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COST OF ENVIRONMENTAL PROTECTION: A CASE STUDY OF A BIOMASS POWER PLANT IN SERBIA

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SUMMARY

Biomass power production offers significant potential for the Republic of Serbia, especially for AP Vojvodina, as it is an agricultural area with large quantities of plant residues. However, in order to use these resources sustainably, the price of the produced energy should include the cost related to environmental protection. The aim of this paper is to use the LCC method to determine the cost arising from environmental protection in a biomass power plant. The results show that the investments in equipment for reducing pollution in a biomass power plant of the capacity 1MW accounts for 1.08% of the total investments. Also, the environmental cost accounts for the lowest share in the cost price. If investments are (voluntarily) made in purifier filters, they amount to 1.53 EUR/1,000kWh (1.52% of the total cost). If the investments in filters are excluded from the calculation (as under the existing legislation these filters in Serbia are still not mandatory), then the environmental cost is 0.91 EUR/kWh (only 0.91% of the cost price). Therefore, in financial terms the cost of environmental protection does not pose, as is often assumed, a threat for business of such a plant and socially responsible producers should not try to avoid them.

Key words: biomass, cost internalisation, life cycle, economic instruments

INTRODUCTION

During the past few decades there has been a growing awareness that replacement of conventional (fossil fuel-based) energy sources by the renewable ones is a precondition for sustainable development (Mirasgedis et al., 2000; Owusu & Asumadu-Sarkodie, 2016). Consequently, the importance of biomass as a raw material for power production has increased.

Biomass is defined as the non-fossilized and biodegradable organic material originated from plants, animals and micro-organisms (Bhattacharya et al., 2003; Carneiro & Ferreira, 2012). Biomass includes plants and parts of plants, residues and by-products of plant and animal production, residues from deforestation, as well as biodegradable residues in food and timber industries that do not contain hazardous substances and separated biodegradable fraction of municipal waste (Tomanović & Stojanović, 1983; McKendry, 2002). The most significant advantage of biomass as an energy source is in its renewability, which gives biomass a substantial advantage over the traditional, fossil fuels, which are non-renewable in the relevant time period and therefore cannot be a basis for long-term development plans. In addition, biomass power production is a concept that is environmentally (more) friendly compared to fossil fuel power production, as biomass power production releases only carbon-dioxide which is bound during photosynthesis. Therefore, these fuels fit into the natural, closed cycle of CO₂.

Power production from biomass offers significant potential for the Republic of Serbia, especially for AP Vojvodina, as it is an agricultural area with large quantities of plant residues, primarily crop residues. The total potential of

biomass in the form of crop residues as an energy source in Serbia is estimated at about 3 million tons (Martinov et al., 2005; Brkić et al., 2011), while at least half of it is in Vojvodina. This amount depends on the structure of sowing, which has no significant fluctuations. In addition, there is significant potential within animal production (Milić et al., 2011).

By signing the Treaty Establishing the Energy Community in South-East Europe in 2005, as well as its ratification in 2006, the Republic of Serbia adopted directives related to increased use of renewable energy sources. During 2009 and 2010, the Biomass Action Plan was drafted and adopted for the period from 2010 to 2012 for the Republic of Serbia. The Action Plan defines the strategy for using biomass as a renewable energy source, in accordance with the existing national legal regulations and European directives (Milić & Tica, 2012).

The primary reason why utilization of biomass so far has been small is the low heating value of biomass per unit of transport volume and its spatial dispersion (Zekić & Tica, 2010; Zekić et al., 2010), which affects the production cost of this type of energy. Since these technological characteristics cannot be changed or avoided, when making decisions it is important to analyze not only the economic, but also the environmental and social effects that the development of this industry can have on local communities, especially rural communities (Farbaš et al., 2015).

The energy sector today, just like any other sector, has significant adverse effects on the environment. Therefore, if we want to achieve sustainable development of this sector, determining investments in a certain plant should also include investments in environmental protection, so that the cost of operating such a plant also includes fees, taxes, charges, fines and other economic and financial instruments for environmental protection, which opens a constantly topical issue of potential impact of environmental protection on firms'/sectors' competitiveness (Dechezleprêtre & Sato, 2017).

The aim of this paper is thus to determine the environmental protection cost in a biomass power plant, as well as to determine the share of the cost in the total investments and in the price cost of the produced energy, which is of great importance when analyzing and making decisions on investing in such a plant. The analysis included the economic instruments which are currently being implemented in the Republic of Serbia. Since legal regulations of the Republic of Serbia still do not stipulate the issues related to valorization of external cost, companies are not obliged to pay for external cost they cause, nor do they receive financial benefits through government subsidies for voluntary undertaking of environmental actions. Bearing in mind that the process of Serbia's EU accession entails the obligation to harmonize the national legislation with EU norms in this area, the ambition of this paper is to serve as a model for determining the cost of environmental protection by using the LCC method (since it is realistic to assume that the issue of economic valuation of externalities will become obligatory for every business entity in future); also, the paper is to prove that environmental protection does not have to, as is often assumed, pose a threat to business of biomass power plants in financial terms, as well as to discourage the attempts of avoiding environmental protection, which is not uncommon in absence of institutional mechanisms that would prevent this.

MATERIAL AND METHODS

The paper employs the method of calculating the life cycle cost (LCC - Life Cycle Costing method). This is a widely accepted economic method of project evaluation, in which all the cost arising from planning, ownership, development, production, construction, operation, maintenance and disposal is considered as potentially relevant for decision making, providing a much better assessment of the efficiency of long-term project cost compared to alternative methods, which focus only on the initial cost and short-term operating cost (Fuller & Petersen, 1995). Barringer & Weber (1996) very simply define life cycle cost as a sum of cost estimates from the beginning of a cycle to the disposal of both equipment and projects as determined by a specific analytical study. Politano & Frohlich (2006) explain that the LCC method seeks to optimize the cost of acquisition, ownership and physical use of assets over their useful life cycle, trying to identify and quantify all the significant cost involved in the life cycle, using a present value technique. With this method it is possible to make a complete analysis of all the cost, while the compromise between the cost elements during life phases of assets provides the optimum choice. There are a growing number of authors who apply the LCC method in their research (Yuan et al., 2021; Pernilla & Baumann, 2004; Schau et al., 2011; Tamburini et al., 2015).

After identifying the elements of the total cost, the following formula can be used in order to calculate the total cost of a life cycle (Politano & Frohlich, 2006):

$$LCC = C_i + C_o + C_m + C_d$$

wherein:

LCC - total life cycle cost

C_i - cost of the initial acquisition, which includes the cost of project designing, documentation and permits, investment in purchasing land, construction of facilities, equipment procurement and the cost of interest on investment loans

C_o - operating cost, which includes the energy cost, the labour cost, the cost of raw materials (in this case, biomass) and the cost of materials used in the production process (chemicals, lubricants, etc.)

C_m - maintenance cost, which includes the labour cost for preventive and corrective maintenance, the cost of spare parts, the overhaul cost (labour and spare parts)

C_d - cost of disposal.

The LCC method has been increasingly used as a criterion for evaluating investment projects (El-Kordy et al., 2002). In application of this method there are more and more attempts to include at least a part of the external effects in the calculation. However, estimating external effects, especially the environmental effects, is very complex, because the processes in the nature, and hence the impact of humans on them, are very difficult to predict due to the synergistic effects that multiply the impact of individual emissions on the environment, as well as due to the so-called delayed effect of certain emissions on the environment (Prekajac & Josifidis, 1998). Therefore, the calculation most frequently includes only what is relatively easy to identify, such as the cost of environmental taxes and/or fines. This approach was used also in the LCC model applied in this study. The applied LCC model does not focus just on the standard calculation of the inputs and outputs, but the calculation includes the cost of environmental taxes and/or penalties.

The previously described model of the LCC method has been expanded in this paper by the cost of environmental protection (C_e):

$$LCC = C_i + C_o + C_m + C_d + C_e$$

$$C_e = C_{tax} + C_{fe}$$

wherein:

C_e - cost of environmental protection

C_{tax} - taxes, charges, fees or fines for pollution (e.g. the special fee for protection and improvement of the environment, the fee for environmental pollution, the fee for substances that deplete the ozone layer, the fee for emissions of SO_2 , NO_2 , particulate matters and disposed waste, etc.)

C_{fe} - cost of using the equipment for environmental protection (depreciation cost, cost associated with operating such equipment).

Calculations in this paper are based on the data on investments and operating cost of a biogas plant for power and heat generation of installed capacity 1MW, located in the Autonomous Province of Vojvodina, which is a region in the Republic of Serbia with the greatest potential for biomass production. Other publicly available sources which provide information on the norms and regulations on these issues have also been used.

RESULTS AND DISCUSSION

Determination of the cost of environmental protection in biomass CHP plant of installed capacity 1MW

In addition to a number of so-called command and control mechanisms, economic instruments have a growing importance in implementing Serbian national strategies of environmental protection and sustainable development. Munitlak Ivanović & Penezić (2005) explain that economic instruments directly or indirectly lead to changes in the behaviour of economic actors, by stimulating ecologically acceptable and/or discouraging ecologically unacceptable behaviour, accompanied by generating income for investments that improve the quality of the environment.

According to the existing regulations in the Republic of Serbia related to operating biomass power plants, the following economic instruments for financing environmental protection are applied:

Fee for environmental pollution – these fees are to be paid by any physical or legal entity that causes environmental pollution by emissions or waste, or by producing, using or placing on the market raw materials, intermediate products or final products that contain substances harmful to the environment. According to the legal regulations, calculation of pollution fees is made on the basis of pollution sources, as follows: for emissions of individual sources

in the amount of 74 EUR per ton of SO₂, and in the amount of 60 EUR per ton of NO₂ emissions. This fee should implement the “polluter pays” principle, but in the business conditions in Serbia – in absence of monitoring that would keep track of the levels of emissions made by certain entities – despite the existence of the Decree, the fee collection is not as efficient as it is supposed to be.

Special fee for protection and improvement of the environment – which may be prescribed by units of local self-government within their competence and in accordance with their needs and specificities of their territory. Based on the data analysis of cities and municipalities in Serbia, this fee in 2014 amounted to an average 0.0245 EUR per m² of the facilities, or 0.004 EUR per m² of the land used for business purposes. The collected funds are specifically used for protection and improvement of the environment on the basis of the established Program for using resources of the Budgetary Fund for Environmental Protection, and in accordance with the action and remediation plans. However, since the fee is paid per m² of the facilities or land used by economic entities, the fee does not implement the “polluter pays” principle, and therefore it is not stimulating for changing of the practices. The main aim of this instrument is collecting special-purpose funds for protection and promotion of the environment. As collecting of the first fee described above is inefficient, it is not uncommon that the funds collected through these special fees are the only funds that local self-governments have at disposal for implementing the activities of the action and remediation plans in municipalities.

The calculation in this paper is based on the existing obligations for operating a biomass power plant. However, since Serbia aspires to become an EU member, all the requirements that refer to other members will be applicable to Serbia, as well. Therefore, the paper also presents the calculation of the price cost in case of making investments for environmental protection, in order to draw a comparison and determine which option has greater impact on the business. A special aspect of the environmental cost analysis is preventive investing. The analysis in this paper thus includes also the cost incurred as a result of investing in filters for reducing pollution emissions, so this kind of cost is included in the price cost of the produced electricity.

Investments in environmental protection include investments related to environmental protection activities (methods, technologies, processes, equipment, etc.), with the purpose of collecting, treating, monitoring and controlling, reducing, preventing or disposing pollution or any other degradation of the environment which arise from plant operations. Investments in environmental protection can be:

- Investments in pollution prevention during the production process (investments in integrated technologies) – investments in new methods or adapting the existing methods, technologies and/or equipment to prevent or reduce the amount of pollution generated in the production process
- “End-of-pipe” investments – investments in new methods, technologies and/or equipment for collecting and disposing pollution after it has been made, for processing and disposing hazardous substances and for monitoring and measuring the level of pollution (investments in air purifier filters, devices for waste water treatment, collection and treatment of waste, etc.).

In terms of the investment support in Serbia, there are both national and international financial resources for realization of such projects, managed through different funds and institutions. The process of assigning these kinds of resources for special-purpose use of biomass for construction of CHP (Combined Heat and Power) plants – done by the government, and through the authorized Ministry of Mining and Energy – was completed in October 2015.

Current expenditures for environmental protection include labour cost, expenditures for operating and maintaining equipment for environmental protection and payments to the third parties for services of environmental protection, which have the purpose of preventing, reducing, treating or disposing the pollution or any other degradation of the environment resulting from the activities of the business operations. These costs include:

- Internal current expenditures – operating and maintain equipment for environmental protection (expenditures for materials and energy), labour cost (only for the employees working on environmental protection), and other internal current expenditures (education, providing information, administrative duties related to environmental protection, etc.).
- Current expenditures paid to the third parties related to environmental protection (external current expenditures) – payments to government institutions, public companies and specialized producers for providing services of environmental protection, excluding payments of environmental taxes and fines.

Since the installed capacity of the plant does not exceed 1MW, the existing legal regulations do not require the energy permit for its operation, so there is no cost in this regard. The input parameters of the model are investments in the land, facilities, plants and equipment, as well as the cost of environmental protection. All the used data are obtained from the technical and technological documentation, which was the basis for construction and initiation of the plant operation. The investment value of the plant is shown in Table 1.

Table 1. Initial cost of a biomass power plant of the capacity 1MW

Initial cost	Amount	% share
Investments in designing and development of the project	220,000	5.8
The land under the facilities 0.5 ha	4,500	0.1
Land along and around the facilities 1.5 ha	13,500	0.4
Construction facilities	215,000	5.7
Plant and equipment	3,150,000	83.6
Financing cost (interest rate 6%)	164,310	4.4
Total	3,767,310	100.0
Initial cost per generated kWh*	0.448	

Legend: * - The plant has the installed nominal capacity of 1MW and at the annual basis it can produce about 8.4 million kWh of electricity when operating at full capacity.

The initial cost depends largely on investments in the plant and equipment, which account for 83.6% of the total initial cost. The obtained results are consistent with the results indicated in other similar studies (Odavić et al., 2017; Gasol et al., 2010; Carneiro & Ferreira, 2012). Most of the authors who have dealt with similar subjects point to the difficulties in analyzing the total initial cost and determining the average values. These difficulties are explained by the variety of applied technologies, the very processes, as well as the used fuel. When it comes to the initial cost, there are significant differences in the reviewed literature. The factor that has the primary impact on investments per a capacity unit is the total capacity of the plant. The values of the initial cost range from 1,346 EUR/kW to 4,463 EUR/kW. These differences largely stem from the method of calculation and the level of coverage of the investment. This also applies to the operating costs (Carneiro & Ferreira, 2012) which cover the cost of raw materials, energy, labour, reagents, public utilities, maintenance and reparation, as well as depreciation cost. These costs in this case study are calculated on an annual basis and are presented in Table 2.

Table 2. Operating cost of a biomass power plant of the capacity 1MW in EUR

Operating cost	Amount (Euro)	Structure (%)
Cost of raw material	535,000	64.1
Energy cost	33,600	4.0
Cost of chemicals	12,500	1.5
Labour cost	29,000	3.5
Cost of public utilities	14,500	1.7
Maintenance and reparation	85,000	10.2
Depreciation cost**	124,977	15.0
Total	834,577	100.0
<i>Cost per kWh</i>	<i>0.099</i>	

Legend: ** - The estimated life of a plant is 30 years. The depreciation rate is 3.33%.

The data presented in the table above show that the cost of raw materials accounts for the largest share in the total cost (64.1%), followed by depreciation cost (15.0%).

When calculating the income from the plant business, incentive feed-in tariffs are used. These tariffs are prescribed for produced 1 kWh by a biomass power plant of the capacity 1MW, which – according to the Decree on Incentives for Privileged Energy Producers – currently amounts to 0.1326 EUR for 1 kWh. Having considered the operating cost of the plant, it can be concluded that there is a significant margin between the selling price and the operating cost. Namely, the operating cost accounts for 74.66% of the selling price of 1 kWh, which does not differ greatly from the results obtained by Tica et al. (2015).

Combustion plants emit harmful gases and particles into the air. Through combustion, biomass power plants emit about 40 tons of pollutants a year. In order to prevent this, it is necessary to install in the power plants special chemical filters, which reduce up to 95% of SO₂ emissions and 90% of NO₂ emissions. The cost of using these filters is calculated in the amount of 41,000 EUR per year, which corresponds to the highest prices on the market for this type of filters (Tab. 3). The cost of environmental protection may possibly include also the cost of educating the employees, as well as the consumers, about the ways of preventing pollution, although in this model they are not included.

Based on the obtained results, it can be seen that the investments in equipment for purification in a biomass power plant of the capacity 1MW does not have a substantial share in the total investment value. Specifically, the

investments for purification account for 1.08% of the total investments in the plant. By analyzing the impact of different costs on the cost price of producing 1,000 kWh, it can be concluded that the cost of environmental protection has the lowest share in the price. If investments in purifier filters are (voluntarily) made, the cost of environmental protection amounts to 1.53 EUR/1,000 kWh, i.e. 1.52% of the total operating cost. Since installing special filters for reducing harmful gases and particles is still not mandatory according to the legislation of the Republic of Serbia, the calculation without these costs was also made, so that only the costs mandatory for companies were calculated. As a result, the environmental protection cost is reduced to 0.91 EUR/1,000 kWh, accounting for only 0.91% of the cost price.

Table 3. Calculation of the total cost of environmental protection for a biomass power plant of the installed capacity 1MW in the Republic of Serbia

No.		Quantity/ amount for calculation	Unit of measurement	Amount per annum (€)	Total (€)	Total without chemical filters (€)
1	Investments				41,000	0
1.1	Chemical filters	1.00	kW	41	41,000	0
2	Current expenditures				12,845	7,659
2.1	Labour	1.00	P	3,600	3,600	0
2.2	Depreciation cost				2,733	
2.3	Equipment maintenance	1.00	kW	2	2,000	0
2.4	Fee for environmental protection	40	t	135	0	5,403
2.5	Special fee for protection and improvement of the environment				2,256	2,256
2.5.1	For facilities	5,000	m ²	0.30	1,500	1,500
2.5.2	For land	15,000	m ²	0.05	756	756
	Cost of environmental protection per 1,000 kWh				1.53	0.91

CONCLUSION

In the Republic of Serbia, the economic instruments related to environmental protection are still underdeveloped. Consequently, the “polluter pays” principle is not sufficiently implemented, regardless of the declarative commitment to its implementation. In the meantime, environmental pollution continues. In the process of European integration a legal framework is being developed and it should provide the necessary basis for applying instruments modelled on EU practice. However, the existing legal solutions used for setting tariffs and collecting fees for environmental protection are not adequate, especially regarding the quantitative indicators on the basis of which the fees for environmental protection are determined. The existing principle of making calculation per square meter fails to consider the level of pollutant emissions, which is certainly one of the reasons why the level of the fee collection is not satisfactory. This, further, results in a low level of budgetary resources of local communities that could be used to support the development of environmentally friendly investments.

The obtained research results of the case study on the biomass power plant of the installed capacity 1 MW show that the investments in purification equipment account for 1.08% of the investments in the plant. The environmental cost accounts for the smallest share in the cost structure of biomass power production. If investments are made in purifier filters, the environmental cost amounts to 1.53 EUR/1,000 kWh, i.e. 1.52% of the total operating cost. When investments in filters are not included – since according to the existing legal regulations in Serbia they are still not mandatory – the cost is even smaller, amounting to 0.91 EUR/1,000 kWh, accounting for only 0.91% of the cost price.

The obtained results indicate that the cost of externalities does not have significant impact on the business of the plants in financial terms, considering that there is a significant margin between the selling price of electricity and the total operating cost. Thus, in order to act socially responsible this kind of costs should not be avoided, regardless of the absence of institutional mechanisms and/or economic instruments which will force/stimulate sustainable production.

Conflict of interest: The authors declare that they have no conflict of interest.

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