

WIDE-SCALE VILLAGE ELECTRIFICATION WITH PV HYBRID POWER SYSTEMS IN WESTERN CHINA: EXPERIENCE GAINED

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ABSTRACT: In the framework of the Sino-German Financial Cooperation currently four Solar Energy Programs are being implemented in four provinces in China. More than about 200 villages of different size will be equipped with PV hybrid plants and mini-grids. A number of systems in operation and management of decentralized plants since more than one year show that consumption is (i) very much varying during the seasons and (ii) depending on the working activities of the rural population. Systems and customers need a responsive on-the-spot service and close monitoring. Local operators act as important intermediates between customers and the service agency. The unit investment costs are strongly influenced by the size of the village to be electrified and show lower unit costs for bigger villages. This general tendency and often encountered fluctuation in number of inhabitants result in the fact that electrification with PV hybrid systems is only a viable possibility for villages bigger than 30 households.

Keywords: Rural electrification, PV hybrid village systems, RESCO

1 INTRODUCTION

1.1 Background

Based on a Chinese project proposal which was approved and given support by the German Ministry for Development and Economical Cooperation (BMZ) through a financial agreement made between the Chinese Ministry of Finance (MoF) and the German Development Bank KfW, the Solar Energy Program for implementing PV-Diesel Hybrid (PVH) systems for village electrification in Western China began in early 2002.

Commencing with the western provinces of Yunnan and Xinjiang, the pilot program of the Sino-German Financial Cooperation has now expanded to include two additional provinces: Qinghai and Gansu.

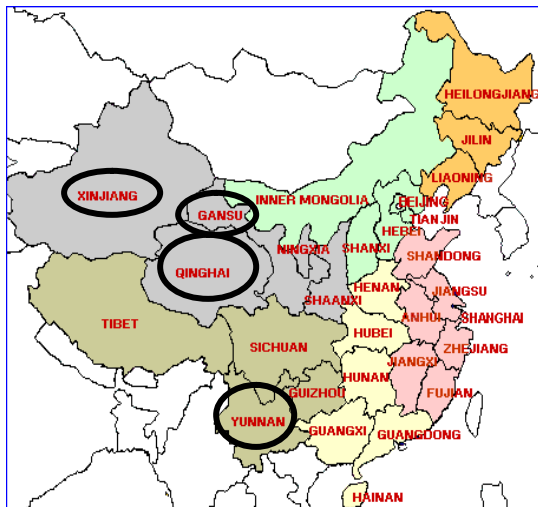


Figure 1: Provinces of the Solar Energy Program of the Sino-German Financial Cooperation

1.2 Program approach

The approach chosen for the pilot program also clearly defined the cornerstones on which the large-scale program was to be set:

- Project ownership lies with local institutions;
- Responsibility for running the systems lies with selected local service companies;
- The villagers benefiting from the power plants are to pay fees for the electricity they consume;
- The local service company, responsible for Operation and Maintenance (O&M), should ensure that adequate fees are collected to guarantee that running costs are sustained.

A Sino-German consultant team lead by Projekt-Consult GmbH was put in charge of supporting the local partners during the implementation of the project. Prospective villages, i.e. those without a grid connection and which satisfied a given set of selection criteria were selected in each province. Provincial service companies were given support in establishing management regulations for appropriate O&M schemes and fee-collection procedures to assure that operations would remain sustainable. To install the village power systems, formal offers from construction companies were called for by public tender.

After having successfully passed the Preliminary Acceptance Inspection carried out by the Consultant, the installed village power systems have to run successfully for a testing period of one year before the Final Acceptance Inspection is made and concluded with the issue of a Final Acceptance Certificate (FAC).

From then on, the provincial service companies are to be fully responsible for the sustainable operation of the systems from which the rural villagers are to benefit.

1.2 Design and construction

The basis for the design of the PV-Hybrid (PVH) plants was the outcome of a reconnaissance inspection by local experts into what the typical characteristics of the individual village proposed by the local authorities were. Given this basic information (e.g. number of households, existence of school and health station, anticipated load and demand of the village, meteorological data) the System Integrator was then requested to design, deliver and install the PVH stations.

Generally, the PVH plants have to be designed in such way that they can supply sufficient energy to a given village to meet its basic electricity needs. Therefore – at least at the starting off phase – no heavy loads, such as washing machines, were allowed to be connected. In the case where, after installation, the consumption of the village decreased or increased with time (connection of additional appliances, increase of village population), then the capacity installed would have to be adjusted by the responsible service company so as to match the actual requirement.

For this, PVH village power systems have to fulfill certain design criteria:

- a PV generator to meet the basic electricity demands during most of the year;
- a diesel genset as a back-up component, especially during the winter or rain season;
- a battery bank covering an average of 3 - 4 days autonomously;
- a modular inverter design that allows for system modifications;
- a village mini-grid to supply end-users within a given range of the village.

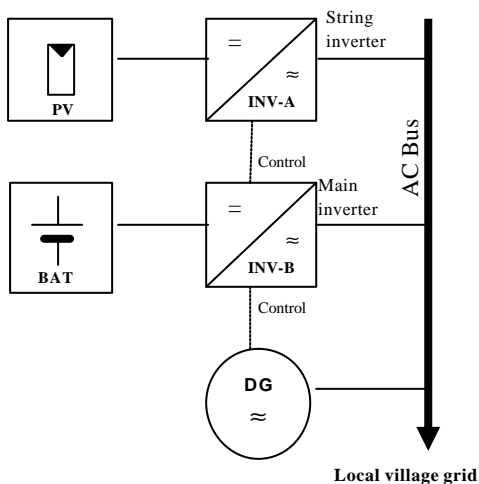


Figure 2: Scheme of a PVH system

All PVH plants make use of the same standard components to easily facilitate any technical service required, as well as to effectively manage spare parts; at the same time, all PVH plants can be designed individually just by combining different numbers of

standard components in the required and appropriate way.

2 EXPERIENCES AND FIRST RESULTS

2.1 Achievements up to now

For the turn-key projects of each province, public tenders for appointing the System Integrator and construction companies were carried out. For the provinces of Yunnan, Xinjiang and Qinghai, the German System Integrator Shell Solar GmbH was selected, whereas the contract for Gansu Province went to the German System Integrator Schott Solar GmbH. Supplying the project with PV modules manufactured by their own companies, both System Integrators chose the electronic components of the modular inverter type produced by the German manufacturer SMA AG. All other system components were supplied by Chinese manufacturers, the selection of which being the responsibility of the System Integrator.

The provincial service companies tendered regional construction companies for civil engineering works, such as the construction of station housing and the village grid.

The System Integrator started construction work on a first batch of systems in 2004 with PVH plants showing PV arrays ranging between 4.5 kWp and 16.5 kWp. In 2005 the first batch of PVH village power systems in Yunnan and Xinjiang passed the preliminary acceptance inspection successfully; the final acceptance inspection of these plants is scheduled for the spring of 2006. In parallel, the second batch of PVH plants is under construction.

In Qinghai and Gansu, construction work on the first batch of PVH plants started in early 2006 and will be finished by mid-year 2006. The second batch systems in Qinghai and Gansu Provinces are currently in the planning stage, and installation is to be carried out in the second half of 2006.

	1 st Batch	2 nd Batch	Remarks
Yunnan	17	35	1 st batch systems already running, 2 nd batch systems under construction
Xinjiang	9	26	1 st batch systems already running, 2 nd batch systems under construction
Qinghai	12	(>35)	1 st batch systems under construction, 2 nd batch villages already identified
Gansu	25	n.a.	1 st batch systems under construction, 2 nd batch villages to be identified
TOTAL	63	(>96)	

Table 1: Number PVH to be installed in the Solar Energy Program

It is estimated that when the program in the four provinces is concluded, a total of nearly 200 villages with

a total population of about 35,000 people, i.e. approx 9,000 households, will be serviced by village power systems based on electricity supply from PVH stations.

2.2 Administrative and management issues

New procedures have had to be developed, discussed and agreed upon (technical criteria, tender specifications, management regulations, supply contract forms, test specifications, acceptance procedures etc.). A large number of parties have been involved in the implementation of the program in each province (governmental institutions at different levels, different manufacturers and construction companies, service companies, tendering companies and others), which called for an intensive amount of communication and coordination. A number of changes and modifications during the execution of the project (changes of villages selected, adjustments in system design, changes of responsible personnel) had to be dealt with in cooperation with the respective partners.

In general, PV systems have to be designed according to the actual site data provided (meteorological, administrative, load and demand). However, due to significant fluctuations in the number of households which would actually be connected to the village grid, estimating the required demand proved to be very challenging. In addition, local authorities often envisaged a higher consumption rate needing larger and more expensive PVH plants, although the ability of the villagers to pay for such higher consumption in no way justified these expectations.

Last not least, local villagers and authorities – heedless of the procedures of the project, although these had been previously explained and instructed – nevertheless expected a fast implementation (i.e. the immediate installation of hardware). So wherever the availability of any other technical and financial solution was manifest (e.g. grid extension, rapidly implemented projects, lower tariffs), the villagers and local authorities skipped the agreements made and switched to the alternative offer, which then created complications. Of special impact was the so-called Song Dian Dao Xiang program, the national quickly-to-be-had township electrification program: The implementation of this program has no selected local bodies to accept ownership of PV stations, or who are responsible for the maintenance of the essential cost-covering tariffs to pay the upcoming costs of O&M and replacements.

Settling these problems and finding adequate solutions, to which all partners could agree on, unavoidably caused delays. But after having settled difficulties like this, all the systems now under operation are successfully serving the villagers.

3 COST ISSUES

After having concluded supply contracts with System Integrators and local supply construction companies for all four provinces, the first analysis of the data on design and related costs was made. The preliminary result of this analysis is shown in Figure 3. From this analysis some general conclusions can be drawn:

- The unit investment cost (UIC) is strongly influenced by the size of a village and shows lower unit costs for bigger villages.
- For villages with more than 80 households the UIC ranges between 1,000 to 2,000 Euros per household, with UIC figures decreasing for larger villages.
- For villages with 40 to 80 households the UIC ranges between 2,000 to 3,000 Euros per household, with UIC figures decreasing for larger villages.
- The costs for PVH systems in villages with less than 30 households become increasingly prohibitive.

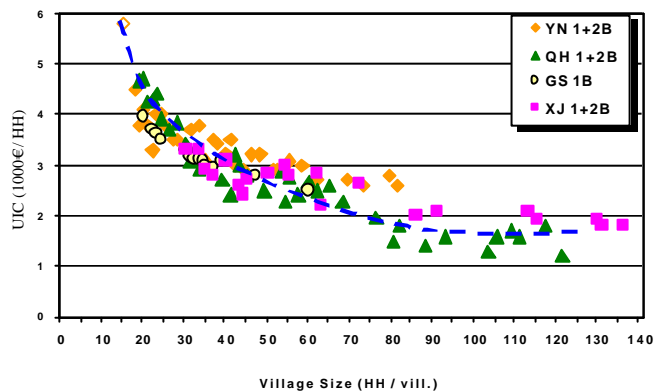


Figure 2: Unit investment cost vs. village size in the Solar Energy Program of the Sino-German Financial Cooperation

It was noticed that tenders for the appointment of local construction companies for the erection of the grid and station housing were found to be of interest only to a limited number of construction companies. In addition, these companies asked for prices higher than expected, claiming high fixed costs for limited activities at remote sites. This contributed to increased unit investment costs, especially for smaller villages.

In order to lower the overall costs and costs for the units, several technical and administrative adjustments were introduced for the second batch systems. However, it is to be expected that the general conclusions indicated above will not change drastically.

4 FIRST CONCLUSIONS AND RECOMMENDATIONS

Selection of the suitable villages: For small villages (with less than 20 to 30 households), standardized Solar Home Systems (SHS) of different size should be considered and a limited supply security with less power available accepted. For larger villages (more than 30 households) PVH village power systems might be the most appropriate solution, depending on the specific site conditions. However, considering the actual prices for conventional grid electricity and PV technology, there is a point where the extension of the conventional grid would be the best choice.

Transparent and consistent regulations: Rules and regulations are to guarantee that operation is sustainable through proven procedures and responsibilities, and require the full understanding and agreement by all the parties involved. The in-house regulations of the service company need to be developed, good relationships with end-consumers in the villages of the different regions officially established, and the staff involved in the project trained respectively. Indeed, a new utility in a difficult environment has to be built up. Even for already existing companies, this is a new kind of business and is therefore an opportunity as well as a challenge.

System management: Life in rural areas is not static: In addition to eventual fluctuations during the year due to the seasonal movements of herdsmen, the population of rural villages can increase or decrease with time. In addition, villagers must learn for the first time just which appliances and consumption patterns have the greatest impact on their electricity bill. Obviously, there is a strong need for a detailed supervision of what is really generated and consumed in the village power system. Obviously, data monitoring and evaluation is most important when the PVH plant starts generating power and villagers start consuming. Only by continuously monitoring power generation and village consumption can the service company be in an adequate position to judge the performance of each system and, where necessary, implement adequate modifications.

Recommended in any event is to work in close coordination with other institutions or companies related to grid extension work: The grid connection of any given village is also a political issue and not only the result of economical analysis.

While aiming to help rural villagers improve their living conditions, new challenges – and new opportunities – will arise for to service companies to provide a sustainable power supply by using renewable energy resources.

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