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[1.]Srđan VASKOVIĆ, [2.]Petar GVERO, [3.]Dragana KALABIĆ,
[4.]Vlado MEDAKOVIĆ, [5.]Azrudin HUSIKA

DETERMINATION VALUES OF FINANCIAL SUBSIDIES IN ACCORDANCE WITH THE EXERGY QUALITY FOR FUELS AND HEAT PRODUCED FROM BIOMASS

[1-2,4-5.] Faculty of Mechanical Engineering, University of East Sarajevo, BOSNIA & HERZEGOVINA
[3.] Ministry of Industry, Energy and Mining Republic of Srpska, BOSNIA & HERZEGOVINA

Abstract: The importance of bioenergy is particularly evident in recent years. The most important part in bioenergy supply chain is production of fuels. Due to cheaper energy production from fossil fuels, energy from biomass is less competitive than fossil energy. For this reason, there are subsidies for energy production from biomass. In the Republic of Srpska and Bosnia and Herzegovina there are defined only subvention for electricity produced from biomass, while the lower forms of energy are not subsidized. In accordance with the defined amount of subsidies for 1 kWh of the produced electricity we can define the value of subsidies for the produced heat energy and fuels from biomass. For that we should take into account exergy quality of these forms in comparison with electricity. This paper describes one such approach.
Keywords: Biomass, exergy quality, fuels, heat, subsidies

1. INTRODUCTION

The total value of the financial subsidy of the produced energy from renewable sources shall be calculated as one price per unit of energy that is paid to the producer of renewable energy as an incentive and that price is depending on the prices prevailing on the energy market. It is common that the price of energy production from renewable energy sources is above the market prices of fossil energy. The reference market price largely dictated by the price of energy produced from fossil fuels. Therefore, in order to compensate for the difference between the cost of energy production from renewable energy sources and the market price of energy is needed subsidies and support the use of renewable energy. The difference of course is determined by the level of competitiveness of some forms of renewable energy. The final outcome of the use of subsidies for the production of energy from renewable sources is to achieve full competition in energy production from renewable sources of energy obtained from fossil fuels. About the methodology of budget subsidies more in the literature [1].

This article will not deal with the methodology and assumptions for calculating the value of subsidies. The theme of this work is that the previously defined value of the subsidy for the production of electricity from biomass, it will determine the value of subsidies for lower energy forms such as heat and fuel. Access defining the value of subsidies for heat and fuel was made with the help of factors exergy quality of these forms. As an example, the paper taken certain plants from the Republic of Srpska and for their capacities are calculated values of potential amount of subsidies in accordance with the prescribed value of subsidies for electricity produced from biomass, defined by the Operator of the renewable energy. Very similar values subsidies for produced el. energy from biomass are defined by the Operator of the renewable energy in Federation of Bosnia and Herzegovina. To understand the application and the importance of factors exergy quality, the following chapter going to explanation.

2. THE COEFFICIENT OF EXERGY QUALITY FOR DIFFERENT PRODUCTS AT OBSERVED ENERGY CHAINS

Various forms of energy have different quality. There are different basic energy forms: kinetic energy, potential energy, thermal energy, chemical energy, electrical energy, electromagnetic energy, sound energy and nuclear energy. Energy is said to be "useful" if it can be entirely transformed by an ideal system (i.e. without losses) into any other type of energy. Useful energy, otherwise known as exergy, only represents a part of energy. Electrical and mechanical energies are very "high quality" forms of energy: their exergy index is 100% since exergy is equal to energy. Exergy calculations require a reference state or environment. The reference environment is the ultimate sink of the all energy interactions [2]. The exergy content of an energy resource can be obtainined by multiplying its energy content by a quality factor of energy form q.

$$q = \frac{\text{exergy}}{\text{energy}} \qquad (1)$$

Chemical energy is a much-used basis for primary energy conversion. The exergetic efficiency combustion of an ideal combustion process is determined by the second law of thermodynamics, and depends on the absolute temperature levels of combustion $T_{combustion}$ and of the environment T_0 [3]. The exergy content of heat depends on the temperature of the energy carrier and the temperature level of applicable ambient (dead state). Some energy forms and their respective quality factors are found in [4]. The temperature is a quality parameter for heat. The exergy content of heat Q:

$$E_x = W_{max} = Q \cdot \left(1 - \frac{T_0}{T}\right) \qquad (2)$$

Generally, when we have in the consideration three energy forms such as: electricity, heat, fuel (chemical exergy), we can define three equivalent coefficients for comparison. As we know, electricity is the highest quality of energy form. Electricity has the quality factor equal to 1. For all other types of energy forms like fuel and heat, the quality factor must be less than 1. Figure 1. shows different kind of energy forms.

Figure 1. Different kind of energy forms

The following table provides an overview of the coefficients of exergy quality for different energy forms.

Table 1. Coefficients of exegy quality for different energy forms

	Energy forms		
Coefficients f_{ex}	Electricity	Fuel	Heat energy
	$E_j = 1$	$F_j = \mu_{exp}$	$H_j = \left(1 - \frac{T_0}{T}\right)$

where: μ_{exp} - exergy efficiency for production electricity from different type of fuel for defined technology, T_0 - environment temperature [K], T - temperature of heat reservoir [K], E_j, F_j, H_j - coefficients of exergy quality for electricity, fuel and heat.

Also, we can define combined coefficient of exergy quality for energy chain and its energy products:

$$f_{ex} = E_j \cdot e_j + F_j \cdot f_j + H_j \cdot h_j \qquad (3)$$

$$e_j + f_j + h_j = 1 \qquad (4)$$

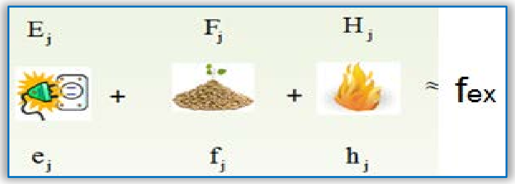

Figure 2. Equivalent factor of exergy quality

where: e_j, f_j, h_j - percent of simultaneous production of electricity, fuel and heat at energy chain. Figure 2 presented combined equivalent factor of exergy quality for electricity, fuel and heat.

3. EXAMPLE OF CALCULATION FINANCIAL SUBSIDIES FOR SELECTED PLANTS

Example of defining subsidies is taken for three cases: CHP plant, plant hot-water boiler and a pellet plant. All plants plants are realistic plants that are already operational and those plants located on the territory of the Republic of Srpska. CHP plant with ORC process is taken from the literature [5].

3.1. Data for CHP plant with ORC process:

$P_n = 5140$ boiler nominal power in kW

$P_e = 1000 - 50 = 950$ electric power plants, net of own consumption in kW

$P_t = 4095 - 400 = 3695$ thermal power reduced by the drying effect

$T = 353$ water temperature by the CHP process 80° C

$T_0 = 273$ reference ambient temperature, 0° C

$\eta_b = 0.87$ boiler efficiency

$\eta = \eta_e + \eta_t = 0.766$ the overall energy efficiency of the plant

$O = 43$ percentage oxygen content of the wood chips,%

$C = 50$ percentage carbon content of wood chips,%

$H = 6$ percentage hydrogen content in wood chips,%

$N = 0.3$ percentage nitrogen content in the wood chips,%

$w = 0.43$ the moisture content of wood chips

$\eta_{eks} = \frac{e_E + e_T}{e_G} = 0.23$ exergetic efficiency factor

$f_{21} = \eta_{eks} = 0.23$

$e = \frac{P_e}{P_e + P_t} = 0.205$ the percentage of electricity production

$h = \frac{P_t}{P_e + P_t} = 0.795$ the percentage of heat generation

$E = 1$ exergy factor of electricity

$H = \left(1 - \frac{T_0}{T}\right) = 0.227$ exergy factor of heat for defined parameters T and T_0

$f_{ex} = E \cdot e + H \cdot h = 0.38$ overall coefficient of exergy quality of the resulting products el. energy and heat

The planned annual production of electricity: E_E.
The planned annual production of thermal energy: E_T.
The value of subsidies for electric energy S_E=0,1620 BAM/kWh of installed electric power up to 1 MW for solid biomass power plants [6].
The value of subsidies for electric energy S_E=0,1468 BAM/kWh for installed electric power of 1 to 10 MW of solid biomass power plants [6].
Equivalent installed capacity is about 1+ 3,695/3 = 2,231 MW, which means that the subsidies will go into the category of plants over 1 MW and out of this facility S_E=0,1468 BAM/kWh.
The equivalent value of the subsidy for the produced electricity and heat will be:

$$S_{ek} = f_{ex} \cdot S_E = 0.055784 \text{ KM/kWh} \quad (5)$$

Reduced by the aggregate kWh produced electricity and thermal energy of the plant planned value of the subsidy annually for this installation will amount to:

$$S = S_{ek}\,(E_E + E_T) \quad (6)$$

where is E_E, E_T, quantity produced el. energy and heat annually.

3.2. Data for heating plant in Prijedor (Bosnia and Herzegovina)

$P_t = 10000$ useful output of thermal power plants decreased by the drying power in kW

$T = 383$ water outlet temperature, 110° C

$T_0 = 273$ referentna temperatura okoline, 0° C

$H_d = 7500$ lower heating value of fuel in kJ / kg, corresponding to humidity 50%

$\eta_t = \frac{P_e}{\frac{m_f \cdot H_d}{3600}} = 0.832$ energy efficiency boiler for 100% load

$O = 43$ the percentage oxygen content in the wood chips,%

$C = 50$ percentage carbon content of wood chips,%

$H = 6$ percentage hydrogen content in the wood chips,%

$N = 0.3$ percentage nitrogen content in the wood chips,%

$ehv_0 = 19.49$ lower heating value of wood for food, MJ / kg

$w = 0.5$ the moisture content of the wood chips

$\eta_{eks} = \frac{e_T}{e_G} = 0.16$ exergetic efficiency factor

$h = 1$ the percentage of heat generation

$H = \left(1 - \frac{T_0}{T}\right) = 0.287$ exergy factor of heat for defined parameters T and T_0

$f_{ex} = H \cdot h = 0.287$ overall coefficient of heat exergy quality

Calculation data about plants taken from [5].
The planned annual production of electricity: E_e.
The planned annual production of thermal energy: E_T.
The value of subsidies for electric energy S_E=0,1620 BAM/kWh of installed electric power up to 1 MW for solid biomass power plants [6].
The value of subsidies for electric energy S_E=0,1468 BAM/kWh for installed electric power of 1 to 10 MW of solid biomass power plants [6].
Equivalent installed capacity is approximately 0 + 3.10 = 3.33 MW, which means that the subsidies will go into the category of plants over 1 MW and out of this facility SE = 0.1468 BAM / kWh.
The equivalent value of the subsidy for heat produced will be:

$$S_{ek} = f_{ex} \cdot S_E = 0.0421316 \text{ KM/kWh} \quad (7)$$

The planned value of the subsidy for the production of heat on an annual basis would be:

$$S = S_{ek}\,(0 + E_T + 0) \quad (8)$$

where the E_T annual production of heat. If the approximate market price of 1 kWh of heat produced in BiH equal to about 0.07 BAM/ kWh, then the share of the subsidy according to this way of subsidizing is about 60% of the cost of 1 kWh of thermal energy.

3.3. Data about pellet plant:

As a reference example was taken pellet plant: "The company for the production of packaging made of wood and the production of eco-briquettes pellets, EU PAL doo Pale" in Bosnia and Herzegovina. Calculation data for plants taken from [5]. Annual capacity: 10 000 tonnes. For exergy factor for the production of quality fuel (pellets) is taken exergetic coefficient of efficiency of electricity production from CHP plants. Reference can take a mean value of exergetic efficiency of these plants. For our case is:

$$f_{ex} = \eta_{eks} = 0.16.$$

Lower heating value for pellets is H_P = 4,7-5 kWh/kg, taken 15 MJ/kg.
Pellet press capacity K = 2 t/h.
Approximate calculation of equivalent power levels for pellet press products in one hour is:

$$P_G = \frac{K \cdot t \cdot H_p}{3.5 \cdot 3600} = \frac{2000 \cdot 1 \cdot 15}{3.5 \cdot 3600} = 2.3\text{MW} \quad (9)$$

The plant belongs to the category of about plants over 1 MW with an equivalent value of subsidies from S_E = 0.1468 BAM/ kWh.
The equivalent value of the subsidy for the produced fuel per 1 kWh of thermal power will be:

$$S_{ek} = f_{ex} \cdot S_E = 0.023488 \quad (10)$$

Simplified per kWh produced amount of energy stored in the form of fuel, the planned value of subsidies annually for this installation will amount to:

$$S = S_{ek}\,(0 + 0 + E_G) \quad (11)$$

Where is the E_G annual production volume of fuel in the form of pellets. If we take into account that the approximate cost of 1 ton of pellets market in BiH equals 250 BAM, approximate calorific value of 4.5 kWh / kg, which means that 0,055 BAM/ kWh value of 1 kWh of calorific value of this fuel. In this case, the value of the subsidy is about 42% of the production costs of 1 kWh of thermal power pellets. Approximate value of subsidies under the previous amount to about 100 BAM per each tonne of pellets produced. This paper reviews the values do not provide subsidies annually for the produced heat and fuels, but only potentially share of subsidies in total production cost of heat and fuel. For concrete plants could easily calculate the value of possible subsidies premnožavanjem with total annual production volume of heat or fuel.

4. CONCLUSIONS

For successful use of renewable energy sources and especially biomass, in addition to monitoring of technological and scientific developments in this field, the dominant factor is certainly a economic background of the whole process of exploitation of renewable energy resources. With regard to biomass as a renewable source of energy is one specific form of renewable resources to the reason that depends on supply chain of fuels from biomass. On the other hand, Bosnia and Herzegovina and Republika Srpska is to have significant quantities of biomass, particularly wood residue origin of forest management and from primary and secondary wood processing. For these reasons, it is necessary to help this type of renewable energy resources to be competitive in the energy market. If we take into consideration that the Serbian Republic and the Federation of Bosnia and Herzegovina have not adopted the Law for thermal energy prodution as well as under developed system of subsidizing fuel and heat energy produced from renewable energy sources, this approach to defining subsidization of lower energy forms can be very useful for determine the value of subsidies in relation to electricity produced from renewable energy sources. On the other hand, this paper opens a interesting question in the field of energy a philosophy which is: Do this really worth subsidize electricity in an efficient cogeneration plants to biomass, if only subsidized electricity and thermal energy as a byproduct can not exploit and will again this subsidized electricity back to a lower form of quality, ie. used for heating? Perhaps it is better to subsidize clearly defined capabilities to producing heat and fuels with adequate planning of all facilities (for the production of electricity, heat and fuels) in accordance with the needs of the energy market? In any case, this question opens up a lot of controversy and discussion and of course directions for further research.

Note

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