

A PROPOSAL FOR THE USE OF AUTOCHTHONOUS ENERGY SOURCES

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Abstract: The execution of this project involves the utilization of autochthonous energy sources in order to obtain additional income to finance the works planned for the area under study. The renewable energy sources to be used are: wind, with the construction of 3 wind farms; and biomass, with the construction of a plant for biomass gasification. An agro-industrial complex will be built to recycle part of the calorific energy that is extracted from the gasification process.

Keywords: wind power, biomass gasification, calorific energy, grain dryer, dehydrator, distillation, greenhouses.

1. INTRODUCTION

This study is centred on a set of boroughs located in the province of Huesca (Spain) whose principal activity is agriculture. In this region, in spite of the limited water resources and the lack of suitable channelling systems, irrigation cereals are grown as horticultural crops that, due to their characteristics, demand big quantities of water throughout the year. All these factors have led to the construction of a reservoir with great storage capacity, to allow both for water regulation and supply to the crops grown on the area according to their needs.

The construction of this reservoir has a high economic cost for the users and requires a large amount of energy that the existing electric network is unable to provide.

For this reason, it was necessary to find solutions to supply electric power while generating revenue to finance the works of the reservoir and to modernize the irrigation system.

Since the amplification of the electrical network was not economically viable, the use of autochthonous energies with such purposes was taken into consideration. The first surveys were directed to the utilization of water to generate electric power, but several were the disadvantages that led us to rejecting this option.

The use of the wind resource was then studied owing to its high profitability in the short term, although it did not guarantee power adequacy. Therefore, we had to look for another type of renewable energy to guarantee that power adequacy. Observing the market of the renewable energies we saw that the energy from the biomass was ideal in combination with wind power and besides the quantity of biomass present in the zone would make it possible to develop this new activity.

2. UTILIZATION OF WIND ENERGY

As already said, the utilization of wind power offers high profitability in the short run, so the development of this activity will generate enough revenue to finance the works to be carried out in the area. Nevertheless, as we have also pointed out, eolic energy provides uncertain adequacy of electric power, because when there is no wind, we

do not obtain electric power. For this reason REESA (Spanish Electric Networks Ltd.) limits the capacity of evacuation of this type of energy to the network. At the moment, in the Comunidad Autónoma de Aragón, the region in which the area under study is found, the installation of new wind farms has been banned as the granted amount of power evacuation has run out.

In order to partially overcome this problem, the Government of Aragon, in its decree 93/1996, proposes the installation of small wind farms, with a maximum power of 5 MW in which R & D & i projects can be developed, the evacuation to the net of the generated energy being guaranteed in these cases. The factors taken into account for the study of the zone where the farms would be located are: proximity of the aerogenerators' possible situation to the community's consumption points; the existence of an Electrical Substation for Transformation, as well as the consultations made to the technical personnel of the Government of Aragon. As a result, the installation of three wind farms was advised.

To check the feasibility of installing these three wind farms for investigation, a measurement plan has also been carried out for the calculation of the eolic power potential of the zone. An annual energy production of 31.436 GWh, which approximately corresponds to 2,400 hours per aerogenerator, shows the profitability of the installation of these three low-power wind farms.

Therefore, after the favourable results obtained from the measurements, we began to speculate with the possible projects of wind power research that could be developed.

In the outline of these projects we have taken into account aspects related to the zone of study and, if possible, aimed at obtaining sufficient electric power, an objective that was achieved in our first wind farm. The purpose of this second project is to develop a system of regulation of electric power supply between the three aerogenerators in this farm and one of the 14 equipments that, as shall be described later, will make up the biomass gasification plant in such a way that, as the energy from the aerogenerator decreases, the biomass equipment is started.

On the other hand, bearing in mind the high amount of electric power that is used in the mentioned area owing to the activity of several pumping stations, for the second wind farm we have studied the adjustment of the curves of consumption of the pumping stations to the curves of availability of the resource with the installation of a regulation system between the aerogenerators and the pumping stations.

Having finished with the ideas for projects aimed at the problems that the zone poses, the third wind farm will be based on a feasibility study for installing an aerogenerator of 3 MW, non-existent to date in the Region. The purpose of this third project is to obtain the power curve of this aerogenerator and in this way, given the information about the functioning of the 2 MW aerogenerator, which will also be used in this farm, scale-up the curve of the 3 MW onto other zones.

Once defined, all three projects of wind power research would have solved the problem of the generation of income to finance the works to be carried out in the described area. However, their development would not have settled the question of obtaining an adequate supply of electric power. For this reason, the idea of installing a biomass gasification plant using the residues of the cereal crops grown in the area was taken into consideration. The main problem with biomass gasification is related to its degree of development, which due to the experimental phase in which it is nowadays, needs a great investment for implementation and offers profitability in the mid to long terms. Nevertheless, financing the gasification plant with the income generated by the wind farms, we would have solved this problem.

3. UTILIZATION OF AGRICULTURAL RESIDUES

As previously mentioned, the functioning of the gasification plant would be based on the utilization of cereal stubble, principally soft wheat, hard wheat, maize, barley and sorghum.

The gasification plant would consist of three buildings, two of them for the storage of straw, and the third one would house all the equipments involved in the gasification process.

Considering the high amount of power that is needed in the zone, the intended gasification plant will be formed by 14 biomass equipments. The gasification process can be roughly described as follows. The biomass fed in the gasifier is warmed to 1,200 ° C in low-oxygen conditions, in order to prevent combustion. An energetic gas is obtained as main product that, after several thorough cleaning processes, fuels a gas engine for the generation of electricity by means of an asynchronous generator. As by-products of this gasification process, ashes are obtained, which constitute a mineral residue that may be valuable, and calorific energy, which must be -at least partly- reused in order to insure the profitability of the biomass plant.

4. PROPOSALS FOR THE USE OF THE CALORIFIC ENERGY FROM THE GASIFICATION PLANT

Observing the calorific energy that is produced in the gasification plant, approximately 13 million Kcal, we can assure that the utilization of this calorific energy would increase its profitability. It is for this reason that we are interested in finding a solution that allows us to use this high quantity of energy and that is, if possible, related to the principal activity of the zone of study: agriculture.

The crops traditionally grown there are maize, alfalfa and the horticultural ones. Both maize and alfalfa are two high-protein crops so they bear excellent properties for livestock feed but have the disadvantage that a large quantity of water is stored in their tissues. That is the reason why both crops need to go through an industrial drying process previous to their marketing.

A crop's drying or dehydration process involves passing through a warm stream of air in order that it loses its water content, thereby avoiding that the product is attacked by fungi, or continues its vegetative activity, which would limit its preservation. Another advantage of this industrial process is that the product can be given a new shape, allowing for a better storage. Although crop drying used to be an optional stage, with the passage of time certain regulation changes have been introduced and it is now obligatory.

This made us think that one of the first uses to consider for the above mentioned energy would be destined to the drying of these crops. We would use the warm air released by gasification to diminish the dampness of alfalfa and maize. After estimating the annual yields of the crops grown in the area (30,000 tpa alfalfa and 20,000 tpa maize) we observe that, at its best, the utilization of this energy is very small even in the months in which both plants were running (the maize dryer would work from October to December and the alfalfa dehydrator from April until October). The maximum estimated consumption is 6 million Kcal / h.

The other crops produced in the area, the horticultural ones, do not need any industrial processes requiring calorific energy for their marketing, so our conclusion was that we had to find an alternative crop that could be grown there and for whose marketing the use of large quantities of calorific energy were essential. The only drawback for this new crop is the water supply, therefore it should not have big water needs.

In addition, the climate is very extreme in that area; winters are very cold with little rainfall, whereas summers are very dry and hot. These climatic conditions, the structure of the soil, as well as the characteristics that we have previously mentioned led us to the conclusion that the crops that would adapt best are aromatic plants.

This type of crop perfectly adapts to the agroclimatic conditions of the zone, and for its marketing it needs either a drying process or a distillation process in order to obtain the essences destined to the cosmetic, pharmaceutical, and dietary industries. These crops present good prospects due to their medicinal properties and to the growing social demand, which makes their development in that particular place especially interesting, since it might prevent an ever-increasing emigration to the big urban areas. As a consequence, the exploitation of the aromatic plants would lead to the reduction of this migration movement and the organization of a whole infrastructure in the surroundings.

The disadvantage that these plants have is that during the first phases of vegetative development they are very weak and seem to be negatively affected by low temperatures, frost, and intense winds, three common conditions in the area studied. That is why it is necessary to protect the crop at least within these first months of development -from January to February- so that they can enjoy the best moisture, temperature, and light conditions.

The best way of creating this environment is keeping the crop in greenhouses where the right atmospheric conditions for the plants can be controlled, using the heat from the gasification plant as calorific source for the heating of the greenhouses.

These greenhouses do not require a high investment but their profitability is influenced because the crops produced reach a high price in the market. Nevertheless, in our case this profitability would be reduced because, in the first place these are crops that must be developed in the field for at least two more years and, in the second, because the greenhouses would only be in service two out of twelve months, which in the long run would render them unviable, though the figures of calorific energy consumption would approach very much those of energy production in the gasification process.

After analysing the advantages and the disadvantages of the installation of the greenhouses, in order to make them viable in the months when there were no aromatic plants, we found the optimal solution: using the facilities for the production of highly marketable, out-of-season crops like tomatoes, peppers, courgettes... together with the seedlings of the horticultural species subsequently demanded by the local farmers.

In summary, as an alternative for the utilization of the calorific energy from the gasification plant we proposed the construction of an agro-industrial complex consisting of: a dryer for maize and aromatic plants, an alfalfa dehydrator, an essential oil distiller as well as a set of greenhouses to produce various crops throughout the year. The energy that this complex would use can approximately be estimated as follows: both the alfalfa dehydrator and the maize dryer would consume 6 million Kcal / h altogether; the drying and distilling processes of aromatic plants, 5 million Kcal / h; and finally the greenhouses during the highest consumption months, that is to say from January until March and not coinciding with any other installation, 11 million Kcal / h. During the rest of the year the energy consumption would be very much lower, diminishing from March to one half, there being months with no need for heat energy at all.

5. ECONOMIC STUDY

The variables analysed in the economic study relating to the biomass gasification plant are the following:

- Number of equipments: 2, 7, and 14
- Loan interest: 5 and 6 %
- Purchase price of the biomass: 0.03; 0.036 and 0.042 €
- Sale price of the thermal energy: 0.018; 0.024; 0.030 and 0.036 €
- Utilization of the thermal energy: 50, 75, and 100 %
- C.P.I: 3, 4, and 5 %
- Period of amortization: 10, 15, and 20 years

The study of all these variables has given way to a detailed economic study. Due to its length, we shall include only the most unfavourable case, in which the variables of study are:

- Interest: 6 %
- Purchase price of the biomass: 0.042 €/kg
- Cost of maintenance: 0.01 €/kWh
- Cost of personnel: 0.002 €/kWh
- Price of the thermal energy: 0.024 €/therm with 75 % of utilization
- C.P.I: 4 %
- Loan amortization: 15 years

In these conditions the annual cash flow amounts to 1 528 359 €

If these results are now added to the wind variables, with values of 15 MW and 2,400 hours the cash flow obtained amounts to 2 447 198 €.

On the other hand, the economic study relating to the utilization of the calorific energy from the gasification plant is shown in table 1 below:

Table 1. Economic study on the utilization of the calorific energy

	AROMATIC PLANTS	ALFALFA DEHYDRATOR	GREENHOUSES	MAIZE DRYER
CASH FLOW (€)	207,019 €	475,714.93 €	33,704.36 €	413,683.27 €
V.A.N	1,263,095 €	1,736,855 €	177,711 €	1,357,693 €
T.I.R	24.47%	16.35 %	14.37%	15.20 %

6. CONCLUSION

The necessary works to carry out this project for utilization of autochthonous energy sources are expected to start next November.

At the moment, the most important conclusion that can be drawn is the feasibility of building an agro-industrial complex which is entirely ecological, since it will not use energy derived from fossil fuels. At the same time, it will provide the funding for a regulatory reservoir on the site, and for the modernization works of the existing irrigation system. To finish with, new research lines have been opened in the fields of renewable energy sources and distributed generation, and we expect that this project will convey a powerful stimulus to rural development and sustainable development.

7. BIBLIOGRAPHIC REFERENCES

- MINER e IDAE, *Plan de fomento de las Energías Renovables en España*, diciembre de 1999.
- Ley 54/1997 de 27 de noviembre del Sector Eléctrico, BOE número 285, 28 de noviembre de 1997
- Real Decreto 2818/1998, de 23 de diciembre, sobre producción de energía eléctrica por instalaciones abastecidas por recursos o fuentes de energía renovables, residuos y cogeneración, BOE número 312, de 30 de diciembre de 1998
- IDAE, *Manuales de Energía Renovables, Energía Eólica*, Edición 1996
- Real Decreto 93/1996 de 28 de mayo del Gobierno de Aragón
- Cabrera, M., *Biomasa: análisis coste/beneficios, Anejo 2*, año 1999
- Fernández, J., *Informe sobre cultivos energéticos lignocelulósicos para el plan de fomento de las energías renovables*