenergyworld.com/rea/news/article/2013/08/the-solar-pricing-struggle.

[13] GTM/SEIA: U.S. Solar Market Insight Q4 2012 & 2012 Year-in-Review

[14] IBID.

Table 8: **Turnkey Prices of Typical Applications**

Category/Size	Typical applications and brief details	Current prices per W (Q4 2012)
OFF-GRID Up to 1 kW	N/A	N/A
OFF-GRID >1 kW	N/A	N/A
GRID-CONNECTED Specific case	For example: 1-5 kW roof-mounted system, if relevant	
GRID-CONNECTED up to 10 kW		$5,04
GRID-CONNECTED >10 kW		$4,27
GRID – CONNECTED (utility-scale plant, if relevant)		$2,27

Table 8a: National trends in system prices (2012 USD/W) for Residential & Commercial PV[15]

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Median Price, ≤ 10 kW (USD/W)	$9,79	$9,16	$8,79	$8,85	$8,95	$8,60	$8,21	$6,97	$6,19	$5,31
Median Price, 10-100 kW (USD/W)	$9,40	$8,77	$8,43	$8,31	$8,58	$8,26	$7,91	$6,60	$5,70	$4,94
Median Price, > 100 kW (USD/W)	$8,24	$8,20	$8,01	$7,90	$7,58	$7,62	$7,69	$5,76	$4,92	$4,62

3.6 Labour places

In 2012 more than 119 000 people in the United States worked in the solar sector. This is an increase of approximately 13 500 places from 2011. These labour places are defined as those workers who spend at least 50 % of their time supporting solar-related activities, including the solar-thermal and concentrating solar power industries. While this may overestimate the labour figures for PV, it is the only comprehensive analysis available for the

[15] Barbose, G.; Darghouth, N.; Weaver, S.; Wiser, R. (2013). "Tracking the Sun VI: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012." Berkeley, CA: Lawrence Berkeley National Laboratory.

U.S. market. The methodology for calculating 2011 labour places was updated in 2012, and therefore is different from previous estimates.

Table 9: Estimated PV-related labour places in 2011 and 2012[16]

	2011	2012
Installation	48 656	48 656
Manufacturing	37 941	29 742
Sales & Distribution	13 000	16 005
Project Development	--	7 988
Other	5 548	8 105
Total	**105 145**	**119 016**

3.7 Business value

Table 9 provides the value of PV business in the United States for grid-connected systems. Because off grid installation data are incomplete, those data are not included in the country's value of PV business. Thus, the value of total PV business is higher than stated.

Table 10: Value of PV business

Sub-market	**Capacity installed *in 2012* (MW)**	**Price per W**	**Value (MM USD)**	**Totals (MM USD)**
Off-grid domestic	N/A	N/A	N/A	
Off-grid non-domestic	N/A	N/A	N/A	
Grid-connected distributed	**1 523**	**4,70 USD/W**	*7 151*	***7 151***
Grid-connected centralized	**1 803**	**2,43 USD/W**	*4 374*	***4 374***
Total			**11 525**	***11 525***
Export of PV products *(including information from Tables 4 & 5)*				*N/A*
Change in stocks held *(including information from Tables 4 & 5)*				*N/A*
Import of PV products *(including information from Tables 4 & 5)*				*N/A*

[16] National Solar Jobs Census 2012, undertaken by The Solar Foundation and BW Research Partnership. November 2012.

Value of PV business	***11 525***

4 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

The rate of PV deployment is subject to various non-technical factors in the United States Such factors include, but are not limited to, access to capital, federal government policies and support for PV projects, state-level policy initiatives, utility programs, and building codes. Table 10 lists the support measures for PV in the United States during 2012 and depicts the non-technical framework for PV deployment. Table 11a highlights the specific support measure of third-party ownership structures.

Table 10: PV support measures

	On-going measures
Renewable Energy Credit (REC) purchase programmes purchased separately from electricity	There are seven REC regional tracking systems or registries and at least 30 REC products available.
Capital subsidies for equipment or total cost	Federal: 30 % Investment Tax Credit, State: At least 22 states, the District of Columbia, and Puerto Rico offer capital subsidies
Green electricity schemes	To date, more than 860 utilities, including investor-owned, municipal utilities, and cooperatives, offer a green pricing option. For more information, visit www.eere.energy.gov/greenpower/.
Renewable portfolio standards (RPSs)	29 states plus the District of Columbia, Guam, Puerto Rico, and Virgin Islands, have an RPS.
PV requirement in RPS	16 states and the District of Columbia have solar or distributed generation provisions.
Investment funds for PV	Capital investment in solar companies declined to 2,5 BUSD in 2012 (from 8,0 BUSD); capital investment in PV projects increased to 11,5 BUSD (from 8.5 BUSD).
Income tax credits	Federal: federal investment tax credit of 30 % for residential, commercial, and utility systems. - About 1,6 BUSD in income tax credits were awarded to solar installation owners (excluding the 1,9 BUSD of 1603 U.S. Treasury grant awards). - State: 22 states offer tax credits for solar projects.
Net metering	43 states plus the District of Columbia and Puerto Rico have net metering policies. See the report, "Freeing the Grid," for a review of best practices.

	http://freeingthegrid.org/#download-ftg/
Net billing	
Other state and local activities	38 states plus Puerto Rico offer property tax incentives for renewable energy projects. 41 states offer loan programs for purchasing renewable energy projects.
Activities of electricity utility businesses	Several electricity utilities have begun engaging with PV development, either through direct ownership of centralized and distributed PV assets, partial ownership in PV development companies, or joint marketing agreements.
Sustainable building requirements	Federal: No federal codes exist, but DOE produces best-practices guides for sustainable building for both residential and commercial buildings

Table 11a: Third-party ownership, PV financing scheme

PV financing scheme
Third-Party Ownership The up-front capital requirements of PV installations often deter PV adoption. Innovative third-party financing schemes that address high up front capital requirements, such as solar leases and power purchase agreements (PPA), are becoming more prevalent. In 2012 approximately 69 % of residential systems installed through the California Solar Initiative[17] used third-party financing arrangements.

4.1 Indirect policy issues

In December of 2012, in an effort to make U.S. PV manufacturing more competitive, and to settle claims by U.S. manufacturers that Chinese manufacturers "dumped" product into the U.S. market and received unfair subsidies from the Chinese government, the U.S. Department of Commerce issued orders to begin enforcing duties to be levied on products with Chinese made PV cells. The majority of the tariffs range between 23% -34% of the price of the product. However, some U.S. PV manufacturers unsuccessfully filed a petition with the Department of Commerce seeking to extend the tariffs to modules assembled in China, claiming that Chinese manufacturers are circumventing these duties by sourcing their PV cells from Taiwan. China announced in July 2012 that it would launch anti-dumping and anti-subsidy probes on solar grade polysilicon products imported from the U.S. (along with South Korea and the European Union) in what many believed to be retaliatory measures against U.S. investigations into Chinese cell manufacturing. Preliminary measures have been instituted in 2013; however they only apply to polysilicon used for goods sold into the Chinese domestic PV market.

[17] In 2012, the California Solar Initiative composed 80 % of all California residential installed capacity, and 32 % of all U.S., residential installed capacity.

4.2 Interest from electricity utility businesses

Electricity utility interest continues to increase in the United States. The key drivers are policy—the federal tax credit (30 %) at the national level and RPSs at the state level. To date, four broad categories of utility solar business models have emerged in the United States: utility ownership of assets, utility financing of assets, development of customer programs, and utility purchase of solar output.[18]

Utility ownership of assets allows the utility to take advantage of the tax policy benefits and earn a rate of return on the asset (for investor-owned utilities), while providing control over planning, siting, operating, and maintaining the solar facilities. The variety of ownership explored in the United States is:

- Ratebasing solar on non-residential customer sites
- Ratebasing solar at substations and utility facilities
- Owning community solar equipment
- Owning inverters on customer sites
- Acquiring existing or new solar projects from developers in the present or future:
    - turnkey acquisition, or purchase and sale agreement
    - power purchase agreement with buy-out option
    - acquisition of sites for development
    - "flip" transactions that can take various forms.

The issues related to utility ownership include:

- Some state restructuring rules that do not allow generation utilities to own distributed generation
- State or commission policy or guidelines that prohibit or specifically limit utility ownership to specific conditions
- Regulatory or stakeholder concern about the rate impacts, utilities' costs relative to private market pricing and capabilities, ensuring that the utility operates in a fair and competitive environment, and related issues.

Utility Financing of Solar Assets is a solar business option for utilities that do not choose to own solar assets for tax, cost, regulatory, or competitive considerations. To be successful, regulators treat the financing and lost revenue costs associated with a solar project as assets, allowing the utility to earn a rate of return on "investment". Some of the options for this solar business model include:

- Ratebasing solar loans and recovering lost revenues
- Supporting turnkey installations and ratebasing shareholder loans
- Supporting a feed-in tariff (FIT) with solar revenue streams and ratebased shareholder loans.

[18] The Solar Electric Power Association has continued to define, research, and track utility solar business models since early 2008. These business models are differentiated from general market activity by the short- or long-term economic value (or future potential) they bring the utility and its ratepayers, relative to traditional market activity that often has negative utility value. See the following websites for more information.
http://www.solarelectricpower.org/media/156968/usbm%20executive%20summary.pdf and
http://www.solarelectricpower.org/media/84333/sepa%20usbm%201.pdf

Development of Customer Programs refers to utility programs that are designed to increase access to solar energy by lowering costs, for both the utility and the customer, compared to a traditional customer-sited photovoltaic system. Community solar programs involve a community or centralized 0,1 MW to 20 MW PV system. Specific classes of participating customers can be allocated a proportional share of the output from the system to directly offset their electric consumption bill (remote net metering) or the customers are offered a fixed-rate tariff that is competitive with retail rates or will be in the near future as electric prices increase.

Utility Purchase of Solar Output is a business model often applied by publically owned utilities (POUs) to create value to their communities through local solar development. Some POUs have developed a FIT to purchase solar power. Solar power purchases through a FIT are often made available instead of net metering, thus mitigating revenue erosion while providing a clear contractual understanding for purchase that supports financial viability for solar developers.

4.3 Interest from municipalities and local governments

Permitting and regulatory requirements for PV installations in the United States can vary greatly across the country's more than 18 000 authorities having jurisdiction (AHJ) and over 5 000 utility service territories. To date, the lack of standardization has posed a barrier to the rapid deployment of solar technology, though state and local governments are working to address this challenge. For example, Vermont has implemented a pre-defined permitting process for solar installations of 10 kW and under, to decrease paperwork processing times and regulatory uncertainty. Now, an installer or homeowner in Vermont can apply for all necessary permits for a proposed PV system with one, single registration form which specifies system components, configuration, and compliance with interconnection requirements. At the municipal level, the City of Los Angeles has moved towards decreasing permitting barriers by eliminating building height restrictions for roof mounted PV systems, as long as the system under consideration adheres to set-back requirements. Meanwhile, the City of Santa Cruz has demonstrated genuine leadership in promoting residential solar by eliminating building permits for PV systems that are not visible from public thoroughfares and do not extend more than 12 inches in height from the building's roof. As an increased number of states and cities adopt similar, streamlined permitting and interconnection models, greater PV deployment will likely be achieved.

4.4 Standards and codes

Model building codes in the United States are developed by the International Code Council. During the current revision cycle, there are many PV-related changes being considered, both for residential and commercial systems. The Solar Energy Industries Association, the Solar America Board of Codes and Standards, and the industry at-large is involved in the development process.

The most pressing topics in the development of product standards in the United States are the amendments to UL 1703, a safety standard for "Flat-Plate Photovoltaic Modules and Panels." A revised version of the standard was released in May, 2012 to address the need for a fire-safety test for photovoltaic *systems*, rather than for separate panels and modules.

5 Highlights and Prospects

In 2012, the U.S. residential, non-residential and utility-scale markets all experienced rapid growth, once again breaking a record for total and cumulative PV installations. PV capacity continues to be concentrated in a small number of states, which include California, Arizona and New Jersey. "After years of announcements and preliminary milestones, the first wave of truly utility-scale solar came on-line in 2012. Eight of the ten largest PV projects operating today were completed in 2012, including a number of recipients of the DOE Loan Guarantee program."[19] With 3,0 GW of PV projects under construction at the end of 2012, which have individual capacities above 5 MW in size, total installations in 2013 are expected to increase yet again. Though some incentive programs in the United States have expired or been reduced, many projects currently under construction have already qualified to receive an incentive award. Some of this growth has been attributed to the increased success of third-party-owned systems, particularly in the residential sector; in many residential markets this model represented over 50% of installs in 2012. In addition, PV component pricing, globally, has reached historic lows, which should further drive U.S. demand in the near future. In addition, although certain states with solar RPS goals have experienced short-term oversupply, current standards still mandate approximately 8,5 GW of PV capacity by 2025.

U.S. PV cell/module shipments in 2012, after five years of growth from 2006-10, declined for the second year in a row. Overcapacity issues persist in the global PV manufacturing, and many U.S. PV cell/module manufacturers have been unable to compete with lower-priced foreign manufacturers who were able to scale-up their production capacity more rapidly. However, U.S. manufacturers were able to compete effectively in other areas of the value-chain in 2012, such as PV inverters and polysilicon.

[19] GTM/SEIA: U.S. Solar Market Insight Q4 2012 & 2012 Year-in-Review.

ANNEX A: COUNTRY INFORMATION

1) Retail electricity prices (Annual Average 2012) *
All sectors: 0,0987 USD/kWh
Household: 0,1188 USD/kWh
Commercial: 0,1012 USD/kWh
Industrial: 0,0670 USD/kWh
Transportation: 0,1050 USD/kWh

Source: U.S. Department of Energy, Energy Information Administration

http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_3

*Note: these averages are not representative of all customers because electricity rates vary widely depending on service area.

2) Typical household electricity consumption (kWh)
In 2011, the latest year with information available, the average monthly electricity consumption was 940 kWh (126,1 million customers consuming 1 422,8 billion kWh).

Source: U.S. Department of Energy, Energy Information Administration

http://www.eia.gov/electricity/data.cfm#sales

3) Typical metering arrangements and tariff structures for electricity customers (for example, interval metering? time-of-use tariff?)

These rules vary from state to state and utility to utility.

4) Typical household income
In 2012 the median annual household income was
51 017 USD.

Source: United States Census Bureau

http://www.census.gov/newsroom/releases/archives/income_wealth/cb13-165.html

5) Typical mortgage interest rate, 2012 (Freddie Mac)
30-year fixed: ranged from 4,08 % to 3,31 %; average: 3,66 %
15-year fixed: ranged from 3,30 % to 2,63 %; average: 2,93 %

Source: Freddie Mac – Historical Rate Tables

http://www.freddiemac.com/pmms/index.html?year=2012

6) Voltage (household, typical electricity distribution network)

Approximately 120 V_{AC}

7) Electricity industry structure and ownership
The United States' utility industry structure and ownership model is diverse and varies between deregulated and regulated markets. A brief overview is provided below:

Investor-owned electric companies. Sell power at retail rates to several different classes of customers and at wholesale rates (for resale) to state and local government-owned utilities, public utility districts, and rural electric cooperatives. Account for about 55 % of total kWh sales in the United States.

Source: http://www.publicpower.org/files/PDFs/USElectricUtilityIndustryStatistics.pdf

Publicly owned electric utilities. Owned by the city or municipality in which they operate and are financed through municipal bonds. They are self-regulated. Approximately 15 % of the kilowatt-hours sold each year come from the 2 000 municipally-owned systems.

Source: http://www.publicpower.org/files/PDFs/USElectricUtilityIndustryStatistics.pdf

Electric cooperatives. Private, independent electric utilities that are owned by the members they serve. Democratically governed businesses, electric cooperatives are organized under the Cooperative or Rochdale Principles, which anchor them firmly in the communities they serve and ensure that they are closely regulated by their consumers. Deliver 5 % of the total kilowatt hours sold in the United States each year.

Source: http://www.publicpower.org/files/PDFs/USElectricUtilityIndustryStatistics.pdf

8) Price of diesel fuel
3,97 USD per gallon in 2012

Source: U.S. Department of Energy, Energy Information Administration

http://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_nus_a.htm

9) Typical values of kWh / kW for PV systems in parts of your country.
Typical solar radiation in the United States ranges from 3 kWh/m^2/day to 7 kWh/m^2/day

Source: The National Renewable Energy Laboratory,

http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/