TECHNOLOGICAL AND ABSORPTION CAPACITY IN A SOLAR ENERGY CLUSTER

JOSÉ C. ALVAREZ
Professional Studies for Executives, Universidad Peruana de Ciencias Aplicadas, Lima, Peru
pciijalv@upc.edu.pe

KAZUO HATAKEYAMA
SOCIESC, University Center Tupy- Joinville, Santa Catarina, SC, Brazil
khatakeyama@uol.com.br

ABSTRACT

The sector of renewable energies is studied for the possibilities that offer to take care of the environmental and the energy conservation. In the production areas, it is need to understand some topics like the technological capacity and absorption capacity to identify the patterns of learning, specifically in the cases of small enterprises that belong to an incipient cluster, in a region with availability of solar energy resources, like Arequipa in the south-west of Peru. In this context it's developed this study for identify the technological capacity and learning aspects, for this solar enterprise cluster acting in that region. The methodology is the case study, through the application of a questionnaire - that was formulated according the theoretical base about this topic - to seven enterprises. The results of the research are useful to planning the local development through the application of tools as the technological surveillance and forecasting.

Key-words: solar energy, solar energy cluster, absorption capacity, technological capacity.

INTRODUCTION

The absorption capacity and the technological capacity are basic concepts that shown how the enterprise has learned and how it has been constructed its technological paths. In particular the participation, of the enterprises, in clusters influences its absorption capacity and its technological capacity.

At the renewable energies sector there are some studies about these aspects. So, Jaegsberg and Ure (2011) after an study of five European solar energy clusters suggested that the solar energy clusters could learn experience of another similar clusters more developed, also they highlights the importance of the regional universities and the need of a bottom-up approach. The extensive use of solar energy in the world is still in the infant stage, albeit is well known that is the permanent source of energy.

Building a solar energy innovation system in Arequipa

A national innovation system joints the national actors in all the national space for a better understanding of the innovation process in a systemic conception. While the regional innovation system concept, according Cook et al (1997), permits to analyze the innovation in a regional scale, in a more complete form in part for the proximity of actors. On the other hand, authors as Malerba (2002) advocate for a sectoral focus for the innovation.

However it's possible to integrate these concepts through a multi level focus, through the concept of regional - sectoral innovation systems as Cook (2002) has suggested, specifically for the biotechnology.

In this context it is analyzed the solar sector at the Arequipa region. It's also important to remember that according Casas (2002) the knowledge networks are previous steps to the innovation networks that imply innovation systems.

According IncaInnova (2010) "Solar energy is one of the strongest options for the future because of its enormous potential. Although currently much more expensive than the alternative green energy sources, solar energy technologies are also experiencing some of the most rapid growth rates and equally rapid cost reduction rates".

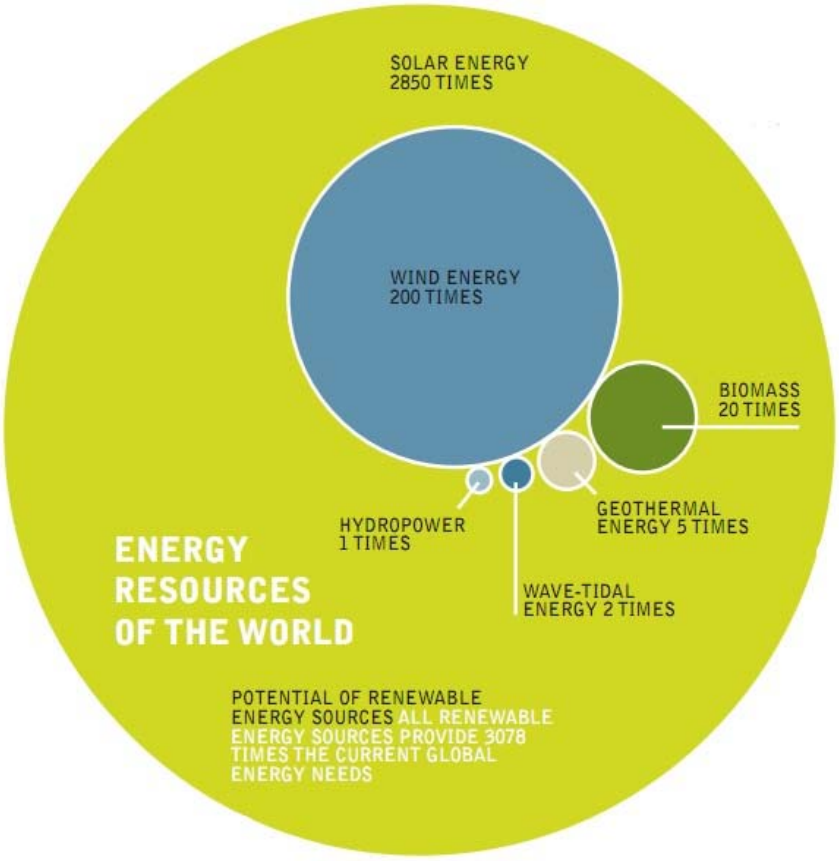

Figure 1: Potencial sources of energy – Source: INCA innova

Inca Innova (2010) also adds that "Furthermore, as the sun is the most abundant source of energy on earth, it is not surprising that large advocacy groups, like the *Desertec Foundation*, which envisions solar energy from North Africa and the Middle East to provide as much as 15% of European electricity demand by 2050".

According Inca Innova (2010) "The Region of Arequipa experiences some of the highest levels of solar irradiation in the world, reaching annual levels above 2500 kWh for every square meter. It also a region that is realizing its sensitivity to climate change as glaciers in Andes East of the city are reducing at problematic rates. INCA Innova believes that the Region of Arequipa, particularly in the city of Arequipa, is a location with incredible potential, due to its comparative advantages and its

increasing need for sustainable adaptation, to establish and build a solar energy technological innovation system".

Inca Innova (2010) adds that "Recently, the government of Peru contracted of 173 GWh per year of photovoltaic solar energy during 20 years period. Four plants will be built with capacity of 20MW each. The plants will be built in the Southern region of the country, in the regions of Tacna, Arequipa and Moquegua, which possesses high solar radiation, around of 2 300 KWh/m². The electricity generated by the plants will be integrated to the grid of national electricity system of Peru with the guarantee of price during 20 years. The photovoltaic solar energy plants consisted of set of solar cells assembled in the large panels with the surface facing towards the direction of sun from sunrise to sunset".

Figure 2: Solar panels to capture energy from the sun

Besides that, the Universidad Nacional de Ingeniería - UNI in collaboration with the Universidad de Jaen - Spain has installed, for research object, three photovoltaic solar panels of 3 kW each one in Lima, Arequipa and Tacna.

The interesting Arequipan geographic condition, as a high solar irradiation levels, have implicated the emergence of several enterprises that look for a better utilization of the resource. However, the main problem is the scarcity of studies about the knowledge networks and the construction of technological capabilities in this region that has benefits of the renewable energies as solar energy. The specific problems are:

- There isn't mapping of the potential absorption capacity and achieved absorption capacity in solar energy enterprises in a region with availability of this renewable resource.
- The technological capacity around this technology in a region on study wasn´t determined.
- The opportunities of learning and continuous improvement of the productive process in the solar energy enterprises of the region in study aren't identified.

This paper aims to understand the technological path of these enterprises, identifying its absorption capacity and its technological capacity, where the research question of the study is: how is the knowledge constructed into the small enterprises at the solar cluster of Arequipa?

After answering that question could be possible to identify, through a technological surveillance study, technological opportunities to increase the level of knowledge in this specific area and consequently turn more innovative these enterprises.

METHODOLOGY

The methodology is the case study. The questionnaire was designed according the revision of theoretical concepts as absorption capacity and technological capacity, after that the survey was applied to a sample of seven (07) small enterprises that act in the solar topic in Arequipa. The analyses of the surveys are followed by the conclusions and recommendations as the implementation of tools as the technological surveillance.

Importantly that seven enterprises is an acceptable sample of approximately fifty solar enterprises that act in Arequipa.

DEVELOPMENT OF TECHNOLOGICAL AND ABSORPTION CAPACITY THROUGH KNOWLEDGE NETWORKS

Technological capacity

Lall (1992) identified three factors that influence the national technological capabilities in developing countries: capabilities, incentives, and institutions. For this author the technological capability would have three dimensions: physical investment, human capital, and technological effort. This author through analyzing the national technological capabilities in eight developing countries, established its interdependence with some indicators, as Gross Domestic Investment as % GDP, patents granted, scientists/engineers in R&D, all scientists/engineers per million population.

For the evaluation of the technological effort, in particular for the enterprises acting in the solar area, some aspects could be considered, as: new product design, improve at the installations, thermodynamical analysis, knowledge about equipment testing and elaboration of curves of efficiency.

The technological effort is reflected, for example, in the realization of the energetic and exergetic analysis of solar collectors of flat plane as that was made by Faria et al (2010) in Brazil.

According Dou (2005) the construction of the technological capacities take place since a capture of technologies through informal or formal transfer, that could be after the participation in joint ventures or through establishing alliances that help the technological development. Katz (1996) through his study of the acquisition of technological capabilities highlights the importance of the mechanism of promotion of the small enterprises.

Figueiredo (2004) express that the technological learning will be reflected in the technological capacity, that has been kept in four components: physical - technical systems, knowledge and qualification of the workers, organizational systems, products and services. He added that the evaluation of the technological capacity should be more complete and not only the evaluation of the extreme points, the simply adoption of technological process for one side, and the patents generation for the other.

For the determination of the technological capacities, this author has formulated a model for seven (07) levels of technological competences since basic until advanced, for five (05) technological functions. According this author the technological capacity reflects local and sectoral characteristics that need to be understood, and that the previous determination of the technological capacity is the base for the design of technological policy. He also highlights that the enterprises in emergent countries need to accelerate the accumulation of technological capacities.

Absorption capacity

Zahra and George (2002) present the concept of absorption capacity in two phases: the potential absorption capacity (acquisition and assimilation) and the achieved absorption capacity (transformation and exploitation).

The potential absorption capacity is more linked to the knowledge accumulated by the enterprise in the time, while the achieved absorption capacity is linked to the action taken by the enterprise looking for use its knowledge, through new products or new process. Both concepts are an indicator of the innovation and competitiveness of the organizations.

Noblet et al (2011) have operationalized the concepts of Zahra and George (2000) for a sample of ten (10) software enterprises in France.

Knowledge networks

Levin and Knustad (2003) have studied a case of knowledge networks in Norway, with the actor network theory, they have found that the learning and knowledge networks need to be supported by the commercial interest for their sustainability.

Casas (2002) after analyzing some economic sectors in Mexican regions, like the strawberry in Guanajato, through projects with the public research institutes, point out that the knowledge networks are previous steps to the innovation networks formation and both of them could contribute to the consolidation of local and regional innovation system.

CASES STUDY RESULTS

The solar technological trajectory in Arequipa would have begun when a national center of technology and research, called Itintec, transferred in 1986 to an Arequipan enterprise E8 the technological pack for the fabrication of solar heaters of flat plane with ten tubes. After a time, this technology was disseminated in Arequipa region. Another company E9 deepened the use of this technology, making subsequent alliances with a Brazilian company that provided technology.

Now, some solar enterprises of Arequipa are manufacturing solar heaters, with collectors of flat planes, while others enterprises import collectors of vacuum tubes for its solar equipments; and in regard to solar photovoltaics technology, all Arequipan companies buy technology and foreign products.

Seven (07) enterprises that act in the solar energy business were interviewed in Arequipa. The products and services that these enterprises offer are:

- Solar thermal energy: water heating systems (domestic, commercials and industrial), solar cookers, solar driers,
- Solar photovoltaic energy: panels, photovoltaic posts, solar illumination,

About the knowledge available at the enterprises, the respondents said, as can be seen in the Chart 1:

Chart 1: Knowledge available at the enterprises

Enterprise	Results
E1	"Selection of products, conversion of photovoltaic energy since 12 V to 220 V, determination of electrical needs, selection of heaters considering 30 liter per capite, installation of equipment"
E2	"Concepts, identification of foreigner exports, process of production, technical quality, and sales"
E3	"All that is referred to photovoltaic availability, solar pumped, heating water, dimensions of the photovoltaic systems connected to the electrical net"
E4	"The entrepreneur is an electronic engineer of the Universidad Nacional San Agustin de Arequipa - UNSA that has participated in several skill training in the field. Identification of information available in Internet and strategic alliances with other small enterprises. Project to facilitate heat water for a tannery"
E5	"About the heating water for domestic and industrial use. We know that it's possible to desalinize. About installation of solar photovoltaic panels"
E6	"Theorical and practice knowledge of physical principles about the process of transformation of the solar energy in thermal energy and electric energy"
E7	"Production of tubes and tanks, importation, distribution (markets and reports)"

According to the seven (07) levels of the proposal of Figuereido (2004), the enterprise of the solar cluster of Arequipa are in the basic levels because the capacities identified are routine for the use and the operation of foreign technology.

About the forms that the enterprises acquire knowledge it was found that, as can be seen in the Chart 2:

Chart 2: Forms of knowledge acquisition

Enterprise	Forms of knowledge acquisition
E1	"Through informative conferences, capacitation with external experts. Analyzing the photovoltaic system and its installation. Learning by doing in the action. Capacitation courses of photovoltaic energy in Lima"
E2	"Through courses, the practice and continued capacitation in photovoltaic energy"
E3	"The founder of the enterprise captures the ideas in other countries. Also we have mechanical engineers of the Universidad Catolica Santa Maria and UNSA. In the UNSA we have participated in a course of renewable energy
E4	"Based in our own experience. The manager of the enterprise used to install solar equipment while he worked for another enterprise. Also we make tests in our factory"
E5	"Through our participation in events and workshops. Also through the information available in Internet"

Enterprise	Forms of knowledge acquisition
E6	"The entrepreneur, who studied physical, has been specialized in renewable energies. Also trough reading of articles and ideas interchange in meetings"
E7	"Through the importation, the sales and the market. Doing benchmarking with another enterprises"

It was found that the more common forms to acquire knowledge by the enterprises of this "cluster" is through courses and participation in events and conferences.

However, there is only little generation of knowledge in its tacit form, through the socialization of tacit knowledge and its incorporation in good practices in installation and maintenance of equipment.

About the evaluation of the learning, the practices found are shown in the Chart 3:

Chart 3: Learning evaluation

Enterprise	Comments	Evaluation
E1	"Send them to install the equipment and the subsequent verification"	Control quality of the installations
E2	"Through the practice and monitoring the competence for separate them"	Benchmarking with the competence
E3	"Through the interchange of information about the daily activities and also meeting where all the participants speak"	Through the socialization of the knowledge
E4	"Through the satisfaction of the customers, asking them for check some filtration or failure in some installation"	Feedback of the customers
E5	"An indicator is the absence of reclamations of the customers. When appeared reclamations we have solved they, and this permit us to advance. We are very exigent to choose materials and in the testing of the imported equipment"	Feedback of the customers
E6	"The workers receive capacitation about installation and maintenance of equipment. The learning is through the experience"	Capacitation and socialization of the learning
E7	"Based in the experience acquired through the years, has been possible to solve problems"	Through the problems solution

The learning evaluation is focused in tacit aspects and it is also tacit.

These enterprises acknowledge that they need to acquiring new knowledge, about this aspect it was found that, as can be seen in the Chart 4:

Chart 4: Knowledge requirements

Enterprise	Knowledge requirements
E1	"Always there are new aspects. A customer of a mining company looks for 2 kWh of electricity by three phases installation, that there is not in Peru until now. It is necessary to have invertors of 600 W but in three phases. We look for the information in the internet"
E2	"Knowledge about marketing and sales. New technologies and new products. Commercialization and importation. The selection of a good external commercial partner"
E3	"New technologies about photovoltaic solar panels. More information about photovoltaic kits linked to the electrical net. Manufacture process of photovoltaic panels. Optimization of solar heating water"
E4	"More knowledge about solar energy. Projects for the use of solar energy: thermal and photovoltaic. Design of projects with photovoltaic energy. There is not an institution that offer capacitation in this topic"
E5	"About solar driers and solar radiation in the floor for heating of Andean houses using radiation. To build prototypes of heating houses and areas for the protection of domestic animals in Andean areas"
E6	"About energy polices. New technologies, different types of vacuum tubes, and new process of manufacture process"
E7	"About equipment using solar energy to import and commercialize. New products that use solar energy"

The identification of the needs of knowledge for these enterprises could be classified as:

i. Solar thermal heating: energy efficiency in the water heating, vacuum tubes for solar heaters, driers, houses with solar heating for Andean areas.

ii. Solar photovoltaic energy: three phases' electrical generation, kits to connect panels to the electrical net.

iii. Commercial knowledge about marketing, sales and foreign manufacturers.

iv. New solar technologies and new solar products.

The two first knowledge requirements could be captured by the "cluster" through courses with foreigners' experts and encouraging the university – industry interaction. For the two following knowledge requirements it is necessary a previous study of technological surveillance followed by a knowledge management in a similar form to the proposal of Galeano et al (2008).

A professor of the Universidad Nacional de Ingeniería - UNI, who leads a renewable energies center, proposes a *"diagnostic of solar thermal technology in Arequipa with a proposal of technological improved"*. He also suggest that *"all manufacturers should design its products according the national standards as NTP 399.405 and show its curves of efficiency in the label of their products. The Universidad Nacional San Agustin de Arequipa - UNSA - could give the certificate these tests"*.

Chart 5: Innovations introduced

Enterprise	Innovations introduced
E1	"We are introducing a new type of solar heater better than the offered by the bigger local enterprise"
E2	"Solar lanterns for mining customers. Ovens and solar cookers"
E3	"Photovoltaic compact systems. Heat pipe tube solar collector system"
E4	"Personalized customer attention. Solar toys. Diversified solar products"
E5	"Automatic control of a solar system for industry"
E6	"Automatic lighting systems with solar energy. Automatic pool heating air systems"
E7	"Improvement in the functionability and efficiency of solar heaters"

In all the cases when the enterprise has reported about introduced innovation, really they present diffusion of foreigners technologies.

CONCLUSION

The "clusters" that are very decisive for the competitiveness of the nations need to be encouraged in spite of they are in its incipient or initial form as it's the case of the solar energy cluster of Arequipa.

The technological knowledge that needs the solar energy enterprises of Arequipa could be acquired through projects with the regional universities that also should improve its technological capacities and improve its knowledge generation.

This improve will imply that these enterprises become innovators and not only as dependents of foreign technology. For this, their absorption capacity, potential and achieved, should be encouraged.

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