

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 2011

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Definitions, Symbols and Abbreviations

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

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

<u>Installed PV power</u>: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m², cell junction temperature of 25°C, AM 1,5 solar spectrum – (also see 'Rated power').

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

<u>PV system</u>: 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.

<u>CPV:</u> Concentrating PV

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

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

<u>Off-grid domestic PV power system</u>: 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.

<u>Off-grid non-domestic PV power system</u>: 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'.

<u>Grid-connected distributed PV power system</u>: System installed to provide power to a gridconnected 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.

<u>Grid-connected centralized PV power system</u>: 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.

<u>Turnkey price</u>: 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).

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

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

<u>Market deployment initiative</u>: 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.

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

<u>Performance ratio</u>: 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).

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

PV support measures:

	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 22 participating countries are Australia (AUS), Austria (AUT), 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 and the US Solar Energy Industries Association are also members.

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 2011. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

The PVPS website <u>www.iea-pvps.org</u> 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 1 867 MW of PV (including CPV) grid-connected generating capacity in 2011, bringing cumulative installed capacity to 3 966 GW. This represents an 88 % growth in cumulative capacity over 2010. More than 60 000 PV systems were connected in 2011, compared to 50 000 in 2010, for a 20 % growth in the number of grid-connected systems installed annually. At the state level, California represents 29 % of new capacity in 2011 compared to 32 % in 2010, indicating stronger growth in other states.

By the end of 2011, there were approximately 214 000 distributed, grid-connected solar electric systems installed in the United States; the nation added 770 MW of utility-scale generation capacity that year alone.

1.2 Costs & prices

From Q1 2011 to Q4 2011, national weighted average system prices fell by 23 %, from a high of 5,33 USD/ W_{DC} to 4,08 USD/ W_{DC} . However, when examining system prices on a perwatt basis, it is important to highlight that much of this decline is attributed to an increased share of large-scale, utility PV installations in 2011.

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 69 USD/kg to 43 USD/kg, from Q1 2011 to Q4 2011. Meanwhile, the price of modules declined from 1,78 USD/W_{DC} to 1,15 USD/W_{DC} for the same period.

1.3 PV Production

In 2011, the United States produced approximately 1 322 MWp of PV modules. A breakdown of module production, by technology, is provided below.

Technology	2011 Annual	2011 Annual
	Capacity (MW _{DC})	Production (MW _{DC})
Crystalline silicon	1 312	786
Thin film	972	536
Total	2 284	1 322

1.4 Budgets for PV

The U.S. Department of Energy (DOE) allocated a research, development, demonstration, and deployment (R D & D) budget of 259,5 MUSD to the Solar Energy Technologies Program (SETP) in fiscal year (FY) 2011 (October 2010 to September 2011). These funds financed RD&D activities in partnership with national laboratories, universities, private industry, sub-national governments, and non-governmental organizations. To obtain SETP 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. The U.S. Department of Treasury dispersed 1,1 BUSD in grants in lieu of the Investment Tax Credit under Section 1603 to PV projects. Under the Loan Program Office, the DOE closed deals, committing to guarantee 5,6 BUSD in loans on seven PV electric generation projects totaling 2,3 GW_{AC} of combined capacity, and 0,4 BUSD on two PV manufacturing facilities totaling 1,1 GW_{DC} of combined production capacity.

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 1 867 MW_{DC} of new grid-connected PV capacity added in 2011. 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 2011, there were nearly 214 000 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 267 MW_{DC} installed in 2010 to 770 MW_{DC} installed in 2011.

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 2005 to 2011. In 2011, the U.S. added 1 867 MW of capacity, more than double the capacity added in 2010.

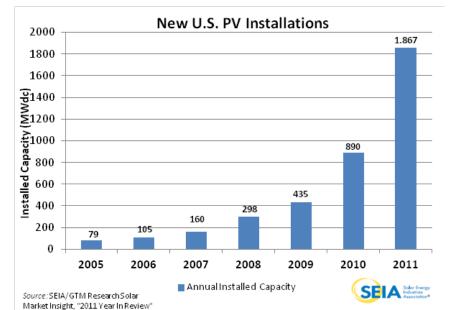


Figure 1: New U.S. PV Installations

Table 1 displays annual installed, grid-connected PV capacity for 2011 across two submarkets. Annual installed PV capacity totals 1 867 MW in 2011, with grid-connected distributed capacity of 1 097 MW and grid-connected centralized capacity of 770 MW. For off-grid installations, domestic and non-domestic segmented data is unavailable for 2011.

Sub-market/ application	off-grid domestic	off-grid non-domestic	grid- connected distributed	grid- connected centralized	Total
PV power installed in 2011 (MW)	-	-	1 097 MW	770 MW	1 867 MW
Amount of CPV in the above (MW)		-	-	(12 MW)	
Amount of PV in hybrid systems (MW)		()			

 Table 1: PV power installed during calendar year 2011 in 4 sub-markets.

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.

Total national (or regional) PV <u>capacity</u> (from Table 1) as a % of total national (or regional) electricity generation capacity	<u>New</u> (2011) PV capacity (from Table 1) as a % of new electricity generation capacity	Total PV <u>electricity</u> production as a % of total electricity consumption
0,38 %	9,40 %	0,14 % (in 2011)

Table 2:	PV power and t	the broader national	energy market.
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A summary of the cumulative installed PV Power, from 2002-2011, 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, 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.)

	Cumulative installed capacity as at 31 December									
Sub- market	2002 MW	2003 MW	2004 MW	2005 MW	2006 MW	2007 MW	2008 MW	2009 MW	2010 MW	2011 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	17	59	115	193	298	449	731	1 108	1 731	2 828
Grid- connected centralized	11	14	16	17	17	26	42	100	367	1 137
TOTAL (MW)	28	73	131	201	315	475	773	1 208	2 099	3 966

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

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.

<u>Federal</u> Over the course of 2011, 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 that supported PV expired. A short-term program, established through Section 1603 of the American Recovery and Reinvestment Act of 2009 (ARRA), allows owners of non-residential solar energy property, who would otherwise receive the 30 % federal ITC, to receive an up-front 30 % cash grant instead. This choice is intended to reduce the solar industry's reliance on third-party tax-equity investors, many of whom dropped out of the solar finance market in late 2008 because their tax base was decimated by the global financial crisis. As of October 31, 2011 the program had awarded 22 060 awards to 870 MW of solar projects. To be eligible for this program, projects must have begun construction by December 31, 2011, and must be placed in service by the end of 2016.

The ARRA also established a 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. Under a loan guarantee, a government entity promises to assume a private entity's debt if the private entity defaults on its repayment obligations. The DOE, which was required to finalize all awards by September 31, 2011, guaranteed loans for seven PV generating assets, totalling 6,1 BUSD, and four PV manufacturing facilities, totalling 1,3 BUSD.

<u>State, Local, and Utility</u> 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, 2011, sixteen states and Washington D.C. had RPS policies with specific solar provisions.

Several other emergent policy and financing mechanisms have potential to incite further solar market expansion through the establishment of widespread local and utility programs. Such policies include state-level feed-in tariffs and time of use rate structures. Previously, innovative public/private financing programs that allowed property owners to finance PV systems through adjustments to their property taxes were gaining traction in the United States. However, such programs, commonly referred to as Property Assessed Clean Energy (PACE) programs, stalled in 2011 as a result of Federal Housing Finance Administration concerns over the fact that PACE assessments establish senior liens with priority over existing mortgages.

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

2011 was marked by a number of notable large-scale PV projects, with 28 projects over 10 MW_{DC} coming online. Most notably, the first 48 MW phase of the 150 MW Mesquite Solar Project in Arizona, the 38 MW San Luis Valley Solar Ranch in Colorado, the 37 MW Long Island Solar Farm in New York, and the 34 MW Webberville Solar Farm in Texas were all completed in 2011. There were an additional 3 GW of utility scale projects under construction throughout the year as well. Several large PV projects, funded by the DOE Loan Guarantee Program, broke ground in 2011, including the 250 MW California Valley Solar Ranch, and the 550 MW Desert Sunlight projects in California. Figure 2, below, depicts utility-scale PV projects in the United States.

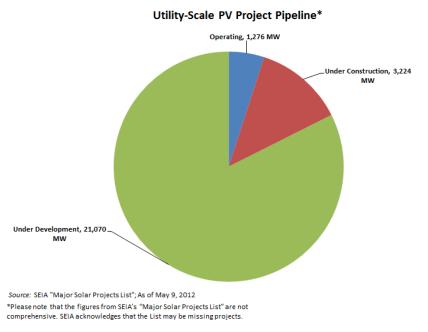


Figure 2: Utility Scale PV Projects in the U.S.

2.3 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 SETP-funded research and development activities include those that:

- 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, develop, and demonstrate new balance of system components, including power electronics and building-integrated photovoltaics, as well as investments in smart grid technologies, to enable higher penetrations of photovoltaic systems on the grid.
- Conduct applied scientific research that provides the technical foundation for significant increases in solar PV cell efficiency, to enable commercial and nearcommercial PV technologies in achieving installed system cost targets of \$1 per watt direct current by the end of the decade.
- Provide up to 12,5 MUSD for the Rooftop Solar Challenge, an initiative in which cities, states, and regions are awarded funding to develop innovative ways to drive measurable improvements in market conditions for rooftop PV across the United States, with an emphasis on streamlined and standardized permitting and interconnection processes.

2.4 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 ¹	Demo/ Field test	Market incentives ²
National/federal (\$)	259 464 461	DOE: 222 933 496	9 577 303	Sec 1603: 1,1 BUSD*
State/regional	Not Available			

Table 4a Breakdown of Solar Energy Technologies Program FY 11 R&D Activities

Activity	USD
Research	88 686 697
Development	134 246 799
Demonstration	9 577 303

¹ 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.

² *Sec 1603 is the 30 % grant in lieu of the Investment Tax Credit. ** LPO is the Loan Guarantee Program.

Deployment	26 953 662
Total	259 464 461

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 40 658 metric tons of polysilicon feedstock in 2011, representing 19 % of the global market. All three companies rank amongst the world's top six polysilicon producers. However, the United States has lost market-share to polysilicon producers in China and South Korea, which produced 35 % and 16 % of global polysilicon in 2011 respectively³. 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.

Wafer manufacturing in the United States decreased 34 %, from 542 MW in 2010 to 360 MW in 2011, after having grown 79 % from 2009 to 2010⁴. There were four companies engaged in wafer manufacturing: Solar World America, Evergreen Solar, Solar Power Industries, and MEMC Electronics; however, in March 2011, Evergreen Solar closed its 160 MW wafer-cell-module facility. Of the three remaining companies, MEMC Electronics remains the only one that is not fully vertically integrated.

Table 5 depicts production and capacity for U.S. polysilicon feedstock and wafers. In 2011, the spot price for polysilicon decreased from 69 USD/kg to 43 USD/kg.

3.1 Production of feedstocks, ingots, and wafers

Table 5: Production information for 2011 for silicon feedstock, ingot, and wafer producers $^{\rm 5}$

Manufacturers (or total national production)	Process & technology	Total production	Maximum production capacity
Hemlock Semiconductor Group	Silicon feedstock	23 716 tonnes	29 300 tonnes
REC	Silicon feedstock	12 867 tonnes	16 000 tonnes
MEMC	Silicon feedstock	4 075 tonnes	6 000 tonnes
Total		40 658 tonnes	51 300 tonnes

³ GTM Research

⁴ Ibid.

Solar World America	Si wafers	163 MW	250 MW
МЕМС	Si wafers	135 MW	180 MW
Solar Power Industries	Si wafers	36 MW	56 MW
Evergreen Solar	Si wafers	26 MW	0 MW
Total		360 MW	486 MW

3.2 Production of photovoltaic cells and modules

According to GTM Research, the United States produced 509 MW_{DC} of c-Si cells and 786 MW_{DC} of c-Si modules in 2011. With thin-film cell and module production totalling 547 MW_{DC} , U.S. production of c-Si continues to outpace U.S. production of thin films. However, the United States is a leader in early stage thin-film PV technologies over other countries, because thin films are less labour intensive than c-Si modules and require a skilled workforce to maintain high efficiencies and production yields. Moreover, the United States has a well-established specialty-gas infrastructure, which includes the production of trichlorosilane, a by-product of polysilicon feedstock production. Such gases can be used in thin-film manufacturing, furthering the United States' comparative advantage in thin-film PV.

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

Company	Technology	Total Production (MW/yr)		Production Capacity (MW/yr)	
Crystalline Silicon Manufacturers		Cell	Module	Cell	Module
Evergreen Solar	Mono/Multi c-Si	24	16	0	0
SolarWorld	Mono/Multi c-Si	291	291	500	350
Solar Power Industries	Mono/Multi c-Si	30	13	50	50
Suniva	Mono/Multi c-Si	119	43	170	90
Silicor Materials (CaliSolar)	Mono/Multi c-Si	45		75	-
Schott Solar	Mono/Multi c-Si	-	64	-	85
Sharp	Mono/Multi c-Si	-	116	-	210
Solon	Mono/Multi c-Si	-	15	-	0
Motech	Mono/Multi c-Si	-	24	-	40
Pevafersa	Mono/Multi c-Si	-	12	-	20

Table 6: Production and	production ca	pacity information	for 2011
	production ou	puolity innormation	

			1		
Wanxiang	Mono/Multi c-Si	-	10	-	20
1SolTech	Mono/Multi c-Si	-	17	-	35
Helios USA	Mono/Multi c-Si	-	17	-	40
Kyocera	Mono/Multi c-Si	-	14	-	30
Mage Solar	Mono/Multi c-Si	-	24	-	40
Suntech Power	Mono/Multi c-Si	-	35	-	50
SunPower	Mono/Multi c-Si	-	42	-	75
Advanced Solar Photonics	Mono/Multi c-Si	-	0	-	100
MX Solar	Mono/Multi c-Si	-	29	-	65
tenKSolar	Mono/Multi c-Si	-	7	-	12
Thin-Film Manufactu	irers		-	-	
Abound Solar	CdTe	36	36	65	65
Applied Quantum Technology (AQT)	CIGS	3	3	15	15
Ascent Solar	CIGS	6	6	20	20
Dow Solar	CIGS	1	1	5	5
First Solar	CdTe	242	242	252	252
Global Solar	CIGS	8	8	40	40
Heliovolt	CIGS	4	4	20	20
ISET	CIGS	2	2	10	10
MiaSole	CIGS	60	60	150	150
Nanosolar	CIGS	10	10	40	40
Nuvosun	CIGS	6	6	40	40
GE	CdTe	12	12	30	30
Sencera	a-Si	7	7	35	35
SoloPower	CIGS	2	2	10	10
Solyndra	CIGS	60	60	0	0
Stion	CIGS	1	1	10	10
Sunlogics (EPV/New Millenium)	a-Si	4	4	20	20
United Solar	a-Si	55	55	150	150
WK Solar	CdTe	25	25	90	90
Xunlight	a-Si	5	5	25	25
Grant Total		1 056	1 333	1 822	2 339

As shown in Table 6, First Solar was the largest U.S. producer of thin-film modules in 2011. 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 96 % of its modules in the Philippines. In 2011, Total, a French oil company, purchased a majority of SunPower's shares.

3.3 Module prices

The average price of PV modules decreased 14 % for large buyers and 29 % for mediumscale buyers from 2010 to 2011. However, these numbers do not fully reflect the true price reductions that occurred in 2011, because factory-gate prices fell below 1 USD/W at the end of the year.

Table 7: Typical module prices for a number of years	Table 7: Typic	al module pri	ces for a nu	mber of years ⁶
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Year	1995	2000	2005	2008	2009	2010	2011
Standard module price(s): Typical (Mid-range buyers, USD/W)	\$5,01	\$3,79	\$3,65	\$3,65	\$2,82	\$2,36	\$1,67
Best price (Large quantity buyers, USD/W)	\$4,90	\$2,75	\$3,03	\$3,25	\$2,18	\$1,48	\$1,28

3.4 Manufacturers and suppliers of other components

Inverter manufacturing is one of the few sectors to grow, by production and capacity, in the U.S. solar supply chain. In 2011, the U.S. produced 1,6 GW of inverters and had a year-end capacity of 7,3 GW—a growth from 2010 of 58 % and 122 % respectively. While there is a large amount of excess capacity, the additional cost of that excess capacity continues to be relatively low, and is made up for by the flexibility to respond to changes in demand. "One of the unique opportunities in the U.S. market is the growing acceptance and adoption of distributed optimization, which includes low-voltage inverters, microinverters, and DC power optimizers. As a whole, the distributed optimization space rose to 18,9 MW, accounting for 21,6 % of residential installations in the fourth quarter of 2011. While microinverters represent 93 % of distributed optimization right now, acceptance of DC optimizers is continuing to grow."⁷

2011 factory-gate inverter prices ranged from 0,34 USD/W_{AC} to 0,44 USD/W_{AC} for residential; 0,23 USD/W_{AC} to 0,29 USD/W_{AC} for commercial; and 0,20 USD/W_{AC} to 0,23 USD/W_{AC} for utility-scale projects.

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

⁶ Navigant Consulting (2012), Photovoltaic Manufacturer Shipments, Capacity & Competitive Analysis 2011/2012, Report NPS-Supply7 (April 2012)

⁷ GTM/SEIA : U.S. Solar Market Insight Q4 2011 & 2011 Year-in-Review

than 3 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 5,79 USD/W in 2010 to 4,75 USD/W in 2011.

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

Category/Size	Typical applications and brief details	Current prices per W (Q4 2011)
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		\$6,14
GRID-CONNECTED >10 kW		\$4,80
GRID – CONNECTED (utility-scale plant, if relevant)		\$3,62

 Table 8: Turnkey Prices of Typical Applications

Table 8a: National trends in system prices (current) for (specify application,
for example from table 8 above)

YEAR	2006	2007	2008	2009	2010	2011
Blended Average Price USD/W	\$7,90	\$7,90	\$7,60	\$7,50	\$5,79	\$4,75

3.6 Labour places

In 2011 more than 100 000 people in the United States worked in the solar sector. This is an increase of approximately 6 500 places from 2010. 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 U.S. market. The methodology for calculating 2010 labour places was updated in 2011, and therefore is different from previous estimates.

	2010	2011
Installation	43 934	52 503
Manufacturing	24 916	24 064
Sales & Distribution	11 744	17 722
Other	12 908	5 948
Total	93 502	100 237

Table 9: Estimated PV-related labour places in 2010 and 2011⁸

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.

Sub-market	Capacity installed <i>in</i> <i>2011</i> (MW)	Price per W (from table 8)	Value (USD)	Totals (USD)
Off-grid domestic	N/A	N/A	N/A	
Off-grid non-domestic	N/A	N/A	N/A	
Grid- connected distributed	1 097	5,31 USD/W	5 820 750	5 820 750
Grid- connected centralized	777	3,34 USD/W	2 536 210	2 536 210
Total			8 356 960	8 356 960
Export of PV pro	N/A			
Change in stock	N/A			
Import of PV pr	N/A			
Value of PV busin	8 356 960			

Table 10: Value of PV business

⁸ National Solar Jobs Census 2011, undertaken by The Solar Foundation and BW Research Partnership. October 2011.

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 2011 and depicts the non-technical framework for PV deployment. Table 11a highlights the specific support measure of third-party ownership structures.

	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 20 states, the District of Columbia, and Puerto Rico offer capital subsidies
Green electricity schemes	Green pricing programs are offered by utilities in 41 states. More than 20 states have environmental disclosure policies in place, requiring electricity suppliers to provide information on fuel sources used and, in some cases, emissions associated with electricity generation.
	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	U.S. private sector capital investment reached 8,4 BUSD in 2011.
Income tax credits	 Federal: federal investment tax credit of 30 % for residential, commercial, and utility systems. About 1,4 BUSD in income tax credits were awarded to solar installation owners. 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://www.newenergychoices.org/uploads/Freeing TheGrid2010.pdf
Net billing	
Other state and local activities	38 states plus Puerto Rico offer property tax incentives for renewable energy projects.
	38 states offer loan programs for purchasing renewable energy projects.
Activities of electricity utility businesses	
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 2011 approximately 47 % of residential systems installed through the California Solar Initiative⁹ used third-party financing arrangements.

4.1 Indirect policy issues

In October, 2011 SolarWorld, on behalf of a coalition of seven solar panel manufacturers, filed a complaint with the U.S. International Trade Commission (ITC) and Commerce Department. They alleged that Chinese module makers 1) sold products in the United States for less than fair value ("dumping") and 2) received unfair subsidies from the Chinese government. For these reasons, the coalition asked that the ITC and Commerce Department impose duties on cells/modules between 50 % - 250 % of their imported price. If the ITC and Commerce Department do agree to impose tariffs, this has the potential to disrupt trade between the two countries, increase the underlying price of all modules sold in the United States (because Chinese panels are viewed as the cause for low module prices), or induce China to impose retaliatory counter-tariffs on U.S. solar goods (for example, polysilicon, PV manufacturing equipment). A final decision is expected in the second half of 2012.

⁹ In 2011, the California Solar Initiative composed 93 % of all California residential installed capacity, and 36 % 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.¹⁰

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:
 - o turnkey acquisition, or purchase and sale agreement
 - power purchase agreement with buy-out option
 - o acquisition of sites for development
 - o "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

¹⁰ 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

• Supporting a feed-in tariff (FIT) with solar revenue streams and ratebased shareholder loans.

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." The standard is currently being updated to address the need for a fire-safety test for photovoltaic *systems*, rather than for separate panels and modules.

5 HIGHLIGHTS AND PROSPECTS

Date

Much of the growth in installed PV capacity, especially in the second half of 2011, came from non-residential and utility-scale installations. PV capacity continues to be concentrated in a small number of states, which include California and New Jersey. With 2,4 GW of PV projects under construction at the end of 2011, which have individual capacities above 5 MW in size, total installations in 2012 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. 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. manufacturing, which doubled its PV cell/module shipments from 2009 to 2010, faced some difficulty in 2011. Because of overcapacity issues in global PV manufacturing, which caused a rapid decline in price, three U.S. manufacturing companies filed for bankruptcy in August and September of 2011. In addition, others closed facilities or delayed capacity expansion. However, some companies did announce plans for large increases in manufacturing capacity. GE announced plans to build a 400 MW PV manufacturing facility, coming on-line by 2013. The DOE also awarded two loan guarantees to PV manufacturing facilities in 2011, with a combined capacity of 1,1 GW.

ANNEX A: COUNTRY INFORMATION

1) Retail electricity prices (Annual Average 2011) * All sectors: 0,0999 USD/kWh Household: 0,1180 USD/kWh Commercial: 0,1032 USD/kWh Industrial: 0,0689 USD/kWh Transportation: 0,1058 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.

- Typical household electricity consumption (kWh) In 2010, the latest year with information available, the average monthly electricity consumption was 958 kWh (125,7 million customers consuming 1 445,7 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 2010, the latest year with data available, real median annual household income was

49 445 USD.

Source: United States Census Bureau

http://www.census.gov/prod/2011pubs/p60-239.pdf

5) Typical mortgage interest rate, 2011 (Freddie Mac) 30-year fixed: ranged from 5,05 % to 3,91 %; average: 4,45 % 15-year fixed: ranged from 4,29 % to 3,21 %; average: 3,68 %

Source: Freddie Mac – Historical Rate Tables

http://www.freddiemac.com/pmms/index.html?year=2011

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:

<u>Investor-owned electric companies</u>. 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 73 % of total kWh sales in the United States.

Source: http://www.nreca.org/members/Co-opFacts/Pages/default.aspx

<u>Publicly owned electric utilities</u>. Owned by the city or municipality in which they operate and are financed through municipal bonds. They are self-regulated. Approximately 11 % of the kilowatt-hours sold each year come from the 2 000 municipally-owned systems. Publicly owned utilities also include public utility districts and public power districts, State authorities, irrigation districts, and joint municipal action agencies, which supply another 4 % of sales.

Sources: http://www.nreca.org/members/Co-opFacts/Pages/default.aspx http://www.eia.doe.gov/cneaf/electricity/page/prim2/toc2.html

<u>Electric cooperatives</u>. 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 10 % of the total kilowatt hours sold in the United States each year.

Source: http://www.nreca.org/members/Co-opFacts/Pages/default.aspx

Price of diesel fuel
 3,84 USD per gallon in 2011

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/m²/day to 7 kWh/m²/day

Source: The National Renewable Energy Laboratory,

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