

Ex-post Evaluation 2007

**Resource-conserving Irrigation with
Photovoltaic Pumping Systems, Chile**

Brief Report

gtz

Produced by: AGEG Consultants eG, Kirchheim unter Teck
This report was produced by independent external experts.
It reflects only their opinion and assessment.

Published by:
Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

Evaluation Unit

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Eschborn, June 2008

Tabular overview

The evaluation mission

Evaluation period	July 2007 – March 2008 Mission in Chile 23 September 2007 to 12 October 2007
Evaluating institute/ consulting firm	AGEG Consultants eG, Kirchheim unter Teck, Germany
Evaluation team	Dipl.- Bauing. Peter W. Wicke Agraring. Jorge Alache

The project/programme

Title of the project/programme according to the order	Resource-conserving Irrigation with Photovoltaic Pumping Systems
Project/programme number	1997.2048.3
Overall term broken down into phases	January 1998 – May 2002
Total costs	1,117,600.- (of which 127,550.- in Chile)
Objective of the project/programme	Users and operators of the pilot systems as well as intermediary institutions can evaluate PV-operated irrigation systems and share their application-specific experiences
Lead executing agency	UTA Universidad Tarapacá (state university) in Arica
Implementing organisations	Universidad de Tarapacá – CIM (Centrum für Internationale Migration) – CODING Corporación de Desarrollo de la Ingeniería (Corporation for the development of engineering science)
Other participating development organisations	INDAP Instituto Nacional de Desarrollo Agropecuario (National Institute for Agricultural Development)
Target groups	Small farmers with irrigation parcels in Vitor, Chaca, Chacarillas, Codpa

The rating

Overall rating <i>On a scale of 1 (very good, significantly better than expected)</i>	2
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<i>to 6 (the project/programme is useless, or the situation has deteriorated on balance)</i>	
Individual rating	Relevance: 3; Effectiveness:2; Impact: 3; Efficiency: 2; Sustainability: 1

The ex-post evaluation of the development measure *Resource-conserving irrigation using photovoltaic pump systems* was performed by the independent experts Peter W. Wicke and Jorge Alache (contractor AGEG Consultants eG, Kirchheim u.T., Germany) in Chile in the period September 2007 to October 2007. As part of this pilot project, in which the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, (German Technical Cooperation) participated in an advisory capacity, the application possibilities of photovoltaic water pumps (PVP) for small-scale irrigation were tested in the period January 1998 to mid-2002. This occurred in cooperation with the three partner countries Ethiopia, Chile, and Jordan. In the context of the development measure, it was to be clarified whether photovoltaic pump systems are advantageous compared with diesel pumps for irrigating selected crops. The project objective was:

Users and operators of the pilot systems as well as intermediary institutions can evaluate PV-operated irrigation systems and share their application-specific experiences.

The present evaluation refers, by way of example, to the pilot project in Chile at four locations that were analysed. The project contribution there included provision of the photovoltaic pumps, on-the-job training, public relations work, consultancy and continuous support, as well as documenting the experiences. At the time Germany's assistance ended in May 2002, the partner experts and equipment users in the three project countries Chile, Ethiopia and Jordan had been qualified to evaluate the PVP technology for irrigation purposes from organisational, economic and technical perspectives and where appropriate to share their experiences with intermediary institutions. It was possible to demonstrate the technical reliability and ecological advantages of the irrigation systems during the pilot projects in the three countries. Valuable findings were made at least in Chile as regards the economic evaluation of the application potentials of such systems.

Regarding the **context** in northern Chile, it should be noted that at the beginning of the project Chile was not yet undergoing an energy crisis – a situation which is quite different today, in 2007. Chile procures 95% of its crude oil and 100% of its natural gas from outside its national borders. Over the last few years, the main supplier Argentina has been in breach of contract. Chile is now experiencing significant price increases for fuel. The country gained initial experience with the PV technology in Antofagasta as early as 1972. On a larger scale, photovoltaic technology was employed between 1995 and 1999 for the “Solar Home Systems, SHS” in remote areas, away from the power grid. This SHS program is still being continued today, led by the United Nations Development Program, UNDP, with financing from the Global Environment Facility, GEF.

The project area is located in the most northern Arica & Parinacota region (formerly region I – now the newly founded region XV) and is characterised by generally prevailing extreme dryness and fruit and vegetable cultivation in small coastal valleys, largely limited to irrigated farming. In view of the water shortage experienced in the northern region, technologically highly developed, resource-conserving irrigation methods, such as trickle irrigation and micro dispersion, are used and correctly applied in the main production centres.

Regarding the **concept and objective** of the pilot project, the following should be emphasised. In the light of the extraordinarily high solar radiation potential in the project region, and the presence of ground water flows in small coastal valleys, the concept was to introduce, test and evaluate new irrigation practices using this renewable energy resource. The focus was on sustainable small-farm agriculture in the desert region. The following aspects were especially important in the pilot project: clarification of the framework conditions for advantageous use of PVP irrigation systems; integration qualification and competence of the operators for evaluating application of the PVP systems; advantages of the PVP systems from technical, economic and social perspectives; documentation of the test results; determination of the potential for dissemination.

The experts primarily concentrated on **evaluating** the test measures during the time between 1998 and May 2002, and in the period after completion. The professionalism of the two Implementing organisations involved in the test programme, UTA-CER Universidad de Tarapacá - Centro Energía Renovables and the non-governmental organisation CODING Corporación para el Desarrollo de la Ingeniería, grew strongly as a result of the project. The PVP irrigation system technology proved to be altogether successful in the region. However, since completion of the project measure (2002), the PVP installations are still on loan in the care of the operators of irrigated farming parcels. There is a need for action regarding the transfer of ownership, the installations and clarification of future ownership.

The selected rural intervention locations with excellent geo-climate conditions for the use of solar energy at that time were located away from the power grids. The daily solar radiation of the zone exceeds 7 kWh/m² (i.e. three times as much as in Germany).

The installed PVP systems produced varying results. Presently, one of the four systems installed in 1998 is in perfect condition, and the pump and irrigation technologies are adjusted to each other. Two additional systems are operational; however their potential is not used sufficiently due to the irrigation methods and/or management applied. A further system was buried by an earthquake. The unsatisfactory results are due to the selection of the

locations, with selection criteria such as access, solar radiation, expert knowledge and experience of the operators, parcel sizes and ground water not being observed consistently.

The partner organisations and small farmers participated equally in supporting the project, and in achieving the project goal through interdisciplinary actions, attending seminars and forums, workshops and the involvement of non-governmental organisations.

The experts ascertained sustained effects with respect to the strengthening of the project executing organisation and of those responsible for implementing the project. The project executing organisation was the University of Tarapacá UTA in Arica with its Centro de Energía Renovable CER in conjunction with the non-governmental organisation CODING, Corporación de Desarrollo de la Ingeniería. The UTA department considered - and still considers - itself as the trailblazer for renewable energies and has good contacts with international institutes and institutions. Remarkable strengthening of the participating institutions was achieved with respect to the dissemination of renewable energies, specifically due to intensive technical consultation, specialised education and continuous monitoring. Contacts with a network that is committed to the expansion of renewable energies deserve particular mention. In evaluating the development policy effectiveness, the experts made the following findings using the DAC (Development Assistance Committee) criteria:

In the opinion of the experts, the **relevance** of the development measure was accorded widely varying importance at the different levels. At the national state level, the PVP irrigation project is virtually unknown. The experts had the impression that the governmental department was primarily interested in improving the legal framework conditions for renewable energy, particularly for *non-conventional renewable energy* and rather in the megawatt range (for wind energy/hydropower/biomass). Measures for more remote, local, smaller projects meet with less interest. The low awareness of the pilot project in northern Chile is also due to the low financial volume involved.

At the regional level, awareness and approval of the project can be found. The representatives of medium level administration authorities view the project intervention favourably and feel it has prospects for the future in the context of the energy crisis. At the target group level (fruit and vegetable farmers), the relevance of the development measure is now seen positively as the sensitivity toward available energy resources has grown. For the project implementing levels (UTA/CODING), the development measure is of utmost relevance, particularly as jobs, research activities and general prospects for the future are associated with it. **Relevance is rated satisfactory (3).**

The operators of the systems and the executing organisations unilaterally consider the **effectiveness** of the development measure to be good. The project goals were essentially achieved. The systems have been operating reliably for nine years, are resource-conserving and offer financial benefits. The implementing organisations have been able to considerably increase their expert capacities. Due to the weakness regarding the location of the sites, however, the sociocultural prerequisites to ensure that system management is also optimal are lacking in some cases. If the agricultural extension service becomes active with its assistance tools, including start-up financing of irrigation innovations at the local level in the smaller, remote valleys too in future, the effects of the project, which are significant even now, can be even further increased. **Effectiveness is rated good (2).**

With respect to the **impact** of the demonstration measure, the experts were able to detect only indirect and isolated improvements locally in the living and working conditions. They attribute this, among other things, to a very limited project budget (EUR 127,550 in Chile) and to the limitation to just a few pilot locations. At the supraregional and national levels, the impact is even less and hardly visible. The project has sent almost no signals. However, one must consider that the locations of the installations are very remote from the densely populated centres of the country. At the regional and local levels, however, the project has brought about technological improvements in irrigation and efficiency increases in production. In the meantime, sensitivity regarding the general energy problem has risen, and the demonstration project will gain increasing importance also in the wider surrounding area of the previously tended irrigation valleys. It has already attracted the attention of several state services (including Servicio Agro Ganadero), and useful contacts and an exchange of experiences exist with alternative technology centres. The project brought about by far the greatest impact in the capacity development of UTA/CODING. The experiences collected foster the constant contact and exchange of information of UTA/CODING with companies to which engineering consulting services are offered. **Impact is rated satisfactory (3).**

Regarding **efficiency**, the experts made the following findings. Using a small financial contribution, a wide spectrum of services was provided by the responsible parties (UTA/CODING) in a very short time. The four pilot stations that were set up were equipped with different components and received continuous support. Over a period of four years, operating data was intensively collected and evaluated. The resulting experiences were documented and shared.

The energy efficiency of photovoltaic pump technology was clearly proven, at least during the four-year test phase. The energy invested in the systems (measured in kWh) was recovered within a period of less than four years. The ecological benefit associated with the test

programme with a view to reducing CO₂ emissions has been limited so far. It will probably remain this way for the time being, as the PVP irrigation pump systems cover only part of the pumping requirement and additional parcels are tended with conventional diesel pumps/units. Regarding the increase in income, excellent results are apparent in at least one location (Chacarillas). For the other locations consolidation measures are required to allow the development measure to achieve an overall economic breakthrough. The hitherto limited economic efficiency has underlying sociocultural (established habits) and location-specific (e.g. change in ownership of parcels) causes and could only have been predicted to a certain degree.

Compared to traditional pump systems, the economic benefits of smaller PVP irrigation systems (up to about 3.5 ha) demonstrated by various analyses conducted by GTZ (Heitkämper 1999/ Kublank 2001 and 2002) were confirmed ex post by the development measure, and in the future greater penetration is to be expected as the gap between decreasing PV module costs for the provision of energy and rising fuel costs for diesel engines widens further. **Efficiency is rated good (2).**

In the assessment of **sustainability**, emphasis is placed on the reliability of the PVP systems tested so far in the pilot phase. In the future, it will be possible to use the existing pilot systems up to the assumed service life of at least 15 years and more. In addition, the analysed PVP project, in conjunction with other alternative technology interventions, shows clear indications of ongoing development, particularly due to the continuous activities of UTA/CODING. In the foreseeable future, there will be visible, sustainable results based on the increased capacities and performance of UTA/CODING (consolidated institution building), with lasting effects for the new region XV. **Sustainability is rated very good (1).**

As a result of the observations listed above and with regard to the five criteria, an **overall good assessment (2)** is obtained.

The demonstration project tends to contribute to important Millennium Development Goals, (MDG). The project selectively pursued the approach of job creation and thereby contributed to improved incomes (MDG 1: poverty reduction). Furthermore, an important training mission at the levels of implementing organisations (capacity) and the vegetable farmers was associated with the pilot project (MDG 2: education – continuing education – training). In addition, an integration of women can be detected, extending beyond the traditional status of the female indigenous population. Female Peruvian and Bolivian work immigrants as well as native Aymara women, who work in the parcels as day labourers, have the same rights as men (MDG 3: gender equality).

A contribution to the protection of natural resources is achieved per se from the concept of the development measure to conserve ground water supplies. In addition, through the use of the clean PVP technology, CO₂ emissions at the project locations are selectively avoided (MDG 7: sustainability and protection of resources).

The project has played a role in fostering and continuing to make strategic use of an international network (contacts with European institutes, e.g. in Almería, Kassel, Jülich, Aachen, and others; exchange with universities in Peru: Universidad Nacional de Ingeniería Lima and University of Tacna) for future cooperation (MDG 8: networks – technology transfer).

The experts assess the contribution to a sustainable development as follows:

The development measure does not yet make a large contribution to the sustainable progress of the rural area of Arica. Decreased migration to the cities and protection of the local/regional ecosystem by the spot measure are extremely limited, even at the intervention locations. The project lacks the stronger integration of relevant institutions and an approach for sustainable rural regional development that goes beyond the promotion of renewable energies and alternative technologies.

This leads to the following **conclusions – recommendations**:

Worldwide, the total number of commercially marketed systems for photovoltaic pumping has increased from about 1,800 in 2000 to ten times this amount annually in 2007, with the focus being on agricultural irrigation. Today, the benefits of PVP systems with respect to economic and ecological effects are better known, and the systems are technologically well-engineered. Potential users today are more sensitised. This has created the prerequisites for further dissemination of the systems. The experience gained as part of the pilot programme could also prove beneficial in terms of approach for other regions around the world with similar agro-meteorological conditions, including the northeast of Brazil, the coastal regions of Peru and North Africa.

In the opinion of the experts, the project has a very limited design, although the objective was demonstrative test operation of the special PVP systems. In the context of the worldwide alternative energy discussion, and in view of the present energy crisis in Chile, it is advisable to think about integral ER concepts, including the diversification of the different technologies and their local dissemination.

The use of existing networks (with CER-Lima, University of Tacna, Peru, COPASA, Arequipa, Peru) as well as the fostering and expansion of further global networks for the increased use of photovoltaic systems and alternative energy strategies is recommended

(e.g. with Agricultura Urbana y Periurbana AUP, Centro Alamar, La Habana, Cuba, with the EU measure Euro Solar, with the EMAS group in Bolivia, and with Practical Action, Lima, Peru).

The experience gained during the project should be processed and marketed by GTZ for other users in the specific irrigation field.

Locally (in northern Chile), the PVP systems are being accepted by the four operators, and the climatic conditions (solar radiation) are extremely favourable. In order to improve the application conditions, the project should receive further support as part of German development cooperation. On the technical side, service providers specialised in sophisticated irrigation systems and guaranteeing continuous technical support for the irrigation systems and advisory service for the farmers are available. The project executing organisation UTA has the necessary capacities for the continued development and dissemination of the analysed technology. While the project largely achieved the desired goals in the demonstration phase, in the opinion of the experts there is still considerable need for action in several respects.

- After nine years, the status of ownership of the installed PVP systems must be clarified; it is recommended that ownership of the PVP systems, which are on loan, be transferred to the operators.
- Wells and irrigation structures should be restored to a technically sound condition, and the organisational aspect should be given more weight. The follow-up process should be combined with the parallel support of a project in region IV proposed by the CNE-GEF-PNUD group.
- The potential of PVP systems with relatively high output (> 1.1 kW) should be explored for larger parcels in suitable locations and for suitable operators.
- In order to improve the inter-institutional coordination, the experts recommend fostering collaboration of the authorities responsible for water management in the region.