Renewable and Sustainable Energy Reviews 67 (2017) 426–436

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Short-term boosting of biomass energy sources – Determination of biomass potential for prevention of regional crisis situations

Kamila Vávrová [a,*], Jaroslav Knápek [b], Jan Weger [a]

[a] Department of Phytoenergy and Biodiversity, Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Publ. Res. Inst., Květnové nám. 391, 252 43 Průhonice, Czech Republic

[b] Czech Technical University in Prague, Faculty of Electrical Engineering, Dept. of Economics, Management and Humanities, Prague, Czech Republic

ARTICLE INFO

Article history:
Received 7 April 2015
Received in revised form
17 August 2015
Accepted 7 September 2016

Keywords:
Biomass potential
Crisis situation
Energy crops
Straw
Logging residues
GIS

ABSTRACT

The article deals with the evaluation of the hypothesis that long-term sustainable potential of solid biomass (the so-called standard potential) for energy purposes can be significantly increased in the short run when breaking some constraints assumed for biomass growing, collection and utilization. Evaluation of biomass potential (both standard and additional) is based on a developed methodology using detailed spatial and empirical data (GIS). Potential is determined for the defined area using a bottom-up approach where these yields are derived in relation to climate and soil conditions of each land plot of agricultural and forest land. Results of methodology testing have proven that biomass potential from agriculture and forest land can be significantly increased in the short run (typically from 18% up to 40% in our case studies depending on biomass source and region). There are three major sources of additional biomass potential: reduction of straw ploughed into soil, changes in utilization of harvested timber from forests and shortening of rotation of SRC plantations. Performed analyses show great variations of biomass potential between the regions depending mainly on composition and age distribution of the forests stands in studied regions of similar size.

© 2016 Elsevier Ltd. All rights reserved.

Contents

* Corresponding author.
E-mail addresses: vavrova@vukoz.cz (K. Vávrová), knapek@fel.cvut.cz (J. Knápek), weger@vukoz.cz (J. Weger).

http://dx.doi.org/10.1016/j.rser.2016.09.015
1364-0321/© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

Biomass plays a decisive role in the portfolio of renewable energy sources in the EU. The total contribution of RES to the primary energy sources in the EU reached 7423 PJ in 2012 (22.3% of the total primary energy sources). Of this amount, biomass contributed about 65.5% [1].

RES play an increasingly important role in the context of the EU energy policy. In October 2014, strategic objectives in climate and energy policies were approved [2]. Those objectives include, inter alia, an additional increase in the share of RES in the final energy consumption up to 27%. Longer-term objectives of the EU (Energy Road Map 2050) work with even more significant objectives in the field of RES and direct the energy industry in the EU towards decarbonisation [3].

In the Czech Republic, the share of RES in primary energy sources reached 8.7% (157 PJ) in 2013, while the share of solid biomass was app. 60% of total RES contribution. After adjusting for the contribution of liquid biofuels and biogas, the total share of biofuels is 83% of the total contribution of RES to primary energy sources [4].

Biomass is, both in the context of the entire EU and the Czech Republic, the RES with the greatest potential for development. The main sources for the future development of biomass as an energy source are, first, the use of residual biomass after logging in forests, and in particular the use of agricultural land for targeted cultivation of biomass for energy purposes.

Czech Republic can increase its biomass potential by app. 40% from 120 PJ in 2014 to 165 PJ in 2030 by growing energy crops on farmlands while maintaining food security [5].

Biomass, unlike other types of renewable energy sources, has many benefits arising from its character. Its logistics and use are similar to those of conventional fossil fuels especially of brown coal that still plays a significant role in the Czech Energy Statistics in contrary to most Western European countries (about 40 mil. tonnes of brown coal and 9 mil. tonnes of hard coal was mined in 2013, low quality brown coal is still massively used for local and centralized heating [6]):

- Biomass can be relatively easily stored and transported.
- Biomass can be modified to biofuels and thereby increase the possibilities for its use in terms of installed technologies in the electricity / heat producing plants or by final consumers.
- Biomass potential in a given location can be increased (mobilized) if necessary as an additional source of energy in the event of disruptions in the supply chains of conventional fuels (for instance due to natural and political reasons).

As a local source of energy, biomass contributes to the achievement of the pillars of the EU energy policy – i.e., to ensure both a reliable energy supply and energy security. Biomass also allows decentralization of energy systems and is suitable as a fuel especially in areas with lower population density and locally available biomass sources.

As a local and domestic source biomass can also contribute to the diversification of fuels used for power generation and heat production. Biomass cannot substitute fossil fuels in full. For example, in the Czech Republic consumption of fossil fuels was app. 1350 PJ, of which app. 700 PJ was from coal, while the total solid biomass consumption was only 86 PJ. In the long run, however, the contribution from solid biomass is expected to reach 160 PJ by 2040 [7], thus increasing the reliability of heat and power supply on local levels. In the Czech Republic a significant portion (app. 38% in 2012) of households is supplied with heat from centralized heating systems from a central source of heat (heating plant). Heating plants here usually have several boilers that enable diversification of the fuel source used. Identification of standard and also additional biomass potential can provide valuable data when preparing development plans for future heating systems especially taking into account preparation for potential situations when conventional fuel delivery may not function (e.g., problems in natural gas import, problems in logistics chains etc.) – as described in Section 2.1.

1.1. Task and novelty – biomass and crisis situations

The aim of the work presented in this article is to verify a hypothesis that biomass potential from agricultural and forest land for electricity and heat production can be significantly increased in crisis situations (which are characterized with the lower availability of conventional fossil fuels – namely of coal and natural gas).

To test this hypothesis, a methodology for evaluating biomass potential was developed and tested on case studies using GIS tools and detailed spatial data (soil, climate, yields, protection of nature and other sources).

The main novelty of this work is its focus on evaluating "additional" biomass potential as fuel for local or regional energy crisis situations, which are predicted to happen more frequently in the EU for multiple reasons. The causes of these crisis situations include a high dependency on energy sources from politically unstable regions, climate extremes due to climate change and unfriendly human activities such as acts of terrorism, wars and social clashes.

Validation of the hypothesis and quantification of additional biomass potential for a given region or country potentially offer important data when preparing developmental strategies of energy and related infrastructure (considering also energy security issues) and also when preparing crisis management plans (for different levels from local to state) on how to operate the so-called critical infrastructure during a crisis situation. The lack of conventional fuels or problems in their logistics chains is a possible critical situation that could occur. In this context, assurance of heat and power generation to meet the minimum requirement to run components of critical infrastructure (e.g., hospitals, transportation systems, food assurance etc.) plays an important part of the process.

Biomass in principle is a very heterogeneous category; different types of biomass often have significantly different parameters either in terms of the calorific value or of the technology (or the technological constraints) for its use. In many cases, the supply of biomass from local sources (in the vicinity of heating plants or power plants) could be significantly increased in the short term. If the infrastructure of these resources is not prepared for this, however, then it is a purely hypothetical increase in the biomass potential without the possibility of specific immediate use. Increase of biomass utilization (as the potential substitute for conventional fuels) needs proper preparation of the energy infrastructure to ensure preparedness for potential biomass utilization (e.g., diversification of boiler technologies in heating and cogeneration plants).

Identification of additional biomass potential in a given territory (as the time-limited increase of conventional – long-term available biomass potential) requires among other steps, respecting the conditions of individual land plots in the analyzed territory – e.g. their soil and climate conditions (which also reflects water availability), potential biomass losses thanks to adverse relief of surface, etc.). The methodology uses a "bottom-up approach" (i.e., derivations of expected biomass yields according to the soil and climate conditions and respecting other constraints like biodiversity protection etc.). It is implemented in a GIS environment enabling modelling of standard and additional biomass for

Download English Version:

https://daneshyari.com/en/article/5482746

Download Persian Version:

https://daneshyari.com/article/5482746

Daneshyari.com