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Task 1

Exchange and dissemination of information on PV power systems

National Survey Report of PV Power Applications in China 2011

Final version

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Definitions, Symbols and Abbreviations

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

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

Installed PV power: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m_2, cell junction temperature of 25$_o$C, AM 1,5 solar spectrum – (also see 'Rated power').

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

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

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

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

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

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

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

BIPV: BIPV is defined as building-integrated PV, which requires that the building team along the

entire supply chain - including architects, building designers, engineers, building owners and utility companies - work together to design and build the special designed PV modules into the building's very "skin" as an element, from the inception of the project onwards, which particularly stands for the adopting of solar building material, such as solar tiles, solar façade and shingles.

BAPV: BAPV is defined as building-attached PV. In this process, the photovoltaics are a retrofit, the normal PV modules are used and not necessary to use special designed PV module, simply added to the new built or existing buildings.

NDRC: China National Development and Reform Commission

FYP: China Five-Year Plan

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

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

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

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

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

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

Currency: The currency unit used throughout this report is EUR

RES: Renewable Energy Sources

PV support measures:

Feed-in tariff: an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh somewhat higher than the retail electricity rates being paid by the customer;

Capital subsidies: direct financial subsidies aimed at tackling the up-front cost barrier, either for specific equipment or total installed PV system cost

Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Co-operation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme (IEA-PVPS) is one of the collaborative R&D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The 21 participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Malaysia (MYS), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), the United Kingdom (GBR) and the United States of America (USA). The European Commission, the European Photovoltaic Industry Association and the US Solar Electric Power Association are also members.

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

Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. An important deliverable of Task 1 is the annual Trends in photovoltaic applications report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the China National Survey Report for the year 2011. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

The PVPS website www.iea-pvps.org also plays an important role in disseminating.

1 Executive summary

In FY 2011, the annual PV installed capacity in China was 2.5GW, cumulated 3.3GW in total.

1) Domestic market rapidly raising

In 2011, PV industry in China was rapidly growing. In the year, China NDRC issues FIT incentive policy for PV grid-tied application, which was speeding up the rapid growing of China domestic PV market. The total annual installation of PV approached 2.5GW, 400% increasing than previous year. China has become the 3rd PV market in the world.

2) PV technology is continual developing, production cost is continual reducing

Currently China PV industry has completely mastered the key production technologies of poly-silicon cell. The conversion rate of mono-crystal approached 17.5% and poly-crystal 16.6%. The production cost is continuously reducing, by the 4th quarter of 2011, the production cost had been dropped down to <$0.9/Wp for major manufacturers.

3) Localization of the production equipment manufacturing and related materials

Mono-crystal furnace, poly-crystal casting furnace, laminating machine and so on, all can be made in China with large production scale. These domestic made equipments now have significant market share in China. The localization level of the PV related materials is increasing. PV standards, certification and testing regulation have been established.

4) Industry scale is continual growing, investment is continual increasing

The export value of solar cell was US$22.67 billion, 12.3% increased compared with previous year, which was 60% of the global market. 64600 tons of poly-crystal up-stream material was imported, with value of US$3.8 billion, 36% increased. Domestic production capacity was gradually released, yield in 2011 was 84000 tons, the 1st producer in the world.

5) Retail price is dropping, stress to PV business operation is gradually increasing

Losses incurred at various levels in major PV manufacturers in China, 4th quarter 2011. The situation at middle and small businesses are even much worse. Based upon the survey made by CCID Thinkbank PV Industry Research Institute, more than 50% of middle/small PV module manufacturers were stop production, the production scale of 30% of the PV businesses were largely reduced, 10-20% of the businesses was under normal operation or with slight reduction. Many poly-silicon manufacturers were reducing their production output, stop production or even bankrupt. Many employees were laid off.

1.1 Installed PV power

The domestic PV system market in 2011 showed a significant increase compared to 2010. In 2011, grid connected and off-grid PV systems with a total PV power of 2,500 MWp were installed, which represents a 400% growth of the domestic market compared to the year2010. The cumulated total installed PV reaches 3,300 MWp by the end of 2011.

On-grid applications more and more dominated the market for PV in 2011, with grid-connected systems (GCS) accounting for about 2,485 MWp of the total installed capacity in 2011, which

represents 99.4% of the total installation.

In 2011 only a cumulated 15 MWp were installed for rural electrification and off-grid industrial applications.

1.2 Costs & prices

In 2011, system price for installed PV systems in China was again dropping compared to the previous years. The reduction was 30%. In 2011 average system price for typical on-grid systems was RMB 17.5Yuan/Wp, about 2.15 EUR/Wp.

83% of PV module price has been reduced during last 6 years. It was RMB 36 Yuan/Wp in 2007, and by 2011, it was RMB 9 Yuan/Wp. The lowest retail price once dropped down to ~RMB 5 Yuan/W (~0.63EUR) in 2011. The manufacturing cost of solar cell processing stage reached RMB 1.15/W.

The price of Si wafer in December 2011 was US$1.01, which was 41% dropped compared to December 2010 (US$1.70)

1.3 PV production

Global solar cell yield in 2011 was 35GW. In the top 10 world-leading solar cell manufacturers, China occupied 8 seats (Includes China mainland and Taiwan).

Total production capacity of top 10 Chinese solar cell manufacturers is 16GW, and annual yield in 2011 was 11GW.

Total production capacity of top 10 module manufacturers in China was 14.8GW, and annual yield in 2011 was 10GW.

The total delivered PV modules made in China was 21GW in 2011, 141% increased compared with last year, contributed 60% of global outputs. The revenue of the industry was more than 300 billion Yuan RMB (~37.5billion BEUR).

1.4 Budgets for PV

The following table shows the major government sponsored PV programs, which is continually active and under implementation.

Table 1: Initial capital investment and FIT of National PV projects in China

Project name	Bidding time	Location	Project type	Initial investment or price for winner (RMB 10,000/ kWp)	FIT
Solar PV building project	Start from 2009	Nationwide	111projects , 91MWp	Subsidy: 15~20 Yuan/kWp	Self consumption, the rest is fed in grid based upon the price of eliminate sulfur coal-fire generation unit
Golden-sun program	Start from 2009	Nationwide	275projects , 632 MWp	Subsidize 50%~70% of initial investment	Self consumption, the rest is fed in grid based upon the price of eliminate sulfur coal-fire generation unit

Beside above investment arranged by the central government, many PV related R&D has been planned in 12th FYP and budgeted by provincial government and enterprises. The funding allocation made through 12th FYP by central government for projects related with energy is 1 billion RMB (~130MEUR).

2 Implementation of PV systems

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries.

For the purposes of this report, PV installations are included in the 2011 statistics if the PV modules were installed between 2011-1-1 and 2011-12-31 although commissioning may have taken place at a later date.

2.1 Applications for photovoltaic

The applications of PV in China can be classified as three fundamental categories: Off-grid PV power systems for rural electrification; off-grid non-domestic or industrial PV power systems, such as telecom remote base transmission stations, PV garden lights, PV or PV/Wind hybrid street lights; and grid-tied power systems.

Until 2007, off-grid installations were the major application for PV systems in China. Solar home system (SHS) and solar village system (SVS) provide electricity to remote households and rural communities where are far away from the traditional utility grid, which includes the isolated islands. But not exclusively in rural electrification, but also PV is an alternative for some industrial application, such as communication base transmission system (BTS), street/garden lights for urban communities, battery charge station, and PV powered traffic control systems, etc.

Since 2008, the large scale grid-connected PV power station has been developing in China, which become the dominant role of PV application.

Recent years, PV has been applied to building construction, which includes building integrated PV application (BIPV) and Building attached PV (BAPV). Building related PV receives strongly support from the government, this plays more and more important role in solar market.

Due to limited policy support and incentives, grid-tied distributed generation (DG) is still facing big barriers, but things are changing.

2.2 Total photovoltaic power installed

The domestic PV system market in 2011 showed a significant increase compared to 2010. In 2011, off-grid and grid connected PV systems with a total PV power of 2,500 MWp have been installed, which represents a 400% growth of the domestic market compared to the year2010. The cumulated total installed PV reaches 3,300 MWp by the end of 2011.

On-grid applications more and more dominated the market for PV in 2011, with grid-connected systems (GCS) accounting for about 2,485 MWp of the total installed capacity in 2011, which represents 99.4% of the total installation, compared with 95.8% in 2010 (Total installation of PV in 2010 was 500MWp) and 41% in 2007 (Total installation of PV in 2007 was 20MWp).

During the recent past years, the off-grid sector plays a minor role in the China PV market. In 2011 only a 15 MWp were installed in this sector for rural electrification and off-grid industrial applications.

For past five years (2007-2011) basis, an average market growth of 223% per year for all PV installations in China can be reported. Table 2 shows the PV power installed in five sub-markets during 2011.

Table 2: PV power installed during calendar year 2011 in five sub-markets

2011 Installed PV in China by Sectors			
No	**Market Sectors**	**Annual Ins. (MWp)**	**Share (%)**
1	Rural Electrification	10	0.4
2	Communication & Industry	5	0.2
3	PV Products	5	0.2
4	BIPV & BAPV	480	19.2
5	LS-PV	2000	80.0
	Total	2500	100.0

Source: Wang Sicheng

A summary of the cumulative installed PV Power, from 2000-2011, broken down into five sub-markets is shown in Table 3.

Table 3: Cumulative installed PV power in five sub-markets[1]

Year	Rural electrification	Telecom and Industry	Distributed Generation	Building related PV	LS-PV	Annual Inst.	Cumulated Inst.
	(MWp)	(MWp)	(MWp)	(MWp)	(MWp)	(MWp)	(MWp)
2000	2.00	0.80	0.20	0.00	0.00	3.00	19.00
2001	2.50	1.50	0.50	0.01	0.00	4.50	23.50
2002	15.00	2.00	1.50	0.01	0.00	18.50	42.00
2003	6.00	3.00	1.00	0.07	0.00	10.00	52.00
2004	4.00	2.80	2.00	1.20	0.00	10.00	62.00
2005	2.00	2.90	1.50	1.30	0.20	8.00	70.00
2006	3.00	2.00	4.00	1.00	0.00	10.00	80.00
2007	8.50	3.30	6.00	2.00	0.20	20.00	100.00
2008	4.00	5.00	20.50	10.00	0.50	40.00	140.00
2009	9.80	2.00	6.00	34.20	108.00	160.00	300.00
2010	15.00	6.00	6.00	190.00	283.00	500.00	800.00
2011	10.00	5.00	5.00	480.00	2000.00	2500.00	3300.00
SubT	81.80	36.30	54.20	719.79	2391.90	3284.00	

Source: Wang Sicheng

[1] Before 2000, the total installed PV capacity was about 16MWp. This has been reflected in the cumulated installation in year 2000, but not to be included in the breakdown sectors.

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

2009, China started carrying out the "Solar PV building applications demonstration program" and "Golden Sun demonstration program". These two programs clearly provided the subsidy to PV system, which officially kick-off the PV market in China. Also, the large programs such as Concession Bidding program and Golden-sun Demonstration Program, drives the development of PV systems to its large scale. The financial investment per KW and cost per kWh is dropping down significantly.

1) Capital (Financial) subsidy

March 2009, China Ministry of Finance (MoF) issued "The notification of the Ministry of Finance on Printing and Distributing the Interim Measures of the solar PV building applications fiscal subsidy funds", clearly stated that the central government will allocate certain amount capital from Renewable Energy Special Fund to support the demonstration and popularize the PV application in urban and rural building construction. Sept 2009, first 111 solar-roof projects were listed, total capacity is 91MW, budgets as RMB 1270 Million Yuan (~141 MEUR, 1EUR = 9 RMB)

July 2009, China Ministry of Finance (MoF), Ministry of Science and Technology (MoST), and National Energy Administration (NEA) jointly announced the "Notice on the Implementation of the Golden Sun Demonstration Project", clearly stated that the central government will allocate certain amount capital from Renewable Energy Special Fund to support the PV applications in variety of areas, and also support the industrialization of key solar technology. First batch of 294 Golden-sun projects were approved, total capacity is 642 MWp. These projects will be finished within 2-3 years.

Table 4: National demonstration programs

Program name	Scale
Building related PV	First batch: 111projects, investment 141 MEUR, capacity 91MW
Golden-sun	Grid-connected projects : 222, capacity 290.558MW Off-grid projects : 18, capacity 46.031MW Large scale PV power stations: 35, capacity 295.64MW

2) Concession program and Feed-in-tariff (FIT)

In 2007 and 2008, China National Development and Reform Commission (NDRC) approved four PV power stations, which include two in Shanghai, one in Inner Mongolia and another one in Ninxia. The FIT is RMB 4 Yuan/kWh (~0.4EUR/kWh).

In 2009 and 2010, NEA organized two national PV power station Concession biddings. The concession operation period is 25000 full working hours and 25 years respectively.

Between March and June, 2009, China NDRC initiated first 10MWp desert PV power station

bidding. 13 tenders participated in the bidding. The FIT for the final winner is 1.09yuan/kWh (~0.121 EUR/kWh).

April 2010, China NDRC approved another four utility-scale PV power station in Ninxia, FIT is RMB 1.15Yuan/kWh (~0.128 EUR/kWh).

Table 5: Final price of bidding for desert PV station in China, 2010

Location	Capacity MWp	Tender	FIT (Yuan/ kWh)
Gonghe, Qinghai	30	Yellow River Upper Stream Hydropower Development Company	0.7288
Henan, Qinghai	20	Yellow River Upper Stream Hydropower Development Company	0.8286
Baiyin, Gansu	20	Zhongdian International New Energy	0.8265
Jinchang, Gansu	20	Huaneng New Energy	0.7803
Wuwei, Gansu	20	Zhongdian International New Energy	0.8099
Yulin, Shanxi	20	Huaneng New Energy	0.8687
Alashan, IM	20	Inner Mongolia Guodian New Energy	0.8847
Baotou, IM	20	Baotou Luneng Baiyuerbo Windpower	0.7978
Bayanzuoer, IM	20	Inner Mongolia Guodian New Energy	0.8444
Hami, Xinjiang	20	Zhongdian Xinjiang New Energy Investment	0.7388
Turufan, Xinjiang	20	Zhongdian Xinjiang New Energy Investment	0.9317
Hetian, Xinjiang	20	Zhongdian Xinjiang New Energy Investment	0.9907
Qingtongxia, Ninxia	30	Huaneng New Energy	0.9791

2.4 Highlights of R&D

1. Current situation of R&D

1) PV cell technology

Currently there are dozens of research institutes, organizations and companies are engaged in PV cell R&D, their research scopes are covering almost all kind of PV cell technologies.

(1) Silicon PV cell

The highest conversion efficiency of PESC, 19.8%, is obtained by Beijing Solar Energy Research Institute. Many institutes are working on improving the efficiency of HIT, such as Electric Engineering Institute (China Academy of Science), State Grid, and so on. The highest efficiency reported in 2005 was 17.2%, and keep rising up. Other types of PV cell, such as IBC, EWT and MWT are under R&D, but rare reports are released results.

Along with the rapidly development of PV industry in China, many PV manufacturers have established their own research department, such as SunTech, Yingli and JA Solar. The efficiency PLUTO PV cell, developed by SunTech jointly with UNSW, is 19% for mono-crystalline silicon. Yingli, introduced the boron diffusion N-Type production technology from ECN, average efficiency of 18.8% will be expected when the project approach its batch production. JA Solar adopted the technology from Innovalight, rising the efficiency to 18%.

(2) Thin-film PV cell

Thin-film PV cells, includes CIGS, CdTe and A-Si/microcrystalline, are also under R&D by research institutes, such as Nankai University, Beijing University, Tsinghua University, shanghai University, No 18 Research Institute of China Electric, Sichuan University and so on.

Nankai University has a long history in research on CIGS which was supported by National 863 Program[2] of MoST. Total investment was RMB 50 million. The project developed the experiment facility and test base of CIGS, equipment and production processes, becoming a research platform for CIGS R&D.

Sichuan University is spending the longest time in research on CdTe PV cell. Their R&D result is the large area CdTe PV cell ($993.6cm^2$) with efficiency of 8.25%.

Tianjin Nankai University has been continued engaging in research on A-Si for four sequential "Five-year plan" (6^{th}~9^{th} Five Year Plan, FYP), completing the progress from fundamental research to industrialization of A-Si production.

National Program, 973[3], starts from 10^{th} FYP, supports the researches on microcrystalline. After

[2] National High-tech R&D Program (863 Program) In 1986, to meet the global challenges of new technology revolution and competition, four Chinese scientists, WANG Daheng, WANG Ganchang, YANG Jiachi, and CHEN Fangyun, jointly proposed to accelerate China's high-tech development. With strategic vision and resolution, the late Chinese leader Mr. DENG Xiaoping personally approved the National High-tech R&D Program, namely the 863 Program. Implemented during three successive Five-year Plans, the program has boosted China's overall high-tech development, R&D capacity, socio-economic development, and national security. In April 2001, the Chinese State Council approved continued implementation of the program in the 10th Five-year Plan. As one of the national S&T program trilogy in the 10th Five-year Plan, 863 Program continues to play its important role.

[3] The National Basic Research Program (also called 973 Program) is China's on-going national keystone basic research program, which was approved by the Chinese government in June 1997 and is organized and implemented by the Ministry of Science and Technology. The 973 Program is created on the basis of existing research activities and deployments made by the National Nature Science Foundation and major dedicated pre-studies, to organize and implement basic research to meet the nation's major strategic needs.

973 projects in 10th FYP, the efficiency of small-area microcrystalline approached 9.2%, and 11.8% for small-area stacked layer cells. With the support of 973 in 11th FYP, the main target for microcrystalline is to low the production cost and key technical issues in industrialization.

(3) Concentrator solar cell

The organizations involving in the R&D of Concentrator solar cell are 811 Research Institute, Shanghai Solar Energy Engineering Research Center, Xinao Group, Semiconductor Research Institute of CAS, and so on. Currently the efficiency of GaInP2/Ga(In)As/Ge is 35%, while Shanghai Solar Energy Engineering Research Center approaches 37%, which is sponsored by 863 program.

The efficiency of solar cell developed by Sanan Optoelectronics, has been increased from 10% to current 36%. They have developed 50KW CPV power system (single module of 25KW), with 28% of module efficiency.

(4) Other solar cells.

Some research institutes are also engaged in broader research on Nanocrystalline TiO_2 thin-film PV cell, organic PV cell, etc.

2) Power electronics, control and component of BOS

The project, MW-class PV grid-connected power station, initiated by MoST in 2006, is to research and develop key equipment and power electronics for large-scale grid-tied power station. The capacity of power station shall be ≥1MW, life time ≥20 years, finishing the research of grid-tied inverters (<100KVA). The output efficiency at rated power shall be ≥90%, voltage output range 220/380V±5%, frequency range 50±0.2Hz, THD <5%, the price shall be 30% less than the similar products on international market.

2010, the National "Key Technology R&D Program" of the MoST supports the key technologies in wind/PV/storage/transmission demonstrations, which is carrying out by State Grid.

3) Equipment

Among more than ten types of crystal silicon production equipment, six or more types of equipment made in China now have become the dominant in China PV manufacturers. The quality of elemental crystal furnace, diffusion furnace, plasma etcher, washing & texture making machine, assembly laminating machine, and solar simulator are closed to the international level, while the performance cost ratio is obviously higher.

4) Test technology and equipment

There are few solar PV product testing laboratories. They are listed in the Table 6.

Table 6: Solar PV related test laboratories

Name	Major test items
No. 18 Research Institute of China Electronics Technology Group Corporation	Solar PV calibration and test/PV module/Thin-film/Batteries for PV power storage, etc.
The Chinese Academy of Sciences (PV) Power System And Wind Power Generation System Quality Test Center	Solar cell, module, controller, inverter and off-grid PV system, etc.
Shenzhen Electric Product Quality Test Center	Solar cell, module, thin-film, controller, inverter, wiring box, Batteries for PV power storage, etc.
National Solar PV Product Quality Supervision and Inspection Center	Solar cell, module, thin-film, controller, inverter, PV systems and products
Yangzhou PV Product Test center	PV module, thin-film, etc.
China Telecommunication Technology Labs (CTTL)	Controller and inverters, etc.
811 Institute of Shang Aerospace Technology Research Academy	Crystalline PV modules, etc.

Source: Wang Yibo, Research on China PV technology

2. R&D projects be arranged in 12th FYP

Most major R&D projects have been planned in China 12th FYP. The 12th FYP is lasting from 2011 to 2015.

(1) Overall target of R&D by 2015

- Making breakthrough in all aspects, promoting PV power generation application scale-up.

The efficiency of PV conversion shall reach >20% for silicon cell, 10% for silicon-base thin-film; CIGS and CdTe thin-film is to be commercialized;

- Developing the design capacity and system integrated equipment for 100MW-class PV power station. The system installation cost shall drop down to 16,000Yuan/kW (Without heat storage) and 22,000Yuan/kW (With 8 hours heat storage); FIT <0.9 Yuan/Kwh; power generation cost drop down to 0.5Yuan/kWh;
- Breaking through the solar building heating and heat storage technology;
- Establishing national technical standard system and product testing platform.

(2) Major technical index

- 30% of production cost for Poly-silicon will be reduced, domestic supply rate of material will be t least 50%;
- All equipment for silicon cell production line will be made domestically, be able to provide "Turn-key" silicon cell production line with self-owned intelligent property;
- Making technology and equipment breakthrough in 100MW grid-tied PV station, 10MW PV

micro-grid and 10MW regional building related PV;

- Developing empirical study demonstration base for solar power utilization;
- Develop 24 demonstration projects, 28 innovation platforms, establish more than 50 standards.

(3) Major projects and key projects related with PV have been arranged in 12th FYP

- **Material area**

Major project:

Major technology research on high efficiency energy saving large-scale silicon materials clean production

Key project:

Research on key PV cell related materials production technology

- **Component area:**

Major projects:

Pilot experiment of new PV cells and advanced technology research;

Major technologies for the production low-cost ultra-thin silicon cell with efficiency >20%;

R&D on major equipment and complete production processes for the production of large-scale thin-film PV cell with efficiency >10%.

Key projects:

R&D on Complete Dye-sensitized Solar Cells (DSCs) production line for annual production capacity of 5MW with efficiency of 8% and module production.

- **System area**

Major project:

Demonstration for large-scale grid-tied/micro-grid PV system design and system integration, and R&D on related equipment

Key project:

Key technology and demonstration on silicon-based BIPV

Also, National 973 Plan will support the R&D on next generation of super-efficiency of new concept of PV cells with 40% conversion efficiency.

3. Other R&D

China EPA and CAS (China Academy of Science) also supports the R&D in PV industry. For example, EPA supports the project of "Study on renewable energy (Solar panel)'s impacts on environment and its manufacturing management" and CAS supports the project of "Development and demonstration of power prediction of large-scale PV power station and research on large-scale PV power station's impact on local environment".

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

Table 7: Initial capital investment and FIF of National PV projects in China[4]

Project name	Bidding time	Location	Project type	Initial invest -tment or price for winner (RMB 10,000/ kWp)	FIT
National Township Electrificati on program	2002.4~ 2002.7	Western 8 provinces	10~150 kWp, off-grid	8~10	RMB 3000 Yuan/kWp per year for some areas
National Township Electrificati on program	2002.4~ 2002.7	Tibet	10~150 kWp, off-grid	10~12	
4 projects PV power stations	2008.5	Shanghai, Inner Mongolia, Ninxia	100~1000 kWp Grid-tied	N/A	4 Yuan/kWh
Dunhuang Concession bidding	2009.2~ 2009.5	Dunhuang, Gansu	2 of 10MWp, desert PV power station, grid-tied	1.9~2.1	1.0928Yuan/kWh
Demonstrat ion	2009	Ninxia	5MWp, 10MWp	By utility	1.15Yuan/kWh
Solar PV building project	Start from 2009	Nationwide	111projec-t s , 91MWp	Subsidy: 15~20Yuan/kWp	Self consumption, the rest is fed in grid based upon the price of eliminate sulfur conventional generation unit
Golden-sun program	Start from 2009	nationwide	275project s , 632 MWp	Subsidize 50%~70% of initial investment	Self consumption, the rest is fed in grid based upon the price of eliminate sulfur conventional generation unit

Source: Li Junfeng, Wang Sicheng, et al, China Solar PV Outlook 2011

[4] The exchange rate between EUR and RMB is varying time by time: The average price of Dec.31, 2008, 9.659; Dec. 31, 2009, 979.71; Dec. 31, 2010, 8.8065; Dec. 31, 2011, 814.66.

Beside above investment arranged by the central government, many PV related R&D has been planned in 12th FYP and budgeted by provincial government and enterprises. The funding allocation made through 12th FYP by central government for projects related with energy is 1 billion RMB (~130MEUR).

3 Industry and growth

3.1 Production of feedstock, ingots, wafers and thin film photovoltaic components

Benefitted by Europe PV market, China PV industry has been developing quickly since 2004, and become the largest PV manufacturing nation in the world. 13GW PV cells were produced in 2011, increased 68.4%; 21 GW of Solar modules delivered, which represents 60% of the global yield.

Based upon the market demands, the PV production supply chain has been well developed. In the supply chain, about 20~30 manufacturers have real production capability of polycrystalline silicon, more than 60 manufacturers producing PV wafers, and more than 60 manufacturers producing PV cells, along with 330+ PV module manufacturers. The revenue is over RMB 300 Billion (~36.8 BEUR).

Table 8: China major PV manufacturers and production chain

Manufacturer name	Poly silicon	Ingor	wafers	PV cells	PV module	PV systems
Yingli						
SunTech						
Changzhou NESL Solartech Co., Ltd.						
LDK Solar						
Hanwha SolarOne Co., Ltd						
JinkoSolar Holding Co., Ltd.						
Canadian Solar Inc.						
Daqo New Energy Co.,Ltd						
GCL-Poly Energy Holdings Limited						
ReneSola Ltd						
China Sunergy						
JA SOLAR Co.,Ltd						

Major product Minor product Production line

Source: Junfeng Li, Presentation on Photon Poly Silicon conference, Berlin, April 12, 2011

PV production chain and annual yields of 2011 and its comparison with 2008 as shown in the following chart.

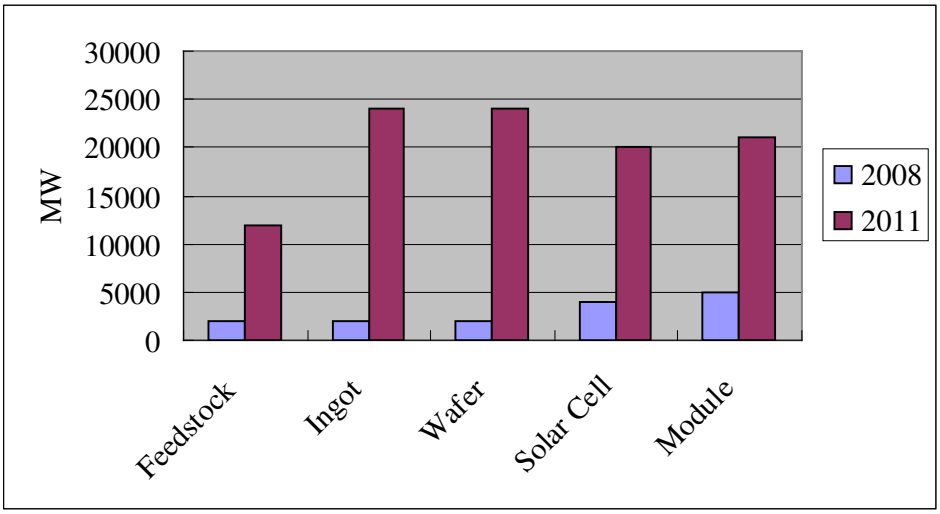


Figure 1: Annual yields of 2011 and its comparison with 2008

Source: Wang Sicheng, Incentive Policies and Market Trends of PV in China, 2012 Solarbuzz China PV Conference, July 19th, 2012

In 2011, the production capability of poly-silicon in China was 165,000 Tons, actually produced poly-silicon 84,000 Tons, increased 87% than last year, 35% of the global yields. Meanwhile, China imported 64,6000 Tons of poly-silicon (43%), increased 36% than past year, with value of US$3.8 billion (~3.1BEUR). The price of poly-silicon was US$70-80/kg, and dropped to recent US$25-28/kg.

The gap of poly silicon production technology between China and world advanced level is narrowing. The production technology of thousand-ton class is made breakthrough. Cyclic utilization, environment-friendly and low power consumption production are approached. Two poly silicon manufacturers' production cost is closed to its counterparts in the world. Their power consumption for poly silicon production approaches 120KWh/kg, and the production cost dropped down to US$ 20/kg. The leading manufacturer, GCL-Poly Energy Holdings Limited, approaches annual yield of 30,000 Tons in 2011, and production cost low as US$22.5/kg, becoming 3rd in the world. The poly-silicon production technology is continuing developing. The power consumption for hydrogen reduction process has dropped down to 70kWh/kg from 80~90kWh/kg in 2010. The power consumption of hydrogen reduction for few advanced manufacturers in China now has approached to 50kWh/kg.

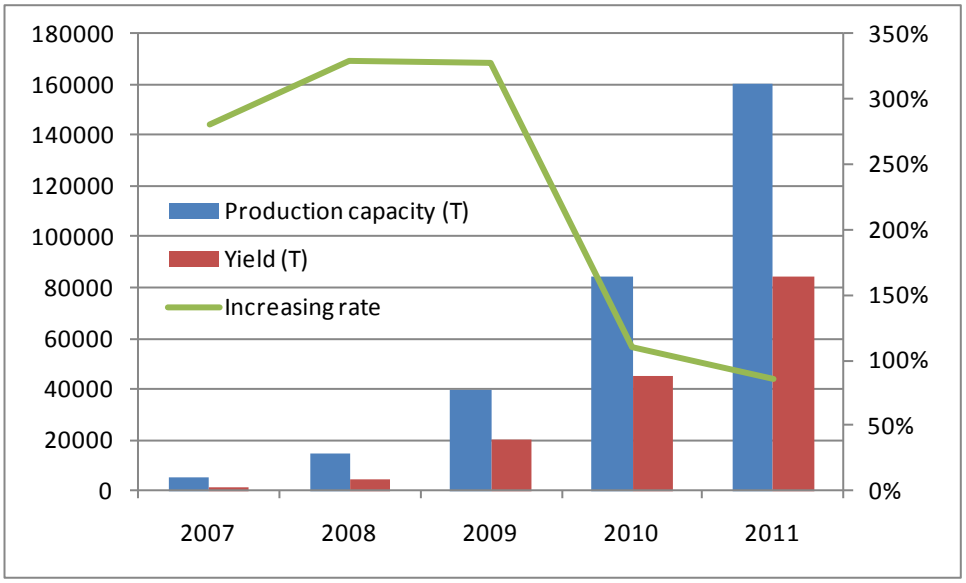


Figure 2: 2007-2011 Poly-silicon production capability and yield in China

Source：CPIA, April 2012.04

Table 9: Annual yields of top 10 China Poly-Silicon manufacturers.

Unit: Tons	2010	2011
GCL-Poly Energy Holdings Limited	17800	29410
LDK Solar	5011	10453
China Silicon Corporation Ltd.	4117	8135
Daqo New Energy Co.,Ltd	3771	4600
Sichuan Renesola Ltd	2646	3386
Yichang CSG Polysilicon Co., Ltd.	1404	2581
Asia Silicon Co., Ltd.	1218	2292
Leshan Ledian Tianwei Silicon*	1618	1800
Tianwei Sichuan Silicon Co., Ltd. *	1268	1700
Sichuan Yongxiang Polysilicon Co., Ltd*	1000	1400
Total	39853	65757

Source: secretariat of China PV Industry alliance, April 2012

PV industry in China has mastered the key technologies in entire PV production chain, and continuing innovation and development, such as PV cell technology and poly-silicon manufacturing technology. The efficiency of poly-silicon PV cell has approached to more than 16%, the efficiency of monocrystalline silicon produced at Suntech approaches 18.8% and poly-silicon 17.2%. Yingli Green Energy Holding Co., Ltd, Trina Solar, Canadian Solar Inc., JA SOLAR Co., Ltd., have their own special technologies, the conversation efficiency reaches top-level in the world, the material of high purity silicon consumption has dropped down to 6 g/W from the world average level of 9g/W, which helps reducing the whole PV production cost.

In 2011, global wafer delivered was more than 40GW, among them, China produced 24.5GW, the production of wafer produced by GCL-Poly Energy Holdings Limited and LDK Solar contributed 17% of global total yield. The production cost was continuing dropping. The price of Si wafer in

December 2011 was US$1.01, which was 41% dropped compared to December 2010 (US$1.70)[5]. Some wafer manufacturers were laying off the employees, even have been out of business due to wafer market recession.

The global output of thin-film solar cell in 2011 is about 3700MW, ~900MW was silicon-based thin-film solar cell, CIGS was 700MW, CdTe was 2100MW. In China, the thin-film solar cell production capability was 1.5GW in 2011, the annual delivered PV thin-film was 450MW, almost all of them are silicon-based. In 2010, the thin-film solar cell production capability was 1GW, the annual delivered PV thin-film was 400MW6

Table 10: Major Thin-film solar cell production capability in China

Manufacturers	Capacity (MW)	Type
Hanergy Holding Group Limited*	1500	Silicon based
Trony Solar Holdings Co. Ltd	204	Silicon based

Source: Based upon the information released by the business.

* stands for estimation.

3.2 Production of photovoltaic cells and modules

Global solar cell yield in 2011 was 35GW. In the top 10 world-leading solar cell manufacturers, China occupied 8 seats (Includes China mainland and Taiwan). The total production capacity of global top 10 solar cell manufacturers in 2011 was 17.67GW, the annual delivered solar cells were14GW. The manufacturing cost of solar cell processing stage reached US$0.18/W.

The top 10 solar cell manufacturers in China are listed in Table x. Total production capacity of these top 10 manufacturers in China is 16GW, and annual yield in 2011 was 11GW.

Table 11: Annual production capability and yield of China top 10 solar cell manufacturers

Manufactures	2011 Annual production capacity (MW)	2011 Output (MW)
Suntech Power Holdings Co., Ltd *	2400	1900
JA SOLAR Co.,Ltd	2800	1700
Yingli green energy holding Co.,Ltd	1700	1603
Trina Solar	1900	1510
Canadian Solar Inc. *	1300	1000
JinkoSolar Holding Co., Ltd*	1200	810
Hanwha SolarOne Co., Ltd*	1300	800
Hareon Solar Technology Co., Ltd	1500	669
LDK Solar	1500	610
EGing Photovoltaic Technology Co.,Ltd	600	476
Total	16100	11078

[5] http://www.windosi.com/, March 20, 2012.
[6] Estimated by China PV Industry Society.

The top 10 solar module manufacturers in China are listed in Table 12. Total production capacity of these top 10 manufacturers in China was 14.8GW, and annual yield in 2011 was 10GW.

Table 12 top 10 solar module manufacturers in China

Manufactures	2011 Annual production capacity (MW)	2011 Output (MW)
SunTech Power Holdings Co., Ltd *	2400	2090
Yingli green energy holding Co.,Ltd	1900	1603
Trina Solar	1900	1510
Canadian Solar Inc. *	2050	1323
Hanwha SolarOne Co., Ltd*	1500	835
JinkoSolar Holding Co., Ltd*	1200	761
LDK Solar	1600	607
JA SOLAR Co.,Ltd	1200	483
EGing Photovoltaic Technology Co.,Ltd	600	450
Hareon Solar Technology Co., Ltd	560	428
Total	**14810**	**10090**

The annual increasing rate of yields of solar PV modules in China was more than 100% in 2005-2008, 70% in 2008-2010. In 2011, it was more than 100% again. The total delivered PV modules are 21GW, 141% increased compared with last year, contributed 60% of global outputs. The revenue of the industry was more than 300 billion Yuan RMB (~3.75billion BEUR).

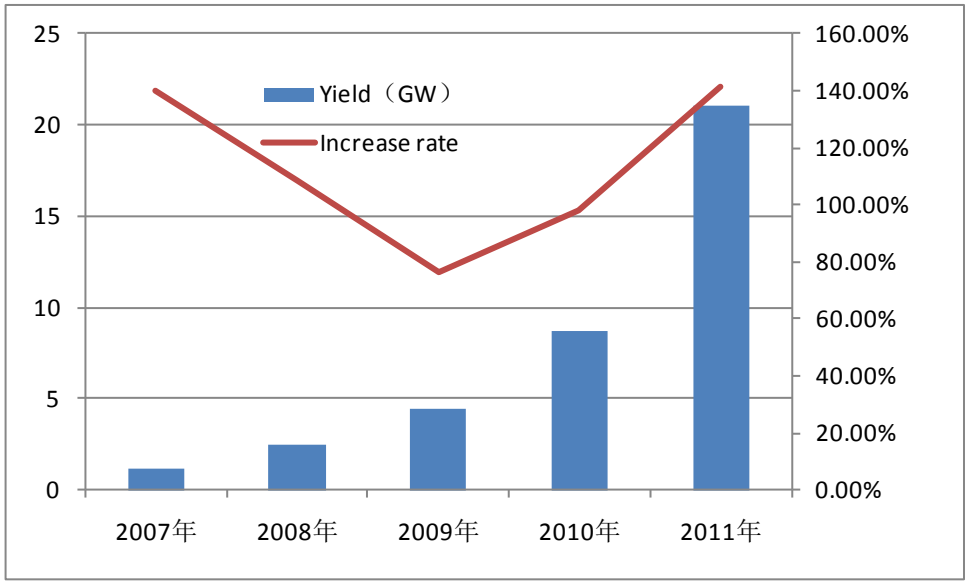


Figure 3: Solar PV modules manufacturing and growing rate in China, 2007-2011
Source: CPIA

3.3 Module prices

83% of PV module price has been reduced during last 6 years; the historic PV module price in China was shown in Figure 4. It was RMB 36 Yuan/Wp in 2007, and by 2011, it was RMB 9 Yuan/Wp. The lowest retail price once dropped down to ~RMB 5 Yuan/W (~0.63EUR) in 2011.

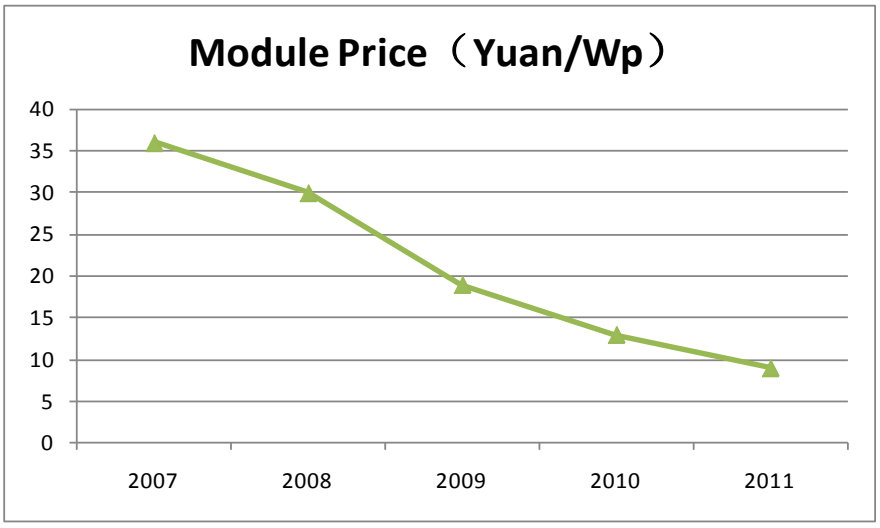


Figure 4: PV module price in China, 2007~2011

Source: Wang Sicheng, Incentive Policies and Market Trends of PV in China, 2012 Solarbuzz China PV Conference, July 19th, 2012

3.4 Manufacturers and suppliers of other components

1. Inverter

Statistics shows that there is 135 inverter manufacturers in China, most of them were entering inverter business after 2007. Some of them are still under the stage of R&D. Based upon the statistics released by CQC (CHINA QUALITY CERTIFICATION CENTER), only 53 manufacturers has obtained the certification issued by CQC.[7] The major manufacturers are Sungrow Power Supply Co., Ltd., Beijing Soaring Electric Technology Co., Ltd., Shenzhen KSTAR Science and Technology Co., Ltd., XJ Group Corporation, Nanjing Guanya power equipment Co., Ltd., Beijing Corona Science & Technology Co., Ltd., Guangdong Zhicheng Champion Group Co., Ltd. and Tebian Electricity Apparatus Stock Co., Ltd.

Also, based upon the statistics from HIS iSuppli[8], the total 23.4GW inverters were delivered in 2011 in the world, the yield in China is 1.4GW, about 6% of the global yields.[9]

Now China can make a kind of complete series of inverters, which covers from small capacity single-phase inverter, such as 1.5kW, 2.5 kW, 3kW, 4kW, 5kW, 6kW and so on, mostly to be applied to off-grid PV or hybrid power system, and large capacity for grid-connection, such as 10kW, 20 kW, 30kW, 50kW, 100kW, 250kW, 500kW and so on.

The capacity of inverter made in China is becoming larger and larger. The inverter is safe and flexible to connect to the grid with high electric quality and efficiency.

Table 13 is the major inverter manufacturers and their products

Table 13: Major inverter manufacturers and their product types

Name	Location	Major product type
Sungrow Power Supply Co., Ltd.	Anhui	SG100K3, SG250K3, SG500KTL SG10K3, SG30K3, SG50K3SG1K5TL SG2K5TL, SG3K, SG5K, SG6K-B
Beijing Corona Science & Technology Co., Ltd.	Beijing	KGI-5
BEIJING RIJIA POWER SUPPLY CO., LTD	Beijing	LBBC-20-T3
Beijing Chunshu Rectifier Co., Ltd.	Beijing	JYNB-100A
Anhui EHE New Energy Tech.Co.,Ltd.	Anhui	EHE-N5K
Guangdong Zhicheng Champion Group Co., Ltd.	Guangdong	CPPV-2450P, CPPV-2360P , CPPV-2180P,

[7]Situation and trend analysis of China inverter industry, China industry research network, (http://www.chinairn.com), Feb. 1, 2012

[8] Photovoltaic Inverter Market Suffered Slight Setback in 2011 [EB/OL]. (2012-01-30). http：//www.isuppli.com/Photovoltaics/MarketWatch/PsSes/Photovoltaic-Inverter-Market-Suffered-Slight-Setback-in-2011.aspx.

[9]Situation and sustainable development strategy research on China PV industry, China Export & Credit Insurance Corporation, 2012-5-16, http://www.sinosure.com.cn/sinosure/xwzx/rdzt/ckyj/ckdt/xyzt/qcxy/dxctsbyj/149216.html

		CPPV-2050P, CPPV-2025P
Yangzhou Jing Xu Power Co., Ltd.	Jiangsu	CPPV-2450P, CPPV-2360P, CPPV-2270P, CPPV-2180P
Zhuzhou CSR Times Electric Co., Ltd	Hunan	GTI-250
Zhongda Dentsu Inc.	Shanghai	RPI203N,RPI362S,RPI202S
XJ Group Corporation	Henan	GBL200-500/270-HE-SN

The following table shows the distribution of inverter manufacturers who won the bidding of China PV stations in 2009.

Table 14: Distribution of inverter bidding for China PV stations in 2009

Manufacturer	Installed or delivered Inverter for PV stations in 2009(MW)	%
Sungrow Power Supply Co., Ltd.	105.6	52.5%
Powerone	30.2	15.0%
ASIRobicon	10	5.0%
Siemens	9	4.5%
Satcon	33	16.4%
Refu	4	2.0%
Schneider	4	2.0%
SMA	1	0.5%
Nanjing Guanya power equipment Co., Ltd.	2	1.0%
Kaco	2.4	1.2%
Total	201.2	100%

The output of inverter industry in China in 2010 was increased more than 100%, the total capacity was 30+ GW. 1MW grid-tied centralized inverter has been developed too.

2. Tracking system

Variety of non-concentrating automatic tracking systems have been developed in China, which includes active and passive horizontal single-axis tracking device, tilt single axis tracking device and dual-axis tracking system. Dual-axis tracking system can bear the load of 100m^2, about 10KW poly-silicon PV panels, which is closed to international advanced technical level. Low magnification reflect concentrating system and high magnification lens concentrating system are under developing. The concentrating rate of high magnification lens concentrating system

developed in China can reach 400 times.

3. Battery

Battery used in PV power system is for off-grid and micro-grid power storage. The battery manufacturing industry has been developed driven by China national rural electrification program during 2002-2004, when China central government initiated a national rural electrification program, called National Township Electrification Program (Song Dian Dao Xiang). The program uses solar and wind power to electrified 721 villages where the local village government is located. Total capacity for solar and its hybrid systems is 16MW. That market demands drove battery manufacturing industry developing quickly.

There are more than 1000 battery manufacturers in China. The major battery manufacturers who supply battery for PV station power storage in China are: Jiangsu Shuangdeng, Shandong Shengyang, Chongqing Wanli, and so on. Typical battery to be used in China for PV systems is valve regulated Lead-acid (VRLA) battery and gel battery. New type of battery are also developed and to be used, such as Iron Battery developed by BYD.

Since the market for off-grid power station is very smaller, and micro-grid has not been fully developed, the batteries demand in China PV industry is not too big.

3.5 System prices

In 2011, system prices for installed PV systems in China again dropped compared to the previous years. The reduction was 30%. In 2011 average system price for typical on-grid systems is RMB 17.5Yuan/Wp, about 2.15 EUR/Wp.

The PV system price in China is continuing dropping since 2007. The according figures for typical PV system are shown in Table 15.

Table 15: PV system price, 2007-2011

Year	2007	2008	2009	2010	2011
System Price (Yuan/Wp)	60	50	35	25	17.5

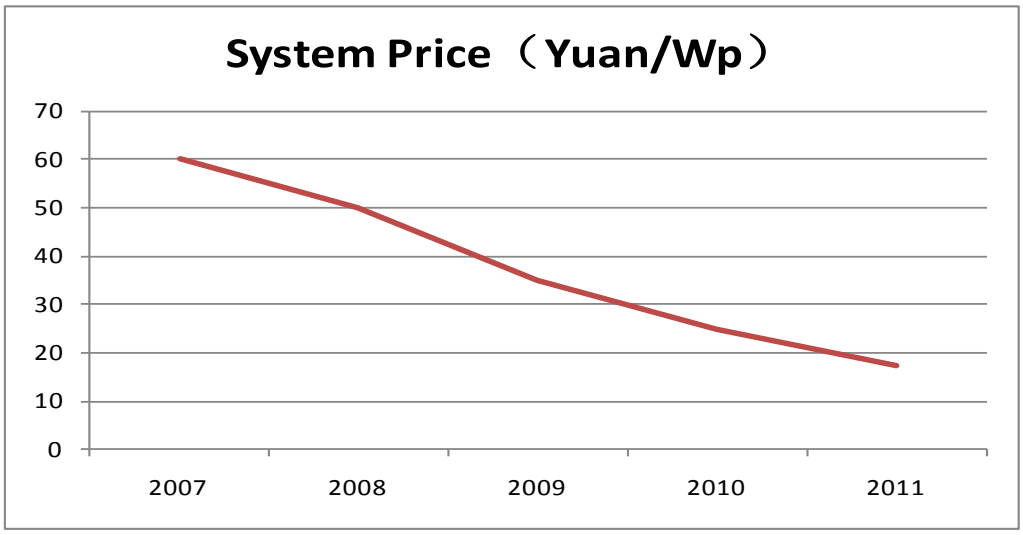


Figure 5: PV System Price

Source: Wang Sicheng, Incentive Policies and Market Trends of PV in China, 2012 Solarbuzz China PV Conference, July 19th, 2012

3.6 Labour places

The estimated labor placed in PV industry in China from 2008 to 2011 is shown in Table 16. Now there are about 500,000 employees working in PV industry nationwide.

Table 16: Labor placed in China PV industry, 2008-2011

	2008	2009	2010	2011
Labor Place(1,000)	200	300	300	500

Source: Yuwen Zhao, 11th China PV conference and Exhibition, Nanjing, Nov. 11-20, 2010
Junfeng, Li, Sichengwang, China Solar PV Outlook 2011, Aug. 2011
Secretariat of China PV Industry Alliance, April, 2012

3.7 Business value of installation

The system price of PV system has been decreased significantly from 2007 to 2011 (Ref to above table and chart), which was only 30% of the one in 2007.

The annual installation of PV in China from 2007 to 2011 is listed as Table 17.

Table 17: China Annual PV installation, 2004-2011

Year	2004	2005	2006	2007	2008	2009	2010	2011
Annual Inst. (MW)	10	8	10	20	40	160	500	2500
Cumulative Inst. (MW)	62	70	80	100	140	300	800	3300

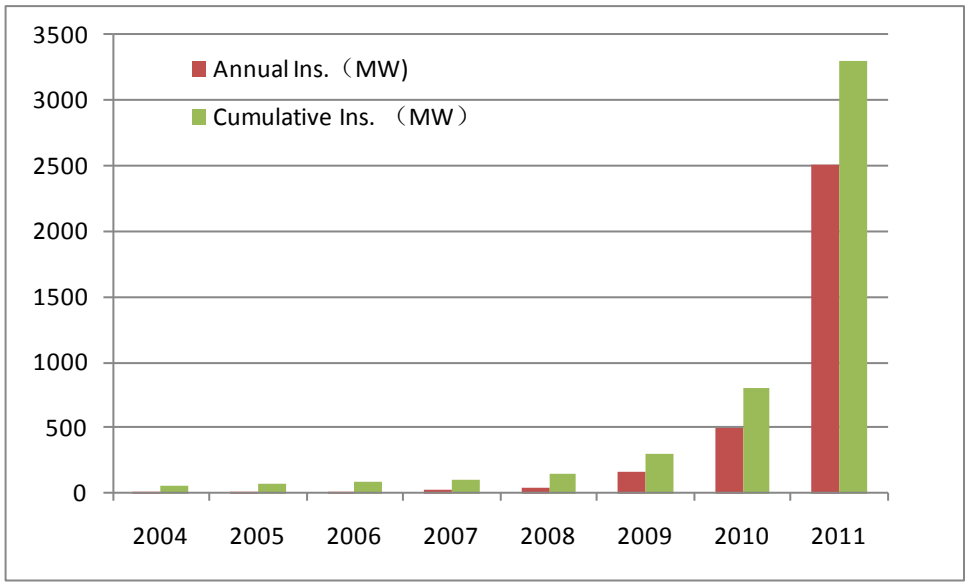


Figure 6: China Annual and cumulated PV installation, 2004-2011

Source: Wang Sicheng, Incentive Policies and Market Trends of PV in China, 2012 Solarbuzz China PV Conference, July 19th, 2012

This shows the increasing domestic PV market growing in China.

In 2011, besides the publishing of "PV industry development plan in 12FYP", also announced the nationwide FIT, raising the renewable energy extra charge and planning adjust the PV installation plan in 12th FYP. These measures have greatly promoted the growing of PV market in China.

Except the large scale PV power stations, distributed generation, micro-grid and small scale off-grid PV market are also emerging.

In 2011, 2.5GW PV systems has been installed in China, reached a total installed capacity of 3.3GW, which represents 5% of the global total installed capacity.

Table 18: Global and China cumulated PV installations, 2005-2011

Year	Global Cummulated	China Cummulated	China
	(MW)	(MW)	(%)
2005	5361	70	1.31%
2006	6956	80	1.15%
2007	9550	100	1.05%
2008	15675	140	0.89%
2009	22878	300	1.31%
2010	39000	800	2.05%
2011	66700	3300	4.95%

Source: Wang Sicheng, Incentive Policies and Market Trends of PV in China, 2012 Solarbuzz China PV Conference, July 19th, 2012

The value of China PV industry is about 300 billion Yuan RMB (~37BEUR) in 2011. The historical value of China PV industry is shown in Table 19.

Table 19: Value of China PV industry, 2008-2011

	2008	2009	2010	2011
Output Value(RMB)	200	300	300	300

Source: Yuwen Zhao, 11th China PV conference and Exhibition, Nanjing, Nov. 11-20, 2010

The historical export of China PV products is shown as Figure 7.

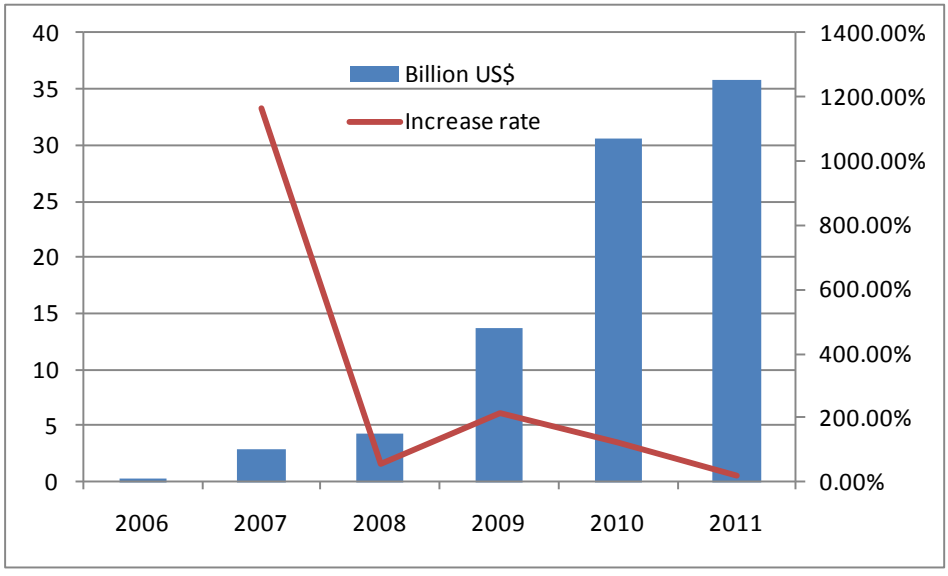
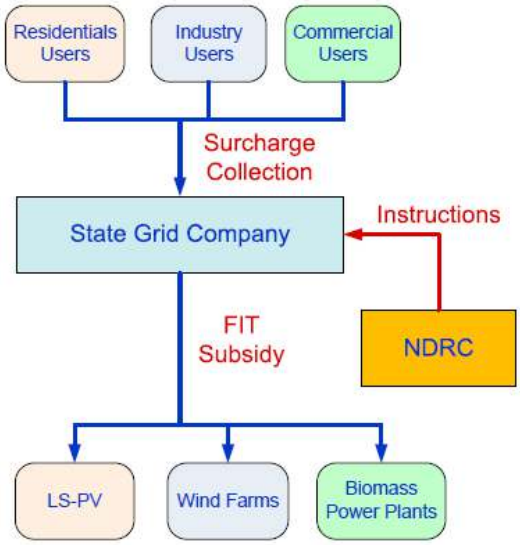


Figure 7: Export value (Billion US$) and increasing rate (%) of China PV industry

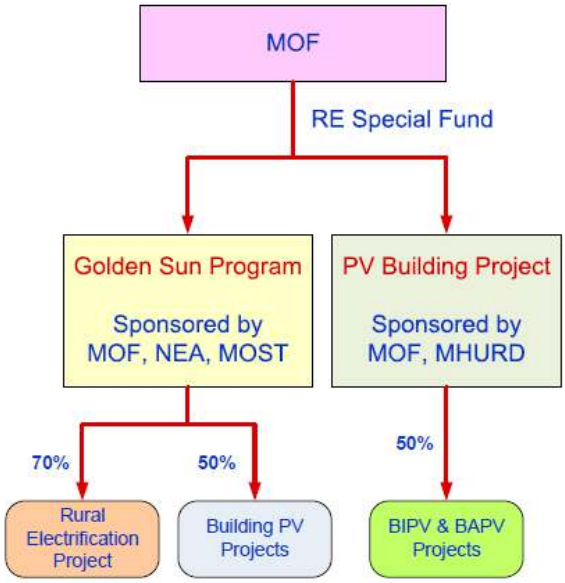
Source: OFweek industry research center

4 Framework for deployment (Non-technical factors)

There are two fundamental incentive policies in China to promote the PV Market. One is Renewable Energy Feed-in-Tariff, another is investment subsidy. The mechanism of these two policy systems are working as the following charts. The FIT regulation is mostly applied to large utility scale PV power stations, while Capital Investment Subsidy is applied to building related PV applications, such as rooftop solar generation.



FIT Subsidy Policy



Subsidy to Capital Investment and Self-consumption to offset Grid-Electricity

Three important things occurred in China in 2011 which were greatly promoting the development of PV industry.[10]

a) FIT of PV was released by NDRC in July, 2011.

b) Electricity surcharge of RE was doubled in Nov, 2011.

c) The market goal of PV in 2015 was updated to 15GW.

Nationwide FIT for PV was released in July, 2011:

- RMB 1.15 Yuan/kWh for the projects finished before the end of 2011;
- RMB 1. 0 Yuan/kWh for the projects finished after Dec.31, 2011;

Electricity surcharge of RE was doubled

The regulation was issued by Price Bureau of NDRC (Nov. 29, 2011)

The surcharge for RE in the electricity nationwide will be doubled from 0.4 cents/kWh to 0.8

[10] Wang Yibo, Country Report China: Status and Prospects of PV Large-Scale Application in China, IEA PVPS T14 5th Expert Meeting: Workshop, May, 2012

cents/kWh. This will allow 20-24 billion Yuan to be collected every year to support RE power generation.

Update PV installation goal to 15GW in 2015

The installed PV capacity by 2015 has been updated time by time. It was 10GW before, but in late 2011, it has been modified to 15GW. (Furthermore, it is said that it has been modified to 20GW recently). Updated market goal has a positive impact on industry development.

Besides these, the financial support for R&D provided by MOST is about 500 Million Yuan per year.

By now, the significant progress in PV R&D, PV mass production, PV cost reduction and PV domestic market expansion has been achieved, and these are pushing the PV industry quick development.

4.1 Indirect policy issues[11]

To develop PV industry, refer to Europe and America's policies and incentives, China has announced many industry policies. The main law governs RE is "China Renewable Energy Law". And also, China sets its national plan for its near/long term target of RE; and through well designed Business Models and innovative Financing Mechanisms to promote the industry development. These policies can be classified as three categories. See Table20.

Table 20: National policy related with PV industry (Still in effective)

Type of policy	Title	Issued organization
Planning policy	Decision to speed up the cultivation and development of strategic emerging industries	State Council
	"Renewable energy middle and long-term development planning"	NDRC
	"12th Five year plan for Renewable Energy Development"	NDRC
	Guidance on the promotion of the international development of the emerging strategic industries "	MOC
	"Renewable energy industrial development guidance catalog" notice	NDRC
	National Energy Technology "12th Five-Year Plan (2011 ~ 2015)	NEA
	Notice on the issuance of the industry key common technologies Development Guide (2011)	MIIT

[11] Situation and sustainable development strategy research on China PV industry, China Export & Credit Insurance Corporation, 2012-5-16, http://www.sinosure.com.cn/sinosure/xwzx/rdzt/ckyj/ckdt/xyzt/qcxy/dxctsbyj/149216.html

	"Industrial restructuring Catalog (2011)"	NDRC
	“Solar photovoltaic industry, "the 12th Five-Year Development Plan”	MIIT
Support policy	Implementation of views "on accelerating the solar PV building applications	MOT
	"Renewable energy prices and cost-sharing management pilot scheme"	NDRC
	“Renewable energy development fund levy Interim Measures on Management”	MOT
	"Golden Sun Demonstration Project (Finance Building [2009] No. 397)	MOT
	“Improve the solar PV tariff policy”	NDRC
	Notice on strengthening the management of follow-up of the demonstration of solar PV building applications	MOT
	“Organization of the 2012 renewable energy construction demonstration Notice”	MOT
	“Notice on to do the 2012 annuity solar demonstration”	MOT
	“On the organization and implementation of the 2012 annual solar PV building applications demonstration”	MOT
Monitoring/regulating policy	"Foreign Investment Industrial Guidance Catalogue (2011 Amendment)"	NDRC, MOC
	“notice to meet the polysilicon industry access conditions”	MIIT

* NDRC : National Development and Reform Commission

NEA: National Energy Administration

MIIT: Ministry of Industry and Information Technology

MOT: Ministry of Treasure

MOC: Ministry of Commerce

1. Planning policy

Recent years, China NDRC developed many plan related with renewable energy, such as “12th Five year plan for Renewable Energy Development”, and "Renewable energy middle and long-term development planning”. These official documents clearly define the targets and direction of PV industry, and also through government planning to adjust the targets and direction time by time. For example, based upon the information from NEA, the “12th Five year plan for Renewable Energy Development” will adjust the PV installed capacity to 15GW by 2015, with 200×10^{8}kW•h annual electricity generation capacity.

2. Support policies

The supportive policies can be classified as four sub-categories:

1) RE fund raising policy,

2) Support the development of desert large scale PV power station through concession bidding, such as the bidding in 2009 and 2010;

3) Support building integrated PV projects, such as “Golden Sun Demonstration program” and “Building related PV application demonstration program”,

4) Feed-in-tariff policy to support PV distributed generation.

3. Monitoring/ regulating policies

To optimize the PV industry structure and reduce the advocate orderly competition, some monitoring, regulating policies and retrain condition were released, such as the “notice to meet the polysilicon industry access conditions” published by MIIT.

4.2 Standards and codes[12]

China's photovoltaic grid industry is still in the early stages of development, PV grid-connection standards are still inadequate, the photovoltaic grid standards have been issued are:

GB/Z19964-2005 "photovoltaic power plants access to power system technical requirements
GB/T20046-2006 "grid interface of photovoltaic (PV) system characteristics"
GB/T19939-2005 “photovoltaic systems and network technology requirements "
SJ/T11127-1997 photovoltaic (PV) power generation system over-voltage protection – Guide
Q/GDW617-2011 "photovoltaic power plants connected to the grid technical requirements”,
Q/GDW618-2011"photovoltaic power plants connected to the grid test procedures ".

Recently, the review of three national standards prepared by EPRI, "Photovoltaic power station access power system requirements”, “Technical specifications of photovoltaic power generation system access distribution network requirements" and "Photovoltaic power plant reactive power compensation", has been passed. The three GB revision of the system will protect the power system security and stability in the large-scale photovoltaic power generation and network and reliable power supply, and promoting China's photovoltaic power generation to the rapid development path but healthy and orderly[13].

Meanwhile, China national Standard Administration Commission has worked with Ministry of Industry and Information Technology and NEA, established a team to promote the PV industry and its standards, and also issued the <notice on the establishment of the team to promote the PV industry and its standards>, authorized China Electricity Council (CEC) as the team leader, be responsible the daily management of grid-tied PV power generation standardization.

[12] Situation and sustainable development strategy research on China PV industry, China Export & Credit Insurance Corporation, ,2012-5-16, http://www.sinosure.com.cn/sinosure/xwzx/rdzt/ckyj/ckdt/xyzt/qcxy/dxctsbyj/149216.html.

[13] The photovoltaic power station access power system provides three photovoltaic GB through expert review, http://www.chinaelc.cn/ch_hangye/zhengce/2012041815593.html, April 18, 2012

5 Highlights and prospects

China is the largest PV manufacturing nation, but in long term, 90-95% of its PV products were exported to Europe and North America due to less incentive policy and regulation available in China to promote the deployment of PV in China domestic. May 17, U.S. Department of Commerce make a preliminary anti-dumping on Chinese PV products, determine the PV products exported from China made by Chinese enterprises to in the United States an anti-dumping measures, imposed punitive tariffs ranging from 30% -250%. Furthermore, SolarWorld, the leading solar energy companies in Europe, officially on Tuesday jointly to the European Commission application for antidumping investigations initiated on Chinese solar panels.

From other hand, September 22, 2009, China President Hu Jintao said in the opening ceremony of the United Nations summit on climate change, China will further integrate climate change into economic and social development plans, and made great efforts to develop renewable energy and nuclear energy, non-fossil energy accounting for primary energy consumption is about 15% by 2020. The 15% target will have a significant impact on China's energy development and energy structural adjustment. During next four years, new wind power capacity will be added at the rate of 15-20GW per year, which is closed to its capacity upper limits. Hydropower is also approaching its growth limits. By 2020, almost all hydro resource will be utilized. The development of nuclear power is slowing down due to Fukushima No.1 Nuclear Power Plant failures following the Great East Japan Earthquake in Japan. Therefore, solar power will be put more responsibilities on the effort to achieve government using RE and protecting environment goal.

5.1 Stakeholder initiatives and awareness raising

To achieving the target of 15% of non-fossil fuel target in primary energy consumption in China, and also, help Chinese PV manufacturers when it is suffering from international trade protection environment, the most effective way is to develop China domestic PV market. The stakeholders, includes government, national utility (national power grids), PV industry and all other related government administrations, such as Ministry of Finance (MoF), Ministry of Science and Technology (MoST), Ministry of Housing and Urban-Rural Construction (MoHURC), and China Academy of Science (CAS), are all taking actions to support PV industry and PV applications in China through planning, financial supporting, R&D, demonstration, and deployments, which covers from:

1) Large scale utility power generation station, such as 500MW PV station in Xingtai, Hebei[14],

2) Distributed generation and micro-grid demonstration, such as Green-county, Renewable energy municipal and demonstration projects initiated by NEA;

3) Building integrated PV application, such as rooftop PV installations, for example, PV panels will be installed on the rooftop of all government buildings, and middle/elementary schools in Beijing;

4) Off-grid rural electrifications;

5) Solar powered products, such as solar/wind hybrid street lights.

[14] http://www.windchn.com/webinfo/wfview000156717.html

6) Advanced technology and new production process researches, and so on.

Through these real activities, PV products domestic application rate has been increased from 5% to 20% in 2011, and will continuously grow in near future.

5.2 Prospects

1. Development trend of solar cell

Along with the price reduction of silicon materials, the conversion efficiency increasing and the production costs dropping, the PV module price will continue reduced. A conservative prediction is that, by 2015, 50% of the production cost will be further reduced, another 2% of conversion efficiency will be achieved (0.3~0.4% per year), the energy consumption for poly-silicon production will be 50% less than it is.

Current profit rate for solar cell manufacturing is about 30%, it will be reduced to 10~15%. Within five year, the cost for solar module will drop down to US$0.5-0.6/Wp, retail price will drop down to US$0.7~0.8/Wp/. With other installation cost, the solar system price will approach US$1.3~1.5/Wp.

The conversion efficiency of thin-film is lower, the manufacturing technology and equipment is incomplete, the R&D shall be enhanced. 2010, the production output of CdTe has approached 1.4GW, mostly by First Solar, the production cost has been dropped down to US$0.6/Wp. The price of Te is increasing since it is a scarce materials, the room for CdTe price dropping is limited.

The yield of A-si and Micro-crystal solar cell in China is 750MW in 2011. Due to its complicated production processes and expensive production equipment, the technology shall be further innovated and improved.

2. Trend of solar market in China

Reviewing China available renewable energy resources, to approach the target of national non-fossil energy to achieve 15% of total energy consumed by 2020, developing solar power generation is a must. The PV industry is facing new challenge and opportunity.

Based upon China national 12th FYP and current situation, non-fossil energy shall achieve 11.4% of total energy consumed by 2015. The planned total installed solar power capacity by 2015 was 10GW, and 50GW or more by 2020. But the target by 2015 has already been updated to 15GW[15]. This means that 3-4GW new installation will be added every year from now to 2015. Both utility scale power station and distributed generation will have its own market. Several incentive policies and regulations will promote the rapidly development of China domestic solar market.

Following up with the experience of wind power industry development history in China, the market demands continuously doubling is possible after the annual installation beyond 500MW. The estimated annual new installation of PV will be 3-4GW per year during 2011-2015, while ~10GW per year during 2016-2020. The annual installation of PV will break 20GW after 2020.

[15] China Energy Network, Dec. 29, 2011

From other hand, China still has its problems and barriers in its PV industry development, such as:

Problems from utility-scale Power Plants

- Grid-connections: Developers have to build H-voltage transformer stations by themselves;
- High land Tax：2-6 Yuan/m^2 per year charged by local government；
- Forced Stop-generation：Limited by the capacity of transmission grid, PV plants were forced to stop generation few days in a week by grid company；
- PPA Period：20 years? 25 years? or 25000 hours? Has not been confirmed by government；
- Cash flow: Subsidy payment has been delayed nearly two years.

Problems faced by DG (BIPV and others)

- User side Grid-connection：The more power electricity generated by PV, the less electricity sold by grid company, so Grid company dislike PV system to connect at user side and in most cases, ask the developers to connect PV systems to high-voltage grid and to sell PV electricity totally to the grid company. In this case, the cost will be much higher due to adding transformer station and the income will be much lower due to the tariff has to be the whole-sell price of coal-fire power plant (0.35 Yuan/kWh).
- DG mode is conflicted with power law；
- Subsidy mechanism: 100% of subsidy will be received against commission. How to supervise the afterword operation?
- Permission expense to the developers: Several permission charges have been proposed by utility: Design of grid-connection, Test of grid connection, Backup fee, Monitoring & Data Transfer system. Is affordable?

PV industry and market in China will continue moving forward along with the overcome and removal of these problems and barriers.

Annex A: References, methods and accuracy of data.

This information is simply to give the reader some background about the national environment in which PV is being deployed. It is not guaranteed to be 100 % accurate nor intended for analysis, and the reader should do their own research if they require more detailed data.

[1] Junfeng Li, Presentation on Photon Poly Silicon conference, Berlin, April 12, 2011

[2] Wang Sicheng, Incentive Policies and Market Trends of PV in China, 2012 Solarbuzz China PV Conference, July 19th, 2012

[3] Situation and trend analysis of China inverter industry, China industry research network, (http://www.chinairn.com), Feb. 1, 2012

[4] Photovoltaic Inverter Market Suffered Slight Setback in 2011 [EB/OL]. (2012-01-30). http：//www.isuppli.com/Photovoltaics/MarketWatch/PsSes/Photovoltaic-Inverter-Market-Suffered-Slight-Setback-in-2011.aspx.

[5] Situation and sustainable development strategy research on China PV industry, China Export & Credit Insurance Corporation, 2012-5-16, http://www.sinosure.com.cn/sinosure/xwzx/rdzt/ckyj/ckdt/xyzt/qcxy/dxctsbyj/149216.html

[6] Wang Yibo, Country Report China: Status and Prospects of PV Large-Scale Application in China, IEA PVPS T14 5th Expert Meeting: Workshop, May, 2012

[7] The photovoltaic power station access power system provides three photovoltaic GB through expert review, http://www.chinaelc.cn/ch_hangye/zhengce/2012041815593.html, April 18, 2012

Annex B: COUNTRY INFORMAION

This information is simply to give the reader some background about the national environment in which PV is being deployed. It is not guaranteed to be 100 % accurate nor intended for analysis, and the reader should do their own research if they require more detailed data.

1) Retail electricity prices - household, commercial, public institution

The tariffs in China are varying based upon different geographic locations, user categories and time using electricity. The following table shows the example[16].

Table 21: Electricity tariffs in China

Unit: RMB Yuan/kWh

City		Beijing	Shanghai	Guangzhou	Qinghai
Household	< 1Kv	0.4883	0.617	0.61	0.4271
	1~ 10Kv	0.4783	0.612		0.4271
	10~ 35Kv	0.4883			
Commercial	< 1Kv	0.821	0.920	1.0178	0.2228-0.9342
	1~ 10Kv	0.806	0.895	0.9928	0.2210-0.9260
	10~ 35Kv	0.799-0.791	0.870	0.99-0.9678	0.2191-0.9179
	110Kv	0.776	0.850	0.98	
	> 110Kv	0.761			
Industry	1~ 20Kv	0.637	0.895	0.7142	0.1450-0.5916
	20Kv	0.627		0.7142	0.1413-0.5753
	35Kv	0.617	0.870	0.6892	0.1413-0.5753
	110Kv	0.597	0.850	0.6892	
	> 220Kv	0.577	0.850	0.6642	0.1376-0.5590

Source: State Electricity Regulatory Commission (SERC)

2) Typical household electricity consumption

In 2009, the average person per household in China was 3.1, the average electricity consumption was 365.9 kWh. The average electricity household consumed in 2009 was1, 134.29kWh.

(Source: China Statistical year book 2011)

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

[16]Many places carries out summer electricity tariff, such as Shanghai, and also, many places carried out common, peak and valley price, such as Qinghai. The exchange rate between EUR and China RMB in 2010 was~8.8.

- Regular metering, or prepaid card metering. The interval for regular metering is one month.

- Summer price is carrying out, which is high than other seasons.

- Common, peak and valley price structure is used. Peak price is much high than valley price so as to shift the peak load.

4) Typical household income

Table 22: Typical household income

	per capita disposable income of urban dwellers		per-capita net incomes for rural families	
	Amount (Yuan)	Index (1978=100)	Amount (Yuan)	Index (1978=100)
2010	19,109.4	965.2	5919.0	954.4

2010 nationwide average persons per household is 2.88.

Source: China Statistical year book 2011

5) Typical mortgage interest rate

The mortgage interest rates in China vary time by time. The following table was the rate effective on July 7, 2011.

Table 23: Mortgage interest rates in China

Terms	Annual interest rate %
<= 6 months	6.10
> 6 months, <= 12 months	6.56
> 1 year, <= 3 years	6.65
> 3 year, <= 5 years	6.90
> 5 years	7.05

6) Voltage (household, typical electricity distribution network)

- Household: 220V

- Distribution network: single phase,220V, three phase 380V, 10KV, 35KV, 100KV, 220KV, 330KV, 500KW, and 1000KV.

7) Electricity industry structure and ownership

Five major power generation corporations: Northeast China grid company, North China Grid company limited, Center China Grid company limited, East China Grid company limited, Northwest China Grid Company Limited.

These companies all belong to State Grid Corporation of China (SGCC), and China Southern Power Grid Co., Ltd. (CSG).

They are all state-owned enterprises.

8) Retail prices of oil

The retail price of oil in China is verying periodically following with the international crude oil. The newest retail price effective from the date of August 8, 2012) are:

- Gasoline

90#：6.37-7.45 Yuan/liter

93#：6.74-8.00 Yuan/liter

97#：7.11-8.39 Yuan/liter

- Diesel oil:

6.60-7.25 Yuan/liter

(Source: http://oil.usd-cny.com)

9) Typical values of kWh/kW for PV systems per year in China

Table 24: Solar Resources and PV Output in Western China

Solar Resources and PV Output in Western China							
Province	**Average Horizontal Solar Irradiation (MJ/m2/y)**	**Average Horizontal Solar Irradiation (kWh/m2/y)**	**PV Tilted Angle (Degree**	**Irradiation on Tilted PV (MJ/m2/y)**	**Irradiation on Tilted PV (MJ/m2/y)**	**System Efficiency (%)**	**PV Annual Output (kWh/kW/y)**
Xinjiang	5304.84	1473.57	45	6100.56	1694.60	80	1355.68
Tibet	7885.99	2190.55	30	8832.31	2453.42	80	1962.73
Inner-Mon	6041.35	1678.15	45	6947.56	1929.88	80	1543.90
Qinghai	6142.93	1706.37	40	7064.37	1962.32	80	1569.86
Gansu	5442.78	1511.88	40	6259.19	1738.67	80	1390.93
Ningxia	5944.80	1651.33	42	6658.17	1849.49	80	1479.59
Shanxi	5513.84	1531.62	40	6340.91	1761.37	80	1409.09
Shaanxi	4730.51	1314.03	40	5440.08	1511.13	80	1208.91
Yuannan	5182.78	1439.66	28	5597.40	1554.84	80	1243.87
Average	**5798.87**	**1610.80**	**38.89**	**6582.28**	**1828.41**	80	**1462.73**

Table 25: Solar Resources and PV Output in Eastern China

Solar Resources and PV Output in Eastern China							
Province	Average Horizontal Solar Irradiation (MJ/m2/y)	Average Horizontal Solar Irradiation (kWh/m2/y)	PV Tilted Angle (Degree)	Irradiation on Tilted PV (MJ/m2/y)	Irradiation on Tilted PV (MJ/m2/y)	System Efficiency (%)	PV Annual Output (kWh/kW/y)
Heilongjiang	4683.69	1301.03	50	5386.24	1496.18	80	1196.94
Hebei	5008.89	1391.36	42	5609.96	1558.32	80	1246.66
Guangxi	4595.91	1276.64	25	4963.58	1378.77	80	1103.02
Jilin	5034.39	1398.44	45	5789.55	1608.21	80	1286.57
Guangdong	4478.03	1243.90	25	4836.28	1343.41	80	1074.73
Hubei	4312.92	1198.03	35	4959.86	1377.74	80	1102.19
Shandong	5123.01	1423.06	40	5891.46	1636.52	80	1309.21
Henan	4764.36	1323.43	40	5479.02	1521.95	80	1217.56
Liaoning	5067.41	1407.61	45	5827.53	1618.76	80	1295.01
Jiangxi	4832.08	1342.24	30	5218.65	1449.62	80	1159.70
Jiangsu	4855.49	1348.75	35	5341.04	1483.62	80	1186.90
Fujian	4410.74	1225.21	30	4763.59	1323.22	80	1058.58
Zhejiang	4314.60	1198.50	35	4746.06	1318.35	80	1054.68
Hainan	5125.10	1423.64	25	5381.35	1494.82	80	1195.86
Beijing	4835.52	1343.20	42	5508.00	1530.00	80	1224.00
Tianjin	5260.11	1461.14	42	5891.33	1636.48	80	1309.18
Shanghai	4729.25	1313.68	35	5202.18	1445.05	80	1156.04
Average	**4790.09**	**1330.58**		**5340.92**	**1483.59**	**80**	**1186.872**