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1687

Distr.
LIMITED

ID/WG.468/4(SPEC.)
21 April 1987

ENGLISH

United Nations Industrial Development Organization

Expert Group Meeting and
Study Tour on Standardized
Small Hydropower Plants

Hangzhou, China
18-29 May 1987

SMALL HYDROPOWER DEVELOPMENT IN
ARGENTINA*

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COUNTRY PAPER OF THE ARGENTINE REPUBLIC

1- INTRODUCTION

The Argentine Republic is rich in surface hydraulic resources. Its varied geomorphological structure, as well as its prevailing temperate-humid climate, create a favourable field for the exploitation of hydroelectrical power.

The country's technically feasible hydroelectrical potential has been estimated at 40.000 Mw. In 1984, the total installed capacity of electrical generation was 15.280 Mw, of which 5.380 Mw (35%) belonged to hydroelectrical generation installations, and 9.900 Mw (65%) to thermoelectrical generation installations (including nuclear ones). Thirteen per cent of the Argentine Republic's hydroelectrical potential has been developed. In 1984, consumption per capita was 1490 kwh, which exceeded the 1.017 kwh Latin American average.

However, Argentine geographical and demographical features suggest that a considerable number of inhabitants in low density areas will be deprived of national or provincial electricity public utilities for many years. At the same time, it is important to settle the necessary conditions so that such population may have access to electric energy. This possibility is essential for these inhabitants to improve their living standard as well as their physical and intellectual progress.

Within this context, electric energy generated by SHP turns out to be an interesting possibility for most of the areas involved.

When geographical conditions are favourable, the small hydropowerplant combines mechanical simplicity and solidness, economy and independence of external supplies.

This paper will next describe the historical background concerning this type of plants in the country, the process that has led to their present situation, the development of studies and works in different provinces, an outline of the present national institutional aspect and, finally, a description of the main guidelines of the National Subprogram on SHP.

2- HISTORICAL BACKGROUND

In our country, there is a great number of SHP installations, 120 approximately, the oldest ones having been installed at the end of last century.

In fact, in 1896 the "Compañía Andina de Electricidad" opened the Zonda Hydropower Plant in San Juan, 17 km west of the capital city, with an installed power of 280 kW. A year later, in 1897, the "Luz y Fuerza" Company of Córdoba opened the Casabamba Plant on the river "Primero", with a 30 meter fall and an installed power of 3.500 kW.

From the beginning of the twentieth century up to the end of the forties, several SHP were built in many provinces. Records in regard to the matter can be found in provinces such as Jujuy, Salta, Tucumán, Córdoba, Mendoza, San Juan, Río Negro and Buenos Aires, among others.

Many of these plants were built by private companies, cooperatives mainly. For example, in 1911 the "Compañía Eléctrica del Norte Argentino" opened an 875 kw hydroelectrical plant which included two Diesel engines operating together in Jujuy, on the River Grande, near the capital city. This plant was expropriated in 1944. There is another case in the same province, namely, the 150 kW SHP near San Pedro, built in the Leach Estancia. In 1923, the Cacheuta Hydropower Plant was opened, 38 km away from Mendoza city, with an installed power of 9.600 kW. This plant was also built by a private company.

In the early fifties, the exploitation of hydroelectrical energy was irrelevant. Its installed power capacity was below 50.000 kW (practically 3% of the installed capacity in the country at the time), meanwhile, oil was imported to generate electric energy.

The subject of SHP was not dealt with in a centralized way, following the guidelines of a Plan or Program, and the efforts were made by provincial or private agencies.

By the end of the forties, and as a consequence of the merging of the "Dirección Nacional de Irrigación" (National Irrigation Department) and "Centrales Eléctricas del Estado" (State Electric Plants), the "Agua y Energía Eléctrica" Company (Water and Electric Energy) was founded. Bill N°15.336 established its functions, among others: to produce and transmit electric energy within the country, operating the regional systems with hydroelectrical and thermoelectrical plants, transmission lines and primary transformer stations, which,

once interconnected, were to make up the National Interconnection Network.

"Agua y Energía" produced a considerable development in the hydroelectrical field, though the emphasis was laid on plants of major importance.

To illustrate we can say that from 1950 to 1960, it opened 31 H.P. with an installed capacity of 275.000 kW. Since 1890, only 42.000 kW had been installed.

In 1980 began to operate a Microplant and Aerogeneration Sector, with headquarters in Neuquén city, which offers technical assistance to the provinces on the evaluation of potential hydroelectrical sites.

3- PRESENT SITUATION

The low cost of oil between 1950 and 1970 prevented hydroelectrical projects, particularly small ones, from competing with thermoelectrical ones. Due to the 1973 oil crisis, the world became aware of oil reserves limits and of the need to rationalize the use of energy, and to find new alternative sources. Simultaneously, the most developed countries suddenly increased their investments in the investigation and development of possible alternative sources.

The crisis affected Argentina too. In 1978 the first institutional effort was made by a federal agency, the "Consejo Federal de Inversiones" (CFI - Federal Investment Council), which called experts for a meeting with a view to encourage the development of studies and projects concerning SHP.

From that moment onwards, and through the CFI, comprehensive studies on the subject were carried out in each province (Mendoza, Chubut, Santa Cruz, Catamarca, Tucumán).

However, the lack of a small plant development policy at a national level, clearly resulted in the low number of such plants built during recent years. According to statistics given by the IMEG, the most important national manufacturer of small hydraulic turbines, the market has been shrinking and, at present, it is remarkable small. Besides the works carried out by the provinces themselves, following their own programs, there is practically no development on the parts of private interests owing, among other reasons, to restrictions imposed by the legislation in force. Except for the specific case in Misiones of the Arroyo Dorado project, which exchanges electric energy with the "Cooperativa Eléctrica de Oberá" system, the legislation specifically forbids private companies to sell electric energy. This regulation forces small producers to reduce their projects to meet their own needs, and thus preventing them for designing a plant with a greater capacity and sell the surplus.

All these situations, together with the analysis of their solution, are included in the National Subprogram on SHP that is being developed by the "Dirección Nacional de Conservación y Nuevas Fuentes de Energía", under the "Secretaría de Energía de La Nación" (Conservation and New Energy Resources Direction-National Energy Department).

It is important to remark that since 1978, the SECYT (Technique and Science Secretary) has supported SHP investigations and developments through its National Investigation Program of

Non Conventional Energy.

Misiones and Neuquén are the provinces that have experienced the greatest growth concerning these matters. They have successfully developed SHP Implementing Programs. The experience in those provinces, and the improvements in some others are next described.

3.1 - Experience in Misiones

The Province of Misiones is geographically located in the centre of an area called "Cuenca del Plata", which concentrates the world's highest hidric resources potential suitable for exploitation. It is placed in the north-east region of the country, and it is bounded by Paraguay and Brazil. It has unique climatic and topographic characteristics, as well as natural resources.

The School of Engineering, a branch of Misiones National University, has been developing a Hydropower Microplants Program as an energy alternative, improving the use of water ways, in order to meet the demand of rural areas, most of which are in need of electric energy, and nowadays concentrate 60% of the whole population.

In 1972, Eng. Erik Barney, a pioneer in this subject in the country, assisted by a French inmigrating artisan, Mr. Gastón Gaillou, started studying and developing the Mitchell-Banki turbine. Now, sponsored by the SECYT, he has developed high performance versatile machines, with a 60 to 70% rate of efficiency and frequency return times of 4 to 5 seconds for 20% overloads.

In 1984, both the National and Provincial Governments

showed great interest in what Misiones University had investigated in Oberá. Microturbines development and SHP in isolated rural areas were declared of public interest by the Provincial Government. In that year, an agreement between the Provincial Government and the University was signed, and several projects for groups of users were carried out.

The School of Engineering provided adequate technology, the Provincial Government facilitated its execution and, both, the University and the Province enabled the Hydropower Microplants Program to offer colonists in Misiones a better use of their available natural resources, helping them to raise their living standards and giving them an opportunity to know the most elementary benefits given by electric energy.

The Program is executed following two basic projects: Unifamiliar Projects and Community Projects.

The former are those where the School of Engineering gives free technical assistance to colonists and producers in Misiones and other provinces, with respect to the installation of SHP, generally for domestic use. All the basic studies are carried out at the School of Engineering and, in many cases, the user has the microturbine, the generator, the transmission lines, and domiciliary installations completely installed, and he is also provided with an adequate training concerning the use and handling of electric energy. Besides, he also receives advice on the civil work.

The first installation of a microplant to generate electric energy was in 1977, in Pedro Lascarow's farm, a Russian colonist, with a 3 kW asynchronous generation installed power.

As regards Community Projects, these works are executed within the framework of an agreement between the "Ministerio de Obras y Servicios Publicos" of the Province and Misiones National University. They are meant to provide colonists in isolated areas with electrical energy. The system consists in creating a consortium including all the future users. Such consortiums are responsible for administrating the funds given by the Provincial Government to carry out the works. They personally take an active part in both the construction of civil works and the layout of electric energy distribution lines.

The Provincial Government, through its Hydric Resources Department, where the professionals are at the same time teachers at the University, performs a civil work project and supervises its execution. The "Empresa de Energía de Misiones" (Misiones Energy Company), EDEMSE, performs the distribution and transmission lines projects. The School of Engineering is in charge of the whole hydroelectrical mechanical equipment and, in some cases, the students take part in the assembly of the power distribution network. Domiciliary installations are carried out for those who require them, or the necessary technical advice is given, and finally users are trained on the rational use of energy.

The first Community Project performed in this way was the one in Arroyo Dorado, in 1984. This project benefits eight families and a rural school.

The Program is on its way and up to March 1987 the following projects has been executed: the Arroyo Persiguero Project , of 10 kW; the Salto Pereyra Project, of 28 kW; the Salto Carlitos Project, of 16 kW; and the Arroyo Tarumá Project, of 40 kW. At present, the Arroyo Central Project, of 26 kW is being built and about to be opened.

3.2- Experience in Neuquén

The Province of Neuquén, located in the southwest region of the country, in the Patagonia area, and bouded by Chile has also undertaken a Hydropower Microplants Program aimed at developing its small villages.

These villages, mostly indigenous, have been left of any possibility of real growth due to the fact that they do not have electric energy.

Paradoxically, Neuquen in one of the richest provinces in energetic resources. The two large hydroeléctrical plants Chocón-Cerrros Colorados and ALICOPA (Alicurá - Collón Cura - Piedra del Aguila) are there. Besides, it is a very important oil producer.

But these small villages are located either where it is very difficult to install electric energy distribution lines, or very far from energy producing centers. This is the reason why self-production, by means of the hydroelectrical exploitation of small water ways, turns out to be the perfect solution.

Since 1984, the E.P.E.N. (Neuquen Energy Company) has been responsible for implementing the Program, and now its results are obvious: four operating plants: Auquinco, 40 kW; Chiquilihufn, 75 kW; La Fragua, 130 kW and Santo Tomás, 75 kW; and more than 20 SHP planned. Most of these SHP (80%) are under 100 kW. The Nahueve plant, with 4 MW capacity, is the largest project.

The construction of the Auquinco plant, with an installed capacity of 40 kW, was considered as a pilot experience, and several conclusions applicable to the rest of the program have been drawn.

The E.P.E.N. has adopted the concept of adequate technology, using the area's materials for the construction of the civil works, its own engineering for electromechanical equipment, its construction in local workshops and, above all, the indigenous community's active participation in manual labor. In this way, such community considers the plant as its own achievement and takes care of it. Thus, the Auquinco plant is being operated by its users and the E.P.E.N. has been able to economize on expenses, avoiding the installation of a permanent maintenance and operation service.

3.3 - Experience in Mendoza

In 1981, the CFI opened a bidding and contracted the

IATASA-CONETEC-EGASAT consortium for consultant works with the object of carrying out a "Small Hydropower Plants Inventory and Final Projects" in the Province of Mendoza, located in the west of the country, close to the Andes.

The study was divided into three stages: the first consisted in performing the necessary studies in order to define up to forty suitable sites, to be located in isolated and under irrigation areas; the second consisted in the execution of preliminary projects on 25 sites selected according to the results achieved in stage 1; and the third stage dealt with the execution of 15 Final Projects, selected according to the results achieved in stage 2.

The following criteria were used: maximum limit of 10 MW per plant, and distribution of the number of plants to be studied according to the following:

- Plants of 7 to 10 MW , 20% of the total
- Plants of 3 to 7 Mw , 50% of the total
- Plants of less than 3 Mw, 30% of the total

Finally, 13 Final Projects were achieved, appropriate for a public bidding, with powers between 720 and 6000 KW; the powers of selected generating units varied from 360 to 2000 kW. The overall potential is 36 MW, which means an annual generation of 200.000 Mwh.

3.4. - Experiences in other Provinces

The following is a brief description of the degree of development of SHP's studies in the provinces, at present.

Catamarca: The CFI has performed the first stage of the evaluation study of the hydroelectrical potential of small plants, which consists of their inventory . The result of this stage is a list of 16 sites appropriate for the second feasibility analysis stage. The combined power capacity is 17,9 MW, with an annual generation estimated at 157 GWh.

Santa Cruz: There is an Inventory including eight plants with capacities between 480 and 4000 kW, with an overall power of 18 MW. In 1985 the project on the River Los Antiguos was carried out by a technical group made up by professionals belonging to the OEA - CFI - Agua y Energia Electrica and Province of Santa Cruz.

Santiago del Estero:The studies carried out by the CFI consist of four projects on irrigation channels, as a part of a study on the complete electrification of the province. The plants' power go from 100 to 600 kW and total 1070 kW.

Chubut: Five isolated sites were studied. One of them, Cholila, is a final project with a capacity of 1000 kW. The plants' powers go from 80 kW to 750 kW, with a total of 1800.

4 - INSTITUTIONAL ASPECT

As it was mentioned above, the subject of SHPs is directed and coordinated at a national level by the New Power Sources and Preservation Department, under the National Energy Secretary.

With the object of encouraging the development of new and renewable sources, this Department has decided to create a Regional Source Center in each of the provinces that has the greatest resources and experience in this field.

Thus, the following centers have been founded: a Regional Aeolic Center in Chubut, in the patagonic area, which is characterized by its abundant wind; a Regional Center for the development of geothermical energy in Neuquén, in the southwest region; a Solar Energy Regional Center in the Province of Salta, in the northwest of the country, which is an area that has excellent solar radiation levels. Finally, a Hydro-power Microplants Development Center (CREDMHI) has been created in Misiones.

As regards biomass, it is necessary to mention that a collaboration agreement was signed by the Energy Secretary and the "Obispo Colombes" Agroindustrial Experimental Station

in Tucuman, to carry out studies of the production of "alconafta", based on the extraction of alcohol of sugar cane.

Apart from that, in August 1986, the Energy Secretary signed an agreement with the Science and Technique Secretary (SECYT), with the purpose of planning, encouraging, coordinating and orienting technical investigations and developments in the field of New Energy Sources. Every work connected with the Development and Investigation of Small Plants is carried out through the National Program of Non-Conventional Energies Investigations of the SECYT.

5 - MAIN GUIDELINES OF THE NATIONAL SUBPROGRAM ON SMALL HYDROPOWER PLANTS

The New Power Sources and Preservation National Department is carrying out a National Energy Program based on New and Renewable Sources, made up of different Subprograms covering each source.

As for Small Hydropower Plants, six courses of action have been foreseen, whose characteristics, objectives and implementation are listed below:

- 5.1 - National Inventory of Small Hydropower Plants at micro, mini and small hydropower plants level.
- 5.2 - Legal Aspects.
- 5.3 - Institutional Aspects.
- 5.4 - Technological Aspects.
- 5.5 - Evaluation Methodologies of Small Hydropower Plants Projects.
- 5.6 - Financial Sources Analysis.

5.1. National Inventory of Small Hydropower Plants.

Objectives.

- a) To know, at a national level, the capacity of the power to install and the energy to generate through this type of plants.
- b) To know the amount and type of electromechanical equipment to be required to plan the development of a national industry concerning this subject.
- c) To be able to give an answer to international requirements with respect to the offering of equipment as well as financial plans for the works.
- d) To be able to plan, based on an adequate evaluation, the priorities for the construction of small hydropower plants, considering both national and provincial interests.

In order to make up this National Inventory, there are two stages to face:

1. Control of existences.
2. Search of new sites.

1. Control of existences.

It means the control of:

1. Operating plants: it is important to know the states of the works whose equipments are to be renewed.
2. Shut-down plants: the cause of their present situation will be analysed and the technological-economical feasibility of their rehabilitation will be studied.
3. Studies carried out at the following levels:
 - a. Preliminary idea.
 - b. Preliminary Project or Prefeasibility.
 - c. Final Project or Feasibility.
 - d. Executive Project.
4. Hydraulic civil works built with non-generative ends especially in energetically isolated areas (canals, ditches, cutwaters).

The ruling concept adopted states that the field to be occupied by small turbines responds to situations such as rehabilitation of old hydraulic plants, closed due to their obsolete or antieconomical conditions; the construction of derivation dams or reservoirs which did not economically justified the construction of a hydropower plant when they were projected, or merely the searching of new sites for the development of isolated communities, or the reinforcement of an electricity public utility network.

2. Search of new sites.

Once the first stage has been carried out, and its results analysed, this second stage will start according to the following criteria:

- a. The use of the existing civil work.
- b. Simple and small civil work.
- c. Compatibility of the plants' power with respect to the consumption market demand.
- d. Distance from the plant to the market, compatible with the consumption market demand.
- e. Standarization of electromechanical equipment.
- f. Accessibility.
- g. Energetically isolated areas.
- h. Topographic (compact waterfalls).
- i. Power based on great waterfall and low volume.

The first stage will be put into effect through training seminaries to be held in the Province of Misiones, whose trainees will be the Provincial Technical Representatives on said topic.

For the second stage, experts are to be hired, who will carry out the studies supported by professionals of the Regional Center, and technical teams from the provinces involved.

5.2. Legal Aspects.

Objectives.

- a. To encourage the study of a National Bill to allow

each private owner or groups of owners of a Hydropower Microplant to sell the energy surplus to the companies that supply electric energy.

b. To carry out, at a national level, a study of provincial legislations as regards the subject of water handling , in order to know possible restrictions which may exist for the installation of S.H.P. in relation to priority uses.

For the fulfilment of these objectives, an Agreement between the National Energy Secretary and the School of Law of Buenos Aires National University is to be signed.

5.3. Institutional Aspects.

Objective.

To make the 23 provinces become aware of the importance of developing the subject of small Hydropower Plants, encouraging the creation of technical teams who can receive information and advice on this subject.

In the public sector, the agencies that perform the projects have traditionally been "Water and Electric Energy". Provincial Energy Departments. Municipalities. Cooperatives. other public institutions and private companies. However, the idea is that Provincial Energy Departments should be responsible for the development

of the studied projects and the appointment of the above-mentioned technical teams.

5.4. Technological Aspects.

Objectives.

a. To promote the investigations and development of national technologies with respect to electromechanical equipment.

b. To promote the exchange of experience and on the development of these technologies in the different provinces.

c. To use the important infrastructure and experience achieved by the Hydraulic Laboratory of the School of Engineering under La Plata National University, especially as regards turbines' tests.

d. To encourage the development of a national industry concerning SHP electromechanical equipment.

e. To know existing and potential offerers of SHP hydroelectromechanical equipment, at a national level.

5.5. SHP Projects Evaluation Methodologies.

Objectives.

a. To develop a SHP Projects Evaluation Methodology that includes all the aspects involved, the analysis of both, microeconomic variables, regarding a private or financial evaluation, and macroeconomic variables including an overall view of the social and economic aspects.

b. To issue a Manual including that methodology, which is to be used by the different national and/or provincial agencies involved.

In order to achieve these objectives, the assistance of a team of experts will be necessary for the development of a Manual on the Economic Evaluation of Non-Conventional Energy Projects. This Manual will be the basis for the development of the SHP Manual.

5.6. Financial Sources Analysis.

Objectives.

a. To study the possible financial sources for the construction of SHP plants at a national and international level.

b. To analyse the requirements concerning basic information and results of the Economic Evaluation requested by Financial Agencies to grant credits.

c. To encourage new Credit Lines from National and Provincial Banks to finance SHP plants.