PROJECT FEBIOVAL
FEASIBILITY STUDY OF A BIOMASS TO ELECTRICITY DEMONSTRATION PLANT IN VALDECABALLEROS

Contract JOR3-CT98-0249

PUBLISHABLE FINAL REPORT

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ABSTRACT

The objective of the project is to carry out a feasibility study of a 15 MW bioelectricity plant. The plant would be located in Valdecaballeros (Badajoz province, Spain) and fed with *Cynara cardunculus* biomass (as an energy crop), natural biomass (brushwood, *Cistus ladanifer)* and agricultural and forestry residues, in the ratio determined by the availability of these resources.

Particular goals of the project are the following:
ii) Analysis of biomass resources in a 30 Km radius of the selected area. The results of this analysis provide the ratio of the different biomass resources used to feed the plant. It also determines the size of the plant to be implemented. ii) Determination of the optimum strategy to manage the biomass supply to the power plant, assessing the social acceptance of the biomass scheme established. iii) Analysis of the technical and economical viability of cardoon biomass production in experimental plots. Determination of biomass productivity in the conditions of the selected zone. iv) Determination of the pretreatment conditions necessary to use the fluidized bed combustion technology. v) Identification of the suitable combustion conditions (the operation ranges in the combustion tests for bed temperature, velocity of fluidization and excess oxygen) to achieve an efficient combustion process with the different types of biomass selected, in order to avoid the deposition and agglomeration problems associated to the combustion of these materials. vi) To provide a feasibility study of the bioelectricity plant, including the study of basic engineering of the plant, construction, operation and maintenance strategies, cost estimates and the socio-economic and environmental impacts.

Throughout the project course the above mentioned goals have been undertaken resulting in positive outputs in relation to biomass availability, management strategies, impact and combustion process. Thus, it can be inferred that such a project wild be feasible in the area of study from a technical point of view.

Nevertheless, the results obtained in the economic analysis demonstrate that the project has certain difficulties with respect to its financial return. Under the initial basic conditions, an internal rate of return is obtained of 6.15%, meaning that project feasibility is difficult to justify. To achieve an economic profit in the project, the team envisages two possible solutions that will have different repercussions, depending on the adopted alternative.

- *Fuel subsidies.-* To ensure the economic viability of the project, the price of the biomass raw material should be about 0.72 ç€/therm which results in a IRR (Internal Return Rate) of 10% that is considered to be attractive enough for any industrial promoter/investor. In the case of FEBIOVAL project (calculated price of raw material: 0.82 ç€/therm) a subsidy of approximately 0.12 ç€/therm (0.42 ç€/Kg) should be paid by the local authorities, autonomous government, and indirectly by the Central Government.

This subsidy is justified on the ground of the social and economic benefits that the biomass-based power plant will bring to the area concerned, and thus should not be considered as a serious obstacle.

- *Electricity subsidies*.- The other alternative to ensure the economic viability of 10% IRR in this type of projects will be to increase the current subsidies of electricity tariffs from 3.05 ç€/kWh to 3.59 ç€/kWh by the Central Government, according to the findings from the FEBIOVAL project.

Any of these two alternatives will lead to the economic feasibility of the biomass-based power plants. Without such subsidies it will be difficult to attract the necessary investment from the private sector in the current climate, as it has been learned from the FEBIOVAL project, and more specifically from the industrial partner.

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OBJECTIVES

The objective of the project was to carry out a feasibility study of a 15 MW bioelectricity plant. The plant would be located in Valdecaballeros (Badajoz province, Spain) and feeded with *Cynara cardunculus* biomass (as an energy crop), natural biomass (brushwood, *Cistus ladanifer)* and agricultural and forestry residues, in the ratio determined by the availability of these resources.

Particular goals of the project were the following:

- Analysis of biomass resources in a 30 Km radius of the selected area. The results of this analysis provide the ratio of the different biomass resources used to feed the plant. It also determines the size of the plant to be implemented.
- Determination of the optimum strategy to manage the biomass supply to the power plant, assessing the social acceptance of the biomass scheme established.
- Analysis of the technical and economical viability of cardoon biomass production in experimental plots. Determination of biomass productivity in the conditions of the selected zone.
- Determination of the pretreatment conditions necessary to use the fluidized bed combustion technology.
- Identification of the suitable combustion conditions (the operation ranges in the combustion tests for bed temperature, velocity of fluidization and excess oxygen) to achieve an efficient combustion process with the different types of biomass selected, in order to avoid the deposition and agglomeration problems associated to the combustion of these materials.
- To provide a feasibility study of the bioelectricity plant, including the study of basic engineering of the plant, construction, operation and maintenance strategies, cost estimates and the socio-economic and environmental impacts.

TECHNICAL DESCRIPTION

The implementation of a biomass power plant in a selected area requires primarily a study of the availability of biomass resources in the particular regional conditions. This part of the work was focused on the assessment of agricultural and forests residues, together with the available land for energy crops in the area of study. Field tests on the energy crop selected *Cynara cardunculus* were carried out which provided the technical and economical viability of this crop in the zone. This study was complemented with the assessment of the social acceptance of the biomass scheme and the management of biomass supply by identifying the local and regional potential actors that could be involved in the commitment to supply the fuel in a persistent way during the plant life time.

The next stage was to study the thermochemical conversion process of the biomasses selected at pilot plant level, including necessary pretreatments. In this project, the bed fluidized combustion technology was chosen due to it presents relevant advantages from an energetic efficiency and environmental point of view.

The project was completed with the feasibility study of a biomass power plant which included the study of basic engineering of the plant, construction, operation and maintenance strategies, cost estimates and the socio-economic and environmental impacts on the selected zone, as well as the management strategy for electricity production.

RESULTS AND CONCLUSIONS

The activities developed during the Project and the most relevant results are described below.

(I) Assessment of biomass resources, availability of land for energy crops and management of the biomass supply.

PARTNER CIEMAT

Results from analysis of biomass resources and availability of land for energy crop show that the total electric power of the power plant under the conservative alternative would be 13 MW and under the agressive alternative, the total electric power of the power plant would be 22 MW. Thus, from the point view of biomass resources there is not problems for the installation of a bioelectricity plant about 15 MW.

The study of the logistic operations for the procurement and supply of the different biomasses to the power plant provide the final cost and the most adequate management strategy. The following Table summarises these results.

Biomass Type	**Distribution**	**Cost (€/GJ)**	**LHV (MJ/kg)**	**Cost (€/t)**
Olive residues	8%	2.06	14.0	28.8
Forest residues	33%	2.23	12.6	28.1
Cysts ladanifer	44%	1.59	15.7	24.9
Cynara cardunculus	15%	2.17	14.0	30.0
AVERAGE ……		1.93	14.3	27.1

The proposed distribution of biomass resources and the calculated supply costs, make the total cost of biomass placed into the power plant to be 1.93 €/GJ delivered, that is equivalent to 27.1 €/t supplied [with an average low heating value (LHV) of 14.3 MJ/kg].

(II) Social acceptability

PARTNER KCL

The main results in terms of the real possibilities for producing energy from biomass in the zone show that natural conditions favour the building of biomass plants and a political support both at regional and local levels. The study of the population and agricultural conditions of the zone carried out on site has provided a clear social characterisation of the area of study. Environmental perceptions among the population show an unanimous opinion about the advantages that the biomass plant could produce and a high degree of uncertainty in relation to farmers' opinion on setting up the biomass plant in Valdecaballeros, mainly due to the introduction of the energy crops in the traditional agriculture of the zone.

(III) Storage and pretreatment of different biomasses selected as feedstock.

PARTNER CIEMAT

Storage trials have been carried out for the three selected biomasses. The assays have followed the evolution of temperature, moisture and chemical composition during one year of storage in three different conditions for each biomass uncovered outdoors, covered with plastic outdoors and placed in a roofed barn with no walls.

A sensible temperature increase was detected in the brushwood and olive piles at the beginning of the storage. Such temperature increase was caused by fermentation occurred as consequence of the existence of favourable air and moisture conditions within the piles. In the case of *Cynara cardunculus*, pile temperatures have followed similar patterns to ambient air temperature.

The moisture profiles indicate that the better condition to avoid moisture raising is the biomass storage inside a roofed place. To cover the piles with plastic can be also a good option but the initial moisture must be low.

Dry matter loss of the outdoors-uncovered piles has been clearly higher for the three biomasses compared to other storage alternatives. The dry matter loss for the whole storage period is close to 10% of the initial matter for the three biomasses stored outdoors with no cover.

In general it is not a good option to store the considered biomasses at ambient conditions during long term due to the dry matter loss and the moisture raising occurred. However, it is reasonable to take advantage of the dry weather during summertime to get a natural drying. In that sense, it would be a good option to leave the brushwood and olive chips uncovered until the end of the summer.

No significant variations of the chemical composition and the calorific value have been found during the storage period.

Biomass preparation for combustion tests has been made utilising a drum cutting chopper followed by hammer milling for *Cynara cardunculus* and a disk chipper and a disk screen for olive and brushwood biomass.

(IV). Combustion assays.

PARTNER CIEMAT

During this Project, the different biomass combustion experiments were completed. The raw materials used in the combustion testing were *Cynara cardunculus*, *Cistus ladanifer* and olive tree pruning residues.

According the results achieved with these raw materials the following conclusion can be obtained:

<u>Biomass *Cynara cardunculus*</u>

- The biomass of the thistle *C. cardunculus* can be considered a poblematic material to be used as a fuel in fluidized bed combustion processes. This is in relation to the physical, chemical and physicochemical characterictics of that biomass.

From the physical point of view, the low density and extremely fibrous structure of the biomass difficulties the homogeneous fuel feeding flow of the combustion plant causing problems of vault formation in the feeding bin and plugs in the screw feeder, as well as of appropriate fluidization in the combustor.

All this negatively affects to the appropriate fluidization of biomass, the stability of the combustion process and hence favours the formation of ash agglomerates in the bed.

- In spite of the improvements achieved with the modifications described, it can be concluded that the appropriate bed composition is an essential factor to overcome the ash slagging problems caused by the studied fuel.

  The substitution of the initial sand as inert bed component by pure silica particles mixed with 12% limestone to increase the melting point of ash components, allowed to reduce the risk of ash agglomeration. It also permitted to carry out combustion experiments of thistle biomass of up to about 10 hours duration, with no significant fuel feeding, agglomeration and slag problems. All this has been applicable on the condition that the bed temperature did not absolutely exceed 850ºC.

- As regards to combustion emissions, it can be remarked the great fluctuations and, in general, high levels of CO in the flue gases measured during the experiments. This can be due to instabilities in the combustion caused by fluctuations in the feeding flow. A most appropriate combustor design, possibly with introduction secondary air in the freeboard could contribute to reduce the cited emissions.

- The fluidized bed technology is appropriate to achieve a very efficient combustion of the studied biomass, as it has been demonstrated by the efficiency well above 99% that has been obtained in different experiments.

Biomass *Cistus ladanifer*

- The biomass of *Cistus ladanifer* can be considered a good material to be used as a fuel in fluidized bed combustion processes, due to the physical, chemical and physic-chemical characteristics of this biomass (low alkali and chlorine content and high volatile compounds content).

- The fluidized bed technology is appropriated to achieve a very efficient combustion, above 99% energy yield that was obtained in different experiments.

Biomass olive tree pruning residues

- The biomass residues from olive tree pruning can be considered a good material to be used as a fuel in fluidized bed combustion processes, due to the physical, chemical and physic-chemical characteristics of this biomass (low alkali and chlorine content and high volatile compounds content).
- The fluidized bed technology is appropriated to achieve a very efficient combustion, above 99% energy yield that was obtained in different experiments.

The more important conclusion is that the fluidized bed technology is appropriate to achieve a highly efficient combustion of the studied biomasses. It thermal efficiency of over 99 % has been obtained in the different experiments, with all biomasses.

During the combustion assays, samples for the identification and quantification of PAHs were taken.

The most relevant results can be summarized as follow:

- In order to identify and quantify the PAHs separated by Gas Chromatography, Mass spectrometer was used as better analytical procedure, running in ion monitoring mode (SIR) how the most adequate method for complex samples.
- The polycyclic aromatic hydrocarbons formation in the biomass combustion process depends of numerous factors the biomass composition employed, the operation conditions and the combustion plant stability.
- The polycyclic aromatic hydrocarbons emitted into the fly ash, are closely connected to the CO level measurement in the sampling achieved in the different biomasses combustion experiments.

(V) Basic engineering and cost estimated.

PARTNER ENDESA

The analysis of the site proposed for the plant reveals its entire suitability with regard to the geological conditions, the energy structure of the region, and especially with respect to existing infrastructure, particularly access roads, electric lines and availability of water. Not by chance had the site been chosen in the past for the installation of a nuclear power station.

Insofar as the engineering is concerned, a very proven conventional technology has been selected, making use of a simple cycle without intermediate reheating and a grate boiler. The fundamental reason why more novel solutions were rejected is to avoid adding technological risks to a project which presents certain difficulties regarding its economic feasibility under current conditions in the Spanish electricity sector.

The economic analysis demonstrates that the project has certain difficulties with respect to its financial return, in spite of there being a premium in the sale price of electricity generated with biomass which, in the current year, amounts to 3.05 ç€/kWh.

Under the initial basic conditions, an internal rate of return is obtained of 6.15%, meaning that project feasibility is difficult to justify. The yield parameters of the project are particularly sensitive to the price of fuel which, moreover, is a source of concern vis-à-vis the certainty of supply over the entire lifetime of the power station.

It could be considered that truly effective actions for biomass development, should be fundamentally directed towards the fuel in two senses: cost reduction and assurance of supply.

The selling price of electricity also has a major impact on financial parameters. Thus, an increase of 10-15% in the selling price would situate the project in a position of economic profitability.

(VI) Socio-economic and environmental impact.

- Pollution and soil contamination. Ecological implication.

PARTNER CEEETA

This study, as for other studies on renewable fuels for power generation, has allowed providing estimates of externalities induced by the production, transport and use of biomass-to-electricity generation. These estimates were produced on the basis of two ExternE approaches due to the availability, during the last phase of our implementation, of new results from a research project on the ExternE methodology. Hence, estimated externals costs range between 7 and 43 mEuro/kWh with mid value estimates between 19 and 21 mEuro/kWh using the ExternE 1997 approach. When using the ExternE 2000 approach these results are lower vary between 2 and 9 mEuro/kWh with a mid value estimate of 5 mEuro/kWh in case grate fire technology.

Most of the external costs of the biomass fuel chain are related with human health impacts (namely impacts associated to NO_x emissions). Expressed as a percentage of the total external costs for a given scenario, human health impacts account for more than 80%. Moreover, despite the non-inclusion of global warming impacts from the biomass combustion, the power generation stage is responsible for a large fraction of the quantified damages (56 to 80%). Another important issue regarding total damage costs is the existence of some non-negligible positive effects. These positive externalities, namely regarding employment, are a strong argument for the development of biomass projects.

This study within the FEBIOVAL project was designed to estimate environmental and social impacts associated with power generation from biomass fuels. Using data from this project and other data from previous studies, CEEETA applied the ExternE methodology in order to assess external costs and benefits of power generation from biomass at the Valdecaballeros site.

All stages of the biomass fuel chain were addressed in defining its main characteristics but their analysis was not conducted with the same intensity. In fact a priority was given to burdens and impacts considered more relevant for this fuel chain. The major burdens of the biomass fuel chain arise from atmospheric emissions at the power generation stage but other burdens were identified and, when possible, quantified. Impacts on human health, crops, ecosystems, materials, global warming, employment and others defined as priority impacts were assessed or adapted from previous studies.

The CO_2 emissions from biomass combustion at the power generation stage were not taken into account for assessing global warming impacts due to the hypothesis that the biomass burned in this case is used on a sustainable basis. Some impacts associated with the biomass production stage were not taken into consideration for a priority evaluation (e.g. changes in fire risk, visual intrusion and ecological impacts). The damages caused by atmospheric emissions from fuel production and transport were only approximated using indirect calculations performed by the EcoSense model.

In spite of the uncertainties underlying the ExternE analysis (as shown by the continuous improvement of the methodology) and although assessed impacts should be considered as sub-totals, a large set of impacts was calculated and therefore we may say that the main objective of this task was achieved. The overall estimated damage costs range from 2.2 to 9.2 m€/kWh using the ExternE 2000 approach in case

grate fire technology. The range of values is comparable with results obtained in the framework of the ExternE project (European Commission, 1999c) for cogeneration plants using similar energy generation technologies. Furthermore, a comparison with other fuel chains studied in the framework of the ExternE project using the same location and ExternE approach shows that a coal power plant with recent technology and pollution control systems would provide higher external costs and that for a natural gas power plant (combined cycle technology) the conclusion would depend essentially on what assumptions are taken into account regarding global warming impacts.

In general, it may be said that the biomass fuel chain presents quite low damages, smaller than those for a coal fuel chain and in the same range for a natural gas fuel chain (excluding the upper bound of the global warming scenario) considering a combined cycle technology. Furthermore, damages from the biomass fuel chain could be even smaller if improved technologies such as low NO_x burner are selected. On the other hand, biomass projects provide some important positive externalities which values may depend strongly on the local context, namely regarding unemployment. Finally, the implementation of biomass projects for energy generation could constitute an important complementary measure for the fulfilment of the Kyoto target defined for Spain and the reduction of its fossil fuel dependency.

- Influence of biodiversity, sustainability and Life Cycle Analysis (LCA) of the biomass scheme.

PARTNER KCL

This study has shown the existence of highly favourable conditions for building a biomass power plant (BPP) in Valdecaballeros area, because: a) it has strong local support, b) there are abundant biomass raw material, c) there will be few, if any, adverse impacts on the environmental, sustainability or biodiversity in the area; d) political willingness to support the BPP, e) the utilization of agro-forestry residues, brushwood *Cistus ladanifer* and *Cynara cardunculus* will not cause any serious adverse effects, f) any negative impacts can easily be outweighed by the potential benefits.

However, it has not been possible to assess all the impacts due to the lack of long term reliable local data and to the difficulties in assigning economic values to environmental amenity, biodiversity, etc. e.g the possible influence to *C.cardunculus* plantations on climate change, and the preservation of some aspects of biodiversity.

The biomass fuel cycle (BFC) still represents higher costs when compered with fossil fuels if all external costs are not internalised. The BFC also shows that advance technology e.g. BIG/CC, will produce less atmospheric emissions, particularly Nox, SO2 and CO, compared to biomass combustion plants. Thus advance technologies present better environmental advantages.

There is a considerable scope for improving the overall cost of the BPP plant through better management practices, both in the production and use of biomass, and through the introduction of more advance technologies, particularly biomass combustion technology.

- Management strategies.

PARTNER CIEMAT

The aim of the study was the evaluation of the management strategy to execute the current project in a successful way. The most suitable management strategy for the energy production, biomass procurement and the combination of both productive activities is established.

Within this study, a previous identification of potential investors or actors that could be interested in a successful implementation of this project was carried out for both the productive aspects (biomass production and energy generation). Potential actors could be placed in administrative, agricultural, industrial or services sectors. When possible they were established within the studied area or in its surroundings.

The next step of this study was the project presentation to those previous interested actors. An evaluation of their own aims, objectives, strengths and weakness were necessary to carry out. This must be done in order to avoid conflictive objectives between actors and to consider potential synergies between them.

The final result has been an adequate scheme to match all the interests of the actors and link them to the reality of the biomass combustion plant. Other result were the identification of potential financing sources and the most adequate financing scheme of the biomass project.

The output from this study is the present study that integrates the techno-economic analysis with socio-economic and environmental aspects of the implementation of the project, and that has been completed with management strategies for the overall biomass scheme.

(VII) Energy crops.

PARTNER UPM

Cynara cardunculus cultivation was performed in several plots located in Helechosa de los Montes, a small town close to Valdecaballeros (Badajoz). During plant development several factors affected negatively the crop, and as a result, the growth of *Cynara* plants was very poor in all plots.

The evaluation of the biomass productivity of the experimental plots was planned for September 2000. However, the state of the plots in that month did not advise it. The plants that had completed the growth cycle were thinly scattered in the plots, exhibiting poor canopy; moreover, the plant rows did not have any continuity. Although there were some well-developed plants -2 m high, 1,350 g dm aerial biomass plant-1 average- the vast majority of the plants that had completed the growth cycle did not reach 110 cm of height. The aerial biomass weight of such plants was about 530 g with 15% water content (450 g dry matter per plant). The actual plant density in the plots (over the total number of plants that had completed the growth cycle) was less than 20% of the theoretical plant spacing (15,000 to 20,000 plants ha-1) recommended for *Cynara* biomass production. This fact obliged to give up any attempt to estimate the potential of this crop in this area from the trials of this experiment.

In the last Annual Report it was stated that the potential of this crop would be estimated for this Project from the data obtained in other experiments on *Cynara* biomass production that were carrying out in the province of Badajoz, where the

supporting Institution was the "Servicio de Investigación Agraria" of the "Junta de Extremadura". Those experiments were initially conducted by the same UPM research team that is reporting at present.

The experiments started in 1996; therefore there are data on *Cynara* productivity in Badajoz of 4 consecutive crop cycles. The effect of several variables: plant density (8,000 to 50,000 plants ha^{-1}) and nitrogen fertilization (0, 50 and 100 kg N per ha^{-1}) were studied. The results of the experiment on plant density did not show significant differences, either the experiment on nitrogen fertilization. This was attributed to the effect of N fertilizations that had been applied to the crops grown previously in the same plot**.** A summary of the 4-year results is shown in the following table.

Mean results of the productivity of *Cynara* crop (*Cynara cardunculus* L.) grown for 4-year experiment in the province of Badajoz. Results referred to full growth cycles. Productivity expressed on aerial biomass dry weight and on aerial biomass weight containing 15% water content (average water content of the biomass at harvest). Evaluation carried out at the end of the natural growth cycle, that is, when the floral scape was dried.

Growth cycle	Rainfall (mm) (September-August)	Productivity on dry matter basis (ton ha^{-1})	Productivity of the biomass containing 15 % water content
1996-97	565.7	11.7	13.8
1997-98	672.7	13.3	15.6
1998-99	266.8	9.7	11.4
1999-2000	717.5	12.6	14.8
MEAN (representative of the area)	555.6	11.8	13.9

A summary of cost analysis of the *Cynara* biomass production in Badajoz for energy purposed is shown in the next table. The costs of the biomass placed at the Power Plant, on the basis of 15 km distance between the field and the Power Plant are given. As regards the fertilization of restitution, two alternatives are considered: 100% mineral fertilizers, and N mineral fertilizer + ash (P&K restitution). Only a system of harvesting (rotary drum mower + rotobaler) is considered.

Summary of the costs of the Cynara biomass production, placed at the Power Plant. Two alternatives are considered for the restitution fertilization. Harvesting machinery: rotary drum mower + rotobaler. Average distance to the Power Plant: 15 km. Costs expressed on pta ha^{-1} (€.ha^{-1}) .

CONCEPT	**100% Mineral fertilizers**	**N - Mineral fertilizer + Ashes (P&K)**
ESTABLISHMENT	5,630	5,630
PRODUTION	43,336	28,162
HARVESTING	15,000	15,000
TRANSPORTING	17,525	17,525
TOTAL	**81,491 (489.8)**	**66,317 (398.6)**

The unitary costs of the biomass placed at the Power Plant, as referred to field area (hectare), biomass weight (ton) and thermic power (lower heating value) for a 14 ton ha^{-1} biomass production with 15% water content at the harvesting time are shown in the next table.

Unitary costs of the Cynara biomass production, placed at the Power Plant, as referred to field area (hectare), biomass production (ton) and heating value (therm). Two alternatives are considered for the restitution fertilization. Harvesting machinery: rotary drum mower + rotobaler. Average distance to the Power Plant: 15 km. Lower Heating Value= 3.340 therm kg^{-1}

UNITARY COST OF *CYNARA PRODUCTION*	**100% Mineral fertilizers**	**N - Mineral + ashes (P&K)**
Cost per hectare €/ha	489.8	398.6
Cost per ton of biomass €/t	34.9	28.5
Cost per therm ç€/therm	1.04	0.85

From these results it may be inferred that the price of 3 ç€ kg^{-1}, considered in the Project for the feasibility study of the crop, might be kept without any economic loss for the farmer, since the unitary cost of *Cynara* production crop has been estimated at 2.85 ç€ kg^{-1}. Nevertheless, the narrow range between the production cost and the selling price suggests that some specific subsidies –as there are from the PAC to cereal crops- should be established to make the crop more profitable for the farmer.

EXPLOITATION PLANS AND ANTICIPATED BENEFITS.

In the last decades the European Union has produced a considerable effort in promoting the development of renewable energy systems because of their possible environmental, social and economic benefits. Furthermore, in Europe, biomass energy has the largest potential as compared to other renewable energy sources.

In Spain, the national government is increasingly recognising the potential benefits of biomass energy, and thus appropriate policies are being put in place to support biomass energy schemes. The autonomous government of Extremadura is also actively supporting biomass energy and is developing a favourable political framework and implementation planning.

The results obtained in Febioval project show that to make the biomass power plant attractive to the possible investor/promoter the following premises must be fulfilled:

1. Security of fuel supply.

The experience from the FEBIOVAL project indicates that it will be necessary to create a Biomass Supply Association (BSA), to take responsibility for the supply of biomass raw material to the power plant. This should be achieved through contractual agreements with an Electricity Association (EA), according to which the BSA

guarantees the supply of raw material, in accordance with the agreed price with the EA responsible for the exploitation of the biomass power plant.

The BSA shall include co-operatives, farmers, the local councils authorities, the autonomous government, etc. Their mission will be to ensure the supply and quality of the biomass raw material at the plant gate, as agreed with the EA.

The EA will be the sole responsible for the commercialisation of the biomass power plant. The EA shall be formed by small and medium companies and also, preferably, a small scale participation from the large electricity utilities which otherwise may not be interested in small scale power plants, as in the case of FEBIOVAL.

2. Avoidance of potential technological risks

The EA will promote the cheapest commercial technology but will be willing to support new technological improvements, innovations, etc., as the profits generated from the power plant may allow in the future.

In FEBIOVAL project the fluidized bed technology (FBT), has been tested and the know-how of this technology in selected raw material has been acquired.

Nevertheless, the industrial partner, playing a key role in the selection process, selected the grate fired technology since is already commercially available and at lower costs than FBT technology which are still at pilot or pre-commercial stage.

3. Project economic feasibility.

Bearing in mind the current low subsidies (3.05 ç€/KWh given to biomass-based power plants in Spain, this type of plants lack economic attractiveness for the private sector, as the return on investment is considered too low in comparison to other industrial sectors.

Therefore it is possible to conclude that considering the agreed target of the EU to achieve 12% of the primary energy from renewable energy (RE) by 2010, Spain will need to install about 1700 MW of biomass-based power plants. This requires a rethinking of how to achieve these objectives both at the EU and Spanish levels.

To achieve such objectives, the team envisages two possible solutions that will have different repercussions, depending on the adopted alternative.

i) Fuel subsidies

To ensure the economic viability of the project, the price of the biomass raw material should be about 0.72 ç€/therm wich will result in a IRR (Internal Return Rate) of 10% that is considered to be attractive enough for any industrial promoter/investor. In the case of the FEBIOVAL project the subsidy should be approximately 0.12 ç€/therm (0.42 ç€/Kg) and should be paid by the local authorities, autonomous government, and indirectly by the Central Government.

This subsidy is justified on the ground of the social and economic benefits that the biomass-based power plant will bring to the area concerned, and thus should not be considered as a serious obstacle.

ii) Electricity subsidies

The other alternative to ensure the economic viability of 10% IRR in this type of projects will be to increase the current subsidies of electricity tariffs by 0.54 ç€/kWh by the Central Government, according the findings from the FEBIOVAL project.

Any of these two alternatives will lead to the economic feasibility of the biomass-based power plants. Without such subsidies it will be difficult to attract the necessary investment from the private sector in the current climate, as it has been learned from the FEBIOVAL project, and more specifically from the industrial partner.

The Final Report of Febioval Project constitutes the more suitable tool for the exploitation of the results derived from this study. This document compiles and summarizes experimental results, techno-economic studies and conclusions that have been worked out along the project.

This document will be presented to Agriculture Department of the Junta Extremadura (Regional Government) to evaluate the alternative financing strategies that the project could use.

The Regional Goverment of Extremadura should contact the identified actors to promote the project, assuming that the fuel subsidies calculated in FEBIOVAL project, which are necessary to make it profitable from the economic point of view, must be supported by the Regional Government itself.

The dissemination of results will be carried out through conference presentations, courses, seminars, workshop and scientific papers.

FIGURE TO ILLUSTRATE POTENTIAL APPLICATIONS OF THE PROJECT.

The management scheme proposed by Febioval is the following: