ENERGY WILLOW – AN ADVANTAGEOUS FUEL FOR BIOMASS POWER PLANTS

DEZSI A.B.*, DOZESCU S.I.*
*SC FFEE Electrica Furnizare Transilvania Sud SA, Brasov
alex.dezsi@gmail.com

Abstract – The paper analyses the energy willow plantations and presents efficiency calculations in case of using it as chips, briquettes or pellets to fuel the biomass power plants, as well as the advantages of using energy willow in comparison with other fuels.

Keywords: energy willow, biomass, energy crops.

1. GENERALITIES

According to the European Directive 2009/28/CE, on the promotion of the use of energy from renewable sources, is stated (the three 20es rule) that until 2020, each European Union country, is to reduce the CO2 emission by 20% and to produce minimum 20% of the energy from renewable sources [4].

Today, the different countries have varied energetic potential, some have a great hydro energetic potential, and others have aeolian or solar potential. In the case of Romania, the energetic potential in green energies domain is illustrated in the figure 1 chart.

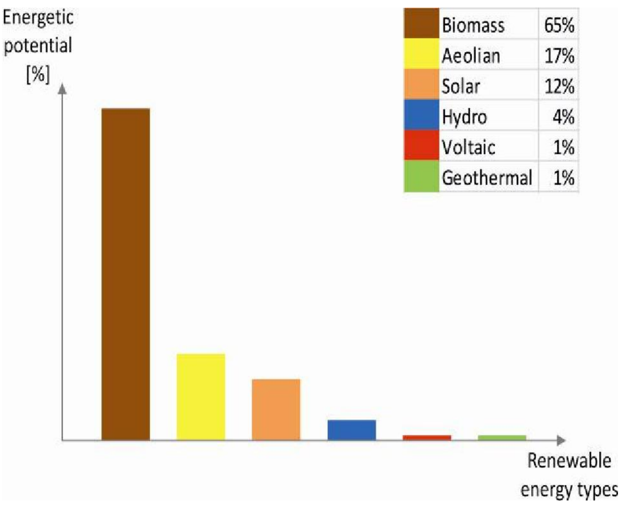

Fig. 1. Romania's energetic potential in the renewable energies domain

Now days, the renewable sources energy production rate in Romania is insignificant compared to other countries from The European Union.

According to ANRE [1] report and to the data supplied by Transelectrica [2], in our country at this moment, in 2010, were produced 59,14 TWh electric energy from renewable sources, that representing only 1,14 % of the total electric energy production.

In the Fig.2. chart is represented the electric energy production structure from our country, in percents, and in Fig.3., the electric energy production structure for the energy produced from renewable sources, also in percents.

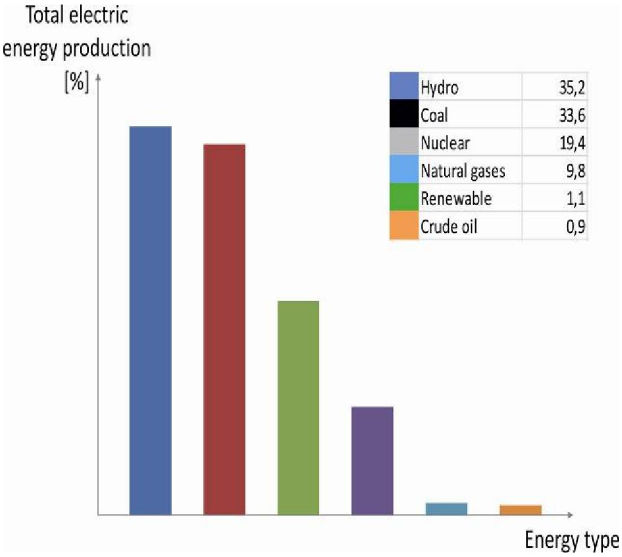

Fig. 2. Electric energy production structure from Romania, in 2010

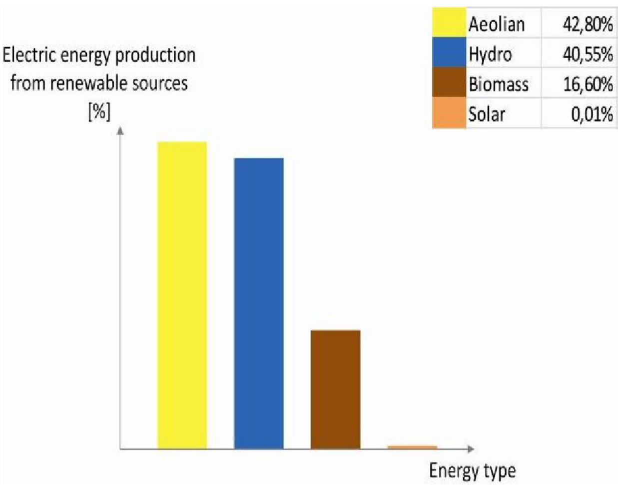

Fig. 3. Electric energy production structure for the energy produced from renewable sources in Romania, in 2010

It can be observed that, although our highest energy potential is represented by biomass, at present only 16,6% is represented by it in the total production of renewable energies.

Moreover, at present there are existing only three licenced producer, consequent on tab.1, from which, and the last two are producing only since 2010.

Table 1. Biomass electric energy producers from Romania

Nr. crt.	Producer	Pi [MW]	Delivered energy in 2010 [MWh]
1	Bioelectric Transilvania, Sebeş, with the unit in Rădăuți	8,08	51.794,96
2	Holzindustrie Schweighofer, Sebeş	8,752	41.614,86
3	General Electric, Pângărați	6,5	19.005,36

By comparison, from the chart in Fig.4. is observed the energy shares, from the total energy production in Spain, in 2009

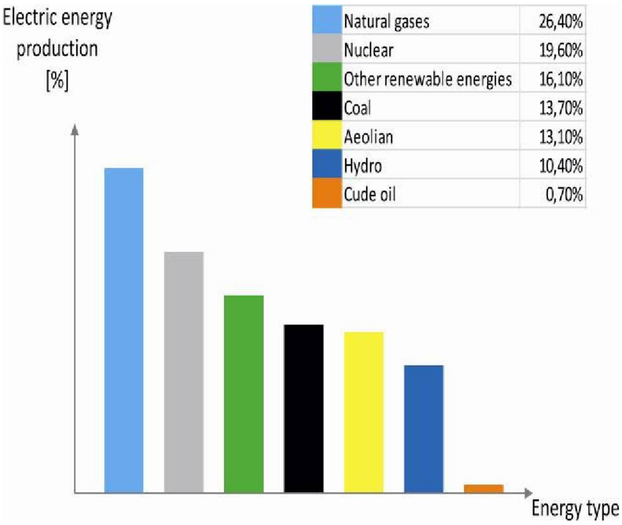

Fig. 4. Electric energy percentile production from Spain, in 2009

In can be seen that Spain is already producing 29,2% of the energy from renewable sources.

If we look at the renewable energies potential from our country, we observe that the highest share is represented by the biomass, with 65%. Therefore is clear that we must point especially to this source.

Mainly, the biomass sources are represented by the waste resulted from wood processing, tree branches and other wood debris resulting from forests, pastures, parks, alleys and gardens cleaning, from special crops, such as corn, from secondary agricultural products, such as straws and, not at least, from energy crops (energy willow, energy poplar, elephants grass etc.).

Nevertheless, the main source, with the highest energy efficiency at this moment, is represented by the energetic willow.

2. ENERGY WILLOW PLANTATIONS

The first energy willow plantations have appeared in Sweden, 28 years ago, country where a special accent was put on this plant, through creation of new species as productive and resistant as possible, reaching nowadays over 50000 ha [5] energy willow plantations.

The crops were then spreading to Baltic countries, Russia, Poland, Hungary and other countries. Such crops have appeared in our country, in various counties, the surfaces covered being yet modest. They had the biggest development in Covasna county, where nowadays energy willow is cultivated, especially Doris and Inger species, on a surface of approximately 40 ha [8].

In the pictures from Fig.5. and Fig.6, are represented images of these plantations from Tinoasa and Poian villages, from Covasna county, area where the biggest energy willow producers from our country are situated.

Fig. 5. Energy willow plantations from Tinoasa

Fig. 6. Energy willow plantations from Poian

The planting can be done mechanized or manual, is made once, and the willow harvesting is done 25-30 years [6]. The manual planting assures an efficaciousness of 95%, while a mechanized planting, easier and with a higher productivity assures an efficaciousness of only 75%.

In order to set up such plantation, the investment is of 1700÷2800 EUR/ha, the price of a seedling being of approximately 0,08 EUR and for a hectare is necessary a quantity of 14000 seedlings [7].

This type of plantation can produce annually 40÷60 t of wooden material, the average crops are 15 t/ha first year, 35 t/ha second year and 45 t/ha each of the following years.

If we take into consideration that, starting with the second year, the maintenance and harvesting costs are of approximately 200 EUR/ha and taking into consideration the initial investment, we obtain the annual expenses curve, as resulting from tab. 2 and Fig.7.

Table 2. Annual expenses an income, on ha, regarding an energy willow plantation

Year	1	2	3	4	5
Expenses [EUR]	2500	200	200	200	200
Income [EUR]	400	900	1200	1200	1200
Year	6	7	8	9	10
Expenses {EUR]	200	200	200	200	200
Income [EUR]	1200	1200	1200	1200	1200
Year	11	12	13	14	15
Expenses {EUR]	200	200	200	200	200
Income [EUR]	1200	1200	1200	1200	1200
Year	16	17	18	19	20
Expenses {EUR]	200	200	200	200	200
Income [EUR]	1200	1200	1200	1200	1200

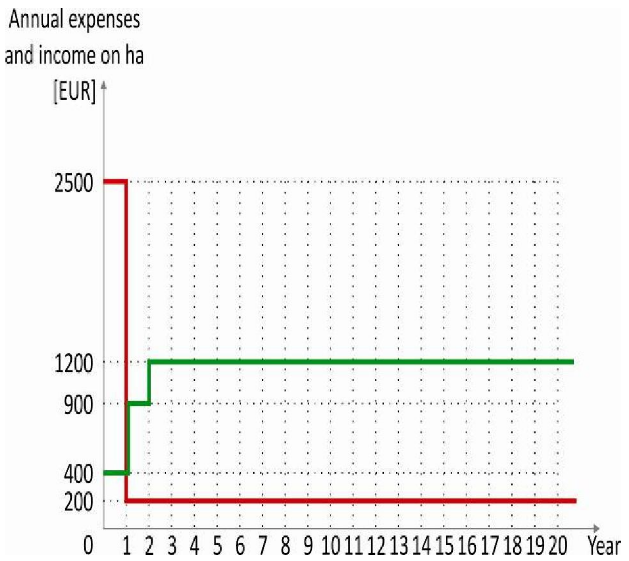

Fig. 7. Annual expenses and income curves

If we take into account that the price for a ton of minced energy willow, with 30% humidity, is 40 EUR and taking into account the estimated annual productions, we can outline the annual income curve, as resulting from Tab.2. and Fig.7.

If we total the expenses and income, starting with the first year, we will obtain the total expenses and income curves, as seen in Tab.3. and Fig.8.

Table 3. Total expenses and income, on ha, regarding an energy willow plantation.

Year	1	2	3	4	5
Expenses [thousands EUR]	2,5	2,7	2,9	3,1	3,3
Income [thousands EUR]	0,4	1,3	2,5	3,7	4,9
Year	6	7	8	9	10
Expenses [thousands EUR]	3,5	3,7	3,9	4,1	4,3
Income [thousands EUR]	6,1	7,3	8,5	9,7	11,1
Year	11	12	13	14	15
Expenses [thousands EUR]	4,3	4,3	4,3	4,3	4,3
Income [thousands EUR]	11,1	11,1	11,1	11,1	11,1
Year	16	17	18	19	20
Expenses [thousands EUR]	16	17	18	19	20
Income [thousands EUR]	5,5	5,7	5,9	6,1	6,3

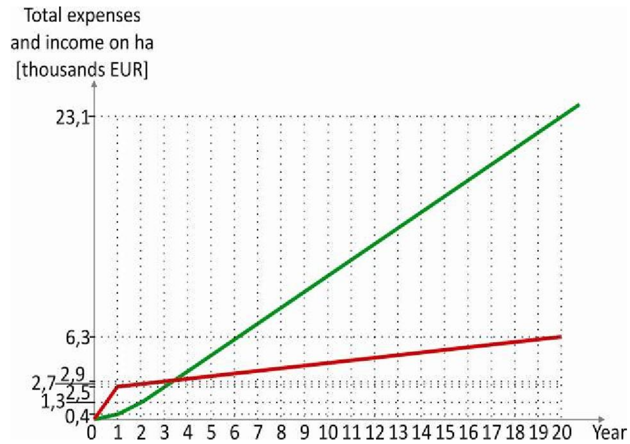

Fig. 8. Total expenses and income curves

3. ENERGY WILLOW FEATURES. COMPARISONS WITH OTHER FUELS.

Through the ages, were created energy willow species resistant to diseases and pests, resistant to various climate conditions (both in warm and cold regions), is proper behaving both in swampy soil and in sandy ones and have a high productivity.

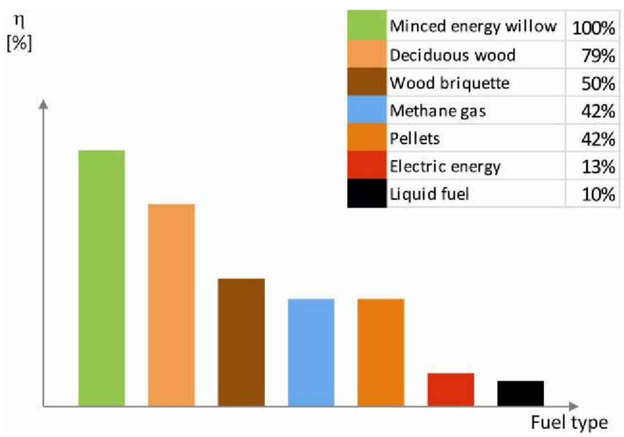

Fig. 9. Heating efficaciousness with various fuel

In one year, it can grow 7 m, during summer it can grow 3÷3,5 cm/day, and it can reach, at base, to a diameters of 7 cm [8].

The energy willow calorific power is 5,7 kWh/kg [5], being greater than the deciduous wood, which is of only 3,1÷ 4,2 kWh/kg.

In Fig.9. chart is observed comparatively data of the heating efficaciousness, as costs, made with various fuels, as regarding the energy willow taken as reference.

It can be clearly that the heating price, using energy willow, is the most advantageous.

In Tab.4. and in Fig.10. are comparatively represented, for various fuel types, the price for producing one kWh of energy [9].

Table 4. The cost for one kWh of energy produced with various fuel types

Fuel name	Calorific power	Fuel price	Produced energy unit price [lei/kWh]
Minced energy willow –30% humidity	4 kWh/kg	0,2 RON/kg	0,05
Deciduous wood – 20% humidity	3,8 kWh/kg	125 RON/mst	0,065
Wood briquette – humidity 18%	4 kWh/kg	0,4 RON/kg	0,1
Methane gas	10 kWh/m^3	1,2 RON/m^3	0,12
Pellets	4,8 kWh/kg	0,6 RON/kg	0,12
Electric energy		0,4 RON/kWh	0,4
Liquid fuel	10 kWh/l	5 RON/l	0,5

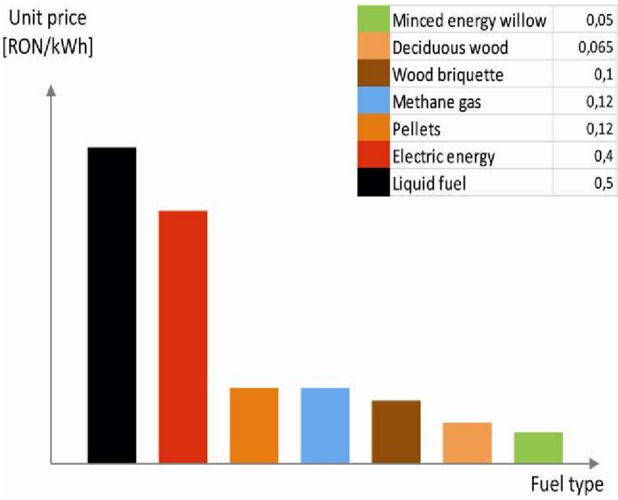

Fig. 10. Cost for one kWh of energy

For example, we are calculating the energy costs for a 150 m^2 building, for which is necessary a quantity of heat Q_C=20kW, meaning that for a whole year we need 3600 kWh. The building has 2,7 m in height inside and we shall provide an average inside temperature of 21^{0}C [9].

We compare the heating of that building in case of using a methane gas central heating station and in case of one using minced energy willow with 30% humidity as fuel.

In methane gas case we need 36000 m^3, with the value of:

$$V=3600\ [m^3]\cdot 1{,}2[RON/m^3]=4320\ [RON] \quad (1)$$

In minced energy willow case we need 9000 kg, with the value of:

$$V = 9000\ [kg]\cdot 1{,}2[RON/kg] = 1800\ [RON] \quad (2)$$

resulting an economy, if we use minced energy willow against methane gas, of:

$$E = 3600 - 1800 = 2520\ [RON] \quad (3)$$

or in percents that is meaning an economy of 58%.

Subsequent, the energy willow can successfully replace the wood, diesel or methane gas, both for realize the heating and form combined production of electric and thermal energy.

Also, we have to take into account that the energy willow have low production cost, for example half of the methane gas production cost.

The quantity of energy willow that can be harvested from 2000 ha is of approx. 100000 t/year, quantity which can heat 14500 houses or can represent the fuel for a cogeneration power plant of 10 MW.

In the Fig.11. chart is represented the dependence between the power and annual quantity of energetic willow for a power plant.

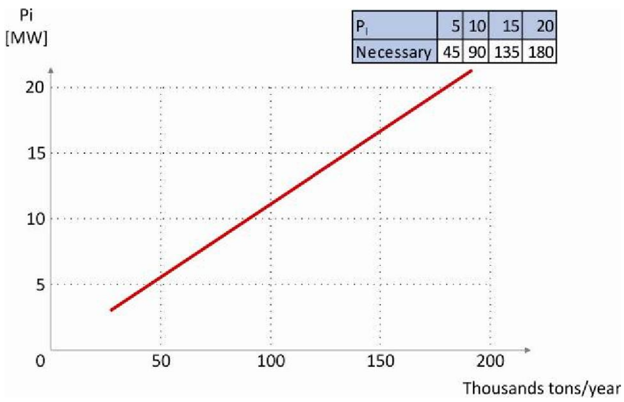

Fig. 11. The dependence between the installed power and necessary energetic willow

The dry energy willow use is preferred because the efficaciousness in this case in 2,5 times higher compared to humid mass. In Fig.12. it can be observed that, drier the willow higher the calorific power.

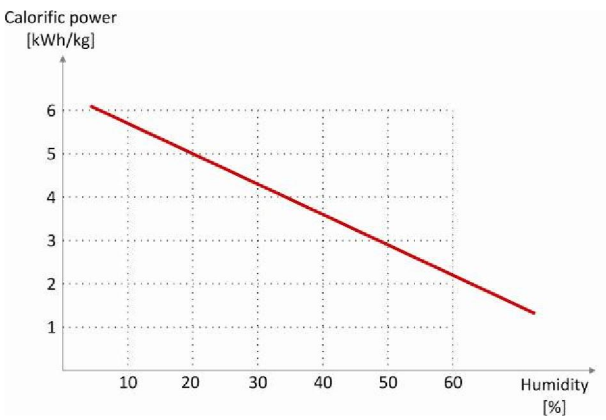

Fig. 12. Calorific power function on humidity

If the willow is stored as mince or as been harvested, in several months, the water content drops to 14÷16 %.

The energy willow can be used as a fuel in various shapes: as harvested and being cut to a certain dimension in order to fit the power station (Fig.13.), chopped (Fig. 14.), briquettes (Fig.15.) or as pellets (Fig.16.).

Fig. 13. Cut willow

Fig. 14. Chopped willow

Fig. 15. Willow briquettes

Fig. 16. Willow pellets

Considerig that through the usage of briquettes an pellets, the calorific power increases, also the storage spaces an a share of transport expenses decrease, in many countries these represent an economic and elegant mode of use for the energy willow. Nevertheless, in our contry, beacuse the briquettes an pellets production expenses are relatively high, it is the most economic to use chopped energy willow.

4. POWER PLANTS WITH BIOMASS FUEL

As stated in the first chapter, in our contry are operating only three biomass power plants. In the picture from Fig.17., is seen an image of the General Electric power plant from Pângărați, Neamț county.

Fig. 17. General Electric power plant from Pângărați

Further are presented several technical data of this power plant:

- P_i=6,5 MW (only one group);
- It uses 200 t/day of fuel (minced wood 60%, wood bark 20%, sawdust 20%);

– It has a 2 ha raw material storage house;

– It is assured a fuel reserve from own storage housees for 2 months;

– The fuel is collected from a radius of maximum 150 km;

– The power delivered in the system (on a 110 kV LES) is averaging 5,7 MW, the difference being the own consumption.

In Hungary, the biomass power plants took a bigger extent then in our country, ranging from small installed powers to big powers (20 MW), like the power plants in Pornóapáti (2x600 kW), Körmend (5 MW), Szombathely (7,5 MW) and Szakály (20 MW).

Here are some technical data regarding the power plant in Szakály:

– P_i=20 MW;

– The necessary fuel is 180000 t/year, for 7500 working hours;

– The fuel is harvested from a radius of 50 km, from 20000 ha of energy willow plantations;

– The willow is bought for 18 EUR/t;

– It offers 100 jobs;

– 30÷50 trucks/day of fuel are necessary;

– It uses chopped willow (99%) with 40% humidity;

– The investment cost: 55 millions EUR.

Considering the great potential that our country is offering, is foreseen in the near future, the realization of many more biomass power plants.

5. ENERGY WILLOW PLANTATION ADVANTAGES

Further are enumerated the advantages of usig energy willoe and of energy willow plantation realizations, not only for thermic and electric energy production, but also from the point of view of climate and environment impact, social aspects, willow usage for other purposes, etc.[3].

Here are the main advantages:

– The willow briquettes and pellets burn better then wood, diesel and gas, being able to successfully replace these fuels;

– By plating energy willow the forrests are protected by reducing deforestations;

– The harvesting is made while vegetation break (november – march) when the agricultural equipmens are not used for other operations;

– The plantations are suited for silty soil, with pH 5,5÷6,5, but they resist also on sterile soil with pH 3,5÷10, even though the production is smaller;

– Uncultivated, derelicted, swampy, sandy terrains, etc. can be used;

– The plantations cand form protection strips for river dykes and forests;

– It can be used for steep slopes fixing and also for preventing landslides;

– It represents an adequate envrionment for hunt animals;

– They can take annually 20÷30 t/ha of mud resulted from waste water purge;

– They assimilate carbon dioxide and produce oxygen;

– Are creating jobs both on plantations and in willow selling units;

– Can be an important cellulose source, therefore is suitable for paper industry;

– High evapotranspiration capacity (15÷20 l/m2/day), consequent the plantation can be used to elutriate waste water, a biologic purge not being necessary anymore;

– Having a high content of salicinium, it can be used to produce aspirin;

– Also, because of the high salicinium content, the minced willow does not need closed storage housees;

– It resist very well to degradation durig storage as mince;

– It can constitute raw material for fabrication of metilic alcohol;

– It can be used as bulding material (fences, dykes) or as trellises or props in vegetable crops.

6. OBSERVATIONS AND CONCLUSIONS

Considering the multitude of advantages presented by energy willow cultivation, is imperative to increase the surfaces cultivated with this energetic plant.

In order to encourage the actual and future producers, the legislation in this domain should be actualized and concomitantly subventions should be granted to the producers.

Concomitantly, considering the great potential that our country have regarding energetic plants cultivation and taking into acconunt the European directives, the surfaces cultivated with energetic plants should rapidly grow in order to constitute a sure source and in sufficient quantities as fuel for energetic power plants.

Having a high calorific power, small production expenses, high productivity and high energetic efficiency, the energetic willow should constitute the main fuel for biomass energetic power plants.

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