

Photovoltaics Integration in Chile

M. Alejandra Porter P.

Universidad Del Desarrollo, Concepción, Chile
e-mail: aleporter76@hotmail.com

ABSTRACT: Photovoltaic (PV) systems are technologies that emerged to produce electricity through the use of solar energy. The first applications were in those areas where the cost was competitive compared to investments for grid connection. In Europe, the use of the technology has been encouraged in BIPV (Building Integrated Photovoltaic), to diminish the CO₂ emissions in the atmosphere, encouraged by the Kyoto Protocol (1997). The aim of this work is to analyze the application level of PV in Chile.

Chile is still in early stages of PV history, for the approaches done, have concentrated only on rural areas with the creation of PER (Rural Electrification Programme). Although Photovoltaic Technology has an important role to play in the government goals, for achieving rural electrification targets, there are no initiatives to encourage the installation in grid-connected BIPV projects, due to cost, loads of conventional sources, lack of laws that include co-generation and absence of Energy Policy Programmes to support integration in urban environments.

This paper gives a general view of the PV application in the country, including assessments and recommendations to remove barriers from a macro to a micro scale, in order to trigger the inclusion of PVs in the urban scenario.

Keywords: renewable energy, photovoltaic, PV.

1. INTRODUCTION

During the last decade Chile has been engaged with PV systems, since the creation of certain programmes, to find a solution for the lack of electricity in rural areas, and diminish migration towards urban zones.

The PV market has only been explored in the rural sector, due to an absence of energy policies that enables the co-generation, in order to sell the produced electricity of non conventional renewable energy sources, to any of the four electric interconnected systems in Chile from North to South. However, it is important to mention the organizations that are behind the use of PV in the present market.

2. PHOTOVOLTAIC MARKET

There are also some other initiatives supported by governmental and private entities, which make use of such technology where there is no access to electricity grid.

2.1 Governmental Institutions

The main institutions that have encouraged the use of PV are:

- *National Energy Commission (CNE)*, which created the "*PER programme*" (Rural Electrification Programme) in 1994. This organization is in charge of distributing the annual funds assigned to rural electrification (FNDR-ER)¹ in each region, in agreement

¹ FNDR-ER: National Fund of Regional Development-Rural Electrification.

with the dispositions of the Law Budget. Finally, it is the one that develops new financial international resources such as World-Wide Environmental Fund of the United Nations (GEF).

- *Environmental National Commission (CONAMA)*. Its mission is to promote the environmental sustainability. Together with the CNE, this commission administrates the financial aspects with the support of the GEF, for projects that promote CO2 reduction.

2.2 Other Institutions

Educational Institutions and private companies have undertaken specific initiatives to make use of PV technology. For example:

- *Renewable Energy Centre, Universidad de Tarapacá (UTA)*.

- *Solar Energy Laboratory, Universidad Técnica Federico Santa María (UTFSM)*.

- *Private Companies* are present in the Chilean market at a small scale, installing PV systems in various regions of the country. All of their expertise has been used in the rural electrification frame, such as indoor-outdoor lightning, water pumping, telecommunications and remote monitoring.

3. PHOTOVOLTAIC SYSTEM APPLICATION

This part of the work refers to some examples and targets of PV applications done through PER programme and private companies.

3.1 Rural Electrification Programme (PER)

The government promotes the use of PV systems among other non-conventional renewable energy sources, to supply isolated communities with electricity. The general targets between the years 2000-2006 were to reach a 90% coverage for electrifying rural housings. The final achievements are presented in the Table I.

Table I: Rural Electrification Coverage

Regions	1999	2005
I	88%	89%
II	92%	99%
III	90%	83%
IV	76%	82%
V	89%	94%
VI	85%	94%
VII	80%	94%
VIII	75%	93%
IX	66%	88%
X	62%	91%
XI	70%	98%
XII	83%	90%
RM	89%	99%
Total	76%	92%

Table I shows that the general average has achieved the government targets by the year 2005, though the III, IV and IX regions have not come to the expected 90%, but the last two ones, have considerably increased their coverage.

After the first pioneering rural electrification projects had been installed with the use of ERNC², the government could visualize the flaws and obstacles to accomplish the goals shown before; produced by the lack of certification procedures, qualification programmes, technical incapability, knowledge absence of the systems and their hazards. Aware of such inconveniences, in September 2001, the agreement CHI/00/G32 was signed between the Development of the United Nations Programme (PNUD), the National Energy Commission (CNE) and the Foreign Office, called "*Barriers Removal for Rural Electrification with Renewable Energy*".

3.1.1 Application Examples

Generally the stand-alone systems are designed to provide a minimal supply which ranges from 2 to 4 light points, from 1 to 2 current connections, to enable the use of a TV and/or radio. The installed capacity fluctuates between 35 and 75Wp. More sophisticated systems are those near the 160 installed Wp, including additional electrical equipments, such as, music equipments, colour TV and a refrigerator (e.g. Fig. 1).

² ERNC: Energías Renovables No Convencionales (Non-Conventional Renewable Energies).

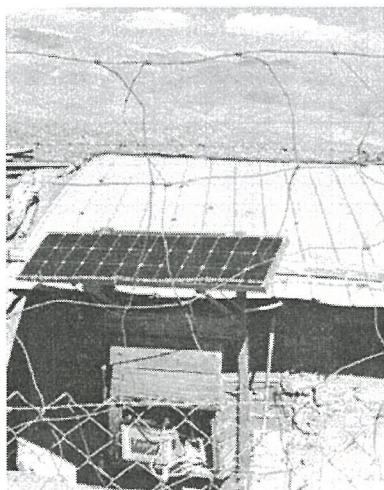


Figure 1: A typical stand-alone system, installed by PER programme in rural areas.

All applications done through PER are regionally registered in detail in the following website, <http://www.renovables-rural.cl/>, which describes location site, number of beneficiaries and a short description of the project and the employed technology.

3.2 Private Company Projects

Several projects have been installed by a few private companies, mainly in rural areas, like indoor-outdoor lightning, water pumping, drip irrigation systems, telecommunications, remote monitoring and hybrid systems. As it is not possible to analyze them all, only 3 examples will be shown to have a global view of PV integration in Chile.

- *Public Highway Lightning:* in a joint venture Solener and Lumisolar Companies have installed, during 2007, several solar posts, powered with PV panels, to illuminate remote highways in the North of Chile. The total installed power capacity ranges between 1.500 - 700Wp. One of those examples is the Alto Hospicio project, placed in the I Region (e.g. Fig. 2).



Figure 2: Public highway lightning, Alto Hospicio PV Project.

- *Telecommunication Stations:* another company in the market, Wireless-Energy, has installed many telecommunication stations along the country. In 2001, they designed and installed, 8 hybrid stations solar-diesel, to power advance communications systems through the Atacama Desert (e.g. Fig. 3).

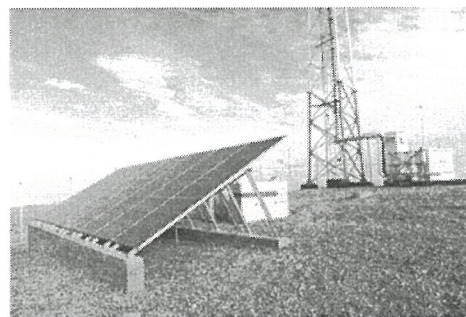


Figure 3: Solar (PV)-diesel hybrid stations.

- *Water Pumping System:* installed on 1999 in Marchigue, VI Region. Due to its low level and distant geographical location, grid connection feasibility was not an option. Therefore, the aim of Wireless-Energy Company, was to achieve an autonomous PV system that would ensure water pumping, for agriculture purposes, all over the year, with the use of high voltage PV panels, operated by a 96% high efficiency inverter.

As it was shown, PV has a presence in the Chilean market; the questions are: how

to remove the barriers to expand its use from the rural sector to the urban areas? Which should be the next steps to encourage its use for BIPV integration, as it is happening in developed countries?

4. FUTURE PV INTEGRATION

Despite PV use is being reliable in the country, its cost is still not competitive with the traditional electricity sources of power that predominate in the urban sector and, consequently it has only made a contribution until now, for rural electrification needs.

Some key aspects that the country must incorporate to its energy policies will be presented. Subsequently, other strategies that might influence the use of this technology will be examined.

4.1. Energy Policy Modification

Laws in the primary electricity sector should include and encourage co-generation; in that way, the generating companies are forced to buy the energy produced by the users that wish to have a grid connected PV system. The promotion of sustainable development and the support to the Kyoto Protocol should also be reinforced; cost-effectiveness seems to be more relevant than environmental consciousness. Nevertheless, recent events that are taking place, should be considered, because they might be the pioneering initiatives to start a new age in terms of non-conventional renewable energy generation, among them:

- *Bill of Law that compels the use of non-conventional energies (April 2007)*. The government started the legislative procedure to approve this law, in order to develop the insertion of alternative renewable energies, with the aim of eliminating the barriers, regarding innovation, to create confidence among the electricity enterprises.

- *III Non-Conventional Renewable Energies Contest*, convoked from the 9th January to the 9th of April 2007, sponsored by CORFO (governmental Chilean organization in

charge of promoting national productive development. The aim of this contest is to finance projects equal or higher than US\$ 400.000, consisting in developments studies and market assessments to encourage grid connected systems, from non-conventional renewable energy sources. The participating projects had to be eligible and technically adequate, according to the Kyoto Protocol Clean Development Mechanism.

In general terms, the schemes just mentioned are promising. Their inclusion is important, to bring forth future country energy policies, so as to follow the same patterns implemented by developed countries, focussed on specific subsidies and BIPV programmes, as the following:

- *Japan*: "Residential Photovoltaic System Dissemination Programme"/ "New Sunshine Project" established in 1993. Demonstration plans for PV Field Test for Public and Industrial facilities.

- *Germany*: "100.000 roofs programme" (1999) / "Full Cost Rates" private owners of PV installations are treated equally to the utilities, i.e., they feed the electricity into the public grid and get a payback rate that allows them to finance and maintain their systems.

- *United Kingdom*: projects financed by the DTI have concentrated on BIPV for commercial facades and educational facilities, i.e. The UK 'Scholar' programme (20 systems installed by the end of 1999).

4.2 Financial Support

4.2.1 Trade Agreements

In the past years, Chile's free economy and open market had established several free trade agreements (TLC), that should be taken into consideration:

- 2003, USA - Free Trade Agreement.
- 2006, People's Republic of China - Free Trade Agreement.

These initiatives not only reduce the exchange taxes between both countries, but they also imply a genuine reduction of cost, because both of them are one of the major

worldwide PV cells and systems components producers.

4.2.2 Selling of Carbon Bonds

The Kyoto Protocol, adopted under the United Nations Framework Convention on Climate Change (UNFCCC), allows the countries in Annex I, to finance projects that reduce carbon dioxide emissions (CO_2), by selling bonds to other nations, (mostly to those developing ones), given credit for the decreases reached, as if they had been done in their own territory; known as Joint Implementation (JI) and Clean Development Mechanism (CDM) (e.g. Fig. 4).

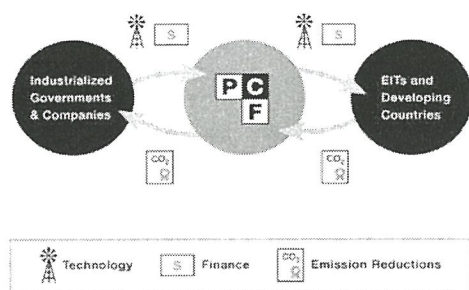


Figure 4: Selling of Carbon Bonds PCF scheme (Prototype Carbon Fund).

4.3 Strategies to ensure PV integration in the urban scenario

The recommendations to deploy PV technology should follow a procedure that will demonstrate PV applications feasibility in different frameworks. Hence, it is recommended that its application includes diverse ranges of size, that is to say, from a micro to a macro scale.

- *Urban elements:* to begin with, PV systems should be integrated in urban elements, to insert the technology in the heart of cities, where the main circulation of the daily population takes place. They could be integrated in bus stops, luminaries, telecommunications, signalizations, sheds, parking canopies, etc. There are also good examples in other countries, in which PV has been installed like, for instance, in

highways, the technology is integrated to sound deflecting barriers, in countries as Switzerland, Austria and Holland.

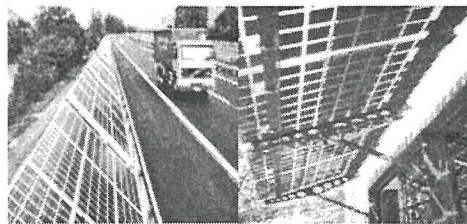


Figure 5: PV applications in urban elements.

- *Educational, Public and Industrial Facilities:* subsequently, it is recommended that Research and Technology Development programmes (R & D), should encourage the insertion of PV systems in educational, public and industrial facilities. These already had excellent results in countries like Japan (PV Field Test), for they helped to improve the PV technology development, apart from being a way to expand this technology in the habitants knowledge. Therefore, the government should establish targets for its capacity introduction, and thus search for partnerships to finance such initiatives, like the ones mentioned on item 4.2.

- *Social housing:* in order to expand the reliability of PV systems in architecture, the government should implement the use of PV in social housing projects, which are one of the primary concerns in the national budget. The architectural design of such projects is similar along the country, in terms of forms, orientation and dimensions; only with some variations in its roof tilt and envelope specifications. This requires a conscious research in defining the design guidelines of PV integration through the country, according to the location of the scheme, due to our extreme diverse topographic distribution.

5. CONCLUSION

Photovoltaic is a technology that is contributing in different aspects all over the world. Whilst in developing countries it is employed as a source of power for rural development, in developed ones it is already applied in the urban environment, through BIPV projects. This further step taken during the last decade, can be attributed to the Kyoto Protocol, supported by the IEA, EC and individual country programmes.

PV applications in Chile are still being generally applied within rural frames, because there are only few initiatives, so as to make PV technology competitive with primary energy sources. The inexistence of co-generation laws, despite there is a project in process (cf. 4.1), refrains further developments, towards PV enclosure in the urban framework.

And last but not least, Chilean future BIPV applications can or will make an important contribution to a sustainable environment, if the outcome of PV follows the analysed arguments. It is worthwhile noting, how unfortunate it is that the future of these technologies is decided by parameters such as cost effectiveness rather than governmental initiatives in which environmental consciousness prevails. Therefore, the resolution of the law in process, mentioned before, is the most hopeful undertaking to build upon it a new way out for PV applications in Chile's daily life.

REFERENCES

- [1] Comisión Nacional de Energía (CNE) (2007). www.cne.cl
- [2] Corporación de Fomento de la Producción (CORFO) www.corfo.cl
- [3] Corporación Nacional del Medio Ambiente (CONAMA) www.conama.cl

[4] Porter, A. 2003. Feasibility Analysis of Photovoltaics Integration in Chile Dissertation for the Degree of MSc in Renewable Energy & Architecture, University of Nottingham, pp56-91, UK

[5] Lumisolar <http://www.lumisolar.cl>

[6] Revista Ecoamérica, www.ecoamerica.cl

[7] Solener <http://www.solener.cl>

[8] Wireless-Energy www.wireless-energy.cl