DEVELOPING SUSTAINABLE RENEWABLE ENERGY IN MEXICO

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ABSTRACT

Energy is a fundamental part of any productive activity: its absence undermines the possibility of sustainable development. Additionally, the generation, transportation, usage and consumption of energy has a strong impact on the environment, and on the quality of life of the population. Mexico´s energy sector represents between 4 and 7% of the country´s GDP, generates almost 40% of the public sector income, and produces close to 8% of the country´s exports. This paper characterizes the accomplishments and future challenge of the México Renewable Energy Program. The goals of the México Renewable Energy Program are to promote the use of renewable energy technologies (RETs), promote environmental sustainability, enhance economic and social development in México, create new business opportunities for the renewable energy (RE) industry and offset greenhouse gas emissions. The program is focused on rural, off-grid, productive-use RE applications. particularly photovoltaic (PV), small wind, and solar thermal systems. As the México RE Program continues its shift from pilot project implementation to replication of its successes, the program team is developing new opportunities and is lacing new challenges. Several Mexican government programs are al varying stages of preparation that will build on and broaden the program.

I INTRODUCTION

In spite of its large reserves of fossil fuels, Mexico has promoted, in a significant way, the use of renewable energy sources, principally in the form of the large-scale hydroelectric plants, which today represent close to 23% of the country´s installed capacity (843 MW). Added to the aforementioned efforts there are important capacity additions expected for the year 2012, which are currently being promoted by the Federal Government through CFE in the fields of hydro-electricity (2,586 MW), geothermal energy (107 MW) and wind-electricity generation (101 MW). Furthermore, regarding self-supply schemes, the country currently has a mini-hydroelectric project of 8 MW and a landfill biogas electricity plant of 7.2 MW, as well as a number of mini-hydroelectric projects currently in the development stages and authorized by CRE, totalling 59 MW.[1]

Regarding sources of finance, Mexico has obtained funds of slightly over US$81 million from GEF, the World bank, and UNDP, to stimulate the large-scale development of renewable energies, to promote research and technical development, as well as strengthening the corresponding institutions, and their capabilities.

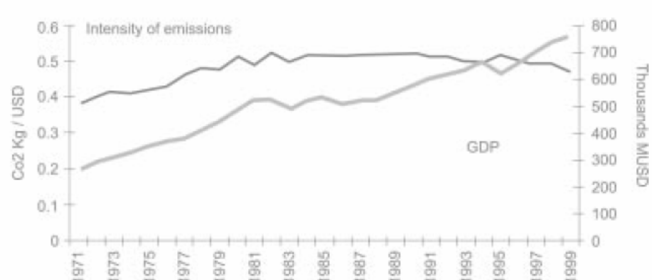
Mexico has always been committed to participate in International Fore, adding its voice to the international efforts to mitigate Global Climate Change in 1993, when it gave its unconditional support to the United nations Framework Convention on Climate Change and also ratified the Kyoto Protocol in the year 2000. In the same direction, in January 2004, the Mexican Committee for Projects to reduce Greenhouse Gas Emissions was created, national authority designated to manage projects within the Clean Development Mechanism (CDM). This effort will allow a reduction in the emission of greenhouse gases, and at the same time will attract additional resources for the promotion of renewable energies and energy efficiency, through the international trade of carbon certificates.[2]

Additionally, Mexico has participated actively in international fore on sustainable development, promoting the use of energy efficiency, the use of cleaner fuels, and the development of alternative energy sources. During the (World Summit on Sustainable Development) in Johannesburg, South Africa, our country supported "Latin American and Caribbean Initiative on Sustainable Development", which calls for at least 10% of total energy usage in the region to be provided by renewable energy sources by the year 2010.

Energy is a fundamental part of any productive activity: its absence undermines the possibility of sustainable development. Additionally, the generation, transportation, usage and consumption of energy has a strong impact on the environment, and on the quality of life of the population. Mexico´s energy sector represents between 4 and 7% of the country´s GDP, generates almost 40% of the public sector income, and produces close to 8% of the country´s exports.[3]

As a result of the measures taken within the energy sector, aimed to increasing the level of sustainable development, Mexico has achieved reduction in the intensity of energy usage over the last ten years, which means that the county´s GDP is increasing constantly, but with more energy efficient processes; this, in turn, means lower environmental impact for each unit of energy consumed (measured in $kgCO_2$/US$), as shown in the figure 1, below.[3]

Figure 1. Intensity of emissions and GDP



Source: Advance Report of Mexico on Climate Change (INE)

II .- CURRENT AND POTENTIAL STATUS

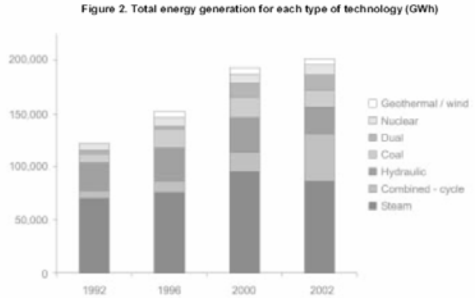
Throughout México, RETs are utilized in a wide variety of manners to help meet energy needs on both local and regional scales. From the large grid-connected geothermal, and hydro plants to the small remote PV home lighting systems, these technologies are providing direct benefits to millions of people across México. In some cases, the industries for these technologies are well established and growing at a steady rate, such as solar water heating in the México City area. In others, however, problems exist in the delivery chain and with user and supplier expectations that seriously limit the growth of these industries. A recent study estimated that the potential market for rural applications of RETs is more than $US 1 billion - more than half of that in the area of water pumping for agriculture [2].

Since 1994, Sandia National Laboratories has managed a successful program in México to develop markets for rural, productive-use applications of RETs. This program is sponsored by USAID and DOE. The goals of the program are to increase the appropriate and sustainable use of RETs, thereby expanding markets for U.S. and Mexican industries. RETs are used as a tool for economic development, environmental protection, and in combating global climate change. The program model has these key tenets, listed below [3]:

- Establishment of strong local partnerships;
- Capacity building with partners, suppliers, and end-users;
- Provisión of technical assistance;
- Implementation of sustainable pilot projects;
- Continued monitoring and evaluation of project and program impacts; and
- Encouraging replication through follow-on public and prívate sector activities.

The current energy policy recognizes the need for diversification of energy sources for electricity generation, through the promotion and development of technologies, which aim to use the primary energy sources by contributing to the sustainable development of the country. Mexico´s geographic location provides significant potential for the generation of electricity from renewable energy sources.

Figure 2. Total energy generation for each type of technology (GWh)



Source: Outlook of the Electricity Sector 2003-2012, SENER, Mexico

The usage of this type of energy makes possible to reduce to the use of fossil fuels and has a positive impact on the environment. In addition, the natural dispersion of renewable energies offers an acceptable opportunity for the generation of energy in a distributed manner. Therefore, the Electricity Research Institute is currently working on a Geographical Information System to the identify the location of these sources within the national territory.

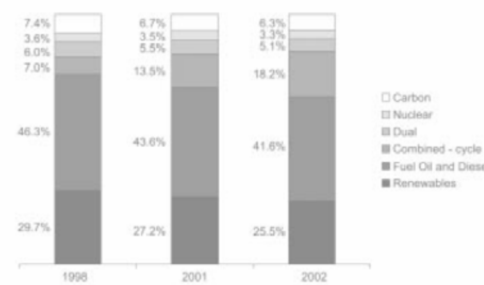
Chart 1. Effective capacity per type of technology (MW)

Year	Hydraulic	Geothermal	Eolian	Nuclear	Carbon	Steam	Combined cycle	Turbogas	Internal combustion	Dual	Total
1992	7,932	730	-	675	1,200	12,787	1,818	1,777	149	-	27,068
1993	8,171	740	-	675	1,900	12,574	1,818	1,777	149	1,400	29,204
1994	9,121	753	2	675	1,900	13,274	1,898	1,777	149	2,100	31,649
1995	9,329	753	2	1,309	2,250	13,594	1,890	1,682	128	2,100	33,037
1996	10,034	744	2	1,309	2,600	14,295	1,912	1,675	121	2,100	34,792
1997	10,034	750	2	1,309	2,600	14,282	1,942	1,675	121	2,100	34,815
1998	9,700	750	2	1,309	2,600	14,282	2,463	1,929	120	2,100	35,255
1999	9,618	750	2	1,368	2,600	14,283	2,463	2,364	118	2,100	35,666
2000	9,619	855	2	1,365	2,600	14,283	3,398	2,360	116	2,100	36,697
2001	9,619	838	2	1,365	2,600	14,283	5,188	2,381	143	2,100	38,519
2002	9,608	843	2	1,365	2,600	14,283	7,343	2,890	144	2,100	41,177

Source: Outlook of the Electricity Sector 2003-2012, SENER, Mexico.

In Mexico, the experienced renewable energies technologies are hydroelectric and geothermal, which together represented 25.4% of the total capacity of the National Grid in 2002, and provided 15.1% of the country´s total national generation.

Figure 3. Effective capacity by technology (MW)



Source: Outlook of the Electricity Sector 2002-2011, SENER, Mexico.
Note: Hydroelectric projects are included in the percentages given for renewable energies.

II.2 Solar Energy

The sun is a source of virtually never-ending, clean and free energy. The transformation of solar energy into thermal energy, or electricity can be carried out at the consumption center, thus there is no need for transportation, nor dependence on other forms of infrastructure.[4]

Photovoltaic system can be applied in remote areas, and inter-connected to the grid to alleviate saturation, especially in regions where the peak in demand coincides with peak in solar radiation. The potential for solar energy in Mexico is one of the highest in the word. Approximately three fourths of the national territory is zones with average solar potential of 5 KWh/m^2 per day [4].

The National Commission for Energy saving (CONAE) considers that, in 2001, there were approximately a total of 115, 000 sq, meters of photovoltaics systems installed throughout the country, providing 8.4 GWh/year of electricity. By the year 2012, it is hoped that this type of generation will represented a total of 30 MW in instalated capacity and 18 GWh/year in energy.

Currently, Commission Federal of Electrify (CFE) has a hybrid plant in San Juanico, Southern Baja California, with the following mixed installed capacities: 17 KW of photovoltaic energy, 100 KW of wind energy, and 80 KW of diesel engine. Additionally, the Commission is working on the installation of a combined-cycle, thermo-solar hybrid plant in Northwestern Mexico, with a renewable energy capacity of 39 MW. The Electrical Research Institute has also installed small photovoltaic system (1.5-2.0 KW) in the Northwest of the country, in order to study the effect of the end-user demand in the transmission grid[4].

The cost associated with photovoltaic systems range from 3,5000 to 5,000 USD/KW. Data from the Electrical Research Institute shows that the average potential of solar in Mexico is approximately 5 KWh/m^2 per day.

II.3 Wind Energy

The use of the wind´s kinetic energy is considered to be one of the mature technologies used for electricity generation, and is commercial available in form of wind turbines with nominal potencical for the production of between 0.5 to 1.5 MW, there are also prototypes with a capacity of up to 3.0 MW.[5]

In Mexico this form of generation has great potential, estimated to surpass the 5.000 MW identified en regions such as: the southern part of the Tehuantepec Isthmus; the Baja California and the Yucatan peninsulas; the central region of Zacatecas, The Mexico-U.S border region; the central high plains; and the coastal regions of the country.
The most significant advances regarding this type of energy have been out by CFE, with the installation of a 0.6 MW facility located in Guerrero Negro, in Southern Baja California and the construction of the La Venta test plan in the State of Oaxaca, with a capacity of 1.6 MW.[6]

Furthermore, other small wind electricity turbines and wind turbines for water pumping installed in remote areas represent 2 MW of installed capacity throughout the country. Information from CRE indicates that the construction of several municipal and industrial projects between 2003 and 2012, will represented and additional capacity of more than 500 MW.

It is worth high lighting the role of CFE in the development of a wind farm for electricity generation at la Ventosa, with an installed capacity of 101 MW (La Venta II). The typical investment cost regarding wind energy currently stand between 900 and 1,400 US$/KW installed capacity, and the generation cost range between 3.5 and 4.0 cents USD/KWh. [6]

II.4 Mini-hydraulic Energy

Although the full potential for this form of energy generation has not yet been completely estimated, CONAE has already identified over 100 possible sites for its exploitation. For example, in the states of Veracruz and Puebla alone, it is estimated thet there is potential for the generation of 3,570 GWh/year, equivalent to an average installed capacity of 400 MW.

It is estimated that the irrigation system canals alone could represent a potential generation of over 300 MW. Permits authorized by CRE in 2002 for mini-hydro-electric generation, indicate that there will be a total of six plants in operation with an authorized installed capacity of 32 MW.

Installation costs regarding this type of energy generation vary widely, without taking into consideration extreme projects, the cost depend on the physical characteristics of the location where the project is to be carried out, on the dimensions of the curtain and on the installed capacity, among other considerations. The investment cost vary from 800 to 1,800 USD/KW installed, with generation cost ranging from 3 to 20 cents US$/KWh.

II.5 Bio-Energy

This technology employs organic material that can be used to produce energy (municipal solid waste or agricultural and forestry residues). The exploitation of these resources can be carried out, either by direct combustion, or by biomass conversion of several combustibles (depending on the technique used: anaerobic, pyrolisis, gasification or bio-digestion fermentation)[5].

The Electricity Research Institute estimates a national production of 90,000 tons/per day, of municipal solid waste, but only can be used 5.889 ton/per day from which approximately, 150 MW of electricity could be generated. This alternative is only profitable for medium and large cities located throughout the country.

In 2003, the first landfill gas to electricity generation project, from anaerobic fermentation of organic municipal solid waste, was initiated in Salinas Victoria, Nuevo León . The project has an installed capacity of 7.0 MW, and generation permit of 58.2 GW/year.[5]

The investment cost for the generation of electricity through the use of biomass currently stand between 630 to 1,170 USD per KW installed, the energy produced cost from 4 o 6 cents USD/KWh.

II.6 Geothermal Energy

The viability of this energy resource will depend upon the development of technology that permits the exploitation of all types of geothermal resources (hot dry rock, geo-pressurized, marine and magma). CFE, which is the only developer of these types of projects in Mexico, has established the existence of diverse thermal manifestations throughout the country. In some locations the Commisions has in fact carried out some exploratory drilling, examples of which can be found in tres Virgens (Southern Baja California), Los Negritos (Michoacan) and Acoculco (Puebla).[1]

It is estimated that the geothermal potential in mexico, regarding hydrothermal system of high enthalpy (temperature above 180ºC) will permit the generation of at least 2,400 MWe. Some researchers have roughly estimated that the reserves of hydrothermal system of low enthalpy (temperatures below 180ºC) to be of at least 20,000 MWt.

Mexico holds the third place worldwide regarding capacity of geo-thermal energy, with 843 MW installed in the following locations: Cerro Prieo (730 MW), los Azufres (88 MW) and Los Humeros (25 MW). This Figure represents 2.0 % of the installed public service capacity. Furthermore, an enlargement projects is currently under way, named Los Azufres II, with 107 MW and a additional project is taking place at Los Humeros, with 55 MW. Environment impact regarding geo-thermal developments can be eliminated almost completely, and it is hoped that the cost involved with this type of project will fall over the next few years to between 3 and 5 cents USD/KWh, thus making it a more competitive option.[1]

II.7 Carbon certificates

In January 2004, the Mexican Committee of Projects for Emissions Reduction and Green House Gas Capture was created, as the National Authority for the Trade of Carbon Emission Reductions for the Kyoto

Protocol and parallel markets. Although Mexico is under no obligation to reduce its carbon emissions within the United Framework Convention on Climate Change, any reduction achieved regarding within the United Nations Framework Convention on Climate Change, any reductions achieved regarding.[3]

Carbon gas emissions may be sold to countries that do have this obligation, under the Clean Development Mechanism (CDM), generates additional economic value for renewable energy, energy saving and co-generation projects, among others. The Kyoto Protocol established that for projects to be approved by the CDM, the host country must prove that the said projects contribute to the sustainable development of the country.

Furthermore, the feasibility of the project must depend on access to the resources provided by the sale of carbon emission reductions.

Nowadays, Mexico has initiated the development of 8 projects emission reductions, all related to electricity generation using renewable energy sources: 4 mini-hydro-electric, 3 of landfill biogas to electricity projects, and 1 wind project. Together, these projects will have an installed capacity of slightly over 300 MW and will reduce CO_2 emissions by over one million tons on an annual basis. Some of these projects still have to be approved by the Executive Board of the CDM, but have already receive a non-objection letter from the Mexican Committee. [3]

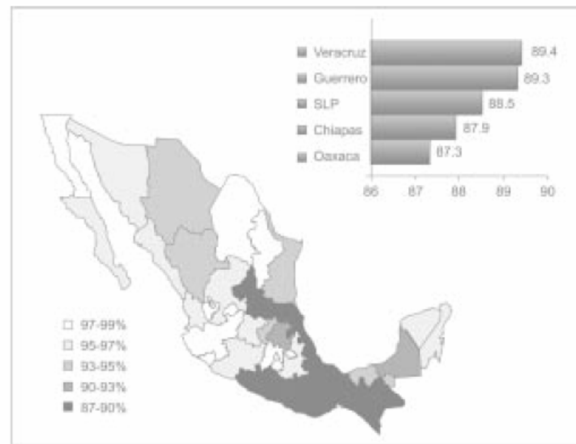
The sale of Certified Emission Reductions to developed countries under the CDM, may give important economical benefits to the energy sector projects, particularly to those using renewable energy that will contribute significantly to their economic viability. The Government of Mexico, through the Mexican Committee of projects for emissions Reduction and Green House Gases Capture is significantly increasing the possibilities to carry out this type of transactions, through actions like the signature of a collaboration agreement with the Japan Bank for International Cooperation (JBIC), which will facilitate the exchange of information and the communication among potential Mexican vendors (project developers) and foreign purchasers. [3]

III.- RENEWABLE ENERGIES AND RURAL DEVELOPMENT

Renewable energies offer important opportunities for applications in regions where conventional energy is still absent, or has only a partial presence. This is particularly useful in the rural sector, among populations with a high level of poverty. The lack of energy in the isolated rural communities constitutes a critical situation, as this associated with the absence of telecommunications, education, health services, and in many cases, drinking water [1].

Although Mexico has a relatively high coverage regarding the provision of electricity (around 95%, according to official data), this percentage is significantly lower in the southern states of the country, which have a lower level of infrastructure, an inferior quality regarding utilities, and where over 10 % of the housing has no access to electricity [1].

Figure 5. Coverage of the National Grid System



Source: INEGI; the XIth General Census of Population and Housing

Besides this, the communities with lack of electricity provision are generally located in mountainous region, primarily in the areas close to the borders between states. Accessing these areas through the use of the national grid means a significant increase in cost. In fact, according to information from CFE (Federal Commission of Electricity) , the expansion of the national grid systems to cover these areas would cost up to three times the cost of coverage through the use of non-conventional system of alternative energy supply [1].

The Hybrid Renewable Energy System (HES) is a viable alternative solution as comparated to system which rely entirely on hydrocarbon fuel. Apart from the mobility of the systems, it also has longer life cycle[5]. In particular, the integrated approach makes a hybrid system to be the most appropriate for isolated communities as remote communities in Mexico.

V .- EXPERIENCIES

Until recently, the only realistic options for rural electrification in Mexico were grid-extension and diesel mini-grids.

Since 1991, eight hybrid systems have been installed in five different Mexican states. The towns are Isla Guadalupe, Ignacio Allende, La Grunidora, El Junco, El Calabazal, Aguas Benditas, X- Calak, and Santa Maria Magdelena. These are inland, coastal, and island sites. These projects are a combination of technical demonstrations and precommercial pilots[8].

Four of the installations have a diesel generator backup. All but Isla Guadalupe use PV.

Some information on the wind resource was available from the US National Renewable Energy Laboratory (NREL). The best available information was compiled, but not verified. The one exception was the X-Calak installation, where the wind speed was tested and averaged 6.5 m/s. Unfortunately, the developers found less wind than they expected, and in some sites there is very low (about 4 m/s) wind speed 3 months of the year. [8]

The largest installation is at X-Calak, a remote fishing and tourist village.X-Calak is located in the Mexican Yucatan, across the bay from Chetumal, in the State of Quintana Roo. The village was destroyed by Hurricane Janet in 1952. When the village was rebuilt, a diesel powered minigrid was installed. Diesel operation has often proved problematic for these types of villages, with the high maintenance requirements and fuel supply problems. Power was only available for 4-6 hours during the evening.

Celiac users historically paid a flat monthly fee for electrical service when the diesel was operational. Even with diesel operation, fuel availability was inconsistent and would sometimes be appropriated by the village for the community fishing vessel. Prior to the hybrid system, the typical load consisted of lights, television, and radio, since electricity was only available for a few hours. Village refrigerators and ice makers were previously propane powered. [8]

In 1991 the State of Quintana Roo decided to augment the system with renewable energy and secured funding through Pranosol. CONDUMEX, S.A. de C.V. designed and installed the hybrid. The system is under the care of the CFE, the Mexican national utility, Sandia National Labs (a US government national laboratory), Instituto de Investigaciones Electricas (a Mexican government agency) and Southwest Technology Development Institute (located at New Mexico State University) provided consulting services. The system began operation in August 1992.

The system includes a 11.2 kW photovoltaic array, six 10 kW wind turbines, 1738 Ah of 220-volt GNB 6-7C23 deep-cycle flooded lead-acid batteries, a 40 kW AES sine wave inverter, and a 125 kW SELMEC diesel generator. It cost$750,000 and serves approximately 300 people.[4]This amounts to $25,000 per person for electricity, plus continuing operation and maintenance expenses. Without the 35% import duty on the equipment, the total cost would have been $565,000, or $18,833 per person. The diesel generator was the one already on-site. However, it was inoperative until mid-1995. Even now, the back-up generator is used infrequently due to high operating costs. The system was designed to supply 150 kWh/day during the low wind months. The output of the system is 220 VAC-3phase and is stepped up to 2400VAC-3 phase for distribution. The village load can be disconnected from the automated PV/Wind generator and connected to the diesel generator with a manual switch.[8]

The system has worked well technically, though a few electronics problems have occurred and one wind turbine alternator was damaged in 1993 due to a wiring fault. Salt corrosion has also been a problem. The system is performing better than expected, but, unfortunately, the wind/solar generators can not satisfy the current local demand because consumption has grown to more than three times the original projection. The higher electrical demand is at least partly the result of the fact that the villagers are not currently charged for electricity. Also, the distribution wiring in the town is in poor shape.[7]

Electricity is typically available 8-16 hours a day, depending primarily on the wind resources. This is a significant improvement from the previous system's 4-6 evening hours. Wind power provides ~85% of the generated electricity. The PV panels provide the rest. In October, when there is the least amount of wind, 140 kWh/day is provided to the village. In the high wind months, an average of 240 kWh/day is provided. A number of institutional and technical improvements (including more wind generators) are under consideration [7].

The system is extensively instrumented and is being monitored by the U.S.National Renewable Energy Laboratory and Sandia Labs to learn more about the real world performance of village hybrid systems. Sandia National Laboratory , Instituto de Investigaciones Electricas, Southwest Technology Development Institute, and CONDUMEX installed a data acquisition system in March 1993 to monitor performance of the wind/pv/diesel village hybrid power system. Average hourly data is recorded via cellular phone.

V . OPPORTUNITIES

The México RE Program is dynamic and in continual transition. According to the original program plan, funds that were previously available to share the cost of pilot systems are no longer available, and the program is moving fully into the "replication and institutionalization" phase. The importance of the partnerships upon which the program has based its successes will continue to grow.[5]

Several new opportunities are being developed through the program with the goal of replicating the successes to date. To effectively obtain this goal, the program team will work closely with partners to help them further increase their abilities to effectively develop RE components in their programs. Some of these opportunities are presented here.

FIRCO GEF program. Based on the successes of their partnership with Sandia, FIRCO (on behalf of the Mexican Secretarial of Agriculture) is initiating the first-ever Global Environment Facility program focused on agricultural applications of RE. This 5-year program will have an overall investment of SUS31 million in equipment, resulting in the installation of over 1,200 PV and 55 wind water pumping systems. The program plan also includes the development of new applications, such as milk tank cooling, and innovative vendor financing programs.

Secretariat of Energy World Bank rural electrification. The Sandia team, principally Winrock International, is assisting the World Bank and the Mexican Secretarial of Energy (SE) as they develop a pilot off-grid rural electrification program that will include innovative delivery and cost recovery mechanisms and the integration of community projects (i.e., schools, clinics, homes, etc). The plan is to build on RE development successes now realized in the states of Chihuahua and Quintana Roo. [5]

Secretariat of Environment, Natural Resources, and Fisheries (SEMARNAP). SEMARNAP manages all reserves in México, and has recently dramatically increased its budget for management activities, both in terms of personnel and equipment. They are interested in replicating the protected-areas successes of the Sandia team in other reserves in México.

Increased private sector interest. The success of the Sandia program is also replicated through private sector sales to end-users. Although difficult to monitor, the program team is collecting data that shows increases in private sector sales in Baja California Sur, Chihuahua, Sonora, Chiapas, and Quintana Roo, where the program has been operating for several years now. [5]

Other new government and NGO partnerships. Sandia is developing new strategic partnerships. Activities are underway with the Secretariat of Public Education (SEP) for their distant education program. Presently, SEP has over 500 PV-powered rural schools, with more than 1,000 others that are not electrified. Sandia is providing technical assistance in reviewing existing system configurations for improvement. The Sandia team is also helping the Mexican Rural Development Foundation (FMDR) to build capacity to implement RETs in their programs.

New applications. The Sandia team is building partnerships to establish activities with new applications and technologies, including solar water heating, water purification, milk cooling, battery-free refrigeration. and PV ice-making. [5]

VI.- CONCLUSIONS

In Mexico, the promotion of renewable energies is top priority. Reaching the mentioned set of incentives and modifications to the legal and regulatory framework, aim to assure the economic viability of projects currently in the construction stage, or already in operation, and foster the development of new projects to increase the use of renewable energy sources.

The aforementioned actions form part of a national strategy which will allow us to advanced the pursuance of the compromise acquired by the Government of Mexico, of granting to the future generations, a country with economic growth that accounts for the long-term social and environment variables, and that allows to continue its path towards a sustainable development.

Consequently working closely with its Mexican partners, the Sandia team has made great strides in the development of sustainable markets for RE technologies, principally PV , in rural applications in México. This success is most evident in the agriculture and protected areas sectors, while recent activities are making important! impacts in rural electrification. These successes have been achieved through:

- Working with partners to identify and develop RE applications within their existing programs;
- Working closely with suppliers of RE equipment to help them improve their ability to deliver quality systems; and,
- Making sure that end-users understand the technologies and how to properly maintain their systems for maximum benefit.

Through the development of technical specifications, extensive training activities, and the implementation of pilot projects, more suppliers have the ability to design and install long-lasting RE systems. Thus, more end-users have a greater appreciation of the value and capabilities of RETs.

The future brings exciting new opportunities and challenges, as the successes of the México RE Program are replicated in other new programs. The challenges of effectively implementing over 1,300 PIRCO GEF projects focused on RE for agriculture will require a broad-based collaboration of a variety of public and private organizations. Similarly, as the SE moves toward implementing an innovative rural electrification program, both program implementers and suppliers will need to develop new skills to assure success. These and other challenges will be met through continued collaboration among the various organizations that are involved in building and maintaining sustainable markets for RETs. The outlook is good for the program to meet these new challenges and multiply its success many-fold in the coming years.

REFERENCES

[1] Department of Energy Mexico, Renewable Energies in the Sustainable Development of Mexico, 2004. Mexico

[2] Estrada, L. and R. Foster, "Mexico PRODEEM Phase I PV Systems Evaluations and Technical Summary Report," for Sandia National Laboratories. SW Technology Development Institute, NMSU, Las Cruces, New México, April, 2000.

[3] Barnett, B. and D, Di Gregorio, "Market Guidebook of Renewable Energy Applications in México," for Sandia National Laboratories, KPMG Peat Marwick LLP, Albuquerque, New México, June 1998.

[4] Richards, B., C. Hanley, R. Foster, G. Cisneros, et al, "PV in México: A Model for Increasing the Use of Renewable Energy Systems." Advances in Solar Energy: An Annual Review of Research and Development. Volume 13, ISBN: 0-89553-256-5, American Solar Energy Association. Boulder, Colorado, 1999.

[5] Charles J. Hanley and Michael P.R. Developing sustainable renewable energy markets in México: results and future challenges, Sandia national laboratories, New Mexico State University, Technology Development Institute.

[6]D. Ellliott, Wind Energy Resource Atlas of Oaxaca, National Renewable Energy Laboratory NREL. USA 2003.

[7]Chun Che FUNG, A simulation study on the economic aspects of hybrid energy systems for remote islands in Thailand, report in investigation in Renewable Energy 2002 IEEE.

[8] "First-Year Monitoring Results of the Wind/PV Hybrid Power System in Xcalak, Quintana Roo, Mexico" Proceedings, Wind Power 1994, p. 716.