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 2008

Prepared for the U.S. Department of Energy

by the National Renewable Energy Laboratory

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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^{o}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.

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, utilities, 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 U.S. Dollars.

PV support measures:

Enhanced feed-in tariff	an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility) 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, usually at a premium price
PV-specific green electricity schemes	allows customers to purchase green electricity based on PV electricity from the electricity utility, usually at a premium price
Renewable portfolio standards (RPS)	a mandated requirement that the electricity utility (often the electricity retailer) source a portion of their electricity supplies from renewable energies (usually characterized by a broad, least-cost approach favouring hydro, wind and biomass)
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	in effect the system owner receives retail value for any excess electricity fed into the grid, as recorded by a bi-directional electricity meter and netted over the billing period
Net billing	the electricity taken from the grid and the electricity fed into the grid are tracked separately, and the electricity fed into the grid is valued at a given price
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
Electricity utility activities	includes 'green power' schemes allowing customers to purchase green electricity, large-scale utility 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 footprint 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 21 participating countries are Australia (AUS), Austria (AUT), Canada (CAN), 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 and the European Photovoltaic Industry Association are also members.

The overall programme is headed by an Executive Committee (ExCo) composed of one representative from each participating country while the management of individual Tasks (research projects / activity areas) is the responsibility of Operating Agents (OAs). Information about the active and completed tasks can be found on the IEA-PVPS Web site: 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 United States National Survey Report for the year 2008. Information from this document will be used as input for the annual Trends in the photovoltaic applications report.

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

1 EXECUTIVE SUMMARY

The U.S. Federal Investment Tax Credit (ITC) legislation had a great impact on the photovoltaics (PV) power industry during 2008. First, anxiety over the possible expiration of the ITC on 1 January 2009 encouraged a rush by businesses and consumers to install systems using the existing credits. Then, on 3 October 2008, the Emergency Economic Stabilization Act of 2008 (P.L. 110-343) was passed that extended the 30 % commercial ITC through December 2016, eliminated the monetary cap for the ITC applied to residential solar electric installations, and allowed utility companies and alternative minimum tax filers to take the tax credit.

However, the contraction of the global economy has cast uncertainty on the effect of the ITC and other incentives in a time of tight lending and limited tax equity.

Throughout 2008, the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Program conducted programs aimed at developing pilot production of innovative cell technologies, bringing cross-cutting PV products to market and promoting advanced grid developments to accommodate high capacities of PV generation. Important utility-scale PV projects were completed in 2008, supported by federal, state, and local government incentives, and new industry programs — power purchase agreements (PPAs), discounts on employee PV purchases, leasing plans, and community group purchases — also boosted the market.

1.1 Installed PV power

Total U.S. PV capacity increased by an estimated 338 MW (44 %) in 2008 (293 MW grid-tied and 45 MW off-grid) for an estimated total of 1 168 MW of cumulative installed PV capacity at the close of 2008. California accounted for nearly 63 % of all grid-connected PV installations in the country. This is a decrease from the 70 % share of California at the end of 2007. Other states also installed significant new capacity in 2008, including New Jersey, Colorado, Nevada, Hawaii, New York, and Arizona.

1.2 Costs & prices

The installed cost of grid-connected PV systems remained nearly constant as the cash subsidies, especially in California, decreased from 4,50 USD/W installed in 2000 to 2 USD/W in 2007. The installed prices remained relatively constant at 7 USD – 8 USD/W despite increased module prices. Some high-volume customers, primarily builders, were sold systems at low prices of 6,50 USD/W. Reductions in installed costs to compensate for higher module costs were made possible by volume discounts, reduced labour costs owing to increased volume of installations and module efficiency increases, and reduced profits.

A recent study shows that the average cost of PV power systems in the U.S. declined significantly from 1998 to 2007 but remained relatively flat during 2006 and 2007. The 37,000 grid-connected PV systems installed between 1998 and 2007 in 12 states showed average installed costs (2007 dollars) declined from 10,50 USD/W in 1998 to 7,60 USD/W in 2007. The reduction in non-module costs accounted for most of the overall decline falling from 5,7 USD/W to 3,6 USD/W, representing 73 % of the average decline in total installed costs over this period. The cost reduction over time was largest for residential systems. Systems completed in 2006 or 2007 that were less than 2 KW averaged 9,00 USD/W while systems larger than 750 kilowatts averaged 6,80 USD/W. Installed costs varied from a low of 7,60 USD/W Arizona followed by California at 8,10 USD/W and New Jersey at 8,40 USD/W. The highest installed costs were 10,60 USD/W in Maryland.

1.3 PV production

In 2008, the United States provided nearly 412 MW of PV cell production, a growth of more than 52 % over 2007. In addition, production capacity exceeded 685-MW d.c. by the end of the year and was expected to reach 1 150-MW d.c. by the end of 2009. Nearly 54 % of this total was in the form of thin-film modules (EPV Solar, First Solar, Global Solar, and United Solar).

PV module shipments by large U.S. PV companies in 2008 were:

- First Solar: 147 MW
- United Solar: 113
- Solar World (Shell): 61 MW
- BP Solar: 28 MW
- Evergreen Solar: 26 MW

1.4 Budgets for PV

The U.S. DOE allocated a research and development (R&D) budget of 136,7 MUSD in fiscal year (FY) 2008 (October 2007 through September 2008). These funds financed R&D and technology acceptance activities in partnership with national laboratories, universities, and private industry. Because much of the research funding is cost-shared with industry, the amount invested in R&D for 2008 was much greater than this number would indicate. The publicly financed R&D budget for PV decreased slightly from 138,3 MUSD in 2007.

2 THE IMPLEMENTATION OF PV SYSTEMS

2.1 Applications for photovoltaics

Off-Grid

Thirteen percent of the PV systems installed in 2008 in the United States were off-grid systems that have storage (usually deep-cycle, lead-acid batteries) and charge controllers that control charging of the battery to extend the service life through optimum charging and preventing the load from exceeding the design discharge levels. Some off-grid systems are designed as hybrids with diesel or gasoline generators as an integral part of the system.

Domestic

Off-grid PV systems are often used where utility-generated power is unavailable, unreliable (for example, when utility-generated power requires emergency backup power), or too costly (the price of extending power lines costs more than a PV system). Off-grid systems are often best when only small amounts of power are needed such as for small homes 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 d.c. loads. Some larger systems use stand-alone inverters to power a.c. loads and may include a diesel generator as backup. Off-grid consumer-sector installations amounted to more than 40 MW in the United States in 2008.

Non-Domestic

The second-largest sector of the U.S. PV market, off-grid PV, is also used in commercial, industrial, agricultural, and government activities. These include large PV / 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, satellite links, cable links, and small data-link stations. Remote PV systems provide power for sensors and data communication for weather and storm warnings, for monitors of seismic, radiation, and pollution levels, for security phones on highways and in parking lots, and for traffic monitors. PV-powered lighting and signals are numerous along highways and in cities. They are used at bus stops, shelters, and on billboards. They illuminate highway information / construction signs (replacing small-engine generators), serve as inter-coastal navigation aids, and provide supplemental lighting for environmentally friendly corporate headquarters. Off-grid PV is also being used for pumping water into stock ponds and for irrigation control.

Figure 1: a) Telecommunications station in Arizona. b) Solar electricity used for irrigation control.

c) PV is often used for water pumping on farms and ranches in the United States.

Grid-Connected

The United States installed about 293 MW of grid-connected systems in 2008. The systems use all types of PV modules and are usually connected to an inverter that permits the PV system to first serve the building's a.c. load and then to send excess power to the utility grid. The grid-connected market now surpasses all other markets for new installations. According to the Solar Electric Power Association (SEPA), by the end of 2008, there were over 70 000 distributed solar electric systems interconnected across the United States. SEPA estimates that grid-tied PV installations are conservatively expected to exceed 100 000 by 2010 and 250 000 by 2015.

States that led in new grid-tied PV installations were California (182 MW), New Jersey (22 MW), Colorado (22 MW), Nevada (15), and Hawaii (9 MW).

Centralized

Utility-scale PV power plants, the largest of which produces up to 14 MW of electricity, generate electricity used by utilities, IPPs, city, state, and federal governments.

Figure 2: A 14,2-MW PV power plant at Nellis Air Force Base, Nevada.

Distributed

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. The PV systems can be mounted on the ground near the facility, on the building roof, or integrated into the building roof, walls, or windows.

PV can be incorporated into new domestic and industrial buildings as a principal or ancillary source of electrical power (typically, a PV array is incorporated into the roof or walls of a building, and roof tiles with integrated PV cells can now be purchased). In 2008, 270 MW of grid-connected, distributed PV systems (77 MW residential, 193 MW non-residential) were installed.

Figure 3: A 766-kW PV system on the roof of the Rodney Strong Vineyards building in California.

2.2 Total photovoltaic power installed

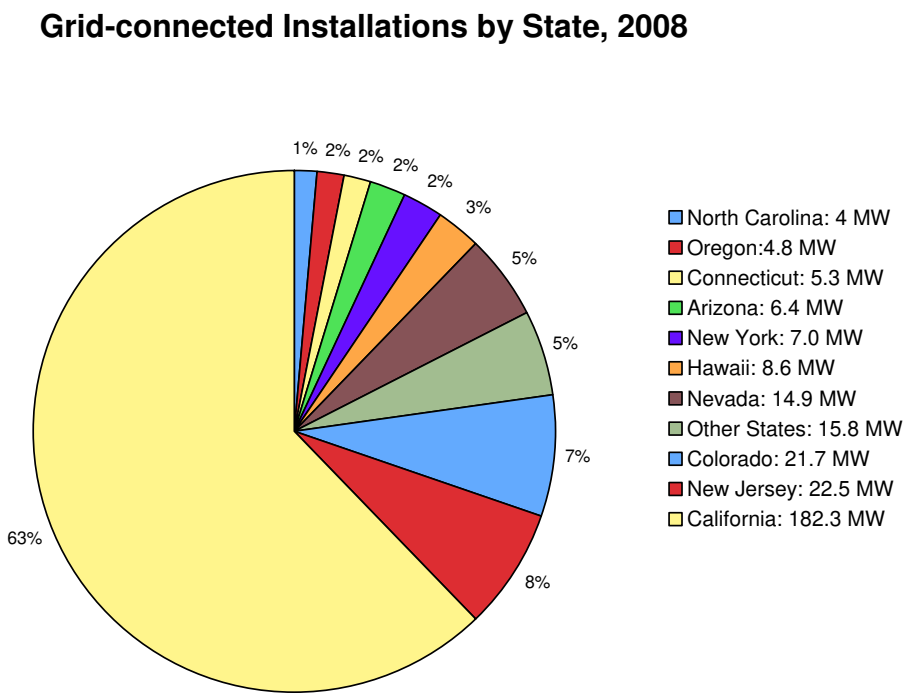

Figure 4: About 63 % of 2008 U.S. grid-tied PV installations were in California.
Source: Interstate Renewable Energy Council (IREC).

Table 1: Total PV power installed during 2008 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 2008 (kW)	20	25	270 MW	23 MW	338 MW

Table 2: The cumulative installed PV power in 4 sub-markets.

Submarket/ application	1995 MW	1996 MW	1997 MW	1998 MW	1999 MW	2000 MW	2001 MW	2002 MW	2003 MW	2004 MW	2005 MW	2006 MW	2007 MW	2008 MW
Off-Grid Domestic	19,3	23,3	27,5	32, 0	37,5	43,5	50,5	58,9	67,9	88,0	100,0	114,0	134,0	154
Off-Grid, Non-Domestic	25,8	30,2	35,0	40,2	46,7	55,2	64,7	77,7	93,7	112,0	133,0	156,0	191,0	216
Grid-Connected Distributed	9,7	11,0	13,7	15,9	21,1	28,1	40,6	63,6	95,6	154,0	219,0	322,0	465,0	735
Grid-Connected Centralized	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	18,0	22,0	27,0	32,0	40,5	63,5
Total	**66,8**	**76,5**	**88,2**	**100,1**	**117,3**	**138,8**	**167,8**	**212,2**	**275,2**	**376,0**	**479,0**	**624,0**	**830,5**	**1 168,5**

Market drivers

About 72 % of non-residential PV installation in 2008 was driven by third-party financing and Power Purchase Agreements (PPAs), according to the AltaTerra Research Network. With PPA financing, commercial customers supply a rooftop or other property to host the PV system and agree to purchase the electricity generated at a specified rate (usually at or below current retail electricity rates) for a long term (20 years). The energy company covers all aspects of the PV installation: finance, design, purchase, maintenance, and monitoring. With this arrangement, the customer can buy solar electricity with no up-front investment, and the energy company and investors can apply available tax credits and incentives to the project. Large retailers also installed commercial PV systems in 2008, and several big corporations announced plans to purchase or lease solar systems in 2009. Most of these arrangements are through power purchase agreements.

Residential installations also benefited from third-party and PPA financing. Companies offering residential leasing programmes for solar power systems in 2008 helped reduce the homeowner's up-front costs for a PV system. For example, a typical 2.5-kW system of 25 000 USD can be reduced in price to 2 000 USD. In addition, residential PPA financing resulted in monthly payments that vary with the electricity production of the system.

Community group purchases by the company 1 Block Off the Grid (1BOG) negotiated up to 48 % off the market price of 2-kW PV systems for its participants in San Francisco during 2008. Other programmes like Go Solar Michigan of the Great Lakes Renewable Energy Association and Go Solar Marin have offered group purchases for several years. Partnerships between PV suppliers and large employers are offering as an employee benefit the option to buy discounted residential solar systems.

Utility programs

Utilities are expected to play a much bigger part in building PV power plants in 2009. This is because the extension of the ITC removed language prohibiting utilities from applying for the 30 % tax credit. Even in the uncertain economy of early 2009, many utilities were actively planning large PV power projects to meet their generation needs and take advantage of the ITC.

The Sacramento Municipal Utility District (SMUD) created the innovative SolarShares programme, which allows customers in the SMUD territory to purchase local 100% solar-generated electricity, offering 'ownership' of a share of the generation from a local plant. For a fixed monthly price determined by each customer's usage profile, the programme gives a credit on the customer's electric bill for their share of electricity producing a 1-MW SolarShares PV system, located in Sacramento County. Subscribers expect to pay about 10 % more for their electricity over the year. SMUD both contracts for renewable electricity from independent power producers as well as builds and owns renewable energy plants. Similar green pricing programmes have been announced in other cities, including Los Angeles, to increase renewable electricity generation and reduce greenhouse gas emissions.

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

Major Projects

Important utility-scale projects came on line in 2008, generating green power for many Americans.

- A 10-MW thin-film (CdTe) PV installation called the El Dorado Solar Energy (a subsidiary of Sempra Energy) project was completed near Boulder City, Nevada,

in fewer than six months. Pacific Gas and Electric Company signed a 20-year agreement to buy the electricity from the project.

- A 3-MW PV project was completed outside of Philadelphia, Pennsylvania, to provide power and renewable energy credits to Exelon Generation LLC. The crystalline silicon PV project is located on the 61 512-m^2 Waste Management G.R.O.W.S. landfill site.
- A 2,3-MW single-roof PV system was installed at Toyota's North America Parts Center in Ontario, California. Toyota will purchase the generated electricity from GE Energy Financial under the SunPower Access™ power purchase agreement program.
- A 2,1-MW solar power system was installed at Applied Materials Inc. corporate campus in Sunnyvale, California.
- A 2-MW PV power plant completed on the rooftop of a commercial building in Fontana, California, is the first project in the three-year, 250-MW rooftop initiative of the Southern California Edison utility.
- A 1,1-MW solar power system supplies electricity to Valley Center Water District, a public water agency and one of the top 20 power purchasers in the San Diego Gas & Electric Company service area.

Several large PV projects were installed in 2008 at busy airports. The most visible was dedicated at Colorado's Denver International Airport, which serves nearly 50 million passengers each year. The 2-MW system spans 51 512 m^2. Another 2-MW system was installed at Fresno airport in California. Also a 2-MW system was installed at Fort Carson Army Base in Colorado.

Demonstration and Field Test Programs

Hundreds of PV systems were installed across the country through the DOE Solar America Initiative (SAI), which provides funding and technical assistance to cities, states, and federal agencies for PV applications. These included large-scale PV installations of more than 100 kW. SAI inaugurated 25 U.S. cities as Solar America Cities dedicated to accelerating the adoption of solar energy at the local government level.

2.4 Highlights of R&D

The DOE PV R&D Program's goal is to develop reliable PV systems with lifetime energy costs competitive with electricity from conventional sources. The PV Program funds work to 1) increase the sunlight-to-electricity conversion efficiency and performance of solar cells, modules, and systems; 2) reduce the manufacturing cost of solar cells, modules, and balance of systems; 3) reduce the installation, interconnection, and certification costs for residential, commercial and utility systems; and 4) increase system operating lifetime and reliability. PV activities are also coordinated with the Office of Science, the Office of Electricity Delivery and Energy Reliability, the Building Technologies Program and the Federal Energy Management Program. The National Renewable Energy Laboratory (NREL) and Sandia National Laboratories (Sandia) are the major national laboratories supporting the PV Program.

In 2008, the PV Program expanded the Solar America Initiative to focus on technology pathways most likely to reach cost competitiveness by 2015. This year, the Technology Pathway Partnerships project, the PV Incubator project, and other solicitations were organized into Applied Research, Systems Development, Technology Evaluation and Integration and Technology Acceptance portions of the PV Program.

Key R&D Results in 2008

Results of the DOE PV R&D Program in 2008 ranged from new, highly-efficient solar cell designs to new processes for high-volume manufacturing of solar materials. *R&D Magazine* awarded two of its four Editors' Choice awards to PV technology advances resulting from DOE partnerships with industry.

- NREL—In laboratory settings, achieved 40,8 % conversion efficiency for its inverted metamorphic triple-junction solar cell; achieved 19,9 % efficiency for a copper indium gallium diselenide (CIGS) solar cell and 19,2 % for a 1-cm^2 cell.
- IBM—Achieved 30 % efficiency for a concentrating PV cell using a thin-liquid metal layer of gallium and indium to enhance the heat transfer properties of a 1-cm^2 silicon solar cell.
- SunPower—Announced a 23,4 % efficient thin-film silicon cell (12,7 cm).
- CaliSolar—Achieved greater than 15 % efficiency for crystalline silicon cells made from upgraded metallurgical-grade silicon feedstock.
- First Solar—Achieved 12,5 % aperture-area conversion efficiency for a cadmium telluride (CdTe) module.
- HelioVolt—Achieved 12,2 % CIGS efficiency with its process technology.
- Ascent Solar Technologies, Inc.—Achieved greater than 9,5 % efficiency for its production-line flexible CIGS monolithically integrated modules.
- Sencera International Corporation—Achieved 7 % sunlight-to-electricity conversion efficiencies under standard test conditions for single-junction silicon solar cells made using plasma-enhanced chemical vapor deposition.
- University of Washington—Achieved 5,1 % efficient plastic solar cells using alkanedithiols additives to dye-sensitized solar cells.
- Pacific Northwest Laboratory in collaboration with NREL—Developed a flexible barrier coating for CIGS modules that passed stress tests for temperature and humidity equivalent to certification standards.
- NREL—Installed four new environmental test chambers to provide enhanced PV module testing.
- Sandia—Demonstrated prototype crystalline silicon PV cells that are only 20 microns thick; compared PV performance models using a full year of data; demonstrated a draft version of a predictive reliability model; and completed the first two years of the Long-Term Inverter Performance Characterization effort.

Applied Research

Conducts cross-cutting research on semiconductor material, device, and processing issues that benefit multiple companies and/or technologies were divided into four main research areas.

Process Development and Integration Laboratory (PDIL) Infrastructure, Engineering, and Integration—a unique collaborative facility at the National Renewable Energy Laboratory where industry and universities can work closely with NREL scientists on integrated equipment to answer pressing questions related to photovoltaics. The integrated equipment includes deposition, processing, and characterization tools. The PDIL works with a wide range of PV materials from crystalline silicon to thin-films (amorphous, nano- and microcrystalline silicon, copper indium gallium diselenide, and cadmium telluride) to organic PV. In 2008, funding was ramped up to complete the PDIL.

Electronic Materials and Devices—research in semiconductor materials, device properties, and fabrication processes to improve the efficiency, stability, and cost of photovoltaics. This research supports technology in near, mid- and long-term time frames.

Measurements and Characterization—research in analytical microscopy, electro-optical characterization, surface analysis, and device performance. In 2008, more than 70 PV

research partners were supported in industry, academia, and NREL. An improved solar simulator will reduce uncertainty in high-efficiency concentrator measurements, and a luminescence spectrum-imaging system will be used for characterizing industrial silicon wafers and solar cells.

University and Exploratory—research on fundamental scientific problems associated with all PV materials and devices and investigates innovative ideas that may lead to next-generation technologies.

Systems Development

Works through cost-shared contracts with industry to advance the development of PV systems and components. It features three primary R&D projects: Technology Pathway Partnerships (TPPs), the PV Incubator Project, and the University Process and Product Support.

Technology Pathway Partnerships (TPPs)—industry-led, three-year projects designed to progressively reduce the cost of commercially available PV systems and components. Members of the TPPs include industry, universities, laboratories, and other governmental entities broadening the base and increasing the likelihood of achieving the goals. Modeling suggests that, in 2015, outcomes and benefits could include 4 GW of cumulative new capacity. Partnerships begun in 2007 are exploring solutions for the residential rooftop market, the commercial rooftop market, and the utility (multi-megawatt) market.

The PV Incubator Project—launched in 2008 to help startup PV companies work with the national laboratories to make module prototypes and pilot manufacturing processes. The PV Incubator project invested 17,6 MUSD (matched by company cost share) in six company-led, early-stage projects in 2008.

University PV Process and Product Development Support—launched in 2008 to apply the special capabilities of the universities through competitively awarded, university-led process and product development projects. 'Future Gen' awards totalling 21,7 MUSD were made for 25 projects at 15 universities and 6 companies for laboratory-scale processes, prototype production and market-oriented research that emphasises direct, near-term improvements in PV products and development processes.

Technology Evaluation and Integration

Evaluates technical advances throughout the Solar Program using independent testing and analysis, including the evaluation of ongoing system-level progress of the Technology Pathway Partnerships.

Systems Analysis—benchmarking, modeling, and analysis for the systems-driven approach to PV technology as well as market, value and policy analysis. This activity focused on analysis of the U.S. electrical grid and the impact of PV on the distribution system as well as market, value, and policy studies. PV system cost and performance analyses were also performed.

Systems Test and Evaluation—testing and evaluating all PV modules, inverters, and controllers developed under the other elements of the research programme.

Component Testing and Evaluation—universities, industry, and the National Laboratories work to improve the efficiency of cell materials and devices by investigating their fundamental properties and operating mechanisms. This work also addresses reliability

issues of PV modules and balance-of-system components. In 2008, three-year contracts were established to develop advanced inverters and energy management systems.

Technology Acceptance

DOE conducts aggressive market transformation activities to accelerate acceptance of market-ready solar technologies.

Codes and Standards—led an industry forum with more than 100 attendees for Article 690 of the National Electric Code that resulted in 46 proposals and follow-up on public comments for inclusion in the 2008 National Electric Code. SAI is also developing voluntary solar codes and standards for PV modules and established the Solar America Board for Codes and Standards (www.SolarABCs.org).

Training and Certification—published 52 issues of the Interstate Renewable Energy Council (IREC)/SAI e-newsletter for 1 700 subscribers. Funded IREC activities including providing training workshops for code officials on solar water heating, developing PV resources for community colleges, and supporting North American Board of Certified Energy Practitioners (NABCEP) in developing new certification programmes.

Technical Partnerships and Demonstrations—awarded funds to several organizations to provide technical assistance to states and utilities interested in pursuing PV installations and policies, including the Interstate Renewable Energy Council (IREC), the Clean Energy Group, the National Association of Regulatory Utility Commissioners (NARUC), and the Solar Electric Power Association (SEPA). In the Solar America Cities initiative, DOE established strategic partnerships with 25 cities through a competitive funding opportunity and awarded a combined 2,5 MUSD in financial assistance. These Solar America Cities, which are committed to accelerating the adoption of PV at the local level, work with a variety of municipal, county, and state agencies; universities; developers; and nonprofit organizations to power their municipalities with PV. In addition, communications and outreach work is funded to showcase solar technologies and provide information to consumers, industry professionals, government officials, and scientists via exhibits at large conferences and through its Web site: www.eere.energy.gov/solar/solar_america.

Technical Outreach—created a readily accessible database of current and previous years' bills on energy (See Solar State Legislation: www.ncsl.org/programs/energy/energypolicy.cfm.) Launched a Web site (www.statesadvancingsolar.org) that serves as a resource for state policy makers and decision makers interested in developing a solar programme. Released the 'Solar Energy Technology and Policy Reference Guide.' Released 'The Peer Matching Online Tool' (www.solarelectricpower.org/peer/) to share information and best practices to help all utilities improve their solar programmes.

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

Table 3: Public budgets for R&D, demonstration/field test programmes and market incentives for PV (MUSD).

Funding Level 2008 (MUSD)	TOTAL	R&D	Demo/Field Test	Market Incentives
National/federal	DOE: 136,7*	122,5	14,17	

State/regional				>505,50

* http://www.cfo.doe.gov/budget/09budget/Content/Volumes/Volume3a.pdf p 177-187

Solar Program	FY 2008 Budget Appropriation
Applied Research	$37,200,000
Systems Development	$64,800,000
Test & Evaluation	$21,700,000
Market Transformation	$14,300,000
Concentrating Solar Power	$30,000,000
Solar Heating & Lighting	$2,000,000
Total, Solar Energy	$170,000,000

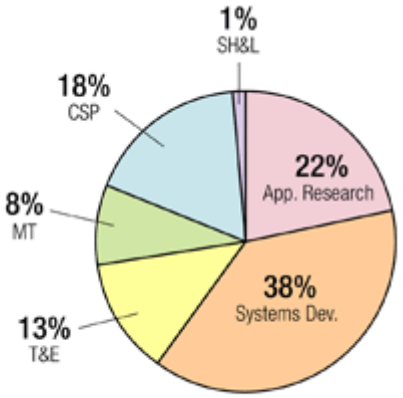

Figure 5:The Solar Program Budget.Source: http://www1.eere.energy.gov/solar/budget.html

3 INDUSTRY AND GROWTH

3.1 Production of feedstock, ingots, and wafers

Table 4: Production and production capacity information for 2008 for silicon feedstock, ingot and wafer producers

Manufacturers	**Process & Technology**	**Total Production**	**Maximum Production Capacity**	**Product Destination**	**Price**
Hemlock Semiconductor Corp.	Silicon feedstock	12 320 tonnes	14 630 tonnes/year	15 % U.S., 85 % export	$70/ kg
Renewable Energy Corp	Silicon feedstock	6 667 tonnes	7 500 tonnes/year	15 % U.S., 85 % export	$70/ kg
Solar Recycling Services	Silicon feedstock	2 000 tonnes	2 000 tonnes/year	15 % U.S., 85 % export	$70/ kg
MEMC	Silicon feedstock	4 800 tonnes	6 000 tonnes/year	15 % U.S., 85 % export	$70/ kg
Total Silicon Used by PV – United States		25 787 tonnes	30 130 tonnes/year		
IN-HOUSE WAFER PRODUCTION					
Solar World America	Wafers	78 MW	100 MW/year	70 % U.S., 30 % Export	
BP Solar	Wafers	28 MW	40 MW/year	80 % U.S., 20 % Export	
Evergreen Solar RIBBON	Wafers	27 MW	59 MW/year	90 % U.S., 10 % Export	
Solec Intl. EXPORT TO SANYO	Wafers	30 MW	30 MW/year	100 % Export	

SCHOTT SOLAR RIBBON	Wafers	11 MW	15 MW/year	70 % U.S., 30 % Export	
Total Wafers		174 MW	244 MW/year		

3.2 Production of photovoltaic cells and modules

The U.S. solar industry in 2008 increased domestic PV manufacturing capacity by 65 % to 685 MW of capacity. Of about 100 active PV cell and module manufacturers in North America, 72 are seen as startups that are bringing innovative technologies to market. Venture capitalists invested almost 1 600 MUSD in solar companies in the third quarter of 2008 alone compared to more than the 1 050 MUSD total venture capital investment in 2007. In the fourth quarter, 1 300 MUSD was invested in 28 venture capital rounds. Companies developing thin-film modules using CIGS or CdTe received some of the largest rounds of investments. SoloPower and AVA Solar each raised more than 100 MUSD in 2008 while Solyndra reported raising more than 219 MUSD from 23 investors. Nanosolar took in 300 MUSD in investments.

In addition to expansion of existing facilities, the following PV companies opened new manufacturing facilities in 2008: EPV Solar, 20-MW capacity, Robbinsville, New Jersey; Global Solar Energy, 40-MW capacity, Tucson, Arizona; HelioVolt, 20-MW capacity, Austin, Texas; Konarka Technologies, 10 million m^2 per year of flexible solar film, Lowell, Massachusetts; Miasolé, 40-MW capacity, Santa Clara, California; Nanosolar, up to 1-GW capacity per year, San Jose, California; SolarWorld, 500-MW capacity by 2011, Hillsboro, Oregon; Solon AG, 60-MW capacity, Tucson, Arizona; Suniva Inc., 32-MW capacity by 2010, Norcross, Georgia.

Total PV cell and module manufacture, together with production capacity information, is summarised in Table 5 below.

Table 5: Production and production capacity information for 2008 for each manufacturer

2008 Module Manufacturer	Technology Type	2008 Production (MWp)		2008 Max Capacity (MWp)	
		Cells	Modules	Cells	Modules
CRYSTALLINE					
Solar World (U.S.)	Single-crystal silicon	78	85	100	100
BP Solar (U.S.)	Multi-crystal silicon	28	20	40	35
GE Energy	Single-crystal silicon	NIL	NIL	NIL	NIL
Schott Solar	EFG ribbon silicon	11	11	15	15
Evergreen Solar	String Ribbon	27	27	59	59
Total Crystalline	**CRYSTALLINE**	**144**	**143**	**214**	**214**
THIN FILM					
United Solar	Amorphous silicon	113	113	180	180

First Solar	CdTe	147	147	147	147
Global Solar	CIS	7	7	16	16
Total Thin Films	**THIN FILM**	**267**	**267**	**343**	**343**
OTHER					
		18,7	18,7	108,6	108,6
TOTAL PRODUCTION / CAPACITY		**448,7**	**447,7**	**665,6**	**665,6**

3.3 Module prices

Average module prices at the factory decreased slightly from 3,75 USD/W_p in 2007 to 3,65 USD/W_p in 2008.

Table 6: Typical module prices since 1994

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Price*	4,00	3,75	4,00	4,15	4,00	3,50	3,75	3,50	3,25	3,00	3,50	3,60	3,75	3,75	3,65

*Estimated by PV Energy Systems, Inc. (1994–2007), Prometheus Institute (2008).

Manufacturers and suppliers of other components

- PV inverters (for grid-connection and stand-alone systems) and their typical prices

The dramatic increase in the market for grid-connected residential PV systems has greatly increased the sales and number of models of small inverters. More than 15 inverter manufacturers serve the U.S. market, and some inverters are branded to be sold under several different names. SMA America Inc.'s share of the market for grid-interactive inverters was reported to be greater than 60 %. However, a large percentage of the inverters sold in the United States are now imported. Sharp, which installed more than 100 000 inverters in Japan, entered the U.S. market in 2003. All utility-interactive inverters installed in the United States must be listed for safety under the UL1741 standard by one of three major, nationally recognized testing laboratories. The California Energy Commission list of eligible inverters for its Emerging Renewables programme now exceeds 150 models. Sandia National Laboratories continued to work with Xantrex (Trace, Inc.) and GE on their high-reliability inverter designs.

In 2008, a new inverter strategy was introduced by Suntech Power Holdings Co., Ltd., the world's leading manufacturer of photovoltaic (PV) modules. The Enphase Micro-inverter bolts directly to the solar system racking, reducing installation time and cost. Enphase's Enlighten™ monitoring and analysis system also gives unprecedented insight into the performance of a homeowner's solar system. http://www.enphaseenergy.com

- Battery charge controllers

The United States has several producers of charge controllers. At least 22 brands are available for the U.S. market. Major manufacturers include Morningstar, Xantrex, Specialty Concepts, Sun Selector, and Outback Power. Total production is estimated at 130 000 units to 150 000 units per year. More than 60 % of U.S. charge controllers are exported.

- Systems Designers and Installers

About 30 major companies in the United States are dedicated primarily to the design, sale, and installation of PV systems. When the market comprised primarily off-grid, stand-alone systems (prior to 1996), large distributors had a systems designer-installer who served most of the larger commercial systems (telecommunications, water pumping, remote military, etc.). These designer-installers included Atlantic Solar, Solar Depot, Hutton Communications and SunWize. When state tax credits for grid-connected systems (residential and commercial) were established, several of the distributors became full-service systems installers. Many new or expanded companies were formed to deal exclusively with grid-connected systems. The most notable of these companies is Sunpower (formerly PowerLight), which installs more than 20 % of U.S. grid-connected systems. Sun Edison is another large U.S. systems integrator with several installations over 1 MW.

For the incentive-driven residential market, SolarCity, the largest provider in California, installed about 9 MW of PV at about 4 kW/system in 2008. This was nearly three times the amount installed by the company in 2007.

3.4 System prices

Systems prices have remained relatively constant after rising in 2006. A summary of typical system prices is provided in the following tables.

Table 7a: **Turnkey Prices of Typical Applications in 2008**

Category/Size	Typical applications and brief details	USD/W*
OFF-GRID Up to 1 kW	Telecom, signals, lighting, highway signs, navigation aids, irrigation, cottages, etc.	$7–9
OFF-GRID >1 kW	Telecom, homes, farms, irrigation, signals, government sites, parks	$8–10
ON-GRID Specific Case	2-5-KW roof-mounted system	$7–9
ON-GRID Distributed	Government buildings, warehouses, renewable power set asides-utilities, commercial buildings	$7,5
GRID – CONNECTED (centralized, if relevant)	Power Purchase Agreements	$6,5

*Prices do not reflect add-on costs for warrantees, service contracts, and training. Additional energy storage for uninterruptible power will also increase costs.

Table 7b: National trends in system prices USD/W

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008

Price/ W*	12	11–12	10–12	10–12	10–11	9–11	8–10	7–9	6,50–9	6,50–8	6,50–8	6,50–8	7-9	7–9	6,5–9

*Estimated by PV Energy Systems, Inc. (1994–2007), Prometheus Institute (2008).

3.5 Labour places

In 2008, the Solar Energy Industries Association estimated that the 3 400 solar companies would employ 440 000 permanent employees by 2016.

Table 8 : Estimated PV-related labour places in 2008

Research and development (not including companies)	136,7 MUSD
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	No data available for 2008
Distributors of PV products	
System and installation companies	
Utilities	

The Solar Energy Research & Education Foundation (SEREF) and Google.org recently unveiled an interactive 'solar jobs map' that predicts visually how federal energy policy will increase the use of solar energy and create thousands of new green-collar jobs. Using the dynamic Google Earth mapping software, the Solar Jobs Map shows anticipated state-by-state job growth generated by the U.S. solar energy industry over the next eight years. The interactive map can be found at http://seref.us/solarjobsmap.html.

3.6 Business value

The value of PV product and services in the United States can be estimated by adding the total value of the products installed and the product exported. Table 9 lists the key elements of this analysis. The total value of the installation of U.S. PV systems, the export of modules, and the export of silicon is about 4,284 BUSD.

Table 9: Value of PV business

Sub-market Systems	**Capacity installed *in 2008* (kW)**	**Price USD/W** *(from table 7)*	**Value**	**Totals**
Off-grid domestic	20 000	8	*160 000 000*	
Off-grid, non-domestic	25 000	9	*225 000 000*	
Grid-connected	293 000	7	*2 051 000 000*	
				2 436 000 000
Export of silicon feedstocks				*1 534 326 500*
Change in stocks held				*518 800 000*
Net Import of PV products				*(205 100 000)*

Value of PV business	***4 284 026 500***

4 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

Table 10 lists the main support measures (definitions at start of guidelines) for PV during 2008. Further details on these are to be provided on the following pages.

Table 10: PV support measures

	On-going measures
Enhanced feed-in tariffs	State: California feed-in tariffs for renewable energy systems below 1.5 MW became available in 2008. The price paid to customers is based on the value of electrical generation but is not intended to embed a subsidy or rebate in the price offering. (See www.dsireusa.org for more information on incentives in other states.) Local: Gainesville, Florida, approved an enhanced feed-in tariff to go into effect in 2009.
Capital subsidies	Federal: 30% tax credit for commercial installations can be taken in lieu of the investment tax credit through 2010. State: California Solar Initiative provides for this in the form of 2,50 USD/W subsidy for residential and commercial projects and 3,25 USD/W for systems installed by governments and nonprofits.
Green electricity schemes	More than 1 million homeowners purchased green certificates (renewable energy certificates). Large purchasers of green power include DOE, federal and state agencies, universities, and businesses. Several dozen companies actively market RECs to residential or business customers. For more information, visit www.eere.energy.gov/greenpower/.
PV-specific green electricity schemes	State and regional: 0,2 % of 740 MW renewable energy sales (2006). 2007 and 2008 data not available.
Renewable portfolio standards (RPS)	State: 32 states and the District of Columbia adopted renewable portfolio standards in 2008. (Five states have voluntary standards.)
PV requirement in RPS	State: most states with RPS promoted solar technologies; 13 states and the District of Columbia included a PV requirement.
Investment funds for PV	Venture capital investment in solar reached more than 3 BUSD in 2008.
Income tax credits	Federal: federal investment tax credit of 30 % for commercial and residential systems extended to 2016 and adds provision for utilities to use it. State: See www.dsireusa.org for more information on incentives in states.
Net metering	Federal: all Public Utilities (not private) must offer net metering. State: available in 42 states and the District of Columbia.
Net billing	State: net billing exists in states where net metering is allowed. However, the credit will vary in each state and is not necessarily equivalent to 100 % of kWh.
Commercial bank activities	Federal: subsidized commercial loan program through September 2011.
Electricity utility activities	More than 850 utilities (about 25 % of the total) offer green power programmes in 47 of the 50 states. For more information, visit DOE's Green Power Network: www.eere.energy.gov/greenpower/. The California Public Utilities Commission set a goal to install 3 000 MW of solar energy and provide 2,9 BUSD in consumer incentives by 2017.

Sustainable building requirements	Federal: no federal codes but DOE does produce 'Best Practices' guides for sustainable building for both residential and commercial builders. State and Local: some states and local jurisdictions have sustainable building requirements.

Feed-in tariff incentives were offered for the first time at the state and city government level in 2008. California is considering changes that would expand applications of its feed-in tariff, and other states, including Hawaii and Wisconsin, are considering feed-in tariffs to promote solar installations. The first city feed-in tariff was approved by Gainesville, Florida, to take effect in 2009. The city-owned Gainesville Regional Utilities proposed paying 0.32 USD/kWh for solar power, which could provide a 3 % to 5 % return on investment for residential or business customers participating in the programme. Other cities, including Los Angeles, California, have proposed feed-in tariffs for 2009.

Capital Subsidies or Rebate programmes supported installation of many PV systems nationwide. State clean energy funds have supported more than 50 000 renewable energy projects, including PV, wind, solar, biomass, and hydro by investing about 1,5 BUSD from 1998 to 2007. The state clean energy funds come from a small surcharge on electric bills. On average, for every 1 USD provided by the state fund, private investors provide 1,75 USD of capital. The Clean Energy States Alliance (CESA) has created a national database of renewable energy projects supported by state funds. More than 75 % of the grid-connected PV installed in the U.S. in 2007 was installed in states with a clean energy fund.

California's Self-Generation Incentive Program and the California Solar Initiative provided a 7,9 MUSD rebate check to the Contra Costa Community College District for 3,2 MW of solar systems installed at three locations by Chevron Energy Solutions. New rebate programmes were instituted in four states so that by the end of 2008, 19 states offered PV rebate programs. However, some states have had trouble balancing rebate levels with consumer demand. Nevada and New Jersey stopped accepting rebate applications (for most types of systems) while Connecticut, Florida, Maine, Maryland, and Minnesota ran out of rebate funding. Existing rebate programmes were reduced in California and Connecticut. In Colorado, Xcel Energy (a public utility) lowered its incentive from 4,50 USD/W to 3,50 USD/W in late October because the company was soon reach its Renewable Energy Standard requirements dictated by Colorado law. Several states have lowered (or are likely to lower) PV rebate levels to coincide with the lifting (on 1 January 2009) of the 2 000 USD cap of the federal ITC for residential PV.

Green Electricity Schemes and PV-Specific Green Electricity are available in more than 20 states that have established clean energy funds that will collect more than 6 BUSD in aggregate over the next decade through a small surcharge on retail electricity rates known as a 'system benefits charge'. Almost all of the state funds currently provide some form of support for customer-sited PV. Many funds have implemented what are commonly known as 'buy-down' programmes, where funds are distributed as grants to subsidize or buy down the initial cost of a system. California has committed to a 10-year, 3 BUSD solar programme that reduces rebate levels each year by approximately 10 % with subsidies zeroing out after 10 years.

New Renewable Portfolio Standards (RPS) were operating in 32 states and the District of Columbia.

Income Tax Credits will have a continuing influence thanks to the extension of the PTC and the ITC discussed earlier. Utilities especially, due to their continuing profitability even in a

poor economy, are expected to pursue ownership of PV generation stations in the years ahead to satisfy RPS and benefit from tax credits.

Net Metering remains a very popular policy tool for promoting PV and other renewables. In 2008, 13 states and the District of Columbia enhanced existing net-metering policies, Michigan established a new net-metering policy, and Texas abandoned net metering. In addition, eight states adopted new or expanded comprehensive, interconnection standards.

Green Financing included two other new government initiatives, the Connecticut Solar Leasing Program and the Property Tax Financing Districts being set up by municipalities in California, including Berkeley, San Diego, and Palm Desert. The Berkeley FIRST program allows property owners to borrow money from the city's Sustainable Energy Financing District to install PV systems. The property owners repay the cost of the system over 20 years through an annual assessment on their property tax bills.

4.1 Indirect policy issues

DOE technology acceptance activities, designed to remove barriers to the acceptance of new solar technologies in the marketplace, often make use of experts in the DOE R&D Programme at NREL, Oakridge National Laboratory, Sandia National Laboratories, the Southeast and Southwest Regional Experiment Stations, and private firms. Under this effort, DOE selected 25 'Solar America Cities' to receive shares of 5 MUSD and important technical assistance from programme experts to help create sustainable solar market infrastructures in their areas. Technical assistance to states and utilities is also provided by other organizations, including the Interstate Renewable Energy Council, the Clean Energy Group, the National Association of Regulatory Utility Commissioners, and the Solar Electric Power Association. The Solar Energy Industry Association in the U.S. represents solar companies, providing policy and other analysis and information to the industry, and lobbying Congress on behalf of the industry.

Recognizing that technology acceptance is affected by issues of interconnection to the grid, DOE sponsored the Renewable Systems Interconnection (RSI) study, which resulted in 14 published reports. Following recommendations from the RSI study, DOE began to invest up to 24 MUSD (plus company cost share) in Solar Energy Grid Integration Systems projects.

A study was completed to determine the land required for photovoltaics (PV) to provide 100 % of the electricity for each state. While this scenario is extreme, it does provide insight into the potential scale of land-use impacts associated with meeting a large fraction of the nation's electricity requirements from PV.

4.2 Standards, codes, and certification

The largest of several new testing laboratories opened by national laboratories in 2008, Underwriters Laboratories (UL) announced the opening of its 1 858-m^2 PV Technology Center of Excellence certification facility in San Jose, California. It is the largest commercial laboratory for PV testing and certification in the United States with 14 test chambers and two solar simulators. Underwriters Laboratories is working to conform the UL1741, 'Standard for Static Inverters and Charge Controllers for Use In Photovoltaic Power Systems', to International Electro-Technical Commission (IEC) standards. It will include inverters and charge controllers for all distributed generation and to match the requirements of the IEEE 1547 standard. Coordination with both the NEC and IEEE interconnect guidelines will remain a valuable activity for finalizing the revised UL1741 standard that now integrates with IEEE1547.1 for anti-islanding and other performance requirements. Personnel from Sandia continue to update a draft test protocol for performance certification of inverters for PV applications to include assessment of maximum-power-point tracking and

array utilization. The California Energy Commission adopted most of the protocol to provide inverter certification for its Emerging Renewables programme in 2005.

Technology acceptance activities of the DOE PV programme included the creation of the Solar America Board of Codes and Standards (SolarABCs), which is designed to improve the development of codes and standards that facilitate the installation of safe, high-quality PV systems.

The United States actively participated in the International Electrotechnical Commission activities for PV-related standards. In related work, programme experts also contributed to the first international concentrator qualification document, the International Electro-technical Commission standard 62108: Concentrator Photovoltaic Modules and Assemblies—Design Qualification and Type Approval.

The Arizona State University Photovoltaic Testing Laboratory (PTL) has been converted to a for-profit company (TUV-PTL) and continues to perform module certification tests based on the accreditation certificate they received from the American Association of Laboratory Accreditation. The TUV-PTL regularly performs tests on all types of PV modules according to IEEE 1262, IEC 1215, IEEE 1262, IEC 61215 (crystalline silicon module qualification tests), 61646 (thin-film qualification), and PV-3 for silicon and amorphous silicon modules. Some testing also includes the UL1703 requirements. Most of the PV modules qualified today meet reciprocity requirements with European standards. The TUV-PTL tests are accepted throughout the world.

The framework for a single national voluntary certification programme for PV installers began in 2003 and continues to be applied. Called the North American Board of Certified Energy Practitioners (NABCEP), the national voluntary practitioner certification programme is accredited by the American National Standards Institute and has over 420 certified PV installers in the United States. Exams are administered twice each year.

A certification protocol for PV inverters to better characterize their operation and to certify the performance relative to power throughput is implemented by the California Energy Commission. Certified inverters must be used in installations subsidized by the Commission's Emerging Renewables programme, which maintains a list of eligible inverters as well as selected testing information on its Web site. The weighted California efficiencies and characteristics are available to installers and designers.

5 HIGHLIGHTS AND PROSPECTS

The total value of the installation of U.S. PV systems, the export of modules, and the export of silicon is about 4,284 BUSD.

5.1 PV deployment in 2008

Even with the uncertainty about extension of the tax credits, U.S. PV capacity increased by about 44 % in 2008. While module costs increased, system costs remained constant. With the extension and improvements to the Federal tax incentives, increased deployment can be expected in 2009.

5.2 PV production in 2008

U.S. PV cell production increased 52 % over 2007. This indicates a growing trend toward domestic manufacture. Planned capacity expansion into 2009 will continue this trend. Thin-film products now account for slightly more than half of the production in the United States.

5.3 Forward-looking issues

The stronger dollar could hurt exports of U.S. products, and the economic slump has caused some companies to reduce their sales forecasts. There are some concerns of module oversupply, demand uncertainty, and falling prices and, hence, industry profits. PV module prices are expected to fall as much as 12 %. Related prices for silicon and thin-film materials are expected to fall nearly 30 %.

On the positive side, the Federal ITC was extended, the cap on the amount of ITC allowed for residential installations was removed, and utilities are now allowed to benefit from the ITC. With increased production, construction of transmission, and incentives, PV is poised to become a contributor to economic recovery in 2009 and beyond.

ANNEX A: METHOD AND ACCURACY OF DATA

The data in this report are taken primarily from data collected by the Energy Information Administration, the U.S. Department of Energy, the Solar Energy Industries Association, the Prometheus Institute, Sherwood Associates, and PV Energy Systems, Inc. These data are believed to be accurate to within ±10 %. The accuracy of the U.S. installation data is estimated to be within ±10 %. The currency used in this report is U.S. dollars.

Sources for more information:

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ANNEX B: COUNTRY INFORMATION

This information is simply to give the reader some background about the national environment in which PV is being deployed. It is neither guaranteed to be 100 % accurate nor intended for analysis, and readers should do their own research if they require more detailed data.

Description	Value	Source
1) Retail electricity prices – household, commercial, public institution (average retail price)	All sectors: 0,899 USD / kWh Residential: 0,1024 USD / kWh Commercial: 0,940 USD / kWh Industrial: 0,639 USD / kWh	U.S. Department of Energy Energy Information Administration
2) Typical household electricity consumption (kWh)	In 2007, the average monthly electricity consumption for a typical household was 936 kWh.	U.S. Department of Energy Energy Information Administration
3)Typical metering arrangements and tariff structures for electricity customers	These rules vary from state to state.	See www.dsireusa.org and www.irecusa.org for more information. The U.S. DOE also publishes information on utility tariffs and pricing Issues at www.eere.energy.gov/de/utility_tariffs_pricing.html.
4) Typical household income (assumes married household)	In 2007, the median annual household income was 50 233 USD. 2008 stats are not yet available.	U.S. Census Bureau: www.census.gov
5) Annual average mortgage interest rate	30-year fixed: 6,03 % 15-year fixed: 5,62 %	Freddie Mac – Historical Rate Tables http://www.freddiemac.com/dlink/html/PMMS/display/PMMSOutputYr.jsp
6) Voltage (household, typical electricity distribution network)	Approximately 110 volts a.c.	
7) Electricity industry structure and ownership	Diversified and deregulated—separate generation, transmission, and distribution. Utility ownership varies: Shareholder-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. Provide about 70 % of all power in the United States. Municipally owned electric utilities. Owned by the city or municipality in which they operate and are financed through municipal bonds. They are self-regulated. Approximately 11 % of the nation's power needs are met by about 2 000 municipally owned systems.	

	Federally owned utilities. Agencies of the Federal government involved in the generation and/or transmission of electricity, usually sold at wholesale prices to local government-owned and cooperatively owned utilities and to shareholder-owned companies. These government agencies are the Army Corps of Engineers and the Bureau of Reclamation, which generate electricity at federally owned hydroelectric projects. The Tennessee Valley Authority transmits electricity to the Tennessee Valley.	
8) Price of diesel fuel	3,80 USD per gallon (2008 average price)	U.S. Department of Energy Energy Information Agency
9) Typical values of kWh / kW for PV systems (national average range) 2007	Household: 0,23–0,32 USD / kWh Commercial: 0,16–0,22 USD / kWh Public Institution: 0,13–0,22 USD / kWh	U.S. Department of Energy Energy Information Agency