Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

Geothermal Direct Use Methodology to Develop Sustainable Projects in Mexico and Latin America.

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Keywords: direct uses, social impact, sustainability, methodology.

ABSTRACT

Opportunities for use the medium and low enthalpy geothermal resources (<180°C) in Mexico and Latin America have a great potential. These opportunities cover from balneology to industrial applications including heating, ventilation, and air conditioning. In 1959, Mexico was pioneer for geothermal power generation in Latin America. Nevertheless, this has had a significant lag in terms of their wide-ranging use through geothermal direct uses. For this reason, the iiDEA Group through the Engineering Institute of the National Autonomous University of Mexico (UNAM) has developed a methodology in order to achieve implementation of geothermal direct use projects. The above, consolidate myriad areas of expertise aligned to ensure a successful and sustainable project, highlighting the social component of the projects and addressing strategies that look for the benefit of local communities. This paper describes the process to integrate and link the technical, environmental and legal frameworks with the economic, social and politics features. This detailed methodology offers a guide to mitigate the barriers and challenges that prevent the development of geothermal direct uses projects, taking account the specifics needs of each community according to the geothermal resources available. The technical issues as temperature and mass flow of resource are analyzed, also business issues as product´s marketing channel, political issues as government support and lack of specialized technical advice are tackled. Mainly the collaboration schemes involving local community into the operation and business of projects are putted in the foreground. Therefore, this paper describes the experience of the first geothermal exploration permit granted by the Secretariat of Energy of Mexico for the development of a direct use project in Mexico, which include the social impact assessment in the community of Mesillas, Nayarit, site where permission was request. In summary, this proposed method aims to adopt good practices for development of sustainable geothermal projects, looking forward to achieve the consolidation of Mexican Geothermal Resource Centers.

1. INTRODUCTION

Geothermal resources are used throughout the world for: power generation and by the use of the heat directly what its so-called Direct Uses (DU). If this last one is properly managed, an integral use of the geothermal resource might be obtained. Mexico and Latin America have a huge potential of geothermal resources, however, there have not been successful of integral projects, which take a full advantage of the geothermal resources. There is experience in power generation but in regards DU are not being using except for balneology in a low level of marketing.

Currently the use of geothermal resources applied to DU have been a successful alternative in distinct parts of the world to be used in industry, obtaining multiple benefits that make geothermal projects can be perceive as a sustainable option (Gazo & Lind, 2010; Mburu & Kinyanjui, 2012; Lund & Boyd, 2015; Van Nguyen, et al., 2015, Franke & Nakagawa, 2017; IRENA, 2017; SENER, 2018).

Nowadays, 82 countries benefit of DU of geothermal heat through various applications. At the beginning of 2015, the installed capacity was 70.329 MWth, a 45% increase than in 2010. In 2014 the DU of geothermal meant an energy saving of 350 million barrels of oil or what is the same to stopping using 46 million tons of coal which prevented the emission of 150 million tons of CO_2. Likewise, in the last 5 years 20 billion dollars were invested in 49 countries in application of DU projects of geothermal energy. Therefore it is very important to establish methodologies and learn from the successful and already developed projects to establish schemes for the use of low enthalpy geothermal energy (Lund & Boyd, 2015).

In this paper, the most important points are mentioned to carry out a DU project of geothermal energy following an applied methodology that has as a target to develop a profitable and sustainable project, giving main emphasis to the social and economic issues which could represent meaningful savings and benefits when is using geothermal resources holistically.

2. METHODOLOGY

The implementation of DU projects in Latin America has had an incipient growth in comparison to other places of the world. Nevertheless, it is necessary to note that compared to the power generation there is a greater area of opportunities (Iglesias, et al., 2015; Bona & Coviello, 2016; Franke & Nakagawa, 2017; Tsagarakis, 2019). This methodology has the purpose of developing DU projects that generate a positive impact on society, the economy and the environment with greater success probability (SP). This positive impact leads to understand and accept geothermal energy, which would serve as a spearhead for the bigger project's development like the power generation.

It is important to mention that in the accomplishment of any geothermal project a sustainable exploitation of the resource is sought, for which it is necessary to look at the social, environmental and economic impact; as well as the technical, legal and political support that can be obtained. To demonstrate the methodology, information from the case study is shared and it is grounded in a social recognition visit that was carried out in the Mesillas community in Nayarit. For this objective, a query was implemented that allowed us to identify the perception of the population regarding this energy source and the degree of interest in a mango dehydration project.

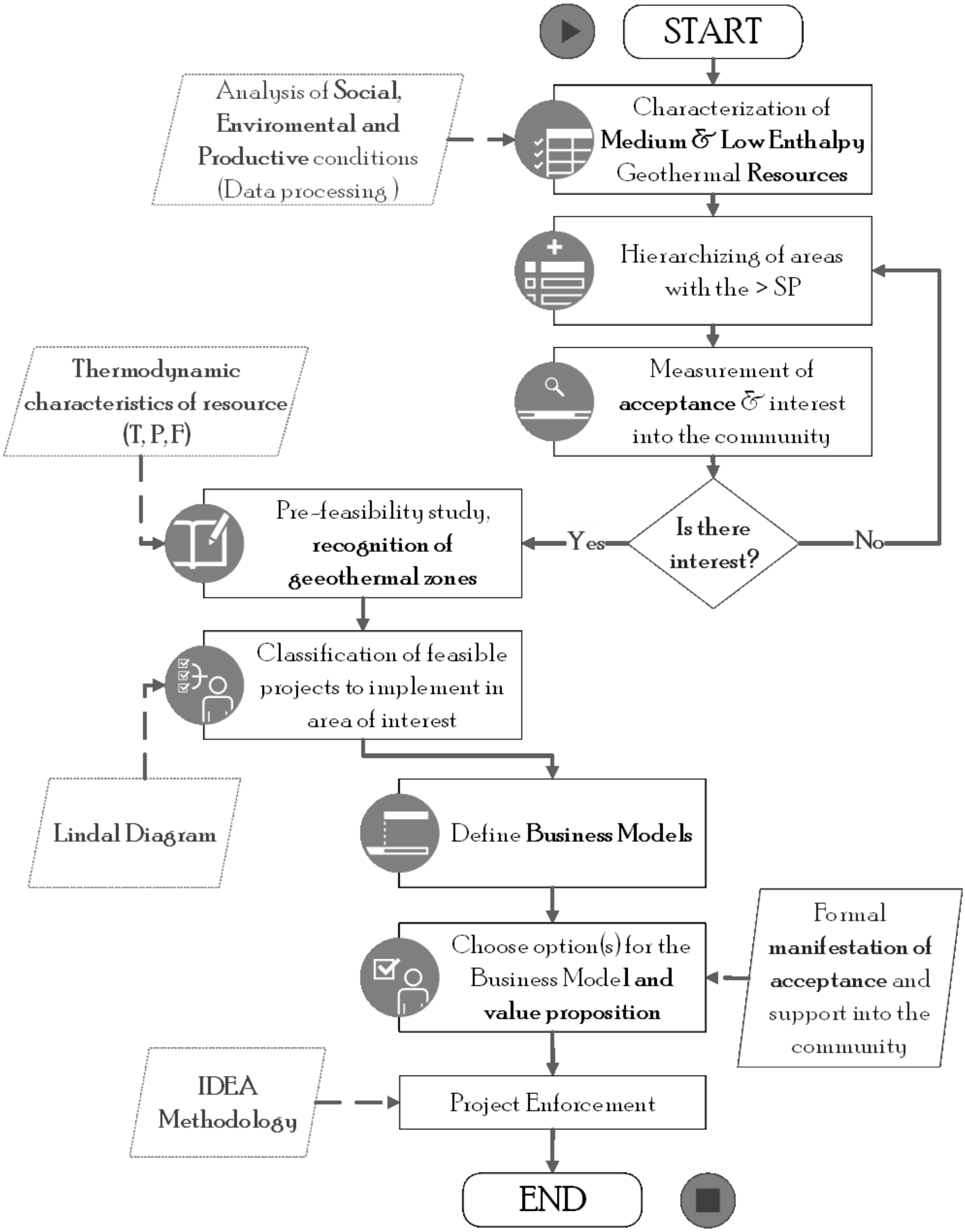

Figure 1: Methodology for DU Projects, iiDEA.

From start, it is important to identify the main stakeholders: the community is the most important piece in the development of the project, the developer or hero of the project is the person (or institution) accomplished of creating synergy among the other interested parties. The government is the one who will give permission and support to the development of the project. In the same way, the experts and consultants will be responsible for giving certainty to the operation and sturdiness of the project. There will be requirements to the stakeholders and information feedbackrelated to the project based on the proposed methodology, so it is important an active involvement of all members for the success of the project. The ideal characteristics that must have the stakeholders are responsibility, proximity, representation, political skills and strategy purpose (Shortall, et al., 2015; González Troncoso, 2016; Meller, et al., 2018; Vargas Payera, 2018).

2.1 Characterization of Low Enthalpy Geothermal Resources

Currently, there are many studies to estimate geothermal potential, where are highlighted the medium and low enthalpy resources. For example, it is well known that Mexico has a privileged geographical location for low enthalpy geothermal. In figure 2, we can find the geographical distribution of some of the 2.082 known hot spots and hot springs surface manifestations up to 2014, as well as the geothermal fields under exploitation. Of the total of known surface manifestations there is only enough data to estimate the potential of 1.637 that constitute 927 geothermal systems located throughout 26 of the 32 states of the country. Of the total of known surface hot spots and hot springs manifestations, there is only enough data to estimate the potential of 1.637 that constitute 927 geothermal systems located throughout 26 of the 32 states of the country. It was also estimated that the total thermal energy stored in these hydrothermal geothermal systems is between 1.278 and 1.514 EJ, with a success probability (SP) of 90%. Therefore, of the 927 systems identified, is estimated that 40% has a temperature ranges of 100 to 149 ° C, and 50% is found in a range between 62 to 100 °C (Iglesias, et al., 2015; Prol-Ledesma & Moran-Zenteno, 2019).

Figure 2: Low Enthalpy Geothermal Areas with the greatest SP

2.2 Hierarchizing of areas with the greatest SP

The hierarchizing of areas with the greatest SP is a job that requires secondary sources, to perform the analysis of social, environmental, legal and productive conditions of the interest geothermal area. The above includes the analysis of the number of men and women in the region, the immigration rate, the distribution of the educational population of 15 years and much more. It is important to check if the area of interest is not within an ecological reserve or prone to a high environmental impact. Consulting the activities and products that are already carried out in the area to support them instead of inserting new ones.

A first step assessment will indicate if it is possible to prioritize areas according to the following: there is not environmental barriers, there are agroindustry activities which involves thermal processes lower than 120 ° C and at the same time reside a target population who wishes to participate in the projects. This will lead us to the pre-feasibility study by zones and in this way, we will delimitate the target populations, which means, the community that have access to the geothermal resources and favorable conditions for the deployment of direct use projects.

2.3 Measurement of acceptance & interest into the community

This is the key point of the methodology. Whether or not decide to continue the development of the low enthalpy geothermal project will depend on population interest, but more than anything else, on the community acceptance in regards to the project itself (Shortall, et al., 2015; González Troncoso, 2016; Franke & Nakagawa, 2017; Meller, et al., 2018; Vargas Payera, 2018; Yasukawa, et al., 2018; Tsagarakis, 2019). As part of the management of one or several DU in a delimited site and for each one of the project stages (Identification, Design / planning, development and execution of the DU), all the works related to the social evaluation to the communities are essentials. The goal is to get to know the current state of the community, including organization, cultural activities, economics and inclusive political relationship with the geothermal resource. Identification of the knowledge and perception regarding the geothermal resource, and the degree of interest for develop a productive project (that takes advantage of this potential), to maximize an economic activity present either in the area or to create a new one.

A definition of social acceptance, with a socio-political approach, is defined in three dimensions: socio-political, community and market. The first covers the technological acceptance by all interested parties; the second is related to the trust between the parties with the surrounding community and the third about the acceptance among consumers, companies and investors (Vargas Payera, 2018; Yasukawa, et al., 2018).

The fieldwork was designed to achieve knowledge of the social context of the geothermal area known as Mesillas where it was analyzed the social management of a productive project for fruitdehydratation. This work consisted in the implementation of instruments and tools that allowed us working directly with the community, which were addressed mainly in the development of studies for geothermal exploration and in a social cartography. These resultant visual tools (poster and maps) will help to involve the community with the project and will be able to detect the way in which the inhabitants perceive their space.

It is important to note that a level of acceptance of tolerance to the planned project was identified in the population, in a level 1 of 3 according to Meller, et al., 2018. Where, the higher the level the greater commitment of the community with the planned project. In addition, it is important to emphasize that in any project of DU is seeks to strengthen the acceptance of projects to achieve to level 3. In that context, through surveys and inclusion of the protagonist groups, we seek to establish strong links with the community so that they are directly related to the project, thus avoiding any confrontation or problem in the near future.

Based on these assessments, activities are established to promote the socialization of the exploitation of geothermal resources, avoiding any disinformation within the population and mitigating conflicts between communities and developers. Indicators are also implemented to measure the degree of socio-economic impact of a project, once the DU project is defined.

2.4 Classification of feasible projects to implement in areas of interest

The processes that harness the heat in the direct way can be, among others, those contained in the Lindal Diagram in Figure 3. These include Ground Source Heat Pumps (GSHP), space heating and greenhouses, fish farming, drying of agricultural products, industrial uses, balneology, air conditioning and thawing. Depending on the location and the physical, chemical and thermal conditions of low enthalpy geothermal resources, these can be harnessed by implementing cascade schemes, achieving an integral and more effective use of geothermal energy (Ganzo & Lind, 2010, Lund & Boyd, 2015, Franke & Nakagawa, 2017; SENER, 2018).

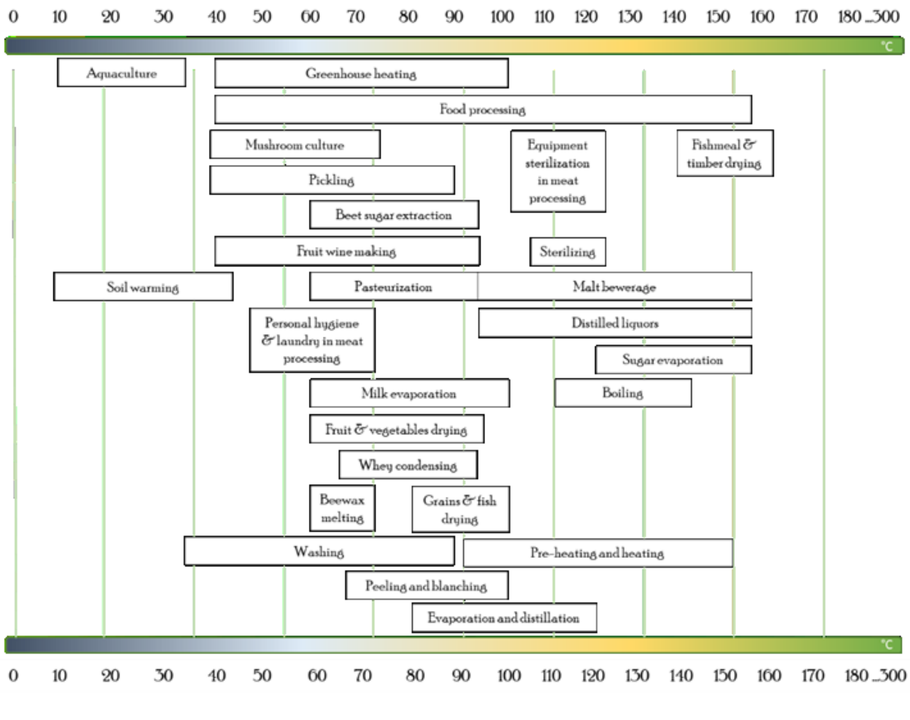

Figure 3: Lindal Diagram (Van Nguyen, et al., 2015)

2.5 Choosing options for the Business Model

The successful possibilities of productive projects are wide, however, the understandable projects accepted by the surrounding community are recommended, for this reason, the activities already carried out before the new project should be taken into account so that their introduction be as natural as possible (Franke & Nakagawa, 2017; Yasukawa, et al., 2018). In this study case, the objective is to perform a Technical-Economic Analysis of a cascade system for the implementation of a Geothermal Resource Center. Situated in an Ejido[1] into the locality of Mesillas, Compostela, in Nayarit State, which integrate the following systems: a Food Dehydrator, a coffee dryer, a system for aquaculture (shrimp farming) and a Thermal Park for recreation and well-being.

The aim of the project is quantifying the natural potential of geothermal resources, which the municipalities have to generate an economic, business and social development in the region, taking in advantage the high demand in the tourism and food sector in the area.

Once the analysis is available, the proposal must be presented before to governmental entities or private investors with the purpose of obtaining the economic resources that will contribute to the execution of the project.

The Ejido is characterized as a coffee production zone. Of a total to 75 producers that make up the Ejido core, 71 are focused on the cultivation and harvest of coffee, which is distributed practically throughout the periphery of the community, except to the northwest where the volcano of Molote is located.

Although the same producers do not have accurate accounts on the volumes of production, the marketing mechanisms has practically been the same for years, that means, the production (a cherry variety) is sold to the marketers and only few producers carry out the roasting and the final sale of the product.

Something that is well know is that in the last two years more than 50% of its production has been lost as consequence to the Roya plague, which kills the coffee plant. There was reported that the Ejido produced more than 1000 tons per year, for which it works throughout the year in order to keep the plantations free of pests such as the coffee fly, which is currently controlled. The working days made mainly by men begin at 6 am and end between five or six in the afternoon. At harvest time, the producers hire indigenous collectors from nearby communities who are paid an average of $ 3 pesos per kilogram of cherry coffee collected. The above means that this activity hold up not only the local community, but also helps communities near Mesillas.

2.6 Project Enforcement

The IDEA Methodology was developed and applied by the iiDEA Group at UNAM Engineering Institute for the development of technological innovation projects, which implies a process of solving engineering problems. It is raised under four main axes: **I**dentify, **D**evelop, **E**valuate and **A**dvance.

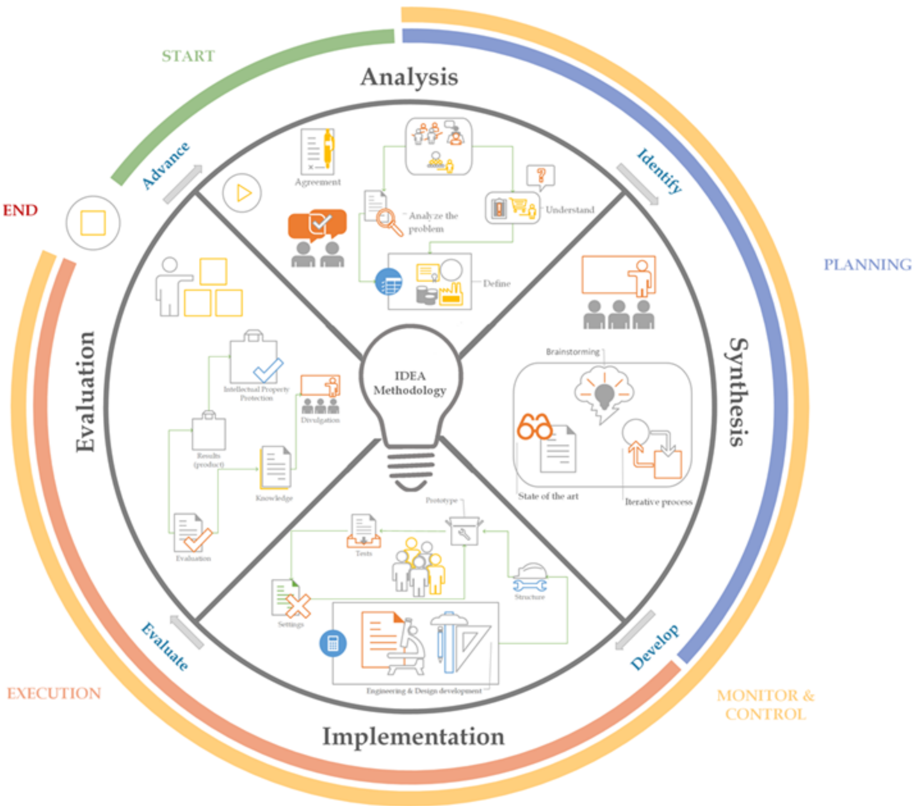

Figure 4: IDEA Methodology.

[1] Land legally shared between neighboring members of a town where cattle usually gather or grow crops.

The methodology has been adapted from experience. It seeks to solve innovation problems by systematically sequencing the process in order to improve management during the development of technological innovation projects. The methodology is grouped into: analysis, synthesis, execution and evaluation.

Analysis

It is the initial stage of the project; it begins with the approach meetings that will result in a project development letter or participation agreement between entities. These meetings seek to understand the problem (question the project per se), know the company (its origin and vision) and the customer (user needs).

Likewise, it is possible to define special concepts of the project. Among the main ones highlight budget, scope, targets, management, agreements, and human resources, among others. And all those ones which emanate in the development of project planning in their different areas of knowledge

Synthesis

The synthesis of the project means to move from the abstract to the real, the state of the art of the project begin, which leads to a brainstorming and proposal development. An Iterative & Incremental development leads to the evolutionary guidelines of technology, until all the technical and physical contradictions that lead to inventive activity are solved and thus reach to the solid solution.

Execution

Is in this stage when begins the execution, monitoring and control of the project. Once the synthesis of the project is obtained, starts the creation of the documents of engineering (basic and to detail). Simulations, experiments and spreadsheets are made in order to validate the idea and continue its development. From this, diagrams and plans are created to specify the product information to manufacture.

The construction of the prototype begins where the tests are carried out and the hypotheses are validated. The necessary adjustments are made until the complete system is put into operation.

Evaluation

In the evaluation, all project information is integrated into reports and manuals. From this, derive knowledge, a product, and the dissemination of it. Intellectual protection is carried out and technology is transferred through the business scheme that has been selected. At this stage, the final product is obtained, and the monitoring and control of the project is concluded.

3. WHAT TO EXPECT FROM THE USE OF THIS METHODOLOGY?

The main reason for this methodology is to change the way of gaze and develop geothermal projects, leaving as the main axis a DU project, and if possible, power generating through distributed generation (small scale); at best, to have a Geothermal Resource Center. This is because the costs and risks involved in the development of a Direct Use project are lower, with faster return rates and greater job creation (Jennejohn, 2010; CANGEA, 2014; RESOURCE PARK, 2014, Franke & Nakagawa, 2017).

The development of geothermal projects, mainly generation plants, have important implications in relation to the high initial investment cost. Which makes it difficult to obtain loans or other options of financing. This is due to the high risk involved during geothermal exploration. Which derives from the fact of the confirmation of the location of resources; the high costs of drilling and the uncertainty involved before the profitability of the project can be determined (IRENA, 2017)resources; the high costs of drilling and the uncertainty involved before the profitability of the project can be determined (IRENA, 2017)

(Witter, et al., 2019) talks about the risk and uncertainty of geothermal exploration. Both are different: risk is associated with the probability of success, while uncertainty is the inability to define something exactly. All geothermal projects have both risk and uncertainty. A measure to mitigate uncertainty is the availability of more exploration data, as well as geological parameters with a greater influence on geothermal production, which is necessarily reflected in a higher cost in the exploration stage. Uncertainty is present in the exploration of geo-sciences (geology, geochemistry and geophysics).

The current average cost of the well on land is described as a power function of its measured depth, the completion costs of oil and gas wells increased by more than 250% between 2003 and 2008, followed by a modest 15% drop in 2009. Compared to oil and gas drilling in the same period. In addition to assessing the current cost of drilling geothermal wells, this study provided a cost database of 146 geothermal wells that can improve the accuracy of future correlations of drilling costs (Lukawski, et al., 2014).

If the construction of the Geothermal Resource Center is taken into account as proposed: a food dehydrator, coffee dryer, aquaculture (with shrimp) and balneology. It will cost approximately $4 million pesos per coffee dehydrator and a dryer unit to process 6 to 12 tons of product per month (depending on the product). The investment for the construction of ponds and heating equipment for aquaculture of river shrimp is approximately $ 10 million, in that sense for this economic evaluation the production of 118 kg of product every 6 months was considered with a sale price of $ 120 / kg according to research by Arzola & Maya, 2012. And it is considered the construction of a hot springs spa, using as a guide the work of Escobedo, 2001, for the installation and construction. And the market study for balneology of the iiDEA group, with these data it is possible to have an idea of how it would impact this use in the construction of a geo-thermoelectric plant, then the elements that would make up a spa with 500 visitors per month with an approximate range of $ 4 to 7 million pesos are listed. Which gives an approximate total cost of 25 million pesos.

The construction of a 25 MWe geothermal power plant in the state of Michoacán is considered, costs have been calculated based on the study of costs and benchmarks for the formulation of investment projects in the electricity sector (COPAR GENERATION 2015)

(CFE , 2015), and the work of ICEIDA (VERKIS, 2014) are about $ 100.000.000,00 pesos. If the typical uncertainty and expense profiles are complemented for a geothermal power project (IRENA, 2017) with respect to an equivalent of DU, it is observed that the risk remains at all time below that of power generation. In addition, the costs of the DUs are kept 4 times below that of geothermal plants Figure 5.

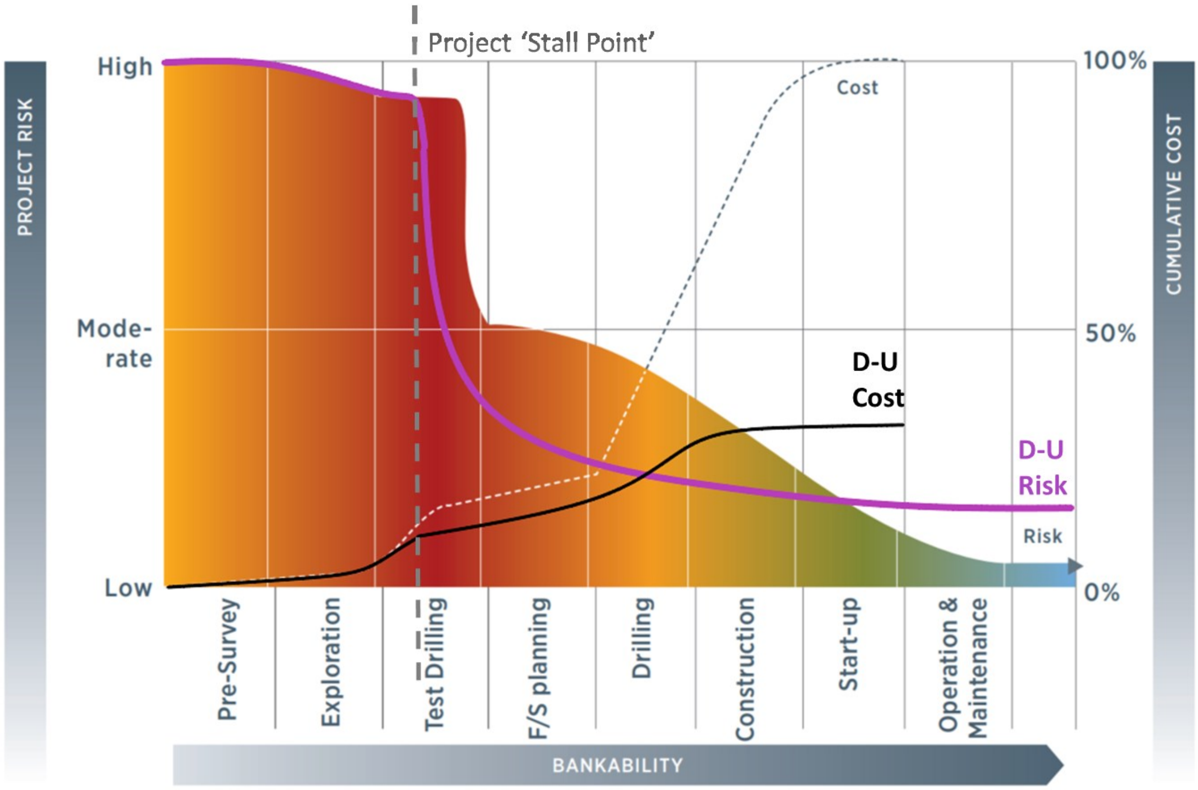

Figure 5: Risk and Costs of Direct Use (DU) and Power Generation (PG) projects (IRENA, 2017).

4. SOCIAL, ENVIRONMENTAL AND ECONOMIC IMPACT

When geothermal heat is harnessed through the appropriate application of technology, a sustainable alternative is created to reduce the deterioration of the environment and the fight against poverty of communities that have geothermal potential within their heritage, but due the lack of access to timely information on energy use, this is completely ignored Figure 6. The knowledge for the development of the potential of this resource allows nearby communities for their exploitation, which is less invasive in the landscape compared to oil projects, providing the opportunity to be managed and achieved by the tenants themselves. This management becomes directly in the economic empowerment of the localities that in many occasions are in a situation of poverty, marginalization and job insecurity.

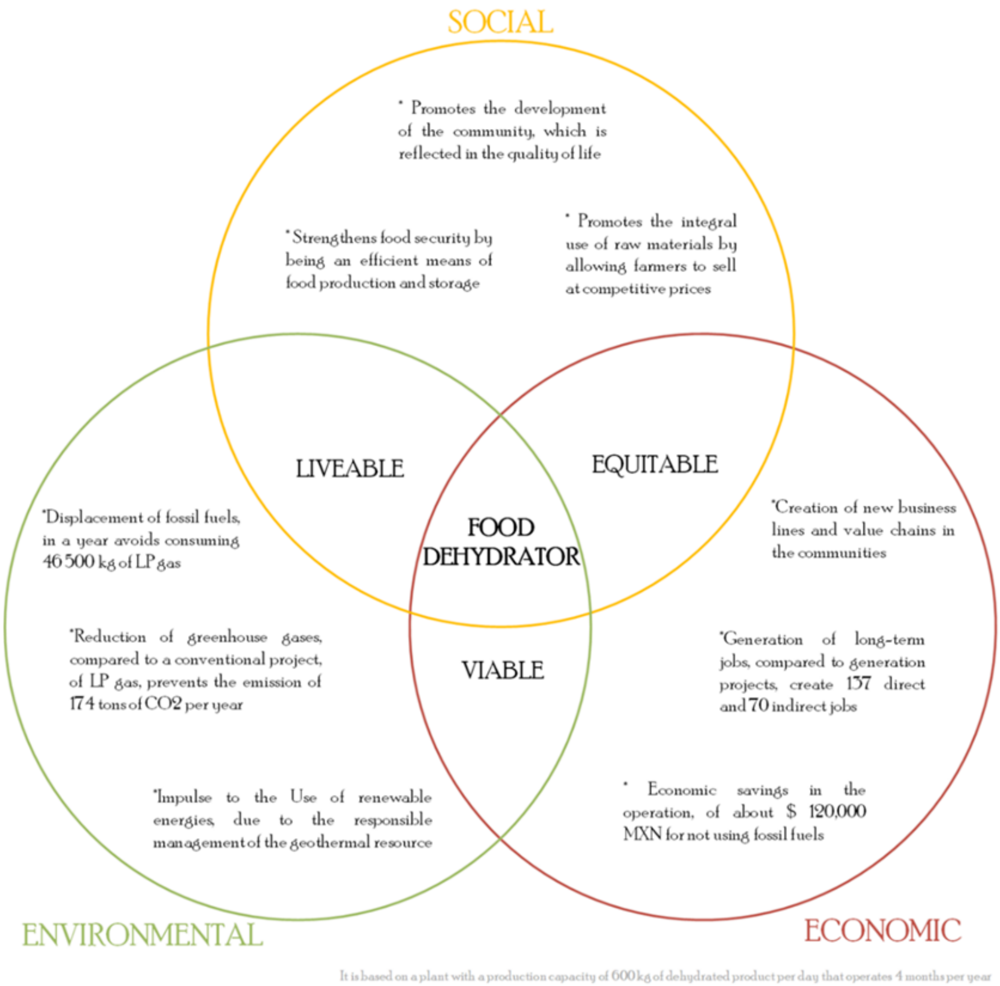

Figure 6: Direct uses of geothermal energy, sustainable projects.

The development of a project such as the Geothermal Food Dehydrator (GFD) would essentially influence the following aspects:

a. Since ancient times and to current date, drying of medicinal plants, grains and meats has been a common conservation practice to ensure the availability of food and medicinal products throughout the year. Today the dehydration of vegetables and meat not only has a purpose for self-supply, but also offers a productive and commercial alternative for the national and international market.

b. Food dehydration responds to the need to guarantee access to food security that is constituted as part of human rights, which are essential to improve people's quality of life.

c. During the stages of exploration, construction, installation and operation of the GFD, the main human resources are supplied by the region inhabitants, thus offering new and better job opportunities.

d. It allows small producers to obtain better competitive conditions for their products in terms of supply and demand in the market.

e. The approach of this technology and its ecological implications entails an implicit awareness of climate change as well as the conservation and preservation of the environment, resulting in a cognitive exercise that when it is reinforced with environmental education strategies will allow new generations to get involved and so reproduce the best practices of interaction with their environment.

It is important to highlight the impact of DU projects, by giving a leading role to communities as stakeholders of change in climate change mitigation; by creating opportunities for technological innovation that can be linked to research and scientific development from a local level. In fact, this creates the needs to carry out joint work between the main stakeholders and those affected by the promotion of this work, since the government has the faculty to create the necessary conditions so that all this effort has favorable and successful results.

However, it is important to take in considerationthe factors that can have a negative influence on social acceptance, such as: disclosure of erroneous or limited information to the community; smear or unfavorable campaigns by local and/or state media. A disturbing attitude towards the use and protection of water or the seismic activity inherent in the site, low levels of audience by the community in the processes of consultation and development of the project; as well as adverse effects on natural emanations such as hot springs, geysers, etc. (Vargas Payera, 2018)

The implementation of DU projects represents an immediate energy saving by stopping the use of fossil fuels and the reduction of greenhouse gases (GHG). In Mexico, goals for the year 2030 have been established through the Technological Route Map (TRM) for DU of Geothermal Heat (SENER, 2018), which proposes to achieve an installed capacity as follows: 400 MWth of GSHP, 1.000 MWth of applications with fluid and 2.400 MWth of applications in cascade. Therefore, there is 3.800 MWth in projected installed capacity of DU projects by 2030. This energy would represent 107.222 TJ/year, if an efficiency factor of 0.7 is taken (Lund, 2015; SENER, 2018); however, in the use of technologies, there would be annual savings of 3.003.429,00 tons of natural gas, in case of using fuel oil it would be 3.604.114,00 tons or 4.641.662,00 tons in the case of the use of coal (CFE, 2015). To calculate the main emissions that would cease to be emitted into the atmosphere by 2030 (carbon dioxide, sulfur oxides and nitrogen), data from COPAR 2015 and the latest global revision of geothermal DUs were used (Lund, 2015). From these data, it is obtained that, if the DU displaces the consumption of natural gas, 3.12 billion tons of CO2 and 624 billion tons of NOx would cease to be emitted. In the case of fuel oil, the decrease would be 13.3 billion tons of CO2, 1.9 billion NOx and 63.6 billion tons of SOx. Finally, if coal is replaced as a source of energy, a decrease of 15.4 billion tons of carbon dioxide, 2 billion tons of nitrogen oxides and 67 billion tons of sulfur oxides would be achieved.

In the economic framework, it is important to differentiate that the sources of employment that are generated through geothermal plants are mostly temporary, while in the case of DU projects, a greater number of jobs are generated. The most successful case is the Resource Park in Iceland, where there is a Geothermal Center that took advantage of an environmental problem to transform it into the biggest tourist attraction in which the company today is recognized as the largest generator of jobs (RESOURCE PARK, 2014). As can be seen in Figure 8 there are a large number of jobs at the construction stage of a geothermal power plant (Jennejohn, 2010), but once the operation is started the plant is maintained with a payroll of 60, while the Blue Lagoon water park operation is maintained with 700 employees.

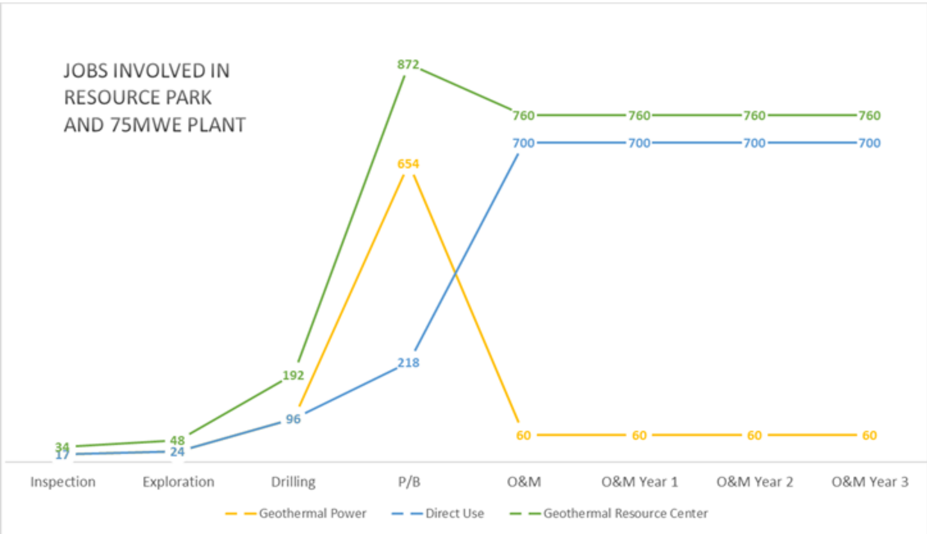

Figure 7: Jobs generated in Geothermal Power Plant, Direct Use and on both (RESOURCE PARK, 2014).

On the other hand, the Canadian Geothermal Energy Association (CanGEA) reported a cascade use where a 2 MWe plant was operated in conjunction with an onion dehydration plant of 8.200 tons per year of dehydrated product. In Figure 9 the development of both projects and the advantages of implementing DU and PG are compared.

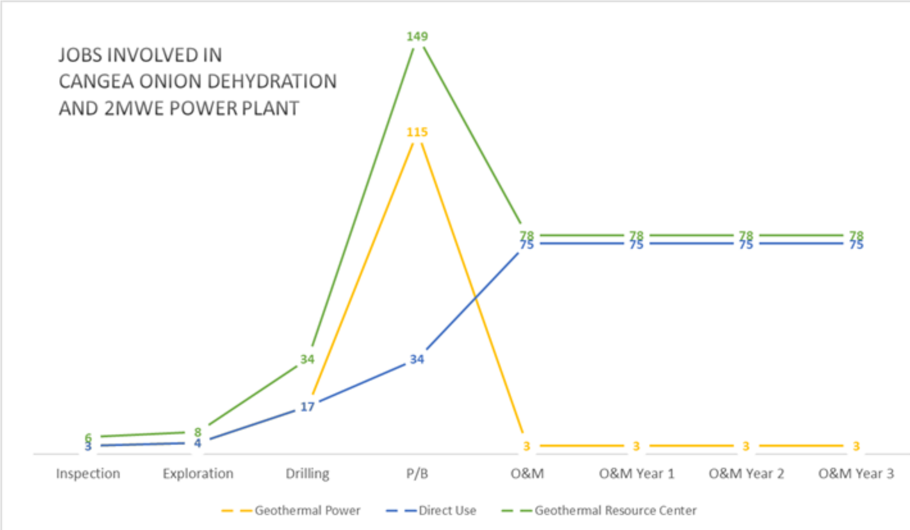

Figure 8: Jobs generated in Geothermal Power Plant, Direct Use and on the whole (CanGEA, 2014).

In summary, it can be confirmed that the developments of direct heat use projects meet the sustainability objectives: social, environmental and economic. With lifespan of 25 to 30 years, which generates confidence in the surrounding communities, reducing the emission of GHG and creating jobs that allow the surrounding population to appropriate the projects and at the same time protecting them from misinformation (Tsagarakis, 2019).

5. TECHNICAL, LEGAL AND POLITICAL SUPPORT

The assimilation and development of a technology that allows a greater use of geothermal energy in a holistically way. Is one of the barriers that has already been working and of which more progress has been made in some Latin American countries, in addition to the social acceptance, risk and cost of projects, geothermal regulation is one of the three biggest barriers to their successful development (Bona & Coviello, 2016; SENER, 2018; Yasukawa, et al., 2018). In Latin America, few countries have a specific regulatory framework for geothermal energy (Mexico, Peru and Chile), and these focus on exploitation exclusively for power generation. Leaving a large area of opportunity abandoned for the regulation of productive projects that only extract heat from the subsoil with minimal losses.

In Mexico, there is the Regulation of the Geothermal Energy Law (RLEG), which describes the Direct Uses (DU) as follows:

"Those uses in which geothermal energy can be used other than the generation of electric energy, among which are, urban or greenhouse heating, canning, drying of agricultural or industrial products. Thawing, wool washing and dyes, refrigeration by absorption or by absorption with ammonia, extraction of chemical substances, distillation of fresh water, recovery of metals, evaporation of concentrated solutions, manufacture of paper pulp, among others, which must be indicated in the Concession title that at effect granted by the Secretariat."

In this context and in accordance with the provisions of article 3 of the Geothermal Energy Law (LEG) and its Regulations, the application and interpretation of both instruments for administrative purposes corresponds to the Secretariat of Energy (SENER), to whom it is responsible issue general provisions.

Based on this regulatory framework, the first geothermal exploration permit was granted exclusively for the development of a DU project. The Mesillas permit was granted on May 28, 2018 through an official letter DGEL/211/412/2018, marking a before and after for geothermal energy in Mexico because it opened the opportunity for interested companies seeking to take advantage of medium and low resources enthalpy for DU projects of subsoil heat.

Currently, there is an operational installed capacity of 936.2 MWe, distributed in its five geothermal electric fields throughout the Mexican territory (SENER, 2018), contrary to the installed capacity of DU. Taking into consideration the available applications of space conditioning, water desalination, agribusiness, tourism, among others; that could use the energy remnants (steam and water phase) of the geothermal fields currently in operation (Cerro Prieto, Los Azufres, Las Tres Vírgenes, Cerritos Coloraditos and Domo de San Pedro), would have a heat capacity of approximately 13.461 MWth.

There is evidence that in México the priority has been given to the development of projects for large-scale power generation, leaving behind the development of the DU of geothermal heat. Nevertheless, the Federal Electricity Commission (CFE) has made efforts to use residual heat into a small heating project at its facilities in the geothermal field of Los Azufres, Michoacán. Similarly, in the 90's CFE made several prototypes for wood drying, food dehydration and mushroom farming; which currently no longer operate.

Overall, it can be said that in Mexico this resource is used only for balneology and recreational uses which do not need any technological development for its use, having to the date an installed capacity of just 155,30 MWth (Gutiérrez-Negrín, et al., 2015).

In order to strengthen the scientific and technological capacities of the country, in 2014 the Mexican Center for Innovation in Geothermal Energy (CeMIEGeo) was launched, consisting of a group of institutions and companies focused on geothermal energy. The CeMIEGeo is currently in charge of six research projects related to geothermal DU and which are expected to add to the integral use of the country's geothermal resources.

6. CONCLUSIONS

The fact of jointly carrying out power generation projects and direct uses of geothermal energy significantly reduces the technical and economic risk, increasing social acceptance, and considering electricity generation as one of the multiple products resulting from the integral use of geothermal resources.

By taking full advantage of geothermal resources, a positive impact is achieved in different areas, but above all arouses a social interest in geothermal projects, resulting in greater integration by local people with their geothermal resources.

The realization of geothermal power generation projects that focus on direct applications of ground heat and that seek an integral use of geothermal energy through its cascade uses, will guarantee a lower project risk and cost; adding a greater generation of jobs and confidence that will result in the empowerment of the surrounding communities.

It is necessary to replicate this methodology in different Latin American countries to refine and improve the details of the social integration of the projects, as well as the pertinent studies in environmental matters and the definition of the commercialization of the projects to obtain profits.

To give legal certainty to investors, it is necessary to understand the different frameworks that regulate the natural resources of Latin American countries, to determine from the beginning the certainty of the projects and their feasibility.

7. REFERENCES

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