Planning Report On the PV Scale-up Use in Hohhot City

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March 2010

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Acknowledgement

With being assigned by National Energy Administration, and funded by U.S. Energy Foundation, Institute of Electrical Engineering, CAS, Hohhot Research Center for Economic & Social Development and Inner Mongolian Institute of Electric Power Sciences teamed up a research group; and with nearly one year jointly working, the *Planning Report on the Scale-up Use of PV Power in Hohhot* was finalized cooperatively.

During the implementation of the project, it has been greatly supported by leaders and experts from Inner Mongolia Development and Reform Commission, Hohhot municipal government, Hohhot Development and Reform Commission, Hohhot Investment Promotion Bureau, Hohhot Planning Bureau, Hohhot Construction Bureau, Hohhot Environmental Bureau, Inner Mongolia Power Group Co., Ltd, Inner Mongolia Huade New Technology Co., Inner Mongolia University of Science and Technology, etc.

U.S. Energy Foundation not only funded the research, but also arranged the international experts to provide high-level consultation, and particularly, the members of the research group and some Chinese experts were arranged to visit in Germany and Italy, so as to ensure the successful implementation of the project.

The comprehensive studies and profound analysis of the contents of project were done and the valuable advice and suggestions from many experts were obtained, which had the research and the report much more efficient and perfect.

Hereinto, we would like to express our sincere gratitude to U.S. Energy Foundation, all the authorities and institutes which offered instructions and support to the project, and all the people having worked hard for this report! Also we are sorry that it is impossible for us to list out all the names of the supporters here.

Any errors or deficiency herein will be due to the research group.

Content

1. Background and targets

1.1 Project name

Development Plan for the Scale-up Application of PV power in Hohhot.

1.2 Basis for Research

In China, the incentive policies for renewable energy are being gradually improved. In order to put the overall requirement for China's development of renewable energy into effect, to create a good environment for the development of renewable energy electric power and increase its proportion in electric power consumption, National Energy Administration determined to select typical cities to implement demonstration projects of scale-up application of PV power, so as to establish the mechanism, codes, standards and other related incentive policies concerning urban PV application which is appropriate to China's conditions and thereby extend to the other cities.

It conform with the *Development Planning Outline of PV Industry of Hohhot (2010-2020)* and *The Regulations of Hohhot City People's Government on Further Accelerating PV Industry Development,* to launch the demonstration projects of municipality scale-up application of PV power in Hohhot City which owns the superiority in rich resources, industries and locality, which speeds up the city's transform of the economic development pattern and adjustment of energy mix and helps to reach the strategic targets of "the Capital City of New Energy".

According to the instruction of the National Energy Administration, U.S. Energy Foundation provided the fund for the prophase studies of the project and also arranged the international experts to provide consulting in terms of the advanced international policies and technologies in order to ensure successful implementation of the project. Institute of Electrical Engineering, CAS, Hohhot Research Center for Economic & Social Development and Inner Mongolian Institute of Electric Power Science, together with local experts, set up a research group, jointly made study on the planning of the project.

1.3 Reason and process of project presenting

1.3.1 Status of energy, electric power and environment of China

1.3.1.1 Status of China energy

The quantity of the Chinese per capita fossil energy owning is lower. The per capita coal quantity in China is only half of the world's average level while that of petroleum and natural gas is only 1/15 of the world's average level. In 2008, China's total consumption of primary energy has increased up to 2.85 billion from 1.04 billion tons equivalent coal in 1990, ranking the world's No.2 energy consuming state; the net energy importation amounted to 0.25 billion ton equivalent coal, roughly 10% of the total consumption of primary energy the year, as shown in Fig 1-1.

With the overall advancement of China well-off society, high industrialization of the country and the improvement of the lives for the people, the rapid growth of the demand for energy will occur soon. According to the proved reserve of fossil energy resource and the social and economic development speed, the sustainable supply issues of energy has been put into the government's agenda and China is facing a serious challenge in terms of energy.

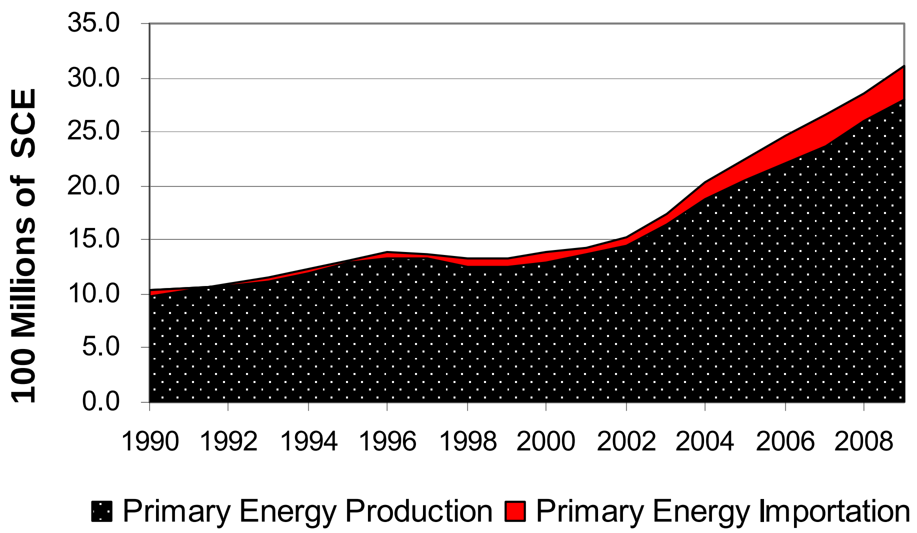

Fig 1-1 China primary energy production and importation

1.3.1.2 Status of China electric power

It is urgently to be improved for the electric power mix of China which is largely dependent on coal-fired power. In 2008, the state overall power generation was 3,433.4 TWh, in which coal-fired power generation contributed 2,779.3 TWh, taking up 80.95% of the total power generation.

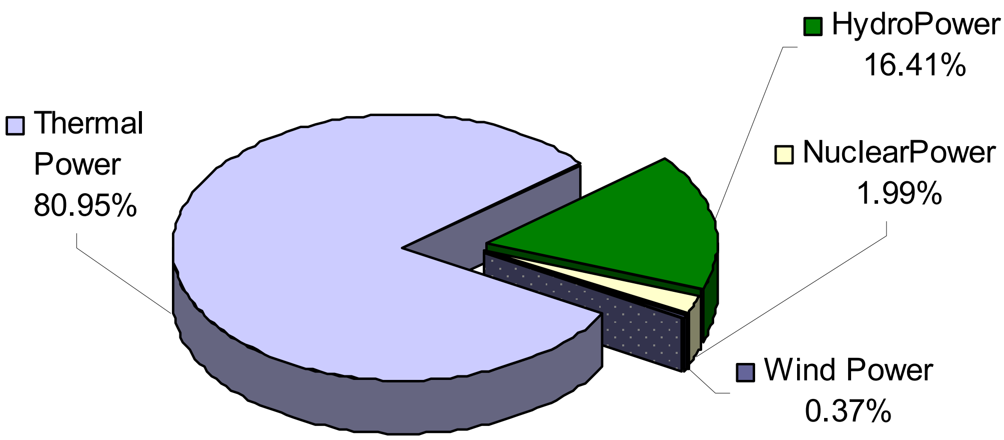

Fig 1-2 Chinese electricity generation profile in 2008

The long-term coal-fired power generation of China has lead to the deterioration of ecological environment; it is urgent for China to take the effective actions to harness renewable energy sources.

China pays great attention to the utilization and development of renewable energy sources. On Sep 22, 2009, president Hu Jintao gave an important speech entitled of *Working Together to Address the Climate Challenge* at the opening ceremony of the UN Climate Change Summit and presented the target of "Greatly develop renewable energy and nuclear energy and make effort to have the non-fossil energy consumption up to around 15% in the total consumption of primary energy by 2020".

With the rapid development of the national economy, China's electric power consumption has been rising at a fairly rapid speed. It is imperative to accelerate the development of renewable energy sources. In Fig1-3 the growth tendency of China's electricity consumption from 2002 to 2009 is shown. Affected by the international financial crisis, the power consumption dropped largely, before then it was kept growing rapidly in the previous consecutive 6 years, and the annual increasing rate of power consumption was merely 5.6% in Sep-Oct of 2008. In 2009, power consumption gradually came up back and saw rapid increase in the second half of the year with annual power consumption of around 3,640TWh. As predicted in the *Analysis & Prediction Report on the Demand and Supply of the State Electric Power and Economic Operation Situation (2009-2010)*, subject to active factors boosting the economic growth, the annual power consumption of the whole society will come up to around 3,970 TWh in 2010 and will increased by 9% over the previous year.

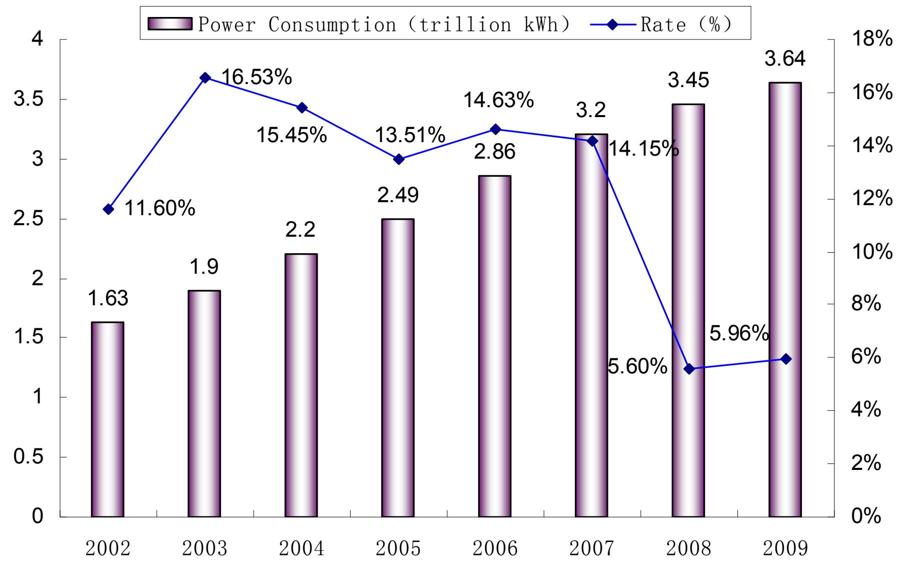

Fig 1-3 Tendency of China's electric power consumption

1、 Prediction of experts from State Grid Corp

Based on comprehensive analysis and comparison of predicted results, such as unit consumption method of output value, per capita power consumption method, growth rate method and mathematical model method, and combining with the existing economic situation and outlook to 2030, a baseline solution to power consumption of the whole society in 2010-2030 has been gained.

Electric power consumption of the whole society will be up to 3,970 TWh in 2010 At an average annual growth of 9.9% during "11th Five-Year Plan" period; 4,810 TWh in 2012 at an average annual growth of 10.1%; 5,970 TWh in 2015 at an average annual growth of 8.5% during "12th Five-Year Plan" period; 7,670 TWh in 2020 at an average annual growth of 5.1% during "13th Five-Year Plan" period; and 10,370 TWh in 2030 at an average annual growth of 3.1% from 2021 to 2030.

By referring to the China's historical annual maximum load utilization hours and considering the economic growth, structural change in power consumption, geographical location and climatic characteristics, implementation of demand-side management (DSM) measures, electricity tariff and industrial structures in different regions, it is estimated that the annual maximum load utilization hours will decrease year by year and will be approximately 6,200 hours by 2010; 6,100 hours by 2020 and 6,000 hours by 2030.

Based on the forecast of electricity consumption of the whole society, it is estimated that the maximum load will be up to 634 GW by 2010, at an average annual growth of 10.4% during "11th Five-Year Plan" period; to 780 GW by 2012 at an average annual growth of

10.9%; to 989 GW by 2015 at an average annual growth of 9.3% during "12th Five-Year Plan" period; to 1.27 TW by 2020 at an average annual growth of 5.2% during "13th Five-Year Plan" period; to 1.72 TW by 2030 at an average annual growth of 3.1% in the next decade of 2020-2030.

2、 Prediction of experts from China Electric Power Enterprise Council

Zhao Xizheng, the Board Chairman of China Electric Power Enterprise Council, pointed out in 2007 that the power consumption of the whole society will amount to over 6,000 TWh by 2020.

According to China's current situation of economic development and resources and by fully considering the development of coal-fired power, hydropower and nuclear power, which can not meet the power consumption demand of the whole society in the future only by relying on the above conventional power supply. Therefore, speeding up the development of renewable energy sources is not only the inevitable way to optimize the energy mix, meet the power consumption demand, improve the ecological environment and realize the sustainable development, but also the solid assurance for national energy strategy safety.

1.3.1.3 Status of China environment

China's coal-power dominated power energy mix not only speeds up the exhaustion of fossil energy resources, but also imposes increasingly serious environmental and economic problems and negative social impacts. Sulfur dioxide resulting from coal burning has caused serious acid rain covering a third of the national land area in China. In 2008, of the 477 cities (counties) monitored, 252 cities were exposed to acid rain severely, accounting for 52.8%. Enormous quantity of carbon dioxide emission of coal burning has brought about greenhouse effect which causes global warming.

According to the statistics made by related institutions, 70% of soot emission, 85% of sulfur dioxide emission, 67% nitrogen oxide emission and 80% carbon dioxide emission are from coal combustion. In table 1-1 is the sulfur dioxide emission by coal-fired power in China. In 2008, China's sulfur dioxide emission was up to 23.212 million tons; soot emission 9.016 million tons, and industrial dust emission 5.849 million tons.

Table 1-1 Statistics on SO_2 emission of China's coal-fired power

Year	2004	2005	2006	2007	2008
Annual SO_2 emission of coal-fired power (10^4 tons)	1,200	1,300	1,350	1,259	1,150
National total annual SO_2 emission	2,255	2,549	2,589	2,467	2,321
Percentage %	53.2	51.0	52.1	51.0	49.6

Fig 1-4 is the statistic diagram on CO_2 emission of China's different sectors. In 2007, CO_2 emission from power and heating supply sectors account for 50% of the national total emission. According to the report of *CO_2 Emission from Fuel Combustion 2009* released by International Energy Agency, China's CO_2 emission were 6 billion tons accounting for 21% the global emission amount in 2007; The CO_2 emission in China have been ranked the No.1 in the world. Even though China's greenhouse gas emission grows slowly at annual rate of 2.9%, the greenhouse-gas emission will be doubled that of 2007 by 2030.

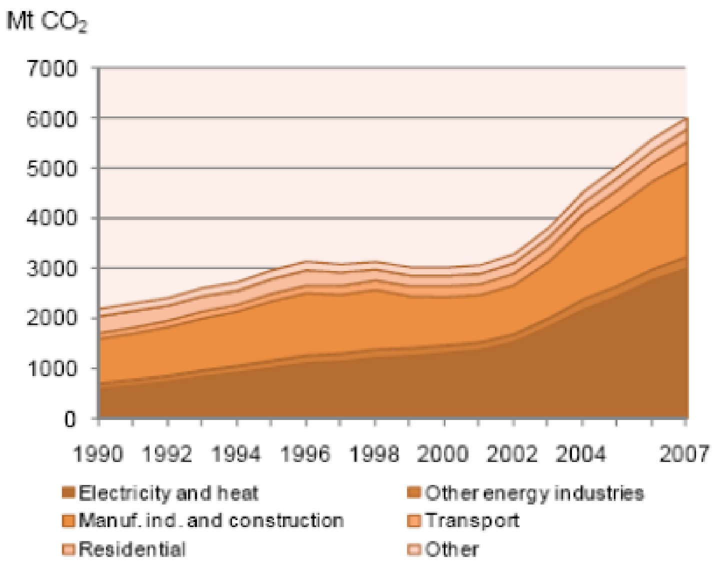

Fig1-4 CO_2 emission of China's different sectors

As a responsible large country, China must take effective actions to solve environmental problems. On Nov 25, 2009, State Council premier, Wen Jiabao, officially announced the target of the campaign to control greenhouse gases at the State Council Standing Committee conference: By 2020, the carbon dioxide emission per unit GDP will be lowered by 40%-45% than that of 2005.

1.3.2 Prediction of solar power generation

In 2007, the National Development and Reform Commission clearly put forward the developing target in the *Middle and Long Term Program of Renewable Energy*

Development, so as to speed up the development of renewable energy including solar energy, reduce the proportion of coal in the energy mix, and make effort to bring renewable energy consumption up to 10% of the total energy consumption by 2010 and 15% by 2020. Solar energy is an important renewable energy source. The target is as follows: the installed capacity of solar power will be up to 300 MW by 2010 and 1,800 MW by 2020.

Based on the forecast of IEA on the development of solar power generation, 12% of the global electricity will be supplied by solar power generation by 2050. By calculating in such a way, the electricity generation by solar energy shall reach 1.1 TWh in China by 2050. The accumulative installed capacity of solar power system will reach 730 GW with 1,500 hours full operation in a year. Solar power generation will play a much more remarkable role in power mix with increasing the installed capacity. As shown in Fig 1-5 is the development tendency of China's annual power generation by solar energy.

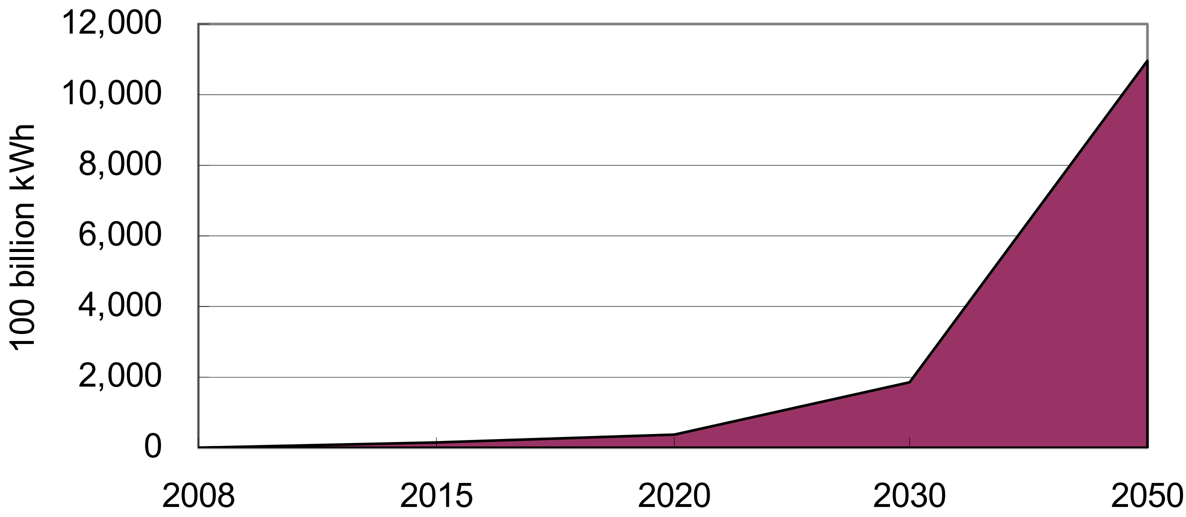

Fig 1-5 Forecast on tendency of China's annual power generation by solar energy

1.3.3 Significances of urban scale-up application of PV power

1. Necessity of launching the urban PV power scale-up application

1) Optimizing electric power configurations

It is urgent to bring up the non-fossil energy consumption to 15% of the total consumption of primary energy by 2020 and to meet the future power demand and the strategic requirement for sustainable development of the power system.

2) Assuring the sustainable development of PV industry in China

By the end of 2008, the accumulative installed capacity of PV power system in China reached 140 MW (less than 1% of that in the world). In 2008, the accumulative installation capacity of PV power system in China was about 40 MW, only accounting for 2% of 2 GW solar cells production the year, which means that 98% solar cells had to be exported oversea. Chinese PV enterprises were facing an embarrassment for which the market was fully relying on the foreign market. In order to keeping the long and well sustainable development of the Chinese PV enterprises, it was absolutely necessary to expand the domestic PV application market within as soon as possible.

3) Improving safety of urban electric power supply

Urban scale-up PV power can directly access to the urban/rural distribution grid and save the long-distance power transmission as a useful supplement to the urban power system. Besides, as the PV power system starts and stops easily, with freely load-controlling and adjusting, and PV power system can be run independently each other, which helps to make up the deficiency of the power supply system in safety and stability and assure the electric power supply.

4) Enhancing establishment of resources-efficient and environment-friendly cities

Cities are the principal sites of electric power consumption. The manner and efficiency of power utilization of a city influences the ecological environment and social and economic development. With the expediting the process of industrialization and urbanization, new cities will be occurring more and more in the future. Therefore, it is important to carry out the scientific development concepts, enhance ecological civilization, establish an industrial structure, growth manner and consumption mode which enable resources energy resource conserved and ecological environment protected, to promote the low-carbon development modes represented by energy conservation, new energy expansion and application and lower CO_2 emission intensity, to drive along and enhance sustainable economic development, relieve ecological pressure, build a resources-efficient and environment-friendly society and enhance harmonious co-existence between man and nature.

5) Environment protection, energy conservation, and emission reduction

China ranks the worlds No.1 in CO_2 emission and in the forefront place in greenhouse gases emission of methane and nitrous oxide. In order to protect and improve China's environment, it is absolutely necessary to exploit and utilize solar energy and other clean and renewable energy.

6) Launching emergency PV power projects, improving emergency responding mechanism

In the people-concentrated cities, the emergency shelters shall be built to provide spaces for victims relieving and rescuing in a disaster. Emergency power play critical role and assure the power supply for communication, relief and rescuing and refuge facilities electricity use as the conventional power fails. Solar PV power provides the basic demand of power and guarantees power supply in case of any failures of grid. Installation of solar power will not rely on conventional energy, no energy consuming and without pollution, and safe, reliable and free of maintenance.

2. Necessity of demonstration projects of urban scale-up application of PV power

1) Enhancing urban scale-up application of PV power

Building-PV power system mainly refers to the installed PV power system on buildings roof. It is the optimal way to promote the application of PV power generation in cities by the distributed power sources inter-connected to the terminal of utility power grid. The prevalence of PV power generation in cities of Europe, America and Japan were all started from the building PV system, and nowadays, building PV power system and technology have been matured in technology and management has been systemized and regularized.

Building PV power system is the early integration between the solar power system and buildings. It was first developed by Germany and gradually became popular after the demonstrating application programs as follows: 1,000 PV Roofs Program was carried out in 1991-1995; 100,000 Roofs Program in 1995-1998 was based on the accumulation of technology and practice; "*Renewable Energy Law*" was enacted by the Germany in 2000; accumulative installed capacity of 100,000 PV Roofs which reached 300 MW had been finished in the autumn of 2003; in order to further accelerate the process of developing PV power system, the German government revised "*Renewable Energy Law*" and promulgated *Feed-in Tariff Subsidy Program* which attracts more private investment in 2004; and the German government revised Feed-in Tariff Subsidy Plan in 2008, which speeded up the annual decline rate of tariff. At the end of 2008, Germany's installed capacity of PV systems amounted to 5.3GWp. Being motivated by Germany, other countries, one by one, imitate the Germany to make the buildings PV power development plan.

Germany's experience shows that developing large comprehensive demonstration projects of solar PV application in cities achieved great effects. In particular, integration between the PV system and buildings help to reduce the system cost without occupying land and which is very helpful for the construction of low-carbon cities. Besides, demonstrating projects are quite important for the extension of China's solar PV market, which will not only exhibit the China's technical level of solar PV power, but also gain practical experience and technical data for scale-up application of solar energy.

2) Establishing mechanism, codes, standards, and incentive investing/financing policies appropriate to China urban PV power application projects

Foreign incentive policies on PV development

PV power system is promising potentially in the urban application of PV technology and been widely used in Europe, America and Japan. The incentive policies in those countries for the PV power application market can be divided into: 1) providing a feed-in-tariff with the fixed investment benefit, being representative of Germany; 2) providing financial subsidies on the investment side, which take up certain portion of the initial investment cost, presented by Japan; 3) the mixing policy of above both policies in California, USA, as shown in Table 1-2. Other incentive policies I, such as the low loan interest rate, tax credit, etc.

Table 1-2 Foreign incentive policies

Type	Country	Incentive Policies
Tariff-side subsidy	Germany	In 2004, as it is promulgated by Feed-in Tariff, tariff is Euro 0.45-0.62 /kWh, legally effective 20 years and tariff will be decreased 5%-6.5% year by year. In 2008, Germany passed a bill that the tariff will be decreased 8% in 2009 and 2010, and it will be decreased 10% each year from 2011.
	Spain	In 2006, the tariff was Euro 0.23-0.44/kWh, in effect for 25 years. Planned the accumulative installed capacity reach 400 MW by 2010.
Investment-side subsidy	Japan	In 1994, 50% of the installation cost of solar power system subsidized by government and decreased to zero in ten years; "Net Metering" was adopted to pay for tariff; and commercial banks provide preferential low-interest loans.
Mixed Subsidy	California of USA	In 2006, almost 70% of the installation cost of solar power system was subsidized by government and decreased year by year; "Net Metering" was adopted to pay for tariff, in which the surplus electricity of the fed-in PV power over the end-user electricity consumption shall be purchased by utility power grid with the retail electricity price; The tax credits are for 30% of the cost of the PV systems and the maximum credit for individuals is US$2000.

In 2004, the German government launched *Feed-in Tariff*. The government forced Grid Companies to purchase solar power which will be shared and subsidized by whole society finally. After the implementation of feed-in tariff in Germany, Italy, Greece, France and other European countries also introduced the feed-in tariff and which brought about the explosive growth of PV installations.

The Japanese government ran a successful program of investment subsidies in 1994 to 2003, installation of the system was subsidized directly. By the end of 2004, Japan led the world in installed PV capacity with over 1.1 GW.

In 2006, California approved the "*California Solar Initiative*", offering a choice of investment subsidies or Feed-in Tariff for small and medium systems and a Feed-in Tariff for large systems. With the large PV power system, the initial feed-in tariff is US$0.39/kWh, which would last just 5 years, then, it will decrease year by year.

The current "China Golden Sun Program" adopts the investment-side subsidy. Through the implementation of the project, at a certain extent, the urbanization application of PV power has been promoted. However, the incentives policies not only increase the government financial expenditure and the burden on tax payers, but also easily only pay attentions to the installed capacity and ignore the actual electricity generation of the PV power system. According to the international experience, the policy of tariff-side subsidy is more effective in case of promoting the application of PV power in the long term. In order to ensure that a PV power station can normally operation for 20 years or longer, more attention should be paid attention to not only the construction quality but also the actual operating effect. The yearly subsidization shall be based on the actual annual power generation, in the form of FIT, the subsidy shall be allocated into the yearly subsidy. The incentive policies can have the project ownership perform the regular operational maintenance and effectively ensure the sustainable development of PV power projects.

From the global view, tariff-side subsidy is the mostly effective policy to enhance application of PV power under which the PV subsidy is shared among all the power consumers. This highlights the practical effect of PV power and effectively enhances utilization of PV equipment. The shortcoming, however, is that it increases the burden on the management authorities.

So far, in general, China's development of solar PV power is in the starting demonstration stage. The state and the local governments are launching demonstration projects of solar PV grid-connected power and gradual extension, however, these isolated, regional and small-scale grid-connection demonstration projects do not have the overall environment of urban solar energy utilization and the large–scale comprehensive application pattern being adjusted, through which series of problems such as the technical standards and codes, investment model and channel, tariff subsidy and operation procedures and policies have not been solved as well.

Therefore, it is urgently needed for China to implement the urban solar PV comprehensive utilization and demonstration program with an integral planning and scaling–up, so as to formulate a complete promotion mechanism, to perform the practical operation of the renewable energy law, to form a collective exhibition of policies, systems, technical standards, engineering technology and engineering implementation concerning solar PV utilization in a city selected, and convert the individual demonstration projects into all–dimensional comprehensive demonstration of the project. Promoting the urban solar PV market in China in a large scale has been put into the agenda.

By establishing large comprehensive urban demonstration projects of PV application, it will be possible to study the optimal integration and matching design technology of distributed power system under grid inter–connection condition, and key technologies of grid connection of distributed power micro–grid, to define technical codes and standards concerning the constraints to short circuit current, protection configurations, voltage control and electric quality indicators of the accessing system, to reinforce the studies on the overall performance of distributed power on the safety and stability of the power system and explore the development pattern of distributed power in China as a whole.

1.3.4 Conditions for urban scale–up PV application

1.3.4.1 Fundamental conditions

As roughly estimated, China's total building area of houses is about 40 billion square meters, of which the total usable area of the building roofs is about 0.316 billion square meters. According to the 100W/m^2 installation density and 1000 hours annual operation, the total electricity output will be 31.6 TWh (shown in Table 1–3).

Table 1–3 Estimates on PV power generation of available roofs installation in provinces and regions of China

No.	Province	Solar Energy Resources	Available Roof Area	Estimate on Power Generation and Installed Capacity	
		kWh/m^2·year	$\times 10^4$ m^2	Power Generation $\times 10^8$ kWh	Installed Capacity $\times 10^4$ KW
1	Guangdong	1,200–1,400	3,300	28–54	355–670
2	Jiangsu	1,300–1,450	2,750	24–45	295–555
3	Shandong	1,400–1,500	2,300	22–40	265–500
4	Henan	1,300–1,400	1,900	17–30	205–390
5	Zhejiang	1,250–1,300	1,700	14–26	170–315
6	Hebei	1,450–1,700	1,450	15–28	190–350
7	Sichuan	1,000–1,800	1,400	15–30	200– 370
8	Hunan	1,000–1,200	1,400	11–20	130–245
9	Anhui	1,250–1,400	1,300	12–21	140–260
10	Liaoning	1,300–1,500	1,250	12–22	145–270
11	Hubei	1,000–1,350	1,200	10–18	120–225
12	Guangxi	1,100–1,350	1,180	10–18	120–220
13	Jiangxi	1,250–1,350	1,150	9–17	115–210
14	Fujian	1,250–1,450	1,050	9–17	110–210
15	Heilongjiang	1,250–1,400	850	7–14	90–170
16	Yunnan	1,200–1,700	750	8–15	100–190
17	Shanghai	1,300	750	6–12	75–145
18	Shanxi	1,400–1,650	700	7–14	90–170
19	Beijing	1,600	700	7–14	90–170
20	Shannxi	1,100–1,650	700	7–13	90–165
21	Chongqing	1,000–1,200	700	5–10	65–120
22	Inner Mongolia	1,250–1,800	550	6–13	65–125
23	Jilin	1,350–1,450	650	6–12	75–140
24	Guizhou	1,000–1,300	500	4–8	55–100
25	Gansu	1,300–1,900	350	4–9	45–85
26	Xinjiang	1,500–2,050	350	4–8	55–80
27	Tianjin	1,450–1,500	300	3–5	35–65
28	Hainan	1,300–1,600	200	2–4	25–45
29	Qinghai	1,700–2,050	100	1.5–2.5	15–25
30	Ningxia	1,600–1,700	100	1–2	10–20
31	Tibet	1,300–2,150	50	0.5–1	5–10

Note: Power generation is estimated based on the maximum value of solar energy resources; power generation and installed capacity are considered according to thin–film PV modules and mono–crystalline silicon PV modules respectively.

In the *Middle and Long Program of Renewable Energy* and the *"11th Five–Year Plan" of Renewable Energy*, China will have 1,000 sets of roof grid–connected PV systems installed with accumulated capacity of 50 MW by 2010, and 20,000 sets installed with accumulated capacity of 1GW by 2020.

1.3.4.2 Industrial conditions

Recent years, China's PV industry has been growing rapidly, China has established a complete PV industry chains from poly-crystalline Si material to PV application products, Which was motivated by the national "*Brightness/SDDX Program*" and three billion Yuan (RMB) funded by central governmental, it was since 2020 that Chinese PV industry have experienced the large scale development.

By the end of June in 2009, there were 19 poly-crystalline Si projects being put into production and more than 10 other poly-crystalline Si projects were under construction or the poly-crystalline Si projects were expending. The production output of the overall planning would be over 100,000 tons by 2010.

By the end of 2008, there were more than 60 ingot/wafer manufactures and annual production output of over 20,000 tons; Solar cell companies were more than 60, the production of solar cell was 2GWp with an annual growth of 16.5%. China kept the position of the world's largest producer of solar cells. The sale was up to RMB 200 billion and the employees' number was about 100 thousand.

In China there were a group of PV manufacturing enterprises with international competency and reputation. In the ranking of the world top 10 largest PV manufacturing enterprises in 2008, the three were from the China Mainland. PV industrial chain has already been formed in China, large scale-up, internationalization, and specialization PV industrial chain were already owned. In China's PV industry the fully preparation for domestic PV scale-up application was in place.

1.3.4.3 Engineering technical conditions

As of the end of 2008, China's accumulated installed capacity of PV power was 140MW, which lays firm foundation for the application of PV power technology in the country, as shown in table 1-4.

Table 1–4 Accumulative installed capacity and market distribution of China's PV power generation in 2006–2008

Market	Accumulative installed capacity (MW)			Accumulative market distribution（%）		
Year	2006	2007	2008	2006	2007	2008
Rural electrification	33	42	48	41.3	42	34.3
Communication & Industry	27	30	35	33.8	30	25
PV products	16	22	30	20	22	21.4
Urban grid–connected PV system	3.8	5.6	26.1	4.8	5.6	18.6
Open field PV system	0.2	0.4	0.9	0.3	0.4	0.6
Total	80	100	140	100	100	100

In China, there are some of the larger demonstration projects of urban solar PV grid–connected power as follows

- 1 MW grid–connected PV demonstration project in Shenzhen Park Fair,
- 1.5 MW grid–connected PV power station for five–star hotels in Baoding,
- The megawatt–level grid–connected PV power system in Shanghai World Expo Park, China Mansion and the Theme Mansion;
- 105 kW grid–connected PV power station Bird Nest of Olympic Stadium,
- MW–level grid–connected PV power station in Shanghai Harbor New City,
- MW–level grid–connected PV power station in Shanghai Solar Energy Engineering Center and
- 1.2 MW grid–connected PV system in Wuxi airport, etc.

In addition, with the great support of the “Golden Sun Program”, projects approved in 2009 already amounted to 298MW.

Table 1–5 List of Golden Sun Demonstration project (kW)

Beijing	18,155.35	Henan	20,690.3
Tianjin	23,825	Hubei	14,800
Hebei	5,341.6	Hunan	21,933.8
Shanxi	461	Guangdong	13,182.2
Inner Mongolia	12,719	Shenzhen	12,707.8
Liaoning	12,500	Sichuan	311.58
Heilongjiang	622.08	Yunnan	7,465.56
Shanghai	7,393	Shannxi	3,797.5
Jiangsu	15,615.2	Ningxia	3,000
Zhejiang	27,281.58	Qinghai	730
Anhui	16,602.8	Xinjiang	2,172.19
Fujian	14,676.26	Tibet	1,000
Jiangxi	21,694	Xinjiang State Farm	3,000
Shandong	8,000	General Logistics Department	8,800
Total		298,477.72	

All these projects indicate that the technical condition in China for launching the urban building PV grid-connected power project has been ready and complete.

1.3.4.4 Policies conditions

1. **National policies**

Ever since the enactment of the *Renewable Energy Law of the People's Republic of China*, there have been a series of policies concerning the pricing, tax, compulsory market portfolio and grid-connected and gird-access associated with renewable energy as follows.

- *Mid to Long-Term Development Plan for Renewable Energy* (NDRC Energy [2007] No. 2174), on 31st August, 2007.
- "*Renewable Energy Development 11th 5-Year Plan*" (NDRC Energy [2008] No.610), on 3rd March, 2008.
- *Guidance Catalogue for the Development of Renewable Energy Industry* (NDRC Energy [2005] No.2517), on 29th November, 2005.
- *Temporary Measurements for Pricing and Expense Allocation Management of Renewable Energy Power Generation* (NDRC Pricing [2006] No.7), on 1st June, 2006.
- *Interim Measures on Renewable Energy Tariff Add-in Revenue Adjustment and Allocation* (NDRC Pricing [2007] No.44), on 31st August, 2007.
- *Relevant Management Regulations for Renewable Energy Power Generation* (NDRC Energy [2006] No.13), on 5th January 2006.
- *Interim Measures for Special Fund Management of Renewable Energy Development* (MOF and CIN [2006] No. 237), on 20th June, 2006.
- *Guideline on Boosting-up of Solar PV Integration with Buildings* (MOF and CIN [2009] No. 128) , on 23rd March, 2009.
- Notification on "*Measures on Financing Subsidy to Solar PV Power Integration with Buildings* (MOF and CIN [2009] No.129), on 23rd March, 2009.
- Interim Measures on Financial Grant Management of the Golden Sun Demonstration Project (MOF, MOST and NEA [2009] No. 397), on 16th July, 2009.

China already has created the policy environment for the developing of large-scale solar PV demonstration projects. In 2006, MOF and CIN co-issued documents such as

Implementing Instructions on Accelerating the Application of Renewable Energy Application in the Buildings, *Interim Measures on Special Fund Management of Renewable Energy Integration with Buildings* and *Notification on Evaluation Criteria for Demonstration Projects of Renewable Energy Integration with Buildings*, and so on. In the documents, it stated to support and recommend the demonstration application of renewable energy integration with buildings, and the demonstration subsidizing methods and operating procedures were stipulated definitely, and it was determined that the projects demonstration and extension will be implemented in the five provinces (autonomous region and cities) with better working basics, such as Beijing, Inner Mongolia, Shenzhen, Liaoning and Shandong.

In March 2009, MOF and CIN co-issued *Implementing Guideline on Boosting-up of Solar PV Integration with Buildings and notification on "Measures on Financing Subsidy Fund of Solar PV Power Integration with Buildings*. In July 2009, MOF, CIN and NEA promulgated notification on *Implementing Golden Sun Demonstration Projec*t. The first batch subsidy funds for the solar PV integration with buildings demonstration projects summed up to RMB 1.27 billion Yuan. These incentive policies will help to enhance the application of solar PV power in China and also be in favor of the sustainable development of the solar energy industry.

2. **Local government policies**

Following the incentive policies by the central government and authorities, such as the Ministry of Finance and the National Development and Reform Commission, concerning renewable energy, the provinces and municipalities put forward the programs and policies encouraging and supporting urban solar PV application as follows, herein listed partially:

On 22nd April, 2009, Kunming of Yunnan province issued *Kunming City's Promoting the Upgrade and Development of Solar Energy Industry,* in which, it was indicated that, by 2015, the application of city and town solar heating systems and BIPV/BAPV will account for more than 95% of newly-built buildings, the prevailing rate will be over 70% in urban areas and more than 35% in rural areas, and the solar PV power application of the whole Kunming City will reach 200 MW or above by 2015.

On 11th May 2009, *Zhejiang province guidelines on Accelerating the Promotion Application and Industry Development of PV and Other New Energy Resources* states that one-million roofs power generation program will be implemented, the roofs of public buildings, workshops, residential area installing PV power system will cover one million square meters and the power generating capacity reach 50 MW or above.

On 19th June, 2009, *Jiangsu's Guideline on the Promotion of PV Power Generation* in that in Jiangsu the installed capacity of PV grid-connected power generation will reach 400 MW, among which the installed capacity of building PV power system will reach 260 MW, the installed capacity of BIPV/BAPV will reach 10 MW and the installed capacity of terrestrial PV power will reach 130 MW.

On 30th July, 2009, Guangzhou promulgated *Guangzhou's Plan for the Development of New and Renewable Energy Sources (2008-2020)* stating that Guangzhou will promote solar PV power generation, formulate maneuverable regulations on the feed-in-tariff of grid-connected solar PV power, launch the PV power generation projects, and install PV power systems on the buildings in the building-limited districts around Baiyun International Airport and on major landmark buildings of Guangzhou City, the installed capacity of grid-connected PV power demonstration projects reaches 5 MW by 2010 and 100 MW by 2020.

On 14th October, 2009, Shaanxi province released *Medium to Long-Term Development Plan for Solar Energy in Shanxi* in which the total area of BIPV/BAPV projects will reach 1,500,000 square meters by 2020; the total installed capacity of large-scale grid-connected solar power demonstrative stations will reach 150MW, including large-scale grid-connected solar PV power station and 1,000 demonstration projects of urban roof solar PV power.

On 15th December, 2009, Shandong province government issued the *Notification on Several Policies for Accelerating the Development of New Energy Industry* indicating that Shandong supports the grid-connected solar PV power station and PV-integration-with-LED demonstration projects of public lighting. It will be focused on the BIPV/BAPV projects with above 300 kW including PV roofs and PV curtain walls of the residential buildings, government office buildings and large public buildings; and the other BIPV projects with being synchronized of architecture design and the construction.

The 30 BIPV/BAPV projects with above 30 MW will be constructed in three years; and 1-2 demonstrative projects of MW-level ground PV power station will be implemented. The project of "One-million Lamps Lighting" will be carried out in terms of the public lighting; the key project will be granted to 60 PV-integration-with-LED demonstration projects; and 1 million LED lights will be applied all over the province with the capacity of

50,000 kW in the next 3 years. The demonstration project of BIPV/BAPV will be subsidized based on RMB10 Yuan/Wp and the project of PV- LED integration with RMB 5 Yuan/Wp.

On 30th December, 2009, Shenzhen City Government issued *Development Plan for the Recovery of New Energy Industry in Shenzhen (2009-2015),* in which the implementation scheme for BIPV/BAPV in public buildings was worked out, firstly the BIPV projects will be implemented on the public buildings, municipal buildings, and high-grade residential buildings, BIPV projects including Creativity Sci-tech Industrial Park (1 MW), DuPont Park (1.1 MW), etc will be speedup up. The application level shall be lifted up; the scale of PV power shall be expanded as well. By 2015, the installed capacity of BIPV/BAPF project will reach above 20 MW totally.

On 7th January, 2010, Beijing Municipality issued *Guidelines on Accelerating the Exploitation and Utilization of Solar Energy and Promoting the Development Industry in Beijing*, in which it is stated that 20MW PV roof project will be implemented by following the principle of "supporting the high-end and first-applying-first-gaining". Before 31st December, 2012, with regard to the first 20 MW grid-connected solar PV integrated with buildings and wind-solar hybrid power projects will be subsidized by municipal finance with the standard of RMB 1Yuan/Wp based on the actual power-generation operation situation, besides the subsidy of the national favorable policies.

As summarized as above, in China it is in place to develop the large comprehensive demonstration projects of urban solar energy harnessing. Now the large demonstration projects shall be implemented as soon as possible, so as to remove all the constraints on the urban solar energy industry development, and so as to push forward the comprehensive utilization of solar energy totally.

1.3.4.5 Advantageous condition for PV demonstration projects implementation in Hohhot

1. Superiority for policy

As one of the important central cities of the minority areas and the *West Development Stratagem*, in Hohhot the minority autonomous policies and national west development policies are carried out.

In addition, the Hohhot City government also addresses great importance to the utilization and development of solar energy resources, having released the documents of *Regulations on Hohhot People's Government on Further Accelerating PV Industry Development and Development Planning Outline of PV Industry of Hohhot (2010-2020)*, which had laid the solid foundation for the expansion of PV power market in the city.

2. Superiorities for the location and resources

Hohhot is powered by Inner Mongolia West Power Grid under relatively independent architecture where management layers are fewer and it is easier to establish and implement the policy mechanism and management procedure. The city has the big potential to consume the solar PV electricity effectively for its rapid growth of electric power load.

With rich solar resources, convenient land and air transportation system, thorough postal and telecommunication services, mass developing zones, high-quality labor forces and perfect service facilities, Hohhot owns good foundation and conditions for the development and utilization of the solar energy power technology.

3. Industrial advantages

After several poly-crystalline silicon material projects developing and being put into production, e.g. 10,500 tons polycrystalline silicon project started and 1st phase project was put into production of Inner Mongolia Shenzhou Guiye Co, Ltd, 18,000 tons poly-crystalline silicon project of Inner Mongolia Dalu PV Material Co, Ltd, the mono-crystalline silicon and wafer project of Inner Mongolia Zhonghuan PV Material Co, Ltd, and mono-crystalline silicon bar and wafer project being put into production of Inner Mongolia Sunnergy Co., Ltd, the industrial cluster of PV material manufacturing has been established in Hohhot, the dominant product is poly-crystalline silicon and supporting products are complemented by mono-crystalline silicon and silicon wafer.

Hohhot owns complete supporting enterprises for the chemical industry, such as China National Offshore Oil Corporation Inner Mongolia Tianye Chemical Co., LTD, Inner Mongolia Sanlian Chemical Group and others small and medium size silicon or organic chemical enterprises, which provide raw material support for the PV material manufacturing chain.

At present, Inner Mongolia Shenzhou Guiye Co, Ltd has built 100 kW grid-connected PV power project. Other projects are under construction, including 5 MW grid-connected PV power station project in Jinshan Development Zone, 1 MW grid-connected PV power project of Inner Mongolia Shenzhou Guiye Base and 2 MW demonstration projects of Inner Mongolia Riyue Solar Technology Co., LTD, etc.

1.3.4.6 The Problems with building-PV development in China

By the end of 2008, China's installed capacity of building-PV amounted to 26MW, most of which are demonstrative and the commercial operation mode has not established. The current operation mechanism and subsidy policy for PV power projects are still far from guaranteeing large scale and sustainable commercialized development of urban building-PV power system. Therefore, the following problems are still opened in the scale-up developing of building-PV power application,

1. The 50%-70% subsidy rate defined in "Golden Sun Program" is close to that in America and Japan and is also investment-side subsidy. If there will be 500 MW PV power projects new-installed in the next 2-3 years, the amount of subsidies by the state will be up to RMB 10 billion Yuan. It is worthy of discussing whether the government is able to guarantee such large amount each year in its fiscal budget; investment-side subsidy may lead to much more preference of the installed capacity of the equipment to the actual effect of PV power generation.
2. A set of viable mechanism for PV power project is needed. For that building-PV power technology is a fairly new application in China, which involves the use of building roofs, composition of project owners, operation mode of project, application and approval procedures of project, service and maintenance management and settlement, therefore it is necessary for the state to set up a set of viable operation mechanism so as to manage, supervise the work, and to assure the well and ordered development for the PV power projects.
3. The technical standard systems for grid connection shall be further consummated. The building-PV power systems involve use-side grid inter-connection, which directly affects the electricity quality and safety of the end users. As a result, it is necessary for the state to establish and improve the relevant national technical standards, so as to provide the powerful guarantee for the design, installation, grid connection, service and maintenance of building-PV power system.
4. Feed-in-tariff system is needed urgently. Though it is stipulated that the government determine the rate of solar generation tariff, there has not been any uniformed feed-in-tariff policy cross the country concerning solar power generation yet. It is fairly necessary that the state issues the specific rules on the feed-in-tariff of PV power generation and in order to enhance the application of large scale

building-PV grid-connected power.

1.4 Targets and outcome of the project implementation

1.4.1 Implementation target

The first target of the project implementation is to complete the research report on the development planning of urban scale-up application of PV power in Hohhot, and to put forward and establish all the necessary mechanisms including systems, codes, standards and procedures concerning the urban PV application projects and the related incentive policies appropriate to Chinese conditions by referring to the international successful policies and practices, and by complying with the Renewable Energy Law and existing national policies, so as to lay the firm foundation for the implementation of the PV power demonstration project in Hohhot.

The second of this project is to make out planning for the three type demonstration projects of PV application in terms of the building PV power system, suburban deserted land grid-connected PV power system and emergency use PV power, and to bring PV power generation up to 1% of the total power consumption in Hohhot by 2012, and achieve 1.5% by 2015. By considering the conditions of all the aspects, the installed capacity of the PV power systems of the three categories above will be as shown in Table 1-1 below.

Table 1-6 Target total installed capacity by 2012 (MW)

Project	Installed capacity
Building PV power system	15
Suburban deserted land PV grid-connected power system	60
Emergency PV power use	2

The third target of this project is to push forward the urban scale-up PV power to a practically viable stage and then extend over cross the country, as the above two targets are reached.

1.4.2 Anticipating output

1. Complete an investigate report on the roofs of the public buildings in Hohhot
2. Complete an investigate report on deserted salty and alkali land available for PV power in Hohhot;
3. Complete planning report on the development plan for urban scale-up PV power

demonstration projects in Hohhot, based on the studying of the project and the collecting of the foreign policies, standards, codes, information and documentation;

4. Make out management systems for demonstration projects of urban scale-up PV power generation.
   (1) Code for the access of urban building-PV power projects in Hohhot
   (2) Implementation method of Hohhot for demonstration projects of urban building PV
5. Propose the catalog of standards to be established and proposed draft of management codes based on the existing national standards and management codes, and by referring to the international practices.
   (1) Hohhot grid inter-connection technology management rule on the building-PV grid-connected power system
   (2) Technical requirement of grid inter-connection technology on Hohhot building-PV grid-connected power system
   (3) Technical code on Hohhot building-PV grid-connected power system grid inter-connecting inverter
   (4) Hohhot inspection and acceptance code of building-PV grid-connected power project
   (5) Electricity metering and tariff settlement method of Hohhot building-PV grid-connected power
   (6) Interim management method of building-PV grid-connected power technology and the supervision
6. By 2010, the total installed capacity of demonstration projects of building-PV power system, suburban PV grid-connected power system and emergency PV power will come up to 77MW and the annual power generation will account for 1% of the total annual electricity consumption of the city.
7. Set up training bases and training systems of PV power, in order to train PV professional personnel and relieve the talented people insufficiency in the future scale–up development of PV power; Intensifying the acquaintance of the people and the whole society with PV power will help to develop the scale-up application of PV power.

2. Profile of Hohhot

2.1 Social and economic conditions in Hohhot

Hohhot lies on the Tomochuan Plain in the northwest of North China and the middle of Inner Mongolia Autonomous Region at E110°46′–112°10′ and N 40°51′–41°8′. It is the capital city of Inner Mongolia Autonomous Region and the political, economic, technological, cultural and educational center of the region.

Hohhot is located at the intersection of three great strategy bases of Huanbohai Economic Circle, Western Development and Revitalizing Northeastern Old Industrial Base. It is the core of "Hohhot–Baotou–Yinchuan" economic belt and the centre of "Hohhot–Baotou–Erdos" Golden Delta, but also national energy base and distribution centre for international logistics center.

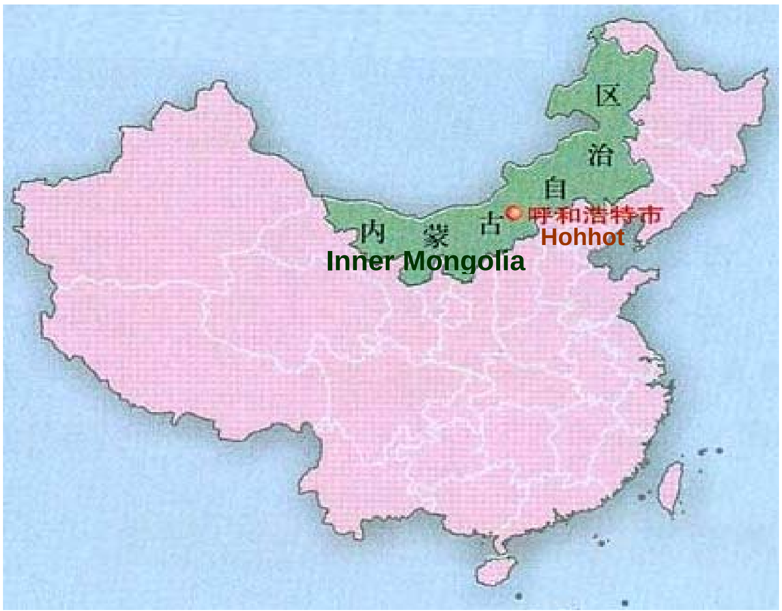

Fig 2–1 Location of Hohhot

Hohhot occupies total land area of 17,000 square kilometers, among which the built–up area is 160 square kilometers, governs 4 districts of Yuquan District、Huiming District、Xichen District、Saihan District, 5 counties of Tumotezuo Qi、Tokto County、Horinger County、Qingshuihe County、Wuchuan County and 1 national level Economic and Technological Developing Zone. The permanent residents is 2.635 million, among which there are 1.7 million urban residents, there are 36 ethnic groups including the Mongolians as the autonomous nationality, Han, Hui, Manchu, Dawoer and Ewenke ethnic groups etc. Hohhot was named as a cultural city of national history, one of China's outstanding tourist cities, exemplary city of the national unity and progress and "Milk

City".

Fig2-2 Region division of Hohhot

Over the past years, Hohhot economy has achieved the rapid, harmonious and healthy development. In 2008, the Hohhot's total production value was up to RMB131.64 billion and the gross local fiscal revenue was RMB15.83 billion. Urban and rural resident's per capita income reached RMB 20,267 Yuan and 7,051 Yuan respectively. The Hohhot regional gross product ranks the No. 4 and the income of urban and rural residents occupies the first place in west 11 provincial capital cities. The above items rank No.19, No.5 and No.9 respectively in the 27 provincial capital cities of China. Hohhot has been awarded the reputation as of "Top 20 Global Growth Cities", "TOP 100 most dynamic cities in China's economic development" and "Top 100 China's tourist cities".

In 2007, Hohhot presented the development strategy of "Being Oriented toward the East"; and meanwhile presented the concept of "One Core and Two Circles" in which (One Core means that the city core area is inside the 2nd Highway; Two Circles of half hour economic circle and half city-town circles with 50 km radius, based upon the 5 base points of the capital towns of the five counties). The constantly improving development ideas aim at developing Hohhot as a regional central city, with a powerful comprehensive service function and radiating driving force.

Hohhot has established a modern agricultural and husbandry system with being centralized of diary, a new industrial system featuring of high technology and high added value and a modern service system dominated by productive services and tourism; the six industrial clusters composed of dairy industry, electric power, IT, bio-pharmacy, metallurgical and chemical, and mechanical manufacture; and three industrial bases of a dairy base, a coal-fired power base and an bio-ferment base. Hohhot is rich in high-purity and high-grade silicon resources, with huge quantity of the reserve, and is suitable for the developing of the poly-crystalline silicon industry, a number of silicon enterprises like Shenzhou Guiye, Nanjing Dalu Poly-crystalline silicon and PV industry projects have been introduced in Hohhot.

2.2 Climate and solar energy resources

Hohhot is subject to the mid-temperate continental monsoon climate where winters are long and cold, summers are short and hot while springs and autumns see the violent changes in the climate. Its annual average temperature increases from north to south. The annual average temperature is about 2℃ in north Daqing Mountain and 6.7℃ in the south. The average temperature of the coldest month keeps as -12.7℃-16.1℃ while the hottest month is 17℃-22.9℃. The frost-free season is 75 days in northern mountainous areas, 110 days in hilly areas and 133-134 days in southern plains. The average annual precipitation is 335.2-534.6mm. The prevailing winds of the year are NW and SW, in May- Sep the SW wind is prevailing; the rest of months are of NW wind.

Table 2-1 Characteristic of extreme weather

Phenomenon of Extreme Weather	Data	Time of Occurrence	Remark	
Maximum air temperature （℃）	36.7	2005.6	-	
Minimum air temperature（℃）	-35.6	2003.1	-	
Maximum daily rainfall（mm）	79.4	2002.6	-	
Maximum wind speed m/s	22.2	2007.5	Wind direction: NNW	
Occurrence of extreme weather in a year (average of ten years)	Type of extreme weather	Frequent occurrence time	Time of duration	Number in a year
	Thunder	March-September	Two hours	4.1
	Stormy wind	April-May	-	3.3
	Sandy-dusty storm	March-May	One day	1.7
	Continuous raining	June-July	Three to four days	-

Hohhot is subject to strong solar radiation and great number of sun shinning hours. For the majority of the region, the annual hours of sunshine range of 2,800-3,000. As recorded at TumotezuoQi Meteorological Station about 70km away from Hohhot (E 111°09', N 40°41'), the average annual solar radiation was 1,319kWh/(m^2 year)and the annual hours of sunshine was 2,863h in 1999-2008, as shown in Table 2-2.

Table 2-2 Average solar irradiation (1999- 2008)

Month	solar radiation MJ/m^2	solar radiation kWh/m^2	Sun shinning hours h	Monthly max wind speed m/s	Daylight max temperature ℃
1	221.24	61.46	180.7	13.20	2.52
2	275.13	76.43	198.3	15.16	9.53
3	409.57	113.77	245.5	17.18	19.19
4	496.21	137.84	268.6	16.32	27.55
5	596.4	165.67	294.5	19.46	32.04
6	558.75	155.21	291.3	15.88	34.28
7	545.31	151.48	265.4	16.88	34.47
8	498.1	138.36	255.3	15.84	32.05
9	381.22	105.89	252.2	16.52	29.66
10	333.2	92.56	244.8	15.98	22.16
11	239.66	66.57	195.3	14.96	13.5
12	196.34	54.54	171.0	13.98	6.32
Total	4,751.13	1,319.76	2,862.8	-	-

In order to further survey solar resource of Hohhot, in Sep 2009, Institute of Electrical Engineering, CAS installed two small weather data acquisition systems in Hohhot to timely measure the horizontal solar radiation, solar radiation on 40° slope, air temperature, wind velocity and wind direction. One system was installed on the roof of the Hotel of Inner Mongolia Electric Power Research Institute (N40°47', E111°40') and the other was on the roof of the office building of Shenzhou Guiye Co, Ltd (N40°47', E111°32'). See also Fig 2-3.

Fig 2-3 Weather data acquisition system

At present, meteorological data from October 2009 to February 2010 has been acquired through the two DAS. The solar radiation data recorded by the two sets of meteorological DAS is shown in Table 2–3, with the preliminary analysis of the data.

Table 2–3 Solar Radiation Data of Shenzhou Guiye (kWh/m^2)

Month	Shenzhou Silicone Office Building		Inner Mongolia Electric Power Research Institute Hotel Roof		Weather Station of Tumotezuo Qi
	40° slope	Horizontal plane	40°slope	Horizontal plane	Horizontal plane
Oct. 2009	171	116	168	120	93
Nov. 2009	112	66	116	65	67
Dec. 2009	92	45	93	44	55
Jan. 2010	101	45	111	53	61
Feb. 2010	98	53	105	57	76
Total	574	324	593	340	352

Note: More details see Appendix 2.

As shown in the above table, the solar global radiation on the horizontal plane is 324kWh/m^2 and 340 kWh/m^2 from Oct 2009 to Feb 2010. The data difference between the two sets of DAS and the TumotezuoQi Meteorological Station are –7.95% and –3.4% respectively, very approximately, compared with 352 kWh/m^2 from the Meteorological Station in Tumotezuo Qi, which is sum of corresponding months (Jan, Feb, Oct, Nov, Dec) of the ten year averagely (1999–2008), Data of solar global radiation on south bound 40° slope are much more of 74.7% and 77.3% respectively than that of solar global radiation on the horizontal plane.

The actual measurement shows that it is viable for the planning of solar power developing to use the multiple years solar global irradiation in TumotezuoQi Meteorological Station, accordingly the number of 1.75 can be used as the multiplying coefficient of southward 40° slope solar global irradiation.

2.3 Roof conditions, suburban deserted land and emergency refuges

Fig 2-4 Hohhot Administrative Map

According to the survey of this project, see also Appendix 3, total of the building area is about 64 million square meters of houses in Xincheng District, Huiming District, Yuquan District and Saihan District, with about 10 million square meters of roof area. Based on the calculation of that 15% of the total roof area can be utilized for PV power, Hohhot owns about 1.59 million square meters of available roofs as shown in Table 2-4.

Table 2-4 Hohhot Roof Conditions (10,000 m^2)

District	Building Area	Roof Areas	Available Roof Areas
Huiming District	1,409	235	35
Saihan District	2,421	403	60
Xincheng District	1,624	271	40
Yuquan District	939	156	24
Total	6,393	1,065	159

According to the statistics (in Appendix 4), there are 27 pieces of waste land in the suburb of Hohhot, the waste land is worthless to exploit and utilize, with a total of land area of 221 square kilometers.

At present, the planned emergency refuges in Hohhot mainly consist of large parks and squares. According to the statistics (see also Appendix 5), there are 33 locations and the organizations equipped with emergency power supplies, including municipal, medical, communication departments, traffic commanding centers, plazas, sports gyms and parks, etc. All the emergency power supplies are intended to meet the need of the comprehensive emergency corresponding loads for the basic daily life needs, commanding, lighting, communicating, and rescue in the special cases.

2.4 Infrastructures

Hohhot is one of the most important central cities for China's West Development Strategy. Here, it enjoys convenient land and air transportation, thorough postal and tele-communication services, sufficient electric power supply, convenient and economical electric power transmission, with many developing zones, high-quality labor forces and the perfect service facilities, which are very beneficial to turning the production elements into productivity advantages rapidly.

Hohhot is predominant in geographical location; in the east is 440 kilometers to Beijing, in the north 490 kilometers to the inland open port Erenhot, the west 150 kilometers to Baotou, 100 kilometers from Junggar large-scale energy base and 300 kilometers away from Erdos natural-gas field in the southwest. Hohhot is one of 45 major transport hub cities in China. Beijing-Lanzhou railway, Beijing-Lanzhou highway, M110 and M209 cross the city. Hohhot-Junggar railway and Hohhot-Junggar highway have become important channels linking the north-west provinces to Beijing. Hohhot Airport has more than 40 skyways to domestic major cities, two international skyways to Ulan Bator of Mongolian and Chita of Russia; cargo chartered air line to Russia and eastern European countries as well as direct line to Hong Kong. The international railway linking Hohhot and Frankfurt, Germany began to run in 2005. The logistics transportation from Hohhot to Russia and other eastern European countries only needs 15 days.

Hohhot is adjacent to the Yellow River and enjoys abundant water resources and substantial reserve of groundwater resources, with total of 1.434 billion cubic meters. Industrial water use is from the Yellow River mainly.

Nowadays, Hohhot owns 10 characterized developing zones and industrial parks which enjoy the national and provincial favorable policies and are equipped with complete infrastructures, which are the important carriers and developing zones for investment attraction.

2.5 Human resource

So far, there has not been the permanent autonomous region-level PV training institution in Hohhot; although the short-term trainings are available on PV technology, the scale and effect are both limited; complete training mechanism is yet to be established; Hohhot city lacks the secondary technician schools specializing PV power application and related disciplines.

As capital of Inner Mongolia Autonomous Region, there are many secondary technician schools and Universities and scientific research institutes where the talents are gathering. Now the city owns 137 research institutes, 17 high educational institutions and 34 secondary vocational schools involving agriculture, husbandry, wood, water, chemical, electric power, metallurgy, electronic information and social sciences. These institutes and schools also help to contribute to the building of PV training centers.

2.6 Power supply and construction

2.6.1 Current power grid in west Inner Mongolia

The West Inner Mongolia Power Grid starts from Alashan Alliance in the west and ends in Xilingole Alliance in the east, including Hohhot, Baotou, Wuhai, Erdos, Bayannaoer, Ulanchap, Alashan Alliance and Xilinguole Alliance. At present, the West Inner Mongolia Power Grid has already established the backbone grid structure of "two-horizontal and three-vertical" with 500 kV backbone network structure. The two 500 kV outbound transmission lines are connected to North China Power Grid through Fengquan-Wanquan-Shunyi and Hanhai-Guyuan- Pingan, and each Alliance or city has the 220 kV power supply grid.

By the end of 2008, the installed (over 6MW) capacity of West Inner Mongolia Power Grid amounted to 28,260.08 MW. There were 76 coal-fired power plants with total installed capacity of 26,332.10MW; one hydropower station with installed capacity of 540MW and 25 wind farms with installed capacity of 1,387.98MW.

By the end of 2008, in the West Inner Mongolia Power Grid there have been 13 substations of 500 kV, being put into operation, with17 main transformers with total transformer capacity of 12,750 MVA; 83 substations of 220kV involving 144 main transformers with total transformer capacity of 20,279 MVA.

At the end of 2008, Inner Mongolia Power Grid had put 34 circuits of 500 KV into service, total length of 3,325.292km; 241 circuits of 220kV with total length of 6,393.756 km.

2.6.2 Status of power grid in Hohhot

Hohhot power grid locates at the hub of West Inner Mongolia grid as a critical part of West Inner Mongolia grid. The power supply area covers 4 districts (Xicheng District, Huimin District, Yuquan District and Saihan District) and 4 Qis (counties) (Tumotezuo Qi, Tuoketuo County, Helingeer County and Wuchuan County). In addition, Qingshuihe County in Hohhot is power-supplied by Xuejiawan Power Supply Bureaus. Siziwang Qi of Ulanchap City is power-supplied by Hohhot grid. Hohhot grid is connected with Baotou grid in the west, with Ulanqab grid in the east and with Wanxue grid through 500 kV Yongshengyu transformer substation in the south.

By the end of 2008, there were 5 coal-fired power plants on Hohhot power grid with total installed capacity of 1,716MW, namely Hohhot Power Plant (2×50MW), Fengtai Power Plant (2×200MW), Jinqiao Thermal Power Plant (2×300MW), China Datang Hohhot Thermal Power Plant (2×300MW) and Tianye Chemical Power Plant (1×16MW). The capacity of one 500kV Yongshengyu transformer substation is 750 MVA; There are 9 substations of 220kV with 14 main transformers already in service with total transformer capacity of 1,860mVA, including eastern Hohhot substation (2×120MVA), Zhaojun substation(2×120MVA), Wusutu substation (2×120MVA), Yanshanying substation (1×90MVA＋1×120MVA), Taigemu substation (2×150MVA), Kezhen substation (1×150 MVA), Gulou substation (1×180MVA), Yunzhong substation (1×180MVA) and Taijiying substation (1×120MVA).

Hohhot power grid has formed a pentagon annular network with Wusutu 220kV substation, Hudongjiao 220kV substation, Zhaojun 220kV substation, Yongshengcheng 500kV substation and Taigemu 220kV substation as the summits.

In 2008, the highest power load of Hohhot power grid in summer was 970MW and in winter was 895MW.

2.6.3 Prediction of load and electricity demand

2.6.3.1 Prediction of load of power grid in west Inner Mongolia

Inner Mongolia has captured the historical opportunity of "Western Development Program", by exerting the location and resource superiorities, Inner Mongolia's economy experienced rapid growth and economic performance has been improved remarkably. More and more optimized economic structure and better and better development potential are emerging.

The rapid economic and social development of Inner Mongolia Autonomous Region has brought along rapid growth of electric power demand. In the "10^{th} Five-year plan" period, the average yearly increase rate of electricity consumption of the whole society in the region was 21.3%. In 2006, the electricity consumption of the whole society in the region amounted to 87,811.87GWh, increased by 31.5% from the previous year. In 2007, the electricity consumption of the whole society in the region amounted to 116,021GWh, by 32.12% from the previous year. In 2008, the power consumption of the whole society in the region amounted to 122,057GWh, by 5.2% from the previous year.

The power demand in the west Inner Mongolia power supply areas has experienced a rapid growth many years. From 1990 to 2005, the power consumption of the whole society averagely increased 14.7% yearly and the average annual growth rate is 10.8% during the "8th Five-Year Plan", 7.97% during the "9th Five-Year Plan" and 25.9% during the "10th Five-Year Plan". In 2005, the total power consumption of west Inner Mongolia grid reached 54,230 GWh; in 2006, it came to 70,152GWh with an increase of 29.36% over the previous year; in 2007, it totaled about 91,266 GWh with an increase of 30.10%; and in 2008, it was up to 96,595 GWh with an increase of 5.8% over the last year.

Being affected by the violent changes of economic environment both domestically and abroad, since the last quarter of 2008, the industrial growth rate of the autonomous region has obviously receded. The prices of coal, steel, nonferrous metal products have dropped sharply; many enterprises have to suspend or partially suspend production; and the electric power load of west Inner Mongolia has decreased obviously. It was in 2009 that west Inner Mongolia was facing the serious challenges. The domestic and international economic situation rapidly changed; the financial crisis has swept across the global and has not yet bottomed; uncertainties and potential risks were increasing significantly; and the outside condition for the country was still rather serious.

However, as the state started to implement a series of policies and to take measures to expand internal demand and facilitate economic growth, and a number of major construction projects were launched in the autonomous region, demand for energy and raw materials were gradually increasing, with the reconstruction of home and domestic enterprises and the speed-up of the adjustment of industrial structure, the power load in West Inner Mongolia has been kept growing steadily.

The prediction of the power grid of west Inner Mongolia was based on the economic development tendency of west Inner Mongolia (see Table2-5).

Table2-5 Forecast on power load of west Inner Mongolia Grid (MW)

No.	Region	2008	2009	2010	Growth Rate of the "11th Five-Year Plan"	2011	2012	2013	2014	2015	Growth Rate of the "12th Five-Year Plan"
1	Hohhot	895	950	1,100	12.89%	1,250	1,430	1,640	1,860	2,100	13.81%
2	Baotou	2,682	2,880	3,300	9.19%	3,800	4,370	4,900	5,500	6,000	12.70%
3	Central of Erdos	678	700	780	13.18%	910	1,120	1,330	1,560	1,800	18.20%
4	Xuejiawan Area	628	650	695	6.51%	810	930	1,110	1,300	1,500	16.63%
4.1	Xuejiawan	393	400	435	4.03%	500	580	680	780	900	15.65%
4.2	Zhun Qi	235	250	260	11.63%	310	350	430	520	600	18.20%
5	Grid of Wuhai	2,152	2,300	2,590	8.54%	2,940	3,320	3,790	4,240	4,700	12.66%
5.1	Wuhai	965	1,000	1,200	5.95%	1,300	1,450	1,630	1,800	2,000	10.76%
5.2	West of Erdos	795	890	930	16.68%	1,100	1,250	1,410	1,560	1,700	12.82%
5.3	Alxa	392	410	460	3.36%	540	620	750	880	1,000	16.80%
6	Ulanchap Gird	1,330	1,435	1,550	9.92%	1,780	1,980	2,190	2,600	3,050	14.50%
6.1	Ulanchap	1,205	1,300	1,400	10.24%	1,600	1,770	1,935	2,300	2,700	14.04%
6.2	Xixi Grid	125	135	150	7.19%	180	210	255	300	350	18.47%
7	Bayinnaoer	987	1,000	1,090	12.09%	1,200	1,270	1,400	1,540	1,700	9.30%
8	Xilinhot Grid	228	240	260	14.01%	300	410	520	660	800	25.21%
9	Total	9,580	10,155	11,365	9.90%	12,990	14,830	16,880	19,260	21,650	13.76%
10	Comprehensive power supply load	8,718	9,241	10,342		11,821	13,495	15,361	17,527	19,702	
11	Maximum power supply load	8,850	9,380	10,500	12.14%	12,000	13,700	15,600	17,800	20,000	13.75%

As indicated in Table 2-5, the maximum power load of West Inner Mongolia Power Grid was 9.38 GW in 2009; by 2010, the maximum power load of the grid will come up to 10.5 GW. The average annual increase rate was 12.14% in the “11th Five-year Plan” period. As estimated, the maximum power load of West Inner Mongolia Power Grid will come to 20GW by 2015. The net increased load will be 9.5 GW, with the annual increase rate of 13.75% in the “12th Five-Year Plan” period.

2.6.3.2 Prediction on the power load in Hohhot area power grid

Under the favorable situation of the state's west development strategy, Hohhot takes full advantages of its geographical location, makes great effort on reform and opening, establishes practicable preferential policies and has attracted a large numbers of industrial enterprises to invest in Hohhot. At present, there have been couple of established economic developing zones of Jichuan, Jinshan, Jinqiao, Ruyi, and Yulong, ect., and the circular economy industrial parks established in Wuchuan, Tuoketuo County, and Qingshuihe District, where the electric power load was increased quickly. In the "10th Five-Year Plan" period, the average increase rate of the city's total power consumption was 11.03%.

With reference to the recent year's economic development of Hohhot City, the estimate of the power load of Hohhot grid in the "11th Five-year Plan" and "12th Five -year Plan" are shown in Tab 2-4. The power load of Hohhot will be estimated as 1.1GW in 2010, the increase rate is 12.89% in the "11th Five-year Plan"; and the highest load of the area will come up to 2.1GW by 2015 and the increase rate is 13.81% in the "12th Five-year Plan" period.

2.6.3.3 Prediction on electricity consumption in Hohhot City

Hohhot persists in taking a new road of industrialization, focuses on developing non-mineral resource and high-technology industry, and makes effort in improving the development level of a new industrialization. Currently, in the city, six advantageous industries such as dairy industry, electric power, electronic information, bio-pharmacy, metallurgical chemical engineering and machinery manufacturing have been formed. In 2008, its gross domestic product achieved RMB 131.617 billion Yuan and has a growth of 13.6% than the last year.

Power consumption of Hohhot for the tertiary industry and resident electricity use and the increase in 2004～2008 are listed in Table 2-6 below.

Table 2-6 Statistic of electricity consumption of the whole society in Hohhot 2004～2008

(0.1 TWh)

	2004	2005	Increase rate	2006	Increase rate	2007	Increase rate	2008	Increase rate	Average increase
Electricity demand in whole society	30.18	46.79	55%	62.52	34%	78.19	25%	82.92	6%	29%
1st industry	3.55	4.9	38%	12.43	154%	7.75	-38%	5.91	-24%	13%
2nd industry	16.7	29.6	77%	42	42%	54	28%	58	7%	36%
3rd industry	4.56	6.42	41%	7.04	10%	8.18	16%	10.1	23%	22%
Resident life	5.37	5.86	9%	7.35	25%	7.74	5%	8.44	9%	12%

As indicated in the above table, the total electricity consumption of Hohhot has increased rapidly in 2004-2006. It has grown at a lower rate from 2007 to 2008; especially in 2008, it developed at a low rate of only 6% due to the economic recession, and the average growth rate was 29% in 2005-2008.

With considering the urban economic and social development factors, the estimate of the electricity consumption of the whole society in Hohhot in 2011～2015 is shown in Table 2-7 below.

Table 2-7 Prediction on electricity demand of the whole society in Hohhot in 2011-2015

(0.1 TWh)

	2011	2012	2013	2014	2015
High plan	97.86	107.65	118.42	130.26	143.28
Medium plan	91.21	98.51	106.39	114.9	124.1
Low plan	85.66	92.17	99.18	106.72	114.83

2.7 Local environment and emission

2.7.1 Local environment state

According to *the Announcement on Environmental Conditions of Hohhot in 2008*, the monitoring results of five urban automatic air monitoring stations indicate that the annual daily mean of sulfur dioxide is 0.049 mg/m^3, nitrogen dioxide is 0.046 mg/m^3, inhalable particles (PM_{10}) is 0.070 mg/m^3. Based on the *Ambient Air Quality Standard* (GB3095-1996), in type-II regions (residential communities, mixed districts of business and traffic and residents, cultural districts, general industrial and rural areas), the daily mean limit value of sulfur dioxide is 0.15 milligrams per cubic meter, dioxide is 0.08 mg/m^3, inhalable particles (PM_{10}) is 0.15 mg/m^3. The daily mean value of sulfur dioxide, nitrogen dioxide and inhalable particles are all meet the Class-II national standards for air quality in Hohhot.

According to the analysis in the daily air quality report of Hohhot by Ministry of Environmental Protection, primary pollutants in Hohhot are sulfur dioxide and inhalable particles.

Coal-fired power plants are the main sources of sulfur dioxide and inhalable particle emission. So far, the total installed capacity of Hohhot is 6.5 GW and that of the power projects under construction amounts to 3.099 GW. Therefore, it is seriously required to control pollutant emission from coal-fired power plants.

Table 2-8 Pollutant discharge of coal-fired power plants Unit: ton

Item \ Year	2006	2007	2008
Chemical oxygen demand	443	362.13	790.72
Emission of ammonia nitrogen		3.4	16.3
Emission of sulfur dioxide	110,695.8	90,372.7	62,965.89
Emission of nitric oxide	101,574	94,762	76,566
Emission of dust	30,368.1	7,721	6,829

2.7.2 Planning of the energy saving and emission reduction

In order to gain the rapid growth of economy, to maintain stable environmental quality of the whole city with evident improvement of people’s lives, and to control the total emission of main pollutants, and to keep on improving the city’s environmental quality, and to build a resources-efficient and environment-friendly society, Hohhot City Government enacted a document of “*Instruction on Accelerating Industrial Structure Adjustment and Reducing Total Pollutant Emission* (Hohhot Gov DRC [2007] 59)”.

In the document, it was stated that "according to the Reduction Target Responsibility Agreement on the total emission of main pollutants in Hohhot during the '11th Five-Year Plan' signed by and between government of Inner Mongolia Autonomous Region and government of Hohhot City, the main pollutants such as carbon dioxide and chemical oxygen demand shall be reduced by 18.76% and 5.19% respectively from 2005 levels by 2010.

By 2010, the emission of sulfur dioxide in Hohhot must be controlled below 94,000 tons, among which the emission of sulfur dioxide from thermal power industry shall not exceed 64000 tons. In order to ensure that the goal can be achieved, while accelerating the development of clean energy, the desulfurization application and expansion in coal-fired power plants shall be speeded up ".

2.8 Application of PV power technology and the policies

2.8.1 Application of PV power generation in Hohhot

Hohhot is engaging in its grand goal of "Great Change in10 Years" in urban construction, goal of which are to make the layout of urban construction more rational, to have the urban functions more perfect, features more distinctive, ecological environment more favorable, management more scientific and environment more beautiful. The purpose is to make Hohhot a national forest city and a model city of environmental protection.

So far, a 100kW grid-connected PV power project has been built in Inner Mongolia Shenzhou Guiye PV Base. Projects undergoing include: a 5MW grid-connected PV power station project in Jinshan Development Zone, a 1MW grid-connected PV power project at Inner Mongolia Shenzhou Guiye Base and a 2MW demonstration project of Inner Mongolia Riyue Solar Energy Technology Co., Ltd, as shown in Table 2-9.

Table 2-9 Application summaries on PV power technology of Hohhot (kW)

No.	Name of Project	Geographical Location	Type	Commence-ment of Construction	Scale of Construc-tion	Progress
1	Demonstration project of solar PV power on the roof of factory in Inner Mongolia DaLu Polycrystalline silicon	Tuo County	Grid-connected power	2009	1,000	Project preparation stage
2	BIPV project of Inner Mongolia Shenzhou Production Base	Jinqiao	Grid-connected power	2009	1,196	Project preparation stage
3	Golden Sun demonstration project of Inner Mongolia Riyue Solar Energy Technology Co., LTD	Ruri South District	Grid-connected power	2009	2,000	Project preparation stage
4	Golden Sun project of Xiangdao Ecological Agriculture Manor	Baoheshao Town of Xinchen District	Grid-connected power	2009	2,000	Project preparation stage
5	MOST 3 – 5 kW PV grid-connected demonstration project	Xincheng District	Grid-connected power	2006	3	completed
		Saihan District			3	completed
6	Demonstration of Wind Power /Solar energy street lamp	In the Courtyard of IIM DRC, East 2nd Ring	100W Solar +100W Wind Power	2009	15	completed

2.8.2 Policies

1. *Regulations of Hohhot City People's Government on Further Accelerating PV Industry Development*

The document stipulated that all preferential conditions shall be assured on the aspects of the organization leadership, administrative services, land use, power use, water and gas supply, taxation, administrative fees collection, corporate financing, construction of technical innovation platforms, talent education, training and incentive mechanisms, etc. Meanwhile, on the aspect of the expansion of solar energy PV market, the Regulations specifically pointed out that "'Solar Roof Program' shall be actively carried out for the demonstration projects of PV-buildings; much efforts shall be made on a number of key projects in order to ensure the annual construction capacity of no less than 5 MW each year; priority shall be given to the public buildings such as government office building, schools, hospitals, airports, activity centers for teenagers, etc; subsidies of RMB 10 Yuan per watt shall be given by the government so as to subsidize the initial investment of PV application and the subsequent yearly subsidies amount shall be tuned according to the future development of industry."

2. 11th *Five Plan of Hohhot for Energy Conservation and Emission Mitigation* (draft for discussion)

Enhance utilization of renewable energy. The demonstration projects of water sources, ground source, wind energy, solar thermal, solar PV, and BIPV and so on shall be integrated by integrating urban residence and public buildings construction and retrofitting, With regard of any newly-built projects, demonstrative project of architecture science and technology as well as renewable energy application which have executed the 50% energy-saving standards can enjoy the de-rating policy of RMB-20-50 per square meter in terms of urban supporting facilities.

3. *Hohhot Industries Development Planning Outline* (2010-2020)

Substitution of 1.1 million ton standard coal, reduction of emission of 2.8 million ton carbon dioxide, 9300 ton sulfur dioxide, 8,100 ton nitrogen oxide shall be gained each year.

Increase the proportion of new energy; bring the installed capacity of PV power up to more than 15% over the city's total installed capacity, accounting for around 5% of the PV power in China by 2020.

In terms of the application of PV power, relying on some undergoing and proposed projects such as BIPV/BAPV, PV stations and wind farms in Hohhot city area, Jinshan, Wuchuan and other urban district, several application zones of demonstrating PV power and wind-PV hybrid power generation zones shall be established. 1) Project development shall be stressed on the BIPV/BAPV demonstration application of at public building such as schools, hospitals, airports, centers for teenagers, government departments, and a couple of solar powered lighting demonstration projects shall be implemented by selecting highways, urban main roads, parks, squares, residential areas, large buildings and landscape lighting so as to expand the market of solar energy application. 2) Greatly develop the wind -PV hybrid power in Wunchuan County in terms of wind power projects, the focus shall be on the wind-PV hybrid power projects, by selecting the area as the wind farm where is of rich solar energy resources and the transmission lines are reasonable. 3) Promote the deserted land solar power stations developing, in the unutilized waste land area in Hohhot, by selecting the sites where the backbone grids have the enough bearing capacity and are adjacent to the power load centers."

4. Construction Planning Outline for Hohhot City New Countryside (draft for comments)

Rural grid reconstructing and retrofitting shall be enforced; "Village-to-village and Household-to-Household Electrification Program" shall be fully implemented while strengthening the construction and renovation of the rural grids. The power supply such as grid extension, new village centralized power supply system, independent household power supply system of new energy shall adopted to enhance the dispatching capability of rural grid and to solve the problems of rural electricity accessing and rural electricity use in rural area step by step.

Actively develop clean energies of wind energy, solar energy and small hydropower projects which are suitable to the rural area, extend "Electricity Substitution of Fuel", and the renewable energy technologies of solar water heating; to integrate the renewable energy utilization with environmental protection in the rural areas closely and provide clean living energy for farmers.

3. General Plan of Project Implantation

3.1 General design

According to the predicted total power consumption of Hohhot in future, considering the high, medium and low options, by 2012, the power consumption of Hohhot will come to around 10 GWh. Assuming that in Hohhot annual PV systems operation hours is 1,300 hours, in order to reach the target that PV power generation will be 1% of the total power consumption in Hohhot, the needed installed capacity of PV power system should be 77MW or more.

The PV development program of Hohhot covers building PV power system, suburban deserted and waste land PV power system and the PV power supply in the emergency system. Based on the usable area of the building roofs in Hohhot, the area of the usable open field in the suburb and the power capacity required for the emergency systems, the proposed installed capacity by 2012 are shown in the table below:

Table 3-1 Installed PV capacity of Hohhot in 2012

Project type	Installed capacity
Building PV power system	15 MW
Suburban open field PV power system	60 MW
PV power in emergency system	2 MW

After the demonstration project is implemented, the project implementation experience shall be concluded, the trial mechanisms, standards and codes will be improved as well, the subsequent projects shall be proceeded and expanded. The target is that PV power generation will be 1.5% of the total power consumption in Hohhot in 2015.

3.2 Demonstration projects of PV power generation（2010-2012）

3.2.1 Building PV power system

3.2.1.1 Capacity planning

Roof PV system belongs to one of the building amounted PV in the building integrated PV. That is, to install the sealed PV panel (flat or curved) on the roof of a building already completed, and connected to the distributed generation system of the power grid on the end user side. This is a method to utilize the solar energy by cumulating. So far, the total installed capacity in the world is very large under the proven technology, and the management is being systematized.

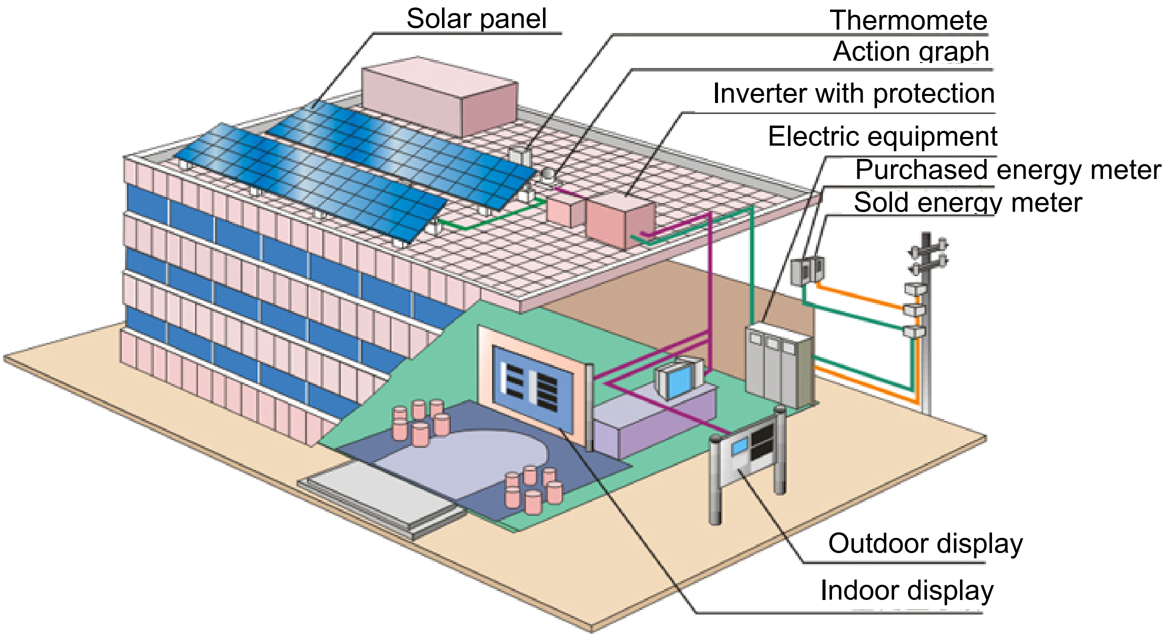

Fig 3-1 Building PV power system

In this report, Hohhot roof grid –connected PV power project is divided into four districts to implement: Huiming District, Hansai District, New City District and Yuquan District where the building roof area will be utilized one by one. The surveys show that Hohhot now has about 64 million square meters of residential buildings with about 10 million square meters of roof. Supposed the 15% of roof area is available for PV power system installation, the development potential for the building PV power is 160MW, as detailed in the table below.

Table 3-2 Potential of Building PV development capacity in different districts of Hohhot

Description	Proposed District	Building area (10^4 m^2)	Roof area (10^4 m^2)	Available capacity for development (MW)
Building roof gridded PV power	Huiming District	1,409	235	35
	Saihan District	2,421	403	61
	New District	1,624	271	41
	Yuquan District	939	156	23
Total		6,393	1,065	160

The potential calculation formula of the building PV power system is as follows:

$$S_d = S_j / 6$$

$$G = S_d \times 15\% \times 100W / m^2$$

Where:

Sj—House building area;

Sd—roof area;

6 — Number estimate of the buildings floors in general;

15%—Proportion of available roof area;

100W/㎡—Installation density of PV systems.

Under the priority to urban public buildings and public welfare buildings, in accordance with the statistics of the buildings qualified for installing building PV power system, the capacity of the building PV power system available for priority development is as listed below:

Table 3-3 Proposed installed capacity of different districts of Hohhot

Projects	Planned districts	Building area (10000 m^2)	Roof area (10000 m^2)	Installed capacity (MW)
Building PV grid-connected power	Huiming District	80	13	2
	Saihan District	200	33	5
	New District	240	40	6
	Yuquan District	80	13	2
Total		600	100	15

It is planned that the building-PV power projects will be completed in three years. By 2012, 1 million square meters of roof in the four districts will be installed with PV power system with total capacity of 15MW.

3.2.1.2 Prediction of the power generation

With the solar radiation data for power generation prediction, the 1,319kWh/m^2 in Tab 2-2 is used herein, an average data of Hohhot yearly based on the Tumotezuo Qi Meteorological Station data in 1999-2008.

There are various energy losses in electricity transferring of grid-connected PV power system, which result in not all 100% of the electricity generated enter the grid. The losses of PV system are listed in table 3-4,

Table 3-4 Losses of PV system

Temperature loss	~1-2%
Inverter loss	~2-3%
Loss from PV array matching	~1-2
DC line loss	~0.5-1.5%
AC line loss	~1.0-2.0%
Pollutant loss	~3%
Total	～16-20%

It can be concluded from Table 3-4 that the total loss of the PV system is about 18%. Namely, the system efficiency is 82%.

Hohhot is located on the north latitude 40°. In order to pursue the maximum power output, 40° slope be defined as the installation angle of the PV array. Based on the system efficiency of 82%, with the preliminary calculation, the 1st year power generation in these four districts is in Table 3–5.

Table 3–5 Estimation of power generation in the first year each district Unit: 10,000 kWh

Month	Solar radiation	Huiming District	Saihan District	New City District	Yuquan District	Grand Total
		2MW	5MW	6MW	2MW	
Jan	61.46	19	47	57	19	142
Feb	76.43	20	51	61	20	153
Mar	113.77	26	65	78	26	194
Apr	137.84	31	77	92	31	230
May	165.67	32	81	97	32	244
Jun	155.21	30	74	89	30	223
Jul	151.48	28	70	84	28	210
Aug	138.36	25	64	76	25	191
Sep	105.89	23	57	68	23	170
Oct	92.56	21	54	64	21	161
Nov	66.57	18	44	53	18	132
Dec	54.54	17	41	50	17	124
Total	1,319.78	290	724	869	290	2,173

As shown in Table 3–5, in the 1st year, 21.73GWh electricity will be generated by the 15MW PV power system in the four districts. Assuming power system output attenuation rate is 20% over 25 years, the annual power generation in the last year will be 17.56 GWh. The yearly power generation over the 25 years service period will be 19.64GWh averagely, and the total power generation will be 490GWh, showed in table 3–6.

Table 3–6 Calculation of electricity generation of the power system in 25 Years

Year	Electricity generation (10MWh)	Year	Electricity generation (10MWh)	Year	Electricity generation (10MWh)
1	2,173	10	2,016	19	1,860
2	2,155	11	1,999	20	1,843
3	2,138	12	1,982	21	1,825
4	2,121	13	1,964	22	1,808
5	2,103	14	1,947	23	1,790
6	2,086	15	1,929	24	1,773
7	2,069	16	1,912	25	1,756
8	2,051	17	1,895		
9	2,034	18	1,877		

3.2.2 Suburban PV power system

3.2.2.1 Capacity planning

Building open-field grid-connected PV power system is the inevitable way for the development strategy of solar PV power generation, as the direction of PV power, and it is the mainstream of the world's PV power. At present, a large number of field grid-connected PV power stations have been built and operated. As it is proved by practice, with matured technology and remarkable economic, social and environmental benefits, grid-connected PV power in the open areas is becoming one of the main power technologies in the future.

By utilizing the deserted land resources and abundant solar energy resources in the suburb of Hohhot, the technical features of PV power generation with simple and flexible installation and maintenance, and modularization shall be exerted as much as possible. The large scale grid-connected PV power stations will be built so as to be suited to the sites conditions and to supply green electricity for the suburban power grid and residents.

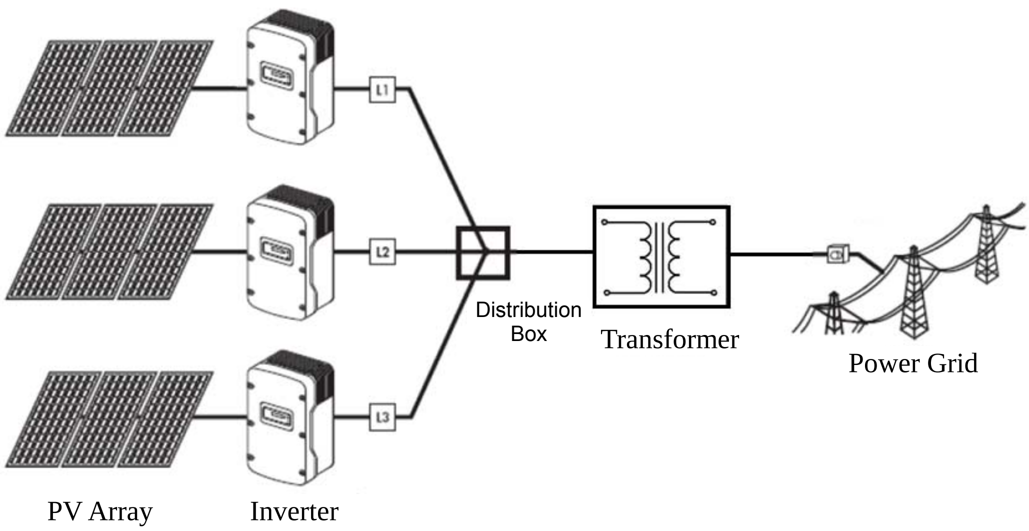

Fig 3-2 Architecture of suburban PV power system

There are total of 27 pieces of waste lands for grid-connected PV power plants in the suburb of Hohhot being surveyed, totally with 221 square kilometers (showed in table3-7). Based on the 30MW installed capacity per square kilometer, the potential capacity for development of PV power is roughly 6.6GW.

Table 3-7 Waste land survey for PV power plants sites in the suburb of Hohhot

No.	Name	Area of field (sq. km.)	Conditions of grid inter-connection		Meteorological Station	
			Distance away from substation (km.)	Voltage (10,000 kV)	Name	Distance (km.)
1	Natural Village West, Taisuiying, Yingcun Village, Nanguo County	6	1	50	Tuo County	30
2	Zhangzong Village Southeast	0.67	1	3.5	Tuo County	26
3	Baohaoying Village West	1.3	1	3.5	Tuo County	25
4	Shenli Getu Village South	6.67	6	50	Tuo County	38
5	Beidou Lingai Village Southeast	0.87	4	3.5	Tuo County	30
6	Xinhe Village, Wushenjia Town	1	6	3.5	Tuo County	15
7	Zhangsihao Village, Shuanghe Town	1.5	7	3.5	Tuo County	7
8	Yangsanyao Natural Village, Administrative Village, Hetongying, Xinyingzi Town	2	7.5	3.5	Tuo County	20
9	Dabeiyao Village, WuShenjia Town	1.9	8	3.5	Tuo County	20
10	Zhulihan Natural Village, Shulin Administrative Village, Wushenjia Town	0.67	12	3.5	Tuo County	15
11	Guanshiyao Village North Beach	3	15	3.5	Tuo County	15
12	Naitongying Village Northwest Beach	3	15	3.5	Tuo County	10
13	Sangai Village South Beach	2.5	15	3.5	Tuo County	10
14	Wushenjia Village, Wushenjia Town	1.33	18	3.5	Tuo County	18
15	Liuheying Beach, Shangtuhai Country, Wuchuan County	6.9	14.5	22	Wuchuan County	22
16	North District, Village Committee, Donghouhe Village, West Wulan Bulang Town, Wuchuan County	35	3	11	Wuchuan County	47
17	Northwest District, Village Committee, Shenlatu Village West Wulan Bulang Town, Wuchuan County	53	1.5	5	Wuchuan County	53
18	Deshenggou Country, Wuchuan County	2.3	7	5	Wuchuan County	32
19	Shuangyucheng Village Committee	15	5.2	11	Wuchuan County	50

No.	Name	Area of field (sq. km.)	Conditions of grid inter-connection		Meteorological Station	
			Distance away from substation (km.)	Voltage (10,000 kV)	Name	Distance (km.)
20	Datan North District Northwest District, Village Committee, Shenlatu Village West Wulan Bulang Town, Wuchuan County	41	4	5	Wuchuan County	58
21	Shangsanhao Village South, Gonghuci Village Committee	5.5	3.6	11	Wuchuan County	53
22	Honghezhen Country, Econonic Development Zone, Qingshuihe County	1.5	1	110	Qingshuihe County	23
23	Guliban Village South, Shengle Town, Helin County	4	3	110	Helin County	30
24	Yuxitou Village Northeast, Chengguan Town, Helin County	6.67	8	110	Helin County	45
25	Shebiya Village, Shebiya Country, Helin County	5.33	12	110	Helin County	30
26	Dazaolai Village South and Surrounding Area, Shebiya Country, Helin County	7.33	4.5	110	Helin County	30
27	Dielisu Village South and Surrounding Area, Shebiya Country, Helin County	5.33	4.5	110	Helin County	30

The surveyed deserted and waste land is classfied into 5 classes by the distance between power grid and candidate sites, the capacity potential of sites are listed in Table 3-8 below,

Table 3-8 Classification statistics of distance from deserted land to grid

Distance between site and substation (km)	Area (km^2)	Theoretical available capacity for development (MW)
1～3	101	3,030
3～5	60	1,800
5～10	37	1,110
10～15	13	387
15～18	10	295

As the first batch of projects of grid-connected PV power in the suburb of Hohhot, it is proposed to select the suitable waste land within 1～5km range of the substation, the grid-connected PV power stations will be 60MW totally by 2012. The electricity generation of the PV power station will be supplied to the local grid via step-up transformers and to meet the living electricity use of the residents for the daytime.

3.2.2.2 Prediction of power generation

The solar radiation data for power generation calculation of suburban grid-connect PV power system is 1,319kWh/m^2 showed in table 2-2, which is the average yearly data in 1999-2008 provided by Tumotezuo Qi Meteorological Station.

It is impossible to transform 100% of electricity into the grids due to various losses in energy transmission. The losses of PV system showed in table 3-9.

Table 3-9 Losses of PV power system

Temperature loss	~1-2%
Inverter loss	~2-3%
Loss from PV array matching	~1-2
DC line loss	~0.5-1.5%
AC line loss	~1.0-2.0%
Pollutant loss	~3%
Total	～16-20%

According to practice, the total loss of suburban PV power system is about 20%, so system efficiency will be 80%.

Hohhot is located on the north latitude 40°. In order to generate maximum electricity, 40° installation angle is defined for the PV array. Based on the system efficiency of 80% and local solar irradiation, with the roughly calculating, the 60MW suburban grid- connected PV power system's electricity generation in the first year, as shown in Table 3-10.

Table 3-10 Estimation on power generation of suburban PV system in the first year Unit: 10,000 kWh

Month	Solar Radiation	Electricity generation	Month	Solar Radiation	Electricity generation
Jan.	61.46	590.5	July	151.48	798.5
Feb.	76.43	620.9	Aug.	138.36	732.6
March	113.77	768.6	Sep.	105.89	668.2
April	137.84	889.1	Oct.	92.56	649.2
May	165.67	927.4	Nov.	66.57	550.2
June	155.21	842.1	Dec.	54.54	518.8
Total				1319.78	8,556.1

As shown in Table 3-10, about 85.56 GWh of electricity will be generated by the 60MW

PV system of suburb in the first year. Assuming the output attenuation of 20% of the system over 25 years, the annual power generation in the last year will be about 69.13 GWh. The annual power generation of the PV power system in the 25 years service period will be 77.34 GWh yearly, and the 25-year total power generation will be about 1,930 GWh, showed in table 3-11.

Table 3-11 Power generation calculation of the PV power system in 25 Years

Year	Power generation (10 MWh)	Year	Power generation (10 MWh)	Year	Power generation (10 MWh)
1	8,556	10	7,940	19	7,324
2	8,488	11	7,872	20	7,256
3	8,419	12	7,803	21	7,187
4	8,351	13	7,735	22	7,119
5	8,282	14	7,666	23	7,050
6	8,214	15	7,598	24	6,982
7	8,145	16	7,529	25	6,913
8	8,077	17	7,461		
9	8,009	18	7,392		

3.2.3 PV power supply in emergency system

In Sep 2004, at the 4th plenary meeting of 16th term CPC, it was clearly pointed out that whole society alarming system shall be established, and the emergency responding system shall be set-up with unified commanding, complete functioning, prompt responding, and effectively operating, the ability to assure the public security and to handle abrupt events shall be improved.

In the clause 6.1.4 in article 6 of the national standard - *Sites and Ancillary Facilities for Earthquake Emergency Refuges (GB21734—2008),* it was specifically presented that "emergency power supply facilities shall be installed so as to assure the electricity use for lighting, medical treatment and communication, the power supply system shall be powered by multiple circuits power grid or powered by solar energy, or equipped with portable generators as emergency power supply facilities".

Electric power is the basic conditions for life and work. Establishing effectively electric power security & emergency-responding mechanisms and dealing with power emergencies rightly, effectively and rapidly are of significance in safeguarding national security, social stability and the safety of citizens' lives and properties.

At present, many cities in China are building emergency refuges, most of which use diesel generator as the emergent standby power. Diesel generator is widely used for the stability of operation, portability and practicality, but fuel supply and high noise are fatal drawbacks.

PV power is characteristic of easily installing and flexible size. In case of failures of the power grid, PV power enables to supply continuously electricity and provides important guarantee of electricity for the rescue and relief, emergency responding, and maintaining for basic living of the victims. As a result, solar PV power system installed in emergency refuges and public places as emergency power supply, supplying necessary electricity in the event of disasters to assure the electricity supply for the important institutions of communication, commanding and medical treatment, will help to relieve the disaster, mitigate the losses from the disasters, and to minimize the damage to people’s lives and properties. Even in the stage of reconstruction after disaster, PV power system can provide electricity as ever before.

3.2.3.1 PV application in emergency system

1. PV power application in emergency refuges

So far, in Hohhot, the planned urban emergency refuges are mainly of the large parks and squares where necessary open areas are planned as shelter areas for large numbers of victims of a calamity. Each of the emergency refuges is the main gathering place and aid center for victims of disaster, where the integrated power supply shall be assured for the daily life, commanding, lighting, communication and first aid. According to the characteristics of refuges, the applications of emergency power supply can be classified as follows,

- Centralized supply power, providing electricity for work lighting, communication dispatching, control & management and medical rescue etc.
- Distributed supply power, providing independent road lighting, signal instruction, domestic power, and power for special equipment.

In the light of the above power supply methods, there are several combinations of solar PV power system with emergency power supply.

a) PV systems are installed on the roof of emergency refuges such as landscape buildings, houses and buildings, bulletin boards, resting areas and other facilities with wide coverage. The power generated by PV system will be fed into grid and can be used to charge batteries as well.

Characteristics:

- In the non-emergency cases, the power generated by PV system not only powers lighting for parks and squares and supplies electricity for daily use, but also reduces the conventional power consumption in refuges. Thus the goal of energy saving will be attained.
- Substitute power grids to charge batteries used as energy reserves and ensure batteries to be always fully charged.
- In case of emergent events (breakdown of the public power grid), it will replace the power grid and supply great amount of electricity, so as to ensure the electricity supply in the daytime and store the electricity use for night.
- Compact and beautiful, no extra land area occupation and harmlessness to the environment of the scenic spots.

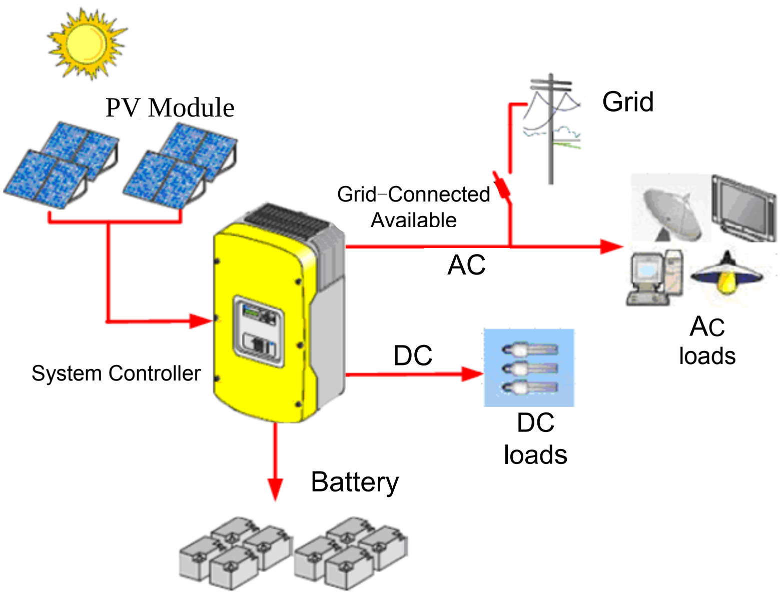

Figure 3-3 Composition of centralized emergency PV power system

b) A number of portable PV systems can provide power to the evacuated people, for lighting and basic electricity use. At present, portable PV power system are mostly used in nomadic families in the west China. In the daytime, a small solar panel can be unfolded to charge the built-in storage batteries, which can power the lamps at night.

Figure 3-4 Composition of portable emergency PV power source

Characteristics:

- Portable PV power source, as a small power supply system, provides electricity for both lighting at night for the groups in tents and electricity for radios, and power to the small equipment charging.
- In the daytime, portable PV power source charges the built-in storage batteries, which supply power for the lighting at night, and ensure power for other small equipments.
- Small and easily moved, the system can meet the electricity need of the small scattered groups.
- The system is simply structured and cheap. The size of system can be designed flexibly according to the usage requirements.

c) Upgrade the street lamps, indicating boards and signal lamps by applying the PV power system. These lamps can be directly retrofitted into the solar energy powered facilities or the hybrid facilities. Usually the faculties are powered by utility grid, in emergency powered by solar PV power system.

d) Special equipment used for emergency medical rescue and communication control shall be equipped with PV power supply, according to the electricity use features of the equipment and the power supply requirements in emergency. Special solar panels and system controllers can be designed for specific purposes. Under normal circumstances, the power supply is used as electricity storage equipment, in emergency, it can be unfolded on an open field and power supplies directly to the equipment.

2. Emergency PV power application in schools and sport gym

Schools and stadiums are also planned as emergency refuges in emergence. since these two facilities are simple with limited space, which mainly are composed of buildings and play grounds, where a certain number of emergency PV power supplies may be furnished to guarantee the night time lighting and necessary communication in the event of emergency.

Power consumption in schools and stadiums mainly are used for lighting under normal conditions. For the roof PV power provide most of the load for daytime lighting and help to save the electricity. Besides, installing PV systems in schools is of the importance of educating of PV power technology.

3. Emergency PV power application for first aid in hospitals

Emergency power supply for first aid in hospitals mainly assures the electricity supply for lighting and basically necessary equipment in the operation rooms, rescue rooms and emergency wards. By selecting the roofs of the hospital buildings, PV power system is amounted on the roofs and inter-connected to the existing emergency power supply system, and the existing emergency power supply will be recharged by solar energy, as the electricity is out of use, PV power supply can be assured when the power grid is off for a long time as well.

4. Emergency communication and commanding PV power for transport and fire-alarming

With regard to the transport and fire-alarming systems, it is essential to guarantee power supply for the lighting and communication devices in the event of emergency. As these electricity-using devices consume not very much and with high mobility requirement, It is recommended that the portable PV power supply is in priority to choose, so as to guarantee timely and effective electricity supply for the communication devices.

3.2.3.2 Capacity designing

As investigated, there are 33 organizations and locations in Hohhot which have been installed emergency power supply system, including municipality office buildings, medical treatments, communication, fire-fighting, transport commanding centers, plazas, sports gyms and parks. Emergency loads mainly include lighting devices, office devices and communication devices. As partial devices need to work normally under emergencies against abrupt events, the emergency power supply capacity should be ranged of roughly 10%~15% of the load capacity.

According to the state requirement for emergency refuge electricity use, and in order to satisfy the comprehensive needs of emergency electric power load for the basic daily life, commanding, lighting, communication and the first aid in the special periods of time, the total emergency power of Hohhot is estimated roughly as 2 MW, as shown in the table below.

As the emergency load category varies from various organizations and locations, the emergency power capacity to be installed is as detailed in the table below.

Table 3-12 Planning capacity of emergency PV power supply in Hohhot

Organization /location	Estimated capacity kW）	Organization /location	Estimated capacity（kW）
Government/ administrations	310	Traffic commanding center	100
110 commending centers	100	First aid centers	130
Communication	1,200	Squares /parks	220
Total		2,060	

With considering that emergency PV power is not intended to generate the electricity and supplied to grid, the main goals is to guarantee the battery to be fully charged and to supply power of emergency responding in the small range, therefore in this report the power generation is not calculated with the emergency PV power system.

According to the prediction above, the total power generation from the building PV power system and suburban PV power system will be 107 GWh in 2012, with occupying about 1% of the predicted power generation of Hohhot of the year.

3.2.4 Project implementation plan

According to the distribution features and relevant construction conditions for the three types of demonstration projects, namely building PV power system, suburban PV power system and emergency PV power system, under the unified guidance of Hohhot City Government, by integrating urban development plan of the Hohhot and the relevant regulations of urban grid-connected PV power system and the local conditions of power grid, supporting industrial projects and local economy, and so on, the demonstration projects shall be carried out stage by stage, so as to ensure the smooth implementation of the demonstration projects.

The yearly targets are as follows,

No. 1 stage (in 2010): According to the relevant requirement and the planning, the projects planning report shall be submitted as soon as possible, and the project feasibility study and the preparations for the implementation of the project shall be launched; the relevant information needs to be further surveyed and summarized, so as supply the basic information for project implementation; the medium-and-long term development plan of the PV power in Hohhot based on the information shall be made well, in which the categorization, distribution and implementation methods of the application of Hohhot PV power shall be clearly defined as well. The relevant organizations and departments lead and organized by Hohhot City Government shall work out and promulgate the guideline documents for urban PV power development, set up institutions, standardize the implementation procedures and requirements of management, and improve the standard and code for the PV grid inters-connecting. Fully preparation shall be made in the early stage of urban large scale PV power demonstration project.

No.2 stage (in 2011), the public bidding and construction work shall be finished in terms of 5MW building PV power system and 20MW suburban PV power system based on various standard and regulations. Through the project implementation, the rationality of all the standards, regulations and criteria should be further testified and improved as well.

No.3 stage (in 2012), based on the experiences of the first half year's work, the public-bidding and construction task for the 10MW building-PV power system, 40MW suburban PV power system and the 2MW emergency PV power shall be completed, and to reach the targets of the overall plan.

With the completion of the above three stages, Hohhot Development and Reform Committee organizes the relevant institutions to evaluate the implementation of the demonstration project, discuss the problems occurred in the implementation process, and the rationality of standards and regulations, summarize the experiences, so as to make out a set of project management mechanisms and extend it to other cities.

No.4 stage (in 2015): by summing up experience and advancing the trial mechanisms, standards and codes, other 20MW building-PV power system, 60MWt suburban PV power system shall be built with efforts by 2015, based on the Hohhot City PV power developing potential and the China's PV power application level in current time, PV power generation will be up to 1.5% of the total power consumption in Hohhot in 2015.

3.3 Comparison on the project implementation and schemes

Urban PV power application is the important market of large scale application of power generation of PV technology. Some developed countries have it listed as the key project to be developed. The building-PV power generation is connected into the grid on the users' side; electricity is generated and consumed locally, which saves the investment in power generation and transmission. The technology can not only effectively reduce building energy consumption, but also meet the power demand in daytime, for the coincidence of time between the electricity generation and the electricity consumption.

Building PV power system is very promising in urban PV technology application and has been widely used in Europe, America and Japan. By of the end of 2008, the installed capacity of building-PV power amounted to 26MWp in China, most of which are demonstration projects The international experience shows that the effect of investment-side subsidy is not as good as that of tariff-side subsidy because the latter can more easily form an effective business operation model. In China, with regard to the urban scale-up commercial application of building-PV power, the firstly needed issue is to clarify what kind of ownership companies will have the right to develop the projects, how to organize the approval of projects and to implement the projects, especially the management and maintenance responsibility after the completion of the projects' construction, and the metering of electricity generated and settlement of the power tariff so that urban PV power system can not only be installed in large scale, but will also operate safely and sustainably.

As a demonstration project of urban scale-up application of PV power, utility grid company plays an irreplaceable important role in the project implementation, in this report the three options for the construction, management and operation and maintenance associated with the building PV power project in Hohhot are presented herein preliminarily: utility grid company will be as the main body of operation, power generation company as the main body of operation, and roof owner independently invests.

3.3.1 Principal operation mode of power grid

The project owner may be solely of Inner Mongolia Electric Power (Group) Co., Ltd, or by cooperating with the large power generation enterprises and competent PV power product manufacturers in China, Hohhot Urban Solar PV Power Co., Ltd is set up, to be responsible of the project construction and the operation, maintenance and management thereafter with Inner Mongolia Power (Group) Co., Ltd as the main investor, PV power system is managed as the peak-clipping power source.

In the early demonstration project, Hohhot Urban Solar PV Power Co., Ltd will use the roofs of large and medium state-owned enterprises workshops, non-profiting organizations and government office buildings within the jurisdiction region of Hohhot, the roof will be acquired uniformly by Hohhot City Government, with proper compensation, unified management, and package development.

The project will be deployed with the system of unified application, approval, design, procurement and construction, and be supervised and accepted under the applicable national systems and standards in order to ensure the construction level and service quality of the projects.

As the project is completed, Inner Mongolia Power Co. affiliated power supply organizations can be assigned to supervise the operation of the system by remote monitoring or local inspection periodically, to record the electricity generation, and notify maintainers to inspect and repair on the spot as finding any of failures or abnormalities in the system equipment.

3.3.2 Principal operation mode of power generation companies

Large power groups in China may set up a PV power generation Co., Ltd either alone or together with Inner Mongolia Power (Group) Co., Ltd with responsibilities for the project construction and the operation, maintenance and management thereafter, with large power groups are the main body of investment.

As for the implementation of the project, Hohhot will be divided into 4 districts based on the administrative area, the available capacity shall be determined according to the different conditions, and the public bidding for building PV power projects in each district shall be done in separate 4 packages. The 4 winner companies will develop the project in their own districts respectively.

In the first stage, the 4 owner companies will use the roofs of large and medium state-owned enterprises workshops, non-profiting organizations and government office buildings within the jurisdiction of Hohhot; roof acquisition is done by Hohhot City Government with a given compensation. Projects of each district will be submitted for being approved and procured separately, the unified design will be done by Inner Mongolia Power Design Institute, the project will supervised by governmental authorities, and will be supervised and accepted under applicable national systems and standards so that the investment will be relative independent and the implementation will be relatively unified.

If ownership firm consists of power generation enterprise alone, Inner Mongolia Power Co. may be consigned to monitor the operation and power generation quantity of PV power system, the owner company's maintainers shall be notified for any abnormalities or failures with paying according fees to power company. If power generation company holds share by providing operation and maintenance and monitor the operation of the system, inspect and maintain the system and measure the power generation, no commission will be paid.

3.3.3 Independent investment mode by roof owner

The roof owners, as the owner of the project, will incorporate a Roof Solar PV Power Co., Ltd on their own with responsibilities for the application, construction, management and operation of their own PV power projects under independent legal person status.

The ownership company will employ a certified institution to design the building PV power system, which will be inspected and accepted by the governmental institutions or utility power grid before a grid inter-connection license is issued.

The project will be invested voluntarily, free of construction and self-borne profit and loss. It will be maintained by the owner, the risk shall be borne by owner or of the insurance company.

3.3.4 Comparison of operation modes

Each of the three modes of operation and management above-mentioned has its own features. The advantages and drawbacks in the project implementation are listed in Table 3-13 below,

Table 3-13 Comparison of three modes of operation and management

	Principal operation of grid company	Principal operation of power generation company	Independent investment of roof owner
Qty of owners	Individual owner	One owner per district in four districts	Multi owners
Roof feature	Enterprise workshop, non-profiting enterprises and government office buildings	Enterprise workshop, non-profiting enterprises and government office buildings	House owner's roofs
Roof use	Free acquisition by government	Free acquisition by government	Self use
Operation mode	Designation by government	Bidding by district	Self application
Application procedure	Simple	Simple	Complex
Approval procedure	Simple	Simple	Complex
Management cost	Low	Low	High
Quality control	Easy	Easy	Hard
Operation quality control	Easy	Easy	Hard
Operation maintenance cost	Fairly low	Low	High
Electricity generation metering	Simple	Simple	Complex
Electricity charge settlement	Simple	Simple	Complex
Plant-power separation principle	Not conformed	Conformed	Conformed
Enthusiasm of roof owner	Low	Low	High
Market competition	Unfavorable	Favorable	Favorable

By comparing as above, as a demonstration project of urban PV power application, the options of single owner or a small number of owners are recommended in the urban scale-up application of PV power in Hohhot, and the roofs of the public buildings and the enterprise workshop, non-profiting enterprises and government office buildings shall be selected to develop under simple ownership in order to avoid dispute upon ownership of roofs, which will be helpful for the project construction and the operation, maintenance and management thereafter of the power stations. Besides, since grid-connected PV power cannot be torn apart from the power grid Corp., so that the important role of the power grid company in operation, maintenance, electricity metering and measurement and tariff settlement of the PV power project shall be considered thoroughly, utility power grid shall participate in the project extensions of urban PV power by means of effective systems, the benefit and responsibility shall be defined, safe connection of the grid system and the quality of the power distribution shall be guaranteed, and the cost in the electricity measurement and tariff settlement shall be reduced as well.

As all the policies and national standards are improved and gradually opened, more and more organizations and roof owners will be allowed to participate in the commercial projects of the urban PV power system. The operation option can be adopted in which power generation companies are the holding share, utility grid will be shareholder, roof owners are leaseholder, package construction, package operation and package management shall be suggested. The power grid company will measure the electricity, make out the electricity list and verify the electricity. The income of the project company will be decided by the electricity and the tariff.

3.4 Supporting policies, mechanism and technical standard for urban distributed PV power project

Urban scale-up PV application is closely linked to municipal projects and facilities, and closely related to the living and production activities in cities. Scale-up application of PV power in Hohhot includes commercial projects invested and managed by project owners such as building PV power system and suburb waste land area PV power station, and non-commercial and public welfare PV power system of emergency PV power, the respective supporting policies, mechanisms, standards and technical codes are needed pertinently, in order to guarantee the ordered, scale-up and successful implementation and sustainable development of the projects.

3.4.1 Instruction for application

Several instructive criteria for application shall be worked out according to the principle of the *Development Plan Outline of PV Industry of Hohhot (2010-2020)* and *The Regulations of Hohhot City People's Government on Further Accelerating PV Industry Development* as guideline and implementation basis for urban scale-up PV application. The main documents include,

1). Hohhot City's Decision on Urban Scale-up Application of PV Power Technology

2). Hohhot City's Development Plan for Urban Scale-up Application Special Program of PV Power Technology

Urban PV power in Hohhot includes building PV power, suburban PV power and emergency PV power.

3.4.2 Implementation code for building PV power system in Hohhot

Hohhot *Management Method of Building PV Power system* on basis of existing regulations of relevant administrations according to applicable national law and policies, the principle, requirement, management and financial regulations of Hohhot on building PV power system shall be regularized fully with the characteristics of generality and practicability. Such codes shall include the followings.

1). Hohhot City's Admittance regulations for construction of building PV power system;
2). Hohhot City's investment requirement for the construction of building PV power system and power use;
3). Hohhot City's implementation procedure for the construction of building PV power system;
4). Hohhot City's construction code and requirement for building PV power system;
5). Hohhot City's management, operation maintenance, electricity metering and fees settlement method on building PV power system;
6). Definition of the relationship between building owners, project owners and utility power grid, and responsibilities, rights and obligations of the parties concerned.

Since building PV power system is closely related to the buildings, the strict regulations of quality shall be made not only with the PV power system, but also with the linking parts of building with PV system in design, installation and acceptance. At the meanwhile, those proposals and suggestions given by local construction departments shall be taken into full consideration, and specific requirements for load-bearing, connection fixation of supports and roofs as well as display location and artistic effect shall be presented in accordance with related national laws and regulations so as to guarantee safe operation and easy maintenance.

3.4.3 Requirement for open-field PV power station in the suburb of Hohhot

The national regulations and supporting policies in connection with the construction of open-field PV power station have been enacted, which shall be followed. In order to make full use of the solar resources and the deserted land resources in the suburb of Hohhot, The *Management Method of Hohhot for Open-field PV power station in the Suburb* shall be worked out, based on the specific situation of Hohhot, so as to enhance scale-up application of PV power in Hohhot, facilitate the suburban economic development, increase the suburban farmers' income and upgrade their living standard. By complying with the national regulations, certain extent of economic benefit for the investors shall be available, through the favorable policies and subsidy measures of local government. In Hohhot, construction requirement for suburban open-field PV power station should includes as follows,

1). Significance of suburban open-field PV power station and regulation on site selection;
2). Investment/financing requirement for the project of suburban open-field PV power station, and the electricity use regulations;
3). Implementation procedure for the construction of suburban open-field PV power station;
4). Construction code and requirement for suburban open-field PV power station;
5). Management, operation maintenance, electricity-metering, and settlement method for suburban open-field PV power station;
6). Relationship among the parties involved in the suburban open-field PV power station, and the accordingly responsibilities, rights and obligations.

3.4.4 Implementation procedure of emergency PV power project in Hohhot

Emergency PV power project is a public welfare project aimed at guaranteeing the power supply in case of emergency and is of evident social significance. Therefore, it is necessary to establish a *Management Method of Hohhot for the Construction of Emergency PV Power* to regularize and guide the principle, requirement, management and financial regulations of the project implementation of emergency PV power in Hohhot, so as to guarantee the construction quality and management maintenance of the emergency PV power, in order to have the emergency PV power system to play the role under emergencies.

Such implementation method should include the followings,

1). Significance of emergency PV power project, site and scope of installation;
2). Fund sources and use of emergency PV power project;
3). Requirement and rule on the construction of emergency PV power system;
4). Daily management, maintenance, and emergency service of emergency PV power system;

5). Relationship responsibilities, rights and obligations of the parties involved In emergency PV power project

3.4.5 Framework of technical standards

Establishing applicable technical standards makes great sense for guaranteeing the quality of the projects and exerting all the benefits. A large number of technical standards and codes concerning PV have been already enacted in China; however the technical standards related to the overall performance and quality of the systems are not complete and all-round. Many items are missing in the technical standards related to grid-connected PV power. Therefore, it is required for this demonstration project to bring out more pertinent technical standards and quality management codes according to different applications of urban PV power, with reference to existing national standards and management codes. The documents to be formulated are as follows,

1). Technical Requirement and Test Method for Special Inverter of Grid-Connected PV Power Generation (GB-already formulated, to be published);
2). Code for Safety of Grid-Connected PV Power System (GB- already formulated, to be published);
3). Test Method for the Grid-Connected Performance of PV System (GB-already formulated, to be published);
4). State Power Grid Regulation of PV Station's Grid Inter-connection (trial);
5). Hohhot City Management Method for PV Grid-Connected System;
6). Hohhot Code on Designing of Building PV Power Project;
7). Hohhot Technology Designing Requirement for the Emergency PV Power Supply System.

3.5 Training on application technology of PV power

3.5.1 Necessity and significance of PV power training

1. As increased attention and investment to PV power projects, related policy and law makers and operators are required to further study and understand the knowledge of PV power. At the same time, those people engaged in financial, taxation, business administration, quality technology supervision, banking and investment industries are also required to understand or even be acquainted with it.
2. Compared with developed countries, the application and promotion of PV power in

China are relatively backward. The serious lack of R&D experts and technicians and engineers in PV technology has greatly hindered the large-scale development of PV generation in China.

3. In the regions with high development potentials or that will be beneficial of PV power in the future, systematic and professional training and knowledge disseminating shall be carried out with the users and technicians.
4. In China, the cultivation of professional talents who are required in PV power can be divided into two parts, namely, vocational training and academic education. The former can create technicians and operators in a short time while the later can continuously cultivate high-quality professionals. Therefore, both of them are indispensable in the future promotion of PV power application.

Establishment PV power training bases, knowledge on PV power will be disseminated by training and education, which help to increase PV professional personnel quantity to relieve talent shortage in the scale-up development of PV power in future on the one hand, and will improve the understanding and recognition of the whole society about PV power and be favorable of the scale-up development of PV power on the other hand.

3.5.2 Scenarios on establishing training bases

1、 Objective of establishing PV power training bases

1) Disseminate the knowledge of PV power, to accommodate the talent demand for the development of PV power;
2) Make use of the human resources rationally, enhance employment and be harmonized with the economic and social development;
3) Adapt to the development of PV power in Hohhot, improve the quality of the practitioners of PV power industry;
4) Enhance ordered and fast development of PV power industry;
5) Exert the comprehensive demonstration effect of training on PV power.

2、 Situation of education on solar PV power in Hohhot

1) Lack secondary and technician schools on PV and related disciplines;
2) No permanent autonomous region-level PV power training institutions;
3) Few short-term training programs, with limited effect;
4) Operators of the different PV project, only with simple job training, without continuation training;

5) No complete training mechanism available.

3、 Training plan for PV power technicians

Establish a training center for PV power. The Training Center not only trains the professional personnel directly engaged in solar PV power, but also trains those personnel such as government officials, policy administrators, economists, financial investors, etc. In addition, it is very necessary to disseminate the knowledge of solar power generation to the general residents in order that renewable energy can be used scientifically and actively and reliably, and benefit to the human beings.

Firstly 30 teachers will be trained, including 10 trainees on PV theory, 10 on PV power system, 5 on field PV power management and maintenance, and 5 on sales and marketing of PV power equipment.

A PV power vocational training school, composed of the above trained teachers, offers normal training courses. 10 terms of common training programs per year will be held with two classes per term (30 people per class) and totally 600 persons will be trained per year. Trainee will receive the certificate of training.

And six terms of comprehensive training programs will be held with two classes per term (30 people per class) and 360 persons will be trained totally a year. Trainees will be certified for their job-seeking after they pass the exams.

Total number of trainees per year: 960.

3.5.3 Implementation plan for education and training

1、 Guiding thoughts

Guided by the Deng Xiaoping Theory and the great thoughts of "*Three Represents*", a series of principles and policies on "*Scientific Developing Concept*" and the "*Plan for Medium and Long-Term Development of Renewable Energy*" shall be implemented thoroughly; and with aiming at the sustainable development of talents education in PV power area, the qualified talents education for the green power market and service network of solar energy power shall be focused, so as to assure the gradual promotion and utilization of green power and ultimately contribution shall be made to the establishment of harmonious society between human and nature.

The training work and mechanism shall be closely combined with the national supervision & management system and service management system concerning solar PV power industry, with practicable training plans, high-quality teachers, excellent training materials, complete facilities, strict supervision, inspection and quality evaluation criteria etc. The training work should be systemized and regularized.

2、 Objective and task

1) Define the overall guideline for the sustainable training mechanism of solar power in Hohhot;
2) Preliminarily set up a sustainable training mechanism for solar power in Hohhot, work out the overall plan and training courses, determine the teachers and the number of trainees;
3) Training tasks of solar PV power in Hohhot.

- Set up specialized training bases (training centers). Training facilities include complete equipments of independent PV power system (such as PV module array, battery units, inverters, controllers and loads) and platforms for measuring I-V curves of PV module, measuring charge-discharge capacity of storage batteries, measuring output/input efficiency of inverters and controllers. In addition, a contrasting platform for measuring the efficiency of load and an actual roof training system of independent PV included also.
- Formulate training plans and implementing rules.
- Compile training materials. After collecting and cataloguing existing books and related documents, and classifying and analyzing the collected material, the textbooks suitable for the training system in Inner Mongolia will be compiled.
- Building of team of teachers. Training center employs full-time teachers and some professional experts and scholars from colleges and research institutions. Teachers for advanced classes are required to hold professional title of professor or above, and those for intermediary or below training classes need hold a professional title of intermediate technician or higher.
- Establish examination and evaluation mechanisms. The mechanisms shall supervise the entire training program and check the potential problems, evaluate the comprehensive benefits of PV power training program. An evaluation mechanism shall be also established. The employment and selection of training teachers shall strictly observe the related rules and regulations.

3、 Steps for establishing training institutions

Step 1: Submit the proposed referential policies concerning solar PV power in Hohhot, proposed reform scheme for establishment of comprehensive management service system concerning PV power, fund raising and crediting arrangement proposals;

Step 2: Apply for establishment: Hohhot Solar PV Power Training Institution (Training Center);

Step 3: Prepare to build the training institution, organize to compile teaching material, formulate rules;

Step 4: Establish the training institution formally.

3.6 Scenarios on PV industry developing

By implementing the urban scale-up application of PV power in Hohhot, which drive the development of PV industry, the supporting facilities for the industry will be extended, gradually silicon material, silicon wafer, solar cell, PV module encapsulation, and system integration will have been developed as well, Hohhot City will be built as a high standard PV power industry base in China with complete industrial chain established and the formation of PV industrial profile with large scale and intensiveness.

3.6.1 High-purity silicon material

High-purity poly-crystalline silicon is the upstream product and critical part of solar PV industry. Hohhot is advantageous in developing polycrystalline silicon industry. First, the city is rich in silicon ore resources. Hohhot owns large reserves of high quality silicon ore resources and the grade of silicon ore from the majority ore deposit is above 97%, it is high quality raw material for producing poly-crystalline silicon and is suitable for developing poly-crystalline silicon industry. Secondly, the local electricity price is low for the industrial use. The installed power capacity of Hohhot is 4,641MW. The power supply is steady, and the electricity cost is relatively cheap. The industrial power price is about 30% lower than that in mid-region and east of the country.

PV raw material poly-crystalline silicon industry will be developed by making advantage of the power and chemical industries in Jinqiao, Tuoketuo and Jinshan Industrial Parks. The 10,000-ton level poly-crystalline silicon project in Shenzhou Guiye Industry Co., Ltd. and the poly-crystalline silicon project in Dalu Co., Ltd. will be built in priority. Corporate alliances and powerful alliances are encouraged. The accessing threshold of poly-crystalline silicon projects will be lifted, the emphasis shall been put upon the introduction of large enterprises with strong R&D capability and advanced technology. The effort shall be made in attaining the production capacity of poly-crystalline silicon 30,000 tons by 2015.

3.6.2 Manufacture of solar cells and modules encapsulation

The development of the city's PV industry shall be driven by the grid-connected PV projects implementation in Hohhot, in order to attract the domestic and overseas PV enterprises to invest and open factories in Hohhot, and gradually to develop solar cells and module encapsulation industry.

A number of dominant enterprises will be established by importing technology, attracting investment or cooperating with high educational institutions. By making use of the industrial agglomeration advantages of electronic information, new materials and new energy sources in Ruyi, Jinshan, Jinchuan Industrial Parks, the enterprise clusters of cells and modules will be developed, which is able to link the upstream to downstream of the industrial chain. The production capacity of crystalline silicon cell shall be expanded, high-conversion rate crystalline silicon cell shall be developed, critical technologies for modules encapsulation equipment should be got breakthrough and the technical level of modules encapsulation shall be improved as well. Efforts shall be made to attain he production capacity 3,000MW for wafer and cell, and 1,000MW for modules by 2015.

3.6.3 Supporting industries for PV power

Making use of the existing industrial infrastructures, the PV supporting industries in Jinqiao, Jinshan, JinChuan, and Wuchuan industrial parks and economic developing zones shall be developed. R &D on the supporting devices of solar PV power system, such as high-power inverters, controllers, batteries and supporting systems shall be conducted. The supporting industry for silicon materials and silicon wafer shall be imported and improved: chlorine, hydrogen, cutting fluid, fretsaw, graphite products, crucible and silicon nitride, etc. The supporting industry for battery: electric coating, ammonia and acid, etc. Support industry for PV module includes PV glass, solder strip, EVA, frame, junction box and connector, etc. The relatively complete PV supporting industries shall be created and the superiorities of the industrial clusters with PV manufacture industry shall be exerted.

3.6.4 Construction and maintenance of PV power system

Demonstration projects of urban scale-up application of PV power in Hohhot include building integrated PV power, PV power in the emergency system and suburban PV power system. By making use of this project driving force, great inputs shall be made, so that 3-4 engineering companies of research, design, installation, commissioning, operation and maintenance of BIPV and PV power supply project can be established. The companies will work separately in the districts and guarantee long, safe, reliable and sustainable service for the PV power system. The experience in the construction and maintenance of BIPV and PV power supply gained will be helpful for the large scale development of PV power application.

3.6.5 Implementation plan

1. Building high-standard PV industrial base

By developing leading enterprises of PV industry, a terraced architecture of leading enterprises, backbone enterprises and supporting enterprises of PV shall be formed in Hohhot. It is encouraged and favorable for the enterprises to unify or emerge, by going public, financing, purchasing, and merging, the enterprises can be developed bigger and stronger. The main body function of enterprises in the industrial development shall be exerted as much as possible; enterprises internal management shall be intensified, by optimizing the production flow, increasing the core competence and technical level.

The construction stresses shall be put upon the PV industry gathering area of Jinqiao, Jinchuan, Jishan, and Wuchuan economic developing zone, so as to form clusters of solar PV incubation, transformation, growth and expansion in PV industry cluster districts. In accordance with the principle of key breakthrough, step-wise implementation and gradual proceeding, the construction of major infrastructure and related service facility in industry cluster areas shall be speeded up, and the functions of comprehensive services shall be strengthened. In addition, the related industries developing shall be guided in the direction of “being large, high, exquisite, and new”, so as to create high-standard PV industrial bases.

2. Extending PV power application

By implementing demonstration projects of urban scale-up application of PV power in Hohhot, the PV power application market shall be launched soon. Various demonstrative zones of PV power application shall be established by relying on the BIPV, PV power projects undergoing or being planned in city downtown, TuzuoQi (Jinshan), Wuchuan, Helin, Tuo, Qingshuihe, etc. The urban building integrated PV shall be stressed and BIPV systems shall be installed on the roof of the public buildings in schools, hospitals, government office buildings, and teenager activity centers. The emergency refuge of squares, sports gyms and parks shall be installed with the PV power supply system and the power supply construction of emergency systems shall be improved. The suburban

PV power system shall be developed in waste open fields nearby power load centers and the application of PV power shall be expanded.

4. Estimation of investment in project construction

4.1 Estimation of investment of project

Considering that the price of PV system is declining and there are lots of unpredictable factors in long-term, in this report, only the first stage investment estimation, namely up till 2012, is considered.

4.1.1 Estimation of investment in building PV power grid-connected system

According to the PV power development plan of Hohhot, the installed capacity of building PV systems will amount to 15MW by 2012.

The project investment cost of the building-PV power system consists of three parts: equipment procurement, engineering installation; civil engineering, and other fees of project.

PV power system procuring and engineering installation cost include procurement cost for PV modules, inverters, cables, combiner box, hardware fixation assembly, monitoring and communications equipment, devices connecting to power grid and electrical energy metering devices as well as installation cost of the related devices totals to RMB292 million, which is 74% of the total investment. The civil construction cost includes the basement for the basic supporter of PV array and roof treatment, etc. totals to RMB47 million, with 12% of the total investment. Other fees of the engineering construction including fees of roof use, project preparation, survey and design, training, site preparation, temporary facilities and production preparations, etc. totals to RMB54 million, which is 14% of the total investment.

The total investment of building PV is RMB393 million and the unit KW investment is RMB26,000 / Wp.

4.1.2 Estimation of investment in suburban PV power system

According to the PV power development plan of Hohhot, the installed capacity of suburban PV power system will amount to 60MW by 2012.

The project investment cost of the building-PV power system consists of three parts: equipment procurement, engineering installation; civil engineering, and other fees of project.

PV power system procuring and engineering installation cost include procurement cost for PV modules, inverters, step-up transformer, distribution system, grid connection, DC lightning-protection distribution cabinets, cables, combiner box, supporters, hardware fixation assembly, monitoring and communications equipment, devices for connecting to public power grid and electrical energy metering devices as well as installation cost of the related devices, totals to RMB870 million, which is 73% of the total investment. The civil construction cost includes the treatment for the basement for the basic supporters of PV array, foundation for step up transformers, main control rooms, inverter rooms, road and site treatment, totals to RMB135 million, with 11% of the total investment. Other fees of the engineering construction including the fees for land use, prophase fee , survey and design, training, site preparation, temporary facilities and production preparations, etc. totals to RMB195 million, which is 16% of the total investment.

The total investment of suburban PV power system is RMB1,200 million and the unit kW investment is RMB20,000/ kWp.

4.1.3 Estimation of investment of PV power in emergency system

According to the PV power development plan of Hohhot, the installed capacity of emergency PV power supply will amount to 2MW by 2012.

The project investment cost of the building-PV power system consists of three parts: equipment procurement, engineering installation; civil engineering, and other fees of project.

PV power system procuring and engineering installation cost include procurement cost for PV modules, inverters and controller, battery, DC distribution cabinet with lighting protection function, cables, combiner boxes, supporters, hardware fixation assembly, monitoring and communications equipment and the devices for electrical energy measurement equipment as well as the installation cost of the related devices, totals toRMB80 million, which is 80% of the total investment. The civil construction cost includes the treatment of basement for the basic supporters of PV modules, battery rooms, inverters and roof (or ground) treatment, etc. totals to RMB6 million, which is 6% of the total investment. Other fees of the engineering construction including the fees for land use, prophase, survey and design, training, site preparation, temporary facilities and production preparations, etc. totals to RMB14 million, which is 14% of the total investment.

The total investment of emergency PV power system is RMB100 million and the unti kW investment is RMB50,000 kWp.

The investment estimation of the above-mentioned PV power system is listed in Table

4–1 below.

Table 4–1 Estimation of investment in three PV systems (RMB 10^4)

	Equipment procurement & installation		Civil construction		Other fees for the project		Total invest–ment	Invest–ment per kW
	Amount	Proportion	Amount	Proportion	Amount	Proportion		
Building PV	29,200	74%	4,700	12%	5,400	14%	39,300	2.6
Suburban PV	87,000	73%	13,500	11%	19,500	16%	120,000	2
Emergency PV	8,000	80%	600	6%	1,400	14%	10,000	5

4.2 Financial analysis

4.2.1 Financial analysis of building PV power system

The building PV power project total capacity is 15MW; the average annual on–grid electricity is 19.64 GWh, and the calculated operation period is 26y, including 1y of construction and 25y of normal operation.

Among the total investment of the project, capital accounts for 30% and loan accounts for 70%. Loan refunding is 15 years and its loan annual interest rate is calculated at 5.94%.

Fixed assets depreciation is with the average depreciation of 15 years and the rate of residual value is calculated with 5%.

The rate of maintenance fees is calculated with 1% of the total investment.

The staffs are calculated with 50 persons. The annual average wage and welfare of workers is RMB 60,000 Yuan.

Other fees are estimated with RMB 200,000 Yuan per year.

Corporate income tax rate is with 25%.

The calculation is based on guaranteeing the expenses of the corporate, the tax, surplus reserve and the IRR for capital of 8%. As calculated, the Feed –in–tariff is RMB2.2/kWh without VAT and RMB2.3/kWh with VAT.

The return period of investment is 12.3y.

The income of power generation in the 25y operation period is RMB1.06 billion.

Corporate income tax payment is RMB70 million. The average annual tax payment is RMB2.8 million.

4.2.2 Financial analysis on suburban grid-connection PV power project

The suburban PV power project total capacity is 60MW; the average annual on-grid electricity is 77.34 GWh, and the calculated power plant operation period is 26y, including 1y of construction and 25y of normal operation.

Among the total investment of the project, capital accounts for 30% and loan accounts for 70%. Loan refunding is within 15 years and its annual interest rate of loan is calculated at 5.94%.

Corporate income tax rate is calculated at 25%.

The fixed assets depreciation is by the average depreciation of 15 years and the rate of residual value is calculated by 5%.

The rate of maintenance costs is calculated with 0.5% of the total investment.

The staff number is 75. The average annual wage and welfare of workers is RMB 90,000 Yuan.

Other costs are estimated as RMB 300,000 Yuan annually.

The calculation basis is to guarantee the cost expenses of the project corporate, the tax, surplus reserve and the IRR for capital of 8%. As calculated, the Feed-in-tariff is RMB1.4/kWh without VAT and RMB1.5/kWh with VAT.

The return period of investment is 14.5y.

The income of power generation in the 25y operation period is RMB2.7 billion. The corporate income tax payment is RMB117 million. The average annual tax payment is RMB4.68 million.

4.2.3 Financial analysis on emergency PV power

As emergency PV power belongs to the state public non-profitable facilities, the tariff estimate is not done herein, and only the investment is done without calculating the tariff and the tax specially.

4.2.4 Conclusion of financial analysis

The financial evaluation result shows that:

1、 Building PV power projects and suburban PV power projects meet the requirement for return of the loans and are capable of refund loan.
2、 Profitability: At the IRR of the project capital of 8%, the Feed-in-tariff of building PV power projects in the operation period is RMB2.3/kWh and the investment

return period is 12.3y; the Feed-in-tariff of suburban PV power generation projects in the operation period is RMB1.5/kWh and the investment return period is 14.5y. This proves that the project owns certain profitability.

In a summary, if the project is awarded with the above feed-in-tariff, the investors could be capable of refunding the loans and get certain profits.

5. Analysis of Benefit of the Project

5.1 Environmental benefits

There is no or very little pollutants emission in the utilization of the new and renewable energy resources, which is friendly to the atmospheric and the ecological environment. Therefore, the new and renewable energy resources are clean and green, which is in harmony with the eco-environment that human beings relys upon for survival. In the city the extension of new and renewable energy application can decreases the emission of pollutants of SO_2, NO_X, CO_2, and dust, etc, which will play a great role in mitigating air pollution and protecting the ecological environment in China. And it will not only decrease the consumption of fossil energy but also improve the quality of the urban ecological environment.

As the demonstration projects of solar PV power are built in Hohhot in 2012, the average power generation of the building-PV power system will be about 19.64 GWh and suburban grid-connected PV power system will be about 77.34 GWh. Compared with the coal-fired power, each kWh of green power from renewable energy replaces 350g equivalent coal while avoiding emission of polluting substances like CO_2, SO_2, NOx and dust resulted from the same amount of coal combustion, totally the PV power projects will save a total of 33,940 t equivalent coal, reducing CO_2 emission by 84,594t, SO_2 emission by 2,550t, NOx emission by 1,270t and dust emission by 23,084t, as shown in table 5-1.

Table 5-1 Environmental benefit of urban PV power demonstrative project in Hohhot (Ton)

Pollutant	Building-PV	Suburban waste land PV grid-connected power generation	Total
CO_2	17,128	67,446	84,594
SO_2	516	2,034	2,550
NO_x	257	1,013	1,270
Dust	4,675	18,409	23,084

5.2 Social benefits

Demonstration projects of solar PV power generation technology in Hohhot will bring about the dramatic social benefits as below,

1. Greatly developing solar energy in China will exhibit to the world all the efforts China has made for the objective to reach the proportion of non-fossil energy to 15% of

the primary energy consumption and decrease the carbon emission per unit GDP by 40%-45% by 2020, and the actual actions in developing clean energy, reducing greenhouse gases emission, and improving the livelihood, upgrading China's international reputation.

2. Beautifying city image—makes Hohhot a demonstration city of scale-up PV power application, shows the great attentions of the city's government paid upon the green energy development over the past years, reflects the pursuance to the city's culture and concepts of harmonious development of environment and economy.
3. Enriching the urban power supplies, improving the energy state—developing renewable energy in cities will certainly enrich the city's energy supplies and enhance the safety of energy supply.
4. Helping formulate the incentive policies concerning urban PV application suitable to Chinese conditions, establish viable mechanisms, applicable codes/standards and investment/financing mechanisms, bring urban scale-up PV application into practically feasible stage, and thereby enhance extensive application of renewable energy in cities cross the country.
5. Helping disseminate the scientific knowledge and methods concerning PV power generation and energy conservation, enforce the awareness and ability of energy conservation, advocate economical and civilized living style, and form a social morality of resources-saving, pollution-reducing, and environmental protection.
6. Extending economic areas and create jobs. Development and utilization of renewable energy help drive the rapid development of related industries, and become a new increasing point of economy and create 15,000 jobs.
7. Demonstrative application of emergency solar PV power is particularly significant to the social safety, for it helps avoid the failures of the whole grid which result of the malfunction of few power source points in emergencies. Emergency PV power can provide electricity for 400,000 people in disaster.
8. Stabilizing and improving the livelihood of residents-development of renewable energy helps change the increased energy expenditure and lowered livelihood of the residents caused of the shortage of fossil energy; integration of the renewable energy with building enrich the technological connotation of the buildings, exhibits the concepts of "human-oriented" building, improve the eco-environment quality and enables the harmonious development between human beings and society.

5.3 Application for CDM

In accordance with the principle of “Common but Differentiated Responsibilities” in the United Nations Framework Convention on Climate Change, *Kyoto Protocol* allows developed countries develop the projects having the impact of GHG emission reduction through technology transfer and funding supporting. Clean Development Mechanism (CDM) is a project-cooperation mechanism between developed countries and developing countries, under which, the developed countries will fulfill their obligations of reducing carbon dioxide discharge by purchasing emission reduction indexes, while the developing countries gain profits by selling emission reduction indexes through CDM.

A reference baseline is required, as calculating the CO_2 reduction of solar PV grid-connected power stations, Under the condition of no solar PV power grid-connected power projects, the same amount of electricity will be generated and supplied to the utility grid from the coal-fired power plants, the emission caused by coal-fired power plants shall be regarded as baseline emission reduction. However, solar grid-connected PV power stations will be no carbon dioxide emission in the future. Therefore, CO_2 emission of this project are exactly the base-line emission.

Calculation of baseline emission as follows,

$$BE = EG \times EF$$

Where,

BE : baseline emission, CO_2 tons / year;

EG : annual electricity generation supplied by the project to the grid, MWh;

EF : baseline emission factors of grid electricity quantity replaced by the project, CO_2 tons /MWh.

Based on the baseline emission factors defined by China National Development and Reform Committee (NDRC) in Sep 2009, the location of this project belongs to the China North Power Grid. Therefore, EF equals to 0.8806 tons of CO_2 per MWh. By 2012, demonstration projects of building-PV integration application will amount to 15MW and suburban grid-connected PV power station 60MW, the average power generation will be roughly 96.98 GWh. Through above formula, the CO_2 emission calculated will be 85,400 tons. Through the application of CDM, the demonstrative project of solar PV generation can not only achieve environmental benefit and enormous economic benefit, but also import advanced technologies and realize the sustainable development of society and economy.

6. Conclusion and recommendation

6.1 Conclusion

6.1.1 Urban PV power dominated by roof PV is an important part of PV application

PV application in China has turned from off-grid power in the remote areas and power supply for special uses into PV grid-connected power and substituting conventional energy in forms of large grid-connected PV power station (desert power station) and distributed urban PV power system dominated of building-PV integration power. Since cities are developed in economy with centralized electric power load and large numbers of building roofs available, electric power supply can be obtained without affecting the function of the buildings. Besides, as building-PV power system connects into the power grid system at the end of the power grid, there is no problem of electric power transmission, it is unnecessary for any scale's expansion of the transmission lines. Scale-up application of grid-connected PV power in the developed countries like Germany, Japan and America all started from scale-up application of urban building- PV power.

China's solar power is still at the starting stage. There is still a certain gap with the international level and lacks of the practice and experience of scale-up, marketization and commercialized operation. The "Golden Sun project" approved by the state authority starts up the urban scale-up PV power in China. It will be significance of instructiveness and demonstration for the scale-up, healthy, ordered and sustainable development of urban PV application in China, by selecting typical cities, by initiating practical pilot application projects of distributed urban PV power with certain scale, by thoroughly and systematically studying the technical and economic problems of the the grid safety, power dispatching and operation, in order to gain the experiences in terms of project construction, management, operation and maintenance.

6.1.2 Great necessity on initiating the demonstration projects of urban scale-up PV power in China

Under the increasing pressure of the global energy crisis and environmental problems, it is the general trend to develop renewable energy power. Solar PV power generation will indispensably take a very important position in the future power system for its resources superiority and the own features. With the countries that lead in PV power application and expansion, who's early PV projects started from the urban building PV power, with many years' development, the relatively complete technical and management systems have been developed.

Launching the demonstration projects of urban scale-up PV power application in China by referring to the foreign countries help to optimize the power structure of cities so as to meet the future electric power demand and the strategic requirement of sustainable development of the electric power system; to intensify the safety of urban power supply; to extend the domestic market and to maintain the long term, healthy and sustainable development of China's PV industry; contribute to energy conservation, effectively to carry out the energy-saving and emission reduction, to propagandize and promote environmental protection, to build a resources-efficiency and environment- friendly society; to be able to support the basic emergency electric power supply in the event of failure in the power grid.

Implementation of the demonstration projects will fully exhibit China's PV power technology level, which will be of great importance of China's PV power market expansion, and accumulate the practical experience and technical data for scale –up utilization of solar PV power.

By implementing the comprehensive demonstration projects of urban scale-up solar PV utilization, planned as whole in typical cities, the complete promotion mechanism will be formed, the actual issues on the renewable energy law implementation can be put into effect, the policies, systems, technical standards, engineering technology and project implementation concerning solar PV power will be performed in a city, the comprehensive demonstration of individual project to all-dimensional project exhibition will push forward China's urban solar PV market greatly.

By building large comprehensive demonstration projects of urban PV application, the optimal integration and matching design technology of the distributed power system, and the critical grid-connection technology of distributed power source micro grid system can be studied thoroughly under the grid inter-connection condition, the technical codes and standards associated with the short current limit of grid inter-connection, protection configuration, voltage control and energy quality indicators, and so on can be defined clearly, by stressing the researches on the overall performance of distributed power sources and the research of the effects on the safety and stability of power system, development pattern of distributed power in China shall be studied further as a whole.

6.1.3 The conditions for the urban PV application projects in China is in place

China owns great quantity of urban roof area and the potential for developing roof PV power system is very big. Over the past years, China's PV industry has been developing rapidly; in China a number of PV producers have come out with international competence and world reputation, and have prepared for the scale-up PV application. So far, in China a certain number of urban PV power system have been built. In 2009, in "Golden Sun Project", about 300MW of building roof PV projects nationwide were approved, in which the basic engineering technical conditions for building PV power projects have been established as well.

Since the Renewable Energy Promotion Law's being enacted, state authorities have released 11 policy documents in order to enhance scale-up development and application of grid-connected PV power. Provincial and municipal governments also put forward their own policies and proposals for enhancing PV industry and PV power industries, which are becoming the powerful political support for urban PV power application projects.

As summarized above, the basic conditions are preliminarily prepared for implement the large comprehensive urban demonstration projects of solar PV power. The large demonstration projects shall be implemented as soon as possible, and a number of problems hindering urban PV development shall be solved, so as to accelerate fully the development of comprehensive urban solar energy utilization.

6.1.4 Hohhot has the comprehensive advantageous condition to implement urban scale-up PV power application

As the largest city and capital city of Inner Mongolia Autonomous Region, Hohhot has certain urban scale of economy development. Hohhot is rich in solar resources. The annual sunshine hours is between 2800～3100h and the solar global radiation can be as high as 1,300kWh/m^2. The city enjoys convenient land and air transportation system with thorough postal and communication services, with many developing zones, high quality labor forces and all necessary service facilities, and has owned the basic conditions for developing and utilizing solar generation technology.

Hohhot power grid located at the hub of West Inner Mongolia Power Grid is adjacent to the China North and Beijing-Tianjin-Tangshan (abbreviated as Jing-Jin-Tang) Region, and is the port of West Inner Mongolia Grid output to China North Grid, with the obvious advantages in the location. West Inner Mongolia Power Grid is relatively independent of the national power grid, it is convenient for management and dispatching of renewable energy power and the policy mechanisms and management methods are easier and much more viable.

Hohhot owns a good PV technical and industrial foundation, a complete PV raw material manufacturer cluster has been formed, with being dominated by poly-crystalline silicon material and supported by mono-crystalline silicon and silicon wafer industries. So far, the under-construction grid-connected PV power projects include a 5MW grid-connected PV power station project in Jinshan Developing Zone, a 1MW grid- connected PV power project in Inner Mongolia Shenzhou Guiye Base and a 2MW demonstration project of Inner Mongolian Riyue Solar Energy Technology Co., Ltd, and so on.

The local government is highly intended to develop PV power application, having worked out a series of policies and rules, such as *Development Plan Outline of PV Industry of Hohhot* (2010~2020) the *Regulations of Hohhot People's Government on Further Accelerating PV Industry Development*, the city has owned the integrated advantages and the basic conditions for implementing urban scale PV power application.

6.1.5 Implementation plan of scale-up PV power project in Hohhot

The Implementation of urban scale-up PV power application in Hohhot includes project implementation and the establishment of supporting laws and policies.

Project implementation includes the construction of the demonstration projects of solar PV power, solar PV power industrial chains nurturing and developing, the buildings of capability of PV power like the cultivation and training of professionals of all grades and levels. Demonstration projects include three types: roof PV power system, suburban waste land area PV power, and emergence PV power system. The supporting policies, mechanisms and technical standards for the distributed urban PV power include the PV application guideline and specifications, investing and pricing policies, construction and management codes and related technical standards, these four parts of contents. The targets is that the total power of urban PV power in Hohhot accounts for 1% of the city's annual power consumption by 2012, and 1.5% by 2015.

6.1.6 Investment/financing and benefit of project implementation

Urban scale-up PV power application project in Hohhot consists of three sectors: roof PV power, suburban grid-connected PV power and emergency PV power. As preliminarily estimated of the system cost and equipment procurement, installation cost and other cost for engineering construction, 15MW roof PV power system needs a total of RMB393 million Yuan, unit kW cost is RMB 26,000 Yuan/kWp; 60MW suburban grid-connected PV power system needs a total of RMB1, 200 million at RMB20,000 per kW; 2MW emergency PV power needs a total of RMB100 million at RMB50,000 per kW.

Except for emergency PV power source, that is the non-profiting national welfare utility, investment recovery and profitability does not need to be considered, the other two projects shall consider the cost and expenses of the project, tax, surplus reserve and the IRR for self-owned capital of 8%. As calculated, the Feed-in- tariff is about RMB2.3/kWh for building PV projects in the operation period and the investment recovery period is 12.3y; the Feed-in- tariff is RMB1.5/kWh for suburb waste land area PV power projects in the the operation period and the investment recovery period is 14.5y.

6.2 Recommendation

6.2.1 Speed-up preparation and submit for approval ASAP

1). Submit the *Planning Report on the Development Plan of Urban Scale Application of PV Power in Hohhot* as soon as possible, according to relevant requirement and regulations, and set out to perform the project feasibility study and first-stage preparation for implementing the project.

2). Conduct well the mid- and long term whole planning programs of PV power in Hohhot, and definitely present the classifying and laying-out of urban PV power, and the targets in stage.

3). Define the guiding thoughts, establish the according organizations, work out the work outlines and guideline, regularize the implementation procedures and steps and the management requirement.

6.2.2 Prophase survey and basic information preparation against time

Further detailed investigation and study shall be carried out, according to the content and requirement of the demonstration projects of urban scale-up application of PV power, the related information and data shall be collected and analyzed and summarized well in order to provide fundamental information and data for the project implementation, e.g. solar radiation and other meteorological data at relevant sites, electric power load, electricity demand, supply and development plan, status of distribution/ transmission line and development plan, the under-building roofs and development, municipal construction and development plan, emergency power source status and future demand, the associated industries and development plan, education and talent education status and the coming demand, the current laws and policies and the execution. Only with finding out relevant conditions, and having sufficient information and data, the scientific and rational planning and laying-out can be done, so as to assure the healthy, ordered and sustainable development of urban scale-up application of PV power.

6.2.3 Strengthen policy and financial support from the local government

At present, the cost of the PV power is higher; the PV power price is more expensive than that of the conventional power. Besides support from the state, local governments shall also provide much more preferential measures in policies, tax exemption and financial subsidies so as to enhance the scale-up application of urban PV power.

The China's existing law and regulation systems dominated of *Renewable Energy Law* provide legal basis and guarantee for the development of urban PV power. State authorities and agencies have put forward a number of supporting policies and regulations and rules which not only provide the support and stimulus in terms of policies but also give financial support, however, which are not able to adapt to the development of urban scale-up application of PV power as a whole. Therefore, it is proposed that Hohhot City Government make the viable, specific, and preferential policies and rules, specially by aiming at the different projects, provide more financial support so as to motivate related entities and institutions and all the public of the city, and effectively implement the urban scale-up PV power application, with the goals of attaining a certain scale, exerting the benefit, and keeping the healthy, steady and sustainable development.

6.2.4 Quality management system for PV projects

In order to guarantee the quality of PV products, there are the preliminarily established quality accreditation institution concerning PV products. In 2003, China National Regulatory Commission for Certification and Accreditation approved to incorporate a General Certification Center devoted to the accreditation of renewable energy products. The main basis for the accreditation of the center is IEC standard applied by the international authoritative accreditation institution TUV. So far, the PV industry standard system, compatible to the Chinese condition, has not been set up.

The practices of PV projects in the world show that the IEC international standard in connection with PV products is relatively lagging behind the current development of PV products. Its lab testing indicators do not fully cover the quality requirement of PV modules under the natural conditions so that even though the PV products conform with the IEC standard, 20y service life span under real conditions can not be assured. further more, quality guarantee of PV projects can not be only limited to the quality requirement of PV modules. In order to meet the requirement of the 20y service life, it is required to specify the quality of all the equipment, system design, construction & installation and operation & maintenance in the whole project life cycle.

Therefore, based on the international practices of PV projects and the practical conditions in China, in order to assure the successful implementation of demonstration projects of scale-up PV power in Hohhot, it is suggested to set up “PV Project Quality Management Committee” in Hohhot. The committee will be led by Hohhot City Development and Reform Commission and the membership are composed of governmental authorities closely-associated with PV projects such as utility power, building and environmental agencies, PV modules and device manufacturers and building owners. The committee’s responsibilities are to formulate the accreditation system and standard and design accreditation symbol, the scope will cover all the equipment parts, system design, construction & installation, operation & maintenance throughout the implementation of PV projects. Only enterprises and companies conforming to the quality accreditation standard and awarded the accreditation symbol are qualified to participate in the development of PV projects in Hohhot.

Auxiliary report

Standards & Rules on Power Grid

Inner Mongolia Electric Power Research Institute

March 2010

Foreword

The demonstration projects of urban scale application of photovoltaic generation in Hohhot” is a national demonstration program organized by Institute of Electrical Engineering, CAS as arranged by the National Energy Administration. As required by Inner Mongolia Power (Group) Co., Ltd and Hohhot Development & Reform Commission, Inner Mongolia Electric Power Research Institute undertook the drafting of the “Policies and technical standards for urban photovoltaic generation and power grid in Hohhot“. Working staff in the project team include Niu Jirong, An Zhongquan, Zhao Guiting, Liu Jinguo, Yu Zhixin, Yin Baiqing and Liu Haitao.

Content

Note: These rules have passed internal discussion and preliminary review by relevant functions of Inner Mongolia Power (Group) Co., Ltd and can be officially issued by the government authority and Inner Mongolia Power (Group) Co., Ltd in formal approval procedure after the project is approved.

Executive Method for Urban Building Photovoltaic Generation Demonstration Project in Hohhot

(Draft for Review)

March 2010

Foreword

This Method is drafted by Inner Mongolia Electric Power Research Institute.

Drafters of this Standard include Liu Jinguo, Zhao Guiting and Xue Shouhong.

Executive Method for Urban Building Photovoltaic Generation Demonstration Project in Hohhot (Draft for Review)

The demonstration project of urban building photovoltaic generation in Hohhot is experimental project assigned by the State Development & Reform Commission. This Interim Management Method is constituted to guarantee smooth implementation of this project.

Chapter 1 General Rules

Article 1 Applied scope

This Method applies to the demonstration project of building photovoltaic generation in Hohhot only. Photovoltaic generation in open field may refer to applicable national standards.

Chapter 2 Project Implementation

Article 2 Implementation area

The demonstration projects of urban building photovoltaic generation in Hohhot should be implemented on public buildings with relatively dense but small maintenance radius. As preliminarily decided, implementation areas will be within the 2nd ring road of Hohhot and Ruyi, Jinchuan and Jinqiao Development Zones on the public building roofs. To mitigate the construction difficulty of the projects, we will not consider slope-roof buildings at the moment.

Article 3 Roof utilization

The public building roofs to be used in the demonstration projects of urban building photovoltaic generation in Hohhot will be hired by Hohhot people's government authorities by the rental of 5% income from the power generated. Owners' roofs will be used for free on their own.

Chapter 3 Project Investment

Article 4 Investment principle

According to the plant-grid separation principle, power grid companies can not be investors for the demonstration projects of urban building photovoltaic generation in Hohhot. Only professional generation company or enterprise roof owners can be permitted to invest on the construction during the demonstration period.

Article 5 Investment qualification

The demonstration projects of urban building photovoltaic generation in Hohhot will be implemented in the urban administrative districts area by area (Xincheng District, Saihan District, Hui District, Yuquan District). Investors of each district area will be qualified by public tendering. The principle for the public tendering will be otherwise specified by Hohhot Development & Reform Commission.

Article 6 Investors

Investors qualified by public tendering will incorporate an urban photovoltaic generation company in Hohhot as a legal person for implementing the demonstration projects of building photovoltaic generation.

Chapter 4 Project Construction

Article 7 Access application

Before implementing the projects, the incorporated urban photovoltaic generation company should apply for grid access with relevant department of Inner Mongolia Power (Group) Co., Ltd before it can start feasibility study and design of the access system after approval.

Article 8 Design of access system

The difference in the power distribution systems of public buildings makes it very complicated for the accessing of photovoltaic systems. For this reason, the access systems of the demonstration projects of urban building photovoltaic generation in Hohhot should be designed by the design institute under Hohhot Power Supply Bureau who are familiar with the distribution systems.

Article 9 Installation of access system

As the installation of the access systems of the demonstration projects of urban building photovoltaic generation in Hohhot involves the power cut to the entities and organizations and the reconstruction of the existing systems, in particular, the electric energy metering systems should be confirmed and lead sealed by the power supply department, they should be reconstructed, installed and commissioned by the district supply sub-bureaus under Hohhot Power Supply Bureau who are familiar with the distribution systems.

Chapter 5 Quality Control

Article 10 Construction supervision

To guarantee the quality of the demonstration projects of urban building photovoltaic generation in Hohhot, qualified supervision companies will be assigned during the project implementation to supervise the full construction and installation process.

Article 11 Quality acceptance

The demonstration projects of urban building photovoltaic generation in Hohhot should be subject to quality acceptance in accordance with "Code for acceptance of urban building photovoltaic generation project in Hohhot". Any project that fails the acceptance is prohibited for grid-connected generation.

Chapter 6 Maintenance and Supervision

Article 12 Operation and maintenance

The demonstration projects of urban building photovoltaic generation in Hohhot will be operated and maintained by those who invest on them.

Article 13 Technical supervision

According to the localized management principle for the technical supervision of electric power, urban building photovoltaic generation enterprises in Hohhot should be subject to the technical supervision and management of Inner Mongolia Electric Power Technical Supervision & Inspection Center.

Chapter 7 Supplementary Rules

Article 14

This Executive Method will be enforced after reviewed by Hohhot Development & Reform Commission.

Article 15

The final interpretation of this Executive Method is entitled to Hohhot Development & Reform Commission.

Admittance Criteria for Urban Building Photovoltaic Generation Project in Hohhot

(Draft for Review)

March 2010

Foreword

This Admittance Criteria for Urban Building Photovoltaic Generation Project in Hohhot is constituted specific to the conditions of Hohhot to reinforce management of urban photovoltaic generation projects in Hohhot, foster the photovoltaic generation in Hohhot and guarantee the quality of photovoltaic generation.

This Standard is issued by and under the administration of Hohhot Development & Reform Commission.

This Standard is drafted by Inner Mongolia Electric Power Research Institute.

Drafters of this Standard include Liu Haitai, Xue Shouhong and Li Qiang.

This Standard shall be interpreted by Hohhot Photovoltaic Generation Technical Management Commission.

Admittance Criteria for Urban Building Photovoltaic Generation Project in Hohhot

(Draft for Review)

1. Scope

This Standard covers the management requirement, technical requirements of admittance criterion, admittance requirements for contractors and admittance requirements for photovoltaic modules in connection with the urban building photovoltaic generation projects in Hohhot.

This Standard applies to the urban building photovoltaic generation projects in Hohhot.

2. Normative references

The following documents contain provision which, through reference in this text, constitute provisions of this Standard.

GB/T 19939–2005	Technical requirements for grid connection of photovoltaic system
GB/Z 19964–2005	Technical rule for connecting PV power station to electric power systems
GB/T 20046–2006	Photovoltaic (PV) systems–Characteristics of the utility interface
GB/T 16895.32–2008	Electrical installations for buildings, part 7–712: Requirements for special installations or locations –Solar photovoltaic (PV) power supply systems
GB/T 20321.1–2006	Inverter of wind and solar energy supply power system for off–grid –Technical specification
GB/T 3859.1	Semiconductor converters –Specification of basic requirements
GB/T 3859.2	Semiconductor converters: Application guide

3. Management requirement

3.1 Any building photovoltaic generation project in Hohhot shall strictly comply with this Standard.

3.2 Push forward research, exploitation and application of new photovoltaic generation techniques, encourage to import leading techniques in and out of China; prohibit applying techniques that are apparently outdated or no longer applicable, should be dropped out or are not compatible with the public health or public interest in terms of the technique, safety, effectiveness, economy or legality.

3.3 Hohhot Development & Reform Commission will set up Hohhot Photovoltaic Generation Technical Management Commission (made up of experts in power system, tertiary schools and scientific research institutes related to photovoltaic generation) to take charge of the theoretical and technical demonstration of the projects and provide authoritative evaluation. This will include providing recommendation on the admittance policy for photovoltaic generation projects; providing technical codes and admittance standards in connection with photovoltaic generation; assessing the implementation effect and social impact of the projects and providing other consultation related to technical admittance.

3.4 Normalize the requirements in the admittance criterion for the urban building photovoltaic generation projects in Hohhot. Any building photovoltaic generation project imported to the city, that is not to be built yet, should first be subject to feasibility study by a qualified consultation company for building photovoltaic project consultation. After confirming the safety and effectiveness of the project and through centralized discussion by experts under the practical and realistic principle, the project will be submitted to Hohhot Photovoltaic Generation Technical Management Commission in an "Application form for building photovoltaic project in Hohhot" (appendix 1) for review and evaluation.

3.5 The following documents shall be submitted for any building photovoltaic project in Hohhot:

3.5.1 Corporate information (including corporate qualification, engineering performance, technical staff, equipment and technical conditions) and copies of supporting documents for the corporate legality;

3.5.2 Technical conditions, equipment conditions related to the project, qualification certificate of the project owner and information of technical staff;

3.5.3 Rules, technical specifications and operation procedures related to the project;

3.5.4 Feasibility report of the project.

3.6 Any project started without permission from Hohhot Photovoltaic Generation Technical Management Commission will be punished in accordance with law and regulations and will bear legal responsibility thereof.

3.7 For any project to access the power grid, the owner shall submit an "Application form for building photovoltaic project" to access the power grid, and shall sign a grid connection agreement, a grid-connected dispatch agreement, a power purchase/ sale agreement and a power supply/utility contract with the power company.

4. Technical requirement

4.1 The capacity of a photovoltaic project to be built shall be 10kW min;

4.2 The design institute of the project shall be qualified for electric design and building design;

4.3 Any project of designed capacity larger than 100kW shall be subject to full-process supervision of the construction quality by an independent supervision company throughout the construction;

4.4 In principle, projects are encouraged to consume PV power locally. Where this is not practically possible, self-consumption should take up at least 70% the generation capacity.

4.5 Any project to access the power grid shall comply with provisions in the “Technical requirements for grid connection of urban building photovoltaic generation system in Hohhot” for the grid connection technique.

4.6 Any new metering device of project to access the grid shall be submitted to Inner Mongolia Power Company, relevant departments and entities.

4.7 Each measurement point shall be furnished with electric energy metering devices in conformity with DL/T 448-2000 “Technical administrative code of electric energy metering”, relevant standards and rules for the equipment configuration and technical requirement.

5. Admittance requirements for contractors

5.1 Any contractor shall be qualified for construction of building photovoltaic projects and shall provide supporting documents of their basic information.

5.2 Contractors shall establish a quality management system for the construction process.

6. Admittance requirements for photovoltaic modules

Any engineering device or assembly shall be provided with UL certification issued by the State Solar Photovoltaic Product Quality Supervision & Inspection Center and certification from other international and national institutions for photovoltaic product certification before they are admitted into the photovoltaic generation market of Inner Mongolia.

7. Appendix 1

Application form for building photovoltaic project in Hohhot

Owner's information			
Company (name)		Address	
Postal code		Tel	
Fax		Expected commencement date	
PV generation station's information			
PV station site		Project contractor	
Building name		Company name	
Mail address		Address	
Postal code		Postal code	
Tel		Tel	
Fax		Fax	
Technical data of new station		Technical data of existing station	
Generation capacity （kW）		Generation capacity （kW）	
Building integration	Yes □ NO□	Building integration	Yes □ No□
Building auxiliary	Yes □ No□	Building auxiliary	Yes □ NO□
Whether built on the same roof as existing station		Yes □ No □	
Where independent without grid connection		Yes □ No □	
Whether 100% grid connection		Yes □ No □	
Where part of load in grid connection		Yes □ No □	
Remarks:			
Applicant signature (seal): Date		Approver (seal): Date	

Management Rule for Grid-Connected Operation of Urban Building Photovoltaic Generation System in Hohhot

(Draft for Review)

March 2010

Foreword

Appendices hereto are for reference only.

This Standard is drafted by Inner Mongolia Electric Power Research Institute.

Drafters of this Standard include Yin Baiqing, Zhao Xi, Zhang Peng, Wu Zhiming and Deng Kunling.

Management Rule for Grid-Connected Operation of Urban Building Photovoltaic Generation System in Hohhot

(Draft for Review)

Chapter 1 General Principles

Article 1 This Management Rule is drafted to enable safety grid connection of the urban photovoltaic generation systems and their reliable service after grid connection, and enhance coordination between photovoltaic system and the power grid.

Article 2 This Rule applies to the following conditions:

1). Photovoltaic generation systems mainly refer to the building photovoltaic generation systems that connected to Inner Mongolia power grid and generate power for their own utility. Other kinds of photovoltaic generation systems may also refer to this Standard.

2). Capacity of the photovoltaic generation systems: The installed capacity of building photovoltaic generation P_n should satisfy 10kW≤P_n＜100kW.

Article 3 This Rule mainly covers the grid connection management, operation management and supervision of photovoltaic generation.

Chapter 2 Connection management

Article 4 The owner's application for building photovoltaic generation systems shall conform to "Admittance criteria for urban building photovoltaic generation project in Hohhot" and shall be approved by competent government authorities.

Article 5 The owner or the contractor shall apply with the local power supplier's planning department for access to the power grid in the format and giving the details as described in the appendix hereto. The application shall at least include the following details:

1). Owner or contractor's information including the name, address and contact details;

2). Proposed site of the photovoltaic generation system, plan layout of the building used, No. of the land for building;

3). Qualification of the photovoltaic generation system contractor (qualification of people related to the electric power k);

4). Technical data of the photovoltaic generation system, including the capacity and type of photovoltaic construction;

5). Intention for grid connection (wholly or partly connected).

Article 6 The supplier will respond as whether or not this application is approved. Such approval shall include the following details:

1). Whether or not approved;
2). The reason for rejection if not approved;
3). If approved, describe the exact place of connection of the photovoltaic generation system, the voltage, the distribution transformer, whether expansion is needed, the measurement method, requirements for the design, construction and commission in connecting photovoltaic system to the power grid, and the documents to be submitted

Article 7 Work related to the grid connection of photovoltaic system (including the design, construction, commission , measurement and communication) shall be performed by qualified companies conformed to the power grid requirement.

Article 8 The owner shall accept the requirements of the power grid, sign a purchase/sale contract (including the reading of the power generation, tariff payment method) and dispatch agreement with the power grid. The photovoltaic generation system is not permitted to run without agreement.

Article 9 The grid-connected inverters, metering and disconnectors of the photovoltaic system shall conform to “Technical Requirements for Grid Connection of Urban Building Photovoltaic Generation System in Hohhot”, “Technical specifications for the inverter system of urban building photovoltaic generation in Hohhot” and other applicable rules related to power grid. Grid-connected inverters shall be subject to access inspection and testing before it can access the grid. The testing lab shall be qualified for such work and conform to the requirements of Inner Mongolia power grid.

Article 10 Photovoltaic generation systems shall be designed, installed and tested in accordance with the requirements of the power grid.

Chapter 3 Operation management

Article 1 The grid-connected PV system shall follow the national laws, national standards, industrial standards for electric power and applicable rules of Inner Mongolia power grid.

Article 2 Photovoltaic generation systems under grid connection shall run under the principle of grid safety. Without endangering the safety of the photovoltaic generation system and with approval from the dispatch department, the photovoltaic system shall supply reliable energy to the power grid . The power grid reserves the right to disconnect the photovoltaic generation system from the power grid when the photovoltaic system endangers the power grid.

Article 3 The operation and inspection rule for the protection, inverter and disconnectors of photovoltaic systems shall conform to applicable systems of Inner Mongolia power grid.

Article 4 The duty telephones, the contact details of the duty persons or maintainers of the grid-connected photovoltaic systems shall be submitted to the local dispatch department to keep in touch

Article 5 The gateway meters shall preferably be remote metering. Data collection, maintenance and management of the gateway meters are the responsibility of the local power grid department. Other entities are not permitted to operate the gateway meters.

Article 6 Maintenance of the communication equipment related to the gateway metering shall be the responsibility of the local grid department.

Article 7 Any access to the electrical installation or lines at the access point of the photovoltaic generation system for inspection or maintenance shall be after approval of the dispatch department. Consideration shall be given to double power supply or multiple power supply in the safety measures.

Article 8 Photovoltaic generation entities shall have relevant organization mechanisms and make available operation and maintenance rules. Operation and maintenance of photovoltaic generation shall be registered with the local power supplier. Operators and maintainers shall receive training by the electric power department and be certified for their respective professions.

Chapter 4 Supervision

Article 1 The power grid will supervise the generation of the photovoltaic systems. Any entity or individual that tries to get photovoltaic tariff subsidies from power generation other than photovoltaic generation will be deducted of all the power generation of the year.

Article 2 Any owner or maintainer that operates the gateway meter without permittment by the power dispatch department will be punished according to the rules of the power grid.

Article 3 Photovoltaic system owners shall employ a qualified lab to test the electricity quality of the photovoltaic generation on regular basis as required by Inner Mongolia Electric Power Supervision & Inspection Center and shall correct any over-standard according to the test report. Any over-standard of the electricity quality at the connection point caused by the photovoltaic generation will be punished in accordance with the rules of the power grid.

Appendix

Application form for grid connection of photovoltaic system

<table>
<tr><td rowspan="3">Owner's information</td><td>Company name (name)</td><td colspan="4"></td><td>Legal person</td><td colspan="2"></td></tr>
<tr><td>Address</td><td colspan="4"></td><td>Postal code</td><td colspan="2"></td></tr>
<tr><td>Tel</td><td></td><td>Fax</td><td colspan="2"></td><td>Email</td><td colspan="2"></td></tr>
<tr><td rowspan="4">Contractor's information</td><td>Company name (name)</td><td colspan="4"></td><td>Legal person</td><td colspan="2"></td></tr>
<tr><td>Qualification</td><td colspan="4"></td><td></td><td colspan="2"></td></tr>
<tr><td>Address</td><td colspan="4"></td><td>Postal code</td><td colspan="2"></td></tr>
<tr><td>Tel</td><td></td><td>Fax</td><td colspan="2"></td><td>Email</td><td colspan="2"></td></tr>
<tr><td rowspan="2">PV generation system data</td><td>Installed capacity</td><td></td><td>Type</td><td colspan="5">Building □ Open space □ Other □</td></tr>
<tr><td>Address</td><td colspan="4"></td><td colspan="2">Plot No of land for PV generation system</td><td></td></tr>
<tr><td rowspan="2">PV modules data & inverter qty</td><td>Manufacturer</td><td colspan="4"></td><td colspan="2">Module qty</td><td></td></tr>
<tr><td>Model</td><td></td><td colspan="2">Inverter (3-phase) qty</td><td></td><td colspan="2">Inverter (single-phase) qty</td><td></td></tr>
<tr><td>Operation form</td><td>Part in grid connection</td><td colspan="3">Yes □ No □</td><td>All in grid connection</td><td colspan="3">Yes □ No □</td></tr>
<tr><td rowspan="2">Individual PV modules data</td><td>Power</td><td></td><td colspan="2">Voltage</td><td></td><td colspan="2">Inverter data</td><td></td></tr>
<tr><td>Output power</td><td></td><td colspan="2">Output voltage</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>Applicant</td><td colspan="8">Signature (seal):
Date:</td></tr>
<tr><td rowspan="2">Approval review</td><td colspan="8">Approved □, Approval details:
Approver (Stamp):
Date:</td></tr>
<tr><td colspan="8">Not approved □, Reason description:
Approver (Stamp):
Date:</td></tr>
<tr><td>Remarks</td><td colspan="8"></td></tr>
</table>

Technical Requirements for Grid Connection of Urban Building Photovoltaic Generation System in Hohhot

(Draft for Review)

March 2010

Foreword

This Standard is constituted with reference to **GB/T 19939–2005** “Technical requirements for grid connection of photovoltaic system”, **GB/Z 19964–2005** “Technical rule for connecting PV power plant to power networks”, **Q/GDW 156–2006** “Code for planning and design of urban electric network”, “Safety requirements for photovoltaic (**PV**) grid connection system (draft for approval)” and other applicable standards.

Terms herein are consistent with those applied in relevant standards.

This Standard is drafted by Inner Mongolia Electric Power Research Institute.

Drafters of the Standard include Yin Baiqing, Zhao Xi, Zhang Peng, Deng Kunling and Wu Zhimin.

Technical Requirements for Grid Connection of Urban Building Photovoltaic Generation System in Hohhot

(Draft for Review**)**

1. Scope

This Standard covers the technical requirements for photovoltaic systems of 10kW～100kW to connect to the low-voltage distribution network (voltage rating 380/220V). Any photovoltaic system larger than 100kW should refer to GB/Z 19964.

This Standard is applicable to the building photovoltaic systems that access to Inner Mongolia power grid via static inverters and generate power mainly for their own utility. Other photovoltaic generation systems within this capacity range may also refer to this Standard.

2. Normative references

The following documents are necessary for the application of this Specification. For dated reference, only the dated edition applies. For undated reference, only the latest edition applies.

GB/T 2297	Glossary of solar photovoltaic energy system
GB/T 19939	Technical requirements for grid connection of photovoltaic system
Q/GDW 15 6-2006	Guide for the planning & design of urban power system
GB/Z 19964-2005	Technical rule for connecting PV power station to electric power systems
GB/T 20046	Photovoltaic (PV) systems-Characteristics of the utility interface
GB/T 12325	Power quality-Admissible deviation of supply voltage
GB/T 14549	Power quality: Harmonics in public supply network
GB/T 15543	Power quality: Admissible three-phase voltage unbalance factor
GB/T 15945	Power quality: Admissible frequency deviation of power system
SJ/T 11127	Overvoltage protection for photovoltaic(PV) power system-Guide
GB/T 16895.32-2008	Electrical installations for buildings, part 7-712: Requirements for special installations or locations-Solar photovoltaic (PV) power supply systems
GB 16895. 3-20004	Electric devices for buildings, part 5-54: Selection and installation of electrical installations-Earth Configuration, Protective Conductors and Protective Bonding Conductors

3. Minimum requirement

Photovoltaic systems shall access the power grid bases on condition that they shall not affect the power quality of the power grid.
The minimum capacity of the building photovoltaic system that accesses the power grid shall be more than 10kW.
The capacity of the building photovoltaic system shall preferably be 30% max the capacity of the distribution line.
The short circuit ratio (the ratio of the short circuit current at the connection point to the rated current of the photovoltaic system) shall be 10 min.
The short circuit capacity of the building photovoltaic generation system at the connection point shall not be larger than the rupturing capacity of the breaker.

4. Grid accessing

Building photovoltaic generation systems shall preferably connect to the power grid by using small single-phase inverters (output voltage 220V).
Building photovoltaic systems shall preferably connect to the power grid locally in a distributed manner.
Building photovoltaic generation systems shall have evident connection points and such points shall be subject to the management by the dispatch department.

5. Power quality

Powe quality of building photovoltaic systems shall be controled and conform to the standard in terms of the voltage deviation, frequency, harmonic and power factor. The system shall be able to detect any deviation from the standard or over-limit and disconnect the photovoltaic system completely from the power grid

5.1 Voltage

5.1.1 Voltage deviation

The voltage at the connection point is 380/220V, and voltage deviation shall not be larger than +7%, -10% of the rated voltage of the power grid. Rated voltages of the power grid are three-phase 380V and single-phase220V.

5.1.2 Voltage distortion

Harmonic voltage limit: The total voltage distortion shall be 4% max; odd harmonic voltage content shall be 3.2% max; even harmonic voltage content shall be 1.6% max.

5.1.3 Three-phase voltage unbalance

When connecting to the 380V system by using single-phase inverters, the three-phase unbalance should be considered. Deviation of the access capacities between the three phases at the connection point shall be smaller than 10%.

When a photovoltaic system is working under grid connection (for three-phase output only), the three-phase voltage unbalance at the grid interface shall not exceed that specified in GB/T 15543, i.e. the negative sequence voltage unbalance shall not exceed 2%, and the shall not exceed 4% in short time.

5.2 Frequency deviation

Photovoltaic systems shall run synchronously with the power grid when it is connected to the grid. The rated frequency of the grid is 50Hz. The frequency of the photovoltaic systems after grid connection shall conform to the admissible deviation specified in GB/T 15945, i.e. the frequency deviation limit of the power system is ±0.2Hz.

5.3 Harmonic current

To avoid negative effect on other equipment connected to the power grid, it is required that the output of the photovoltaic system have low current distortion, and harmonics under normal service shall be limited to the percentage listed in table 1 below.

Table 1 Distortion limit for different harmonic orders

Harmonic class	Harmonic order	Distortion limit（%）
Odd	3-9	<3.2
	11-15	<1.6
	17-21	<1.2
	23-33	<0.5
Even	2-8	<0.8
	10-32	<0.4

5.4 Power factor

When the active power outputted from the inverter is larger than 50% its rated power, the power factor shall be 0.98min (leading or lagging). When the active power outputted is between 20%～50%, the power factor shall be 0.95min (leading or lagging).

5.5 DC component

When the photovoltaic system is working under grid connection, the DC current component fed to the power grid from the inverter shall not exceed 1% the rated AC value.

6. Start/stop

Where an instruction from the dispatch department is received by the duty person of the photovoltaic system to disconnect from the power grid, the photovoltaic system shall be able to disconnect manually from the power grid. Where the inverter loses grid-connected measurement signal as a result of failure in the power grid or for any other reason, the inverter shall disconnect the photovoltaic generation system automatically from the power grid.

Where the photovoltaic system stops delivering power to the grid as the voltage and frequency of the grid exceed the admissible limit due to failure in the power grid, the photovoltaic system is not permitted to deliver power to the grid line within a certain period of time after the grid has come back to its working voltage and frequency. Such delay of power delivery shall be within 5min.

Where the photovoltaic system stops delivering power to the grid due to failure in the photovoltaic system itself, the duty person of photovoltaic system shall report the problem to the dispatch department and shall not recover grid connection until approved by the dispatch department.

7. Protection

For any abnormality or failure in the photovoltaic system itself or in the power grid, to guarantee the safety of the equipment and people, the photovoltaic system shall provide protection features as detailed below.

7.1 Over/under voltage protection

The over-/under-voltage protection shall conform to table 2 below. Here, “V” is the voltage of the photovoltaic generation system at the connection point and “V_N” is the rated voltage of the power grid.

Table 2 Response to abnormal voltage

Voltage (on grid connection side)	Max opening time
$V < 50\% \times V_N$	0.1s
$50\% \times V_N \leq V < 85\% \times V_N$	2.0s
$85\% \times V_N \leq V \leq 110\% \times V_N$	Continuous service
$110\% \times V_N < V < 135\% \times V_N$	2.0s
$135\% \times V_N \leq V$	0.05s

The photovoltaic system shall mitigate any overvoltage caused by atmospheric lightning discharge or fluctuation in the grid voltage by shielding, earthing, installing lightning arresters and protection devices.

7.2 Frequency protection

The photovoltaic generation system shall install over-/under-frequency devices and shall stop delivering power to the grid within 0.2s where the frequency at the connection point is in excess of 49.5～50.2Hz. The admissible range and delay are provided to avoid excessive trips as a result of short disturbance.

7.3 Islanding protection

And “islanding” in the photovoltaic system will threat the safety of the people and equipment (user’s equipment and the inverter of the photovoltaic system). Therefore, the grid-connected inverter of the photovoltaic generation system shall provide protection against islanding and shall deliver power to the grid line within 2s after voltage loss in the power grid. The testing method of the “islanding” in the inverter shall be simple and reliable. At least one active and passive protection shall be provided against islanding.

7.4 Lightning protection

Lightning and earth protection of the photovoltaic system and the connection interface equipment shall conform to SJ/T 11127.

7.5 Earthing

Earth protection of the photovoltaic generation equipment shall conform to GB 16895.3-2004 and requirements of the electric power system.

7.6 Short circuit protection

The photovoltaic system shall provide short circuit protection to the power grid. For any short circuit in the power grid, the inverter shall keep its over-current within 150% its rated current and shall disconnect the photovoltaic generation system from the power grid within 0.1s.

7.7 Isolation

For small photovoltaic systems connected into a low voltage distribution network, air breaker are recommended to disconnect the inverter's AC side from the power grid.

8. Safety protection

Electrical apparatuses used in building photovoltaic generation shall be well protected as detailed in GB/T 16895.32.

9. Dispatch

In principle, no dispatch automation system is designed for building photovoltaic systems connected into low voltage power grid. However, in special cases, the dispatch department is entitled to dispatch the photovoltaic generation systems, e.g. by telephone.

10. Grid-connected commissioning and testing

10.1 Grid-connected commissioning of the photovoltaic system shall be performed by a qualified company that conforms to the requirements of the power grid in accordance with applicable national rules and regulations of Inner Mongolia power grid. The commissioning plan shall be approved by the grid department and a report shall be submitted to the grid department after the commissioning is finished.

10.2 Photovoltaic generation systems shall be subject to quality evaluation of the electric energy connected into the power grid by a qualified institute at the beginning of the planning and design. The evaluation report shall be reviewed by Inner Mongolia Electric Power Supervision & Inspection Center and be as a part of grid-connection plan.

10.3 The property and power quality of photovoltaic system shall be tested by a qualified company that conforms to the requirements of the power grid. The testing content shall also conform to applicable national rules and regulations of Inner Mongolia power grid.

Technical Specification for Grid-Connected Inverter of Urban Building Photovoltaic Power System in Hohhot

(Draft for Review)

March 2010

Foreword

This Standard is constituted with reference to **GB/T 20321.1–2006** “Inverter of wind and solar energy supply power system for off–grid –Technical specification”，**DB37/T 729–2007** “Technical conditions for photovoltaic power station”, **JB/T 7143.1** “Technical condition for converter of wind turbine” and “Technical requirements and testing method for inverters specially designed for grid–connected photovoltaic generation (draft for approval)” and other applicable standards.

Terms herein are consistent with those applied in relevant standards.

This Standard is drafted by Inner Mongolia Electric Power Research Institute.

Drafters of this Standard include Yin Baiqing, Zhao Xi, Zhang Peng, Wu Zhimin and Deng Kunling.

Technical Specification for Grid–Connected Inverter of Urban Building Photovoltaic Power System in Hohhot

(Draft for Review)

1. Scope

This Specification covers the technical requirements, testing method and acceptance of inverters for photovoltaic power systems under grid connection.

This Specification applies to grid–connected inverter for low voltage (380/220V) distribution system

2. Normative references

The following documents are necessary for the application of this Specification. For dated reference, only the dated edition applies. For undated reference, only the latest edition applies.

GB/T 2297	Terminology for solar photovoltaic energy system
GB/T 19939–2005	Technical requirements for grid connection of photovoltaic system
GB/T 20046	Photovoltaic (PV) systems–Characteristics of the utility interface
GB/T 20321.1–2006	Inverter of wind and solar energy supply power system for off–grid –Technical specification
GB/T 20321.2–2006	Inverter of wind and solar energy supply power system for off–grid –Testing method
GB/T 14549	Quality of electric energy supply: Harmonics in public supply network
GB/T 15543	Quality of electric energy: Admissible unbalance factor of three–phase voltage
JB/T 7143.1	Technical condition for inverter of wind turbine
GB/T 17626.2–6	Electromagnetic compatibility–Testing and measurement techniques
GB/T 3859.1	Semiconductor converters–Specification of basic requirements
GB/T 3859.2	Semiconductor converters: Application guide
DB37/T 729—2007	Technical conditions for photovoltaic power stations

3. Basic parameters of grid–connected inverter

3.1 Rated output parameters: rated capacity, AC voltage, frequency and waveform.

3.2 Rated input parameters: Rated input DC voltage of inverter.

3.3 Software version.

Refer to “Technical parameters of inverters specially designed for grid-connected photovoltaic generation” for exact parameters.

4. Output power portfolio

The following parameters shall precede others in selecting rated output power of the inverter (in kW).

4.1 Single-phase inverter unit

1.5；2.5；3；5；6

4.2 Three-phase inverter unit

10；30；50；100；250；500；1000

5. Technical requirement

5.1 General requirement

5.1.1 Environment conditions

The inverter shall be able to work continuously and reliably under the following conditions:

1). Ambient temperature: -40℃～+65℃;
2). When relative air humidity is smaller than 85 (under air temperature of 20℃±5℃);
3). Altitude is 1800m max;
4). Not exposed to conductive or explosive dust, or gases that may corrode metal or destruct insulation at the service point;
5). Free of vibration of impact at the service point.

5.1.2 Technical indicators

1) Output voltage

◆ The output voltage of the inverter is AC 50Hz sine wave and the output voltage provides automatic adjustment.

◆ The admissible deviation of single-phase voltage at the AC output side of the inverter is +10%, −15% the rated voltage for single−phase voltage and ±10% the rated voltage for three−phase voltage. For any deviation in excess, an agreement shall be reached between the user and the manufacturer. Rated voltage of the power grid: 380V for three−phase and 220V for single−phase.

2) Output frequency

The inverter shall run synchronously with the power grid when under grid connection. Admissible deviation of the inverter at the AC output side is ±0.5Hz. Rated frequency of the power grid is 50Hz.

3) Harmonic component of output current

The output current harmonic of the inverter shall conform to table 1 below.

Table 1 Current limit for output harmonics of inverters

Harmonic class	Harmonic order	Harmonic content limit（%）
Odd	3−9	<3.2
	11−15	<1.6
	17−21	<1.2
	23−33	<0.5
Even	2−8	<0.8
	10−32	<0.4

4） Efficiency

The maximum efficiency of individual inverter shall be over 95% and under rated output capacity, shall be larger than or equal to 85% for inverters whose output capacity is 2kVA max, and 90% for inverters larger than 2kVA.

5） Temperature rise

Under rated load and normal service of the inverter, the temperature rise in its principal components shall be:

◆ Temperature rise in electric semiconductor power components (thyristors rectifying tubes and field effect transistors) shall conform to applicable standards when measured by the thermometer method;

◆ Temperature rise in transformers and reactors shall be 75℃ max for class E insulation and 60℃ max for class A insulation when measured by the resistance method;

◆ Temperature rise in plastic insulated conductors or rubber conductors connected to conducting parts shall be 45℃ max.

5.1.3 Protection features

Generally, inverters shall be provided with reverse polarity protection, AC−side over/under voltage protection, over/under frequency protection, short circuit protection, overload protection, DC-side over/under voltage protection and earthing protection.

1). Reverse polarity protection

The inverter shall be able to protect instead of damage the system when the polarity of the photovoltaicarray is reversed, and shall work normally when the polarity becomes normal.

2). AC-side over/under voltage protection

When the voltage at the AC output side of the inverter exceeds the voltage range specified in 5.1.2 above, the inverter shall immediately stop supplying power to the grid and send alarm signals and instructions simultaneously. This requirements applies to any phase of a multi-phase system.

The inverter shall detect and respond to any abnormal voltage. The root mean square of the voltage shall conform to table 2 below when measured at the AC output side of the inverter. Here, “V” is the output AC voltage of the inverter and “V_N” is the rated voltage of the power grid.

Table 2 Response to abnormal voltage

Voltage (on inverter AC output terminal)	**Max tripping time**
$V < 50\% \times V_N$	0.1s
$50\% \times V_N \leq V < 85\% \times V_N$	2.0s
$85\% \times V_N \leq V \leq 110\% \times V_N$	Continuous service
$110\% \times V_N < V < 135\% \times V_N$	2.0s
$135\% \times V_N \leq V$	0.05s
The max tripping time is the duration from the occurrence of the abnormality till the inverter stops supplying power to the grid. The main control and supervision circuit shall remain practically connected to the power grid so as to monitor the state of the power grid continuously and function the “connection recovery” feature.	

3). Over/under frequency protection

When the voltage frequency at the AC output side of the inverter exceeds the frequency range specified in 5.1.2 above, the inverter shall stop supplying power to the grid within 0.2s and shall send alarm signals and instructions simultaneously.

4). Short-circuit protection

When detecting any short circuit at the output side, the inverter shall provide automatic protection. Such protection shall be done within 0.5s max.

5). Overload protection

When the photovoltaic power system outputs more power than the max admissible DC input power for the inverter, the inverter shall work automatically under limited current at the max admissible AC output power. The inverter shall cease local to engingrid after working continuously for 7 hours or when the temperature comes over the admissible limit. The inverter shall work normally when everything comes back to normal.

6). DC–side over/under voltage protection

When the input voltage at the DC side goes off the admissible range for the inverter, the inverter shall stop within 0.1s and give alarm signals simultaneously. The inverter shall work normally when the DC–side voltage comes back to the permissible range.

7). Earthing protection

Photovoltaic power systems shall be provided with necessary earthing protection as required for the distribution system.

5.1.4 Insulation resistance and dielectric strength

1). Insulation resistance of the input circuit to the ground, output to the ground and between the input circuit and output circuit of the inverter shall be 1MΩ min;
2). The circuit and the casing shall withdraw sine 50Hz, 1500V voltage between them for 1min without breaking down.
3). Any special requirements will be subject to the specific conditions.

5.1.5 Protection grade

The protection grade shall conform to GB 4208 and shall be IP20 min indoor and IP54 min outdoor.

5.1.6 Load capability

The continuous reliable working time of the inverter shall be larger than or equal to 4h under rated output current and shall be larger than or equal to 1min under 120% the rated output current.

5.1.7 No–load loss

No–load loss of the inverter shall be 3% max the rated capacity under rated input voltage and no load.

5.1.8 Vibration and free fall

1). Place the sample on the vibration test table under vibration frequency of 20Hz, peak amplitude of 0.38mm and peak acceleration of 6.0m/s^2;
2). The free fall impact height is 25mm. The sample bottom shall be 3°from the bottom

to the cement ground. A total of 2 free falls will be performed.

5.1.9 Noise

Noise of the inverter shall be smaller than or equal to 65dB(A).

5.1.10 Communication

The inverter shall provide interface for local communication.

5.2 Special requirements for grid-connected inverter

Generally, a grid-connected inverter consists of an inverter and a connection protector. It not only converter the AC current output from the Photovoltaic power system into AC current, but also control the frequency, voltage, current, phase, synchronization active and reactive power and energy quality (voltage fluctuation, high harmonics). A grid-connected inverter shall also provide the following special features:

5.2.1 Maximum Power Point Tracking

As solar radiation varies throughout the day, the inverter shall be able to track the maximum power point automatically and minimize energy loss of line.

5.2.2 Start/stop of inverter

Try to deploy all the potential of the solar photovoltaic power system for the output power according to the sunshine and enable automatic start and stop to this extent.
When the inverter starts operation, the output power shall increase slowly, i.e. variation in the output power shall not exceed 1000W/s and there shall be no impact on the output current.

5.2.3 Synchronous control function

A grid-connected inverter is different from an independent inverter in that it not only turns the DC current outputted from the solar energy into AC current, but shall also provide synchronous control.

5.2.4 Islanding protection

The inverter shall provide anti-islanding function. The inverter shall stop supplying power to the grid within 2s for any supply failure in the power grid to which the inverter is connected and shall give alarm signals and instructions simultaneously.

5.2.5 Grid-connection recovery protection

Where the inverter stops supplying power to the grid as a result of any over-limit, the inverter shall not supply power to the grid within a certain period of time (10s-5min) after the power grid comes back to the normal voltage and frequency.

5.3 Communication

The inverter shall provide at least 2 interfaces for local communication.

6. Testing of grid-connected inverter

6.1 Test environment

6.1.1 Temperature： 5℃～35℃；

6.1.2 Relative humidity：45%～75%；

6.1.3 Atmosphere pressure：86kPa～106kPa

6.2 Test items

Test items for grid-connected inverters are listed in table 3 below.

Table 3 Test item of grid-connected inverters

No.	Test item	Type test	Shop test	Delivery acceptance test	Remarks
1	Visual and body inspection	√	√	√	
2	Inverter efficiency test	√	√	√	
3	Harmonic test	√	√	√	
4	Power factor measurement test	√	√	√	
5	DC component measurement test	√		√	
6	Noise test	√			
7	EMC test	√			
8	Voltage sag, short interruption resistance test	√			
9	AC side over/under voltage protection test	√	√	√	
10	AC side over/underfrequency protection test	√		√	
11	Islanding effect protection test	√	√	√	
12	Grid connection recovery test	√		√	
13	Output short circuit protection test	√		√	
14	Reverse polarity protection test	√	√	√	
15	Overload protection test	√		√	
16	DC over-/under-voltage protection test	√	√	√	
17	Earth protection test		√	√	
18	Communication interface test	√	√	√	

No.	Test item	Type test	Shop test	Delivery acceptance test	Remarks
19	Start/stop test	√	√	√	
20	Insulation resistance measurement test	√		√	
21	Insulation strength measurement test	√	√	√	
22	Protection degree test	√			
23	Active power control test	√	√	√	
24	Low temperature work test	√	√		
25	High temperature work test	√			
26	Temperature rise test	√			
27	Vibration and free fall test	√			

7. Acceptance

Acceptance will be in the form of document acceptance, on-site inspection and random inspections.

7.1 Document acceptance

Documents include: list of all installation work, engineering specifications, test record, as-built drawings, completed construction inspection record, list of modified work quantities, significant engineering accident report form, breakdown list of installed equipment, commencement report, stop report, acceptance certificate and other necessary documents.

The completed construction technical documents shall be of good quality, in neat appearance, and provide all necessary information in accurate data and detailed markings. The as-built drawings submitted may be the drawings provided by the design institute with any modification marked in red on the original drawing or, where this is impossible, attached with additional drawings.

7.2 Items and details of field inspection and acceptance

The completed project acceptance shall check up with each of the provisions herein. Projects will not be subject to any repeated inspection if they have passed the inspection by the owner’s resident site representative with a conformity certificate endorsed thereby. Where believed necessary by the acceptance organization, these projects shall be subject to a repeated inspection by a selective test.

Appendix

Technical parameters of inverters specially designed for grid-connected photovoltaic generation

Manufacturer		
Model		
Software version		
DC side parameter	DC Maximum voltage（V）	
	Maximum power voltage tracking Voltage（V）	
	DC Maximum cu Power（kW）	
	DC Maximum input current（A）	
	Number of fused string inputs	
AC side parameters	AC Nominal Power（kW）	
	Rated grid voltage（V）	
	Admissible grid voltage range (V±%)	
	Rated grid frequency（Hz）	
	Admissible grid frequency limit（Hz±%）	
	Power factor	
	Current total harmonic distortion THD（%）	
System	Maximum efficiency（%）	
	Protection class	
	Self consumable in night	
	ambient temperature range	
	relative humidity range	
	Admissible max altitude	
Protection Functions	Over/Under Voltage protection (yes/no)	
	Over/Under-frequency protection (yes/no)	
	Islanding effect protection (yes/no)	
	Grid-connection recovery protection (yes/no)	
	Output short-circuit protection (yes/no)	
	LV ride through (yes/no)	
	Transient voltage protection (yes/no)	
	Back discharge protection (yes/no)	
	Reverse polarity protection (yes/no)	
	Overcurrent protection (yes/no)	
	DC over-/under-current protection (yes/no)	
Safety requirement	Insulation resistance	
	Insulating strength	

Communication interface		
EMC	Conducted emission	
	Radiated emission	
	Static discharge resistance	
	Radio frequency EM field radiation resistance	
	Electrical fast transient pulse group resistance	
	Surge (impact) radiation resistance	
	Resistance to conducted disturbance induced from radio frequency field	
	Voltage sag, short interruption resistance	
Dimension	Width、high、depth（mm）	
	Weight（Kg）	
Document requirement	User manual (yes/no)	
	Instructions (yes/no)	
	Conformity certificate (yes/no)	
	Warranty card (yes/no)	

Method for Measurement & Settlement of Power Energy from Urban Building Photovoltaic generation system in Hohhot

(Draft for Review)

March 2010

Foreword

This Method is constituted with reference to **GB/T19939–2005** “Technical requirements for grid connection of photovoltaic system”, **GB/Z19964–2005** “Technical rule for connecting PV power station to electric power systems”, **Q/GDW156–2006** “Code for planning and design of urban electric network” and other applicable standards.

Terms herein are consistent with those applied in relevant standards.

This Method is drafted by Inner Mongolia Electric Power Research Institute.

Drafters of this Method include Duan Qianwei, Li Hang and Yu Jia.

This Method is interpreted by Hohhot Photovoltaic power Generation Technical Management Commission.

Method for Measurement & Settlement of Power Energy from Urban Building Photovoltaic Generation system in Hohhot

(Draft for Review**)**

1、 General principle

This Management Method is constituted to guarantee accurate and reliable service of the photovoltaic generation metering devices, present the "open, fair and just" principle and safeguard the interest of both the power purchasers and sellers.

2、 Scope

1. This Method covers the technical requirements for photovoltaic power systems under 100kW capacity to access the low voltage distribution network (voltage rating 380/220V).
2. This Method applies to the building photovoltaic power systems that connect to the power grid via static inverters and generate power mainly for local consumption.

3、Normative references

GB17215.322–2008	Electricity metering equipment (AC)–Particular Requirements: Part 22, Static meters for active energy (classes 0.2S and 0.5S)
DL/T448–2000	Technical administrative code of electric energy metering
DL/T614–2007	Multifunction electric energy meters
DL/T645–2007	Multifunction electric energy communication protocol
DL/T5202–2004	Technical code for designing electrical measuring and energy metering device
DL/T743–2001	Remote terminal of electric energy

4、Grid Connection Management

1. Marketing department of Inner Mongolia Power Company is the technical management function of the metering devices of the connection gateway electric energy from photovoltaic generation who will confirm the energy metering points of the connection gateway, manage the configuration of the energy metering devices and organize (or have the supplier's marketing department organize) the acceptance of the field gateway energy metering devices.
2. According to Technical Administrative Code of Electric Energy Metering（DL/T448–

2000）and detailed rules on the implementation of gateway electric energy metering devices of electric energy generation enterprises connected with Inner Mongolia power grid(NDYX [2004] 28), each metering point shall be provided with an energy metering device that conforms to the aforesaid standards, codes and rules for the equipment and technical indicators.

3. Electric energy meter shall be a static multifunction energy meter that conforms to0.2S and 0.5S(1) alternating current static meters for active energy (GB/T17883) and Multifunction electric energy meter(DL/T614)as well as Technical specifications for energy meters of Inner Mongolia Power Company(Q/NMDW-YX-005-2009), “Multifunction communication protocol of Inner Mongolia Power Company” (Q/NMDW-YX-006-2009) for the technical performance, and shall be connected to the energy collection and control platform system of Inner Mongolia Power Company in compliance with the “Data communication protocol of the electric energy information collection and control platform system of Inner Mongolia Power Company” (Q/NMDW-YX-001-2009) and the “Data communication protocol of the centralized energy meter reading system of Inner Mongolia Power Company” (Q/NMDW-YX-004-2009) to enable remote collection and analysis of the electric energy information and the management of the application of business power utilization.
4. Energy Measurement Center of Inner Mongolia Electric Power Research Institute is the technical mechanism for the metering devices of the grid-connected electric energy of photovoltaic generation that performs (or have the local supplier’s measurement center manage) regular calibration, failure solution and technical supervision and inspection of the energy metering devices at the connection gateway. Users are not allowed to change or modify any of the energy metering devices
5. Metering devices newly installed, replaced or field calibrated shall be sealed and the user shall be requested to sign on the working warrant.
6. Electric energy meters in service shall be subject to selective inspection and replaced in accordance with technical administrative code of electric energy metering(DL/T448-2000).
7. The monthly electric energy ammount shall be collected and applied by the electric energy suppliers. The annual electric energy ammount shall be submitted to the

marketing department and finance department of Inner Mongolia Power(Group) Co., Ltd

8. Metering devices shall be managed and inspected by the electric energy suppliers. No user is permitted to change or modify any of the energy metering devices without permission.

5、Technical requirement

1. Energy meters shall be installed at the AC side of the inverters. Static AC active power energy meters with anti-reverse function shall be used.
2. Where the generation power is larger than the through meter, a 0.2S current transformer shall be provided.

6、Installation of meters

The metering device of the access system of building photovoltaic power generating systems shall be revamped and installed by the electric energy supply branch bureau.

7、Acceptance of meters

ceptance of the metering devices of building photovoltaic power generating systems shall be organized and authorized by Inner Mongolia Electric Power Research Institute and performed by the electric power supply bureau’s measurement inspection center.

Code for Acceptance of Building Photovoltaic Generation Project in Hohhot

(Draft for Review)

March 2010

Foreword

This Standard is based on **DL/T 1101–2009** "**35kV–110kV** Standard for acceptance of substation automation" and **IEC 61215–2005** "Crystalline silicon terrestrial photovoltaic (PV) modules–design qualification and type approval".

This Standard is issued by and under the administration of Hohhot Development & Reform Commission.

This Standard is drafted by Inner Mongolia Electric Power Research Institute.

Drafters of this Standard include Liu Haitao, Chen Shihui and Guan Yong.

This Standard shall be interpreted by Hohhot Photovoltaic Generation Technical Management Commission.

Code for Acceptance of Building Photovoltaic Generation Project in Hohhot

(Draft for Review)

1. Scope

This Standard covers the acceptance management, acceptance flow, acceptance content and requirements of urban building photovoltaic generation projects in Hohhot.

This Standard applies to the acceptance work of new and rebuilt urban building photovoltaic generation projects in Hohhot.

2. Normative references

The following documents contain provision which, through reference in this text, constitute provisions of this Standard:

GB/T 19939-2005	Technical requirements for grid-connected photovoltaic system
DL/T 448-2000	Technical administrative code for electric energy metering equipment
GB/Z 19964-2005	Technical rule for connecting PV power station to electric power systems
GB/T 16895.32-2008	Electrical installations for buildings, part 7-712: Requirements for special installations or locations-Solar photovoltaic (PV) power supply systems
GB 50171-1992	Code for construction and acceptance of switchboard outfit complete cubicle and secondary circuit electric equipment
DUT 995-2006	Testing regulation on relay protection and power grid automatic safety devices
GB/T 20321.1-2006	Inverter of wind and solar energy supply power system for off-grid -Technical specification
GB/T 3859.1	Semiconductor converters -Specification of basic requirements
IEC 61215-2005	Crystalline silicon terrestrial photovoltaic (PV) modules-design qualification and type approval

3. Acceptance management

3.1 Minimum requirement

A new building photovoltaic project shall be subject to completion acceptance once it is completely finished and shall not be delivered to service without acceptance or when it fails the acceptance. The acceptance work shall follow the sequence of shop acceptance, field acceptance and overall assessment and acceptance. Equipment shall not be delivered before its conformity is confirmed by the shop acceptance work group. Any problem discovered during the acceptance shall be solves within a given time after the field acceptance. When the pending problem is solved, the acceptance work group shall re-accept the equipment pertinent to such pending problem.

3.2 Acceptance organization

3.2.1 The project acceptance work shall be organized by Hohhot Photovoltaic Generation Technical Management Commission. When a project is ready for acceptance, the organizers of the acceptance during different stages of the project shall immediately actuate the acceptance workflow of the stage and organize an acceptance work group specific to the acceptance content and nature of the stage. The group members shall include representatives from the investor, owner, supervisor, contractor, producer, designer and manufacturer. Details involving the part of the power grid shall be acceptance by competent department organized by Inner Mongolia Power Company.

3.2.2 The acceptance work group shall make all necessary preparation before starting acceptance and come into the acceptance process after the acceptance outline passes the review. The acceptance group will have a leadership group and a work group. The leadership group will take full charge of the management, coordination, supervision and instruction of the acceptance work. The work group will have a testing group and a document review group and will take full charge of concrete acceptance work of the project. The group members of the work group shall have required professional technical competence, have been trained on the equipment within their work coverage, be familiar with the acceptance process and have a strong sense of responsibility.

3.3 Acceptance responsibility

The acceptance work group shall review and hand over the quality inspection record of the electric installation work, the test record of the equipment and systems, the drawings and technical documents (and shall approve of those already endorsed by the owner), and shall count and handover the equipment, materials, spares and special tools.

3.3.1 Responsibility of the equipment supplier includes:

a). Compile application report for shop acceptance of project;

b). Compile shop acceptance outline of project;
c). Organize shop acceptance of project;
d). Compile shop acceptance report of project;
e). Participate in compilation of field acceptance report of project;
f). Participate in field acceptance of project;
g). Participate in compilation of overall assessment and acceptance outline of project;
h). Participate in overall assessment and acceptance of project.

3.3.2 Responsibility of equipment user:

a). Participate in shop acceptance of project;
b). Compile field acceptance outline and overall assessment and acceptance outline of project
c). Review acceptance outlines for three stages of project;
d). Organize field acceptance of project;
e). Compile application report for overall assessment and acceptance of project;
f). Organize and take full charge of overall assessment and acceptance of project;
g). Compile field acceptance report and overall assessment and acceptance report of project.

3.3.3 Responsibility of equipment installer and commissioner:

a). Compile application report for field acceptance;
b). Compile field acceptance outline of project;
c). Participate in field acceptance of project;
d). Participate in compilation of overall assessment and acceptance outline of project;
e). Participate in overall assessment and acceptance work of project.

4. Shop acceptance

4.1 Shop acceptance prerequisite

4.1.1 The equipment supplier has completed software development, system integration and commissioning work according to the configuration of the system under the shop environment.

4.1.2 The equipment supplier has built up simulative testing environment, provided conforming testing equipment and completed compilation of relevant technical documentation.

4.1.3 The equipment supplier has completed inspection and testing of the product quality and conforms to the contract and related technical specifications.

4.1.4 The equipment supplier has submitted the quality inspection report and the application report for shop acceptance to the equipment user.

4.1.5 The equipment supplier has compiled a shop acceptance outline and formed a formal literature after reviewed and confirmed by the shop acceptance work group.

4.2 Shop acceptance outline

4.2.1 Compilation of the shop acceptance outline. The equipments supplier shall compile a shop acceptance outline of the project according to the technical documents for public tendering of the project, the technical response for the bidding of the project, the contract technical agreement of the project, the technical documents from the technical liaison meetings and relevant technical specifications, and submit it to the shop acceptance work group for review and confirmation.

4.2.2 Content of the shop acceptance outline. A shop acceptance outline compiled by the equipment supplier shall include (but not limited to) the following details:

a) The system documents and information shall include (but not limited to) the following details:

1) Equipment list and configuration description;
2) Product appraisal certificate;
3) Product shop test report;
4) Product technical specification, operation and maintenance manual;
5) Product schematic diagram, logic block of control objects;
6) Panel/cabinet installation, arrangement and terminal connection diagram (drawing set and software backup);
7) Type test report of relevant equipment (including EMC test report);
8) Quality inspection report;
9) Technical documents for public tendering of project;
10) Technical response to bidding of project;
11) Technical agreement of contract;
12) Minute and memo of technical liaison meetings (technical part);
13) Description of design modification (for any design modification);

14) Application report for shop acceptance.

b) Test items for shop acceptance

1). The shop acceptance test items shall be selected by the equipment supplier as per the project design requirement and submitted to the shop acceptance work group for approval. The testing items shall at least include visual inspection, function test, performance test, continuous stability test and any such other item as required by the shop acceptance work group;

2). Where there are many test points for a certain test item in the shop acceptance test, selective test is permitted. For any selective test, the test points for each selective test shall not be smaller than a third the total points of the tested item. All the selectively tested items shall pass the test. If not, the test shall then cover all the test points.

4.3 Shop acceptance qualification

The shop acceptance may deem to pass the shop acceptance and the equipment may be delivered when the following requirements are satisfied:

4.3.1 All the required system documents and data are available;

4.3.2 All the software and hardware equipment conform to the technical agreement of the project contract in terms of the model, quantity and configuration;

4.3.3 The result of the shop acceptance conforms to provisions herein. There shall be no defective or deviated item in the test result.

4.4 Shop acceptance report

A shop acceptance report shall include the following details:

a). Shop acceptance test record and analysis report;

b). Shop acceptance defect, deviation elimination and adjustment record;

c). The conclusion of shop acceptance.

5. Field acceptance

5.1 Field acceptance prerequisite

5.1.1 Both the hardware and software of the system have been installed and commissioned on the site.

5.1.2 The equipment installer and commissioner have compiled the installation drawings and documents, and commissioned the installed equipment. The drawings and documents are correct and have been submitted to the equipment user.

5.1.3 Auxiliary equipment related to the system (power supply, earth and lightning protection) has been installed and commissioned.

5.1.4 The equipment installer and commissioner have submitted an application report for field acceptance to the equipment user of the project.

5.1.5 The equipment installer and commissioner have compiled the field acceptance outline together with the equipment supplier. The field acceptance outline of the project has been reviewed and confirmed by the field acceptance work group.

5.2 Preparation for field acceptance

5.2.1 The field acceptance organizer of the project shall approve the application report for field acceptance before starting the acceptance and organize a field acceptance work group.

5.2.2 The field acceptance work group shall organize and review the acceptance outline, as-built drawings and installation and commissioning report.

5.2.3 Before the field acceptance, the equipment installer and commissioner shall disclose the installation and use information of the equipment to the equipment user's duty person. The equipment user's operation department shall obtain approval for the acceptance work as stipulated and shall simulate a pre-drilling to guarantee correct operation.

5.3 Field acceptance outline

5.3.1 Compilation of field acceptance outline

The equipment installer, commissioner and the equipment supplier shall compile a field acceptance outline according to the shop acceptance outline and the configuration of the equipment and environment, obtain approval from the field acceptance work group after review and form the formal literature of field acceptance outline.

5.3.2 Content of field acceptance outline

A field acceptance outline shall as a minimum include (but not limited to) the following details:

a). System documents and information shall include the following details in addition to details related to the shop acceptance outline:

1) Product conformity certificate;

2) Production permit;
3) Quality assurance system documents;
4) System construction report;
5) Equipment field installation and commissioning report;
6) List of system test points
7) System design and construction drawings;
8) List of system spare parts;
9) List of special testing instruments and tools;
10) Application report for field acceptance.

b). Testing items of field acceptance. The main purpose of field acceptance is to test whether all the features of the testing system can be functioned and whether the performance indicators of the system can be satisfied. Any testing item not possible under the field conditions or does not need testing shall be agreed by the acceptance work group. No selective testing is permitted during the field test process. Instead, every point shall be tested and the testing process shall cover the secondary circuits of the primary equipment.

5.4 Field acceptance qualification

A project may deem to pass the field acceptance when the following requirements are satisfied:

5.4.1 All the required system documents and data are available.

5.4.2 All the software and hardware equipment are consistent with the shop acceptance in terms of the model, quantity and configuration.

5.4.3 All the results of the field acceptance conform to provisions herein. There shall be no defective or deviated items in the test result.

5.5 Field acceptance report

A field acceptance report shall include the following details:

a) Field acceptance test record, statistical and analysis report;
b) Field acceptance defect and deviation record;
c) Conclusion of on-site acceptance.

6. Overall assessment and acceptance

6.1 Overall assessment and acceptance prerequisite

6.1.1 The system has passed field acceptance. Any pending problem in the field acceptance has been dealt with and has passed retest by the acceptance test group.

6.1.2 The system has run normally within 3 months after field acceptance. The equipment user has submitted a trial operation report.

6.1.3 The application report for overall assessment and acceptance has been reviewed and confirmed by the overall assessment and acceptance work group.

6.1.4 The overall assessment and acceptance outline has formed formal literature.

6.2 Overall assessment and acceptance outline

6.2.1 Compilation of the overall assessment and acceptance outline. The equipment user shall organize the equipment supplier and the equipment installer and commissioner to compile an overall assessment and acceptance outline according to the acceptance items listed herein and specific to the problems in the operation process of the system. The overall assessment and acceptance outline shall be reviewed and confirmed by the assessment and acceptance work group and constitute the formal literature of the overall assessment and acceptance outline.

6.2.2 Content of the overall assessment and acceptance. The overall assessment and acceptance shall cover all the testing items of the system performance listed in the field acceptance outline, the pending problems in the field acceptance and problems discovered in the trial operation.

6.3 Overall assessment and acceptance qualification

6.3.1 The system has run stably and reliably in the 3-month trial operation without any abnormality in the system operation.

6.3.2 The test result of the system performance indicators conforms to the provisions herein.

6.3.3 In the overall assessment and acceptance test, there shall be no defective or deviated item in the testing result.

6.4 Overall assessment and acceptance workflow

6.4.1 After satisfying all the conditions of the overall assessment and acceptance, the equipment user’s operation department shall submit an application report for overall assessment and acceptance, an overall assessment and acceptance outline and a trial operation report.

6.4.2 The overall assessment and acceptance work group shall perform overall assessment and acceptance together with the equipment supplier and the equipment installer and commissioner.

6.4.3 The acceptance shall include item-by-item test and record of all the items listed in the overall assessment and acceptance outline.

6.4.4 When the test is over, the overall assessment and acceptance work group shall compile an overall assessment and acceptance report. The equipment user shall submit to the competent authority according to the overall assessment and acceptance conclusion for approval.

6.5 Overall assessment and acceptance report

An overall assessment and acceptance report shall include the following details:

a) Overall assessment and acceptance outline;
b) Overall assessment and acceptance testing report
c) Overall assessment and acceptance testing statistical and analysis report;
d) Project documents review report;
e) Trial operation report;
f) Overall assessment and acceptance conclusion.

7. Acceptance details and requirement

7.1 Acceptance of grid-connected photovoltaic generation stations shall follow the general principle and technical requirements stipulated in “Access network technical requirements, PV power plant of State Grid Corporation of China (for trial implementation)” and “Technical Requirements for Grid Connection of Urban Building Photovoltaic Generation System in Hohhot”.

7.2 Acceptance of energy metering systems. All the metering points shall be provided with energy metering devices that conform to “Method for Measurement & Settlement of Power Energy from Urban Building Generation in Hohhot” for the equipment configuration and technical requirement.

7.3 Lightning system

Acceptance of the lightning system as an important part of the building photovoltaic project shall be an important job especially for areas subject to frequency lightning.

Lightning and earth protection of the photovoltaic system shall conform to applicable provisions in SJ/T 11127–1997 “Overvoltage protection for photovoltaic (PV) power generating systems –Guide”.

7.4 Test method for grid–connected performance of photovoltaic system

Performance test of the inverter as a critical part of the photovoltaic system for grid connection is an important basis for the grid–connected performance of the photovoltaic system. Detailed testing may refer to P1 and P2 of the RAL–GZ 966 certification system.

7.5 Acceptance of photovoltaic modules and other PV devices

According to the field installation environment and the designed service life, the quality acceptance work of the photovoltaic equipment shall include whether the product has obtained the UL certificate from National Center of Supervision & Inspection on Solar Photovoltaic Products Quality or any other certificate from competent international or national institutions for the certification of photovoltaic products.

8. Supplementary rules

The quality warranty period of the capital construction work of building photovoltaic is one year from the delivery to trial production (imported equipment shall comply with the contract with the supplier). Any defect discovered in this period shall be dealt with by the responsible unit according to the nature and class of the defect.

Interim Management Method for Technical Supervision of Urban Building Photovoltaic Generation in Hohhot

(Draft for Review)

March 2010

Foreword

This Method is drafted by Inner Mongolia Electric Power Research Institute.

Drafters of this Standard include Liu Jinguo, Zhao Guiting and Chen Shihui.

This Standard shall be interpreted by Hohhot Photovoltaic Generation Technical Management Commission.

Interim Management Method for Technical Supervision of Urban Building Photovoltaic Generation in Hohhot

(Draft for Review**)**

The demonstration projects of urban building photovoltaic generation in Hohhot are experimental projects assigned by National Development & Reform Commission. This Interim Management Method is constituted to guarantee successful implementation of these projects

Chapter 1 General Principles

Article 1 Building photovoltaic generation is an important part of renewable energy generation and a keystone program supported by the national new energy industrial policy. This Interim Management Method is constituted specific to the demonstration projects of building photovoltaic generation in Hohhot to guarantee successful implementation of the demonstration projects of "building photovoltaic generation in Hohhot", deploy the basic management function of technical supervision in electric power production and guarantee safety stable and economical operation of the building photovoltaic generation equipment in Hohhot according to "Electricity law of the People's Republic of China", "Management rule on grid-connected operation of power plant" (DJSC [2006] 42 issued by State Electricity Regulatory Commission, "Regulation on technical supervision of power industry" (DAS [1996] 430, Guide for technical supervision of electric power (DL/T1051—2007) and "Management regulations on calibration of electrical measurement, thermal metering and devices of water resources and power departments" (GH [1986] 59.

Article 2 Technical supervision of building photovoltaic generation mentioned herein covers monitoring, inspection, verification and evaluation of the health level and parameters, performance and indicators in connection with the power equipment and their composing systems used in the construction, production and energy transmission of urban building photovoltaic generation in accordance with the prevailing national and industrial standards by standard testing methods and management means to enable the power equipment and systems to work under safe, stable and economic service conditions.

Article 3 Technical supervision of the building photovoltaic generation in Hohhot will stick to the "safety first, prevention focused, integral control" guideline, follow the "lawful supervision, hierarchical management, centralized business” principle and implement full-process technical supervision and management of the planning, construction and production of building photovoltaic generation in Hohhot.

Article 4 Technical supervision of building photovoltaic generation in Hohhot will establish a three-in-one power technical supervision system based on quality, applicable standards and measurement.

Article 5 Building photovoltaic generation enterprises in Hohhot shall carry out technical supervision work and perform their technical supervision functions in accordance with applicable national and industrial standards.

Article 6 All the power equipment of the building photovoltaic generation enterprises in Hohhot shall conform to applicable national and industrial standards.

Article 7 Technical supervision of management of the electric power industry in Inner Mongolia follows the localized management principle. Any building photovoltaic generation enterprise in Hohhot that is connected to Inner Mongolia power grid shall receive the power technical supervision and management.

Article 8 This Method applies to all building photovoltaic generation enterprises in Hohhot that is connected to Inner Mongolia power grid.

Chapter 2 Mechanism and responsibility

Article 9 Inner Mongolia Autonomous Region Economy Commission (referred to as “IMEC” hereinafter) is the administrative authority of the technical supervision of the region’s power industry that instructs and coordinates the power technical supervision and management work of the region, and assesses and evaluates the technical supervision work of the technical supervision executors.

Article 10 Inner Mongolia Electric Power Technical Supervision & Inspection Center is the institution authorized by the region economic commission to perform technical supervision functions and takes charge for everyday centralized management, technical instruction and coordination work of the technical supervision of the region power industry in the region.

Article 11 Inner Mongolia Electric Power Technical Supervision & Inspection Center receives the leadership of the autonomous region economy commission for the power technical supervision work. All the grid-connected building photovoltaic generation enterprises inside the city area of Hohhot shall receive the supervision, management and instruction of Inner Mongolia Electric Power Technical Supervision & Inspection

Center.

Article 12 Responsibility of IMEC

1. Instruct and supervise Inner Mongolia Electric Power Technical Supervision & Inspection Center to follow applicable national and local laws, regulations and technical specifications and standards of the power industry.
2. Constitute guidelines and policies for technical supervision of the region's power industry, organize and instruct Inner Mongolia Electric Power Technical Supervision & Inspection Center to constitute, revise and approve the execution of rules in connection with technical supervision.
3. Inspect the technical supervision work of the building photovoltaic generation enterprises and coordinate relationship between all the stakeholders.
4. Hold regular power technical supervision work meeting of the whole region to summarize and exchange experiences of power technical supervision work, circulate information about power technical supervision work and plan the technical supervision work.

Article 13 Responsibility of Inner Mongolia Electric Power Technical Supervision & Inspection Center

1. Carry out the national and local laws and regulations and the technical specifications, rules, standards and systems of the power industry, carry out the technical supervision work according to laws and periodically report to the competent authority.
2. Establish and consummate the technical supervision system of building photovoltaic generation in Hohhot, supervise, inspect, urge and instruction building photovoltaic generation enterprises in Hohhot to carry forward power technical supervision work.
3. Prepare the annual work plan for technical supervision of building photovoltaic generation in Hohhot, conduct supervision and inspection, information service, technical training, technical consultation, abnormality analysis, testing, inspection and calibration work; conduct the experiments, analysis, inspection, testing, examination and calibration undertaken by Inner Mongolia Electric Power Technical Supervision & Inspection Center; conduct grid-connected special pilot for building photovoltaic generation equipment for grid connection.
4. Constitute and revise rules on technical supervision of building photovoltaic generation in Hohhot and enforce the rules after approval from the competent authority.

5. Organize technical supervision and assessment of building photovoltaic generation in Hohhot and periodically inform of the assessment result.
6. Participate in investigation and analysis of failures in the building photovoltaic generation equipment in Hohhot and failures in the power grid, provide recommended measures against failures and report to the competent authority any significant problem discovered.
7. Conduct technical supervision and inspection of critical parts of the building photovoltaic generation works in Hohhot; provide corrective opinions and requirements in time.
8. Supervise and inspect the photovoltaic generation equipment and materials that comes into the power grid, notify non-conforming products and report to related authority department in time.
9. Keep improving and updating the methods and equipment for technical supervision of building photovoltaic generation, research and popularize the application of new techniques.
10. Master the technical parameters for the controlled equipment and metering devices of the building photovoltaic generation enterprises in Hohhot; instruct the building photovoltaic generation enterprises in Hohhot to create or complete the technical documentation of the equipment and technical parameters and the metering standard devices.
11. Provide recommendations to substantiate and extend the work scope and requirements of technical supervision of building photovoltaic generation specific to new problems with the technical development, production and operation of photovoltaic generation.

Article 14 Responsibility of Hohhot building photovoltaic generation enterprises

1. Carry out the applicable national and local laws and regulations on power technical supervision and the technical specifications, rules, standards and systems of the power industry.
2. Establish and complete the organization system and standard system of their own technical supervision of building photovoltaic generation, and function the supervision departments, people’s responsibilities and assessment system.
3. Receive and cooperate Inner Mongolia Electric Power Technical Supervision & Inspection Center with the technical supervision work of building photovoltaic generation, constitute implementation details and technical measures for their own

technical supervision of building photovoltaic generation, and receive the inspection and testing work by technical institutions authorized by the state.

4. Establish and consummate testing methods and allocate competent technical staff as per the specified technical standards.
5. Implement hierarchical management responsibility of the power technical supervision, test the equipment under their jurisdiction, answer for the maintenance and inspection quality of the equipment, and establish technical documentation of the equipment; solve problems once they are discovered; submit any significant problem to the executor of power technical supervision in time.
6. Reinforce training to their own technical supervisors and keep upgrading their professional level.
7. Submit the testing report of the controlled power equipment, technical parameters and indicators to Inner Mongolia Electric Power Technical Supervision & Inspection Center in the specified format.

Chapter 3 Scope and Content of Technical Supervision of Building Photovoltaic Generation

Article 15 Technical supervision of building photovoltaic generation in Hohhot mainly includes full-process and all-dimension technical supervision in connection with the work feasibility study, planning, design, public procurement, manufacturing, installation, commissioning, delivery, acceptance, operation, inspection and technical reform. In particular, more effort should be put on the technical supervision of the capital construction delivery and acceptance.

Article 16 Technical supervision of building photovoltaic generation in Hohhot mainly covers the insulation (earth system), electrical measurement, relay protection, energy quality and metal.

Chapter 4 Technical Supervision and Management of Building Photovoltaic Generation

Article 17 Building photovoltaic generation enterprises which total installed capacity of 2MW and above are supervised by Inner Mongolia Electric Power Technical Supervision Center and shall sign a technical supervision service contract with Inner Mongolia Electric Power Technical Supervision Center.

Article 18 Technical supervision work of building photovoltaic generation in Hohhot will be under a responsibility system. After a technical supervision service contract of building photovoltaic generation is signed, any significant equipment safety accident due to loss of supervision, omitted supervision or mis-supervision as a result of ineffective technical supervision will be born by the parties according to their respective responsibilities. Any failure of the power grid to work safely and stably as a result of vacuum or disconnection of the technical supervision where a technical supervision service contract of building photovoltaic generation is not signed shall be borne by the building photovoltaic generation enterprise.

Article 19 Professional technical personnel of the building photovoltaic generation companies shall receive training and assessment and be certified for their qualification before they can start the technical supervision work.

Article 20 In the technical supervision work of building photovoltaic generation in Hohhot, all the supervision reports shall be endorsed for acceptance and all the problems will be dealt with by the responsible units. The technical supervision items and indicators shall be submitted to Inner Mongolia Electric Power Technical Supervision Center within the specific time and in the specified format. Significant problems shall be submitted in a special report.

Article 21 Establish and consummate the endorsed acceptance system for full-process supervision of the equipment quality. The power technical supervisor has the right to refuse to endorse on any equipment, material, installation, inspection or reconstruction work that does not conform to the quality requirements and to report such defect in a leapfrog manner..

Article 22 For any significant loss or accident caused to ineffective technical supervision or reduction of the supervision items, lowering of the supervision indicators without permission, overtime testing or extended testing period, and those who neglect their duties shall be claimed for the management and safety responsibility.

Article 23 Establish a prewarning and alarming system for technical supervision. Deliver prewarning, alarming and a correction notice for any significant problem with technical supervision and urge the responsible unit to take corrective actions in time.

Article 24 Provide exclusive supervision to problems that significant affect the safety of the power system until the safety risks are removed.

Article 25 Establish and consummate the technical documentation related to the full construction and production process of building photovoltaic generation in Hohhot. The technical documents shall be complete and continuous and conform to the reality.

Article 26 Any dispute in the technical supervision work of building photovoltaic generation may be submitted to the competent authority for coordination. After coordination, the coordination award shall be binding to both parties.

Chapter 5 Supplementary rules

Article 27 This Method shall be implemented after submission to and approval of Inner Mongolia Autonomous Region Economy Commission.