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Chinese Renewable Energy Industries Asscoication

The Energy Foundation | Research Report

CHINA SOLAR PV POWER POLICY REPORT: DIFFERENTIAL FEED-IN TARIFFS

Chinese Renewable Energy Industries Association Research Group on Policy Recommendations of PV Feed-in Tariff in China

The Chinese PV industry is at an important transition period from industrial infancy to healthy and orderly development, which is in urgent need to establish and improve policies and supporting measures, in particular the policy of PV power generation tariff. This can be attributed to the following: a) price is the most effective policy instrument to promote industrial marketization and large-scale development; and b) in comparison with other policy instruments such as financial subsidies, preferential tax and financial support, the price policy is the most transparent means of management, and is more in line with the requirements of resource allocation of the market. Moreover, for investors, the price policy can intuitively reflect industrial policy orientation of a country, and can also project the return on investment of an industry in a direct and definite manner, thus making investment decisions.

Thus, the soundness of pricing policy is a reflection of industrial maturity. Scientific and reasonable PV feed-in tariff is of greatly strategic significance to healthy development of China's PV industry. Currently, PV tariff policy presents quite a positive signal, and has solved a lot of historical issues with investment incomes of many "approved" projects, which helps to make preliminary design for PV tariff of new projects, and more importantly, paves the way for the future introduction of a more comprehensive tariff. Based on sorting out various policy suggestions on PV power generation at home and abroad, the study proposed recommendations on the policy of PV power generation feed-in tariff in favor of reference for the authorities concerned.

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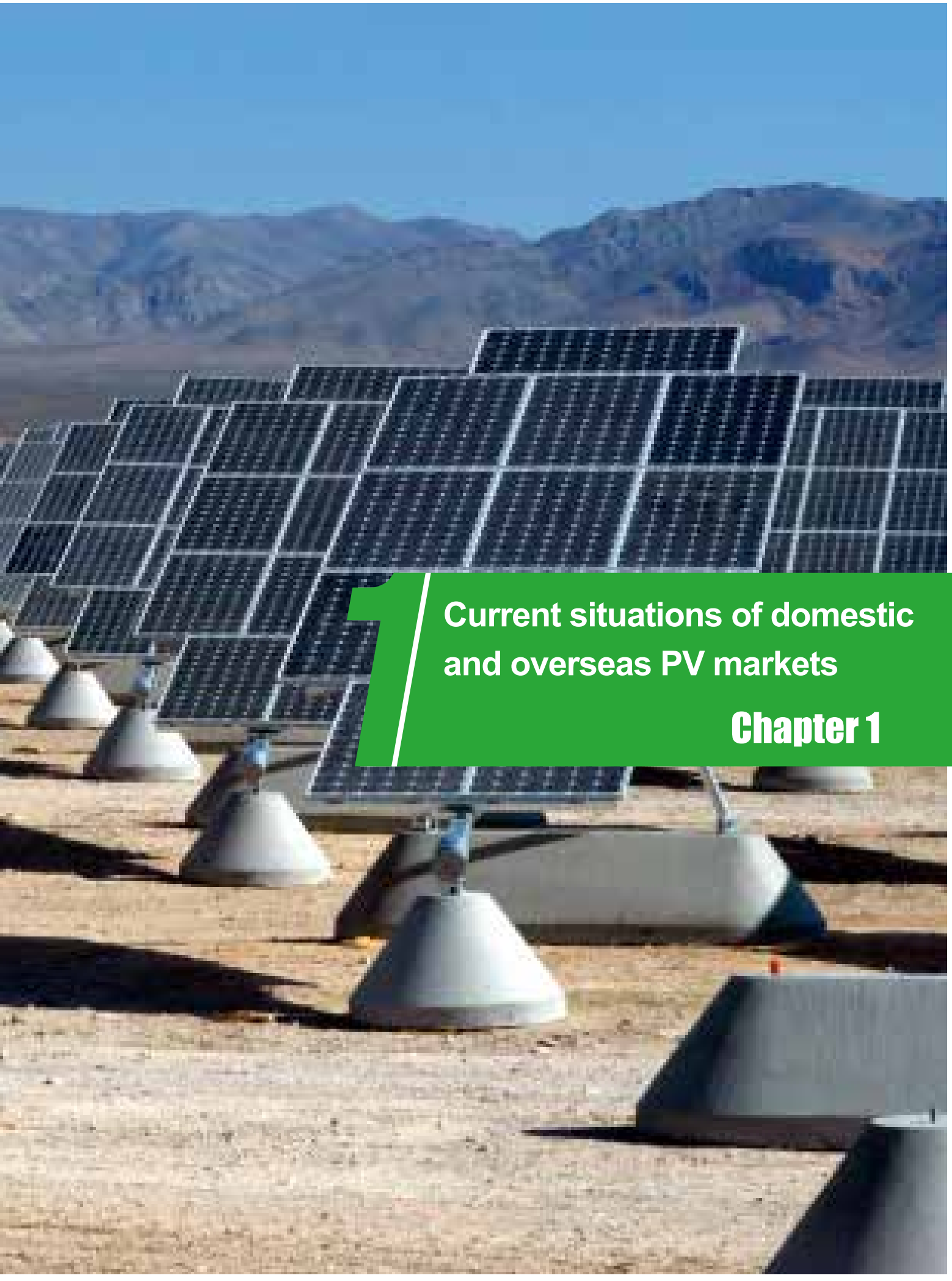


1 Current situations of domestic and overseas PV markets

Chapter 1

Chapter 1

Current situations of domestic and overseas PV markets

After over ten years of development, the global PV power generation industry has entered a stage of large-scale development, with a market growth rate of more than 50% on average during the 10-year period. In addition to increasing importance to renewable energy by nations all around the world, a primary reason is that the price of PV modules and development costs of power plants has dropped significantly, which stimulates explosive growth of the PV market and drives continued prosperity of installed capacity in the global PV market. In 2012, manufacturing cost of the PV system continued to decline, growth rate of newly-increased markets was not as anticipated, and actual installation amount remained at 29.7GW, with a growth rate of only 3.6%. The failure to meet the expectations of market development was mainly attributed to China. However, despite the failure, in 2012, newly-increased PV installed capacity in China remained up to 1,190MW, and grid-connected power generation capacity reached 3.5 billion kWh. Calculated at shipment of the industry association, China's cumulative installed capacity of PV power generation system has totaled over 7GW.

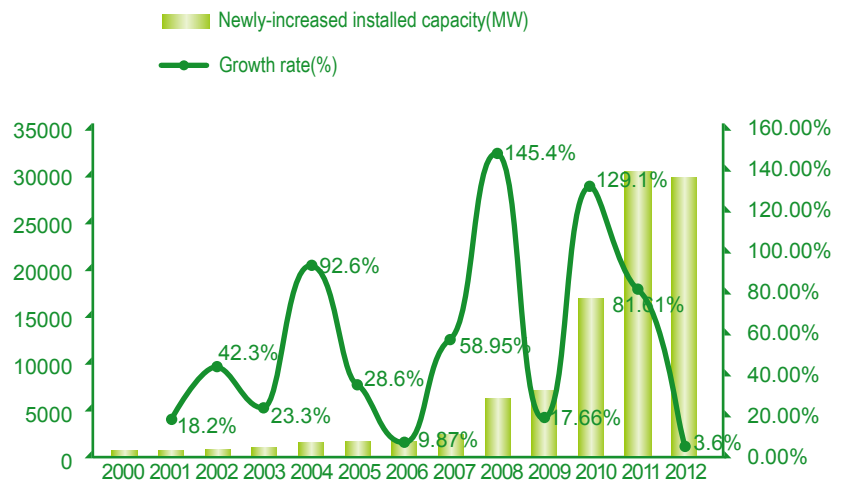


Figure 1-1: Development trend of newly-increased installed capacity for global PV power generation industry in the current year

Source: study by CREIA

From the perspective of market distribution, Europe remains as a leader in the PV power generation market. PV systems with a capacity of 17.5GW were installed in European countries in 2012, accounting for 59% of global installed capacity. The Asian market had a flat performance, with an installed capacity of 3.5GW for China and 3.1GW for Japan, all lower than market expectations generally. For the entire American market, it was better than expected in 2012, with an installed capacity of 3.6GW and with no material impact on wind power and PV imposed by shale gas; and PV power generation reached 3.2GW for the United States in 2012, creating a historic high record. However, for emerging markets well received by the world, such as Australia, Brazil, South Africa and the Middle East, slow development was found due to the impacts of global economic downturn, and their total installed capacity was less than 1.3GW in 2012, among which, Australia had an outstanding performance.

In the past decade, China's PV power generation manufacturing industry grows strong and large-scaled; and by 2012 it had accounted for around 70% of world production. From the viewpoint of market demand, production capacity of PV cell modules in China totaled up to 40GW in 2012, which could meet installation demands for global PV cell modules in 2015. Besides, production capacity of polysilicon had also been increased to over 60, 000 tons. Admittedly, China's cost advantage in large-scale production has made tremendous contributions to the global PV industry.

Nevertheless, the competition in the market of PV modules is intensified, showing an upward trend in export volume of products and yet continually downward in prices. With continuous simmering of economic crises, global trade frictions also gradually get warm. In October 2012, the U.S. Department of Commerce made final decision to levy 18.32%-249.96% anti-dumping duty and 14.78% -15.97% anti-subsidy duty against subsidy and dumping. This initiative acted as a pioneer in discriminations against the trade with Chinese PV industry once again, which brought on trade barriers by European countries against Chinese PV products. Following the US, Europe which accounted for 70% of China's PV export markets launched attacks on China’s PV manufacturing industry, imposing a deadly blow to China’s PV manufacturing industry. Consequently, provided that the situation of export-oriented China's PV industry is not broken, it will be always controlled by others. Currently, the key to solve the problems confronted with China's PV industry is to launch its domestic market in a large-scale manner as soon as possible.

The fundamental factor long plaguing the launch of China's PV market lies in its high cost for long. As technological advances and large-scale production push the manufacturing

cost of PV modules and systems gradually on the decline, PV power generation cost per kWh is significantly decreased. At present, countries around the world have set forth a roadmap of grid parity involving PV power generation. In 2011, in the China Roadmap of Photovoltaics Development—A Pathway to Grid Parity accomplished by Chinese Renewable Energy Industries Association (CREIA) with the support of the Energy Foundation and the World Wildlife Fund (WWF), a development goal was put forward with regard to PV power generation feed-in tariff in China, that is, realizing 0.8 yuan and 0.6 yuan per kWh respectively in 2015 and 2020, as is shown in Figure 1-2. A significant decline in the cost of PV power generation has laid a sound foundation for the formation of the PV power generation market.

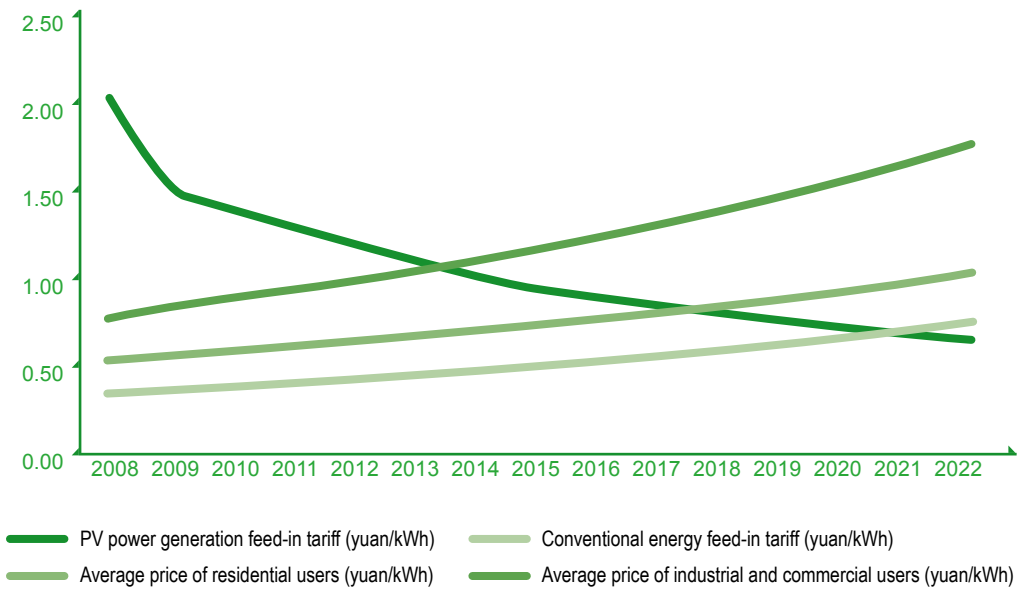


Figure 1-2: China roadmap of photovoltaics development—A pathway to grid parity

Source: Li Junfeng et al., China Roadmap of Photovoltaics Development—A Pathway to Grid Parity, August 2011.

Chapter 2

Practical experience and analysis on PV policies

Chapter 2

Practical experience and analysis on PV policies

2.1 Practices and drawbacks of China

Since 2009, China has promulgated and implemented a series of incentive policies related to PV power generation, which helps to launch the domestic PV market promptly. The policies currently implemented primarily consist of feed-in tariff policy and policy of investment subsidies.

In July 2011, the National Development and Reform Commission (NDRC) enacted a policy of PV feed-in tariff which followed the formation mode of wind power tariff, which is, determining the level of PV feed-in tariff through several rounds of tariff biddings and tenders. The introduction of the feed-in tariff policy has vigorously promoted fast launch of the development of domestic large PV power plants (see Table 2-1), mainly represented by construction of large ground PV power plants. At the same time, it has also eased the problems with excessively low bidding tariff universally responded by the industry in previous days. According to statistics, as of the end of 2012, China's cumulative PV capacity had hit around 4.2 GW.

The policy of investment subsidies related to PV power generation includes PV Building Application Demonstration Project and Golden-sun Demonstration Project. The main objectives of the two policies are small-medium distributed PV power generation systems that are installed on the roof or integrated with buildings; the policies have provided powerful impetus to the development of the China's PV market during the PV power generation period with larger initial investment. By the end of 2012, in 32 provinces (regions) across China, the cumulative building capacity of distributed PV power generation projects had amounted to about 3,775MWp, among which about 3044 MWp was contributed by Golden-sun Demonstration Project, about 525 MWp originated from PV Building Demonstration Project, and approximately 206 MWp was from other distributed power generation projects. As far as provinces are concerned, Jiangsu, Shandong and Guangdong had the most distributed PV power generation capacity across the country, their market share being 15.65%, 7.51% and 7.3% respectively.

In addition to incentive measures of the two national policies, part of provinces, autonomous regions and municipalities at home supported the development of PV power generation positively, and according to local conditions and advantages, promulgated and implemented some local preferential policies. These policies consisted of local feed-in tariff, subsidies and preferential land. However, restricted by the characteristics of short term and strong volatility of local policies, it increased the difficulties of the investment risk assessment on PV power generation.

Either from international experience or implementation practices in China's PV policies, feed-in tariff has been proved to be the most powerful policy mode to promote the development of the PV industry. However, due to some shortcomings, there leaves some space for improvement for China's current policy of PV power generation feed-in tariff. The drawbacks are: unified national tariff; applicable time limit of tariff; adjustment to tariff level as well as the relation between tariff and development scale. To solve these problems, the following aspects are recommended on the part of the nation. a) Take into overall consideration regional resource advantages and grid-connected transmission conditions while improving the policies, and develop tariff according to resource areas; b) set applicable time of feed-in tariff and reduce uncertainties in the course of investment analysis; and c) adjust tariff according to development realities and market scale of the PV industry so as to maintain a healthy and stable development of the market.

2.2 Experience of PV tariff policy at global level

Currently, the main policies in popularizing PV development include feed-in tariff and comprehensive stimulus.

Take Germany for example, the policy of feed-in tariff mainly covers the following policy implications: 1) the grid company purchases PV power generation feed-in electricity with total amount; 2) within a fixed timeframe (20 years for instance), enjoying a feed-in tariff; 3) the feed-in tariff associated with newly-built PV power generation is reduced by scale on a regular basis; and 4) the part higher than conventional tariff is equally shared among all consumers. The policy of comprehensive stimulus implemented by the U.S. includes net electricity metering system, tax incentives and security measures; among the rest, 32 states carry out mandatory market quota and 42 states prefer the net electricity metering system.

In addition to the policies implemented by Germany and the US, there're also other market policies, including premium tariff system and tariff two-track system associated with renewable energy in Spain, and Japan's tariff policy which experienced power generation subsidy to net electricity metering before transiting to feed-in tariff. Too fast changes to the policies often threw the Spanish market into instability. While benefited from a series of progressive policies such as investment subsidies, net electricity metering system, tax incentives, feed-in tariff and secured acquisition, the development and utilization of solar energy in Japan is ranked at the top of the world.

Currently, from the perspective of the selection of policies, development experience of countries includes: PV power generation cost is higher than conventional energy, with obvious feed-in advantages; PV reaches grid parity level, and parity consumption policy has prominent advantages; relatively stable and constantly subtle adjustment are trends of PV power generation policy for major nations; and in countries throughout the world, institutional innovation in the policy of solar energy PV power generation is ongoing.

3

Experience of overseas PV power generation

Chapter 3

Chapter 3

Experience of overseas PV power generation

3.1 Distributed feed-in is a mainstream mode of PV power generation feed-in in overseas countries

The properties of PV power generation enable its advantages of distributed feed-in. To ensure economic and stable operation of distributed PV power generation system, grid-connected operation with public power grids is required. Only by relying on a strong distribution network can large-scale development of distributed PV power generation be achieved. However, due to different modes of access and different rates of penetration of power generation systems, grid-connection of distributed PV systems affects the power system to a certain extent. In view of this, countries around the world adopt various ways to prevent the impacts of distributed PV systems on the grid.

Germany

(1) As far as mode of access is concerned, the distributed PV power generation system is directly connected to the public grid. It's the most effective way to quickly launch the market of PV system application at the initial stage of PV power generation system development.

(2) With improved penetration of the PV power generation system, the government minimizes the quantity of electricity from grid by the distributed PV power generation system by increasing the amount of subsidies of spontaneous electricity consumption.

(3) Pay attention to balancing the interests of parties concerned, emphasize the minimum total utilization cost of the system, and seek the most economical grid-connected operation mode of PV system.

California, the U.S.

(1) Based on power generation for its own-consumption, highlight the minimum utilization cost.

(2) Built on different grid-connected methods of the distributed PV power generation system, implement classified management.

3.2 Cost analysis of grid-connection of distributed PV

Grid-connection cost of the distributed PV system is mainly composed of access cost at PV system side, access cost at the grid side, grid operation and renovation costs and other costs. At present, the grid-connection cost of distributed power overseas is mainly embodied as follows:

Ireland: for grid-connection program flow, it takes approximately 6-9 months (excluding applying for building permits). Grid-connection cost of typical PV systems: approximately 20,000 pounds for 50-99 kW, about 40,000 pounds for 100-150kW, and about 70,000 pounds for others grid-connected with low voltage distribution network.

England: about 800 pounds for the grid-connection cost of PV systems less than 5kW.

Canada: about $ 52,000 for the grid-connection cost of PV systems of 520kW, which is equivalent to about 100 dollars/kW, about 350,000 yuan conversed at the existing exchange rate.

EU: commissioning a number of research institutions (take National Grid of the U.K. for example), the European Union studies grid-connection cost of distributed power access of different types and rates of penetration, including grid renovation and maintenance, as well as power limiting and implementation cost under active control.

The main factors influencing grid-connection cost include: permeability, mode of access, mode of grid-connection, the number and distribution of grid-connection points, as well as grid regulation policies. Considering comprehensively the factors above, estimate the grid-connection cost at the grid side:

(1) Grid-connection cost of distributed PV system

Table 4-1: Analysis on access cost of single grid-connection point under various design options of access systems

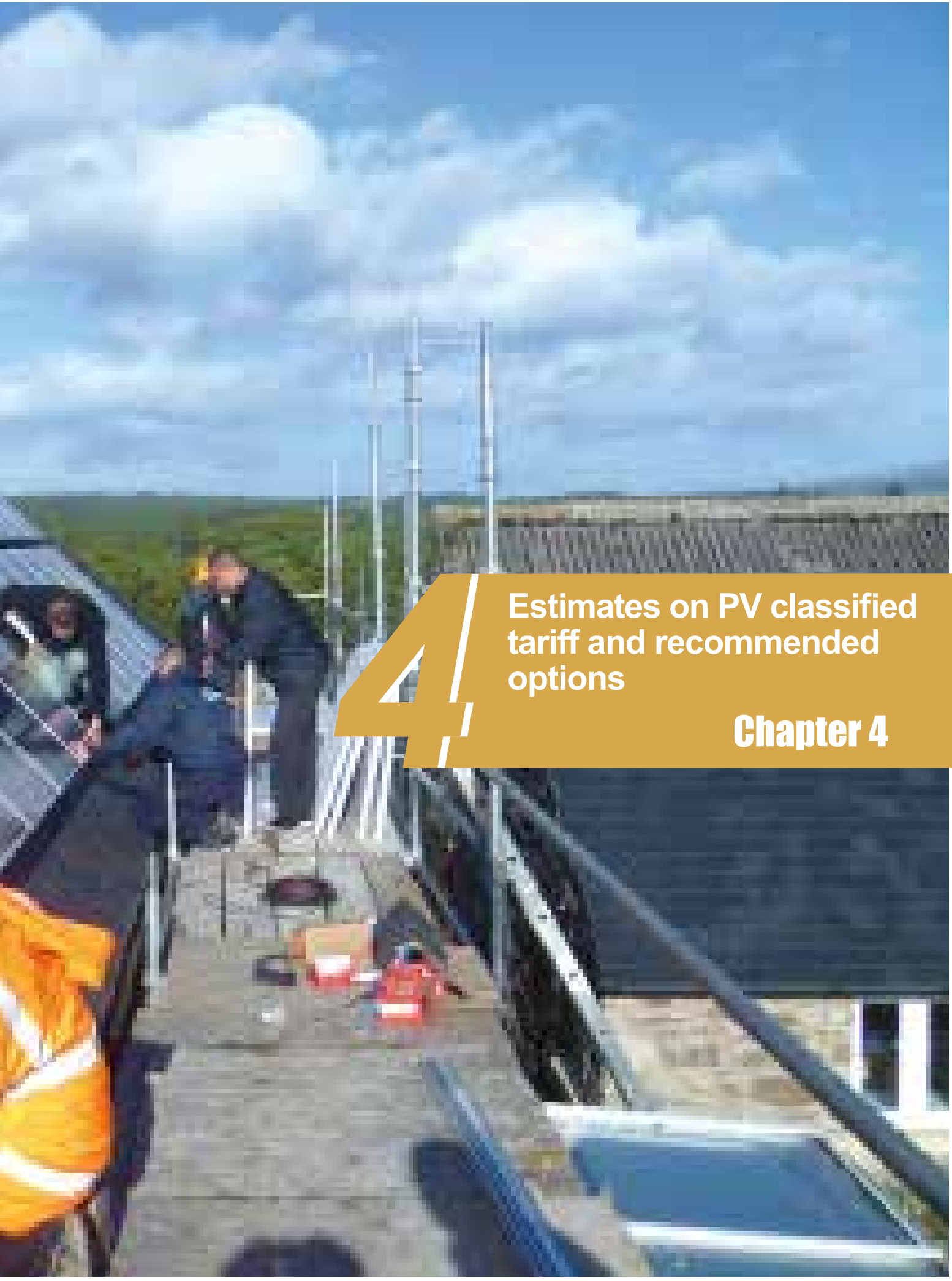
Grade of voltage	Mode of access	Mode of grid-connection	Grid side (10,000 yuan)
380V	line access or configure the electrical room box transformer low voltage bus	Grid-connection and access to the grid	9
	T-connection line connected with 380 V line	Grid-connection and access to the grid	8
	Connected to users' internal grids	Grid-connection and access to the grid	7
		Grid-connection and not access to the grid	12
10 kV	Leased line connected with 10 kV bus in the substation	Grid-connection and access to the grid	47
	T-connection line connected with 10 kV lines	Grid-connection and access to the grid	45
	Leased lines connected with users' 10 kV box-type transformers or electrical room	Grid-connection and access to the grid	35
		Grid-connection and not access to the grid	40
	T-connection line connected with users' 10 kV box-type transformer or electrical room	Grid-connection and access to the grid	35
		Grid-connection and not access to the grid	40

(2) Grid operation and renovation costs caused by the distributed PV system

Table 4-2: Grid renovation cost induced by grid-connected distributed PV system under T- connections and various penetration rates

Unit: yuan/kW

Scenario	Distributed pattern			Relatively concentrated pattern			Concentrated pattern		
Permeability	Passive mode	Positive mode		Passive mode	Positive mode		Passive mode	Positive mode	
		Renovation cost	Implementation cost		Renovation cost	Implementation cost		Renovation cost	Implementation cost
10%	0%	0%	0%	0%	0%	0%	0%	0%	0%
20%	0%	0%	0%	375%	0%	240%	720%	252%	120%
30%	200%	0%	161%	585%	84%	161%	719%	506%	80%
40%	365%	0%	240%	705%	239%	120%	840%	564%	60%



4 Estimates on PV classified tariff and recommended options

Chapter 4

Chapter 4

Estimates on PV classified tariff and recommended options

Through comprehensive analysis on the factors influencing PV tariff, such as initial investment of power plants, generating capacity of the system, operation and maintenance costs, and based on the manufacturing cost of PV modules in four quarters of 2012, the investment amount of 1MW distributed grid-connected PV systems is estimated to be about 10,000 yuan/kW, and the static total investment of 10 MW large PV power plants grid-connected to public grids is estimated to about 10,000 yuan/kW.

Based on historical data of 96 weather stations analyzed, in accordance with solar energy resource reserves, China is divided into four resource areas. As shown in Table 5-1.

Table 5-1: Areas identified by their solar energy resource in China

Areas	Total annual radiation quantity at horizontal plane		Annual hours of equivalent use	Estimated value	Quantity of corresponding stations
	MJ/m^2	kWh/m^2	Hour/year	Hour/year	Pcs
I	> 6000	> 1700	> 1600	1600	16
II	5400-6000	1500-1700	1400-1600	1400	17
III	4500-5400	1240-1500	1200-1400	1200	27
VI	< 4500	< 1250	< 1200	1000	36

4.1 DEstimates on tariff of large grid-connected PV power generation projects and recommendations

Based on the division of four types of resource zones, as well as the methods in Economic Evaluation Methods and Parameters Related to Construction Projects (Third Edition) published in 2006, financial boundary conditions of grid-connected PV power generation tariff estimates for 2013 are delimitated as follows:

Table 5-2: Boundary conditions of grid-connected PV tariff estimates

Boundary conditions of tariff estimates			
Unit static investment (10,000 yuan /kW)	0.8-1.4	Duration of depreciation	15years
Generating hours in a full year (hour)	800-1800	Rate of formation of fixed assets	90.0%
Duration of operation	20years	Value-added tax (VAT) rate	17.0%
Proportion of loans	80%	Income tax rate	25.0%
Duration of loaning	15years	Additional tax rate[1]	10.0%
Interest of loans	6.55%	After-tax baseline internal rate of returns	8.0%
Annual operating cost	2.0%	Duration of capital recovery	< 15years

Table 5-3: Tariff analysis for the four types of identified areas (provided the initial investment of the PV system being 10,000 yuan/kW)

Solar energy resource identified areas	Excellent	Good	Relatively good	Generally good
Hours of equivalent use in a full year (hour)	1600	1400	1200	1000
Reasonable tariff (yuan/kWh)	0.79	0.90	1.05	1.26
Recommended tariff (yuan/kWh)	0.80	0.90	1.00	1.20

Note: The results have taken into account preferential policies such as equipment VAT deduction.

Considering the amount of resources, development cost, output of the grid and other aspects, it is recommended to guide large-scale grid-connection power generation projects via tariff

[1] Additional tax rate includes urban construction fee (5%), education additional fee (3%) and local education additional fee (2%).

to develop the projects in western areas with comparatively abundant solar energy and land resources. Therefore, the tariff of large-scale PV power plant projects is proposed as in the table below. Meanwhile, the recommendations below are to be followed.

(A) In terms of PV power plants, preferential development remains to be encouraged in the western areas with better resources and land conditions as well as excellent output of the grid. It's recommended to adopt reasonable profit pricing during the operating period for the areas endowed with better resource conditions; while the areas with relatively poor resource conditions can focus on development and utilization of distributed PV power plants guided by the policy of rational tariff.

(2) It's recommended to track the prices of PV modules and PV systems on a monthly basis, conduct estimates on tariff levels in all regions in a periodic way, and make adjustments to tariff if necessary and appropriate.

(3) For large ground PV power plants as well as distributed PV systems to be grid-connected to public distribution networks for purposes of centralized-development, in light of policy orientation, efforts should be made to guide them to the areas enriched with land suitable for the development of PV power plants (desert land), better solar energy resources, as well as massive roof resources.

Table 5-4: Recommendations for regional tariff levels of large PV desert power plants nationwide

Identified areas	Total annual radiation quantity at horizontal plane		Annual hours of equivalent use	Estimated value	Recommended benchmark tariff
	MJ/m^2	kWh/m^2	Hour/year	Hour/year	(yuan/kWh)
I	> 6000	> 1700	> 1600	1600	16
II	5400-6000	1500-1700	1400-1600	1400	17
III	4500-5400	1240-1500	1200-1400	1200	27
VI	< 4500	< 1250	< 1200	1000	36

4.2 Estimates on subsidy tariff of distributed PV power generation systems for 2013 and recommendation

Distributed development is generally less effective than concentrated development. However, distributed power generation for own-consumption can serve as a good solution for grid accepted. Therefore, from the perspective of power generation for own-consumption, it is necessary to ensure that: a) the incomes should be higher than that of large-scale power plants as well as that of feed-in-tariff only for surplus electricity; and b) tariff per kWh should be 25% higher than that of large-scale PV power plants. In viewpoint of subsidy basis, own-consumption is based on users' tariff as the basis for subsidy calculation, while both large-scale power plants and surplus feed-in power are estimated on the basis of desulphurization coal benchmark tariff. Distributed development should be self-sustenance oriented in order to avoid a great deal of electricity from grid, thus, it is recommended that the revenues of surplus feed-in power should be significantly lower than that of local PV benchmark tariff.

According to users' tariff levels, incomes from self-sustained power is 25% higher than that of benchmark tariff, revenues from surplus feed-in PV power is 30% lower than that of benchmark tariff, and feed-in tariff subsidy per kWh is estimated in three levels:

Table 5-5: Reasonable allowance standards for various users

Province (autonomous region/ municipality)	Resource zone	Benchmark tariff	Regional tariff of distributed PV	General industrial and commercial industries	Allowance standard	Major industries	Allowance standard	Residence area and school	Allowance standard
				Overall tariff (peak & valley time and usual time)		Overall tariff (peak & valley and usual time)		Basic tariff	
		(yuan/kWh)	(yuan/kWh)	(yuan/kWh)	(yuan/kWh)	(yuan/kWh)	(yuan/kWh)	(yuan/kWh)	(yuan/kWh)
Beijing	III	1.0	1.25	0.93	0.32	0.78	0.47	0.49	0.76
Eastern Inner Mongolia	II	0.9	1.15	0.84	0.31	0.54	0.61	0.47	0.68
Shanghai	VI	1.1	1.35	1.05	0.30	0.84	0.51	0.62	0.73
Hubei	VI	1.1	1.35	1.12	0.23	0.78	0.57	0.57	0.78
Sichuan	I	0.8	1.00	0.99	0.01	0.75	0.25	0.52	0.48
	II	0.9	1.15	0.99	0.16	0.75	0.40	0.52	0.63
	VI	1.1	1.35	0.99	0.36	0.75	0.60	0.52	0.83
Qinghai	I	0.8	1.00	0.70	0.30	0.47	0.53	0.45	0.55
Average			1.20	0.95	0.25	0.71	0.49	0.52	0.68

Currently, the alternatives of subsidies available include subsidies with feed-in tariff per kWh and differential feed-in-tariff subsidies. In order to balance incomes from distributed PV power generation among varieties of users in different regions with various resources as far as possible, the following recommendations are provided for estimated results and feasibility involving the two forms of subsidies:

1) Subsidy for feed-in tariff per kWh

Subsidy for feed-in tariff per kWh refers to the amount of fixed subsidy in level 1 to 3 for PV power for individual use. In case of failure to achieve fair incomes under such subsidy, complex regulation measures are required for improper incomes induced by raised tariff. However, such approach is relatively simple for measurement; through the subsidy calculated with quantity of electricity, it's sufficient to record electricity consumption without tariff records.

For subsidy for feed-in tariff per kWh, the three methods below are recommended for consideration:

a) Setting an unified amount nationwide for the subsidy for feed-in tariff per kWh, say,

0.45 yuan/kWh. As evaluated, under such mode, revenues are higher for industrial and commercial users; while it's lower for users of major industries and close to the gains from PV benchmark tariff, which is not conducive to encouraging the promotion of distributed generation.

b) Setting two levels of fixed subsidies, and giving relatively balanced account to different resources and conditions; granting subsidies to users from industrial & commercial industries and major industries in two levels (0.25 yuan/kWh and 0.5 yuan/kWh). Under such mode, matched revenues are found among different electricity customers, but discrepancies remain in the revenues among users from the same category. For the same province with large differences in resources, revenues differ a lot for different resource zones, which renders difficult to define the levels across the country.

c) Setting an unified amount nationwide for the subsidy for feed-in tariff per kWh, say, 0.5 yuan/kWh, and giving a ceiling value. Under such mode, providing subsidies according to the tariff targeted at users from major industries, and setting a ceiling for general industrial and commercial users, in which way subsidy revenues and subsidy funds can be kept under control, however, automatic meters must be installed for industrial and commercial users. Additionally, since an upper limit (0.5 yuan/kWh) is given for the subsidy for feed-in tariff per kWh, excluding the users with low tariff, national subsidy funds can be saved; but it's not conducive to the access of PV power generation to the household.

Table 5-6: Comparison among three types of subsidy models

Province (autonomous region/ municipality)	Resource subzone	Benchmark tariff	Regional tariff of distributed PV	General industrial and commercial industries	After-subsidy revenues from general industrial and commercial industries	Major industries	After-subsidy revenues from major industries
				Overall tariff (peak& valley time, and usual time)		Overall tariff (peak& valley time, and usual time)	
		(yuan/kWh)	(yuan/kWh)	(yuan/kWh)	(yuan/kWh)	(yuan/kWh)	(yuan/kWh)
I			1.20	0.95	1.40	0.71	1.16
II			1.20	0.95	1.20	0.71	1.21
III			1.20	0.95	1.20	0.71	1.21

Subsidies for the surplus feed-in power estimates above are still provided as per 0.2 yuan/kWh, and the average tariff is around 0.63 yuan/kWh.

4.2.2 Differential tariff subsidies for distributed PV electricity for personal use

For subzone based tariff subsidies for distributed PV electricity for personal use, subzone internal control tariff related to distributed power generation is determined by increasing 25% subzone feed-in tariff. For PV electricity for personal use to be subsided with distributed subzone tariff (i.e. an increase of 25% for subzone feed-in tariff), the amount of subsidy fluctuates with users' tariff; once the users' tariff reaches the level of distributed subzone tariff, the subsidy will stop automatically. This approach takes into account both resource zoning and differentiated tariff among various users. As a result, fair income is achieved, and at the same time, it helps to avoid inappropriate incomes produced by a raise in users' tariff. However, there're also some drawbacks for this approach. Metering is relatively complex; and the amount of subsidy is associated with personal-use PV electricity consumption and users' real-time tariff; besides, automated meters must be installed for peak & valley time as well as usual time. Given this, the following classified tariff policies are recommended.

(1) Total electricity is used for the grid access, and purchased and sold in an unified manner

In fact, this mode is fully identical with that performed by large PV power plants. In metering electricity consumption of distributed PV power generation systems, grid connection points of PV systems are placed at the grid side of users' meters. This means that total PV electricity is fed into public distribution networks and sold to the grid in line with feed-in tariff. The model has lots of merits. a) it's simple, easy to operate, and can ease barriers during grid connection; b) uniform tariff standard enables grid connection management; c) it's favorable to keep distributed PV included in power generation planning and management, and distributed PV power generation is goal-oriented; d) it's free from the problems whether PV power generation is matched with daily load distribution curve and the problem that load changes affect revenues, which ensures the interests of PV project developers to the maximum; e) operation is simple and practical; it's not affected by building types, with great flexibility and high efficiency; and electricity

transactions with grid companies can be secured; the entry is easy for powerful electric companies; and the market can be shortly launched.

Nevertheless, the model also has its defects. If not accompanied with specific binding planning measures, the scale of investment subsided by the state will be uncertain; additionally, it leaves unattainable the purpose of encouraging power generation for its own-consumption.

(2) Own-consumption□feed-in-tariff only for surplus electricity.

Based on the distribution of solar energy resources, demands for distributed PV power generation tariff and all kinds of power sales prices in all regions are largely positive. Therefore, it can be considered to adopt fixed tariff subsidies on the basis of power sales price, or calculate the subsidy amount of PV tariff as per 125% differential benchmark tariff, so as to support the development of distributed PV power generation.

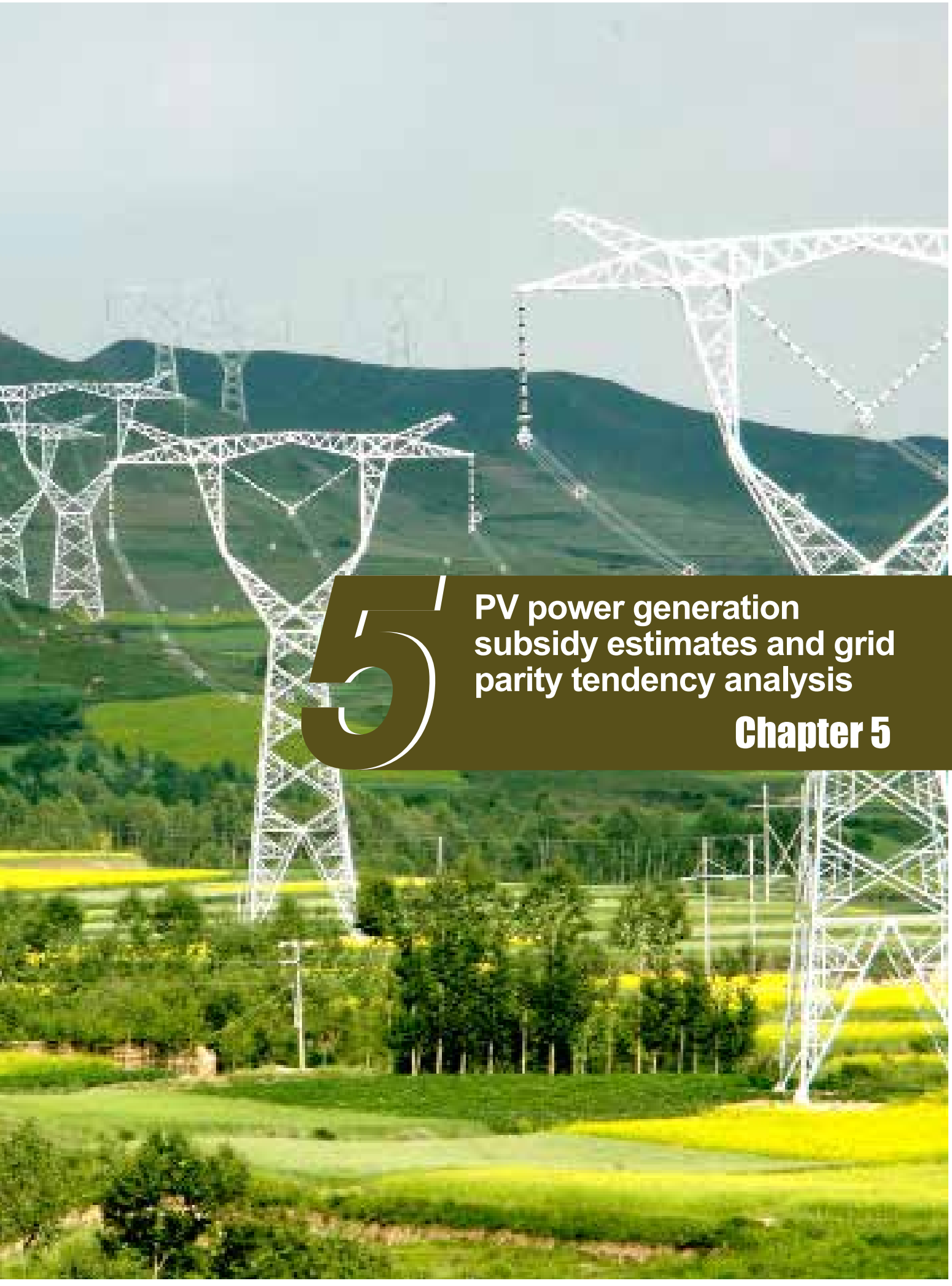
For subzone based tariff subsidies for distributed PV electricity for personal use, subzone internal control tariff related to distributed power generation is determined by increasing 25% subzone feed-in tariff. That is, for PV electricity for personal use to be subsided with distributed subzone tariff, the amount of subsidy fluctuates with users' tariff; once the users' tariff reaches the level of distributed subzone tariff, the subsidy will stop automatically. This approach takes into account both resource zoning and differentiated

tariff among various users. As a result, fair income is achieved, and at the same time, it helps to avoid inappropriate incomes produced by a raise in users' tariff. However, users must equip at least two smart meters which are capable of recording automatically both the quantity of electricity and tariff. Under this mode, no technical obstacles can be incurred. Thus, the report recommends using the policy of subzone based tariff related to distributed PV electricity for personal use. Refer to the following table for details.

Table 5-7: Recommendations for distributed PV classified tariff

Identified areas	PV feed-in differential benchmark tariff	Recommended tariff for distributed PV electricity for personal use	Subsidy for the quantity of surplus feed-in PV electricity
	(yuan/kWh)	(yuan/kWh)	(yuan/kWh)
I	0.8	1.00	0.20
II	0.9	1.15	0.20
III	1.0	1.25	0.20
VI	1.1	1.35	0.20
Average	0.95	1.19	0.20

Note: For the quantity of surplus feed-in PV electricity, granting subsidy of 0.2 yuan/kWh based on local desulfurization and coal benchmark feed-in tariff (0.42 yuan/kWh for national average).



5 PV power generation subsidy estimates and grid parity tendency analysis

Chapter 5

Chapter 5

PV power generation subsidy estimates and grid parity tendency analysis

5.1 Analysis on tariff trends

This report takes the scenario where benchmark feed-in tariff related to coal power conservatively rises, and considers at an average yearly increment of 2%between 2012 and 2020 (typically flat with the growth rate during 2005-2012). After 2020, overall consideration is given to denitrification cost and other factors represented by environmental tax and carbon tax price, with growth rate of tariff up to 3.5%.

In terms of power sales price, the state made adjustment for four times after 2005. Currently, absolute average value of power sales price rises nearly 0.1 yuan/kWh in provinces, autonomous regions and municipalities across the country, about 10-15 % and 15-20% tariff of general industrial & commercial industries and major industries respectively. At present, sales price of general industrial & commercial industries is 0.571-1.0584 yuan/kWh, and tariff of power consumption of major industries is 0.453-0.7097 yuan/kWh. Besides, changes to both coal power feed-in tariff and prices of power transmission and distribution will directly affect the sales price. Therefore, the study mainly deals with comparison among PV power generation and demands for feed-in tariff and sales price; a scenario with a conservative rise of power sales price can be adopted, considering at an average yearly increment of 2% during 2012-2020 and 3.5% after 2020.

5.2 Analysis on trends of PV power generation cost

Initial investment level related to PV power generation has dropped quite fast in recent years, but the price does not fully reflect the cost level. It's expected that there leaves very little space for declined prices of PV cells and modules as well as auxiliary equipment in the coming 3-5 years which may even witness fluctuation and bounce. Given this, the article assumes Scenario 1: under conditions of existing technological processes, PV power generation tariff is basically decreased by 3% per year. From technical point of view, as technological advances will lead to reduced cost, according to the PV Technology Roadmap completed in March 2012 with the support of SEMI, an increase rate of 2-3% will be found in PV cell efficiency by 2020. Therefore, Scenario 2 is assumed in the article: a decline rate of 5% annually for PV power generation cost.

5.2 Estimates on PV power generation subsidies

PV cumulative installed capacity is expected to reach 100GW throughout the country by 2020; cumulative installed capacity is about 8GW by 2013 and 92GW between 2013 and 2020. Among the rest, large PV power plants account for 50%, with a capacity of 46GW and distributed PV systems take 50%, with a capacity of 46GW. Meanwhile, assume PV-related annual installed capacity as follows:

Table 6-1: Assumed annual installed capacity for PV products by type (2013–2020)

Year	2013	2014	2015	2016	2017	2018	2019	2020
Large PV power plants (GW)	2.5	3	4	5	6	7	8.5	10
Users of industrial & commercial industries and others (GW)	1	1.5	2	2.5	3	3.5	4	5
Users of major industries (GW)	0.5	0.5	1	1	1	1	1.5	1.5
Users with low tariff (GW)	1	1	1	1.5	2	2.5	3	3.5
Annual PV-related installed capacity (GW/year)	5	6	8	10	12	14	17	20
Newly-increased PV-related cumulative installed capacity (GW)	5	11	19	29	41	55	72	92

5.3.1 Scenario 1

1) Tariff trends and subsidy estimates for large power plants

Table 6-2: PV feed-in tariff estimates under the mode of unified purchase and sales

Conditions: tariff of desulfurized and coal-fired units is 0.42 yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. National standard fixed feed-in tariff is 0.8-1.1 yuan/kWh, decreasing by 3% annually. Assumed that cumulative installed capacity of large-scale PV power plants is 46GW during 2013-2020, with 1, 300 generating hours in a full year on average and 100% PV feed-in power consumption.

Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Annual subsidy demand (100 million yuan)	17.2	36.5	60.2	87.6	117.7	149.8	185.0	222.0	222.0	222.0
Cumulative subsidies (100 million yuan)	17.2	53.7	113.9	201.5	319.2	469.0	654.0	876.0	1098.0	1320.0
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Annual subsidy demand (100 million yuan)	222.0	222.0	222.0	222.0	222.0	222.0	222.0	222.0	222.0	222.0
Cumulative subsidies (100 million yuan)	1542.1	1764.1	1986.1	2208.1	2430.2	2652.2	2874.2	3096.2	3318.3	3540.3

According to the results estimated, recommended adjustment to PV feed-in tariff is shown in Table 6-3:

Table 6-3: Decreased benchmark PV tariff year by year for identified areas

Calendar year		2013	2015	2017	2020	2022	2024	2026	2028	2030
PV feed-in tariff (yuan/kWh)	VI	1.10	1.00	0.95	0.90	0.85	0.80	0.75	0.70	0.65
	III	1.00	0.95	0.90	0.80	0.75	0.70	0.65	0.60	0.55
	II	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.50
	I	0.80	0.75	0.70	0.65	0.60	0.57	0.55	0.50	0.45

2) Tariff trends and subsidy estimates related to distributed power generation

Table 6-4: Power generated by industrial and commercial industries for their own-consumption (floating internal control tariff: 1.2 yuan/kWh)

Conditions: the average tariff of industrial and commercial industries is 0.95yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. The upper limit of national internal control tariff related to distributed PV power generation is 1.2yuan/kWh, progressively decreasing by 3% each year. Assumed 1, 100 annual generating hours on average for distributed PV electricity for personal use in industrial& commercial buildings, with annual personal-use electricity consumption accounting for 90%.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual subsidy demand (100 million yuan)	2.48	5.37	8.16	10.31	11.32	11.32	11.32	11.32	11.32	11.32
Cumulative subsidies (100 million yuan)	2.48	7.85	16.00	26.31	37.64	48.96	60.28	71.60	82.93	94.25
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Annual subsidy demand (100 million yuan)	11.32	11.32	11.32	11.32	11.32	11.32	11.32	11.32	11.32	11.32
Cumulative subsidies (100 million yuan)	105.6	116.9	128.2	139.5	150.9	162.2	173.5	184.8	196.1	207.5

Table 6-5: Power generated by major industries for their own-consumption (floating internal control tariff: 1.2 yuan/kWh)

Conditions: the average tariff of major industries is 0.71yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. The upper limit of national internal control tariff related to distributed PV power generation is 1.2yuan/kWh, progressively decreasing by 3%. Assumed 1, 300 average generating hours per year for distributed PV electricity for personal use in buildings of major industries, with annual personal-use electricity consumption accounting for 90%.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual subsidy demand (100 million yuan)	2.87	5.44	10.01	14.01	17.44	20.33	23.84	26.54	26.54	26.54
Cumulative subsidies (100 million yuan)	2.87	8.31	18.31	32.32	49.76	70.09	93.93	120.47	147.01	173.55
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Annual subsidy demand (100 million yuan)	26.54	26.54	26.54	26.54	26.54	26.54	26.54	26.54	26.54	26.54
Cumulative subsidies (100 million yuan)	200.1	226.6	253.2	279.7	306.3	332.8	359.3	385.9	412.4	439.0

Table 6-6: Power generated by low-tariff users for their own-consumption (floating internal control tariff: 1.2 yuan/kWh)

Conditions: the average tariff of low-tariff users is 0.52 yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. The national subsidy for feed-in tariff per kWh is 1.2yuan/kWh, progressively decreasingby 3%. Assumed 1,100 annual generating hours on average for distributed PV electricity for personal use in low-tariff buildings, with annual personal-use electricity consumption accounting for 90%.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual subsidy demand (100 million yuan)	6.73	13.00	18.83	26.90	36.79	48.08	60.38	73.27	73.27	73.27
Cumulative subsidies (100 million yuan)	6.73	19.74	38.56	65.46	102.24	150.32	210.70	283.97	357.25	430.52
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Annual subsidy demand (100 million yuan)	73.27	73.27	73.27	73.27	73.27	73.27	73.27	73.27	73.27	73.27
Cumulative subsidies (100 million yuan)	503.8	577.1	650.3	723.6	796.9	870.2	943.4	1016.7	1090.0	1163.3

Table 6-7: Electricity from grid (10%) and subsidy for fixed tariff (0.2yuan/ kWh)

Conditions: tariff of desulfurized and coal-fired units is 0.42 yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. The national subsidy for feed-in tariff per kWh is 0.20 yuan/kWh, effective for a duration of 20 years. Electricity from grid accounts for 10% of total generating capacity.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual subsidy demand (100 million yuan)	0.60	1.32	2.28	3.48	4.92	6.60	8.64	11.04	11.04	11.04
Cumulative subsidies (100 million yuan)	0.60	1.92	4.20	7.68	12.60	19.20	27.84	38.88	49.92	60.96
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Annual subsidy demand (100 million yuan)	11.04	11.04	11.04	11.04	11.04	11.04	11.04	11.04	11.04	11.04
Cumulative subsidies (100 million yuan)	72.00	83.04	94.08	105.12	116.16	127.20	138.24	149.28	160.32	171.36

Total subsidy demand for 46GWdistributed installed capacity for 20years: 198.11 billion yuan.

3) Summary for 20-year (2013-2032) subsidies

Table 6-8: Summary of subsidies

Conditions: the average tariff of major industries is 0.71yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. The upper limit of national internal control tariff related to distributed PV power generation is 1.2yuan/kWh, progressively decreasing by 3%. Assumed 1, 300 average generating hours per year for distributed PV electricity for personal use in buildings of major industries, with annual personal-use electricity consumption accounting for 90%.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual subsidy demand (100 million yuan)	29.90	61.59	99.48	142.29	188.21	236.11	289.13	344.20	344.20	344.20
Cumulative subsidies (100 million yuan)	29.90	91.49	190.97	333.27	521.48	757.59	1046.72	1390.92	1735.12	2079.32
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Annual subsidy demand (100 million yuan)	344.20	344.20	344.20	344.20	344.20	344.20	344.20	344.20	344.20	344.20
Cumulative subsidies (100 million yuan)	2423.52	2767.73	3111.93	3456.13	3800.33	4144.53	4488.73	4832.93	5177.13	5521.33

In summary, total installed capacity reaches 100 GW by 2020 across the country; after 2013, installed capacity of newly-increased large-scale PV power plants is 46GW and the same for distributed PV. Total subsidy demand at a duration of 20 years: 552.13 billion yuan, among which, 354.03 billion yuan is granted to large-scale PV power plants and 198.11 billion yuan to distributed PV. For the same installed capacity, 155.92 billion yuan is saved by subsidies related to distributed PV compared with subsidies via unified purchase and sales.

As of 2020, cumulative subsidies related to distributed PV is expected to be 51.49 billion yuan, and 87.60 billion yuan for large-scale PV; 36.11 billion yuan is saved by subsidies related to distributed PV compared with subsidies via unified purchase and sales.

4) Analysis on grid parity roadmap

The table below shows benchmark PV feed-in tariff and tariff for personal-use distributed PV electricity for subzones across the country in 2013.

Table 6-9 Baseline PV feed-in tariff and tariff for personal-use distributed PV electricity in subzones across the country in 2013.

Resource subzone	Baseline PV feed-in tariff for subzones	Tariff for distributed PV electricity for personal use in subzones	Subsidy for surplus feed-in PV electricity
	(yuan/kWh)	(yuan/kWh)	(yuan/kWh)
I	0.8	1.00	0.20
II	0.9	1.15	0.20
III	1.0	1.25	0.20
VI	1.1	1.35	0.20
Average	0.95	1.19	0.20

Estimate points are made as follows:

- The baseline internal control tariff related to distributed PV is 1.2 yuan/kWh on average;
- During 2013-2032, baseline PV feed-in tariff and tariff for personal-use distributed electricity are decreased by 3% per year; subsidy standard for electricity from grid remains unchanged during the period;
- In 2013, national desulfurization and coal firing baseline tariff is 0.42 yuan/kWh on average, with an average yearly increment of 2% prior to 2020 and 3.5% after 2020; and
- In 2013, the average tariff for industrial & commercial industries, major industries and low-tariff users is 0.95, 0.71 and 0.52 yuan/ kWh respectively, with an average yearly increment of 2% prior to 2020 and 3.5% after 2020.

Based on the conditions above, though tariff for personal-use distributed PV electricity is 25% higher than baseline tariff of large power plants, grid parity tariff can be realized at the power demand sides of industrial &commercial industries and major industries in 2020 and 2025 respectively. However, it's not until 2030 can grid parity tariff can be attainable for both low-tariff user side and coal-fired tariff generation side:

Table 6-10: Schedule of PV tariff grid parity

Baseline where PV internal control tariff reaches grid parity	Year for attainable grid parity			
	Subzone I	Subzone II	Subzone III	Subzone VI
Industrial & commercial industries	2014	2017	2019	2020
Major industries	2020	2022	2024	2025
Low-tariff users	2025	2027	2028	2030
Desulfurization and coal firing tariff	2025	2027	2028	2030

5.3.2 Scenario 2

Conditions: PV tariff declines by 5% annually; yearly increment for coal firing and electricity consumption tariff is 2% prior to 2020 and 3.5% after 2020.

1) Tariff trends and subsidy estimates for large power plants

Table 6-11: PV feed-in tariff estimates under the mode of unified purchase and sales

Conditions: tariff of desulfurized and coal-fired units is 0.42 yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. The national feed-in tariff is 0.8-1.1 yuan/kWh in 2013, decreasing by 5% annually. Assumed that cumulative installed capacity of large-scale PV power plants is 46GW during 2013-2020, with 1, 300 generating hours in a full year on average and 100% PV feed-in electricity consumption. Estimates are only conducted for PV installed capacity after 2013.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Tariff for desulfurization and coal firing (yuan/kWh)	0.42	0.43	0.44	0.45	0.45	0.46	0.47	0.48	0.50	0.52
Annual subsidy demand (100 million yuan)	17.2	35.7	57.6	81.5	106.4	131.1	156.0	179.6	179.6	179.6
Cumulative subsidies (100 million yuan)	17.2	52.9	110.5	192.1	298.5	429.6	585.7	765.2	944.8	1124.4
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Annual subsidy demand (100 million yuan)	179.6	179.6	179.6	179.6	179.6	179.6	179.6	179.6	179.6	179.6
Cumulative subsidies (100 million yuan)	1303.9	1483.5	1663.1	1842.6	2022.2	2201.8	2381.3	2560.9	2740.5	2920.0

Table 6-12: Decreased benchmark PV tariff year by year for subzones

Calendar year		2013	2015	2017	2020	2022	2024	2026	2028	2030
PV feed-in tariff (yuan/kWh)	VI	1.10	1.00	0.90	0.80	0.70	0.65	0.55	0.50	0.45
	III	1.00	0.90	0.80	0.70	0.60	0.55	0.50	0.45	0.40
	II	0.90	0.80	0.75	0.65	0.55	0.50	0.45	0.40	0.35
	I	0.80	0.70	0.65	0.55	0.50	0.45	0.40	0.35	0.30

2) Tariff trends and subsidy estimates related to distributed power generation

For subzone tariff of distributed PV electricity for personal use, subsidy estimates are carried out for industrial & commercial industries, major industries and low-tariff users respectively in accordance with the following data for 2013: average tariff of 1.2 yuan/kWh, personal-use electricity: 90% and electricity from grid: 10%.

Table 6-13: Power generated by industrial and commercial industries for their own-consumption (floating internal control tariff: 1.2 yuan/kWh)

Conditions: the average tariff of industrial and commercial industries is 0.95 yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. And the average tariff of distributed PV electricity for personal use is 1.2 yuan/kWh, progressively decreasing by 5% each year. Assumed 1, 100 annual generating hours on average for distributed PV electricity for personal use in industrial& commercial buildings, with annual personal-use electricity consumption accounting for 90%.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual subsidy demand (100 million yuan)	2.48	5.01	6.89	7.40	7.40	7.40	7.40	7.40	7.40	7.40
Cumulative subsidies (100 million yuan)	2.48	7.49	14.38	21.78	29.18	36.58	43.98	51.38	58.78	66.18
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Annual subsidy demand (100 million yuan)	7.40	7.40	7.40	7.40	7.40	7.40	7.40	7.40	7.40	7.40
Cumulative subsidies (100 million yuan)	73.6	81.0	88.4	95.8	103.2	110.6	118.0	125.4	132.8	140.2

Table 6-14: Power generated by major industries for their own-consumption (floating internal control tariff: 1.2 yuan/kWh)

Conditions: the average tariff of major industries is 0.71 yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. And the average tariff of distributed PV electricity for personal use is 1.2 yuan/kWh, progressively decreasing by 5% each year. Assumed 1, 300 annual generating hours on average for distributed PV electricity for personal use in buildings of major industries, with annual personal-use electricity consumption accounting for 90%.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual subsidy demand (100 million yuan)	2.87	5.30	9.33	12.55	14.99	16.69	18.13	18.53	18.53	18.53
Cumulative subsidies (100 million yuan)	2.87	8.17	17.49	30.04	45.04	61.72	79.86	98.38	116.91	135.44
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Annual subsidy demand (100 million yuan)	18.53	18.53	18.53	18.53	18.53	18.53	18.53	18.53	18.53	18.53
Cumulative subsidies (100 million yuan)	154.0	172.5	191.0	209.6	228.1	246.6	265.1	283.7	302.2	320.7

Table 6-15: Power generated by low-tariff users for their own-consumption (floating internal control tariff: 1.2 yuan/kWh)

Conditions: the average tariff of low-tariff users is 0.52 yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. The average tariff of national distributed personal-use electricity is 1.2 yuan/kWh, progressively decreasing by 5% each year. Assumed 1,100 annual generating hours on average for distributed PV electricity for personal use in low-tariff buildings, with annual personal-use electricity consumption accounting for 90%.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual subsidy demand (100 million yuan)	6.73	12.77	18.13	25.22	33.42	42.20	51.00	59.34	59.34	59.34
Cumulative subsidies (100 million yuan)	6.73	19.50	37.63	62.85	96.27	138.47	189.47	248.81	308.16	367.50
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Tariff for the user-side grid (low tariff)	0.66	0.69	0.71	0.73	0.76	0.79	0.81	0.84	0.87	0.90
Annual subsidy demand (100 million yuan)	59.34	59.34	59.34	59.34	59.34	59.34	59.34	59.34	59.34	59.34
Cumulative subsidies (100 million yuan)	426.8	486.2	545.5	604.9	664.2	723.6	782.9	842.2	901.6	960.9

Table 6-16: Electricity from grid (10%) and subsidy for fixed tariff (0.2 yuan/ kWh)

Conditions: tariff of desulfurized and coal-fired units is 0.42 yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. The national subsidy for feed-in tariff per kWh is 0.20 yuan/kWh, effective for a duration of 20 years. Electricity from grid accounts for 10% of total generating capacity.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual subsidy demand (100 million yuan)	0.60	1.32	2.28	3.48	4.92	6.60	8.64	11.04	11.04	11.04
Cumulative subsidies (100 million yuan)	0.60	1.92	4.20	7.68	12.60	19.20	27.84	38.88	49.92	60.96
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Annual subsidy demand (100 million yuan)	11.04	11.04	11.04	11.04	11.04	11.04	11.04	11.04	11.04	11.04
Cumulative subsidies (100 million yuan)	72.00	83.04	94.08	105.12	116.16	127.20	138.24	149.28	160.32	171.36

Total subsidy demand for 46GW distributed installed capacity for 20years: 159.32 billion yuan.

3) Summary for 20-year (2013-2032) subsidies

Table 6-17: Summary of subsidies

Conditions: tariff of desulfurized and coal-fired units is 0.42 yuan/kWh in 2013, with a yearly increment of 2% prior to 2020 and 3.5% during 2021-2032. The national subsidy for feed-in tariff per kWh is 0.20 yuan/kWh, effective for a duration of 20 years. Electricity from grid accounts for 10% of total generating capacity.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual installed capacity of distributed PV (GW)	2.50	3.00	4.00	5.00	6.00	7.00	8.50	10.00		
Annual installed capacity of large PV power plants (GW)	2.50	3.00	4.00	5.00	6.00	7.00	8.50	10.00		
Total annual installed capacity (GW)	5.00	6.00	8.00	10.00	12.00	14.00	17.00	20.00	0.00	0.00
Tariff subsidy for industrial and commercial industries (100 million yuan)	2.48	5.01	6.89	7.40	7.40	7.40	7.40	7.40	7.40	7.40
Tariff subsidy for major industries (100 million yuan)	2.87	5.30	9.33	12.55	14.99	16.69	18.13	18.53	18.53	18.53
Tariff subsidy for low-tariff users (100 million yuan)	6.73	12.77	18.13	25.22	33.42	42.20	51.00	59.34	59.34	59.34
Cumulative subsidies for distributed PV systems (100 million yuan)	12.67	37.07	73.70	122.35	183.09	255.97	341.15	437.46	533.77	630.08
Cumulative subsidies for large PV power plants (100 million yuan)	17.23	52.94	110.52	192.06	298.51	429.64	585.68	765.25	944.81	1124.38
Total cumulative subsidies (100 million yuan)	29.90	90.01	184.22	314.41	481.59	685.61	926.83	1202.70	1478.58	1754.46

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Cumulative subsidies for distributed PV systems (100 million yuan)	726.39	822.70	919.01	1015.32	1111.63	1207.94	1304.25	1400.56	1496.87	1593.18
Cumulative subsidies for large PV power plants (100 million yuan)	1303.94	1483.51	1663.07	1842.64	2022.21	2201.77	2381.34	2560.90	2740.47	2920.03
Total cumulative subsidies (100 million yuan)	2030.33	2306.21	2582.08	2857.96	3133.83	3409.71	3685.59	3961.46	4237.34	4513.21

In summary, total installed capacity reaches 100 GW by 2020 across the country; after 2013, installed capacity of newly-increased large-scale PV power plants is 46GW and the same capacity for distributed PV. Total subsidy demand at a duration of 20 years: 451.321 billion yuan, among which, 292 billion yuan is granted to large-scale PV power plants and 159.32 billion yuan to distributed PV. For the same installed capacity, 132.69 billion yuan is saved by subsidies related to distributed PV compared with subsidies via unified purchase and sales.

As of 2020, cumulative subsidies related to distributed PV is expected to be 43.746 billion yuan, and 76.525 billion yuan for large-scale PV; 32.779 billion yuan is saved by subsidies related to distributed PV compared with subsidies via unified purchase and sales.

4) Analysis on grid parity roadmap

The table below shows baseline PV feed-in tariff and tariff for personal- use distributed PV electricity in subzones across the country for 2013.

Table 6-18 Baseline PV feed-in tariff and tariff for personal- use distributed PV electricity in subzones across the country for 2013.

Resource subzone	Baseline PV feed-in tariff for subzones	Tariff for personal- use distributed PV electricity in subzones	Subsidy for surplus feed-in PV electricity
	(yuan/kWh)	(yuan/kWh)	(yuan/kWh)
I	0.8	1.00	0.20
II	0.9	1.15	0.20
III	1.0	1.25	0.20
VI	1.1	1.35	0.20
Average	0.95	1.19	0.20

Estimate points are made as follow:

- The baseline internal control tariff related to distributed PV is 1.2 yuan/kWh on average;
- During 2013-2032, baseline PV feed-in tariff and tariff for personal-use distributed electricity are decreased

by 5% per year; subsidy standard for electricity from grid remains unchanged during the period;

- In 2013, national baseline tariff for desulfurization and coal firing is 0.42 yuan/kWh on average, with an average yearly increment of 2% prior to 2020 and 3.5% after 2020; and
- In 2013, the average tariff for industrial & commercial industries, major industries and low-tariff users is 0.95, 0.71 and 0.52 yuan/ kWh respectively, with an average yearly increment of 2% prior to 2020 and 3.5% after 2020.

Based on the afore-mentioned conditions, the analysis below is obtained regarding PV grid parity roadmap:

Large-scale PV power generation projects in resource subzones I~IV will realize grid parity at the generation side in 2022, 2024, 2025 and 2026 respectively, and are flat with feed-in tariff of desulfurized and coal-fired units.

Distributed PV power generation projects in resource subzones I~IV will be flat with tariff of commercial and industrial industries in 2014, 2016, 2017 and 2018 respectively, with grid parity achieved.

Distributed PV power generation projects in resource subzones I~IV will be flat with tariff of major industries in 2018, 2020, 2021 and 2022 respectively, with grid parity achieved.

Distributed PV power generation projects in resource subzones I~IV will be flat with tariff of low-tariff users in 2022, 2024, 2025 and 2026 respectively, with grid parity achieved.

- **Scenario 2 Summary for grid parity roadmap**

Through comprehensive analysis, tariff for personal-use distributed PV electricity is 25% higher than baseline tariff of large power plants, however, grid parity can be realized at the power demand sides of industrial &commercial industries and major industries in 2018 and 2022 respectively. However, it's not until 2026 can grid parity can be attainable for low-tariff user side and coal-fired tariff generation side.

Table 6-19: Schedule of PV tariff grid parity

Baseline where PV internal control tariff reaches grid parity	Year for attainable grid parity			
	Subzone I	Subzone II	Subzone III	Subzone VI
Industrial & commercial industries	2014	2016	2017	2018
Major industries	2018	2020	2021	2022
Low-tariff users	2022	2024	2025	2026
Tariff for desulfurization and coal firing tariff	2022	2024	2025	2026

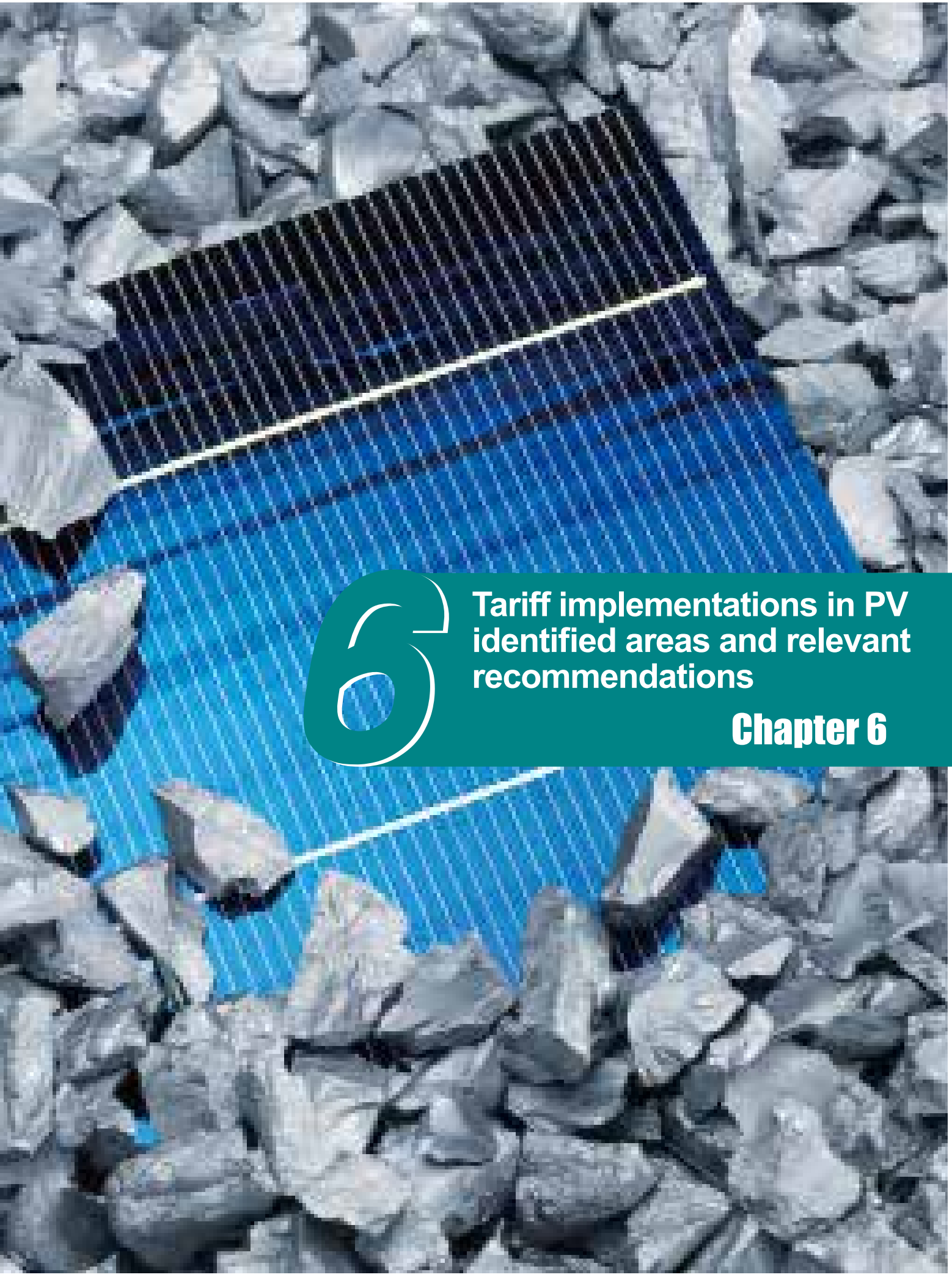
5) Subsidy demand and grid parity roadmap

Table 6-20: Summary of subsidy demands

Scenario 1Subsidy demand	2013-2020
Installed capacity of distributed PV systems (GW)	46
Installed capacity of large PV power plants (GW)	46
Total installed capacity (GW)	92
Cumulative subsidies of distributed PV systems by 2020 (100 million yuan)	514.9
Cumulative subsidies of large PV power plants by 2020 (100 million yuan)	876
Total subsidies by 2020 (100 million yuan)	1390.9
Cumulative subsidies of distributed PV systems for 20 years (100 million yuan)	1981.1
Cumulative subsidies of large PV power plants for 20 years (100 million yuan)	3540.3
Total cumulative subsidies for 20 years (100 million yuan)	5521.3
Scenario 2 Subsidy demand	**2013-2020**
Installed capacity of distributed PV systems (GW)	46
Installed capacity of large PV power plants (GW)	46
Total installed capacity (GW)	92
Cumulative subsidies of distributed PV systems by 2020 (100 million yuan)	437.46
Cumulative subsidies of large PV power plants by 2020 (100 million yuan)	765.25
Total subsidies by 2020 (100 million yuan)	1202.71
Cumulative subsidies of distributed PV systems for 20 years (100 million yuan)	1593.2
Cumulative subsidies of large PV power plants for 20 years (100 million yuan)	2920
Total cumulative subsidies for 20 years (100 million yuan)	4513.2

Table 6-21: Summary of grid parity roadmap

Scenario 1: PV tariff declining by 3% annually	Year for attainable grid parity			
Various users in subzones	Subzone I	Subzone II	Subzone III	Subzone VI
Industrial and commercial industries	2014	2017	2019	2020
Major industries	2020	2022	2024	2025
Low-tariff users	2025	2027	2028	2030
Tariff for desulfurization and coal firing	2025	2027	2028	2030
Scenario2: PV tariff declining by 5% annually	**Year for attainable grid parity**			
Various users in subzones	Subzone I	Subzone II	Subzone III	Subzone VI
Industrial and commercial industries	2014	2016	2017	2018
Major industries	2018	2020	2021	2022
Low-tariff users	2022	2024	2025	2026
Tariff for desulfurization and coal firing	2022	2024	2025	2026



6 Tariff implementations in PV identified areas and relevant recommendations

Chapter 6

Chapter 6

Tariff implementations in PV identified areas and relevant recommendations

In principle, developers are free to choose the form of development; set regional tariff according to solar energy resources and carry out resource identified areas PV tariff and grid settlement respectively on public power plants and self-generation power plants across the country. Regardless of mode of development, tariff is implemented through the grid company; power purchase and sales are settled separately, with no overlap.

6.1 Method of PV differential tariff settlement

6.1.1 Under the mode of public power plants

1) Ground-mounted large-scale PV power plants connected to HV and MV power transmission networks

- In accordance with property boundaries of large-scale PV power plants, booster stations in the plants are invested and constructed by developers;
- Total quantity of PV AC power is fed into HV and MV power transmission networks;
- Grid companies pay to developers basic electricity charge= local desulfurization price × quantity of PV AC power;
- The nation pays feed-in tariff subsidies = (PV differential benchmark tariff - local desulfurization price) × quantity of PV AC power; and
- Period of subsidy settlement: 6 months.

2) PV systems connected to 10kV public power distribution networks

- According to the document by the Office of the State Grid Corporation of China (SGCC) (No.: 1560 (2012)), distributed PV power generation projects connected to public grids, access system projects, as well as connection-induced public grid renovation are invested and constructed by power grid enterprises. Distributed PV power generation projects connected to the users' side, and access system projects are invested and constructed by project owners; connection-induced public grid renovation is done by power grid

enterprises (access projects in the western region is still subject to national current investment policies) ; and booster stations are invested and constructed by power grid enterprises;

- Total quantity of PV AC power is fed into10kV power transmission networks;
- Grid companies pay to developers basic electricity charge = local desulfurization price × quantity of PV AC power;
- The nation pays feed-in tariff subsidies = (PV differential benchmark tariff - local desulfurization price) × quantity of PV AC power;
- Users normally purchase power from the grid at different prices depending on users' nature;
- Developers' revenues = PV basic charge+ PV tariff subsidies; and
- Period of subsidy settlement: 6 months.

3) PV systems connected to 400V public distribution networks

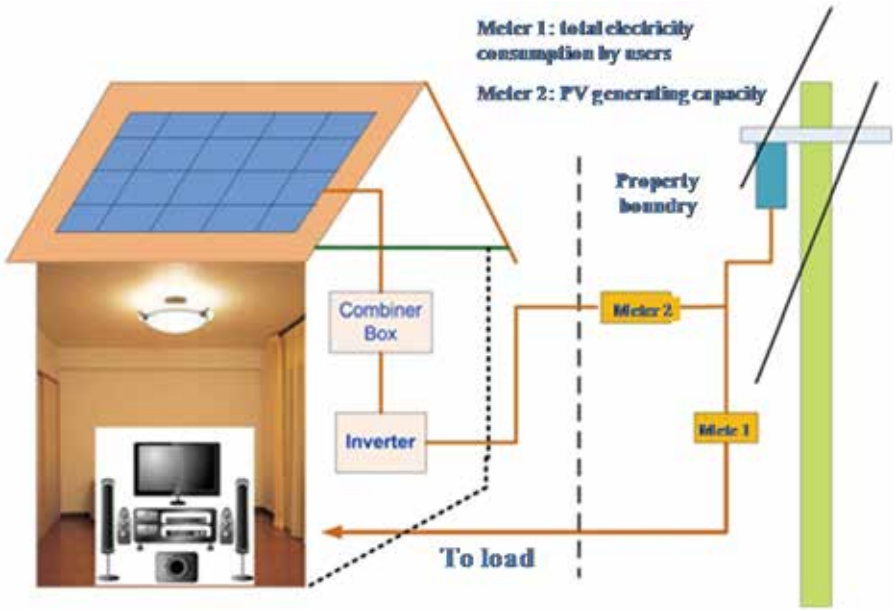


Figure7-1: PV systems connected to 400V public distribution networks

- Access systems and metering units are invested and constructed by grid enterprises;
- Total quantity of PV AC power is fed into 400V public LV power distribution networks;
- Grid companies pay basic PV charge = local desulfurization price × PV generating capacity (Meter 2);

- The nation pays feed-in tariff subsidies = (PV differential benchmark tariff - local desulfurization price) × PV generating capacity (Meter 2);
- Users normally pay the grid based on electricity consumption (Meter 1);
- Developers' revenues = PV basic charge + PV tariff subsidies; and
- Period of subsidy settlement: 6 months.

6.1.2 Under the mode of self-generation power plants

Electricity metering and charge settlement for distributed self-generation power plants of different types follow the scheme below:

1) Connecting to 400V PV self-generation power plants

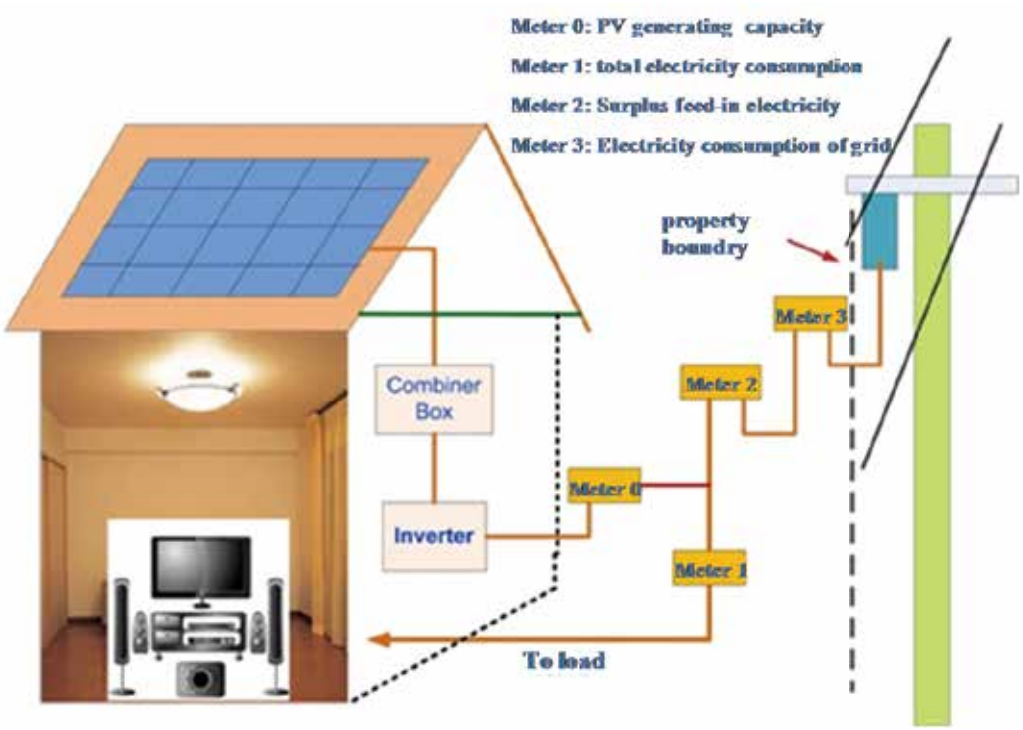


Figure7-2: Connecting to 400V PV self-generation power plants

- Distributed PV power generation projects connected to the users' side, and access system projects are invested and constructed by project owners; connection-induced public grid renovation is done by power grid enterprises (access projects in the western

region remain subject to national current investment policies). And access systems are invested and constructed by developers;

- Grid connection points are located at the load side of grid users' meters, and power is generated for own-consumption;
- The nation grants feed-in tariff (per kWh) subsidies for power generated for own-consumption, or in accordance with 125% of differential benchmark tariff, provides fixed PV power subsidies, at a duration of 20 years;
- For the PV electricity fed back to the grid, the grid will acquire in accordance with the tariff for desulfurization and coal firing. The state also grants feed-in tariff (per kWh) subsidy for electricity from grid, calculated at 0.2 yuan/kWh;
- Meter 0: ordinary meter, installed by developers, records only PV power generation; meter 1: installed by grid companies, automatically records total electricity consumption and bills automatically for peak time, valley time and usual time; meter 2: installed by grid companies, automatically records surplus feed-in electricity and bills automatically as per desulfurization price; meter 3: installed by grid companies, automatically records grid electricity consumption and bills automatically for peak time, valley time and usual time.
- Charge collection of grid enterprises: collecting charges from users according to total electricity consumption and time of use (TOU) rates recorded by meter 1.
- Payment by grid enterprises: basic electricity charges of developers' personal-use PV electricity and basic charges of electricity from grid.

  Basic electricity charges of personal-use PV electricity = total electricity charges meter 1 reads- grid electricity charges meter 3 reads

  Basic charges of PV electricity from grid = local desulfurization price × electricity from grid recorded by meter 2
- Payment by the government: self-use PV electricity subsidies = differential tariff of distributed PV (fixed price or 25% higher than the baseline tariff) ×personal-use PV electricity-basic electricity charges of personal-use PV electricity

  Subsidies for PV feed-back electricity = 0.2 yuan/kWh × PV electricity from grid recorded by meter 2 record
- Period of subsidy settlement: 6 months

2) Connecting to 10kV PV self-generation power plant

- Distributed PV power generation projects connected to the users' side, and access system projects are invested and constructed by project owners; connection-induced public grid renovation is done by power grid enterprises (access projects in the western region is still subject to national current investment policies) ; and booster stations are invested and constructed by developers;
- Charge collection of grid enterprises: charges are collected from users according to total electricity consumption and TOU rates recorded by the meter;
- Payment by grid enterprises: basic electricity charges of developers' personal-use PV electricity and basic charges of electricity from grid;

  Basic electricity charges of personal-use PV electricity =total electricity charges - charges for grid electricity consumption;

  Basic charges of PV electricity from grid = local desulfurization price × PV electricity from grid;
- Payment by the government: personal-use PV electricity subsidies =subzone tariff of distributed PV (fixed price or 25% higher than the baseline tariff) ×personal-use PV electricity (total electricity consumption-grid electricity consumption) -basic electricity charges of personal-use PV electricity;

  Subsidies for PV feed-back electricity = 0.2 yuan/kWh × PV feed-back electricity;
- Period of subsidy settlement: 6 months.

3) Single-user multi-building self-generation power plant

Grid electricity billing points of single-user multi-building self-generation power plants are generally located at the LV side of the power supply transformer. If multiple buildings are to be equipped with PV systems, the most reasonable and economical option is to connect the buildings to the power distribution network in the vicinity rather than connect them to billing points in a concentrated manner.

- The settlement for single-user multi- building self-generation PV power plants (400V) is as follows:
- Connect PV systems of buildings in the vicinity, record PV generating capacity and PV electricity charges recorded as per TOU rates of the buildings. Access systems are

invested and constructed by developers;

- Charge collection of grid enterprises: the following charges are collected from users: grid electricity consumption charge and charge for total personal-use PV electricity (charge for total personal-use PV electricity = charge for total PV electricity -charge for electricity from grid);
- Payment by grid enterprises: charges for total self-use PV electricity + basic charges for electricity from grid;

  Charge for total personal-use PV electricity = charge for total PV electricity–charge for electricity from grid;

  Charge for PV electricity from grid = local desulfurization price × PV electricity from grid consumption;
- Payment by the government: personal-use PV electricity subsidies =subzone tariff of distributed PV (fixed price or 25% higher than the baseline tariff) ×personal-use PV electricity (total PV electricity - electricity from grid) - charge for self-use PV electricity.

  Subsidies for PV feed-back electricity = 0.2 yuan/kWh × PV feed-back electricity
- The settlement for single-user multi-building self-generation PV power plants (10V) is as follows:
- Connect PV systems of buildings in the vicinity, record PV generating capacity and PV electricity charges recorded as per TOU rates of the buildings. Access systems are invested and constructed by developers;
- Charge collection of grid enterprises: the following charges are collected from users: grid

electricity charge and charge for total personal-use PV electricity (charge for total personal-use PV electricity = charge for total PV electricity-charge for electricity from grid);

- Payment by grid enterprises: charges for total self-use PV electricity + basic charges for electricity from grid;

  Charge for total personal-use PV electricity = charge for total PV electricity–charge for electricity from grid;

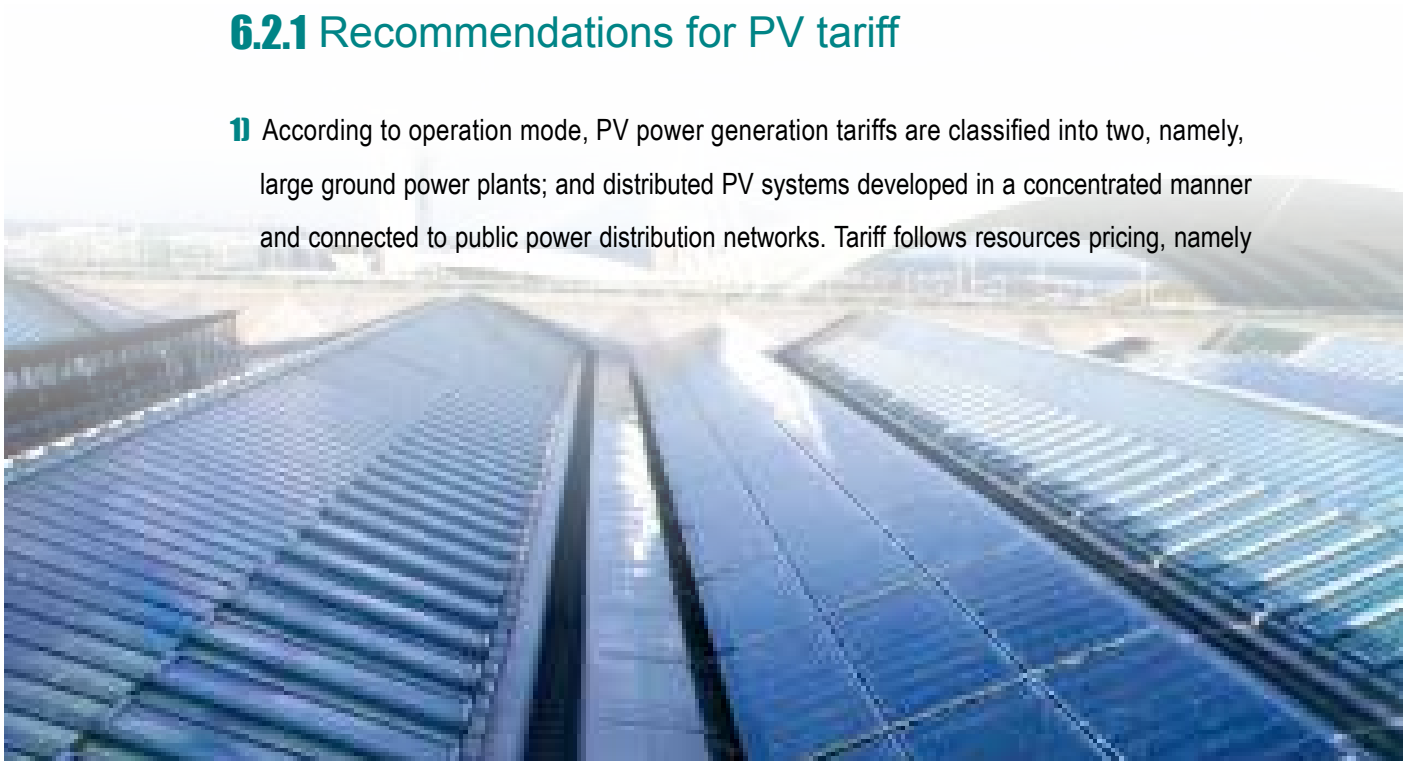
  Charge for PV electricity from grid = local desulfurization price × PV electricity from grid;
- Payment by the government: personal-use PV electricity subsidies = subzone tariff of distributed PV (fixed price or 25% higher than the baseline tariff) × personal-use PV electricity (total PV electricity - electricity from grid) - charge for self-use PV electricity;

  Subsidies for PV feed-back electricity = 0.2 yuan/kWh × PV feed-back electricity;
- Period of subsidy settlement: 6 months

6.2 Relevant recommendations

6.2.1 Recommendations for PV tariff

1) According to operation mode, PV power generation tariffs are classified into two, namely, large ground power plants; and distributed PV systems developed in a concentrated manner and connected to public power distribution networks. Tariff follows resources pricing, namely



developing benchmark PV feed-in tariff according to identified areas. While for PV systems generating power for their own-consumption, feed-in tariff subsidies by kWh or subsidies for differential tariff involving self-consumption distributed PV electricity can be adopted.

2) Differential benchmark PV tariff is determined through tenders. This can be realized by selecting several large PV power plants in four resource identified areas, or by tendering in PV projects related to large buildings connected to public power distribution networks. Before finalizing tender-related tariff, the tariff proposed in the article shall be carried out; and for the differential benchmark PV tariff determined by tenders shall be carried out next year;

3) For subsidies for distributed PV systems, the method of subsidies for differential tariff related to self-consumption distributed PV electricity has the following advantages. It caters for both different resource identified areas and tariff discrepancies among users, realizes fair incomes to avoid the problems with improper benefits in the future. However, though it is difficult to achieve equitable benefits for subsidies for feed-in tariff per kWh, it's preferred by policy-makers due to relatively simple operation and measurement compared with the former. Under the mode of subsidy for fixed tariff, the best subsidy solution is dividing users into three categories, namely, industrial and commercial industries, major industries and low-tariff users. Based on this, specific recommendations are further offered here: subsidizing 0.2 yuan/kWh for commercial and industrial users, 0.4 yuan/kWh for major industries, 0.6 yuan/kWh for residents, schools, hospitals, agricultural electricity and the like (0.3 yuan/kWh for national finance and power grid enterprises); for surplus feed-in power involving distributed

PV for self-consumption, another 0.2 yuan/kWh is subsidized in addition to acquiring as per desulfurization and denitration tariff. In this way, we can take advantage of the market for preferential selection of development models with good economic benefits so as to quickly initiate the domestic PV market, and can also exercise control on subsidy expenditures to a certain degree.

4) It's recommended to establish special tariff areas and approve specific tariff in such areas as Tibet Autonomous Region, Aba Autonomous Prefecture in Sichuan Province, Diqing Autonomous Prefecture in Yunnan Province, Yushu Prefecture in Qinghai Province, Xinjiang Production and Construction Corps, and Heilongjiang Agricultural Reclamation and Construction Corps. Generally speaking, such areas are characterized by harsh natural and climatic conditions, weak infrastructure and economic backwardness. And installed cost in these areas is much higher than that in other regions. Therefore, more subsidies should be provided in terms of tariff to support local economic development. A subsidy of 1.15 yuan/kWh seems relatively appropriate.

5) The nation should offer compensations for the access systems installed by grid companies, including electricity measurement and relay protection, as well as cost of transaction services. As far as subsidy standard is concerned, 0.02 yuan/kWh is subsidized for distributed power generation; for large-scale PV power plants, subsidies is provided in accordance with the afore-mentioned document (No.: CJ (2012) 102), say, (≤50 km: 0.01 yuan/kWh; 50-100 km: 0.02 yuan/kWh; ≥100 km: 0.03 yuan/kWh).

6) It's proposed to strengthen collection efforts on renewable energy. In strict accordance with the current Law of Renewable Energy, it's recommended to conduct renewable tariff across the country except Tibet Autonomous Region; conduct collection uniformly for sold power (power for agricultural production excluded and including power related to agricultural irrigation and drainage) in provinces, autonomous regions and municipalities, and expand the scope of collection to power consumption of all of the self-generation power plants. Meanwhile, as is demanded by development of renewable energy, additional value of electric power shall be increased as appropriate. It' proposed to improve additional value of renewable energy electricity to 0.015 yuan/kWh from the year 2013 and to 0.02 yuan/kWh in 2015, so as to ensure subsidies in full and in place.

6.2.2 Recommendations for management measures

1) Developers are free to choose the form of development in China, say, the modes of public or self-generation power plants, either to adapt to the policy of subsidies for large power plants or the policy of subsidies for distributed power generation;

2) In order to solve difficult intervention of developers and difficulty in charge collection directly from users, grid companies can collect electricity charges from the users and developers pay charges for their own PV electricity consumption and corresponding subsidies, as well as PV electricity from grid charges and corresponding subsidies to ensure revenues and expenditures separate from each other;

3) Property boundaries between the grid and users must be defined. The property boundary of large ground PV power plants is the first mast outside the PV power plants. The basic principles of property boundaries of distributed PV power generation systems are implemented in accordance with the document (No.: 1560 (2012)) issued by the SGCC;

4) Developer's agreement of power purchase and sales is signed with grid companies, but for roofing lease, they are required to negotiate with building owners. To protect the interests of both the developers and building owners, the proposed standard of roofing rental charge is 2 yuan/m2 per year;

5) Finally, it's suggested to simplify subsidy procedures for renewable energy power generation.

CREIA

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