IEA INTERNATIONAL ENERGY AGENCY

SunShot
U.S. Department of Energy

National Survey Report of PV Power Applications in the United States

2016

PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

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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 member countries.

The IEA Photovoltaic Power Systems Technology Collaboration Programme (IEA-PVPS) is one of the collaborative research and development (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 participating countries and organisations can be found on the www.iea-pvps.org website.

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 (PVPS) Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic (PV) power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, and to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. 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 country National Survey Report for the year 2016. Information from this document will be used as input to the annual "*Trends in Photovoltaic Applications*" report.

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

1 INSTALLATION DATA

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, **PV installations are included in the 2016 statistics if the PV modules were <u>installed and connected to the grid</u> between 1 January and 31 December 2016, although commissioning may have taken place at a later date**.

1.1 Applications for Photovoltaics

Growth in the United States' (U.S.) PV market has been propelled by grid-connected PV installations, with approximately 14 762 MW_{DC} of new grid-connected PV capacity added in 2016, bringing its cumulative total to approximately 40 436 MW_{DC}.[1] Because a reliable data source for off-grid systems is not 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 2016, there were more than 1,3 million distributed PV systems interconnected across the United States.[2]

Centralized PV systems (utility applications) generate electricity that is fed directly to the grid, without serving an on-site load. This sector expanded from 4 266 MW_{DC} installed in 2015 to 10 593 MW_{DC} installed in 2016.[3]

Community or shared solar projects, a process in which groups of individuals either jointly own, or jointly purchase electricity from large centralized PV arrays are also growing rapidly in parts the U.S. At the end of 2016, 38 states had at least one community solar project operating or in development.[4] The ownership structures of community solar projects can vary widely, and have been implemented by utilities, developers, and other organizations.

Off-Grid PV: Off-grid systems include storage (traditionally deep-cycle, lead-acid batteries, though lithium ion batteries are becoming more commonplace), 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

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[1] "U.S. Solar Market Insight Report: 2016 Year in Review." GTM Research/SEIA. March 2017.

[2] Ibid.

[3] Ibid.

[4] "U.S. Community Solar Outlook 2017." GTM Research. February 2017.

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. The Energy Information Agency (EIA) estimates that as much as 274 megawatts of remote electricity generation with PV applications (i.e., off-grid power systems) were in service in 2013, plus an additional 573 megawatts in communications, transportation, and assorted other non-grid-connected, specialized applications.[5]

1.2 Total photovoltaic power installed

Deployment statistics are collected by the Solar Energy Industries Association (SEIA) and Green Tech Media Research (GTM Research).[6] These organizations survey nearly 200 installers manufacturers, utilities and state agencies to obtain granular installation data on installations in every state.

Table 1: PV power installed during calendar year 2016

AC			**MW installed in 2016**	**MW installed in 2016**	**AC or DC**
Grid-connected	BAPV	Residential	4 169	2 583	DC
		Commercial		1 586	DC
		Industrial			DC
	BIPV (if specific legislation exists)	Residential	N/A		
		Commercial			
		Industrial			
	Ground-mounted	cSi and TF	10 593		DC
		CPV			
Off-grid		Residential	Not available		
		Other			
		Hybrid systems			
		Total	14 762		DC

[5] Energy Information Administration. Annual Energy Outlook. September 2015. Washington, DC. U.S. Department of Energy.

[6] "U.S. Solar Market Insight Report: Q1 2017." GTM Research/SEIA. March 2017.; more information on the reports methodology is available at: http://www.seia.org/research-resources/us-solar-market-insight/about

Table 2: Data collection process:

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	N/A
Is the collection process done by an official body or a private company/Association?	Collaboration between official body (DOE and NREL) and Association (SEIA)
Link to official statistics (if this exists)	http://www.seia.org/research-resources/us-solar-market-insight; http://www.eia.gov/electricity/

Table 3: PV power and the broader national energy market.

	2016 numbers	2015 numbers
Total power generation capacities (all technologies)	1 093 GW_{AC}	1 074 GW_{AC}
Total power generation capacities (renewables including hydropower)	213 GW_{AC}	192 GW_{AC}
Total electricity demand (= consumption)	4 098 137 GWh	4 091 740 GWh
New power generation capacities installed during the year (all technologies)	28,5 GW_{AC}	21,1 GW_{AC}[7]
New power generation capacities installed during the year (renewables including hydropower)	20,3 GW_{AC}	15,12 GW_{AC}
Total PV electricity production in GWh-TWh	56 221 GWh	39 032 GWh
Total PV electricity production as a % of total electricity consumption	1,3%	0,9%

Source: Data in this table are from the United States Energy Information Administration (EIA)[8] unless cited otherwise.

Table 4: Other information

	2016 Numbers
Number of PV systems in operation in your country (a split per market segment is interesting)	Residential: 1 278 494 Non-residential: 65 962 Utility 1 844
Capacity of decommissioned PV systems during the year in MW	Not available
Total capacity connected to the low voltage distribution grid in MW	16 017 (includes all distributed PV)
Total capacity connected to the medium voltage distribution grid in MW	Not available
Total capacity connected to the high voltage transmission grid in MW	Not available

[7] Includes PV capacity as reported by the Solar Electric Power Association report, "Utility Solar Market Snapshot: Sustained Growth in 2015." Data for utility-scale generation capacity from the United States Federal Energy Regulatory Commission report, "Office of Energy Projects Energy Infrastructure Update for December 2015." https://www.ferc.gov/legal/staff-reports/2015/decinfrastructure.pdf.

[8] http://www.eia.gov/electricity/data/browser/

Table 5: The cumulative installed PV power in 4 sub-markets.

Sub-market	Stand-alone domestic	Stand-alone non-domestic	Grid-connected distributed	Grid-connected centralized	Total (MW)
2004	NA	NA	94	17	111
2005	NA	NA	172	18	190
2006	NA	NA	277	18	295
2007	NA	NA	428	27	455
2008	NA	NA	710	43	735
2009	NA	NA	1 087	101	1 188
2010	NA	NA	1 672	368	2 040
2011	NA	NA	2 807	1 152	3 959
2012	NA	NA	4 373	2 955	7 328
2013	NA	NA	6 277	5 802	12 079
2014	NA	NA	8 932	9 744	18 305
2015	NA	NA	11 848	13 826	25 674
2016	NA	NA	16 017	24 419	40 436

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Table 6: Typical module prices for a number of years

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
Standard module crystalline silicon price(s): Typical[9]	3,25	2,18	1,48	1,37	0,75	0,81	0,71	0,72	0,53
Lowest prices [10]	NA	NA	NA	0,35	0,45	0,40	0,53	0,50	0,37
Highest prices[11]	NA	NA	NA	2,30	1,44	1,97	1,10	1,00	1,00

2.2 System prices

Installed system prices continue to fall in the United States, driven by three primary factors: 1) falling non-module hardware 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 in all sectors and utility scale prices are beginning to drop below 1,50 USD/Wp. This downward trend is somewhat masked for distributed PV systems by the popularity of third-party ownership in the U.S. because systems deployed under these lease or power purchase agreement structures tend to report higher installed prices that reflect higher financing transaction costs and corporate overhead.

Table 7: **Turnkey Prices of Typical Applications – local currency**

Category/Size	Typical applications and brief details	Current prices per W
Off-grid: Up to 1 kW	N/A	
Off-grid: >1 kW	N/A	
Grid-connected: Rooftop up to 10 kW (residential)	Modeled 5.6 kW system with standard modules and racking (Q1 2016)	2,93 USD
Grid-connected: Rooftop from 10 to 250 kW (commercial)	Modeled 200 kW flat roof system with standard modules, ballasted mounting, and string inverters	2,13 USD
Grid-connected: Rooftop above 250kW (industrial)	Modeled 1 MW flat roof system with standard modules, ballasted mounting, and string inverters	2,03 USD
Grid-connected: Ground-mounted above 1 MW		1-axis tracking: 1,49 USD Fixed tilt: 1,42 USD

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[9] Mints, Paula. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2016/2017." SPV Market Research. April 2017.

[10] Bloomberg New Energy Finance. Solar Spot Price Index. Accessed April 7, 2017.

[11] IBID.

Other category (hybrid diesel-PV, hybrid with battery…)	N/A	N/A

Source: Price data developed using bottom up cost model developed by the National Renewable Energy Laboratory.[12]

Table 8: National trends in system prices (current) for different applications – 2016 USD

Price/Wp	2007	2008	2009	2010	2011	2012	2013	2014	2015	H1 2016
Residential PV systems < 10 KW	9,33	8,93	8,51	7,18	6,37	5,41	4,71	4,32	4,10	4,08
Non-Residential ≤500 kW	9,06	8,80	8,70	7,05	5,95	5,16	4,32	3,82	3,56	3,45
Non-Residential >500 kW	7,61	7,49	7,29	5,72	4,75	4,48	3,55	2,79	2,53	2,37
Ground-mounted				4,34	3,61	3,21	2,83	2,43	2,10	Not available

Source: Data from Lawrence Berkeley National Laboratory.[13] Pricing for "residential" and "non-residential" represent the median reported price for behind-the-meter systems for their given size and market segments. Pricing for "ground-mounted" represents the median price of systems 5 MW or greater. Prices in 2016 only include a subset of systems installed in the first half of 2016.

2.3 Cost breakdown of PV installations

2.3.1 Residential PV System < 10 kW

Table 9: Cost breakdown for a residential PV system – local currency

Cost category	Average (local currency/W)	Low (local currency/W)	High (local currency/W)
Hardware			
Module	0,64		
Inverter	0,21		
Other (racking, wiring…)	0,36		
Soft costs			
Installation	0,30		
Customer Acquisition			

[12] Fu, Ran; Chung, Donald, Lowder, Travis; Feldman, David; Ardani, Kristen; Margolis, Robert. 2016. U.S. Solar Photovoltaic System Cost Benchmark: Q1 2016. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/docs/fy16osti/66532.pdf.

[13] Barbose, G.; Darghouth, N.; Weaver, S.; Wiser, R. "Tracking the Sun IX: The Installed Price of Residential and Non-Residential Photovoltaic Systems in the United States." Berkeley, CA: Lawrence Berkeley National Laboratory.

Profit	1,23[14]		
Other (permitting, contracting, financing…)	Engineering, Permitting, Inspection, Interconnection, and Sales Tax: 0,18		
Subtotal Hardware	1,22		
Subtotal Soft costs	1,71		
Total	2,93		

Source: Price data developed using bottom up cost model developed by the National Renewable Energy Laboratory.[15]

2.3.2 Utility-scale PV systems > 5 MW

Table 10: Cost breakdown for a utility-scale PV system – local currency

Cost Category	Average (local currency/W)	Low (local currency/W)	High (local currency/W)
Hardware			
Module	0,64		
Inverter	0,10		
Other (racking, wiring, etc.)	0,20		
Soft cost			
Installation Labor	0,15		
Customer acquisition			
Profit	0,19[16]		
Other (contracting, permitting, financing etc.)	Permitting, commissioning, land acquisition, and sales tax: 0,14		
Subtotal Hardware	0,94		
Subtotal - Soft cost	0,48		
Total Installed Cost	1,42		

Source: Price data developed using bottom up cost model developed by the National Renewable Energy Laboratory.[17]

[14] Also includes overhead and supply chain costs

[15] Fu, Ran; Chung, Donald, Lowder, Travis; Feldman, David; Ardani, Kristen; Margolis, Robert. 2016. U.S. Solar Photovoltaic System Cost Benchmark: Q1 2016. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/docs/fy16osti/66532.pdf.

[16] Also includes overhead and logistical costs

[17] Fu, Ran; Chung, Donald, Lowder, Travis; Feldman, David; Ardani, Kristen; Margolis, Robert. 2016. U.S. Solar Photovoltaic System Cost Benchmark: Q1 2016. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/docs/fy16osti/66532.pdf.

2.4 Financial parameters and specific financing programs

Table 11: PV financing scheme

Average rate of loans – residential and commercial rooftop installations	Weighted average cost of capital for a portfolio of rooftop installations: 5.8-8.7%[18]
Average cost of capital – industrial and ground-mounted installations	Weighted average cost of capital for utility-scale project: 5.5-7.8%[19]

2.5 Specific investments programs

Third Party Ownership (no investment)	The up-front capital requirements of PV installations often deter PV adoption. As a result, innovative third-party financing schemes that address high up front capital requirements, such as solar leases and power purchase agreements (PPA), have become popular. In 2016, Third party owned systems accounted for 53% of residential installations. However, TPO is declining in many markets due to a combination of declining system costs, and new loan products entering the market.[20]
Renting	N/A
Leasing	Leasing remains a popular model for procuring solar energy, especially in states that do not allow residential PPAs. Many solar installers that provide PPA products also have solar lease products.
Financing through utilities	On Bill Financing, a process by which energy efficiency upgrades are financed through utility bills, is being explored by some utilities. 12 states currently have enabling legislation for On Bill Financing, and at least one state (New York) has a state-wide on bill financing program for solar.[21]
Investment in PV plants against free electricity	
Crowdfunding (investment in PV plants)	A number of platforms exist to facilitate the crowdfunding of solar projects. More generally, the Securities and Exchange Commission provides general guidance and annual limits for crowdfunded investments.[22]

[18] Feldman, D; Lowder, T; Schwabe, P. (2016). "PV Project Finance in the United States, 2016." National Renewable Energy Laboratory. http://www.nrel.gov/docs/fy16osti/66991.pdf
[19] Ibid.

[20] "U.S. Solar Market Insight Report: 2016 Year-in-Review." GTM Research/SEIA. March 2017.

[21] National Conference of State Legislatures. "On-Bill Financing: Cost-Free Energy Efficiency Improvements." April 7, 2015. http://www.ncsl.org/research/energy/on-bill-financing-cost-free-energy-efficiency-improvements.aspx, accessed June 26, 2017.

[22] Securities and Exchange Commission "Investor Bulletin: Crowdfunding for Investors." February 16, 2016. https://www.sec.gov/oiea/investor-alerts-bulletins/ib_crowdfunding-.html, accessed May 23, 2016.

2.6 Additional Country information

Table 12: Country information

Retail Electricity Prices for an household (range)	Average: 0,13 USD. Range 0,09 USD (Louisiana) – 0,27 USD (Hawaii) / KWh[23]
Retail Electricity Prices for a commercial company (range)	Average: 0,11 USD. Range 0,08 USD (Oklahoma) –0,24 USD (Hawaii) / KWh[24]
Retail Electricity Prices for an industrial company (range)	Average: 0,07 USD. Range 0,04 USD (Washington) – 0,20 USD (Hawaii) / KWh[25]
Population at the end of 2014 (or latest known)	324 304 407[26]
Country size (km^2)	9 833 517[27]
Average PV yield (according to the current PV development in the country) in kWh/kWp	Typical solar radiation in the United States ranges from 3 kWh/m^2/day to 7 kWh/m^2/day[28]
Name and market share of major electric utilities.	Pacific Gas and Electric (3,2%), Southern California Edison (3,1%), Florida Power and Light (3,0%), Consolidated Edison (1,6%), Georgia Power (1,5%)[29]

3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of PV. Direct support policies have a direct influence on PV development by incentivizing, simplifying, or defining adequate policies. Indirect support policies change the regulatory environment in a way that can promote PV development.

[23] Data, as of 2016, from EIA, forms EIA-861- schedules 4A-D, EIA-861S and EIA-861U. http://www.eia.gov/electricity/data/browser, accessed June 26, 2017.
[24] Ibid.
[25] Ibid.

[26] Annual Estimates of the Resident Population for the United States, States, Counties, and Puerto Rico Commonwealth and Municipals: as of December 31, 2016. Source: U.S. Census Bureau, Population Division. Release Date: June 2017. Census.gov, accessed June 26, 2017.

[27] Data from the CIA World Factbook, as of June 15, 2016. https://www.cia.gov/library/publications/the-world-factbook/geos/us.html, accessed June 26, 2017.

[28] Data from the National Renewable Energy Laboratory, PVWatts – version 1. http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/, accessed July 10, 2014.

[29] Data, as of 2015, from EIA, forms EIA-861. http://www.eia.gov/electricity/data/browser, accessed June 26, 2017.

3.1 Direct support policies for PV installations

3.1.1 New, existing or phased out measures in 2016

3.1.1.1 Description of support measures excluding building-integrated photovoltaics (BIPV), and rural electrification

Most PV in the U.S. is tied to the grid. The process for valuing solar energy sold to the grid is regulated by state and local governments. Net metering is the most popular process for selling distributed solar energy to the grid and 38 states plus the District of Columbia and Puerto Rico have net metering policies.[30] Recently some jurisdictions have seen disputes between utilities and solar advocates over net metering, and several jurisdictions have approached, or are approaching the maximum allowed capacity for net metering programs. Some states have successfully raised these caps; however, others have modified their net metering policies, decreasing the value of energy put onto the grid by PV systems, or moving to alternative rate structures such as time of use. Areas without net metering may employ different practices to value solar energy while some do not compensate for grid-pared solar.

3.1.1.2 BIPV development measures

The voluntary Leadership for Energy and Environmental Design (LEED) certification program produces criteria and guidelines for incorporating energy efficient practices and renewable energy systems into buildings. To date over 44,000 buildings have been LEED certified in the U.S. Numerous state and local governments provide incentives for builders that achieve LEED status.[31]

3.1.1.3 Rural electrification measures

Nearly 99 % of Americans have access to electricity.[32] The Rural Utility Service (RUS) offers loans and loan guarantees to finance energy efficiency and renewable distributed energy improvements to Americans without access to electricity.

3.1.1.4 Support for electricity storage and demand response measures

California has led efforts for energy storage deployment, as it is the nation's leading market for distributed PV deployment. California's Self-Generation Incentive Program offers rebates for "advanced energy storage" that vary based on system size current incentives vary between 0,32 and 0,45 USD/Wh. To-date it has funded approximately 59 MW of storage, and 280 unique storage projects.[33] Additionally, Hawaii Electric Company has identified 17 utility-led energy storage projects to assist with the generation of renewable energy.[34] The current Hawaiian self-consumption program also provides a self-supply option, where PV

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[30] Two other states have no state-wide mandatory rules, but some utilities allow net metering. Six other states offer distributed generation compensation rules other than net metering. Data from the Database of State Incentives for Renewables and Efficiency. http://www.dsireusa.org/, accessed June 27, 2017

[31] LEED http://programs.dsireusa.org/system/program?type=10&

[32] Data from the World Bank. http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS, accessed June 27, 2017.

[33] Data from the Center for Sustainable Energy California. "Program Statistics." May 8, 2017. https://energycenter.org/self-generation-incentive-program/program-statistics, accessed June 27, 2017

[34] HECO. Other Routes to Clean Energy. https://www.hawaiianelectric.com/clean-energy-hawaii/producing-clean-energy/other-routes-to-clean-energy/energy-storage, accessed June 27, 2017.

owners can gain preferential permitting treatment by consuming all PV onsite (no value is given to exported generation). Though still a relatively recent development, an increasing number of PV systems in Hawaii are coupled with smart water heaters, battery storage systems, and other load controls.

Table 13: PV support measures (summary table)

	On-going measures residential	Measures that commenced during 2016 - residential	On-going measures Commercial + industrial	Measures that commenced during 2016 – commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2016 – ground mounted
Feed-in tariffs	3 states currently have FiTs that are accepting new applicants. Some utilities offer feed in tariffs.	Hawaii's FiT closed in April 2017.	3 states currently have FiTs that are accepting new applicants. Some utilities offer feed in tariffs.	Hawaii's FiT closed in April 2017.	N/A	N/A
Feed-in premium (above market price) (i.e. performance based incentive)	Performance based incentive programs for PV systems in the residential sector exist in 20 states.	N/A	Performance based incentive programs for PV systems in the non-residential sector exist in 23 states.	N/A	N/A	Starting in 2016, 150 MW of PV systems located in Oregon with a capacity between 2 and 10 MW are eligible for a \$0.005 per kWh incentive.
Capital subsidies	Federal: 30 % Investment Tax Credit, State: At least 14 states offer capital subsidies.	State subsidies expired in 3 states in 2016.	Federal: 30 % Investment Tax Credit, State: At least 14 states offer capital subsidies.	State subsidies expired in 3 states in 2016.	Federal: 30 % Investment Tax Credit, State: At least 14 states offer capital subsidies.	State subsidies expired in 3 states in 2016
Green certificates	Many states with RPS requirements also allow the trading of renewable electricity credits, and at least 10 states allow for the trading of solar renewable energy credits.	N/A	Many states with RPS requirements also allow the trading of renewable electricity credits, and at least 10 states allow for the trading of solar	N/A	Many states with RPS requirements also allow the trading of renewable electricity credits, and at least 10 states allow for the trading of solar	N/A

			renewable energy credits.		renewable energy credits.	
Renewable portfolio standards (RPS) with/without PV requirements	29 states plus the District of Columbia, Guam, Puerto Rico, and Virgin Islands, have an RPS.	6 States expanded or modified their RPSs in 2016.	29 states plus the District of Columbia, Guam, Puerto Rico, and Virgin Islands, have an RPS.	6 States expanded or modified their RPSs in 2016.	29 states plus the District of Columbia, Guam, Puerto Rico, and Virgin Islands, have an RPS.	6 States expanded or modified their RPSs in 2016.
Income tax credits	Federal: federal investment tax credit of 30 % for residential, commercial, and utility systems. State: 11 states offer tax credits for solar projects.	4 States eliminated solar tax credits in 2016, while one state (Maryland) extended their tax credit program.	Federal: federal investment tax credit of 30 % for residential, commercial, and utility systems. State: 19 states offer tax credits for solar projects.	4 States eliminated solar tax credits in 2016, while one state (Maryland) extended their tax credit program.	Federal: federal investment tax credit of 30 % for residential, commercial, and utility systems. State: 19 states offer tax credits for solar projects.	4 States eliminated solar tax credits in 2016, while one state (Maryland) extended their tax credit program.
Self-consumption	Most states use net metering as a process for compensating self-consumption. However, some states have recently moved to other systems for self-consumption as distributed solar has become a more sizeable portion of their load.		Most states use net metering as a process for compensating self-consumption. However, some states have recently moved to other systems for self-consumption as distributed solar has become a more sizeable portion of their load.		N/A	N/A
Net-metering	38 states plus the District of Columbia and Puerto Rico have net metering policies.	12 states modified their net metering policies in 2015. While most states increased their NEM caps, 3 states transitioned to	38 states plus the District of Columbia and Puerto Rico have net metering policies.	12 states modified their net metering policies in 2015. While most states increased their NEM caps, 3 states transitioned to	N/A	N/A

		a new compensation program, and one state restored a previously eliminated NEM program.[35]		a new compensation program, and one state restored a previously eliminated NEM program.[36]		
Net-billing	N/A	N/A	N/A	N/A	N/A	N/A
Collective self-consumption and virtual net-metering	15 States have virtual net metering or community solar policies.	N/A	15 States have virtual net metering or community solar policies.	N/A	N/A	N/A
Commercial bank activities e.g. green mortgages promoting PV	Connecticut, Hawaii, New York, California and Vermont have created green banks.	N/A	Connecticut, Hawaii, New York, California and Vermont have created green banks.	N/A	Connecticut, Hawaii, New York, California and Vermont have created green banks.	N/A
Activities of electricity utility businesses	Several electricity utilities have begun engaging with PV development, either through direct ownership of centralized and distributed PV assets, community solar programs, partial ownership in PV development companies, or joint marketing agreements.	N/A	Several electricity utilities have begun engaging with PV development, either through direct ownership of centralized and distributed PV assets, community solar programs, partial ownership in PV development companies, or joint marketing agreements.	N/A	Several electricity utilities have begun engaging with PV development, either through direct ownership of centralized and distributed PV assets, community solar programs, partial ownership in PV development companies, or joint marketing agreements.	N/A

[35] North Carolina Clean Energy Technology Center & Meister Consultants Group, *The 50 States of Solar: 2016 Annual Review and Q4 Quarterly Report*, January 2017.

[36] North Carolina Clean Energy Technology Center & Meister Consultants Group, *The 50 States of Solar: 2016 Annual Review and Q4 Quarterly Report*, January 2017.

Sustainable building requirements	Federal: No federal codes exist, but DOE produces best-practices guides for sustainable building for both residential and commercial buildings.	N/A	Federal: No federal codes exist, but DOE produces best-practices guides for sustainable building for both residential and commercial buildings.	N/A	N/A	N/A
BIPV incentives	N/A	N/A	N/A	N/A	N/A	N/A

All data in this table is from the Database of State Incentives for Renewables & Efficiency (DSIRE)[37] unless cited otherwise.

3.2 Self-consumption measures

PV self-consumption	1	Right to self-consume	Yes
	2	Revenues from self-consumed PV	Savings on electricity bill
	3	Charges to finance Transmission & Distribution grids	In some states
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Retail electricity prices in most states, solar specific tariffs and TOU rates in others
	5	Maximum timeframe for compensation of fluxes	Varies by state
	6	Geographical compensation	On-site; at least 15 states have community solar or virtual net metering policies[38]
Other characteristics	7	Regulatory scheme duration	Unlimited
	8	Third party ownership accepted	Yes, at least 26 states + Washington DC and Puerto Rico

[37] Database of State Incentives for Renewables & Efficiency (DSIRE). http://programs.dsireusa.org/system/program/tables, accessed June 27, 2017.

[38] North Carolina Clean Energy Technology Center & Meister Consultants Group, *The 50 States of Solar: 2016 Annual Review and Q4 Quarterly Report*, January 2017.

	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Some states have implemented minimum bills for NEM customers
	10	Regulations on enablers of self-consumption (storage, DSM…)	ToU Tariffs in some states
	11	PV system size limitations	Most states restrict the size of the system of the amount of load a PV system can offset
	12	Electricity system limitations	In some states
	13	Additional features	Multiple other policies depending on the state or at federal level

3.3 Collective self-consumption, community solar and similar measures

Fifteen states have Virtual Net Metering or other community solar enabling policies. Community solar is also available in states without distinct policies, but often require utility participation. Twenty-three other states either have or are working to develop active community solar programs.

3.4 Tenders, auctions & similar schemes

The majority of utility scale PV projects in the U.S. are owned by independent power producers, selling electricity to utilities under long-term power purchase agreements (PPAs). PPAs can provide stable cash flows and assist project developers in securing financing for their project. Utilities typically solicit PPA bids through requests for proposals or requests for offers (RFP/RFO), and select bids based on a number of factors including price, interconnection, curtailment, capacity factor, and contract terms.

Additionally, project owners may choose to bid into wholesale electricity markets. While the terms and structure of these markets can vary, many utilize reverse auction mechanisms, in which entities bid a specific amount of power into the market at a set price. The system operator will dispatch cheaper sources of energy first, moving to more expensive sources as demand increase. Finally, some utilities are able to directly own, finance, and rate base utility solar systems, provided this practice is authorized by their regulator. Historically, many regulators have preferred to have utilities purchase renewables though PPA arrangements, as the RFP process can enable greater price transparency and economic competitiveness.

3.5 Financing and cost of support measures

Financial incentives for U.S. solar projects are provided by the federal government, state and local governments, and some local utilities. Historically, federal incentives have been provided primarily through the U.S. tax code, in the form of an investment tax credit (ITC) and accelerated 5-year tax depreciation (which applies to all commercial and utility-scale installations and to third-party owned residential, government, or non-profit installations). 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.[39]

Many solar project developers are not in a financial position to absorb tax incentives themselves (due to lack of sufficient taxable income to offset deductions and credits), and so they have had to rely on a small cadre of third-party "tax equity investors" who invest in tax-advantaged projects to shield the income they receive from their core business activities (e.g., banking). In doing so, tax-equity investors monetize the tax incentives that otherwise could not be efficiently used by project developers and other common owners of the renewable energy plants.

Federal benefits can be used in combination with state and local incentives, which come in many forms, including—but not limited to—up-front rebates, performance-based incentives, state tax credits, renewable energy certificate (REC) payments, property tax exemptions, and low-interest loans. Incentives at both the federal and state levels vary by sector and by whether or not the systems are utility scale or distributed.

In most cases, solar project developers combine several of these federal, state, and local incentives to make projects economically viable. Given the complexity of capturing some of these incentives—particularly in combination— solar financiers have adopted (and in some cases, modified) complex ownership structures previously used to invest in other tax-advantaged sectors in the United States, such as low-income housing, historical buildings, and commercial wind projects.

Ordinarily, utility-scale projects are owned by independent power producers (in conjunction with tax equity investors), who sell the power to utilities under a long-term PPA. Distributed PV systems are either self-financed, financed through a loan, or are third-party financed. Approximately 53% of U.S. residential systems installed in 2016 used third-party financing arrangements.[40] At least 26 states, the District of Columbia, and Puerto Rico allow for third party financing of solar systems such as PPAs or solar leases (9 states apparently disallow the process or have legal barriers). Additionally, 30 states and the District of Columbia have enabled Property Assessed Clean Energy (PACE) programs which allow energy efficiency or renewable energy improvements to be financed through property taxes.

3.6 Indirect policy issues

In August 2015, the U.S. Environmental Protection Agency (EPA) announced the Clean Power Plan, which stated that beginning in 2020, each state must have a goal establishing their carbon intensity and a plan to achieve emission reductions. While each state can decide how to accomplish its goal, one of the major building blocks to reaching their target is, "expanding zero- and low-carbon power sources," which can include solar.[41] The Clean Power Plan includes a Clean Energy Incentive Program (CEIP) designed to reward investment in renewable energy and demand-side energy efficiency, prior to the intended start of the Clean Power Plan. In 2016, 27 states petitioned the U.S. Court of Appeals for the District of Columbia Circuit for an emergency stay of the Clean Power Plan and the U.S. Supreme Court ordered the EPA to halt enforcement until the case was heard by the lower Court of Appeals.

State governments have also collaborated to develop carbon trading schemes. The Regional Greenhouse Gas Initiative (RGGI), which includes 8 states in the Northeastern U.S., is a mandatory market based trading program designed to cap carbon emissions through the issuance of carbon

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[39] DOE (U.S. Department of Energy). (2012). *SunShot Vision Study*. DOE/GO-102012-3037. Washington, DC: U.S. Department of Energy. http://www1.eere.energy.gov/solar/pdfs/47927.pdf.

[40] "U.S. Solar Market Insight Report: 2016 Year-in-Review." GTM Research/SEIA. March 2017.

[41] EPA. Fact Sheet: Clean Power Plan Framework. http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-framework, accessed May 23, 2016.

allowances through quarterly actions. California has a similar cap and trade program that trades with the Western Climate Initiative in Canada.

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

The U.S. Department of Energy (DOE) is one of the primary bodies that support research and development (R&D) of solar energy technologies. In 2011, when solar power comprised less than 0.1% of the U.S. electricity supply, DOE launched the SunShot Initiative with the goal of making solar electricity cost-competitive with traditionally generated electricity by 2020 without subsidies.[42] At the time, this meant reducing PV prices by approximately 75% across the residential, commercial, and utility-scale sectors. For utility-scale solar, this target is a levelized cost of energy (LCOE) of 6¢ per kWh. Rapid progress has been made in accelerating achievement of these cost reductions, and DOE's Solar Energy Technologies Office (SETO) sees clear pathways to meeting the SunShot 2020 cost targets on schedule. In recognition of the transformative solar progress to date and the potential for further innovation, the SunShot Initiative extended its goals to reduce the average unsubsidized LCOE of utility-scale PV to 3¢/kWh by 2030, while enabling greater adoption by addressing grid integration challenges and market barriers. In parallel, SunShot is targeting concurrent reductions for commercial and residential rooftop PV costs to 4¢/kWh and 5¢/kWh by 2030, respectively. Achieving this goal is expected to more than double the projected amount of electricity demand met by solar compared to the 2020 goal alone, further supporting national goals of energy security, low cost electricity, and environmental stewardship. By funding selective R&D concepts, the SunShot Initiative promotes genuine transformation in the way the U.S. generates, stores, and utilizes solar energy.

The majority of research, development and demonstration (RD&D) funding under the initiative is provided by SETO, thus this summary focuses on the RD&D funded by SETO. The initiative focuses on removing the critical barriers for the system as a whole, including technical and non-technical barriers to installing and integrating solar energy into the electricity grid. In addition to investing in necessary research to improve the performance of solar technologies and facilitate low-cost manufacturing, the Department focuses on integrating solar generated energy systems into the electricity grid, and reducing installation and permitting costs. DOE focuses on innovative technology and manufacturing process concepts as applied to PV. It also supports PV systems integration by developing radically new approaches to reduce the cost and improve the reliability and functionality of power electronics, by supporting industry development through test and evaluation standards, and by developing tools for understanding grid integration issues. Emphasis is also placed on non-hardware related balance-of-system costs including streamlined permitting, inspection, and interconnection as well as performing key analyses of policy options and their impact on the rapid deployment of solar technologies.

Examples of SETO funded research and development activities in 2016 include:

- Working with small businesses to eliminate market barriers, reduce non-hardware costs, and to encourage technology innovation to support SunShot goals.
- Working with industry, national laboratories, and university researchers to enable grid operators to better forecast how much solar energy will be added to the grid and accelerate the integration of these forecasts into energy management systems used by grid operators

[42] The 2020 SunShot target was set to make solar cost-competitive at low levels of solar penetration. Because of its electricity production profile, as solar penetration levels increase its costs must continue to drop to remain competitive in the energy marketplace. More information on the SunShot Initiative can be found here: https://energy.gov/eere/sunshot/sunshot-initiative

and utility companies. These tools will enable grid operators to manage the variability and uncertainty of solar power, ensuring that they can reliably and efficiently integrate large amounts of solar on to the grid.

- Working with researchers to build the PV scientific knowledgebase and develop technologies that have the potential to produce new classes of commercial PV products that improve module performance, reliability, and manufacturability.[43]

Funding in FY16 provided by SETO, as shown in Table 14, accounted for approximately 50% of all public RD&D for PV technology development in the U.S. In addition, the Department of Energy's Office of Science and Advanced Research Projects Agency-Energy (ARPA-E), the National Science Foundation, the Department of Defense, the National Aeronautics and Space Administration, and states such as California, New York, Florida and Hawaii also fund solar R&D.

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

Table 14: Public budgets for R&D, demonstration/field test programmes and market incentives.

Photovoltaic R&D	MUSD 53,2
Concentrating Solar Power	MUSD 48,4
Systems Integration	MUSD 52,4
Balance of Systems/Soft Cost Reduction	MUSD 34,9
Innovations in Manufacturing Competitiveness	MUSD 43,5
National Renewable Energy Laboratory Site-Wide Facility Support	MUSD 9,2
Total	**MUSD 241,6**

[43] Additional information on SETO funded projects is available at http://energy.gov/eere/sunshot/sunshot-initiative.

5 INDUSTRY

5.1 Production of feedstocks, ingots and wafers (crystalline silicon industry)

Table 15: Production information for the year for silicon feedstock, ingot and wafer producers

Manufacturers (or total national production)	Process & technology	Total Production	Product destination (if known)	Price (if known)
SunEdison, REC Silicon, Hemlock	Polysilicon feedstock	29 624 tonnes	N/A	N/A
SunEdison	Wafers	0 MW	N/A	N/A

5.2 Production of photovoltaic cells and modules (including TF and CPV)

Module manufacturing is defined as the industry where the process of the production of PV modules (the encapsulation) is done. A company may also be involved in the production of ingots, wafers or the processing of cells, in addition to fabricating the modules with frames, junction boxes etc. The manufacturing of modules are only attributed to a country if the encapsulation takes place in that country.

Total PV cells and modules manufactured together with production capacity information is summarised in Table 16 below.

Table 16: Production and production capacity information for 2016

Cell/Module manufacturer (or total national production)	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Total		776	1 109	801	1 176
Thin film manufacturers					
Total		NA	590	NA	750
Cells for concentration					
Total		NA	NA	NA	NA
TOTALS		**776**	**1 699**	**801**	**1 926**

5.3 Manufacturers and suppliers of other components

U.S. companies shipped approximately 7,0 GW_{AC} of PV inverters in 2016; approximately half of all U.S. systems installed during that time period.[44] The supporting structures of U.S. systems are primarily domestically manufactured. Battery implementation represents a small but growing portion of the overall U.S. PV deployment market; companies offering integrated solar and battery packages continues to grow in the US, with many companies exploring partnerships or other mergers and acquisitions activity to offer solar plus storages packages. Additionally, micro-inverters and DC optimizers represent a growing portion of the U.S. market.

[44] Ibid.

6 PV IN THE ECONOMY

6.1 Labour places

Table 17: Estimated PV-related labour places in 2016

Research and development (not including companies)	Not available
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	38 121
Distributors of PV products	32 147
System and installation companies	171 533
Electricity utility businesses and government	Not available
Other	18 274
Total	260 077[45]

6.2 Business value

Table 18: Value of PV business

Sub-market	**Capacity installed *in 2016* (MW)**	**Price per W** *(from table 7)*	**Value**	**Totals**
Off-grid domestic				
Off-grid non-domestic				
Grid-connected distributed	Residential 2 583 Commercial 1 586	Residential USD 2,93 Commercial USD 2,13	*BUSD 10,9*	
Grid-connected centralized	10 593	USD 1,49	*BUSD 15,8*	
				BUSD 26,7
Export of PV products				*N/A*
Change in stocks held				*N/A*
Import of PV products				*N/A*
Value of PV business				*BUSD 26,7*

U.S. PV manufacturing, which had grown in shipments 10 times from 2003-2010, followed by a period of contraction caused by rapid decline in prices in 2011 and 2012, continued to recover in 2016. In 2016, U.S. PV cell production was 776 MW, a 24% increase over 2015. Additionally the U.S. produced 1 742 MW of PV modules, a 29% increase over 2015.

U.S. manufacturing also has a significant presence in other part of the PV value chain, including polysilicon, encapsulants, wiring, and fasteners. Thus, between 2010 and 2016 the number of U.S. solar manufacturing jobs has increased by 53%, from 24 916 to 38 121.[46] Furthermore,

[45] Solar Foundation. (2017). National Solar Jobs Census 2016. Washington, DC: The Solar Foundation.

[46] Solar Foundation. (2016). National Solar Jobs Census 2016. Washington, DC: The Solar Foundation.

manufactured hardware is only a portion of the total solar value chain. Industry-wide, approximately 166 500 jobs relating to solar were added from 2010 to 2016, growing from 93 500 to 260 000 employees. The growth rate from 2014 to 2016 is nearly seventeen times faster than what the overall U.S. economy experienced during that same time period.[47]

[47] Ibid.

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

Short description of the electricity industry landscape	The U.S. has a diverse deregulated utility landscape in which roughly 68% of consumers are served by an investor owned utility and the remaining customers are served by municipal utilities or cooperatives. Utilities are regulated at the local, state, and federal level to ensure they provide fair and reliable service to their customers by PUCs, ratepayer groups and federal agencies such as the Federal Energy Regulatory Commission (FERC). Transmission is regulated by Independent System Operators (ISO) or Regional Transmission Organizations, depending on region

7.2 Interest from electricity utility businesses

Electricity utility interest in solar 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, as well as the declining cost of PV. As utility scale solar has become increasingly competitive with retail generation, 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.[48]

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:

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

The issues related to utility ownership include:

- Some state restructuring rules that do not allow generation utilities to own distributed generation

[48] The Smart Electric Power Alliance (formally 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.

- 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:

- Rate basing solar loans and recovering lost revenues
- Supporting turnkey installations and rate basing shareholder loans
- Supporting a feed-in tariff (FIT) with solar revenue streams and rate based 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 publicly 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.

7.3 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 a single registration form specifying 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.

8 HIGHLIGHTS AND PROSPECTS

In 2016, the U.S. market increased its annual installations by approximately 7 GW, from roughly 7,3 GW in 2015 to 14,7 GW in 2016.[49] U.S. annual installations have been growing rapidly during the past five years, from 0,9 MW in 2010 to 14,7 MW in 2016. Much of the recent growth came from utility-scale installations, though the distributed market has also increased in size. PV capacity continues to be concentrated in a small number of states, such as California, Arizona, Nevada, North Carolina, and New Jersey, which comprise roughly two-thirds of the market. However, this trend is changing slowly as 28 states currently have 100 MW or more of PV capacity and 39 states each have more than 15 MW of capacity.[50] While annual installations are expected to decrease in 2017, more than 17 GW of contracted utility scale PV projects were in the pipeline as of the end of 2016, and installations are expected to remain robust.[51] Though some incentive programs in the U.S. have expired or been reduced, many projects currently under construction have already qualified to receive funding. In addition, due to the continued reduction in system pricing as well as the availability of new loan products and third-party ownership arrangement with lower financing costs, most PV in 2016 was installed outside of state RPS requirements.

Industry-wide, approximately 166 000 jobs relating to solar were added from 2010 to 2016, growing to a total of over 260 000 employees (51 000 of which were added in 2016 alone). The growth rate in solar jobs from 2015 to 2016 of 25% was 17 times faster than what the overall U.S. economy experienced during that same time period.[52] PV manufacturing is only a portion of the overall solar value chain, and U.S. PV manufacturing, which contracted in 2011-13 after having shipment growth of 10 times from 2003-2010, continued to recover in 2016. Module production has increased 29% from 2015 to 2016, though continued growth in the manufacturing sector remains uncertain.[53] However, U.S. manufacturing has a significant presence in other parts of the PV value chain, including polysilicon, encapsulants, wiring, and fasteners. In 2016, the U.S. solar manufacturing sector employed 38 121 people, a 25% increase since 2015.[54]

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[49] EIA, Electric Power Monthly (February 2017).

[50] "U.S. Solar Market Insight Report: Q1 2017." GTM Research/SEIA. March 2017.

[51] Ibid.

[52] Ibid.

[53] Ibid.

[54] Solar Foundation. (2017). National Solar Jobs Census 2016. Washington, DC: The Solar Foundation.