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Hydrobium Etli In Cuatzoquitengo: a viable project to resolve energetic problems mexico rural communities

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Introduction

Mexico consolidated, since the first decades of the 21st century, as an important oil producer at the global level. This natural resource has marked the historical evolution of the country, conditioned the economy, defined great part of the political debate and promoted the very construction of different development models. Mexico is today an oil country, the great networks that weave in its interior answer to such dynamic; the commercial balance, the public expenditure, the educational investment, the complex benefits system, the social capital, the foreign policy and even the sociability patterns. And even though the last transition in the development model – in which economic liberalization was given rise – has brought along other prioritized issues to the political and institutional agenda, it is irrevocable the oil permanence as the main articulator of the political, economical and social life of the country.

In spite of the scientific and technological advances of the developed world, that have propitiated a severe questioning to the functioning of the international order with regard to energetic, just a little has been really modified with respect to this order. This is true mainly because the exploitation of the non renewable natural resources has produced, along with other variables, negative effects in the environment and in the way with which the Earth system works. Today we know that the climate change and the degradation and impoverishment of the natural environment is a tangible reality. However, there is an endless demand for fossil combustibles. The relative ease for the extraction of these combustibles, the great availability and the low costs, compared with other energetic sources, are highly valued variables by the global economy.

Science on the other hand, through its multiple disciplines, has participated in the generation of many and better technologies in benefit of the environment in two senses: to

counteract the negative effects of the environmental degradation that already exists and to enable the emergence of new paths for the sustainable energetic functioning of the energy industry. Besides the fact that this projects are concentrated in some countries of the world, the political class has provoked that the results of these to be minor in comparison with the vigorous increment of the demand of hydrocarbon-based combustibles in the markets.

Nevertheless, significant scientific efforts are made in countries like Mexico to counteract the effects of climate change. Examples of one of these attempts to find real alternatives for the generation of clean and eco-friendly energy is the research project *Hydrobium etli* from the UNAM-Genomics Mexico iGEM team, which consists in the generation of electrical energy through the implementation of a genetic circuit into the bacteria *Rhizobium etli*, a symbiont of the bean plant, Phaseolus vulgaris. By doing so, a significant rise in the production of molecular hydrogen is expected, which can be then utilized as an energy carrier. The students behind such research find in Mexico serious conflicts regarding the consumption and the energetic dependence; and not only in environmental issues.

According to a study made by the World Bank[i] (World Bank; 2006), extreme poverty is principally, though not exclusive, a rural phenomenon. Although in the last two decades there has been a significant advance – specially in comparison with the 1980 decade – in the health, educational and social infrastructure domains; the admission and the access to these services are found assume the two more profound conflicts of the Mexican rural communities. This does not implies the non existence of urban poverty nor the full access to these services in the cities; the rural problem increases when the access to these services is in extreme limited and the admission lacks of forms of regional reproduction and integration.

The scientific and technological innovation of projects like the one analyzed here assume the focalized improvement of the access to the electrical energy service that would help to significantly increase the life quality of the inhabitants. The application of this new clean and eco-friendly technology is in essence an amendment to the networks of social development in rural zones in Mexico.

Current Panorama On Energetic Production In Mexico

As of the 21st century, Mexico stands as a country without a central conjoint policy regarding the energetic production. Oil and natural gas, and in general all other energy sources, are variables that determine the macroeconomic growth of any country, and by so, deserve to be treated as proprietary subjects in an independent manner by the federal administration. In Mexico, these natural resources keep functioning, relentlessly since 1979, as fiscal resources to the public expenditure of the current government. Hydrocarbons, in the milieu of a mainly exporter country, must be protected by legislations that compel the efficiency in the activity regarding the extraction, production and delivery of these resources, protected by laws that avoid public squander, that provide fiscal stimulus for the dynamic of the economy and that promote the generation of highly productive industrialization chains.

PEMEX[ii] was a Mexican business entity pioneer in implementing a scheme for the generation of the proper technology for the exploration and extraction of hydrocarbons, as well as to encourage the industrialization of processes with regard to the refining, the infrastructure and the petrochemistry. These activities of PEMEX had many impacts in other economic areas (such as in the communication, the transportation, the fertilizer and the agriculture industries), and in a way it added industrial value to primary sector industries; PEMEX also trusted employment generation as well as the country economic growth as it drew investment into the private and public sectors. However, when the Cantarell oil field was discovered in 1979, one of the biggest oil fields ever found, the Mexican state was suffering a very strong fiscal crisis, this discovery took place just three years before the state declared itself incapable of paying its debts. The exportation revenues and the fiscal incomes simply served to the Mexican boat to take a little longer to sink. The parastatal PEMEX ran out of resources.

According to Gil Valdivia (Valdivia; 2008) Mexico counts today with 12.9 billions of oil barrels, approximately 1.1% of the world's reserves. Our country has the third most important oil reservoir in North America - this one represents 5% of the world's reserves – and the second most significant of Latin America, that counts with approximately 8.6% of

the world's oil reserves. Mexico suministers 1.5 from the 21 millions of oil barrels that requires the United States of America daily. The proved hydrocarbon reservoirs decayed a 47% in 2000-2006[iii]. The favorable set of circumstances in the international climate in that period – the rise in the oil price, the growing economy of the United States, the increase of the PIDIREGAS funds[iv] and the rise of the remittances (Marcos; 2008) - promoted the overexploitation of the oil reservoirs. The objective was to raise the fiscal revenues, by means of an excessive tributary regime, in order to maintain a commercial balance less prone to loss guided by the exportations increment.

> "Mexico faces a great challenge because of the fact that the oil in the future will have to come from oil deposits whose complexity exceeds, by far, the one we have faced until now. To successfully confront it, a major effort will be required oriented to increase the execution and investment capacities, to adopt the best risk administration practices that imply the investments and to utilize the most adequate technology for the exploitation of the new oil deposits."[v]

Despite the drastic plunge the hydrocarbon extraction industry had, in 2009 the fossil combustibles participation in the national energy consumption was of a strapping 89%[vi]. Meanwhile, the renewable combustibles and residues that constitute the solid biomass, the liquid biomass, the biogas and the industrial residues together did not get to more than 4.8% of the energy consumption for the same period[vii]. Clean energy, energy not coming from hydrocarbons whose generation does not produce carbon dioxide and that includes the hydroelectric, nuclear, geothermic and solar energies, among others, only conformed approximately 6.2% of the energy consumption.

Currently, the national electrical supply is a service provided by a state company called CFE[viii]. Such entity must then supply, manage and export electricity to the whole of the national territory. According to Valdivia (Valdivia; 2008), the national installed capacity is of 53,843 Mw, of which 27.8% corresponds to the electricity generation by conventional thermoelectric; 22.6% comes from the hydroelectric industry; 17.7% from combined cycle PI; 10.8% from combined cycle CFE; 5.6% comes from the carboelectric industry; 5.6%

from turbogas; 4.5% is dual; 2.1% comes from geothermic and eoloelectric industries; 2.9% from nuclear; 0.4% from dual and internal combustion.

Though the electrical system attempts to diversify, with the firm objective to achieve an energetic security program, there are left two national challenges, as pointed out by Elías Ayub (Valdivia; 2008): a) The investment of strong capitals into the electric system, at least 5 billion dollars annually; and b) The investment in research projects in relationship with hydrocarbons and electricity, supporting and encouraging the creation of new technologies to productively incorporate new forms of clean and renewable energies.

Mexico contributes with roughly 3% of the greenhouse gas (GHG) emissions in the world, being the Latin American member with the greater proportion contributor (Cárdenas; 2008). Within the GHG generated by Mexico in 2007, carbon dioxide occupied the first place, with almost 4.5 metric tons per capita, due mostly to the fossil combustibles consumption. Therefore, the support to other ways of generating energy must be prioritized.

Beyond the moral justifications about the development of renewable energies, the current Mexican energetic scenario – and to a certain degree, the global scenario – lacks of real viability within the frame of the hydrocarbons production decrease and of the lack of investment into the electrical system. In pragmatic terms, it results fundamental the wager to incorporate new productive technologies into the energy generation scheme with the hope to achieve to sustain a national development model; without a long-term, integral, multisectoral and interdisciplinary vision from the Mexican state, it is not possible to think in energetic security; without energetic security there is no stable economic growth.

> "In this sense, opportunities must be harnessed that offer sustainability in regard to income, employment, social welfare and improvement of life conditions in marginalized areas. The technologies of energetic efficiency and of exploitation of renewable energy sources, besides being alternatives to take the electrical service to marginalized areas and/or of difficult access, are engines of the regional development, with the creation of small enterprises and jobs to the communities. Further, the users of these efficient technologies will result benefited through saving in the expenses they have to make for the

payment of energetic inputs."[ix]

ALTERNATIVE ENERGY PRODUCTION: *HIYDROBIUM ETLI*

Symbiosis is defined as a close interaction between different biological species, which results in an association where all the parties obtain a benefit from their interaction. One of the scarce biological processes capable of atmospheric nitrogen fixation is the one that takes place through the *root nodule symbioses.*

Nitrogen fixation is an essential process for life because fixed nitrogen is required for the most vital mechanisms. It also has a strong role within the enrichment of soil, thus representing a benefit for a variety of vegetal species. The organisms that fix nitrogen are not that common, partly because of the specific conditions -such as anerobiosis environments- the process requires. Some host plants are capable of providing this environment through the formation of specialized structures in their root system called nodules[x]. The nodules are niches where soil bacteria called *Rhizobia* establish and fix nitrogen.

Rhizobium etli is the predominant bacteria found in the nodules of legumes such as the common bean, *Phaseolus vulgaris*. The symbiosis between this two organisms enables the exchange of carbon compounds from the plant and nitrogen compounds from the bacteria. By providing its host plant with the nitrogen compounds, the bacteria acts as an organic fertilizer. This process can be applied to the crop rotation practice as an eco-friendly alternative to artificial fertilizer usage, with the advantage of rendering the nitrogen quantities the host plant actually needs, therefore avoiding over-fertilization.

The nodule micro-environment where *R. etli* is in this symbiosis is appropriate to the enzymatic production of hydrogen. The main goal of the project is to allow the hydrogen production by the bacteria while maintaining the nitrogen fixation capacity. If this is achieved, *Rhizobium etli* will have the capacity of bioremedation[xi] through soil nitrification, and produce a fuel free of hydrocarbons.

To achieve the project's goal, a transgenic strain of *Rhizobium etli* will be engineered by introducing elements from two different bacteria and one algae to orchestrate

sustainable hydrogen production and maintenance of nitrogen fixation, all this, taking advantage of the symbiotic relationship and the usual plant development.

The team has optimized the two constructions[xii] comprising the elements described above, which will allow the efficacy in the production by *Rhizobium etli* of the enzymes involved in hydrogen generation.

To assess the efficiency of this synthetic system in terms of maximizing both hydrogen production and nitrogen fixation, the team will take advantage of tree parameters: the nodulation capacity of the plant, the optimization of the constructions for R. etli, and the nitrogen fixation of the bacteria.

The team will use a strain of *Phaseolus vulgaris* capable of generating giant nodules to explore the impact of nodule biomass in the hydrogen production. Determination the metabolic cost of nitrogen fixation while generating hydrogen is critical, comparisons between a strain of the bacteria incapable of nitrogen fixation and our strain will be used to evaluate the metabolic interaction degree of hydrogen production and nitrogen fixation.

These measurements are very important because they can help to define the sustainability of the project. If the nitrogen fixation and hydrogen generation are productive, the social projections of the research will be quite encouraging.

Viability of a Scientific-Technologic Project

One issue afflicts most of the scientific and technologic innovative projects regarding energetics in countries with similar structures as Mexico: Is a State that holds the monopoly of the extraction, generation, production and commercialization of energy capable of promoting a friendly juridic frame to projects of alternative energy generation like *Hydrobium Etli*?

The legal and political spectrum

Energetic issues in Mexico are as of today delimited by two main legal and political aspects. For one side there is the international right with the agreement about the climate

change: The Kyoto Protocol; and for the other side, the six-year plan that the current government, in this case the PAN political party, proposes for the administration: The National Development Plan 2007-2012.

The Kyoto Protocol[xiii] is an international agreement that has as main objective the emission reduction of six specific types of GHG[xiv] within the principal industrialized countries of the world. Such agreement attaches, for a first step, to developed countries. However, the pression some governments have put into and the initiative of some developing countries, together have boosted the negotiations so that the developing countries be fully introduced to the agreement, as they also contribute in their own measure to GHG emissions.

After the developing countries ratified the Kyoto Protocol and they integrated into the global scheme, in 2005, the negotiations got complicated. The COP, an entity that represents all the participating countries, decided not to impose restrictive fees of emission reduction percentages to developing countries, alluding for the historic responsibility of the industrialized countries with the climate change phenomenon. The developing countries took the compromise with substantial reforms to their development models that prevented the rise of GHG emissions, with the flexible mechanisms the treaty established. Nonetheless, the lack of legal vinculation and the lack individual objectives to developing countries that join the Protocol eliminates all compulsory within the legal frame of the international right and promotes the non-compliance of the Kyoto Protocol goals.

Meanwhile, president Vicente Fox (2000-2006), who witnessed the implementation the Kyoto Protocol in Mexico in 2005, affirmed that there exists the need to modify the economic development model in order to make in friendly with the environment and to avoid GHG emissions. The next government administration (2006-2012), from the same political party PAN, took ahead within its six-year plan a list of actions that searched to mitigate the negative effects of the prevailing development model towards the environment, principally based in the external commerce. Unfortunately, the actions the government has been assuming so far in this regard do not seem to have positive results, what makes us recognize that the mexican compromise to the Kyoto Protocol is nothing but merely speeches and condescension.

Contradictions arise when the current government does not come up with concrete measures – beyond the suggested guiding lines – that satisfy the international commitments. One of the most important examples is the PND 2007-2012, governmental plan that pretends to promote the economic development of the population, in agreement with the environment care and with Mexico natural capital conservation.

To the before-mentioned objectives it will be necessary, according to this plan, the active participation of all the sectors among the population, to change the production and consume patterns for the better exploitation of natural resources, to promote the use of cleaner and more friendly technologies with the environment, to encourage and to favor the implementation of laws and environmental policies with shared actions among the distinct dependencies. And above all, to promote the generation of scientific research that will bring as results the materialization of an efficiency in the sustainable economic development and an evident amelioration, in positive terms of the plan, of Mexican population life quality.

The Mexican Constitutional Article 27 determines that it corresponds exclusively to the State the generation, conduction, transformation, distribution and supply of electrical energy that has by object the public service. Such article gives precedence to the Public Service of Electrical Energy Law of 1975, which gives legal structure to the CFE. This law, that determines the way in which the electrical service shall be delivered throughout the country, also says that, as from the 1986 and 1992 reforms, the possibility to participate in the generation of electricity by self-supply, co-generation and small production. Our project takes place in the self-supply modality of small isolated or rural communities that constitute themselves as cooperatives, co-ownerships, associations or civil societies[xv].

In regard to the sustainability, the PND 2007-2012 plan is armored by the Article 36-Bis of the SPEE Law, that determines as an obligation of the CFE the best use at short- and long-term of the energy at the lower costs possible, taking into account only the stability, the quality and the security of the public service. This makes it impossible the national implementation of clean and eco-friendly energies and subordinates them to the stock market fluctuations. With all this it is understood that even though the CFE contemplates the possibility that projects like *Hydrobium Etli* to be implemented for the generation of electrical energy for the benefit of the rural communities, the CFE will not

work for the application of these kind of project at large-scale.

The Special Program for the Exploitation of Renewable Energies, emanated from the SENER, characterizes the renewable energies as all of them that "are based on cycles and implicit fluxes in nature […] all those that regenerate themselves and are expected to last for hundreds or millions of years..."

The diversification of energetic sources in the national energetic consumption for renewable energies is a mechanism to reduce the country dependence towards the fossil combustibles, at the time that the GHG emissions are proportionately diminished. Having as consequence not only the resources and the environment conservation, but an important economical contribution for the creation of employment and business.

Although renewable energies play a critic role for the sustainable and social development, fossil combustibles remain being the primary energy source in Mexico and a determinant axis of its economy. We can observe this in the total installed capacity for the electrical generation in the country public service, where 75.3% is represented by fossil fuels and only 3.3% is represented by renewable sources[xvi].

It is important to situate the energy obtained by the symbiosis of the bean plant, *Phaseolus vulgaris*, and the bacteria, *Rhizobium etli*, within a kind of renewable energy enunciated in this established framework; we consider that our project fits within the biomass-derived energy source category. The biomass energy is all that that is obtained from animal and vegetable products or residues. Such energy can be exploited in two ways: burning it to produce heat or transforming it into fuel. It is worth noting that in the later, the transformation arises by biological processes, caused by the action of microorganisms.

The *Special Program for Exploitation of Renewal Energies* is a guide of specific action lies and challenges for the federal government, and has as a mission the incorporation of renewable energies to the national energy matrix, and the vision is to achieve a real energetic transition. The Law for *Exploitation of the Renewable Energies and the Financing of the Energetic Transition* – in force since November 28, 2008 – from which derivates this program, regulates the exploitation of renewable energies sources and clean technologies for the generation of electricity with purposes other than public service of energy delivery. With the previously established, the electrification by renewable energies is not only jur-

idical viable, it also is conceived as an engine of social development, because it provides alternatives for the electric service to communities far away from the actual electric grid.

Concerning the Law of *Exploitation of Renewable Energies*, the Energy Regulatory Commission is the one in charge of managing the rules and issues guidelines, methodologies, and administrative dispositions based on the energetic politic established by the SENER. The objective is to regulate the exploitation of renewable energetic sources and generate clean energies for the generation of electricity with purposes other than public services energy delivery and to establish the instruments for the financing of the energetic transition.

The aims of the program are clears: to promote the industrial development in this field, to accelerate the social participation, to increase the capacity of the electrical national system, to define projects for marginalized rural communities, and to spread the use and application of the clean technologies in all the productive activities also in the domestic consume.

Once understood that our project is regulated by the law for the *Exploitation of the Renewable Energies* because it is a renewable energy of the biomass type, the next law will establish the synthetic biology innovation boundaries. The *Biosafety Law of Genetic Modify Organisms* has as objective to ensure safety measures in front of GMO in relation to the release of this, either as experimental release, or a pilot program or commercial project. Roughly speaking, the law names the competent authorities and the way they have to act. As far as we are concerned, an experimental liberation project has to be presented to the CIBIOGEM. The institution will be in charge of the evaluation of the project by the CONACyT to generate proves and necessary insights; in all cases it's required also to do an evaluation by the SEMARNAT. If this institution considers that the project is in relation with the primary economics activities or interfere with rural life, also it must be approved by SAGARPA. Finally, to obtain the authorization the release authorization issued by the CIBIOGEM the project must be approved in safe by the SSA and the SHCP. After the experimental phase, the project may perform similar tests to obtain an authorization as a pilot and eventually must be subjected to the same process to be licensed as a commercial project.

CASE EXPERIENCE: Cuatzoquitengo, Guerrero

Cuatzoquitengo is a little village from Malinaltepec, entity of the Mexican State of Guerrero- in the south region of the country- and part of the Sierra Mixteca region in Guerrero. The village has a population of 1,618 habitants[xvii]. The local language is the mixteco[xviii] and has few Spanish speakers. In this community was conducted a field study aimed knowing people opinion about the possibility of incorporating a project capable of facilitating the provision of public service of electrical energy. Bringing conventional electricity to these areas is a challenge.

Cuatzoquitengo is ruled as a community, the lands are considered communal and every issue about them is a public interest: each year it is named a Commissioner by traditional systems; for making decisions the Commissioner must have a reunion with all other communal authorities, these last are elderly men that own extended land areas; the women, by tradition, don't meddle in political matters unless it is required by the assembly, women are dedicated to maternity, home and field chores.

The community has as main activity subsistence planting and a large part of resources come from remittance of young people leaving in search of employment, it can be national or international migration. The initiative of this youth is the one that has allowed in the last years an accelerated change in the life quality of the community. As much of the indigenous communities in Mexico, Cuatzoquitengo has problems by the owning of the land with neighbors communities. These problems have caused the suspension of electrical service by the intentional flock generators.

Taking into account *Hydrobium Etli* future project bet is to cover the shortage of energy in rural communities, either if it is produced by social conflicts or by being marginalized regions, *Hydrobium Etli* serves as a real alternative for communities with social similarities as the ones in Cuatzoquitengo. It would then have to establish a plan for implementing the new technology in the community, achieve to promote local economic activities, integrating the region in turn, significantly improvement of the life quality and promote rural development in marginal areas in Mexico.

Cuatzoquitengo fulfills the requirements of implementations proposed by the project:

- Electricity shortage by the state company in charge.
- Formal experience in the cultivation of beans. This would not disrupt the cultural tradition of the community.
- Community with a good attitude recipient towards new technologies.
- Not fertilized land in the last 15 years and which would be profoundly benefited from a nitrifying bean crop.
- A poor or moderately poor in nitrogen soil.[xix]
- The feature that makes the law on electricity cogeneration legal forms of traditional community or cooperative.

Similarly it is a suitable place to record strong profits:

- The possibility of the members to continue with their agriculture activities, now with a satisfactory energetic service.
- Increased quality of life for community residents.
- The possibility of integrating the community to regional economic schemes.
- Reinforce awareness about the environment.
- Significantly improve the image of science, and specifically of synthetic biology in the region.
- Have a full contact with new productive technologies in relation with clean energy and eco-friendly.

OUTREACH PRACTICE

To make the spread, our first contact was with the Assembly's main committee, who helped us to contact with teachers considered more qualified for helping to transmit our proposal, including the advantages and disadvantages of synthetic biology represented by the *Hydrobium Etli* project.

After hearing the proposal from the teachers, a meeting was called where they gave

us the opportunity of address to the communal authorities this with the purpose of telling all the details of the project and listen to the opinions. By one hand the presentation was conducted by illustrations and schemes of the bean plant, and by other the implementation of the project. The participations were very clear, "while there is a benefit, we accept the project", commented a member of the assembly. The acceptance of possible future project was unanimous. Nevertheless there were questions and doubts in relation with the environmental theme. "Would there be possible contamination to other cops of the modified bacterium?", "What cares should be done with something genetically modified?". Most of the people expressed interests for actual problems afflicting humanity in relationship with the environment and they thought that searching for eco-friendly alternatives as *Hydrobium Etli* showed the concerned of scientific community for the future of rural communities.

After completing the assembly we received some individual comments, which expressed approval because of the information brought to the community about the new technologies and the way it can be related in a positive way with their activities. One man was ready to show in his house the crop and the *iba chichi plant*- bean in mixteco- that they usually sow. Such was the degree of acceptance in this man that he offered his house in case of a pilot was implemented.

Given the lack of assistance of the community women to the assembly, we headed to their homes. We decided to perform the same explanation and record the process. At first they were insecure and shy, but it just took a few minutes so they could start to formulate interesting questions such as the trees possibilities to contaminate themselves or the potential reverberations on the bean crops. Nevertheless the precise and obvious wondering on the research project and its consequences, they, as well as the community male leaders, showed themselves exited and receptive.

The main purpose of taking the project and explain it to the community of Cuatzoquitengo was the promotion of Synthetic Biology in a place that meets the projects requirements, a place where the scientific breakthroughs are able to take part in society in a benign way.

Notes for Project Implementation

In certain ways, the social success of scientific innovations depends on the implementation policies. It is, indeed, the implementation phase the most important one of the whole process, mainly because it links the scientific breakthrough with society, people in actual interaction with science. This fact will definitely influence the public opinion about science.

Is not our goal to present a detailed study on implementation and execution issues, but we do need to outline the main aspects of the project in order to experience a positive impact on society. Although is not an actual requirement, the fact that Cuatzoquitengo carries out functions with *community* structure (we will referee to *community* as a legal body enabled by the Mexican constitution) opens a wide range of options. On the contrary, if the community does not hold a community organization, the creation of a joint management decision-making instrument is essential for positive results for local residents, the implementation *from above* would provoke only exclusion and depriving patterns. Holding community structure, in Cuatzoquitengo already are joint management and consensual decision-making tools.

In order to fully benefit the entire community and balance the use of this technology, it's important to encourage democratic mechanisms, openness and community involvement such as political joint management. The original social organization of this community provides an ideal framework: the elected local authorities decide jointly with society. Because of the reported gain we see on this joint management is that we propose, as the best implementation way, the creation of a whole-structure *cooperative,* according to the legal requirements of *self-sufficiency.*

The positive consequences of a legal association, such as the latter, are quite clear. Instead of being consumers of the state-owned company CFE, according to the legal road, the community will be the electric power producers, consumers and beneficiaries at the same time. The *cooperativism* permits, by its original principles, the horizontal participation of its members, something that propels democratic coexistence in joint development.

Also, mechanisms promoting community autonomy will be proposed. Unfortunately, we are aware of dependence created by technology. In order to avoid that,

we defend the possibility of a *promoter's system training*. The institution that implements the program will have to train a certain amount of people, the ones in charge of running the project. They must be, at the time, obliged to train the community members and find the most adequate of them, so they can pass the knowledge to the next generation and reproduce effectively the process. As far as possible, members of the community will have to deepen the understanding of the project studying academic programs that helps strengthen the continuity of the innovation. This way of things, the proper tools would have been delivered to the community in order to achieve power sufficiency and dependence of federal institutions.

We do not intent to close dialogue between the local developer institution and the community, but we do try to counteract the institutions possible monopoly by giving the community the needed knowledge and *know-how* to reduce dependence on institutional innovation.

These pointings allow us to outline the project not only in terms of sustainable rural development, but also in terms of economic, environmental and social benefits to the community. At the time of bringing electric power to marginalized settlements in Mexico that have been deprived from it, the project proposes itself as a democracy developer, as long as it is implemented by horizontal involvement mechanisms.

Conclusions

Summing-up, Mexico is in a pressing need for answers. Our deep dependence on fossil fuels for power consumption proves that fact. The answer shall not be only immediate but also holistic. It will have to be structure then as a State policy priority. The success or total failure of the national development model of any economy depends strictly on the political capacity of its leaders to draw long-term power-sufficiency routes. The contemporary power scheme will only see major shifts as long as it bets, systematically, for renewable, clean and *eco-friendly* technologies that can be, above all, productive.

The lack of energy security will translate, necessarily, in the lack of sustainable development. No wonder why, in this research, we intent to bring up the importance of

power diversification through the incorporation of renewable power sources. This type of energetic perform as sustainable mechanisms, that is because they not only search for environmental care but are alternative income and job sources, meaning social welfare.

In the specific case of *Hydrobium Etli* project, which supports bringing power lines to marginalized communities, renewable power sources turn out to be rural development driving force creating small *cooperatives* that improve life quality standards. This is given not only because of the job creation scheme but because of the saving on the power consumption expenditure.

On one hand, the proposal here presented, from Synthetic Biology, shows its commitment with society when it becomes a juridical feasible project under Mexican institutional framework, the only politically possible road of structural shift. On the other hand, the community legal body along with the joint management and democratic involvement mechanisms supports the actual productive implementation possibility. *Hydrobium Etli* is a major effort in a real sustainable construction of a renewed Mexico.

Last but not least, we are completely positive with the study case here presented. It proved that a local indigenous community such as Cuatzoquitengo´s is completely receptive and open to new technologies, improving, significantly, quality life standards.

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Acronyms

CFE Comisión Federal de Electricidad (Federal Electricity Commission)

CIBIOGEM Comisión Intersecretarial de Bioseguridad de los Organismos Genáticamente Modificados (Interministerial Commission on Biosafety of Genetically Modified Organisms)

CONACyT Consejo Nacional de Ciencia y Tecnología (National Council of Science and Technology)

GEI Gases de Efecto Invernadero (Greenhouse Gases)

COP Convención de las Partes (Convention of the parts)

PAN Partido Acción Nacional (National Action Party)

PEMEX Petróleos Mexicanos (Mexican Oils)

PND Plan Nacional de Desarrollo (National Development Plan)

SAGARPA Secretaría de Agricultura, Ganadería, Desarrollo rural, Pesca y Alimentación. Secretaría de Estado (Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food. Secretary of State)

SEMARNAT Secretaría de Medio Ambiente y Recursos Naturales. Secretaría de Estado (Ministry of Environment and Natural Resources. Secretary of State)

SENER Secretaría de Energía. Secretaría de Estado (Department of Energy. Secretary of State)

SHCP Secretaría de Hacienda y Crédito Público. Secretaría de Estado (Ministry of Finance and Public Credit. Secretary of State)

SSA Secretaría de Salud. Secretaría de Estado (Ministry of Health. Secretary of State.)

UNAM Universidad Nacional Autónoma de México (National Autonomous University of Mexico)

[i] The rural poverty in Mexico, is an study accomplished by the World Bank. The study was ordered by the Mexican government to analyze the phenomenon about the entrance in rural areas in Mexico without touch items like health, education and social infrastructure, the entrance is a depth conflict in that areas in our countries.

[ii] Petroleos Mexicanos, PEMEX from now on, is the Mexican state company that manages the exploration, exploitation and marketing of hydrocarbons in the country. It was created on June 7, 1938 by the President Lazaro Cardenas.

[iii] . The importance of the oil in Mexico is so important that Gil Vildavia says that for 2001-2006 period, the macroeconomic balance was good, due principally to the entrance of foreign exchange of the highs achieved in the oil extraction: 2.2 millions of oil barrels by day in 2004, only of Cantarell

[iv] Based on the oil boom, the federation promoted the use of a mechanism called PIDIREGAS which aims to budget funding for Mexican state oil company Pemex, previously endorsed by Congress.

[v] Look the "Programa Sectorial de Energía 2007-2012" en el portal de la Secretaría de Energía, taken on September second, 2011 in Mexico City.

[vi] . Data taken from The World Bank. Retrieved on September 2, 2011 in Mexico City:
[www.worldbank.org]

[vii] Ibíd

[viii] Comisión Federal de Electricidad, for now on CFE is a state institution in charge of the public electricity service. Founded on August, 14 th 1937

[ix] See "Energy Sector Program 2007-2012" on the website of the Ministry of Energy. Retrieved on September 2, 2011 in Mexico City:
[http://www.sener.gob.mx/res/0/Programa 20Sectorial% 20and%%% 202007-2012.pdf 20Energia]

[x] The Nodules are structures formed in the roots of the plants and give an anaerobic environment.

[xi] The Biorremediación are a process that use microorganisms, fungus, plants or enzymes derived of them to takes again its natural condition, to an altered environment by pollution.

[xii] Construction like the synthetic genes. Those form the system who will led the hydrogen production.

[xiii] Is necessary to clarify that the Kyoto Protocol is one of the most important efforts, although isn´t the most effective construction by the international community to fight the climate changes effects.

[xiv] From now and then GEI

[xv] All the mentions are recognized figures for its constitution and have as an objective to prevent the private capital in the electric generation and the production hoarding.

[xvi] Figures taken of the Secretaria de Energia for 2009, when the program was approved

[xvii] Acording to the Censo General de Población y vivienda 2000 reported by the INEGI.
Retrieved september 2, 2011 in Mexico City.

[xviii] Mexican native language, distributed in Puebla, Oaxaca and Guerrero, principally

[xix] According to the secretary of agriculture and water resources SARH1970 Mexico.
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Soil test is appended.