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A contribution to economic evaluation of biomass energy

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Abstract

In order to reduce the energy dependency and ensure the security of the national supply, the increase of the relative share of the primary energy produced in Portugal is a fundamental and strategic objective. This may only be achieved with the increasing use of the endogenous energy resources, where biomass may play a fundamental role in particular for the electricity generation.

The biomass importance in Portugal was recently underlined on the National Strategic Plan for Energy (ENE 2020), pointing out the contribution of this sector to the environmental, economic and social objectives [1]. The aim of this paper is to present an economic evaluation of the electricity production from biomass, based on a survey of financial and social costs of generation applied to the Portuguese case and addressing the dedicated energy crops. The financial costs included the investment, operation and maintenance and fuel costs. To analyze the social costs, published works based in life cycles analysis of were used.

A contribution to economic evaluation of biomass energy

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ABSTRACT

In order to reduce the energy dependency and ensure the security of the national supply, the increase of the relative share of the primary energy produced in Portugal is a fundamental and strategic objective. This may only be achieved with the increasing use of the endogenous energy resources, where biomass may play a fundamental role in particular for the electricity generation. The biomass importance in Portugal was recently underlined on the National Strategic Plan for Energy (ENE 2020), pointing out the contribution of this sector to the environmental, economic and social objectives [1]. The aim of this paper is to present an economic evaluation of the electricity production from biomass, based on a survey of financial and social costs of generation applied to the Portuguese case and addressing the dedicated energy crops. The financial costs included the investment, operation and maintenance and fuel costs. To analyze the social costs, published works based in life cycles analysis of were used.

Key-words: biomass, energy costs

1. Introduction

In the end of the XX century, European Union (UE) was collated with a huge challenge: how to keep a continuous increase of energy production, necessary to the economic growth and, at the same time, how to minimize the adverse effect of its production and use in the environment, ecosystems and human well-being [2]. The growth of the pollution levels along with the shortage of the fossil fuel reserves are concerns that represent strong motivations for the development of new power plants assumed to be environmentally friend. The high efficiency of the biomass power plants along with the use of a fuel associated with renewed life cycles and their possible positive social impacts in particular at regional level, make biomass an interesting alternative for the electricity generation.

It is well recognized the strong link between the energy sector, and the achievement of sustainable development, with strong impacts on three dimensions of sustainability: financial, environmental and social [3].

The recent Directive 2009/28/EC about the promotion of the use of energy from renewable sources proposed measures consistent with the target of at least a 20% share of energy from renewable sources in the Community´s gross final consumption of energy in 2020 and a 10% target for energy from renewable sources in transport.

The Biomass is seen as an energy source that can play a key role for the fulfillment of the goals of the renewable power plants, as it can contribute for the supply of energy in three sectors, electricity, heating/cooling as well as in the sector of biofuels [4]. The increase use of biomass represents also an opportunity to reach a reduction of the greenhouse gases emissions, contributing to the concretization of the international environmental commitments, promoting also the forest management along with the regional development.

This paper presents part of an ongoing research project and aims to give a contribution for the economic evaluation of the production of electricity from biomass based a survey of the financial and social costs of these projects.

The structure of the paper is as follows. Section 2 presents a brief description of the Portuguese electricity sector. Section 3 describes some of the social and economic studies and addresses the issue of the energy external costs. Section 4 contains the analysis of the Portuguese case, presenting a simplified economic analysis of possible biomass power plants operating in the Portuguese market. The main conclusions are summarised at the end.

2. Portuguese Electricity Sector

Under Kyoto protocol and the EU burden sharing agreement, up to 2012 Portugal may increase the greenhouse gas (GHG) emissions in 27% from the 1990 levels [5]. However, in 2008 the GHG emissions had already grown more than 30%. The main origin of the greenhouse GHG emissions in Portugal is related with the energy sector, more specifically with the combustion of fossil fuels. The consumption of energy in Portugal also has increased in recent years. Half of this increase of energy consumption is almost entirely related with electricity production activities. As the only endogenous energy resources of Portugal are the renewable energies, 85% of the total consumption of primary energy was obtained from imported energy sources [6]. This dependence of imported fossil fuels in Portugal is seen as a major problem, with direct economic consequences. The potential increase of biomass for electricity or heat production may give an important contribution to change the structure of the National energy balance, presently with a high share of fossil fuel use [7]. Although not being a direct solution to substitute fossil fuels, the increase in biomass use represents however, a way to promote more adequate strategies, combining both environmental and economic concerns, for the Portuguese energy sector [8].

3. Social and Economic Studies

The social and economic studies are commonly used to evaluate the level of the local, regional and/or national gains and losses with a particular project. Normally, these impacts are measured in terms o financial indices, as the financial return and profits generated to the investor. However, in projects of large dimension specially the ones from the electricity generation sector, other impacts are also fundamental and should be included in the analysis, namely the social, cultural and environmental aspects [9]. More than ever the recognition of the importance of the social and environmental impacts of the activities of electricity production must be part of the project analysis and should be properly accounted for [10].

The costs of the production of electric energy can be classified in private and external costs. The first one encloses the initial investment of capital, which includes different components, such as the building of the power plant, infrastructures for transports, construction, etc. [11], along with all the operation costs. All these costs have a market price. As for the external impacts, these can be divided in costs (negative externalities) and benefits (positive externalities) depending on the impacts being negative and positive, respectively [12]. Some authors underline that not including external costs or benefits in the final price, represent a market failure, as the inclusion of the externalities in the evaluation of costs and benefits can modify the results significantly and lead to different decisions [13]. This way, to provide a fair comparison of the some existing technologies, all the externalities should be internalized in the calculations [14].

A viable substitute of fossil fuel must have not only a better environmental performance, but must also be economically competitive in order to attract investors, and at the same time must give an important contribution to change the general balance of primary energy use [15][16]. An important limitation of the use of the biomass as an energy resource can be the economic costs. Some authors [17] defend that the economic evaluation of energy systems depends strongly on the cost of four factors: cost of capital, cost of maintenance and operation, fuel costs and external costs, when considered. The fuel costs and external costs are sensible to the type of fuel and the efficiency of the used system. All these components of costs depend of course of the type of biomass used and of selected technology [18]. Operations and Maintenance costs depend mainly on the technical performance of the plants, the application of safety standards and human resources needed.

4. The Portuguese case

Biomass is a heterogeneous energy because it can be provided by several sources. This study emphasizes the case of energetic crops, since is still a new market in Portugal. One of the strong aspects of energetic crops is the development of rural lands, the reduction of rural emigration, the enforcement of local industry and the possibility of new jobs. Several crops have been proposed or are still in test phase for energy production in Portugal. The main crops being considered as the ones with more potential for energy production are: *Cynara cardunculus L.*; *Miscanthus sinensis (Anders); Arundo donax L.; Eucalyptus; Salix viminalis and Salix dasyclados; poplar; Brassica napus L. spp oleífera, Helianthus annus L*. and *Glycine max L*. [19].

In the present study the specie considered for the economic analysis was the *miscanthus*. This culture was indicated as one of the most attractive in Mediterranean territory, due to its good rate of adaptability to the environment and to the soil conditions. The high efficiency of this culture for biomass production is established in several countries of Europe, leading to the selection of this culture as one of the most promising ones for dedicated production in uncultivated lands [20]. The *miscanthus* is a crop with reduced environmental impacts, since the large system of roots captures the nutrients, while the stems are used as shelters for the wildlife. This plant has a high production level and a reduced need of nutrients, energy or water, turning it in an interesting option for the carbon reduction objective [21].

For the determination of Net Present Value (NPV) the present value of the estimated cash-flows is computed, based on a previously defined rate of return. The economic analysis intends to go further than the financial analysis, including the externalities in the evaluation.

The data used in economic analysis are described in Table 1.

Table 1: Biomass input data for the case study of energy crops in Portugal

Parameters	Value	Unit	Economic parameters	Value	Unit
Power plant			**Economic parameters**		
Economic life time	20	yr	Discount rate	0.1	_
Installed power	15	MW	**Energy**		
Heat efficiency	0.56	_	Feed in tariff	107	€/MWh
Average load Factor	0.44	_	**Costs**		
			Capital [22]	1464	€/kW
			O&M [22]	43.4	€/kWyr
			O&M	0.004	€/kWh
			Fuel [5]	25.2	€/MWh
			External	14.45	€/MWh

(1) The culture analyze was the culture of *miscanthus*.
(2) The conversion technology considered was the gasification.
(3) The values of external costs were taken from the *ExternE* study. These costs were updated to 2010 according to the Portuguese price growth.

Table 2 presents the results of the proposed simulation.

Table 2: Results of hypothetical scenario for *miscanthus*					
Costs	**Present Value**	**Unit**	**Total Costs**	**Value**	**Unit**
Investment	21.960.000,00	€	Financial	51.621.119,80	€
O&M	7.511.210,90	€	Social[(1)]	56.543.321,80	€
Fuel	22.149.909,00	€	**NPV (financial)**	**1.046.441,60**	**€**
External	4.922.202,00	€	NPV (full cost)	-3.875.760,38	€
Present value of sales	52. 667.561,40	€			

(1) Social costs = Financial costs + External costs

The results show that the investment costs along with the fuel cost represent the highest share of the total financial cost. When the external costs are included in the analyses, the NPV became negative. For comparison purposes, other simulations were conducted for different biomass types, with the results presented and analyzed in table 3.

Table 3: Results for forest biomass and municipal solid waste for the case of Portugal					
Forest biomass			**Municipal solid waste**		
Costs	**Value**	**Unit**	**Total Costs**	**Value**	**Unit**
Financial	58.411.269,38	€	Financial	44.511.472.64	€
Social	64.914.542.33	€	Social[(1)]	51.100.511.23	€
NPV (financial)	**11.173.751,13**	**€**	**NPV (financial)**	**-9.589.568,13**	**€**
NPV (full cost)	4.670.478,19	€	NPV (full cost)	-16.178.606,72	€

(1) Social costs = Financial costs + External costs

According to results of the study for the analyzed biomass sources and based on the assumed data, we can see that the higher financial and social costs are obtained for the dedicated energy crops and for forest biomass, with the municipal solid waste presenting the lowest value. The assumed fuel costs are approximately the same for the municipal solid waste (24.3 €/MWh) and forest biomass (25.7 €/MWh), presenting higher values for the dedicated energetic crops (45.0 €/MWh). The O&M are higher for the energy crops in comparison to the municipal solid waste and the forest biomass. However the negative values obtained for the municipal solid wasted are due mainly to the reduced feed in tariff. In fact, the present feed tariff is 54 €/MWh for the municipal solid waste, a value, clearly lower than the one for forest and energy crops. The differences in the NPV value for the different biomass type are largely driven by the value of the feed in tariff.

The external costs do not have a large impact on the final social costs, because this value is much lower than the financial cost. However, this impact is enough to turn negative the NPV value for the energy crop alternative, reducing also significantly the NPV values of the forest biomass and municipal solid waste.

In order to compare the biomass power generation with other energy forms, data for the wind and natural gas obtained from the study [23] was used. Table 4 presents the financial and social costs of the wind power, natural gas power plant and a biomass power plant using energy crops in Portugal.

Table 4: Financial and Social Costs of wind, gas power and biomass power plant in Portugal.

Wind plant [23]			Gas power plant [23]			Biomass power plant		
Costs	**Value**	**Unit**	**Costs**	**Value**	**Unit**	**Costs**	**Value**	**Unit**
Investment	1150.32	€/kW	Investment	490.37	€/kW	Investment	1464	€/kW
O&M	14.66	€/kW	O&M	22.50	€/kW	O&M	43,4	€/kW
Fuel	-	€/MWh	Fuel	13.91	€/MWh	Fuel	25,2	€/MWh
Financial Costs	77.72	€/MWh	**Financial Costs**	34.68	€/MWh	**Financial Costs**	104.87	€/MWh
Social Costs	78.55	€/MWh	**Social Costs**	104.27	€/MWh	**Social Costs**	119.32	€/MWh

(1) Please be aware that the data obtained in the reference [23] gives respect to 2006. This date is presented only for comparasion purposes.

Both biomass and wind power plants present investment costs significantly higher than the ones obtained for gas power plant. This fact along with the gas cost lead to a lower financial costs for the gas power plant. However, taking in consideration the externalities, wind power presents the lowest social costs. Biomass is the one with both higher financial and social costs. However, it must be said that as the values shown on table 4 were obtained in 2006 and the gas price increase until nowadays could change costs structure and invert the situation. As a final note it should be underlined that being biomass a renewable resource is protected by law and benefits from feed in tariff, reducing this way the investment risk. However, the results also show that the feed-in-values may not be enough to attract the investors.

5. Conclusion

This paper present an economic evaluation of the electricity production from biomass, based on a survey of financial and social costs of electricity generation applied to the Portuguese case. The analysis was largely based on an assumed energy crop (*miscanthus*) that seems to be a promising alternative for the Portuguese region. The results of the simplified economic simulation indicated that when full social cost (financial and external costs) is to be considered, the proposed feed in tariff may not be enough to attract investors. Also, it becomes evident that the fuel prices are the major cost source representing about 43% of the total financial cost for the hypothetical scenario of using *miscanthus* for electricity generation. This way, future work should address in more detail the issue of the selection of the right energy crop for Portugal, a parameter that largely influences the financial viability of the project.

As for the social aspects, bioenergy may be able to bring considerable benefits to Portugal both at National and regional scale. Although the external costs still represent a considerable share of the full social cost, it is important to notice that the biomass externalities are difficult to access accurately due to the heterogeneity of this energy source. Once more, future work should address the determination of these external cost for the particular case of Portugal

6. References

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