RENEWABLE ENERGIES AND SUSTAINABLEDEVELOPMENT IN RURAL AREAS OF COLOMBIA.

THE CASE OF LOS ALTOSIN TOLÚ VIEJO - SUCRE.

Summary

The energy balance of the Los Altos de Tolu Viejo, Colombia, is presented and the renewable energy potential is estimated. It is shown that only a rigorous approach to sustainability guarantees an impact on the economic development of the community, taking into account the sustainability criteria required by the Clean Development Mechanism. An energy model was developed to calculate the demand for irrigation, according to climatic, orographic and crop variables.

Key words: *sustainable development, renewable energies, CDM, LULUCF.*

Abstract

The paper shows the energy balance including the assessment of renewable energy potential, of the rural settlement of Los Altos in Colombia. It is shown that only a rigorous approach of sustainability guarantees a real impact in the economic development of the community, taking into account

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INTRODUCTION

Two facts are currently highlighting the interest of energy in rural development. The first is the international boom in renewable energy technologies, based on biomass, biogas, solar and wind energy, in addition to small hydroelectric plants. These are true alternatives for isolated rural areas, given the economic unfeasibility of providing energy services through interconnection networks and because of the natural potential of renewable energies in these areas, represented by solar brightness, wind and permanent waterfalls and by the wild production of biomass. The size and autonomy of these systems pose challenges both to the design of optimal institutions in imperfect contexts for the administration and sustainability of the solutions, as well as to the discrimination of priorities in demand to meet the activities of greatest benefit, and to the achievement of greenhouse gas (GHG) emissions mitigation targets, where applicable.

A second fact is the opportunities derived from the Clean Development Mechanism (CDM) for the mitigation of GHG emissions, and from the policies on land use, land use change and forestry (LULUCF), which demand from the receiving governments the design of policies for their use, as well as the establishment of goals, strategies, plans, institutions and procedures for their realization. Colombia's National Energy Plan (PEN) 2003-2020 recognizes renewable energies as an alternative for *isolated* (rural) areas and determines that

> "The identification of the energy solution must be made with a basket that primarily takes into account the participation of local sources and considers the potential demands derived

> from agro-industrial development projects. Once the energy solution has been identified and selected, it is necessary to guarantee the recovery of the investment (total or partial, after the subsidies or contributions estimated as necessary), and the totality of the operation and maintenance scheme..., through the generation of productive surpluses" (UPME, 2003 p. 172). (UPME, 2003 p. 172).

The plan considers that

> "to cover the initial investment costs, specialized financial mechanisms should be designed... and take advantage of resources derived from environmental promotion mechanisms, such as the Clean Development Mechanism" (p. 173).

Although the PEN advances in a procedure for the adaptation of renewable energy technologies in rural areas, it is necessary to point out its limitations in order to adequately recognize the problem of energy in rural areas, both in its uses and in its relationship with sustainable development (SD). There, the first use of energy is for cooking food and providing shelter (FAO, 1983), followed by its use as a production input and then as an input for the consumption of other goods and services -lighting, appliances, etc.-. By disregarding this hierarchy of preferences, the use of fuelwood in rural communities goes unnoticed. Perhaps it happens that fuelwood consumption is associated with deforestation, which immediately leaves it to environmental managers, outside the scope of energy policies. However, the problem of unsustainable exploitation of wild fuelwood production is a consequence of the lack of attention to energy policies. This is due to the inadequacy of the current institutional design. Nevertheless, it is worth noting that the PEN rightly prioritizes the use of energy as a production input over its use as a service, although the plan is not structured on a consistent definition of SD.

This article presents the results of a research aimed at exploring the renewable energy potential of a depressed rural area - the Los Altos hamlet in the municipality of Tolú Viejo, Sucre - and seeks to contribute concrete elements to the discussion of rural development policies that appropriately take into account renewable energies and global policies for the mitigation of GHG emissions. In line with the PEN guidelines, we proceed with the *identification of the energy solution to be made*, evaluate *the potential demands derived from development projects*, and calculate the potential of Los Altos to take advantage of the *resources derived from the CDM, to cover the initial investment costs.*

The study was based on different sources: socioeconomic information on Los Altos was obtained from public documents of the municipality and from a census carried out by the author. The latter aimed at assessing energy supply and demand. Physiographic information was obtained from IDEAM[2] , as well as from resources available on the internet. Biogas potential was obtained from a sampling of weekly waste production in the municipality, carried out by the author, as well as from another study carried out by CORPOBOYACÁ[3] in the same area. Demographic data from DANE[4] (1996) of neighboring municipalities allowed the extrapolation of the results to the waste production of other municipalities.

1 IDEAM: Institute of Hydrology, Meteorology and Environmental Studies.

2 CORPOBOYACÁ: Sucre Regional Autonomous Corporation.

3 DANE: National Administrative Department of Statistics.

1. CHARACTERISTICS OF LOS ALTOS

Los Altos, located in the municipality of Tolu Viejo, is made up of 35 families dedicated to agriculture on 1,248.7 ha. Since colonial times, desertification has been an outstanding physiographic feature, favored by the fragility of the landscape and caused by intensive land use (BANREP, 2002). Los Altos borders the urban area of Sincelejo. Together with La Palmira, they are considered the municipality's poorest hamlets. The hamlet is the junction of two small runoff basins, which initially flow into the Merida gully, and in the vicinity of the urban center into the Pechelin River. The rainfall regime is very scarce. The zone's evapotranspiration index is between 0.66 and 0.75 (SUR ORG, 2002, p. 33), which classifies it as desert. There are two annual rainy periods. The prosperous households are located in the valley, while the poorest are located in the upper part. This prosperity is supported by the permanent availability of water.

The village has characteristics of an open agrarian economy (LIPTON, 1968). Here, peasant income from agricultural production is governed by variations in climate and market prices. Because both are exogenous risk factors and because of the absence of insurance markets, farmers avoid them by using conservative production techniques -sow little to lose little-, growing resistant and sometimes unmarketable species, raising resistant animals, generally for internal consumption, and rejecting new technologies. As an open economy, it is characterized by a lack of incentives. Consequently, the resources needed for the new crop depend on savings from the previous harvest (PERRINGS, 1997) and possibly informal moneylenders. Low levels of savings maintain low production; but eventual good results due to favorable weather conditions may cause sharp drops in the following production, due to resource depletion caused by intensive exploitation (LACROIX, 1985) or as a result of good harvests that lead to a crisis due to low market prices. Subject to the uncertainty of environmental and price variations, these communities remain in a permanent state of stagnation, with high levels of malnutrition (FEI and RANIS, 1978; LACDE, 1990) and low academic performance of infants[5] In addition, there are high rates of reproduction (3.9%) and emigration (3.4%), with a predominance of firewood as a source of energy. In the case of Los Altos, the determining factor for stagnation is water scarcity. Those who have a permanent supply have managed to increase their level of wellbeing; those who depend exclusively on the rainfall regime, work on their own crops when it rains, and are employed as day laborers during the drought. The daily wage is 8,000 pesos, or about US$2.7 per day, and in

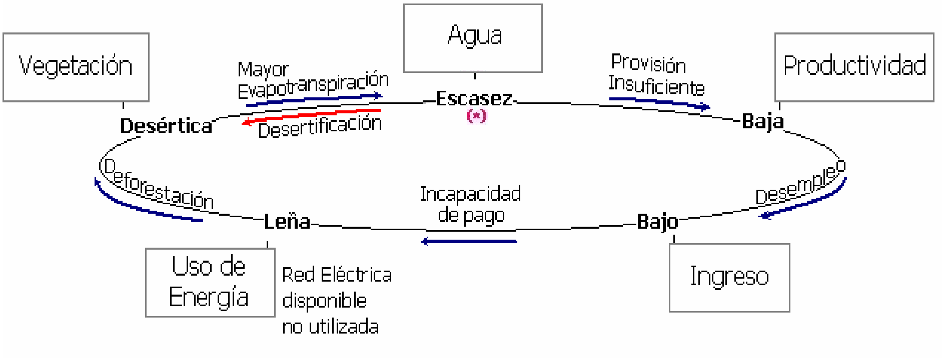
4 According to the comments of the teacher at the rural school.

The average monthly income is about 120,000 pesos, barely 45% of the legal minimum wage6 . In addition, Los Altos supports the municipal garbage dump, with negative impacts such as bad odors and the proliferation of mosquitoes that prey mainly on children. It is also a source of methane emissions, a gas that contributes to global warming.

Under current conditions, the economic and environmental system of Los Altos has two possible trajectories. In the first, if firewood consumption is not balanced, deforestation will be accentuated with an increase in the rate of evapotranspiration and the consequent reduction of the liquid retention capacity, which reduces the water supply and reinforces the deterioration of the vegetation cover. This trajectory would lead to resource degradation and the collapse of economic activity. Nevertheless, and according to what has been detected, firewood consumption is in equilibrium and the system in Los Altos reproduces itself in a stable cycle that keeps farmers in a permanent state of stagnation, with the only hope of "*more of the same*" - in the words of FEI and RANIS (1978). However, the current consumption of firewood does not reach the minimum levels for cooking food (FAO, 1983). This cycle can be seen as a starting point for water scarcity, which produces unemployment and low income as immediate consequences. The low ability to pay prevents farmers from using the currently installed electricity network, so the basic source of energy is firewood. According to historical records (BANREP 2002), the crisis that gave rise to this new state of equilibrium was caused by the intensive exploitation of the land, originating in the 16th century and accentuated in the 18th century, exercised by encomenderos, the church and the corregidor representing the king, who imposed crop quotas on the indigenous people. The cycle is depicted in Figure 1.

Almost two centuries after the end of the colony, the cycle is reproduced and the communities maintain the levels of poverty to which the indigenous people were driven. The model of open agrarian economy is representative in that conservative agricultural practices maintain the balance of the resource and economic activity. The future of the current state depends on the balance between the natural regeneration of the forest and the intensity of deforestation. However, soil productivity is threatened by the negative effects of the use of intensive production technologies, fertilizers and pesticides, and it is not expected that the usual yields will be preserved in the medium term (RUTTAN, 1991, 1999; BEJARANO, 1998; PIERCE, 1993; PEZZEY, 1992).

Figure 1. Stagnation cycle of the open agricultural economy of Los Altos.



Source: author.

1.1. Energy in sustainable development

The above characterization induces the central discussion of this article: the implications of the relationship between energy and SD in the design of rural development policies. In Los Altos, energy should be supplied to boost economic activity via crop irrigation and reforestation, which include but exceed *agro-industrial* projects or for the use of services associated with consumption, within a stricter conception of SD.

According to the PEN, the idea is to leverage CDM funds for economic development in rural areas, via agro-industrial projects. Here it is argued that the PEN guidelines do not properly guide CDM options, due to a lack of understanding of the biunivocal nature of energy and SD. The Los Altos case shows that support for economic development should be through the recovery of the environment and not at its expense. This is the true spirit of global SD policies, as expressed in the CDM and LULUCF policies. On the biunivocal nature of energy and SD, it is worth citing other cases. Energy use is at the heart of the problems of global warming, mostly caused by the use of fossil fuels. Renewable energy technologies are a response to the threat to the sustainability of the planetary community and GHG emission mitigation policies, based on these renewable energy technologies, are the contribution of the global community to address these problems.

The question for recipient governments is, why should local plans overlook this indissoluble relationship between energy and SD, and consider renewables only for their comparative advantages over interconnectivity and the economic opportunities of the CDM? A poor understanding of the significance of renewable energy and global policies for mitigating GHG emissions limits the benefits of these policies to short-range objectives, only rhetorically linked to SD.

The study goes into the evaluation of energy consumption in Los Altos and the projection of demand. It is shown that in order to place energy where it is most appreciated, it should be dedicated to the supply of power for pumping water for both agricultural irrigation and forestry, in the provision of the minimum consumption of firewood. Subsequently, the renewable energy potential is evaluated, the balance between renewable energy supply and demand is made, the potential for CDM is calculated and at the end the policy discussion is taken up again.

2. ENERGY DEMAND

According to the World Energy Council (WEC, 1999, p. 35) "*it has been shown that lack of energy correlates very closely with many indicators of poverty*". Los Altos is no exception: although the 35 households in the hamlet have electricity interconnection, the final installation has not been done or the service is not used, due to low income. Only 7 families use electricity. Paradoxically, along with the inability to use energy as a service, most of the budget is dedicated to the provision of power for pumping water for irrigation and human consumption. This evidences for the rural sector two basic roles of energy: as a service and as an input for agriculture. This clearly shows that the use of energy as a service is a consequence of increased income, and that the provision of renewable energy should be allocated where it is best appreciated: as an input to economic activity: in Los Alto, as power for pumping water for irrigation.

Current energy demand is presented from several perspectives: Table 1 shows demand by economic activity, as proposed by WEC (2003). Table 2 presents the actual demand by fuel and by service. Finally, Table 3 gives the demand as a percentage of the energy budget, by fuel and service. In all cases the information was obtained by the author.

Table 1 shows the agricultural character of the Los Altos economy, with no commercial or industrial activities. Domestic and agricultural activities govern energy consumption. In Table 2, commercial fuels (electricity, gasoline, and propane) account for only 26.9% and are consumed mainly for pumping water for irrigation and for the local aqueduct.

Table 1
Energy demand by economic activity in Los Altos

	Domestic	*Agriculture and aqueduct*	*Industry*	*Other (Water pumping) trade)*
	%	*%*	*%*	*%*

Commercial	4,	315, 3	20,	07	,
Traditional	73,	10,	00,00,	0	

Source: author.

Table 2
Energy demand for fuel and service in Los Altos

Fuel				*Service*		
Electricity	Gasoline	Propane	Wood	Lighting	Appliances Water (irrigation and electric cookingwater supply food	)
	%%%%				%%%%	
8,7616	,891	,	273,14	0,29	1,1822 ,	5376

Source: author.

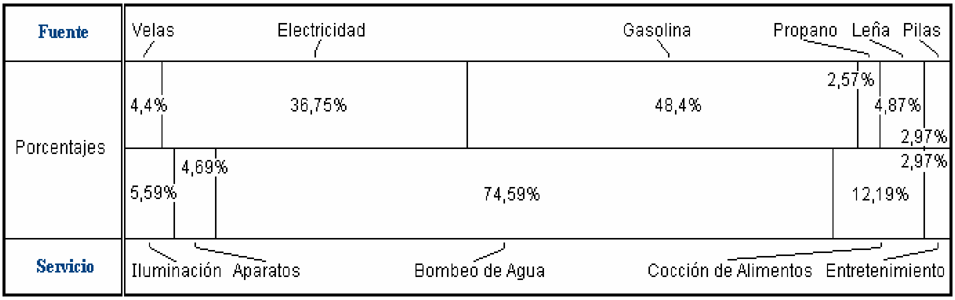
Firewood is the main source of energy, used for cooking food. As additional data to Table 2, three families buy firewood, due to the lack of this resource in their surroundings. 94.3% of the households use a three-stone stove, 8.6% use a gasoline stove and 17.14% use propane. Only one family owns a brick stove. These uses are not exclusive. Electrical energy services (iron, radio, etc.) account for only 1.57% of consumption. The rest of the electricity is used for pumping water from the local aqueduct. Peak electricity consumption does not reach 2.5 kWh and average daily consumption is just over 13 kWh.

The analysis of the energy budget in Table 3 shows the difference between energy as a service and energy as an input for economic activity. It stands out that 74.59% of total energy expenditure is dedicated to pumping water. Cooking food, the most basic service, accounts for 12.2% of the expenditure. Gasoline is used to pump water for irrigation of plots of land, water from runoff reservoirs or small springs.

Table 3 shows the importance of water in the economy of Los Altos. The low income and scarcity of the liquid, while limiting the budget for fuel, forces farmers to spend most of the budget on water.

in the supply of the resource. The heterogeneity of resource distribution appears as an imperfection of the energy market. The limited possibility of saving prevents the effective solution of the problem. Energy appears as a determining factor in the possibilities of improvement.

Table 3
Percentage of the budget by energy source and service, in Los Altos



Source: author.

2.1. Demand for firewood

The study shows that families with the highest level of welfare, and who use commercial sources of energy, are also those who consume the most firewood. This is evidence, as it happens in other parts of the world, that the increase in welfare produces an increase in the demand for biomass. This is explained by the deficit between the basic needs for firewood and current consumption. The objective of a sustainable policy for rural areas cannot be the reduction of fuelwood consumption at the expense of commercial energies, but an adequate supply of biomass. There may be a change in the pattern, with increases in the consumption of commercial fuels, due to increased income, which would probably accompany an increase in fuelwood consumption.

The assessment aims to confront the current fuelwood consumption with the standards for an adequate supply. According to MONTALEMBERT AND CLEMENT (FAO 1983), for Latin America, biomass energy needs in areas above 1800 m are between 18 and 23 Giga Joules (*GJ*) per person per year[7] . In Los Altos, 76.3% of the people consume less than the amount suggested by FAO. Only 5.2% are in the range of 18-23 *GJ/year*, and 18.5% are above.

Considering the 76.3% below range, the additional supply required is between 1,054.55 and 1,569.55 *GJ/year*. These represent 1.52 and 1.78 times the current consumption. At present, the biomass consumed for cooking reaches 40.55 *tons/year*. To cover the current need, between 61.79 and 72.164 tons/year would be necessary.

3. DEMAND PROJECTION

3.1. Energy for irrigation and reforestation

The energy demanded for irrigation and forestation is equal to the work needed to bring water to each of the 35 houses in Los Altos from one or more permanent sources. The inhabitants of Los Altos have dug some subway wells, but they claim that the iron content is very high. The most reliable source of water is the Tolu Viejo River. Historical records obtained from IDEAM show that although the river's flow is not abundant, it is sufficient to sustain agricultural production for the entire village. When processing the IDEAM data, it is found that in 99% of the cases there is some flow, although only 67% of the time it is greater than 1 *m3/sec*. To know the energy, the height of each house and the load of water to be transported are required. The equation to calculate is: where g is gravity, m_i is the total mass of water to be distributed to each house, and h_i is the height of each house with respect to the river level. The height of each house was obtained with the help of a global positioning system.

The volume of water required for irrigation and reforestation depends on the type of crop, soil characteristics and local precipitation, variables contained in the evapotranspiration index. It also depends on the area to be irrigated. The author developed an analytical model for calculating the energy demanded in equation 1, based on the theory developed by FAO (1988, 1997, 2002) based on evapotranspiration, the indices of each crop, precipitation and soil retention capacity[8].

The application of Equation 4 in Appendix 1, with K_c = 1.4 resulted in current consumption and projected water demand:

Table 4
Current and projected water consumption and demand for irrigation and forestry in Los Altos

Current demand for water for cultivation	***for cultivation of 2 has/house***	***for reforestation of 3 has/home***	***for reforestation***
1,222,666.7 (m^3 /year)	1,458,333.3 (m^3 /year)	1,960,000.0 (m^3 /year)	1,458,333.3 (m^3 /2 has/ house/year)

Source: author.

Application of Equation 12 in Appendix 1, including additional efficiency factors, gives the energy requirements:

Table 5
Energy needs for irrigation and reforestation in Los Altos.

Energy	**GJ/year**	**KWh/day**
Current energy demand for cultivation	*961,4*	*731,7*
Energy for 2 has/house	*1136,1*	*864,6*
Energy for 3 has/house	*1704,1*	*1296,9*
Energy for reforestation	*1267.9 (m^3 /2 ha/house/year)*	*964,9*
With 0.35 water pumping efficiency		
Current energy demand for cultivation	*2746,9*	*2090,5*
Energy for 2 has/house	*3245,9*	*2470,2*
Energy for 3 has/house	*4868,8*	*3705,3*
Energy for Reforestation	*3622.6 (m^3 /2 ha/house/year)*	*2756,9*

Source: author.

An average size of 2 ha per plot has been estimated, with growth up to 3 ha. For reforestation, a maximum area of 2 ha per house has been calculated. Due to height differences, the energy demand is not proportional to the average plot size. Adding the water demands for reforestation and cultivation, in the case of maximum demand, a flow of 4 m3/min from the Pechelin river of Tolu Viejo would be required, which is covered with certainty in 99% of the cases.

3.2. Firewood

With respect to deforestation, there are no previous studies to verify whether the current consumption has been deteriorating the production of wild firewood in the area.

Los Altos. However, it is possible to know the production required to ensure the minimum supply, based on projected population growth.

Table 6
Prospectus for biomass demand in Los Altos

Year	2002	2007	2012	2017	2022
Low range (18 GJ/person/year)	*73.2 (tons/year)*	*175,9*	*192,3*	*219,3*	*252,6*
High range (23 GJ/person/year)	*109.0 tons/year*	*224,7*	*245,8*	*280,2*	*371,3*

Source: author.

In estimating the biomass balance, it is necessary to know the density of fuelwood production per unit area. FAO has carried out a complete characterization of forests and plant resources in different regions of the planet, including Latin America (FAO, 1983)[9] . Considering the characteristics of the Los Altos landscape, the trail fits within the description of "scrubland "[10] formation. Considering the scarcity of water and the probable low specific weight of the local wood, 0.7 $^{g/cm3}$ (700 $^{kg/m3}$) has been taken from the suggested range of densities (REHLING 2001) for calculation purposes. Therefore, the biomass production of areas similar to Los Altos could be estimated at 1.5*700 = 1050 kg/ha (see footnote). To produce one ton, 0.9524 ha are required. To produce the current 40.55 tons, 38.62 ha are required per year:

Table 7
Area required to meet biomass needs in Los Altos

Year	2002	2007	2012	2017	2022
Low range (18 GJ/person/year)	*70.1 ha*	*168,4*	*184,1*	*209,9*	*241,8*
High range (23 GJ/person/year)	*104.3 ha*	*215,1*	*235,2*	*268,2*	*355,4*

Source: author.

5 FAO 1983. "The different forest types have been analyzed and grouped according to the following classification: Closed broadleaved forests, Closed coniferous forests, Open forest formations, Savanna with trees, Matorral and Closed forest modified by agriculture and fallows.

6 "They are open forests studded with clearings, found in dry regions of Paraguay and eastern Bolivia, southern Brazil, certain parts of Venezuela, Colombia and central Mexico. They cover a total of 225 million ha, representing 16% of the total area of forest and shrub formations and 20% of the forest area. The average volume is about 80 m³ per hectare, with a production of firewood and charcoal wood of 1.5 m³ per hectare per year" (FAO, 1983).

Considering that the total area of Los Altos is 1248.7 ha, the required area is between 8.3% in 2002 and 28.42% in 2022. Even considering that the cleared areas are larger than in the typical FAO description, doubling the area, the total requirements would be between 16.6% (2002) and 56.8% (2022) of the total area. This allows us to affirm that at present, if there is a deterioration of wild biomass production, it is not due to fuelwood consumption. Moreover, the current natural production of firewood would allow sustaining the requirements of an adequate consumption.

However, the fact that the population of the village is unable to consume minimum levels of biomass reflects the extent to which economic conditions oppress the community in Los Altos. Farm household models (SINGH *et al*., 1986; HANNAN, 1993) have recognized that farm households allocate their resources, time and labor to maximize consumption. That families in Los Altos do not achieve a minimum consumption of firewood is explained by a deficient income caused by an imperfect labor market (STIGLITZ, 1989). That is, if there is the capacity to collect firewood, what prevents a normal minimum consumption is the impossibility of acquiring or growing food. Again, it is evident that the use of domestic energy services is basically a function of income, even if the energy sources are free of cost.

3.3. Demand analysis

Although Los Altos is a rural area and its economic activity reflects the situation of peasant economies, described above as an open agrarian economy, it cannot be classified as a non-interconnected area. There, the electricity grid reaches 35 families. Nor can the backwardness be attributed to the lack of communication infrastructure although for some families, access to a main transportation route takes 2 hours. Los Altos borders the urban case of Tolu Viejo. This has not prevented the peasant economy from behaving like any other isolated rural zone. Thus, it is the economic level of the inhabitants that determines their isolation and not their physical proximity to markets and infrastructure. This points out that the provision of energy services may be irrelevant to economic development if there is no minimum level of income to guarantee its use. It is the economy that impedes the effective demand for energy. Considering that the economic factor is the fundamental factor for the use of energy services, since electricity from the interconnected system is the cheapest, renewable energy-based solutions would be unsustainable in non-interconnected depressed areas. It is to be expected that these areas suffer from lower income levels and therefore the demand for energy services is even further out of reach. Thus, the problem is not one of physical distance, but of poverty. And in such a case, the objective of the policy of expanding energy coverage should be to support economic activity and in the worst case scenario consider the consumption of energy services as a result of improved conditions that must be addressed as a priority. In Los Altos, the energy demand for the extraction andlocation of a natural resource stands out. But in other areas, the requirements maybe different.

4. RENEWABLE ENERGY POTENTIAL

Los Altos has a good renewable energy potential. The only resource that could not be evaluated was wind, because the field study period was insignificant for a reliable estimate of its potential. Other factors are determinant: in flat landscapes it may be feasible to interpolate the results of nearby stations. IDEAM does not have anemometers even close to the site. However, as a rule, the wind potential requires an *on-site* evaluation, especially considering the local variability of the wind caused by orographic irregularity[11] . However, other potentials far compensate for this shortcoming. The main ones are biogas, biomass and solar energy. Los Altos has an outstanding biogas potential thanks to the presence of the garbage dump in the municipality of Tolu Viejo. Because of its current impact on the health of the inhabitants of the village, as well as its participation in GHG emissions, the study was oriented towards exploring the possibilities of biogas.

4.1. Solar energy potential[12]

The average sunshine is 135.3 hours/month. The minimum daily sunshine is 66/30=2.2 h/d. In 92% of the time, the available solar brightness is 4 hours/day. The power density (*KWh/m2*) was calculated with the software developed by GES13.

5. DISCUSSION

With the signing of the Kyoto Protocol, Colombia made commitments to climate change mitigation and adaptability objectives. These, however, are not all the facets of SD in a commodity-exporting, poor and agricultural country. As has been shown, the role of renewable energies within rural communities transcends the expansion of energy services, and is directly related to the promotion of SD based on poverty alleviation (MIDMORE *et al*., 2000, p. 175) and resource preservation.

However, it seems that the energy agencies in Colombia have focused their interest on the economic benefits of the CDM, without an explicit consideration of what is meant by SD. The main shortcoming of economistic approaches to SD is that they do not include the preservation of the interests of future generations as a calculation variable.

The emergence of CDM projects, such as the one studied here, in addition to the Ministry of Mines and the Ministry of Environment, requires the participation of the Ministry of Agriculture. The sometimes opposing interests of each entity require the coordination of policies, in which contradictory visions of the SD give rise to proposals such as "*this, but also that*", "*characterized by good intentions, politically attractive but unrealizable*" (BEJARANO, 1998), or irrelevant; or simply lead to the duplication of some for the benefit of others. This is the case of the Jepirachi wind farm, which represents an important support to the private sector, even when the benefits that its implementation will bring to the local SD do not seem clear.

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7 www.gbunet.de

8 Important aspects such as temporality and permanence of emissions capture, risk and the role of some parties such as Russia, whose specific weight in the supply of emissions capture would create a significant imbalance in the supply of emissions, are still under discussion. See for example (BODE, 2003; DUTSCHKE, 2003; MICHAELOWA, 2001; WONG, 2003).

The energy authorities' tenacity and the flexibility of the environmental authorities17.

The underlying problem is institutional: energy matters are the responsibility of the Ministry of Mines and Energy and the UPME, sustainable development is the responsibility of the Ministry of the Environment and NGOs, and peasant development is the responsibility of the Ministry of Agriculture. While for those in charge of energy, sustainability is understood as the preservation of the energy sector with laudable considerations on the environment, for the peasant sector sustainability refers to the sustainability of production, resources (BEJARANO, 1998; PEZZEY, 1992; PIERCE, 1993; RUTTAN, 1991, 1999) and its economy. The challenge for the authorities is to develop an operational concept of agricultural sustainability that reconciles the different visions and addresses the economic sectors involved, including farmers, among other objectives (BEJARANO, 1998). Therefore, in search of a synthesis that reconciles the diversity of objectives, a policy for the use of renewable energies in rural communities should address the promotion of agricultural activity in rural communities, the participation of these communities in projects on mitigation and adaptability to climate change, and the protection of resources.

In view of the expansion of coverage, the promotion of economic activity in non-interconnected areas, and the use of the benefits of global climate change policies, the main question remains unanswered: who is responsible for the integration of these aspects? According to BEJARANO (1998), it does not seem advisable to maintain the fragmentation of functions, as has been the case with agriculture. On the other hand, economists are aware that the institutional profile defines the policies that can be expected. This makes it necessary to consider, rather than the joint work of different state actors, an institution in charge of the problem as a whole. This can be considered at various levels, including the merger between agricultural and environmental entities. The challenge is not minor: it includes the formulation of policies that integrate the agricultural sustainability of the peasant sector with the care of natural resources and the mitigation and adaptability to climate change, the development of technical capacity in the assimilation and transfer of renewable energy technologies, as well as in emission reduction certification processes.

9 The Ministry of the Environment is in charge of the national office for climate change, whose mission is to manage SD projects that include the reduction of GHG emissions, within the guidelines of the United Nations Framework Convention on Climate Change (UNFCCC). Mitigation projects are managed through the CDM, while adaptability is related to emissions capture (COP 3, Morocco) and LULUCF projects.

6. CONCLUSIONS

1. The use of energy services in rural communities depends mainly on the level of income, and therefore the expansion of energy service coverage to non-interconnected areas should prioritize the promotion of local economic activity. It has been shown that even in interconnected areas, an increase in income is required to make the consumption of energy services effective. In rural areas, the externalities produced by past agricultural overexploitation translate into impacts on current production and give rise to an imperfection in the energy market.

2. A policy oriented to the expansion of energy in rural areas should note that the adoption of renewable energy solutions implies rigorous SD considerations, beyond the global benefits generated by the mitigation of GHG emissions and the economic attractions, due to the biunivocal nature of renewable energies and SD. Only a strict interpretation of SD, based on the inclusion of the interests of future generations, brings to rural communities certain opportunities for incentives from global policies for climate change mitigation and adaptability, through the Clean Development Mechanism and LULUCF projects. It is the duty of the authorities to explore these possibilities.

3. Deficiencies in the interpretation of the SD stem from the institutional fragmentation of the energy issue. Currently, the design of policies aimed at the best use of renewable energies in rural areas involves environmental, agricultural and energy authorities. Rather than joint collaboration, an institutional redesign seems to be required in addition to an integrated policy. The challenges include the agricultural sustainability of the agricultural sector, the promotion of potential initiatives that could benefit from global climate change policies, the development of capacity in technology transfer and in emission reduction certification processes.

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