



# National Survey Report of PV Power Applications in CHINA 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 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](http://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](http://www.iea-pvps.org)

## Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of 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, 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 2015. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

The PVPS website [www.iea-pvps.org](http://www.iea-pvps.org) also plays an important 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 also considered in this report, since China is the largest producer of mobile PV products.

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

### 1.1 Applications for Photovoltaics

By the end of 2016, China's accumulated grid connected PV installation reached 77.72 GW (exclude off grid installation) to maintain first place worldwide in terms of PV installation. Of which, ground mounted LS-PV accounted for 67.43GW, distributed 10.29GW, with a total power output of 66.2 billion kWh accounted for about 1% in the total electricity generation. The newly added grid connected PV installation was 34.54GW more than doubled last year. Of which, ground mounted LS-PV accounted for 30.31GW, distributed 4.23GW which increased 200% than last year under the promotion of incentive policies.

The development of the PV market demonstrated a pattern of transfer to middle and east regions. In the middle and east regions, there were 9 provinces that newly added installed over 1000 MW included Shandong (3.22GW), Henan (2.44GW), Anhui (2.25GW), Hebei(2.03GW), Jiangxi( 1.85GW), Shanxi( 1.83GW), Zhejiang( 1.75GW), Hubei( 1.38GW), Jiangsu(1.23GW). And top five of the provinces with newly added distributed PV installation included Zhejiang (860MW), Shandong (750MW), Jiangsu (530MW) Anhui (460MW) and Jiangxi(310MW).

### 1.2 Total photovoltaic power installed

**Table 1: PV power installed during calendar year 2016**

AC			MW installed in 2016 (mandatory)	MW installed in 2016 (optional but HIGHLY NEEDED)	AC or DC
Grid-connected	BAPV	Residential	4230MW		DC
		Commercial			
		Industrial			
	BIPV (if a specific legislation exists)	Residential			DC
		Commercial			
		Industrial			
	Ground-mounted	cSi and TF	30310MW		DC
		CPV			
Off-grid	Rural Power	2MW		DC	
	Communication&Industry	5MW		DC	
	PV Mobile Products	3MW		DC	

	<b>Total</b>	34550MW	
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**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?	Data on annual and accumulated PV grid-connected installation capacity in 2016 were published by National Energy Administration (NEA). Off-grid installation accounts for a very small scale in China so the data was estimated by PV experts.
Link to official statistics (if this exists)	China RE Power Monitoring report, NEA 2017 (97)

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

<i>MW-GW for capacities and GWh-TWh for energy</i>	2016 numbers	2015 numbers
Total power generation capacities (all technologies)	1645.75GW	1506.73GW
Total power generation capacities (renewables including hydropower)	558.17GW	518.6GW
Total electricity demand (= consumption)	5919.8TWh	5550TWh
New power generation capacities installed during the year (all technologies)	120.61GW	N/A
New power generation capacities installed during the year (renewables including hydropower)	Hydro 11.74GW Wind 18.73GW PV 34.55GW (off-grid not included) Total: 65.02GW	N/A
Total PV electricity production in GWh-TWh	66.2TWh	39.2TWh
Total PV electricity production as a % of total electricity consumption	1.1%	0.71%

**Source: National Energy Administration**

**Table 4: Other informations**

	<b>2016 Numbers</b>
Number of PV systems in operation in your country (a split per market segment is interesting)	Total 78.08GW: Rural Electrification 182MW (0.23%), Comm.& Indus. 90MW (0.12%), PV Products 88MW(0.11%), Distributed and Building PV 10290 MW (13.18%), Ground Mounted LS-PV 67430 MW (86.36%) .
Capacity of decommissioned PV systems during the year in MW	N/A
Total capacity connected to the low voltage distribution grid in MW	N/A
Total capacity connected to the medium voltage distribution grid in MW	10.29GW ( $\leq 35kV$ ) (include:220V,380V,10kV,35kV)
Total capacity connected to the high voltage transmission grid in MW	67.43GW ( $\geq 110kV$ )

**Table 5: The cumulative installed PV power in 4 sub-markets. (MW)**

<b>Sub-market</b>	<b>Stand-alone total</b>	<b>Grid-connected distributed</b>	<b>Grid-connected centralized</b>	<b>Annual Total</b>	<b>Cumulative</b>
2001	4.50	0.01	0.00	4.51	23.51
2002	18.50	0.01	0.00	18.51	42.02
2003	10.00	0.07	0.00	10.07	52.1
2004	8.80	1.20	0.00	10.00	62.1
2005	6.40	1.30	0.20	7.90	70
2006	9.00	1.00	0.00	10.00	80
2007	17.80	2.00	0.20	20.00	100
2008	29.50	10.00	0.50	40.00	140
2009	17.80	34.20	108.00	160.00	300
2010	27.00	190.00	283.00	500.00	800
2011	20.00	680.00	2000.00	2700	3500
2012	40.00	890.00	2630.00	3560	7060
2013	80.00	800	9800	10680	17740
2014	40.00	2050.00	8550.00	10640	28380
2015	20.00	1390.00	13740.00	15150	43530
2016	10.00	4230.00	30310.00	34550	78080



Source: National Energy Administration, Prof. Wang Sicheng

## 2 COMPETITIVENESS OF PV ELECTRICITY

During 2011-2016, the cost of PV has been reduced sharply. It is estimated that PV price will reach grid-parity with traditional coal-fire power at user-side by the year of 2020 and reach to grid-parity at generating side by the year 2025.

### 2.1 Module prices

**Table 6: Typical module prices for a number of years(Units: RMB Yuan)**

Year	2010	2011	2012	2013	2014	2015	2016
Standard module crystalline silicon price(s): Typical	13.0	9.0	4.5	4	3.8	3.5	3.1
Lowest prices	-	-	-	-	-	-	-
Highest prices	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source: Prof. Wang Sicheng

### 2.2 System prices

**Table 7: Turnkey Prices of Typical Applications – local currency (2016)**

Category/Size	Typical applications and brief details	Current prices per (RMB Yuan/W)
OFF-GRID Up to 1 kW	Solar lighting systems, solar home systems, Flashlight, calculator, street lamp and other PV products	22
OFF-GRID >1 kW	Rural stand-alone PV system	18
Grid-connected Rooftop up to 10 kW (residential)	Distributed PV system built on residential rooftop	7.0-10.0
Grid-connected Rooftop from 10 to 250 kW (commercial)	Distributed PV system built on commercial rooftop like malls	7.0-8.0
Grid-connected Rooftop above 250kW (industrial)	Distributed PV system built on industrial rooftop	7.0-7.5
Grid-connected Ground-mounted above 1 MW	Large-scale ground-mounted PV power plant	7.0-7.2
Other category (hybrid diesel-PV, hybrid with battery...)		N/A

Source: Estimation based on findings of a survey to main PV enterprises

**Table 8: National trends in system prices (current) for different applications – local currency**

Price/(RMB Yuan/W)	2009	2010	2011	2012	2013	2014	2015	2016
Residential PV systems < 10 KW	-	-	-	-	-	10	8-10	7.0-10.0
Commercial and industrial	-	-	18	14	12	8-10	7-8	7.0-7.5

Ground-mounted	35	25	17.5	10-12	9-10	8	7-8	7.0-7.2
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Source: Estimation based on findings of a survey to main PV enterprises

## 2.3 Cost breakdown of PV installations

### 2.3.1 Building PV System < 1MW

**Table 9: Cost breakdown for a 1MW Building PV system – local currency (10<sup>4</sup> Yuan)**

No	Items	Equipment	Installation	Others	Total	Share
A	Equipment & Installation	450	27		477	66.11%
1	PV Modules	340	16		356	49.34%
2	Inverters	50	5		55	7.62%
3	Monitoring & Control Equipment	30	3		33	4.57%
4	Other Equipment	30	3		33	4.57%
B	Construction	100	80		180	24.95%
1	Roof Pre-Treatment		10		10	1.39%
2	Supporting Structure	50	10		60	8.32%
3	Cable & Installation	50	10		60	8.32%
4	Grid-Connection		20		20	2.77%
5	Transport & Warehouse		30		30	4.16%
C	Others			50	50	6.93%
1	Survey & Design			30	30	4.16%
2	Management			20	20	2.77%
	A~C Total	550	107	50	707	97.99%
	Budget Reserve				15	2.01%
	Static Investment	10 <sup>4</sup> Yuan			721.5	100.00%
	Unit Static Investment	Yuan/kW			7215	

Source: Estimation based on findings of a survey to main PV enterprises

### 2.3.2 Utility-scale PV systems > 10 MW

**Table 10: Cost breakdown for a 10MW PV system – local currency (10<sup>4</sup> Yuan)**

No	Items	Equipment	Installation	Others	Total	Share
A	Equipment & Installation	4530	280		4810	66.80%
1	PV Modules	3200	150		3350	47.88%
2	Inverters	350	20		370	5.29%
3	Supporting Structure	400	50		450	6.43%
4	Transformers	200	20		220	3.14%
5	Monitoring & Control Equipment	280	30		310	4.43%
6	Other Equipment	100	10		110	1.57%
B	Construction	660	1020		1680	23.33%
1	Foundation		300		300	4.29%
2	Cable & Installation	380	100		480	6.86%

3	Housing Construction		300		300	4.29%
4	Transformer Station	280	50		330	4.72%
5	Transport & Warehouse		150		150	2.14%
6	Auxiliary Engineering		120		120	1.71%
C	Others			569	569	7.90%
1	Land for Housing	PV Farm Rent-Fee Excluded		60	60	0.86%
2	Management			279	279	3.99%
3	Pre-Conditioning			80	80	1.14%
4	System Design			150	150	2.14%
	A~C Total	5190	1300	569	7059	98.04%
	Budget Reserve	2%			141	1.96%
	Static Investment	10 <sup>4</sup> Yuan			7200	100.00%
	Active Investment	Including Interest during installation				
	Unit Static Investment	(Yuan/kW)			7200	

Source: Estimation based on findings of a survey to main PV enterprises

## 2.4 Financial Parameters and specific financing programs

Table 11: PV financing scheme

Average rate of loans – residential installations	4.9%(float within the prescribed scope of 15%)
Average rate of loans – commercial installations	4.9%(float within the prescribed scope of 15%)
Average cost of capital – industrial and ground-mounted installations	7.0-7.5 Yuan/W

## 2.5 Specific investments programs

Table 12: Specific Investments Programs

Third Party Ownership (no investment)	N/A
Renting	N/A
Leasing	N/A
Financing through utilities	N/A
Investment in PV plants against free electricity	N/A
Crowdfunding (investment in PV plants)	N/A
Other (please specify)	N/A

## 2.6 Additional Country information

Table 13: Country information

Retail Electricity Prices for an household (average)	0.54804 RMB Yuan/kWh
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Retail Electricity Prices for a commercial company (average)	0.82514 RMB Yuan/kWh
Retail Electricity Prices for an large-scale industrial company (average)	0.64397 RMB Yuan/kWh
Population at the end of 2015 (or latest known)	1 374 620 000
Country size (km <sup>2</sup> )	9 634 057
Average PV yield (according to the current PV development in the country) in kWh/kWp	By Resources Region: I: > 1500 (up to 2000) II: 1200 – 1500 III: < 1200 (down to 800)
Name and market share of major electric utilities.	N/A

### 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 or simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

#### 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 BIPV, and rural electrification*

2016 was the first year of China's thirteenth "Five-year Plan" period. The publication of a series plans in connection with PV power in the thirteenth "Five-year Plan" defined the short term PV development goals, positioning and focus points, especially policy adjustment mechanism and direction of innovation. Some new policies are being carried out, such as bidding mechanism for construction of regular PV stations and "leading runner" bases, renewable energy full amount purchase guarantee, and voluntary purchase of renewable green energy.

###### 3.1.1.1.1 Development plan and target

2020 PV power development target defined. At the end of 2016, the National Energy Administration ("NEA") issued "Solar power development plan during the thirteenth five-year plan period". The plan set the target that solar power output and on-grid installation shall be no less than 110 million KW by 2020, of which PV power accounts for 105 million KW. In Jul. 2017, however, the NEA issued "Guiding opinion on the implementation of renewable energy development plan during the thirteenth five-year plan period" (Guoxinfaneng [2017] No. 31). The guiding opinion set the target of 86.5GW for the planned newly added installation (including PV stations and "leading runner" bases), and the annual 20GW installation of distributed PV, PV poverty-alleviation and installation in 7 provinces and cities with no scale limitation (4 year total of 80GW) during 2017 and 2020 period. By 2020, the accumulated national PV installation will reach over 240GW.

###### 3.1.1.1.2 Project management

**Project disposition management model will comprehensively adopt competitive method.** In May, 2016, the National Development and Reform Commission ("NDRC") and NEA formally published "Guiding opinions on the perfection of PV scaled management model and adoption of competitive method for project disposition" (Fagainengyuan [2016] No. 1163), which clearly pointed out the direction of implementation of competitive method for PV power project management.

###### 3.1.1.1.3 Electricity price and subsidy

**Continued adjustment of PV power benchmark price according to PV technological advance and cost reduction.** In Dec. 2016, the NDRC issued the "Notice on adjustment of on-grid PV power and onshore wind power benchmark price" (Fagaijiage[2016] No. 2729) to adjust PV benchmark price in three types of resource regions, of which the I type region power price reduced 0.15 yuan/kwh, and II and III type regions lowered 0.13 yuan/kwh, with the lowered power price of 0.65 yuan/kwh, 0.75 yuan/kwh and 0.85 yuan/kwh respectively. The new power price policy was carried out from Jan. 1, 2017, but projects filed before 2017 and became operational before Jun. 30, 2017 would remain on-grid ben power benchmark price of 2016. Adjustment of PV on-grid power benchmark price would be carried out tentatively once a year.

**Led by PV "leading runner" technology bases, explore PV power cost and price demand by means of competition.** In the area of renewable energy, China started in 2016 to select developers and explore power price by means of competition. Developers for construction of "leading runner" base projects and regular PV stations have been selected through invitation for bid. As a result, bidding

power price was significantly lower than the benchmark power price in the same region. The lowest power quotation and bidding winner price could be as low as 0.45 yuan/kwh in the I type resource region, 0.56 yuan/kwh in the II type resource region and 0.61 yuan/kwh in the III type resource region. In the future, it is suggested to carry out in-depth analysis on bidding projects to establish price linkage models and gradually a favourable linkage mechanism between PV bidding price and benchmark price.

**-- Same kwh subsidy level for distributed PV power, adjustment of PV benchmark power price served to encourage developers to adopt the model of “self-generation, self-consumption, and surplus feed-in grid”.**

#### 3.1.1.1.4 Taxation policy

**Continued implementation of PV power preferential VAT, but the term of validity remains.** In Jul. 2016, the Ministry of Finance and State Administration of Taxation jointly issued the “Notice on continued implementation of the policy of PV power VAT” (Caishui [2016] No. 81). The notice clearly indicated that between the beginning of 2016 and the end of 2018, the policy of 50% immediate VAT levy and refund for electric products produced with solar power sold to taxpayers would be continued, and output tax of PV system power sale can be deducted with input tax for procurement of equipment. As a result, a project can be tax free for the first five years.

#### 3.1.1.1.5 On-grid power consumption

**Implementation of renewable energy target guidance system to provide continued development space for the application of renewable energy including PV power.** In Mar. 2016, the NEA issued the “Guiding opinion on the establishment of target guiding system for renewable energy development and application” (Guonengxinneng [2016] No. 54), which clearly set the proportion of renewable energy exclude hydropower for each province by the year 2020.

**The implementation of renewable energy full amount guarantee purchase policy plays a positive role.** In Mar. 2016, the NDRC issued the “Management method of renewable energy full amount guarantee purchase” (Fagainengyuan [2016] No. 625). The key content of the document is that based on on-grid power benchmark price set by the state and hour utilization of the guarantee purchase, combined with market competition mechanism, power grid companies shall purchase full amount of on-grid power generated by renewable energy within the planned scope.

**Table 14: PV support measures (Yes/No)**

	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	Yes	Yes	Yes	Yes	Yes	Yes
Feed-in premium (above market price)						
Capital subsidies	Yes, but only for off-grid rural electrification in remote areas.					
Green certificates	Yes Finance and the NEA jointly issued the “Notice on trial implementation of issuance of renewable energy green power certificate and voluntary purchase					

	trading system” (Fagainengyuan [2017] No. 132). The green power certificate and voluntary purchase trading was launched on Jul. 1, 2017. In due time in 2018, examination of electricity quota and mandatory green certificate trading will be implemented.					
Renewable portfolio standards (RPS) with/without PV requirements	Yes. RPS in China is for Non-Hydro renewable energy (wind, solar heat, PV, biomass, etc.) and not specific requirement for with or without PV. See 3.4.					
Income tax credits	Yes	Yes	Yes	Yes	Yes	Yes
Self-consumption	Yes	Yes	Yes	Yes	Yes	Yes
Net-metering	No	No	No	No	No	No
Net-billing	No	No	No	No	No	No
Collective self-consumption and virtual net-metering	No	No	No	No	No	No
Commercial bank activities e.g. green mortgages promoting PV	No	No	No	No	No	No
Activities of electricity utility businesses						
Sustainable building requirements	No	No	No	No	No	No
BIPV incentives	No	No	No	No	No	No
Other (specify)						

### 3.2 Feed-In Tariff

On Dec. 22, 2015, National Development and Reform Commission issued the new Feed-in Tariff of PV for 2016 (NDRC [2015] No. 3044). The details of PV FIT are shown below:

Table15 2016 FITs for PV Power Plants

Region of Solar Resources	FIT (Yuan/kWh)	Horizontal Annual Solar Resources (kWh/m <sup>2</sup> )	Yield (kWh/kW)
I	0.80	> 1700	> 1500 (up to 2000)
II	0.88	1350-1700	1200 – 1500
III	0.98	< 1350	< 1200 (down to 800)

On Dec. 26, 2016, National Development and Reform Commission issued the new PV Feed-in Tariff for 2017 (NDRC [2016] No. 2729). The details of PV FIT are shown below:

Table16 2017 New FITs for PV Power Plants

Region of Solar Resources	FIT (Yuan/kWh)	Horizontal Annual Solar Resources (kWh/m <sup>2</sup> )	Yield (kWh/kW)
I	0.65	> 1700	> 1500 (up to 2000)
II	0.75	1350-1700	1200 – 1500
III	0.85	< 1350	< 1200 (down to 800)

Remarks:

- 1) For distribution building PV, the projects can choose either selling total electricity to grid to enjoy FIT or self-consumption to get fixed subsidy.
- 2) The FIT period is 20 years.
- 3) Since 2017, the FIT will be reduced every year.
- 4) It is estimated that PV grid-parity will come up before 2025.

### 3.3 Self-consumption measures

Fixed subsidy for self-consumed PV was started in 2013, the measures are as follows:

Table17 2013-2017 Subsidy for Self-Consumption PV

The Value of Distributed PV	
For self-consumed PV (Yuan/kWh)	Excess PV Feed-Back to Grid (Yuan/kWh)
Retail Price of Grid Electricity +0.42 Yuan/kWh	Wholesale Coal-Fire Tariff + 0.42 Yuan/kWh

Remarks:

- 1) The subsidy period is 20 years.
- 2) It is estimated that by the year 2020, there will be no subsidy for self-consumption PV projects.

### 3.4 Renewable portfolio standards (RPS)

On Feb. 29, 2016, the NEA issued the “Guiding opinion on the establishment of target guiding system for renewable energy development and application” (Guonengxinneng [2016] No 54), which clearly defined the proportion of renewable energy exclude hydropower for each province.

Table18 Provincial Level Non-Hydro RE Portfolio Standards by 2020

Provinces	Non-Hydro RE (%)	Provinces	Non-Hydro RE (%)
Beijing	10%	Anhui	7%
Tianjin	10%	Fujian	7%



Hebei	10%	Jiangxi	5%
Shanxi	10%	Shandong	10%
Inner-Mongolia	13%	Henan	7%
Liaoning	13%	Hubei	7%
Jilin	13%	Hunan	7%
Heilongjiang	13%	Guangdong	7%
Shanghai	5%	Guangxi	5%
Jiangsu	7%	Hainan	10%
Zhejiang	7%		

### 3.5 Tenders, auctions & similar schemes

In the area of renewable energy, China started in 2016 to select developers and explore power price by means of competition. Developers for construction of “leading runner” base projects and regular PV stations have been selected through invitation for bid.

### 3.6 Financing and cost of support measures

The Renewable Law published in 2009 defined that “Renewable Energy Development Fund” includes dedicated funds allocated by annual finance of the state and added tariff for renewable energy collected according to law.

The added tariff for renewable energy is specifically used on subsidy to power price of renewable energy and fees for grid connectivity, allocated through grid companies. Since 2006, the state started to collect added tariff from revenue of electricity sales from users excluding power for residents and agriculture. In Dec. 2015, the National Development and Reform Commission for the fifth time increased the standard of such added tariff collection, from 0.015 yuan/kWh to 0.019 yuan/kWh. Now, about 65 billion RMB (~10 billion USD) can be collected each year to support RE power generation.

The dedicated renewable energy fund is directly controlled by the Ministry of Finance. The fund is used on construction of renewable energy projects in remote areas without electricity and renewable energy pilot projects. On Apr. 2, 2015, the Ministry of Finance issued the notice on “Interim management method of dedicated development fund for renewable energy” (Ministry of Finance [2015] No. 87), which clearly defines that the dedicated development fund for renewable energy refers to the dedicated fund allocated by means of central financial budget arrangement and is used on supporting development and application of renewable energy and new energy.

### 3.7 Indirect policy issues

Please give one paragraph on any policy initiatives that may influence the implementation of PV power systems in your country, such as International policies affecting the use of PV Power Systems, the introduction of any favourable environmental regulations, Policies relating to externalities of conventional energy, Taxes on pollution (e.g. carbon tax), National policies and programmes to promote the use of PV in foreign non-IEA countries... etc.

## 4 HIGHLIGHTS OF R&D

### 4.1 Highlights of R&D

#### 4.1.1 Crystalline silicon cell efficiency

In general, China's laboratory research level of crystalline silicon solar cell is at the same time in positions of "leading runner" and "follower". What's leading the world is the lab research in polycrystalline solar cell. Trina Solar's PV Science and Technology State Key Laboratory created a world record of 21.25% efficiency on polycrystalline solar cell, while Jinko Solar Co., Ltd announced 21.63% efficiency for the same product. In monocrystalline solar cell, the same Trina Solar lab joined efforts with Australia State University to have developed a small size (2 cm<sup>2</sup>) IBC cell with lab efficiency of 24.4%, and the efficiency of large size 156 mm x 156 mm monocrystalline solar cell independently developed by Trina Solar reached 23.5%, the highest for large size IBC cell. And the highest efficiency of large size HJT cell (156 mm x 156 mm) by Shanghai Institute of Microsystem and Information Technology under Chinese Academy of Sciences reached 23.3%. What's still lagged behind the world level is the lab efficiency of small size solar cell.

#### 4.1.2 Thin film cell efficiency

Since 2011, efficiency of various types of thin film solar cell have continued to be improved, with new world records created from time to time. Accordingly, the efficiency of modules have increased along with the progress. The following table listed the maximum efficiency of thin film solar cells and modules in China each year.

Table 19. The annual maximum efficiency of some main thin film solar cell and module in China

Type	Si-based		CIGS		CdTe		GaAs			
Year	Cell efficiency	Module efficiency	Cell efficiency	Module efficiency	Cell efficiency	Module efficiency	Thin film cell efficiency	Thin film cell efficiency	Concentrator cell	Concentrator cell
2012	12.6% <sup>2</sup>					8.94%				
2013	15.06% <sup>3</sup>	9.59%						31 %		
2014	16.07% <sup>4</sup>									
2015			20 %		16.28%	13.1%	34.5 %	30.15%		
2016	13.65% <sup>5</sup>		20.33%	12.6 %	17.33%			32 %		

#### 4.1.3 New type and concentrator cell efficiency

Perovskite solar cell efficiency is over 22%; Dye-sensitized solar cell efficiency certified by a third party is 11.9%, the highest efficiency reported by paper reached 14%; Polymeride solar cell efficiency remains at a lower level, and improvement on efficiency and stability is the problem to be solved in the future.

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

## 5 INDUSTRY

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

#### 5.1.1 Polycrystalline silicon material

China's polycrystalline silicon production remained continued increase in 2016 to reach 194,000 tons output, accounting 48.5% of global total output, and a 0.7 percentage point increase on year-on-year basis, and compared with 2015's 165,000 tons, an increase of 17.5%. The apparent consumption of polycrystalline silicon in 2016 was 330,000 tons (polycrystalline silicon output + polycrystalline silicon import – polycrystalline export), so there's still certain amount of gap in demand/supply and need to import the material.

**Table 20: Production information for the year for silicon feedstock, ingot and wafer producers**

Manufacturers (or total national production)	Process & technology	Total Production(tons)	Product destination (if known)	Price (if known)
Jiangsu Zhongneng	mc-Si	70000		
Xinte Energy	mc-Si	22800		
China Silicon	mc-Si	15700		
Asia Silicon	mc-Si	13300		
DAQO	mc-Si	12800		
Sichuan Yongxiang	mc-Si	12300		
LDK	mc-Si	10100		
DunAn	mc-Si	7000		
Jingyang	mc-Si	5600		
Sichuan ReneSola	mc-Si	5100		
Yichang CSG	mc-Si	4700		
Shenzhou Silicon Industry	mc-Si	4000		
Jiangsu Combo	mc-Si	800		
Rest	mc-Si	9800		
Total	mc-Si	19400		

Source: CPIA,2017.3

Describe briefly the overseas activities of any key companies also operating in other countries.

### 5.1.2 Silicon wafer

In 2016, the total output capacity of silicon wafer in China was 81.9GW, the output was about 64.8GW, an increase of 35% on the year-on-year basis, accounting for 86.6% of world output.

The total production capacity of the top 10 silicon wafer manufactures is 58.2GW, 71% of total national capacity; their combined output is about 47.6GW, 73.5% of national total, with much higher product concentration than the concentration in the link of cell and module.

**Table 21 Production information for the year for silicon wafer producers**

Manufacturers (or total national production)	Process & technology	Total Production(GW)	Production capacity(GW)	Price (if known)
GCL-Poly	Silicon wafers	17.3	20	
Xi'an LONGI	Silicon wafers	7	7.5	
Jinko Solar	Silicon wafers	3.9	5	
JA Solar	Silicon wafers	3.7	4.5	
Zhonghuan Solar	Silicon wafers	3.1	3.3	
LDK	Silicon wafers	2.9	3.8	
Yingli	Silicon wafers	2.7	4.3	
Renesolar	Silicon wafers	2.6	3.8	
Green Energy	Silicon wafers	2.6	3	
Sornid	Silicon wafers	2.3	3	
Huantai Group	Silicon wafers	2.1	3	
Rietech	Silicon wafers	2	3	
Trina Solar	Silicon wafers	1.8	1.8	
Dahai Group	Silicon wafers	1.7	2.5	
Hanwha Solar	Silicon wafers	1.3	1.5	
Yichang CSG	Silicon wafers	1.1	1.5	
Rest(Mainland China)	Silicon wafers	6.7	10.4	
Total(Mainland China)	Silicon wafers	64.8	81.9	

Source: CPIA, 2017.2

In 2016, China imported as many as 136,000 tons of polycrystalline silicon, a 20.13% increase on the year-on-year basis, mainly from South Korea, Germany and USA.

The export value of silicon wafer in 2016 was 27.1 billion US\$ with sharply rise.

## 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 may only be counted to a country if the encapsulation takes place in that country.

Total PV cell and module manufacture together with production capacity information is summarised in Table 17 below.

### 5.2.1 Solar cell

By the end of 2016, the total production capacity of solar cell in China mainland was about 63GW, and the output was 51GW, a 24.4% increase on year-on-year basis, accounting 68% of world total, and listed No.1 in the world.

The total output of the top 10 solar cell manufacturers in China is about 30.7GW, 49.2% of national total, and 26.36GW production capacity, 51.7% of national total, flat with last year.

### 5.2.2 PV module

In 2016, the total production capacity of China's PV module was about 84GW, with 57.7GW output; of which China's mainland produced about 79GW, a 22.3% increase on year-on-year basis and accounted 69% of world total. Of the total output, crystalline silicon cell accounted over 99% of total output, thin film cell was about 200MW, while concentrator module was about 20MW.

**Table 22: 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
<i>Wafer-based PV manufactures</i>					
Trina Solar		4700	6000	5000	6000
JA Solar		4600	4800	5500	5500
Jinko Solar		3500	6570	4000	6500
Yingli		3200	2800	4200	4200
Shunfeng Int.		3000	1500	3400	2200
Tongwei		2200		3400	
Hanwha Solar		2100	2100	2300	2250
Canadian Solar		2100	5200	2500	5800
Hareon Solar		1750	950	1800	1500
Talesun Solar		1600	1600	2000	2200
Uniex New Energy		1500		1600	
Risen Energy		1380	1500	1500	2200

<b>Aikosolar</b>		1360		1400	
<b>Fortune</b>		1100		1300	
<b>Eging PV</b>		1050	1500	1200	2000
<b>GCL</b>			4000		5000
<b>Lerri Solar</b>			2400		4000
<b>Hanwha Solar</b>			2100		2250
<b>ReneSolar</b>			1200		1500
<b>Zhshine Solar</b>			750		1000
<b>Jiangsu Seraphim</b>			710		1000
<b>Solargiga</b>			710		750
<b>Jinergy</b>			680		750
<b>Shenzhou Energy</b>			650		700
<b>CECEP</b>			620		650
<i>Thin film manufacturers</i>					
<b>Hanergy Group</b>	Si-based				2700
<b>Hanergy Group</b>	CIGS				145
<b>Avancis</b>	CIGS				120
<b>Rest</b>					
<b>Total</b>			<b>200</b>		<b>2965</b>
<i>Cells for concentration</i>					
<b>Total</b>			<b>20</b>		
<b>TOTALS</b>		<b>51000</b>	<b>53700</b>	<b>63000</b>	<b>79000</b>

**Source: CPIA, 2017.2**

The export value of China's solar cell in 2016 was 810 million US\$ accounted for 5.8% of total PV export production in China with a 11.5% increase on year-on-year basis. China exported 2.9 GW solar cell abroad in total in 2016.

In 2016, China exported 105 billion US\$ of PV module, a 18 % decrease on year-on-year basis, and the volume of the export was about 21.3GW. Because more and more Chinese enterprise accelerated abroad layout and built factories abroad last year.

### 5.3 Manufacturers and suppliers of other components

Balance of system component manufacture and supply is an important part of the PV system value chain. Please briefly comment on the nature of this industry in your country, paying particular attention to recent trends and industry outlook, under the headings of:

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

Driven by strong growth of China's PV market, shipment of Chinese inverter enterprises reached more than 40 GW in 2016, increasing to 51.2% of world market share. Of the total shipment, domestic accounted for about 35GW while export was over 5GW. See typical prices in Table 9 and Table 10.

- Storage batteries
- Battery charge controllers
- DC switchgear
- Supporting structures

Driven by development of Chinese PV market, supporting structures enterprises increased sharply in 2016. With low market entry threshold and fierce market competition, the overall profit rate has been remained at a low level. In order to avoid the awkward low profit situation caused by homogeneous competition, main PV mount enterprises have started to develop downstream applications in recent years.

## 6 PV IN THE ECONOMY

This chapter aims to provide information on the benefits of PV for the economy.

### 6.1 Labour places

Provide an estimate of labour places in the following (where these are mainly involved with PV):

- a) Public research and development (not including private companies);
- b) Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D;
- c) All other, including within electricity companies, installation companies etc.

**Table 23: Estimated PV-related labour places in 2016**

Research and development (not including companies)	N/A
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	
Distributors of PV products	
System and installation companies	N/A
Electricity utility businesses and government	N/A
Other	N/A
<b>Total</b>	

### 6.2 Business value

**Table 24: Value of PV business**

Sub-market	Capacity installed in 2016 (MW)	Price per W(RMB Yuan) <i>(from table 7)</i>	Value(RMB Yuan)	Totals(RMB Yuan)
Off-grid domestic	2	18	36 000 000	
Off-grid non-domestic	8	22	176 000 000	
Grid-connected distributed	4230	7.215	30 519 450 000	
Grid-connected centralized	30310	7.2	218 232 000 000	
	34550			248 963 450 000
Export of PV products			18.45GW Module exported	
Change in stocks held			N/A	
Import of PV products			136,000 Tons of poly-Si imported	
Value of PV business			N/A	



If possible, please provide some brief comment on the industry value chain in your country or provide references to articles, reports dealing with this topic. PV Industry Annual Report of China (2016-2017), edited and published by China PV Industry Association (CPIA) in May of 2017.

## 7 INTEREST FROM ELECTRICITY STAKEHOLDERS

### 7.1 Structure of the electricity system

<p>Short description of the electricity industry landscape</p> <ul style="list-style-type: none"> <li>- structure – vertically integrated or separate generation, transmission, distribution;</li> <li>- retailers and network businesses – integrated or separate;</li> <li>- ownership – private – public (state owned or municipal)</li> <li>- Electricity industry regulator?</li> </ul>	<ul style="list-style-type: none"> <li>- Vertically integrated</li> <li>- -Integrated;</li> <li>- Public (state owned)</li> <li>Yes</li> </ul>
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### 7.2 Interest from electricity utility businesses

Please briefly report on the key drivers and barriers for PV activity by electricity utility businesses in your country (you may also wish to list references for relevant studies that have been published in your country).

Please outline key PV business models that have been implemented or are being considered **by electricity utility businesses** in your country (eg PV plant development / ownership, PV power purchase arrangements, customer PV support initiatives and so on).

2016 was the first year of China’s thirteenth “Five-year Plan” period. The year witnessed surging system reform in electric power industry, and substantial breakthrough in electric power market.

The state published a series of policies in various sectors of electric industry system. On Mar. 1, 2016, the establishment of Beijing and Guangzhou Electric Trading Centers marked the most crucial step of the formation of China’s electric market, followed by the establishment of provincial electric trading centers in other regions across the country. By the end of Sep., China has established 31 provincial electric trading centers, plus two state level electric trading centers. The only province without such a center is Hainan Province.

On Oct. 8, 2016, the NDRC and NEA jointly issued the “Admission and exit management method of power sale company” and “Management method of orderly opening of power distribution network business”, marking a new level of China’s electric system reform. Power sale side market will be comprehensively initiated soon. In Dec. 2016, the NDRC published the pilot reform list for increment power distribution business.

On the other hand, electric pilot reform practices across the country were comprehensively implemented. By the end of 2016, a total of 29 province (district, municipalities) conducted such power system pilot reform (including Xinjiang Production and Construction Corps).

### 7.3 Interest from municipalities and local governments

Please briefly report on the key drivers and barriers for PV activity by municipalities and local governments in your country (you may also wish to list references for relevant studies that have

been published in your country). Please outline key models that have been implemented or are being considered by these authorities.

In 2016, the state adjusted PV power project management policy, the system of state energy administration approval is shifted to local management. Large scale concentrated PV station requires local approval while distributed PV system only needs local filing. Such measures have been carried out gradually, and some provinces and regions will further transfer distributed PV system filing function to lower level of district and city.

Meanwhile, nearly 30 provinces, municipalities and regions have formulated their respective policies to support the development of PV power. Uncomplete statistics listed over 90 local subsidy policies. For the reason of their length no details will be listed here. These policies are well targeted and have played important roles in promoting the localities' PV development.

## **8 HIGHLIGHTS AND PROSPECTS**

### **8.1 Highlight of 2016 development**

#### **8.1.1 Development goals**

In Jul. 2017, the NEA issued “Guiding opinion on the implementation of renewable energy development plan during the thirteenth five-year plan period” (Guoxinfaneng [2017] No. 31). The guiding opinion set the target of 86.5GW for the planned newly added installation (including PV stations and “leading runner” bases), and the annual 20GW installation of distributed PV, PV poverty-alleviation and installation in 7 provinces and cities with no scale limitation (4 year total of 80GW) during 2017 and 2020 period. By 2020, the accumulated national PV installation will reach over 240GW.

#### **8.1.2 Policies**

In Dec. 2015, the NDRC published “Notice on perfection of the policy of on-grid power benchmark price for onshore wind and solar power stations” to adjust the policy on newly built onshore wind and PV power benchmark price. The notice stipulated that for PV projects filed before 2016 and included in scale management would implement reduced benchmark power price in case the projects were still not fully operational by Jun. 30, 2016. In order to obtain higher benchmark price subsidy, those concerned across the country all rushed to install PV systems before subsidy was lowered. By Dec. 2016, the NDRC continued to lower benchmark power prices in three types of resource regions to the levels of 0.65 yuan/kwh, 0.75 yuan/kwh and 0.85 yuan/kwh respectively.

#### **8.1.3 Market**

In 2016, change of policies resulted in sharp market fluctuation. In the first half year of 2016, the newly installed PV surpassed 20GW, higher than the 15.1GW of the whole 2015. However, starting from Jul. 2016, PV market experienced a free-fall drop. Newly added PV installation in the third quarter of the year was only 7GW, a drop of 45% from the previous month. Despite this, due to the effect of rush installation in the first half year, the nation’s newly added PV market surpassed 34GW, an increase of 128% on year-on-year basis, and listed No. 1 PV market in the world for the consecutive 4 years.

Of the newly added PV market, concentrated PV power station construction shifted rapidly from the northwest to middle east regions; distributed PV witnessed a fast growth, with 10% proportion in the newly installation. Under the favourable local PV subsidy policy, household PV market flourished rapidly, and there appeared a trend of diversified application.

#### **8.1.4 Industry**

In 2016, the PV industry continued to develop stably to become one of the few industries in China to reach advanced world level with industrial competitiveness.

From 2012 to 2016, cost in each PV production chain dropped nearly half to lay a solid foundation for on-grid PV parity and large scale promotion and application.

#### **8.1.5 R&D**

In 2016, “Leading Runner” program has been expanded, 5 additional “Leading Runner” projects were launched in Shanxi, Hebei, Inner-Mongolia, Anhui and Shandong provinces and total capacity is 5.5GW. The specification requirements are the same as above.

Stimulated by “Leading Runner” program, PV technologies get big progress and the cost was also going down significantly. The selling price of PV modules is around 2.8 Yuan/Wp to 3.3Yuan/Wp (USD:Yuan = 1.0:7.0) and the system price is about 7 Yuan/W.

The module efficiency of industry products is increased and the manufacturing capacity for “Leading Runner” PV modules in China is more than 10GW already. Module efficiency accelerated obviously and high efficiency cells technology industrialization was speeded up.

## **8.2 Development trend of 2017**

Due to continued decrease of on-grid PV power price after Jun. 30, 2017, there was still an installation rush in the first half year of 2017. Statistics published by the NEA showed that the newly installed capacity in the first half year was 24.4GW, of which PV power accounted for 17.29GW, a reduction of 16% over the previous year; distributed PV 7.11GW, an increase of 2.9 times over the previous year. It is obvious that distributed PV is experiencing a rapid development. Optimistic estimation indicates that PV installation market for the entire year will reach above 48GW.

