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HOUSEHOLD PHOTOVOLTAIC MARKET IN XINING, QINGHAI PROVINCE, CHINA: THE ROLE OF LOCAL PV BUSINESS

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Abstract—This paper assesses the present and future market for household photovoltaic (PV) systems in rural Northwest China, especially from the PV commerce at Xining, Qinghai Province. This unsubsidised free market is now met by the emerging PV industry in China, which includes cell and module manufacturers, and PV system distributors and assemblers. For widespread deployment of such a renewable energy technology, the development of a local free market seems more successful than donor- or 'government subsidy'-driven programmes. Presently, there is a thriving infant PV industry in Northwest China, mostly centred in Xining. Xining-based PV sales companies have extensive networks for selling, marketing and servicing household PV systems for rural farmers and nomads. Small systems are now ordinary items on sale in local shops. Based on interviews and fieldwork observations with seven major PV sales companies in Xining, the household PV market is assessed from the present business operations of these companies. Detail of primary sources is given with the aim of archiving seminal progress in the history of photovoltaic power. The results suggest that although the household PV market will continue to grow, current government and international sponsored PV programmes can create both opportunities and barriers for the infant PV market and industry in China.

1. INTRODUCTION

In China, the number of households without access to grid electricity now or for the foreseeable future ranges between 9 million (Wang, 2000a) and 22 million (CRED, 2000).[1] The majority are located in regions where renewable resources (e.g. solar and wind) are available and therefore can be promoted as effective development. China has abundant solar energy resources and small household photovoltaic (PV) systems are sufficient to meet the initial modest electricity needs of most users (CRED, 2000; Wallace *et al*., 1998). Electricity generation from renewable energy technologies, such as household PV systems, also can be a cost-effective alternative for off-grid rural households with modest electricity needs (Byrne *et al*., 1998; Cabraal *et al*., 1996).

Several state and non-state organisations have been involved in the on-going commercialisation of household PV systems in China—central and local governments, international and multilateral institutions, and the infant domestic PV industry (cell and module manufacturers and PV system distributors/assemblers). In developing countries where total rural electrification is not yet realised, PV programmes for rural electrification have been typically donor- and or government-subsidised with aims to benefit the rural population including the poor (see Acker and Kammen, 1996; Cabraal *et al*., 1996; Domdom *et al*., 2000; Martinot *et al*., 2000). Both the government and donor agencies have been vital to PV market development because they have created one of the world's largest markets for the technology (Santibanez-Yenez, 1996).

Despite the importance of government and donor PV programmes, most donor agencies and governments acknowledge that in order to: (a) ensure that long-term PV diffusion persists after the development assistance phase, and (b) reach all income-levels of society, it is necessary to encourage the development of a comprehensive national industry led by local markets for household PV systems (IFC, 1998; Reiche *et al*., 2000; Williams, 1999). Consequently, the majority of donor-driven PV projects in developing countries today aim to accelerate the commercialisation of household PV systems by providing institutional

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[1]The varied data depend on the source. Chinese official sources have estimated the figure to be between 20 and 22 million. One source had an estimate of 60 million (Zhao, 2001).

Table 1. Market share of different PV applications in China (total installed to 1999)

Application	Cumulative (kWp)	Market share (%)
Communication	5280	40
Agriculture and rural electrification*	3960	30
Other industrial fields	2640	20
Civil commodities and others	1320	10
Total	13,200	100

(Source: CRED, 2000). *Household PV systems are included in this category.

and financial support for the PV industry. However, this objective is, in effect, a subsidy and can distort the long-term growth of the PV market.

The key commercial players are: (i) distributors and local support companies (called here 'PV distributors/assemblers'), and (ii) module and cell manufacturers. Some manufacturers produce both modules and cells, while others only manufacture modules, using either imported or domestic cells. Private interests in all stages of production have proliferated in the past ten years, and government and donor subsidies have targeted all segments of production. From 1992 to 1998, solar cell and module manufacturers have nearly doubled in number, whilst PV distributors/assemblers have more than quadrupled. Before 1992, there were less than ten PV distributors/assemblers in China (most of which were State supported research institutes), but by the end of 1998, there were more than fifty. Most of these are based in the north-western provinces, with about 14 based in Xining, Qinghai Province.[2]

This study assesses the market for household PV systems and the role of domestic PV distributors/assemblers in Xining, because Xining-based PV companies have accounted for more than 80% of the household PV market in western China (Wang, 2000a). Western China has 3000 to 3300 h/y of clear-sky sunshine, the most of any area in China (CRED, 2000). Established networks have been predominantly in Qinghai, Tibet, Inner-Mongolia, Xinjiang and Gansu. The production of the majority of the PV sales companies comprises the following stages: (i) purchasing modules from one or several of the domestic solar cell and module manufacturers; (ii) purchasing batteries from a domestic supplier; (iii) producing controllers, inverters, lamps and lanterns by themselves; and (iv) assembling, marketing and selling the systems at the companies' retail outlets.

Based on interviews directly in Chinese and fieldwork observations by the lead author in July 2000, this paper investigates how Xining-based PV sales companies and their business operations shape the household PV market. Details include marketing strategy, servicing and maintenance policy, and operation of PV retail shops. The study further evaluates how domestic and international institutional and financial support creates opportunities for, and barriers to, the development of a long-term PV market in China.

2. PRESENT PV MARKET AND APPLICATIONS

The two principal applications for China's PV market are household PV systems and industrial systems for powering communications. The market shares of these and other applications are listed in Table 1. The PV market for communications, which ranges from 2 to 10 kWp per installation accounted for almost half the PV market in 1999 and still represents the largest market for PV technology. The second largest market for PV technology is household PV systems ranging from 4 to 500 Wp.[3]

The total PV market is growing fastest for household applications. The latter is predicted to become the major market for PV in the future, growing at 20 to 30% per year from between 2.0 to 2.5 MW per year in 1998 (Sherring, 1998). The main market for household PV systems is in Qinghai, Tibet, Inner-Mongolia, Xinjiang and Gansu. There are also significant sales in Sichuan, Ningxia and northern China. Table 2 provides general information.

By the end of 1999, there were still approximately 2 million rural households (about 10 million people) out of 9 million households that lacked access to grid-electricity in the five provinces. The majority of PV owners in Qinghai are

[2]There is no official figure of the number of PV sales companies. One PV retail shop employee noted that there are now about 18–20 companies in Xining, but not all are legitimate.

[3]Systems of 4 Wp are used mostly to power portable lighting systems and flashlights. Systems of 10 and 20 Wp are the most commonly purchased for rural households.

Table 2. Household photovoltaic market

Province	Number of installed systems	Installed power (kWp)	Number of unelectrified households	Potential market (No. of systems)	Average annual sales (sets)
Tibet	6000	120	120,000	110,000	~10,000
Qinghai	20,000	500	180,000	150,000	~20,000
Inner-Mongolia	10,000	500	400,000	200,000	~10,000
Xinjiang	10,000	200	490,000	150,000	~15,000
Gansu	10,000	200	400,000	240,000	~10,000
Ningxia	3000	60	200,000	120,000	n/a
Shaanxi	1000	20	300,000	120,000	n/a
Other province	20,000	500	≈20,000,000*	200,000	n/a
Total	80,000	2100	≈22,000,000*	1,290,000	

(Source: Wang, 2000a,b) 'Systems' include household PV systems and small lights, including portable lights (PV torches). *20 million is the estimate from Chinese official sources (CRED, 2000); however, another source has argued that the number for 'Other Provinces' is only 7 million (Wang, 2000a). If 7 million is the figure used for this category, then the total number of households without access to electricity is approximately 9 million.

herders. According to a World Bank survey of 96 households with PV systems in Qinghai, about 84% are herders, while the remaining households have mixed occupations of farming and herding (Voravate *et al*., 2000). Table 3 provides general information on households with PV systems in Qinghai.

The typical lighting system purchased is 20 Wp or less. Depending upon the brand, the average cost for a 20 Wp system is between RMB (People's Currency '*renmingbi*') 1300 to 1600 (about USD 158–194), and RMB 65 to 80 (USD 8–10) for very small 1 Wp systems.[4] Table 4 lists the approximate prices of components for a typical 20 Wp household PV system. All PV systems are sold on a cash basis. Government rural electrification schemes to assist poor rural households can subsidise up to 50% of the retail value.[5]

Although household PV-only systems, with batteries, may be cost-effective for some areas, they are not yet for regions where an alternative, such as diesel, wind power or wind/PV hybrid, are feasible. Wind power is accepted to be about one-third the capital cost of PV; hybrids are about two-thirds the cost. For PV, life cycle costs may be calculated (a) using the costs on Table 4, (b) replacing batteries and lamps every 5 years (i.e. assuming careful management of the systems), (c) assuming a 20 year period, (d) considering discount rates only (i.e. no extra inflation term), (e) assuming the systems produce 50 to 100 Wh/day of electricity and (d) with no other recurrent costs. The resulting discounted cost of electricity per kWh (i.e. for about 50 to 100 hours of a light) is given on Table 5.

Table 3. Profile of households with PV systems in Qinghai*

N.B. $US 1 ≅ 8.23 RMB	PV household	General population
Average income per household per month (RMB)**	~800	~600
Asset value—livestock (RMB)	~74,900	~52,800
Monthly spending for lighting energy—candle/butter, kerosene, dry cell batteries, small generator set (RMB)	31.8 (~4% of monthly income)	31.8 (~5.3% of monthly income)
Experience with credit (% is based on 96 households surveyed)	8%	10%

*Information is based on a World Bank survey of 96 households in Qinghai Province (Voravate *et al*., 2000). **The difficulty of assessing the average income per household for Qinghai needs to be stressed. During fieldwork in Qinghai, average income of households was asked, and the range varied significantly. Monthly income depends on the region/village they are from and all the income generating activities aside from the main economic activity of animal husbandry. Some herders are now engaged in the tourism industry and/or supplying the market for one of Qinghai's specialities—a medicinal root.

Table 4. Approximate component costs of a 20 Wp household PV lighting system

	RMB	USD
PV module	760–840	92–102
Sealed lead-acid battery	360	44
Controller	200	24
Case	100	12
9 watts DC energy efficient bulbs	35	4
Wire and connectors	50	6
Tax	180	22
Total cost of a 20 Wp system	1685–1765	210–214

(Source: Sherring, 1998) *Cost of PV module depends on type of PV cells used.

[4]RMB 8.23 yuan = USD $1 (July, 2000).

[5]The amount of government subsidies depends on the socio-economic status of households, local leaders and governments as well as the PV company involved. Therefore, end-users can pay anywhere from 30% to 60% of the system's cost.

Table 5. Discounted 20 year life-cycle cost of electricity: RMB/kWh

Discount rate	1%	5%	10%
50 Wh/d lighting: RMB/kWh	7.4	6.5	5.8
100 Wh/d lighting: RMB/kWh	3.7	3.3	2.9

In comparison, the price of electricity from a utility grid may be expected to be about RMB 0.7 (USD 0.09) per kWh. Thus the output electricity discounted costs are about 4 to 10 times more expensive for these PV systems than grid electricity. However it is doubtful if users ever think in these terms, since it is the convenience and effectiveness of the lighting and radio/TV reception that they consider.

3. PLAYERS IN THE PV MARKET

3.1. Domestic PV industry

The domestic PV industry players are (a) PV distributors/assemblers, and (b) PV cells and modules manufacturers. The household PV market is served by many, varied types of suppliers and can be said to be approaching a free market. In contrast, the PV market for communications is primarily dependent on a small number of government contracts.

From 1990 to 2000 the number of module and cell manufacturers in China doubled from five to about ten. The capacity and capabilities of all the domestic cell and module manufactures are listed in Table 6. The total production of cells in 1999 was 2.5 MWp. Of that total, 1.6 MWp were mono-crystalline silicon cells and 0.5 MWp were amorphous silicon (Wang, 2000b; CRED, 2000). China also has a relatively small import of cells, while exports consist of 1 MWp of amorphous silicon cells (Wang, 2000b). In 1999, the price of mono-crystalline silicon cells was RMB 40–45/Wp (USD 4.86–5.46) and that of amorphous silicon PV cell modules was RMB 25–27/Wp (USD 3.03–3.28) (Wang, 2000b; CRED, 2000). The prices have dropped nearly 50% since 1985. Total installed capacity of operating systems at the end of 1999 was approximately 13 MWp (Zhu, 1999).

The number of PV distributors/assemblers has increased even more dramatically since 1992. There are now over fifty companies distributing and assembling household PV systems. Well-established companies and brands have extensive marketing strategies and networks in the five main north-western provinces. In recent years, there also have been a number of independent distributors, making large purchases at the retail stores of the PV companies and then reselling the

Table 6. Information on solar cell manufacturers in China

Manufacturer	Production start date	Origin of equipment	Technology	Cell capacity (kWp/y)	Module capacity (kWp/y)	Output in 1999 (kWp/y)
Qinghuangdao Huamei Photovoltaic Electronics Ltd.	Imported line: 1990	Spire, USA	Mono-crystalline Si	300	1000	300
Yunan Semiconductor Devices Factory	Old line: 1983 New line: 1987	TPK, Canada	Mono-crystalline Si	500	1000	500
Kaifeng Solar Cell Factory	Old line: 1976 New line: 1988	Spire, USA	Mono-crystalline Si	150	300	200
Ningbo Solar Cell Factory	Old line: 1976 New line: 1988	Spire, USA	Mono-crystalline Si	500	1000	600
General Inst., for non-Ferrous Metals	1987	Spire, USA	Poly-crystalline Si	150	150	100
Wuhan Power Source Factory	1979	Spire, USA	Imported: Siemen's cells	n/a	n/a	200
Jiawei Industries Co. Shenzhen	1997	Spire, USA	n/a	n/a	n/a	200
Harbin-Chronar	1991	Chronar, USA	Amorphous Si	n/a	1000	400
Beijing Mingchengguang	1995	Joint venture with Japan	Mono-crystalline Si	2,000	n/a	n/a
Guofei Group, Shanghai	2000	Domestic	Mono-crystalline Si	3,000	Production started in May 2000	
Yingli, Baoding (at planning 1999)	2001	Domestic	n/a	3,000	n/a	
Total approx.				6,600	4450	2500

(Source: Wang, 2000b). n/a = information not available. Note: production of modules can be larger than cells in any one year, for example by using cells manufactured the year previously.

PV systems at higher prices in areas that continue to lack grid-access.

3.2. Government

The state agencies involved with the promotion and dissemination of renewable energy development and projects are: the Ministry of Agriculture (MOST), State Development Planning Commission (SDPC), State Economic and Trade Commission (SETC), State Power Corporation (SPC) and Ministry of Electric Power (MOEP).

The Renewable Energy Development Programme (1996–2010) is the main policy initiative for accelerating the commercialisation of renewables in China. The renewable technologies affected by this programme are mini-hydropower, wind power, solar PV power, geothermal energy and biomass. The PV component of the programme aims to improve efficiency and reduce systems cost through the development of low-cost solar PV cells and associated equipment. The Chinese government has encouraged PV power projects as an important measure for rural electrification, poverty-alleviation and reduction of environmental pollution. The government's current rural electrification target is to supply electricity to 95% of peasants and herders by the year 2000 (Li, 2000). However, this goal has not been realised and will be difficult to reach in the near term (Yu, 2000; Wang, 2000a). The targets for PV development are shown in Table 7. Significant regions for installing systems are mainly in Qinghai, Xinjiang, Gansu, Tibet and Inner Mongolia.

Provincial and local level governments are typically in charge of planning and implementing rural electrification targets. PV for communications and larger-scale projects are usually handled by the state government whilst large-scale grid connected projects might involve foreign assistance.

3.3. Qinghai Province

Some provincial and local governments have promoted the development of household PV systems by subsidising the costs for poorer rural areas. Subsidies can range from 30 to 50% of retail price. The Qinghai provincial government's immediate objective is to provide systems to about 110,000 of the 630,000 rural households lacking electricity (CRED, 2000). The target is to install 1.4 MW of household PV systems and PV stations for local centralised power with the total capacity of 340 kW by 2010. The local government, in collaboration with the state-supported Research Institute in Qinghai, expects to install 23,000 household PV systems by 2000 and 47,000 by 2010 (Buckeley, 1999). A levy on grid electricity has been set up in order to create a rural electrification fund (Buckeley, 1999). Part of the funds will be used for subsidies for poorer farmers and herder households.

Table 7. Solar PV installation target in China

System type	Targeted capacity (MW)
Household size system	15
Stand alone power station	3.5
Village level power supply system	11.5
Stand by power system (roof top and other grid connected system)	1
Total	31

(Source: Derrick and McNelis, 2000)

3.4. International and multilateral agencies

The main international and multilateral agencies responsible for joint rural electrification projects and the commercialisation of renewables in China are: the World Bank, United Nations Development Programme (UNDP), Global Environmental Facility (GEF), Asian Development Bank (ADB) and the World Wide Fund for Nature (WWF).The proposed World Bank/GEF renewable energy project in co-operation with SETC (1999–2004) is predicted to have an impact on the household PV market when implemented. The PV component has two main objectives: (a) to provide institutional and financial support for the dissemination of household PV and PV/wind hybrid systems for rural electrification and (b) to accelerate the commercialisation of household PV systems by providing financial support for PV sales companies. GEF (Global Environment Fund) grants, totalling 20 million USD, will be used to distribute 200,000 sets (10 MW) of household PV systems in remote areas of Qinghai, Gansu, Inner Mongolia, Xinjiang, Tibet, Western Sichuan and adjacent areas. Part of the funds will also be a direct grant for approved PV sales companies of USD 1.50 per Wp for systems with a capacity of 10 Wp or greater (The World Bank, 2000). Financial support would assist companies to improve PV product quality, strengthen business capabilities and increase marketing efforts.

4. QINGHAI AND PV COMMERCE

4.1. Local market development in Qinghai

The household PV market in Qinghai developed due to government support, popular demand and a

small but growing PV industry.[6] In the early 1990s, the Xining Municipal government not only funded various PV demonstration projects, but also distributed complimentary systems to Tibetan nomads. Promotion, demonstration and installation were contracted with one of the renowned state-owned research institutes, Qinghai New Energy Research Institute (founded in 1983), which established a private holding company called the Solar Electric Power Co. in 1993. It was the only research institute disseminating household PV systems at the time. During the early promotional stages of PV (from 1990 to 1993), the state naturally collaborated with the Research Institute because it was, and still is, under the influence of two state agencies, MOST and SDPC. Other private PV sales companies were not established formally in Xining until 1994. Hence, the majority of grid and off-grid PV power projects in Qinghai up until the mid-1990s were contracted to the Research Institute.

4.2. State-owned enterprises in modern China

Changing business structure and management among state-owned enterprises has been a consequence of China's economic transition from a command economy to a more market-oriented economy in the past two decades. One main outcome of China's transition to a market economy has been the rise of private entrepreneurs and the creation of a modern enterprise within a state-owned enterprise. As a result, there are three types of business enterprises today—private (*mingying qiye*), state-owned (*guoying qiye*) and quasi-private/state-owned (*youxian zerenzi*). The differences between these three types and how they shape market competition will be evaluated in the context of the PV industry because fieldwork findings suggest that the international and domestic programmes with subsidies have not benefited all Chinese PV companies equally.

In the case for the PV industry in Qinghai, the difference between a state-owned and semi-state-owned enterprise is not apparent.[7] In fact, during interviews with general managers of PV companies, nearly all the general managers commonly referred to the only quasi-state-owned enterprise (New Energy Research Institute/Solar Electric Power Co.) as a state-owned enterprise even though a private holding company was established in 1993. The two entities are indistinguishable because the president of the Research Institute and the director of the company are the same person. Moreover, shares rarely are opened to the public. In fact, state employees and workers are typically the shareholders.[8]

Because the Research Institute is still a direct state organisation, administered by MOST and SDPC, it is not surprising that the private holding company is linked closely to the two state agencies. This is a major advantage for the quasi privatised enterprise because the state agencies generally contract with them. A drawback to such an enterprise is its inability to immediately respond to market fluctuations. Bureaucratic inefficiencies can constrain the enterprise's innovation and flexibility to respond to market fluctuations.

Even after private household PV distributors/assemblers emerged as key actors in promoting and selling household PV systems in 1995, the Research Institute and its holding company have continued to receive government contracts for the majority or all of the large-scale PV projects in Qinghai (Ma, 2000; Yang, 2000). Furthermore, when international donors are looking for Chinese PV project partners, the government usually refers them to a government institute or holding company and seldom to a private Xining-based PV company.

4.3. Development of private enterprises

Although the Research Institute receives direct subsidies from the local and central government to disseminate PV systems, this market barrier has neither prevented more private individuals from entering the market nor private PV sales companies remaining competitive. Between 1995 and 2000 more than twelve domestic private PV companies (i.e. distributors and integrators) were established in Xining, Qinghai. Xining currently has the largest number of PV sales companies and retail shops in China. All of the domestic PV sales companies interviewed for this study have extensive distribution, servicing and maintenance networks in neighbouring provinces and autonomous regions. The general managers of most PV companies in Xining were either former employees of the state-owned Research Institute or employed by the first privatised PV sales company, the

[6]The phrase 'PV industry in Qinghai' refers to all the PV distributors/assemblers and the one state-supported research institute.

[7]This has also been said about other state-owned enterprises in transition (Ma, 2000; Yang, 2000).

[8]These characteristics are typical of state-owned enterprises worldwide establishing private ventures.

Qinghai Xining Solar Energy Power Development Centre, founded in 1995.

During the 1990s, independent of government promotion and demonstration projects of household PV systems, there were a number of private individuals who also recognised the lack of electricity in rural areas and a business opportunity. In 1992, a group of about five Chinese graduates in electrical engineering, led by the present general manager of the first privatised PV sales company, began to promote and assemble 10 Wp PV systems for Tibetan herders. Initial production for the PV systems included purchasing PV modules without subsidy from Chinese manufacturers of cells and modules, and then assembling the PV system for end-users. During their two years (1992–1994) of promoting PV systems for Tibetan herders, they were unaware that the state-owned Research Institute existed and had been engaged in similar activities with the government.

The household PV market is considered nearly a free-market and the number of new private investors has increased in the past two years. However, not all new players in the market are interested in the long-term sustainable growth of the market; instead, short-term profit is the main goal. Subsequently, there are now a few small-scale PV distributors producing low quality PV systems offered at very low prices (CRED, 2000; Ma, 2000). There also have been a number of independent distributors (mostly Tibetan merchants) that have been reselling systems (bought in Xining) at higher prices in areas that still lack electricity.

5. FINDINGS—PV MARKET OUTLOOK

In order to assess Xining-based PV companies and the market for household PV systems, fieldwork was conducted by the lead author, mostly in Chinese (full details in Ling, 2000). Direct interviews in Chinese were made with PV general managers in Xining. Interviews elicited information on future business strategies and how current government and international programmes can progress their business. The majority of general managers interviewed had been engaged in PV dissemination and/or research and development from 1993 or earlier. Table 8 lists the companies interviewed. Interviews with sales employees and observations of daily customer–employee interaction in numerous retail shops for the PV companies were necessary because their knowledge of the product and business represents one aspect of the PV companies' business operations. Discussions in Tibetan between Tibetan customers and the lead author required translation into Chinese.

5.1. PV programmes

One topic that was discussed at length during interviews with general managers was the impact of provincial and state subsidies for household PV systems on business operations. There are two domestic policy initiatives which will immediately impact the business of PV companies: 'the Great Development of the West' (*Xibu dakaifa*), which started in 1999, and the government's ambitious plan to provide electricity to all rural households that lack access to grid electricity within the next 50 years. 'The Great Development of the West' will entail the provision of increased funds from the central, provincial and local government for industrial and social development. The second policy plan, rural electrification, signifies the government's long-term commitment to rural electrification and the deployment of PV in meeting this commitment. For PV businesses this is an indication of more market opportunities via government subsidies for rural development.

All companies interviewed, except one, have participated in government PV projects for rural electrification. Although a significant proportion of the companies have worked with the provincial and/or local governments in PV promotional campaigns for electrification, half of the general managers viewed these joint ventures as not profitable. However, they continue participation, expecting to fill a market niche for government PV projects.

The majority of companies recognise that local government PV programmes, which can subsidise close to half of a PV system's retail price, are directed at helping rural households raise their standard of living, with market development secondary or perhaps not even a goal at all. The major disadvantage to government PV projects is that not all of the PV companies have the opportunity to participate in joint-government PV projects because they are usually administered from the top down. Companies do not have the opportunity to bid for contracts because governments at all levels will usually contact their choice of company for collaboration. If the PV project is devised from the MOST or SDPC, then projects will be directly contracted with the only quasi state-owned enterprise, the Qinghai New Energy Research Institute, because this is under the

Table 8. Xining photovoltaic companies interviewed

Company and year established	PV brand	Location of PV retail shops	Annual production capability and type of systems* (No. of systems a year)	Other products	Type of enterprise
New Energy Research Institute (1983)/Solar Electric Power Co. Ltd. (1992)	Nima	Qinghai, Tibet, Xinjiang, Ningxia, Yunan, Gansu and Sichuan	10,000 All types, including PV villages		State-owned
Qinghai Xining New Energy Development Company (1996)	Nida	Qinghai, Tibet, Inner Mongolia, Hunan, Gansu, Sichuan, Pakistan, Mongolia and Nepal	10,000 (3 series of 8 to 300 Wp systems)	DC/AC PV systems and office PV systems	Private
Qinghai Xining Gesun Solar Energy Co. Ltd. (1998)	Ousai	Tibet, Qinghai,njiang Gansu, Sichuan, Inner Mongolia and Xinjiang	10,000 (4 to 50 Wp systems)		Formerly worked for Xinxing brand
Qinghai Xining Solar Energy Development Centre (1995)	Xinxing and Gangwasi	Tibet, Qinghai, Sichuan, Gansu and Tibet	10,000 (3 series of 4 to 300 Wp systems)	Domestic colour TV (lighting) systems and office systems	Private
Qinghai Xining TianPu Solar Energy and Technological Co. Ltd. (1998)	Tianpu	Qinghai, Tibet and Xinjiang	7,000 (10 to 100 Wp systems)	3 kinds of controllers 5 kinds of inverters	Private former Director of New Energy Research Institute
Qinghai Xining Dawa Solar Energy Company (1997)	Dawa	Xinjiang, Qinghai, Tibet, Gansu and Sichuan	7000 (10–20 Wp)		Private former employee at Xinxing
'Xining Tianyu Solar Energy Electricity Co.' (1998)	Shanguang	Xining	8,500 (10–20 Wp)		Private former employee at Xinxing

*Unless noted all systems are DC systems. The figures for annual production are approximate estimates and companies can sometimes overstate production capabilities and number of systems sold. **4 Wp systems products include hand-held torches/flashlights.

supervision and payroll of these two state agencies.

Well-established private PV companies can also vie for government projects if they are not directly from the MOST or SDPC. For example, the provincial power bureau, county leaders, township and village leaders also have initiated PV for rural electrification projects and have sought different private PV companies for project implementation. The decision of which company to contract with is dependent on the following: whether the company is well established, based on reputation, when it entered the market, the price of systems and personal connections with the general manager. The less well-established PV companies and new comers in the market are at a severe disadvantage because the provincial government, and/or local leaders rarely prefer these companies for PV projects.

There was overall consensus (except for the state-owned PV company) by the general managers that subsidised local projects are not desirable and could harm the long-term development of the household PV market. However, they expect that this will gradually change. The opportunities for joint-government projects will only increase in the near future, hence new comers and established companies experiencing decline in sales must either attempt to break into this market niche or attempt to reach the rural populations that are still without electricity.

The proposed five year World Bank/GEF PV grant is one of the first foreign assisted programs that has created opportunities for all PV players based on a set of conditions. Almost all general managers agreed that if successfully implemented, it could raise the quality and production standards, create opportunities for foreign joint ventures and

provide financial support for the companies to expand business operations such as providing better service and maintenance networks for PV end-users. All of the PV companies visited have been approved for the World Bank/GEF grant, but no funds have been disbursed yet. Thus there were two general managers that expressed their doubts as to whether this program would prove beneficial for their business.

5.2. General business operations

Interviews centred on three aspects of business operations: marketing, servicing and maintenance policies and PV retail shops. In general, the three well established companies—Nima, Xinxing and Nida brands —have continued to expand business operations, but the experience of other smaller-scale companies differed. Some smaller-scale PV companies experienced growth, whereas some have cut back on their operations. One general manager noted that sluggish sales coupled by a saturation of PV companies have resulted in low profits and worker lay-offs recently. This company also had to close down one of its two retail shops in Xining last year.

A concern for the three major PV companies that are expanding operations is product quality and differentiation. Not surprisingly, these three companies also have the most extensive marketing, servicing and retail outlets in Qinghai and in all the neighbouring provinces. Marketing has been aggressive among these three companies,i n particular, billboard advertisements in the area where the PV shops are located. All three companies also have daily radio and television commercials in Tibetan language.

Although late entrants into the market will be at a disadvantage because they will not have existing capital to immediately embark on extensive marketing campaigns or even establish an extensive retail outlet, some survive in the short-term by offering significantly lower retail prices for their PV systems.[9] However, the quality of the systems will be jeopardised. If newcomers plan to be long-term market players, they will need to address the issues that the well-established companies are addressing now (e.g. product quality).

5.3. Case studies of retail shops

Selected case studies in Xining of the PV sales companies' retail shops are presented because they provide pertinent insights into a crucial aspect of PV companies' business operations, i.e. how products are marketed and sold. Some shops carried a competitor's brand and/or share space with an electronics store. Interviews with employees (summer 2000) focused on knowledge of customers and products, servicing and maintenance, domestic and international programmes and knowledge of the PV companies' long-term business strategies. In each of the retail shops almost all employees are ethnic Tibetans and every shop has at least one Tibetan employee. This is crucial, because the vast majority of customers are Tibetan herders who do not speak Mandarin Chinese. Fig. 1 shows some of the major channels for PV systems to reach end-users.

Data obtained from all PV retailers is consistent in the following respects: prices given are an average after bargaining and dependent upon type of battery, PV module and case material. Companies also have user manuals included with purchase of a system and product brochures printed in Chinese and Tibetan. All sales employees are capable of demonstrating the use of systems. All PV systems are under warranty and warranty policy varies among companies. Some companies have warranties for specific components, while others cover the whole system within a specific period. Servicing is free under warranty but most companies are willing to service the system even after warranty expires. This depends upon the component that needs servicing though. Customers can purchase and service a PV system at any of the distribution centres or retail outlets outside of Xining.

The strategic location of the PV retail shops is an important aspect of the PV market in Xining. All retail shops are situated next to Xining's central bus station and are near the central train station. Retail shops have congregated near these stations for the convenience of mostly Tibetan customers who travel from remote areas in Qinghai and other provinces or autonomous regions to Xining for their yearly purchases of household products.

5.3.1. Case study 1: 'Television Broadcast Market'(Guangbo dianshitai shangchang) retail shop. Opened in 1999, this shop carries two household PV brands. There are three permanent employees who are ethnic Tibetans fluent in Mandarin. The name of the shop is literally 'Television Broadcast Market' because a government-supported Tibetan radio station is based at the store. Even though two PV brands are sold,

[9]Prices for a no brand name 20 Wp system can be as low as RMB 600 (USD 73).

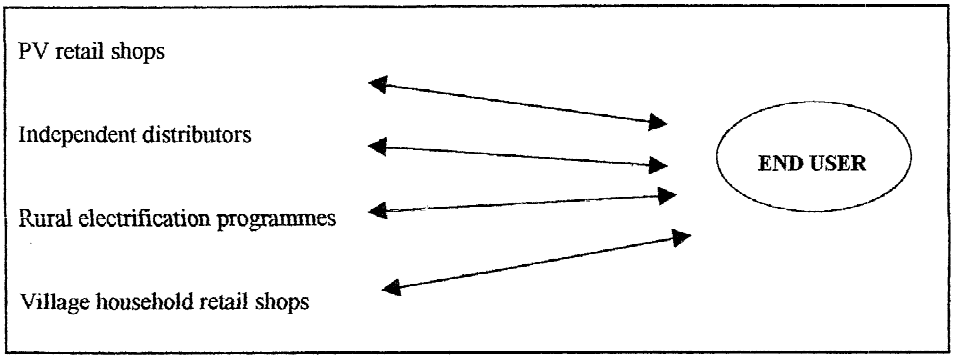

Fig. 1. Potential channels to reach end-users.

the store is primarily the manufacturing outlet for the semi-state supported Nima PV brand.

All employees are familiar with the provincial government PV subsidy programme. However, they had little knowledge of future business strategies or long-term goals of the PV companies. They demonstrated a clear understanding of the difference between the two types of PV business enterprises: state-owned Nima brand and other private PV brands. They noted that as a state-owned enterprise, the government partially had subsidised the opening of this shop and another Nima shop in the area.

According to the account of one employee, both the provincial and central government have worked with Nima brand to provide electricity to nomadic herders. Electrification targets for an entire village have been implemented usually from the central or provincial power. However, in recent years, local village and county leaders have been more active in increasing funds. One employee noted that it is now nearly impossible not to work with, or go through, local village leaders to implement a successful PV electrification program. As one employee noted, to plan and implement a government PV project is actually quite complex because it will need to account for the role of all the local leaders. Fig. 2 illustrates the hierarchy of provincial leaders and the potential political channels a company might encounter or have to go through in order to initiate a project. The initiator of a project can either be a company who knows of an area that lacks electricity and therefore might approach the county or local village leader for a project or households from a village who heard of such government PV programmes.

As ethnic Tibetans, employees can substantially shape a customer's choice of PV brand and system. Employee recommendation regarding which brand to purchase depends on the user's purpose. Employees will recommend the less expensive Yulong brand for entrepreneurial customers engaged in redistributing PV systems for rural customers in their village or in areas where PV has not been introduced yet. Table 9 lists the products in the shop and the retail prices in July 2000.

5.3.2. Case study 2: Nima retail shop. This retail shop opened in March 1999 and only sells Nima PV products. There are about four permanent employees; three ethnic Chinese and one Tibetan. The interview was conducted with a Chinese sales representative.

The employee interviewed has a good grasp of which government departments are responsible for rural electrification PV projects and which

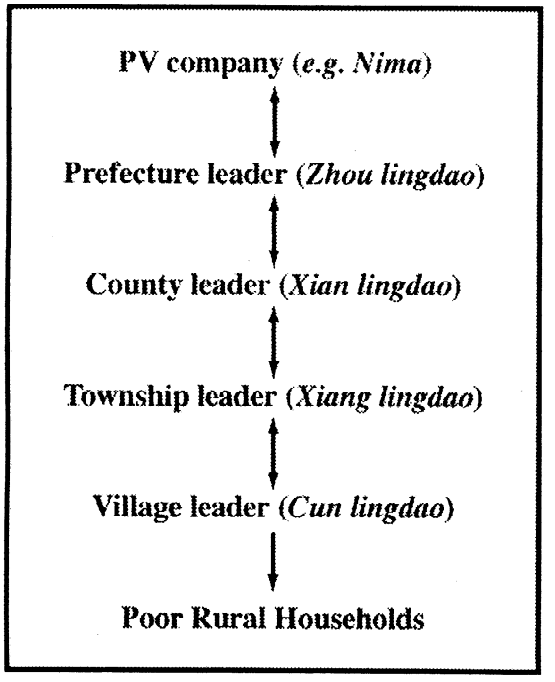

Fig. 2. Hierarchy of provincial leaders.

Table 9. Cost comparison of Nima and Yulong PV systems*

PV brand	Nima	Yulong
Products	4–5 Wp · Metal case: RMB 400 · Wooden case: RMB 380 10 Wp · RMB 800 Special lighting. 20 Wp · Metal case: RMB 1560 Plastic protection. Voltage meter check · Metal case: RMB 1530 No voltage meter. · Wooden case: RMB 1500 No voltage meter.	10 Wp · RMB 730 20 Wp · RMB 1460 Dry battery · RMB 1300 Wet battery

*Current market prices (July, 2000). RMB 8.23 yuan = USD $1.

companies the government has collaborated with. He noted that in a local government PV project, the government typically subsidises approximately 50% of the system, the company makes a 20% reduction and the end-user pays 30%. Government PV programmes traditionally have dealt with the three oldest and largest companies (i.e. those with largest annual production capability, see Table 8). The employee found PV subsidies to be beneficial because it is a nationally planned policy that attempts to benefit the socio-economic conditions of the end-users. He asserted that subsidies would not jeopardise the future market for household PV systems.

All employees are familiar with the geographical regions that still lack electricity. The majority of customers in their shop have been nomadic herders from Qinghai, Sichuan, Tibet and Southern Gansu. Because the current household PV market is driven by price, customers are willing to make long treks (often travelling for 2 days or more) to Xining in order to bargain and compare for the cheapest systems. Nationwide, Xining has the most retail shops concentrated in one area. Compared to other northwest provinces, the majority of farmers and Tibetan herders have a basic knowledge and at least are aware of the technology. This is because PV diffusion in the province had an early start. Some households already own two or three systems.

5.3.3. Case study 3: Xinxing retail shop. Opened in 1996, there are two store employees; both are ethnic Tibetans. One employee had spent more than two years assisting the general manager of this PV company to promote and disseminate in his home village. This brand is one of the three largest PV companies and one of the most well respected brands. They carry two PV brands, differentiated by quality and price. Discussions focused mainly on government subsidy programmes and current market conditions.

In the last two years, PV companies in Xining have depended upon government aid programmes for profit. By contrast, ‘ . . . in the initial years of market development, profits from retail sales alone were sufficient for PV companies to operate and expand because there were only one or two competitors.’ Although profits are lower for government programmes, some companies participate because this is becoming a more popular method to provide electricity for an entire village or county. Furthermore, once a neighbouring village realises that another village can purchase a PV system at a lower price, they will then wait or pressure their local village or township leader to initiate a PV project even if they can afford to pay for a system at retail value.

Unlike other PV sales companies, the company’s product brochure lists all the counties, towns and villages that the company has supplied PV systems to through the government’s PV rural electrification programs. Any customers from the villages listed then are able to purchase any PV system at a discount retail price at any of the company’s retail outlets. Because customers from the villages listed on the company’s product brochure can purchase a PV system in any of their retail stores, it is likely that some customers will seek the lower prices by saying they are from one of the poor villages enrolled in the government PV programme. Presently they do not have a systematic method to keep track of whether customers are from a particular village.

The sales manager partly attributed his concern over the current PV market situation to low quality, ‘fake’ systems being produced and sold on the market. He characterised the market as a mess because there is a lack of business regulation and standards for PV products. Other sales employees from other retail stores also shared the same concerns. Another factor that has affected the market is the increase of private distributors who travel to Xining to make large purchases of household PV parts or systems. These private distributors can either positively impact PV diffusion by purchasing and redistributing reliable systems or they can negatively affect the market by reselling unreliable systems.

5.3.4. Case study 4: Nida retail shop. Established in 1996, this store is the only PV retail shop that sells polycrystalline PV modules with their

systems. The sales manager was a former employee of another PV company. There are two permanent employees at the manufacturing retail outlet for Nida, both of whom are ethnic Chinese. As one of the well-established PV companies, this company demands higher prices for their PV systems because they claim to have one of the best products. Because this company has emphasised product quality, the sales manager stressed that the owners of the company usually are unwilling to reduce prices, even for government rural electrification programmes.

The sales manager noted that while most customers do not understand the difference between mono-crystalline and polycrystalline silicon cells, they will ask whether the solar cells and modules are imported or domestically produced. Customers also associate higher prices with quality. However, the majority of customers who travel to Xining to purchase a PV system usually want the cheapest. Thus the company with the lowest prices typically have the best annual sales, e.g. the Shangguang brand in 1999.

Like other sales employees from other retail shops, this manager also was concerned about the current market situation, especially the number of low-quality, cheap systems and independent distributors purchasing cheap systems in order to resell them in remote areas that still lack electricity. He expressed the need to implement product standards and quality control.

5.3.5. Case study 5: Dawa retail shop. This PV company opened two PV retail outlets in 1995, but due to declining sales in the last year and a half, they closed one in 1999. Two employees work in the remaining PV retail shop—one ethnic Chinese and the other Tibetan. Products are mostly 10 to 20 Wp household PV systems.

The Tibetan employee was aware of the World Bank/GEF programme, but was not familiar with the details. In regards to government PV programmes, he mentioned that the company has participated in some government PV programmes, but probably not as many as other companies because the general manager has not actively pursued government projects. He did not comment on whether or not this would affect the company negatively.

Similar to the comments of sales employees in other retail shops, customers will travel two to three days to Xining, usually to shop for the cheapest PV system on the market. He differentiated the two types of customers, (a) the economically better off customers that will purchase a system based on quality, and (b) the economically disadvantaged ones that will base their decision on price. In general, he noted that the majority of customers who do come to Xining are the ones that want the cheapest system. Although they are shopping for the cheapest system on the market, customers will enquire whether it is a 'fake' system even if they cannot tell the difference.

6. ANALYSES AND DISCUSSION

This section addresses the main research question based on primary data on Xining-based PV sales companies; namely, 'is the household PV market heading toward long-term growth?' Findings suggest that the PV market is still in the early stages of development but will continue to grow in the near term. Nevertheless, the present market in Qinghai might be in a downturn due to the saturation of new players. This downward trend signifies a short-term market fluctuation and therefore is not an accurate indicator for the long-term potential growth. In order to survive, firms will have to build upon networks and stay current on the various activities by all actors involved. A major advantage that private enterprises have over the state-supported Nima brand is the flexibility to respond to market fluctuations.

Market growth is expected due to well-established companies expanding operations and competing for market shares in the five north-western provinces. This study only accounted for the companies' business operations in Qinghai and did not incorporate their operations in other provinces. For example, one of the well-established companies moved to a new location with larger facilities in May of 2000. Moreover, most of the private PV companies are diversifying their products and assessing the feasibility of starting to manufacture PV modules with purchased cells. If they are successful at producing modules, this eventually will lead to the cost-reduction of the company's PV systems. While the proposed World Bank/GEF PV project has the potential to help domestic PV companies expand and legitimise their operations, companies cannot rely and wait on foreign assistance.

6.1. Market barriers

Although the market for household PV systems is expected to grow there are several barriers that may affect the outcome:

Firstly, top-down PV policies mostly favour business contracts with quasi-privatised enterprises or well-established private ventures. This depends on whether the central government or the provincial government administers the PV project. Central government will typically seek the state-

owned enterprise, while provincial and local governments have more autonomy to choose. Another barrier is the central government's lack of transparency. For example, top-down programmes rarely elicit the advice of all the PV sales companies during the design and planning stages of rural electrification programmes. Instead, only some of the PV companies may be informed of the long-term objectives. There is also a lack of information on the motivations of international donor PV programmes, since all of them usually co-operate with one of the state's ministries or departments. Private PV companies are often unaware of the overall strategy and international links of large 'top-down' programmes.

Although all of the companies expressed a desire to establish foreign joint ventures, most, except the state-owned, lacked efficient and speedy communication facilities and the language ability for such contact. Another potential barrier is the increase of independent distributors and small-scale companies producing unreliable products. Some general managers have argued that independent distributors have been a cause of current market distortions because they are reselling low quality PV systems at a high cost. Such systems often malfunction within a short time. Consequently, since 1998, the provincial government has sponsored radio broadcasts in Tibetan warning buyers to beware of these 'fake' systems on the market. However, it is also argued that independent distributors also have contributed to the acceleration of PV diffusion because some have managed to reach segments of the population with reliable systems.

7. CONCLUSIONS

The detailed evidence of this study shows conclusively that an ordinary market for small PV power systems exists in China without state or international agency support. This market is expanding, and the small independent companies are growing in experience and scale of operations. Therefore the goal of ensuring a long-term sustainable local PV market is promising. This study concentrated on one aspect of market development for PV systems, namely the Xining independent sales companies. However, a more comprehensive analysis would include other local actors shaping the market, such as end-users, independent distributors and emerging entrepreneurs and small-scale companies. Most firms are aware that in order to survive, all aspects of business operations must improve so as to adjust to market fluctuations. Raising the quality and standard of products are a concern for all firms wishing to expand. The majority of companies are aware of the various factors affecting market growth, e.g. government influence, independent distributors and smaller firms cutting prices. Even though the government should level the playing field for all PV companies, it cannot do so in the near future. PV companies have remained competitive because they have broadened their business operations and networks and moved quickly to meet demand. Some are already seeking co-operation with foreign companies, despite the difficulty of communication.

In summary, the conclusions of this study are: (a) PV system commerce in China is crossing the boundary from state to private business, (b) there is a multiplicity of changing and expanding PV business outlets, and (c) there is definite evidence that unsubsidised trade in small PV systems are part of everyday commerce.

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