China-EU Energy Collaboration Forum
Feb. 20-21, 2006 Shanghai

Current Status and Future Expectation of PV in China

Wang Sicheng
Beijing Jike Energy New Tech Development Co.
A2-12B09, Changyuantiandi Plaza, No.18 Suzhoujie, Haidian District, Beijing, China.
Post Code: 100080 Tel.: 86-10-82609980 FAX: 86-10-82609975 (76) – 246

CONTENTS

CONTENTS....2
1. PV Role in Energy Supply....3
   1.1. Conventional Energy Resources and Renewable Energy....3
   1.2. Power Supply in China (2004, 2010, 2020)....6
2. World PV Industry....9
3. PV Market in China....10
   3.1. PV Market Development....10
   3.2. PV Market Share in 2004....11
   3.3. Future Prediction of PV Market....13
   3.4. Prediction for Cost Reduction of PV in China....15
4. Market Opportunities....15
   4.1. Rural Electrification....15
   4.2. BIPV in Urban Application....15
   4.3. Large Scale PV (LS-PV) in Gobi Desert....16
5. PV Industry in China....16
6. Problems and Barriers....19
   6.1. Silicon Raw Material (Feedstock)....19
   6.2. Market Development....19
   6.3. Policy Barrier....21
      6.3.1. Renewable Energy Law and Implementation Rules....21
      6.3.2. Difficulties in Implementation of Renewable Energy Law....22
7. Conclusions and Recommendations....22

1. PV Role in Energy Supply

1.1. Conventional Energy Resources and Renewable Energy

Either in China or in the World，the conventional energy resources are limited. The primary energy reserves in China is less than the average level of the world, it is about only 10% of the world reserves. The prediction of main primary energy reserves both in China and in the world are shown in Fig. 1.

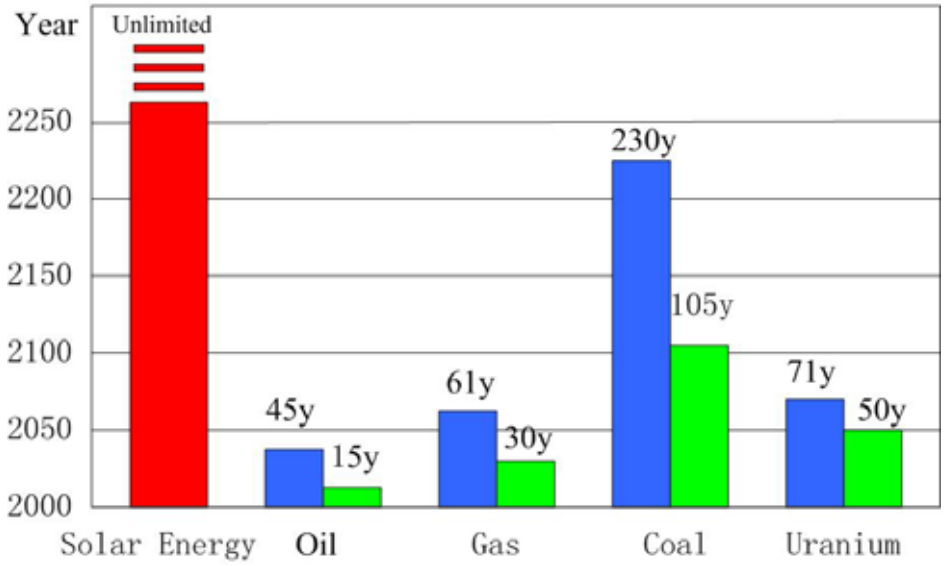


Fig. 1 Primary Energy Reserves in China and in the World

From long term view, Renewable Energy (RE) will become the main energy resources for human being. So RE is taken as future important energy resources to be developed by many developed and developing countries. Within the new renewable energy, wind power and solar PV are growing very fast and they are the main field to be supported by many countries.

According to the expectation of JRC, PV will play a very important role in future power supply and will share 10% of total power supply in the world by the year 2030. RE will share about 30% in total energy consumption. By the year 2050,PV will share 20% in total power supply in the world and RE will share 50% in total energy consumption in the world. Fig 2 shows the future expectation of energy demand in the world by the end of this century.

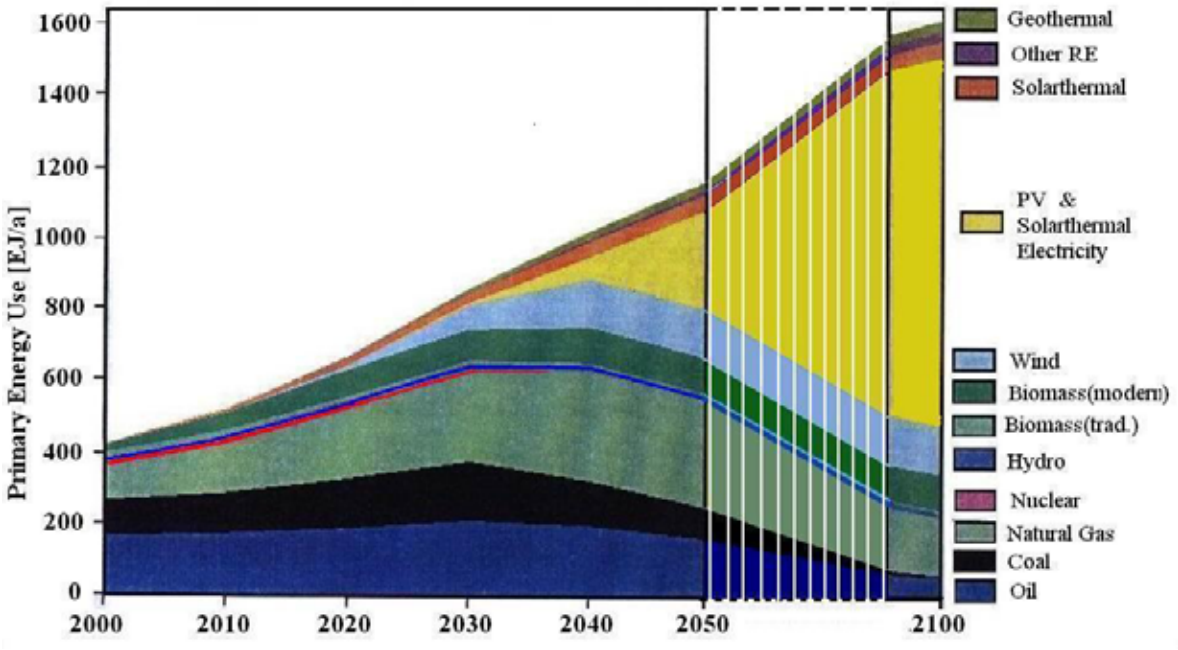


Fig 2. World Energy Expectation（PVNET2003）

China is a big country to produce energy and also one of the largest country to consume energy. In 2004, the total energy consumption in China is about 2 Billion Tce (tons coal equivalent) and it is 25% increase than the value of 2003. Among the total consumed energy, coal is 67.1%, oil is 22.7%, natural gas is 2.8%, and hydro power occupies 7.3%. In 2004, the imported oil was reach to 10,000 Tons which share about 40% of the whole oil consumption in China. Coal is the main role in the whole energy consumption and the share of each type of energy in 2003 are shown in Fig. 3.

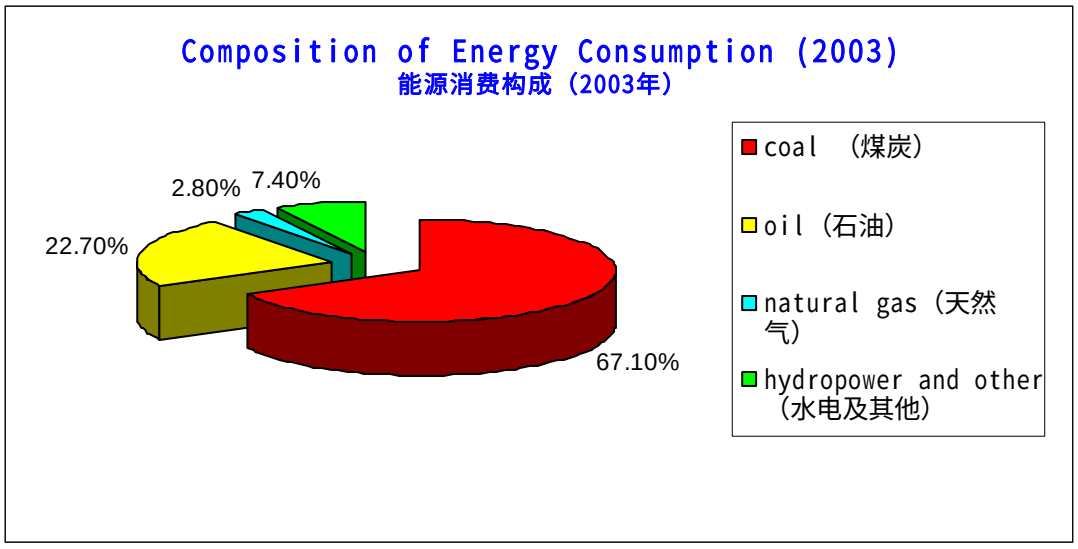


Fig. 3　Energy Consumption in China in 2003

Chinese government has given strong support to RE, mainly covering micro hydro power, wind energy, biomass, solar energy, geothermal energy and ocean energy. The current status of RE in China is as follows:

Hydro Power：The potential economic hydro power in China is 400 billion watt with annual power generation of 1700 billion KWh. In which, the micro hydro power (less than 50MW) resources are about 128 billion watt. By the end of 2004, 74 GW hydro power have been installed in wich 24 GW is micro hydro power.

Wind Power：China is facing to Pacific Ocean, the coastline is as long as 18000Km and season's wind is very strong. In the inland of China, there are many mountains which change the air pressure and make a wide distributed wind resources. According to the prediction made by weather station, there are about 250 billion watt potential wind energy inland of China. There are even more wind resources at coastline and it is estimated that the capacity will be 750 billion watt. The total developable wind energy is about 100 billion watt. By the end of 2004, the total capacity of the installed wind farm is 760MW. The installed stand-along small wind generators in remote rural area is about 180000 sets and the capacity for such application is 40 MW.

Solar Energy：There are 2 types of using solar energy, solar thermal application and solar PV. By the end of 2004, the installed PV is 65MWp. Solar PV is mainly distributed at remote rural area and used for communication and transportation. Grid-connected PV is in demonstration stage currently. For solar thermal application, the installed solar water heaters by the end of 2004 are 65 million square meters which share 40% of the total area of solar water heater in the world. The annual manufacturing capacity of solar water heaters is 12 million square meters in China.

Biomass：Biomass includes the production through agriculture and forest, processing of industry waste, waste water and living rubbish. Currently, there have been 14 million sets of home biogas digester in rural area to produce 3.5 billion cubic meter of biogas annually, 2200 sets of large scale biogas engineering to produce 1.5 billion cubic meter of biogas per year and 2 GW of biomass power generation.

Other renewable energy: Besides wind power, hydro power, solar energy and biomass, there are geothermal energy, ocean energy, etc., but the scale is rather limited by now.

By the year of 2004, the total amount of renewable energy (wood or straw burning are not included) is 130 million Tce and share 6.5% in total energy consumption in China. If only considering the hydro power less than 50 MW, the total amount is 56 million Tce and share 3% in total energy consumption.

RE is the sole energy resources in future to satisfy the energy requirement of sustainable development of human society. Currently, the technologies of micro hydro, wind power, solar water heater, solar PV and biogas production have been developed fast. The technologies of biomass fuel and power generation are under development and have bright future. It is expected that within 20-30 years in future, RE will become the main role in energy supply. The prediction of RE production by the year of 2010, 2020 and 2050 is shown in Table 1.

Table 1 Prediction of RE up to 2050 in China

Calendar Year	**2004**	**2010**	**2020**	**2030**	**2050**
Total Energy Demand（10^8 TCE）	**20**	**23**	**30**	**50**	**70**
Macro-Hydro（10^4KW）	7400	11500	21500	25000	50000
Annual Porduction（ 10^8 KWh ）	2300	3900	7300	8750	17500
Equal to （ 10^8TCE ）	0.82	1.33	2.4	2.71	5.25
Micro-Hydro（10^4KW）	3400	5000	7500	10000	20000
Annual Porduction（ 10^8 KWh ）	1000	1545	2300	3200	6400
Equal to （ 10^8TCE ）	0.36	0.52	0.76	1	1.92
Wind Power （ 10^4KW ）	76	500	3000	10000	40000
Annual Porduction （ 10^8KWh ）	11.4	105	690	2300	9200
Equal to （ 10^8 TCE ）	0.0041	0.036	0.23	0.76	3.04
Biomass Power （ 10^4KW `）	200	550	2000	5000	10000
Annual Porduction（ 10^8 KWh ）	51.8	212	835	2250	5000
Equal to （ 10^8 TCE ）	0.013	0.072	0.28	0.7	1.5
Biogass （ 10^8 m3 ）	50	110	240	400	1000
Equal to （ 10^8 TCE ）	0.036	0.079	0.17	0.3	0.8
Solar Thermal （ 10^4 m2 ）	6500	15000	30000	50000	100000
Equal to （ 10^8 TCE ）	0.085	0.2	0.39	0.65	1.3
PV （ 10^4KW ）	6.5	40	200	1000	10000
Annual Porduction（ 10^8 KWh ）	0.78	4.8	24	140	1500
Equal to （ 10^8TCE ）	0.00028	0.0016	0.0079	0.043	0.45
Others （ 10^8 TCE ）	0.029	0.065	0.26	3.837	6.74
Total （ 10^8TCE ）	**1.35 (0.56)**	**2.3 (0.97)**	**4.8 (2.4)**	**10 (7.29)**	**21 (15.75)**
Share of RE（%）	**6.5 (3)**	**10 (4.2)**	**16 (8)**	**20 (14.6)**	**30 (22.5)**

Notice: 1KWh = 350g coal equivalent.
Blue color: Macro-Hydro not included.

1.2. Power Supply in China (2004, 2010, 2020)

Before 2000, the power supply in China is satisfied to meet requirement. Since 2001, the economic growing very fast in China and 20% increase in power requirement annually. In 2003, power shortage becomes a serious problem and will be more serious in future. The power installed capacity in 2004 is 442.8 GW totally in China in which coal power is 324.9 GW and shares 73.4%; The power generation is 2.19 TWh in China in 2004 in which coal electricity is 1.81 TWh to share 81.7%. Table 2 shows the power generation sectors in China in 2004:

Table 2. China Power Generation in 2004

Type	Installed Capacity（GW）		Generated Electricity （TWh）	
	Capacity (GW)	Share (%)	Electricity (TWh)	Share (%)
Coal	324.9	73.4	1807.3	82.5
Hydro	108.3	24.4	328	15.0
Nuclear	6.84	1.5	50.1	2.3
Others	2.80	0.6	6.3	0.3
Total	442.8	100	2191.7	100

According to the economic growing speed of China, it is not enough just relay oncoal, hydro and nuclear power and there is a gap to be filled with RE power generation. Table 3 shows the power generation by the year of 2010, 2020 and 2050 expected by China Electric Power Research Institute. And the Table 4 shows the gap of power requirement by the year of 2010 and 2020.

Table 3. China Power Generation by the Year of 2010, 2020 and 2050

Year	Capacity（GW）	Generated Electricity（TWh）
2004	442	2191.7
2010	685	3140
2020	1112	5090
2050	2000	9270

Table 4. Power Installed Capacity by the year of 2010 and 2020（GW）

Type	Coal	Hydro	Nuclear	Gas	Gap	Total
2010	500	100	16.4	15.7	52.9	685
	73%	14.6%	2.4%	2.3%	7.7%	100%
2020	750	170	53	48	91	1112
	67.4%	15.3%	4.8%	4.3%	8.2%	100%

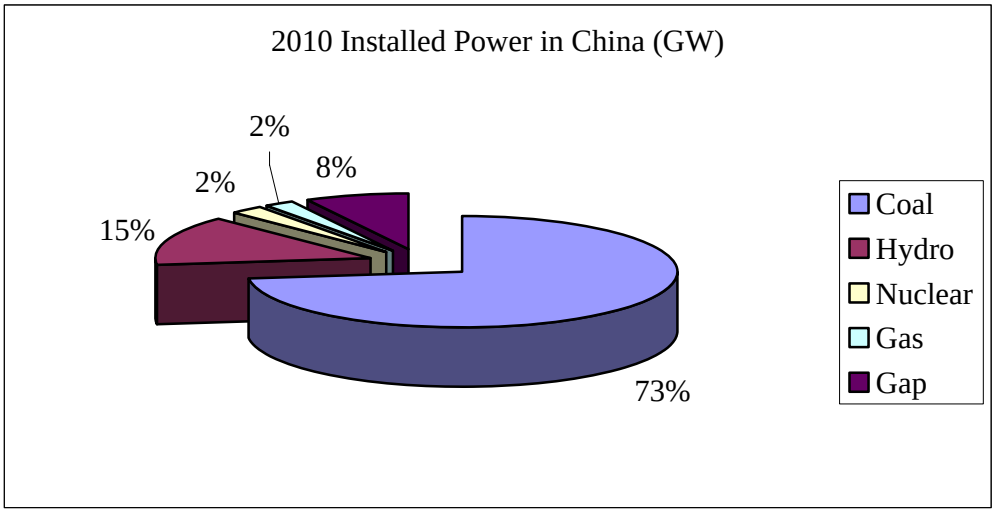


Fig 4. Predicted Power installation by the year of 2010

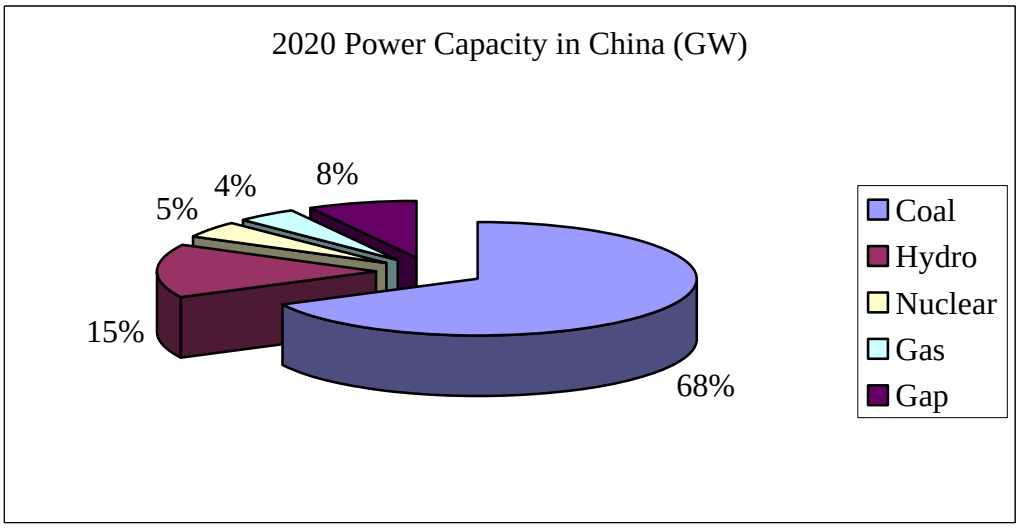


Fig 5. Predicted Power installation by the year of 2020

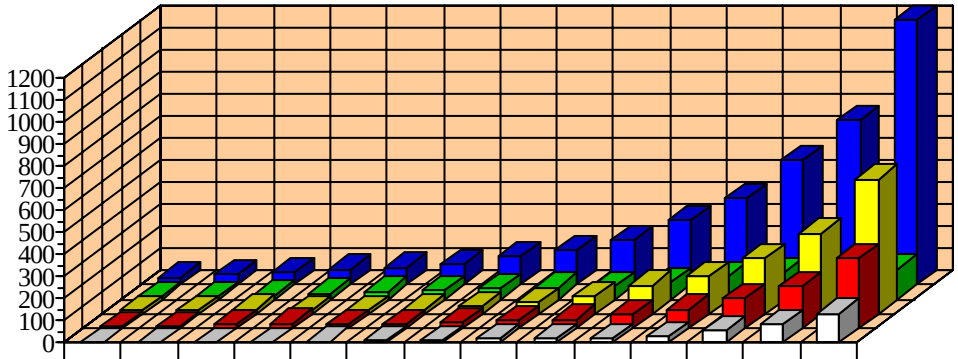
Solar PV will play a role in future power supply in China. It is expected that by the year of 2010, the total installed PV will reach to 400MWp and by the year of 2020, the installed PV will be 2GWp and by 2050, the number will be 100GWp. According to the prediction by China Electric Power Research Institute, RE power generation will share 25% in total power supply by the year of 2050 in which, PV will share 5%. Table 5 shows the situation.

Table 5. Electric Power Capacity by 2050

Type	Capacity （GW）	Share（%）	
Coal	1000	50%	
Nuclear	240	12%	
Gas Power	100	5%	
Large Hydro	160	8%	
Micro Hydro	200	10%	RE 25%
Biomass Power	100	5%	
Wind Power	100	5%	
Solar PV	100	5%	
Total	2000	100%	

2. World PV Industry

In the last decade，world PV market grows very fast and annual shipment increase is more than 30% in the last 8 years. In the year of 2004, PV shipment reaches to 1200MWp and the annual increase even reaches to 61.2%. Fig 6 shows the total PV shipment in the world from 1990 to 2004.



	1988	1990	1992	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Rest of World	3	4.7	4.6	5.6	6.35	9.75	9.4	18.7	20.5	23.4	32.6	55	83.8	135
Europe	6.7	10.2	16.4	21.7	20.1	18.8	30.4	33.5	40	60.7	86.4	135	193	320
Japan	12.8	16.8	18.8	16.5	16.4	21.2	35	49	80	129	171	251	364	610
United States	11.1	14.8	18.1	25.6	34.8	38.9	51	53.7	60.8	75	100	120	103	135
Total	33.6	46.5	57.9	69.4	77.6	88.6	126	155	201	288	391	561	744	1200

Fig. 6 World PV Shipment（PVNET2004）

Table 6、PV Shipment and Cumulative in Last 10 years（GWp）

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Annual Ship.	0.078	0.089	0.126	0.155	0.201	0.287	0.391	0.561	0.744	1.2
Increase（%）	11.8	14.2	42	23.1	30	42.9	35.7	44	32.5	61.2
Cumulative	0.577	0.665	0.791	0.946	1.147	1.435	1.825	2.387	3.131	4.331

Data Source－PV News Paul Maycock

PV market growth in the world mainly due to policy driving in Germany, Japan and US and more than 60% of PV is used in grid-connected sector.

PV roadmap has been set by PV leading countries, like US, Japan and Europe. The comparison of the targets between China and other countries is given in Table 7 and Table 8:

Table 7. Prediction of the Cost of Power Generation by PV

Year	2004	2010	2020
Japan (Yen/KWh)	30	23	14
Europe（Euro/KWh）	0.25	0.18	0.10
US（¢/KWh）	18.2	13.4	10.0
China（Yuan/KWh）	3.8	3.0	2.0

Table 8. Roadmap of PV Installation（GWp）

Year	2004	2010	2020
Japan	1.2	5.0	30
Europe	1.2	3.0	15
US	0.34	3.0	15
China	0.065	0.4	2
World	4.0	14	70

3. PV Market in China

3.1. PV Market Development

China started research on solar cell in 1958 and it was firstly used on satellite in 1971. Solar cell terrestrial application was start in 1973 for beacon light at Tianjin Harbor. Before 1980, PV industry in China was nearly nothing and the annual production is less than 10KW with very high selling price. During 6th (1981-1985) and 7th (1986-1990) national five-year plans, Chinese government starts to give financial support to the PV industry. Various PV demonstrations were installed during that time, such as: solar powered microwave relay stations, army communication systems, cathodic protection for sluice gates and oil pipelines, countryside telephone stations, PV village power systems and solar home systems, etc..

In the year of 2002, PV has more chance than before since the “Song Dian Dao Xiang” (Sending Electricity to the Un-electrified Townships) program was launched

by NDRC. The project has provide electricity to more than 700 un-electrified townships in the western 7 provinces (Tibet, Xinjiang, Qinghai, Gansu, Inner-Mongolia, Shaanxi and Sichuan). The total installed PV was 15.5MWp in which 240KW are small wind power. This program has greatly stimulates the growth of PV Industry. The PV shipment in 2002 was about 20MWp (see Fig. 6) and the cumulated power of PV in whole China reached to 55MW. From 2003 to 2005, PV Industry in China growth very quick and production capacity goes up due to European market, mainly German market. By the end of 2005, Chinese PV module production capacity had been reach to 400MWp and the annual shipment of PV modules were 200MW in which, only 5MW was installed in China while most of them shipped to Europe. Market development of PV in China is shown in Table 9 and Fig. 7.

Table 9. PV Domestic Market Development Since 1976

Year	1976	1980	1985	1990	1995	2000	2002	2004	2005
Annual Install (KW)	0.5	8	70	500	1550	3300	20300	10000	5000
Cumulative (KW)	0.5	16.5	200	1780	6630	19000	45000	65000	70000

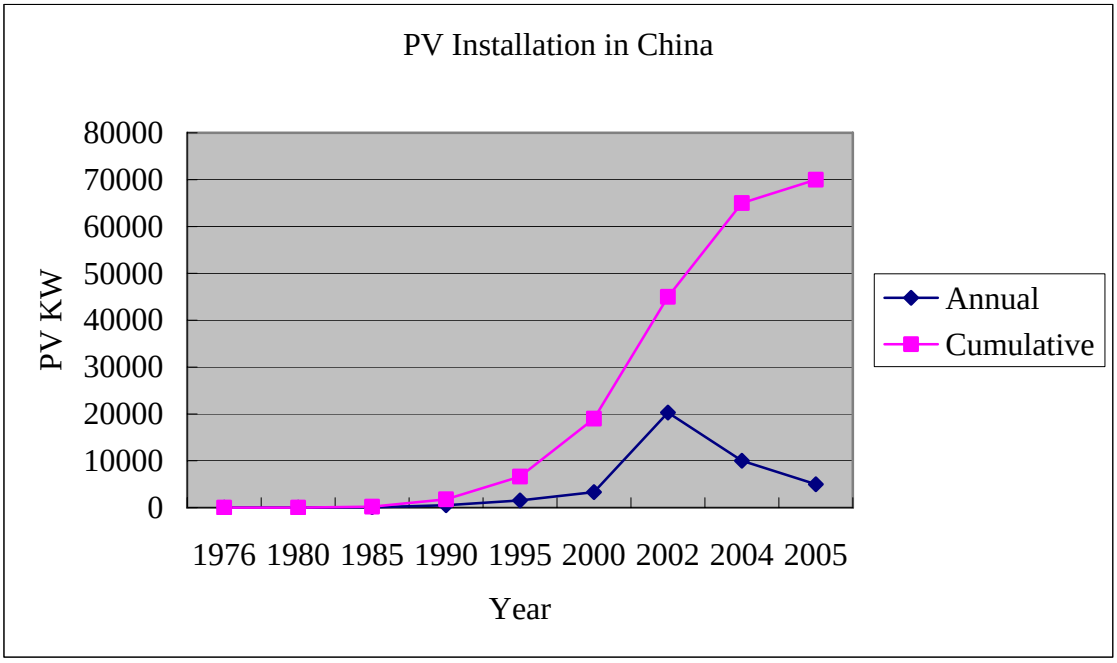


Fig.7. Development of PV Annual Installation and Cumulative in China

3.2. PV Market Share in 2004

The main applications sectors of PV in China are:

Communication and Industrial Uses (36.9%);

- Microwave relay stations

- Optical fiber communication systems
- Wireless communication stations
- Satellite communication and TV receiving systems
- Telephone exchanges for rural areas
- Military communication systems
- Signal systems for railways and highways
- Power systems for beacons
- Weather or earthquake monitoring stations
- Hydrological observation systems
- Cathode protection for sluice gates and oil pipelines

Rural Electrification (approximately 46.2%):

- Stand-alone village PV systems
- Wind-PV hybrid power systems
- Solar home systems
- Solar lighting kits
- Solar water pumping
- Community power (Schools, Hospitals, Restaurants, Hotels, Shops, Karaoke and TV Show Rooms, etc.)

Grid connected application (4.6%):

Grid connected PV includes Building Integrated PV (BIPV) in urban application and Large Scale PV in Gobi desert. Currently, this application is in the demonstration phase, with total amount to 3 MWp by the end of 2004.

PV Products (12.3%):

- Solar hat
- Solar road lamp
- Solar battery chargers
- Solar watches and calculators
- Solar clocks
- Solar yard lanterns
- Ventilators in cars
- Solar-powered automobiles
- Solar-powered yachts
- Solar toys

Table 10. Market Shares of PV in 2004

Market Sector	Installed PV（MWp)	Market Share（%）
Rural Electrification	30	46.2
Communication & Industry	24	36.9
PV Products	8	12.3
BIPV	2.8	4.3
VLS-PV	0.2	0.3
Total	65	100

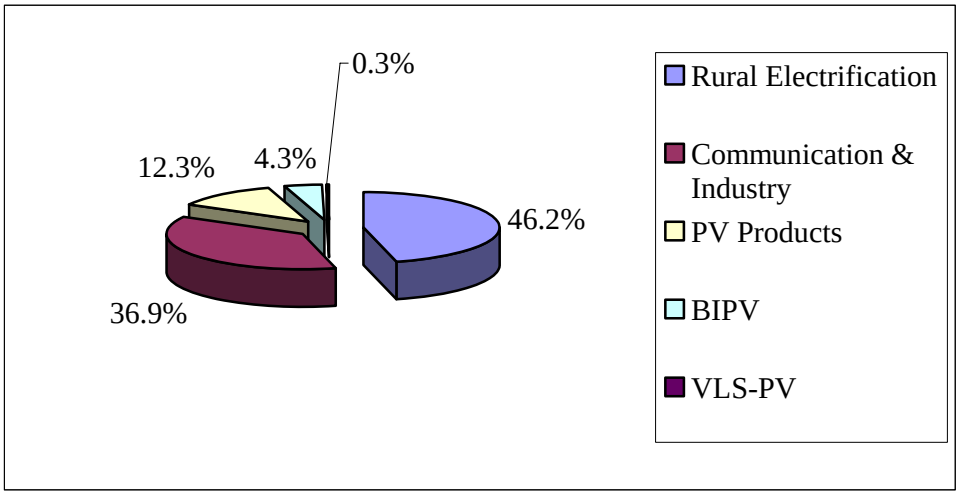


Fig.8 Market Shares of PV in 2004

Among those application sectors, about 50% (communication and PV products) is commercial market, another 50% (Grid-connected PV and Rural Electrification) is now financed by government and will require policy support for a long term in the future due to PV's high cost.

3.3. Future Prediction of PV Market

China is a country with limited conventional energy resources and has big gap in power supply in future. We must take PV as strategic energy and give strong support to its development. According to government program, the cumulated PV installation in China will be 400MW by the year of 2010, and 2GW by 2020. If Chinese Renewable Energy Law is fully implemented, it will not be difficult to reach this target. PV market share of all sectors have been set in the government program (2010, 2020).

Table 11. Market Shares of PV in 2010

Market Sector	Installed PV（MWp)	Market Share（%）
Rural Electrification	250	62.4
Communication & Industry	47	11.8
PV Products	30	7.6
BIPV	53	13.2
VLS-PV	20	5.0
Total	400	100

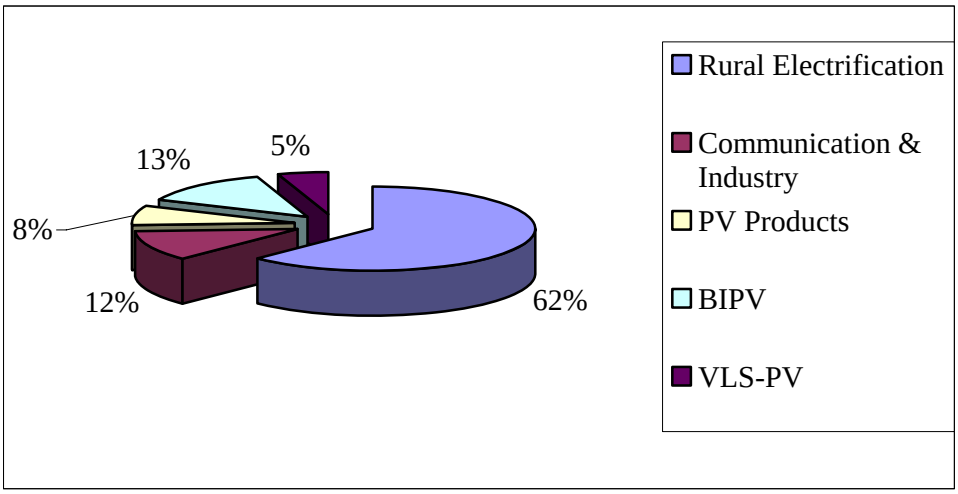


Fig.9. Market Shares of PV in 2010

Table 12. Market Shares of PV in 2020

Market Sector	Installed PV（MWp)	Market Share（%）
Rural Electrification	500	28
Communication & Industry	400	22
PV Products	100	6
BIPV	600	33
VLS-PV	200	11
Total	1800	100

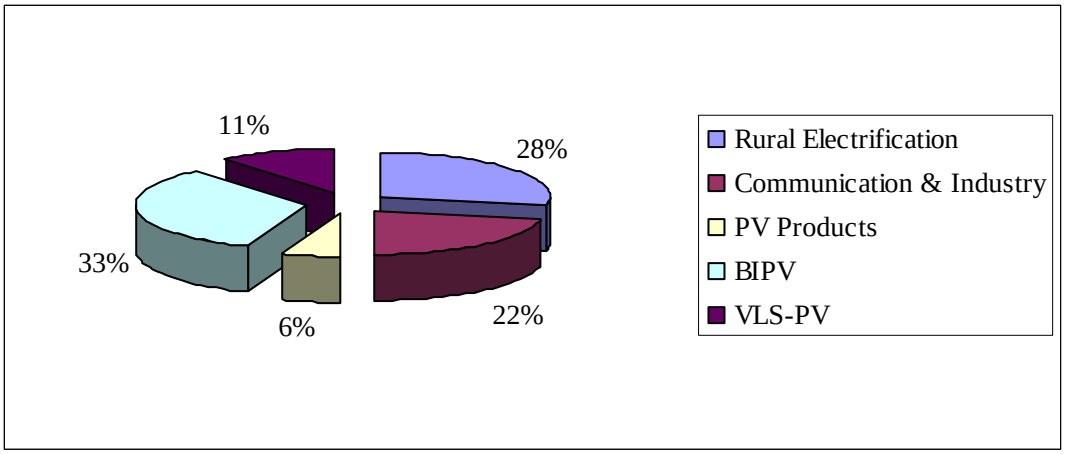


Fig.10. Market Shares of PV in 2020

3.4. Prediction for Cost Reduction of PV in China

Table 13 Expectation of PV Installation and Electricity Produced

Item	Calendar Year		
	2005	2010	2020
Annual PV Installation (MW)	5	130	200
Cumulated PV Installation (MW)	70	400	2000
Annual Electricity Produced (TWh)	0.084	0.48	2.4
Module Price (Yuan/Wp)	35	25	16
Price for Grid-tied PV (Yuan/Wp)	60	40	30
Price for Stand-along PV (Yuan/Wp)	80	60	40
PV Electricity Price (Yuan/kWh)*	3.8	3	2

*: Electricity Price of PV is for Grid-connected Application.

4. Market Opportunities

4.1. Rural Electrification

Chinese government has launched SDDX program in 2002, that is the largest rural electrification project by PV and wind in the world and plan to do SDDC (sending electricity to un-electrified villages) project in next 10 years. 400MW of PV and small wind will be installed during 2006 – 2015 to provide electricity to about 4 million un-electrified households in remote places. The capital investment will be granted by government and it is estimated to be 32 billion Yuan. It is really a good chance for PV, but following factors must be carefully considered:

- Different financing way between village power systems and solar home systems;
- Who will be the ownership of the property of PV systems?
- Where to get money to cover the cost for battery replacement? For no grant from government to pay afterward O&M cost.
- Who will be the RESCO to take duty of O&M and afterward service?
- Tariff collection and business models;
- Quality control and certification issues;
- Service network and spare parts availability for SHS;
- Training.

4.2. BIPV in Urban Application

Now, 60% of PV used in BIPV (Building Integrated PV) in the world. In China, BIPV is now in demonstration stage. According to government plan, 10,000 PV roofs with total 50MW will built before 2010 and another 200,000 PV roofs with total capacity

of 600MW will be built before 2020. BIPV will share 13% in whole PV market in China by 2010 and 33% by 2020. According to RE Law, the capital investment should be born by project developer and the money will be get back from selling electricity to grid company with the price covering PV cost and reasonable profit, that is the policy of Feed-in Tariff. To reach BIPV target, policy of Feed-in Tariff will be the key factor to remove the barrier of high cost of PV and to expand the market.

4.3. Large Scale PV (LS-PV) in Gobi Desert

Large-scale PV built in Gobi desert will play the same function lake wind farm. According to government plan, 2 LS-PV will be built with total capacity of 20MW before 2010 and the cumulative 200MW of LS-PV before 2020. LS-PV will enjoy the same policy of Feed-in Tariff with BIPV systems.

5. PV Industry in China

Before 2000, Chinese PV industry growing in slow speed and there are only 4 main manufacturers to produce c-Si solar cells and 4 to produce a-Si solar modules. The annual production capacity of the PV manufacturers in China is ranged from 0.5MWp to 2MWp. During the 10th national 5 year plan (2001-2005), large PV companies appeared in China, like Baoding Yingli New Energy Co. and Suntech in Wuxi. Market growths very fast during the 10th 5 year plan due to domestic government projects and international market, mainly in Europe. Typical projects of PV during that time are: Electrification for Un-electrified Counties, Argli PV project in Tibet, SDDX program, World Bank/GEF REDP project and UNDP project, and so on. 2003 to 2005, Chinese PV Industry expanded very quickly for several big company involved. By the end of 2004, total annual capacity of c-Si module in China reached to 100MWp (15MWp of a-Si capacity), but the whole PV production chine is not balance. 95% of high pure silicon feedstock need to be imported from foreign countries, very weak in wafer and solar cell manufacturing. Table 14 to Table 18 shows the capacity of all stages in PV manufacturing in 2004.

Table 14 Solar Grade Silicon Feedstock（2004）

No	Manufacturer	Capacity（Tons）
1	Luoyang Zhonggui, Henna	20 (300 under construction)
2	Ermei Semiconductor, Sichuan	20
3	Xinguang Silicon, Sichuan	(1260 Tons under construction)
Total	40 Tons that can produce only 3 MW of solar cells.	

1500 Tons Silicon feedstock can be expected by 2007, but only half of it can be used for PV to produce about 50MW solar cells and the other half is for semiconductor.

Table 15 Wafer Production in China（2004）

Products	Manufacturer	Capacity（MW）
Poli-Si	ZhongYi, Ningbo	2 (2005-8)
	Baoding Yingli	6 (2005-70)
	Jinggong Solar, Zhejiang	10 (2005)
	Jiangxi Saiwei LDK Solar	150 (2005)
Single-Si	Beijing 605 Factory	2
	Xinri, Jinzhou	10 (mainly export)
	Yunnan Semiconductor Factory	0.5
	Ningjin, Hebei	50（80% export）
	Ningbo Solar Cell Factory	1
	Trina Solar, Changzhou	25 (2005)
Total		71.5（20 available）

In 2005, capacity of solar grade mono-Si has reached to 2000 Tons (135MW) and the real production is 1500 Tons (100MW); Capacity of Poly-Si reached to 1200 Tons (80MW).

Table 16 c-Si Solar Cell Manufacturing Capacity（2004）

Products	**Manufacturer**	**Capacity（MW）**	
		2004	2005
Single and Poli Crystalline Silicon Solar Cell	SunTech, Wuxi	50	120
	Yingli, Baoding	3	60
	Shanghai 811	10	10
	Gofly, Shanghai	2	2
	Ningbo Solar Cell Factory	4	20
	Yunnan Tianda	2	10
	Others		50
Total		**71**	**270**

Table 17 Module Manufacturing Capacity（2004）

Manufacturer	Capacity（MW）	Manufacturer	Capacity（MW）
Yunnan Seniconductor	2	Gofly, Qinghai	1
Ningbo Solar	4	Gofly, Inner-M	1
SunTech, Wuxi	25	Huaguan, Tibet	2
Shanghai 811	10	Xian, Jiayang	10
Yingli, Baoding	16	Troni, Shenzhen	4
Nenglian, Shenzhen	2	Kyocera, Tianjin	10
Gofly, Shanghai	2	Zhonglian, Beijing	1
Rixin，Wuhan	1	Linuo, Shandong	2

Xianxing,Shenzhen	1	Quanxing, Guangdong	6
Jiawei, Shenzhen	2	Harbo, Beijing	4
Tuori, Shenzhen	5	Other	1
Sub-Total	70	Sub-Total	42
合 计	**112MWp**		

In 2005, the capacity of C-Si solar modules has reached to 400MW.

Table 18 Amorphous Silicon Solar Panel Manufacturing Capacity（2004）

Products	**Manufacturer**	**Capacity（MW）**
Amorphous Silicon Solar Panel	Harbin Cronar	1
	Trony, Shenzhen	2
	Sun-Moon Circle, Shenzhen	1
	Tuori, Shenzhen	4
	Jinneng, Tianjin	6
	Shihua, Beijing	10 (Under Construction)
Total	**24.5MWp**	

From above Tables, the un-balanced problem in PV manufacturing chin is serious in China in 2004. In 2005, except silicon feedstock, manufacturing capacity of silicon ingot, silicon wafer and solar cell has increased a lot. Manufacturing capacity of c-Si PV modules in 2005 increased to 400MWp and the real production is 200MWp. The supply of solar grade silicon feedstock is remained problem today in China.

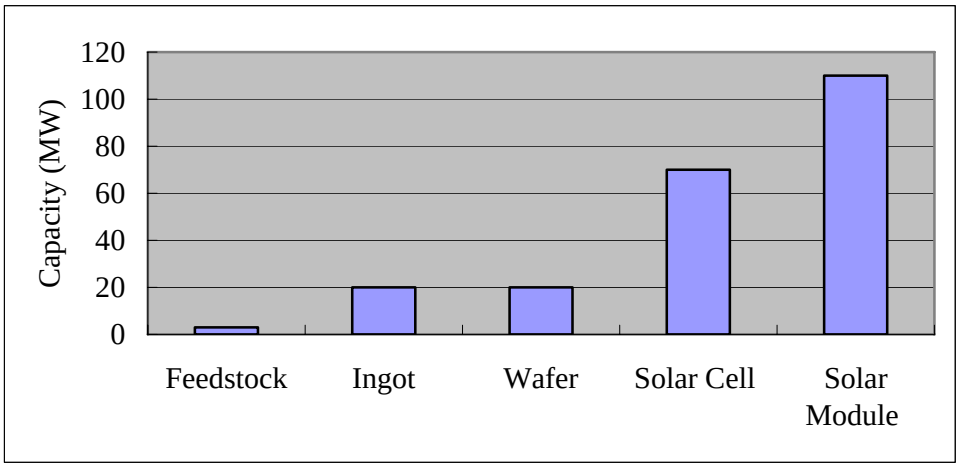


Fig. 11. Manufacturing Capacity of PV Chain in China, 2004

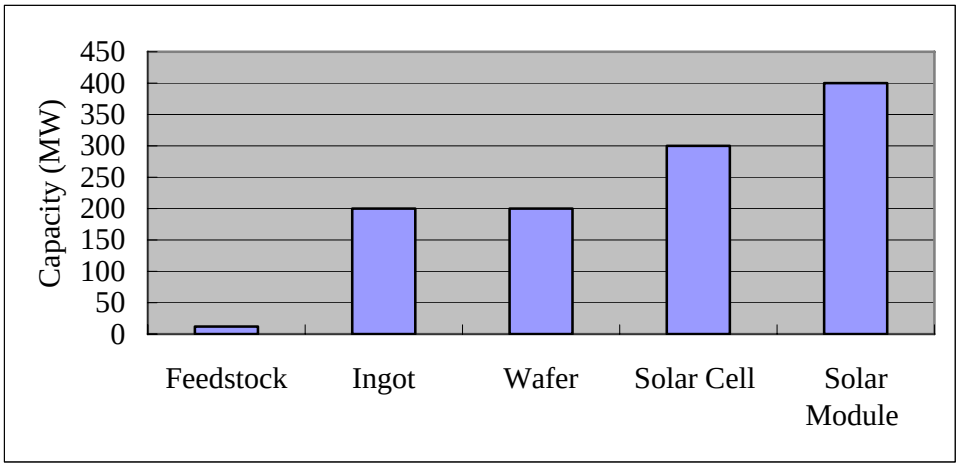


Fig. 12. Manufacturing Capacity of PV Chain in China, 2005.

6. Problems and Barriers

6.1. Silicon Raw Material (Feedstock)

From Table 10 and Table 11, we can see the problem of shortage of silicon feedstock and this problem is not only in China, but in the whole world. Today, 95% silicon feedstock need to be imported from abroad. Shortage of silicon feedstock make the price of PV products go higher. Price of silicon feedstock is from $25USD/Kg in 2002 to $80-100USD/Kg in 2005. Price of final PV module is from $3.0USD/W pin 2002 to $4.0USD/W pin 2005.

China now is doing efforts on this problem, there is a high-pure poly-silicon production line has been established in Leshan, Sichuan province with annual manufacturing capacity of 1000 Ton. Once this production line goes to work, 500 Tons of solar grade feedstock can be provided per year. Luoyang 740 Factory has been expanded to 300 Tons per year and is going to work soon. Even the 2 production lines are fully run and suppose half of the products are solar grade feedstock, there will be only 650 Tons available that can satisfied only 50MWp solar cell production.

It was estimated by “Photo International”, the problem of shortage of silicon feedstock will be released by the year 2007 due to capacity expanding by world leading Silicon manufacturers, like Hemlock, US, Waker, Germany, Tocuyama, Japan.

6.2. Market Development

Market problem is even more serious than silicon feedstock. One may see from Fig. 12, before 2000, Chinese made PV modules are used in domestic market and balanced in exporting and importing (some a-Si modules exported and some c-Si

modules imported). In 2002, China imported nearly 10MWp to support SDDX rural electrification program. Since 2003, Chinese made PV modules are mostly exported, mainly to Europe, and become a large PV exporting country. In 2005, total PV module production was 200MWp, domestic use only 5 MWp, 97.5% were exported. Table 19 and Fig. 13 show the case.

Table 19. Comparison of PV Production and Domestic Market Since 1980

Year	1980	1985	1990	1995	2000	2002	2004	2005
Annual Production（KW）	8	70	500	1550	3300	10000	50000	200000
Annual Installation（KW）	8	70	500	1550	3300	20300	10000	5000

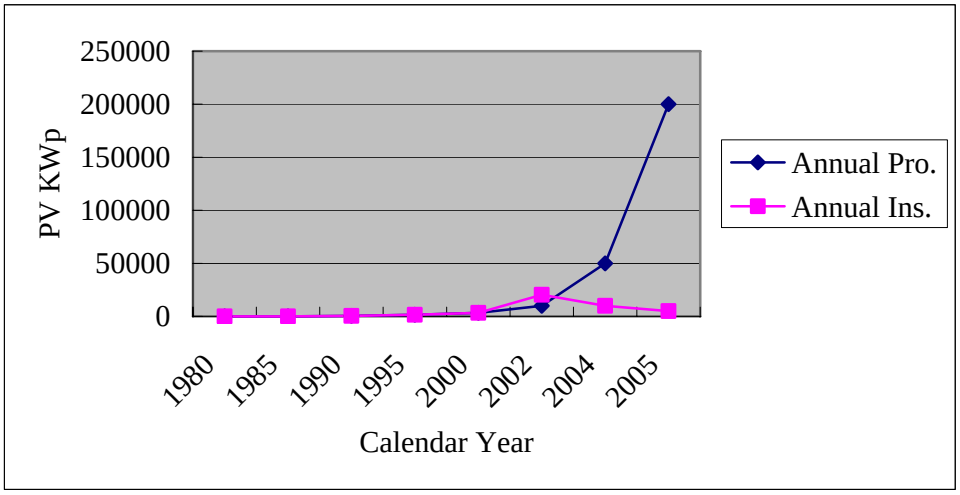


Fig. 13. Comparison between PV annual production and annual installation

It is really dangerous to relay on foreign PV market. The case is different with other commercial market, like textile, everybody will buy it if the quality is good and the cost is low. By now, PV is far away from commercialization, the cost is still too high (50,000 – 80,000 Yuan/KW in capital and 3.5-8 Yuan/ kWh for generated electricity, 10 times higher than grid electricity) and nobody want to buy it if there is no subsidy from government. European PV market is not the commercial market and totally purchased by Governments (German, Spain, Italy, etc.). The market strongly relay on the policy. Once policy changes in European country or they are able to satisfied by domestic products (no matter the price is cheap or not for Government will pay the bill), Chinese PV Industry will face troubles.

Now there are new comers come into PV and existing manufacturers are plan to expand their capacity. Target of Nanjing Zhongdian is 600MW, Suntech is 500MW, Baoding Yingli is 500MW, Changzhou Trina Solar is 100MW, Ningbo Solar Cell is 100MW, Xian Jiayang 100MW and Jiangsu Linyang 100MW-----. Within next few years, manufacturing capacity of PV in China will reach to about 2 GW! That is much more than total shipment in the world today! Where is the market to support such big PV Industry? Does foreign PV market could continue support Chinese PV Industry in future?

6.3. Policy Barrier

6.3.1. Renewable Energy Law and Implementation Rules

The Renewable Energy Law was approved by Chinese People's Congress on February 28th, 2005. The key items and concepts are:

For Grid-connected PV:
Article 14—Grid enterprises shall enter into grid connection agreement with renewable power generation enterprises that have legally obtained administrative license or for which filing has been made, and buy the grid-connected power produced with renewable energy within the coverage of their power grid, and provide grid-connection service for the generation of power with renewable energy.
Article 19—Grid power price of renewable energy power generation projects shall be determined by the price authorities of the State Council in the principle of being beneficial to the development and utilization of renewable energy and being economic and reasonable, where timely adjustment shall be made on the basis of the development of technology for the development and utilization of renewable energy. The price for grid-connected power shall be publicized.
Article 20—The excess between the expenses that power grid enterprises purchase renewable power on the basis of the price determined in Article 19 hereof and the expenses incurred in the purchase of average power price generated with conventional energy shall be shared in the selling price. Price authorities of the State Council shall prepare specific methods.

For Off-grid PV:
Article 15—The Government supports the construction of independent renewable power systems in areas not covered by the power grid to provide power service for local production and living.
Article 22—For the selling price of power generated from independent renewable energy power system invested or subsidized by the Government, classified selling price of the same area shall be adopted, and the excess between its reasonable operation, management expenses and the selling price shall be shared on the basis of the method as specified in Article 20 hereof.

January 4th, 2006, **"The Temporary Implementation Rules for Setting up Feed-in Tariff of Renewable Energy Power and the Sharing of Expenses in Purchasing Electricity of Renewable Energy Power"** was issued by NDRC. In this regulation, some rules are given as bellow:
Article 9— Feed in Tariff of solar power, ocean power and geothermal power shall be determined by government and the price standard shall be set by the price authorities of the State Council in the principle of reasonable cost plus reasonable profit.
Article 12—The excess between the expenses that power grid enterprises purchase

renewable energy power and the expenses incurred in the purchase of average power price generated with local conventional fire power and the excess between the expenses spend on O&M of off-grid RE power systems invested by government and the local average selling price of grid power shall be compensated in the way of adding additional green power price to the ordinary selling price of electricity to the whole electricity users in China.

From above law and regulations, we can see:

1) BIPV in urban and large scale PV in Gobi desert will enjoy the policy of Feed-in Tariff, means the project developer will bear the capital investment and get money back from selling electricity generated by PV and the Grid Company must purchase the electricity with the reasonable price that covers the PV cost plus reasonable profit.
2) For off-grid PV in rural electrification, the capital investment will be granted by government (SHS will be shared by end user in capital) and the extra cost rised from afterward service and O&M will be subsidized by adding green power price to the whole grid electricity in China.

6.3.2. Difficulties in Implementation of Renewable Energy Law

RE Law and Implementation Regulations are good, but by now only on paper. There is no any real example of PV projects have enjoyed above policy by now. PV is more difficult to follow RE Law than wind power that has been accepted by utility company for years.

By now, utility company has not formally accepted PV power and only several demonstration systems are allowed to tied with grid for testing purpose. To be formally accepted by utility company, the following works and efforts need to be further done on PV:

- Set up reasonable feed-in tariff (predict the O&M cost for off-grid PV village power systems);
- Establishing acceptance rules and standards for connecting PV to the grid;
- Persuade Utility company to accept PV and purchase the PV electricity with the set reasonable feed-in tariff;
- Sharing the extra cost to the whole grid in China.

So, only have RE Law be published is not enough, hard efforts need to be done to go through the way of implementation of RE Law and set up practical mechanisms.

7. Conclusions and Recommendations

1) PV will play a very important role in future power supply in China, especially in rural electrification;

2) PV industry in China is growing quickly, but there is unbalance problem in PV manufacturing chain. The problem of shortage of silicon material is the barrier in PV Industry and 95% of feedstock is imported from abroad today;
3) 97% of PV modules exported to foreign countries in 2005. Domestic PV market need to be enlarged urgently, otherwise, Chinese PV Industry will face serious troubles once foreign PV market goes down;
4) PV market development and removing the barrier of high cost of PV are fully depending on the implementation of RE Law. A lot of efforts need to be done for such purpose and demonstration is required to go through the way of policy and set up realistic mechanism.