BIOMASS AS UNIVERSAL ENERGY SOURCE FOR DECENTRALIZED HEATING AND ELECTRICITY PRODUCTION OF SMALL CITIES

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ABSTRACT

This paper deals with analyse of possible usage of biomass power plants for heating and electricity production in small villages and cities. The aim is to describe applicability of such plants in combination with other renewable energy sources in certain parts of electrical grid. Communities, such as local villages and small cities with agricultural companies or wood industry, can advantageously use residues from this production to produce electricity and heat. In paper, a case study for such heat and electricity system for such small city is presented.

1. INTRODUCTION

In present time, there are certain aims to slow down the phenomena of global warming. Some countries, such as Germany, have chosen their way with extensive use of renewable energy sources (RES). Connection of these sources with high installed power into a few points in transmission systems (e.g. connection of large-scale wind parks) can induce large power fluctuations, which can lead to instability of power system, and can induce additional costs, due to higher demands which are put on regulatory power reserves. This can lead to even increasing CO2 emissions, due to lack of regulatory power produced by non-CO2 producing sources. In present time, extensive use of shale gas in United States causes deformation of worldwide natural gas prices. Gas prices, together witch emission allowance prices and lowering coal prices are causing the situation, occurring mostly in Germany, when it is cheaper to operate old, ineffective coal units, with high amount of emissions. Also, switching off all nuclear power plants in Germany suddenly, from one day until another, is not helping with handling of this situation. [1]

Another problem, caused by characteristic nature of electricity, or energy in general, is that the human mankind has enough amounts of energy, to fulfil all its needs, but not in right place in right time, or in right form. From view of electricity, installed power of power plants in European countries is exceeding its current needs, from the view of actual power consumption according period of the year. Renewable energy sources, concentrated on the certain area, are often producing electricity, which grids are not able to transport to places with higher consumption. Therefore power system is not balanced, and in some control areas some units should be turned off, and in other countries some units should be turned on. Building of new power lines is often faced with many problems with land owners, environmentalists, and also with lack of financial resources.

In the past, large power plants with high installed power were built, where demand on higher efficiency of electricity production was put. This induces also need for building large transmission lines. Recent effort, which was put into building of renewable energy sources, went in the way, in which renewable sources were built as large-scale power plants. But in last few years, operational experiences has shown, that sudden increase or decrease of electricity production from large-scale renewable sources, such as wind parks in Germany, can induce problems in power systems of many other countries, not only in Germany.

Because of this fact, it can be worth to think about, whether or not it is possible to include small decentralized electricity production into energy mix. Combination of electricity production from small photovoltaic panels on public buildings, small wind turbines (where applicable), and biomass

produced electricity (combined with heat production), can help to reduce transmission losses and also can help to use some residues from agriculture and forestry, which are produced in rural areas.

2. BIOMASS SOURCES AND UTILISATION

Biomass is biological material derived from living, or recently living organisms. It most often refers to plants or plant-based materials. Wood is still our largest biomass energy resource. But many other sources of biomass can now be used, including plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes.

Biomass can be used as energy source directly, via combustion to produce heat, or indirectly by converting it to various forms of biofuel. Biopower, or biomass power, is the use of biomass to generate electricity. There are six major types of biopower systems: *direct-fired, co-firing, gasification, anaerobic digestion, pyrolysis, and small, modula*r. [3]

Many coal-fired power plants can use co-firing systems to significantly reduce emissions, especially sulphur dioxide emissions. Co-firing involves using biomass as a supplementary energy source in high efficiency boilers together with coal. Gasification systems use high temperatures and an oxygen-starved environment to convert biomass into a gas (a mixture of hydrogen, carbon monoxide, and methane). The gas fuel runs the gas turbine, which turns an electric generator. Anaerobic digestion involves using bacteria to decompose organic matter in the absence of oxygen. Methane can be used as an energy source in many ways. Most facilities burn it in a boiler to produce steam for electricity generation or for industrial processes. Two new ways include the use of microturbines and fuel cells. Microturbines have outputs of 25 to 500 kilowatts. In addition to gas, liquid fuels can be produced from biomass through a process called pyrolysis. Pyrolysis occurs when biomass is heated in the absence of oxygen. Several biopower technologies can be used in small, modular systems. A small, modular system generates electricity at a capacity of 5 megawatts or less. This system is designed for use at the small town level or even at the consumer level. For example, some farmers use the waste from their livestock to provide their farms with electricity. Not only do these systems provide renewable energy, they also help farmers and ranchers meet environmental regulations. [3]

In Slovakia, there are many villages and cities, which are surrounded by forests and fields. Some of forests are even owned by municipality, or municipality has some share in such companies. This gives an opportunity to include residues from agriculture or forestry into energy mix of city or village to produce electricity and heat for public buildings (city hall, community centres, churches, swimming pools, schools, etc.). According to [5], biomass has high potential in Slovakia, around 60 458 TJ yearly. As biomass can be mainly used wood, residues from wood industry, and also so called energy vegetation.

Table 1 – Technically usable biomass potential of Slovak republic [5]

Biomass source	Technical potential (TJ/year)	Current usage	Unused potential
Forest biomass Before 2010 After 2010	 10 180 20 242	1 778	8 402
From this: energy vegetation Before 2010 After 2010	 1 635 5 006	372	1 263
Residues from wood industry	17 570	9 497	8 073
Agricultural biomass	32 708	216	32 492

From this short analysis it can be seen, that biomass in Slovakia has still large space for increasing the amount of its usage. In next chapter, we will present some ideas for biomass utilization in decentralized electricity and heat production.

3. PROPOSED BIOMASS UTILIZATION

As we mentioned before, it is possible to reduce local electricity prices, lower electricity transmission loses, lower heat prices and to process waste product from agricultural production and from forestry. In this chapter, we will present a fictional case study for such small city, which decided to increase biomass utilisation.

Figure 1 – Small biomass power plant

Let's consider small city, with around 20 000 citizens, somewhere in northeast Slovakia, surrounded from north with forests, and from the south, with fields. Large areas of forests are owned by municipality, which is selling wood, and have certain residues from forestry. Also local farmers are producing enough straw, and are considering cultivating fast growing energy vegetation, such as cottonwood. In city are also built three heating collectors, which previously served to distribute heat from boiler houses to flat houses in the city. Boiler houses were converted from coal to gas fuel, to improve their efficiency and to reduce CO2 and NOx emissions.

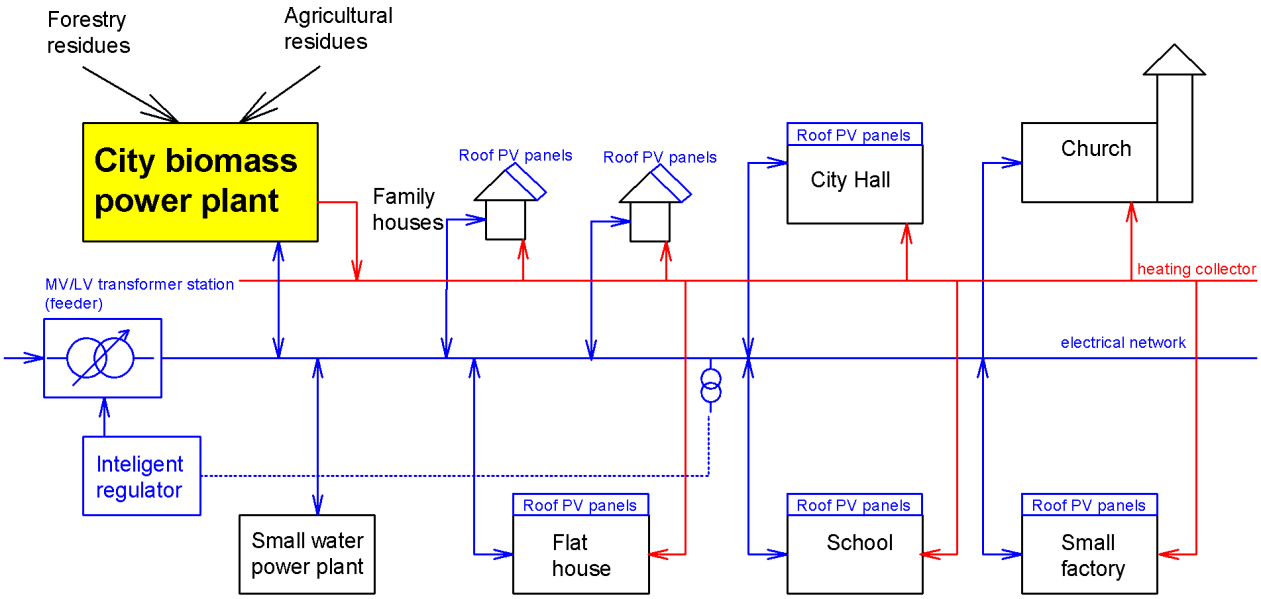

Figure 2 – Proposal of biomass utilization for small city heating and electricity production

Therefore, city has enough fuel resources to build biomass power plant, which will produce heat and electricity for city, and also have good background for improving its energy mix. By interconnecting three separated heating collectors into one, and by improving their thermal insulation,

city can have great opportunity to distribute heat, or even cooling to public buildings, factory, flat houses, and also to small, family houses. Boiler houses will stay in service, due to improve efficiency of heat production, which means, that there is no need for biomass power plant to have so great installed heat power to cover whole consumption of heat for city during most coldest days in winter, or they can supply the city with hot water and heat during planned or unplanned outages of biomass power plant.

From view of electricity, city can reduce its electricity price by using electricity from local sources. Photovoltaic (PV) panels can be installed on public buildings, houses, and biomass power plant operation, together with small water power plant operation can be optimized to react on PV production decreases or increases during passage of clouds, or during days with forecasted cloudy weather. This can decrease city dependence on electricity from outside grid. Intelligent regulator in local transformer station is used to regulate transformer voltage according sensor measurement, to keep voltage in prescribed limits for each customer.

4. CONCLUSIONS

Decentralized heat and electricity production can decrease dependence on external sources from distribution grid for such local city. It can also help to increase share of RES on overall energy mix. Such technologies and ideas are therefore more important to implement and research, than building large-scale RES, because smaller, decentralized sources are reducing demands on regulatory power and power system control. Also, from environmental point of view, biomass, and also waste incineration plants are helping with better waste treatment – residues from agricultural production, from wood industry and from forestry can be processed very near to the place of their production, which also reduces transport cost. By wise subsiding of local municipalities, whole local region can reduce problem with waste and can reduce heat and electricity prices rapidly. This itself can motivate public opinions to support building such decentralized systems.

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