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PATHWAYS OF IMPLEMENTING FOR FAST-GROWING WILLOW TO ENERGY PURPOSES IN ROMANIA[138]

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Abstract: *The paper follows the Life Cycle Analyze of the fast-growing willow from the land & soil characteristic till heat and/or electricity generation.*

There are analyzed the soil capability, the agricultural technologies for crops creation, exploitation, harvesting and storage. At the end are presented new combustion apparatus suitable for this kind of renewable fuels.

Keywords: *Fast-growing willow, Crops technologies, Combustion apparatus*

INTRODUCTION

Willow comprises over 400 species in the Salix genus. The species ranges from large weeping willow trees to dwarf alpine shrubs. Willows are naturally found in cold to temperate climates, including the northern Hemisphere. In the nineteenth and early twentieth centuries, willow was used to make baskets and furniture. It also has strong analgesic properties (salicylic acid) in the bark from which aspirin was derived. Energy willow is a very attractive biomass crop because it is high yielding, fast growing, requires few inputs, has multiple stems, and resprouts after being cut. The energy willow reaches heights of 5 to 9 m in 3 years and 4 to 6 tons per acre per year. Substantial breeding and research trials in recent years show promise for higher-yielding cultivars in the near future [1].

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Cultivation of short-rotation willow coppice was introduced in Sweden after the oil crisis in the 1970s, with the intention of replacing fossil fuels by new energy sources. Extensive research to identify fast-growing species that could be grown intensively for use in energy production suggested that willows grown in coppice systems were the most suitable. Nutrient utilization and stand management were seen to be more cost efficient for willow than for other woody species, and short-rotation willow coppice proved to be a sustainable way of producing fuels that were carbon dioxide neutral, since burning of the biomass would release into the atmosphere the carbon dioxide that the plants had taken from the air. About 16 000 ha of willows in short-rotation coppice systems are currently grown in Sweden, consisting mainly of different clones and hybrids of Salix viminalis, S. dasyclados and S. schwerinii. [2]

Energy willow is a crop that grows quickly and can provide energy for cogeneration in the form of wood chips. Today there is grown energy willow at around 1500 hectares in Denmark, but this figure is steadily increasing [3].

Today, in Romania, energy willow crops are booming, the cultivated area is over 5000 ha. In 2013, Covasna County held its first energy harvesting willow, with a production of 50 t/ha at harvest moisture of 50%. Other cultivated areas are in Harghita, Brasov, Giurgiu, Suceava, Teleorman Counties.[9]

The advantages of growing energy willow are [4]:

- willow trees will grow on a wide range of soils, including on marginal land and areas subject to occasional flooding. This makes them ideally suited to underutilized crop land.
- plantations require little maintenance, including minimal fertilizer and pesticide application.
- once established, willow yields surprisingly low lifetime production costs.
- hybrids have been specially bred to increase resistance to pests and disease.
- are readily established by planting unrooted cuttings and have proven to be a reliable crop.
- willow varieties are bred for upright growth to promote efficient harvesting. Once harvested, the willow plants do not need to be replanted – they grow right back.
- depending on local climate and soil conditions, willow crops can be established and harvested in two or three year rotations.
- purpose-grown willow consistently delivers high-quality, carbon-neutral energy, making it a smart choice of fuel.
- willow crops typically provide consistent yields for 25 to 30 years.

With a productivity of up to 40 tones/hectare wooden mass in 2-3 years, the energy willow can ensure the quantity of the basic raw material for different applications in order to obtain compacted wooden products like solid bio-fuel (pellets, briquettes) or direct combustion products to produce energy and / or electrical power.

I. TECHNOLOGIES FOR CROP ESTABLISHMENT AND HARVESTING OF ENERGY WILLOW

At the establishment of an energy willow crop must be respected a calendar which consists in [5]:

Previous year of planting: establishment of location; preliminary preparation of the land; ordering of cuttings;

In the 1st year: combating of weeds, land preparation, planting; treatment with herbicides; Combating mechanically of weeds; harvesting;

In the 2nd year: mechanical hoeing; fertilization.

The Salix plantations have in the 1st year a yield of about 10 to 15% of the yield of a mature plantation (a plantation is mature from the year three). This year develops the root and strengthens

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the plant. In the year 2, the resulting output is approximately 30-35 % of the yield of a mature plantation. Starting from the year 3 is the maximum yield (30-35 t/ha, at a humidity of approx. 30%), which is maintained in all subsequent years. In figure 1 are shown the energy willow seedlings used for crops formations (Figure 2).

Figure 1. Energy willow seedlings [4]

Figure 2. Seedling plantation [8]

Figures 3 and 4 shows the crops at 1 year and at harvesting (4 years).

Figure 3. One year crop

Figure 4. Harveting

In figure 5 are represented the wood chips, while the figure 6 is the indoor storage.

Figure 5. Willow chips

Figure 6. Indoor storage

The estimated cost of the implementation of a willow crop including harvesting is about 2700-2800 €/ha. Considering that in Romania it will be used 500000 ha with low potential to create crops of fast-growing willow in 10 years, the economic figures should be next [10]:

- Costs for crops implementation: 750.000.000 EUR;
- Harvested biomass: 50.000.000 t/in first 10 years;
- Total harvested biomass (25-30 ani): 300.000.000 t;
- Energy obtained from biomass: 1.046.000.000 MWh;
- Value of the energy obtained from biomass: 83.680.000.000 EUR.

II. CONSTRUCTIVE AND OPERATIONAL CHARACTERISTICS OF BOILERS USED FOR ENERGY WILLOW BURNING

The various solutions for the boilers burning chopped energy willow stems depend mainly on the thermal power of the installation and its destination, that is the combined heat and power (CHP) usage or just the heating of private or public buildings, schools and production spaces such as green-houses or small factories.

Two main types of installations are used: one with cilyndrical horinzontally placed body having flame tube and the other with vertical rectangular water box and furnace chamber. The first type is developed from installations with briquetted straw as fuel and the second type from installations that use wood chops as fuel.

If the thermal power is bellow the 35 to 50 kW thermal power range, there is no convective heat exchanger after the furnace. For boilers with greater thermal power there could be one, two or even three way heat exchangers, that have the hot fumes circulating through pipes and the water outside of them, and are placed horizontally or vertically, with different solutions for cleaning the fume pipes of the ash deposits. Various solutions have been developed usually of helical screw type, with electricaly driven and automated systems. This solution has a also a beneficial effect in intensifying the heat echange processes by the swirling motion of the fumes.

For the furnace construction, one solution is that of fluidized bed the other being of that of fixed or mobile grate, with the willow chops being delivered by a two screw feed system, the resulting ash being extracted by means of of lateral screw systems.

Figure 7. 40 kW ERPEK boiler

Figure 8. The flame inside the 40 kW boiler

The parameters of the fuel feed system are controlled by a photoelectric cell and the fuel is transported by the mobile grate across the furnace floor, that have the stroke and velocity adjusted according to the fuel characteristics (granulation and humidity).The secondary air flow allows a complete combustion and also has a cooling role for the external walls of the boiler, which are covered by a refractary mantle, in order to maintain a temperature high enough (750°C to 850°C) to avoid slugging of the pipes in the convective heat exchanger.

The burning process is controlled by a microchip electronic system having as input the water temperature at the exit from the boiler or the temperature to be maintained in the living or in the working spaces.

Figure 9. The 175 kW boiler

Figure 10. View to the containers for fuel storage

For the medium and large power boiler (as presented in the Figure 9) a standardized container transport and distribution system is used for reducing the fueling time (Figure 10).

CONCLUSIONS AND FUTURE WORK

During the last decade the fast growing willow crops have gained momentum and also a greater part in the biomass use for energy purposes. The approached used has an integrated frame from the soil preparing, planting and crop maintaining to harvesting, transport and storage and it is connected to the boiler development.

The next logical step is to create steam boilers to be used for CHP, in order to have an increased economic efficiency by using the support mechanisms for the renewable energy resources.

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