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Model for evaluation of locally available biomass competitiveness for decentralized space heating in villages and small towns

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ABSTRACT

The paper presents the methodology and the case studies for condition of the Czech Republic of BICOM - BIomass COmpetitiveness Model. The model consists of the following modules: (1) the identification of a biomass potential in a given area using GIS modelling (based on climate and soil conditions), (2) modelling the biomass price (using the methodology of the minimum price from the producer's point of view and evaluating the opportunity cost of conventional agriculture production), (3) modelling the biomass processing and logistics, (4) modelling economic competitiveness of the biomass and coal utilization. Typical price range (without VAT) is 6.9–9.8 EUR/GJ for pellets produced from residual biomass and 7.6–12.4 EUR/GJ for pellets produced from energy crops based on our calculations. Typical price range of coal suitable for local heating is 4.8–5.5 EUR/GJ (without VAT). To reach competitiveness of locally produced solid biofuels introduction would be needed of combination of measures aimed at reduction of minimum price of produced pellets (e.g. subsidies for pelleting technology, improved yields and lower losses) and some measures aimed at restrictions imposed on brown coal (e.g. increase of ecological tax). Saved carbon is calculated for replacement of brown coal by pellets from local biomass, which could be used as argument and benchmark for subsidies targeted on the solid biofuels production from local biomass.

1. Introduction

Biomass can play a significant role in substituting fossil fuels for space heating and hot water preparation on a local level. The Czech Republic is an example of the country, where solid fuels, namely domestic brown coal, are still massively utilized for this purpose, esp. in smaller towns and villages.

A total number of flats in the Czech Republic are 4.75 mil., according to Census 2011 [1], and app. 88% of a total number of flats is inhabited. App. 47.4% of flats is situated in family houses and 51% in blocks of flats (residential buildings). Historically, the flats in residential buildings are dominantly heated from the centralized heating systems (74% in 2001 and 80% in 2011), while the heating of the flats in family houses is primarily based on local boilers and local in-house heating systems (78% in 2001 and 89% in 2011). About 34% of boilers in family houses use solid fuels. About 9% of flats in family houses is heated by the stoves in individual rooms [1]. A dominant type of solid fuel is domestic brown coal.

Coal plays a significant role in heating houses, esp. in small villages in rural areas – typically between 27% and 33% in villages with less than 1000 inhabitants [1]. The importance of coal diminishes in the places with an increasing number of inhabitants – e.g., in towns with more than 20 ths. inhabitants, the proportion of coal is only 3–5%, while centralized heating systems predominate.

Biomass is important fuel esp. in small villages under 2000 inhabitants where there are 24% of all inhabited flats (4.1 mil. flats) in the Czech Republic. Local biomass (fire wood, wood briquettes, pellets) is used for heating in 21% flats, while coal in 25% flats (villages under 2000 inhabitants). Share of biomass and coal is even higher in case of smaller villages below 1000 inhabitants (24% and 29%, respectively). Similarly, as in case of coal, biomass plays

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minimum role in the cities over 20 ths. inhabitants with share only about 1% [1].

Detailed information on individual local boilers and stoves used for heating family houses is available in specialized energy statistics issued by the Ministry of Industry and Trade [2]. According to this statistics, nearly 730 000 households burn solid fuels as the primary fuel for space heating. Solid fuels are used even in newly built family houses – app. 16% (of which fire wood makes 55%, coal 39% and only 6% are pellets) [2].

Despite the governmental programs supporting the substitution of outdated coal boilers in family houses either for biomass boilers (e.g. pellet boilers) and heat pumps, thousands of households still use brown coal as the primary fuel for space heating. Burning low quality coal (esp. in outdated coal boilers) results in relatively high local air pollution in many smaller villages and towns. There are two major reasons why burning fuel in coal boilers predominates at present: (1) space heating based on domestic brown coal is the cheapest option (fuel costs are app. 220 EUR/year for a family house with 150 m^2 of the floor area and thermal losses equal to 7 kW for the reference temperature −15° C); gas and pellet boilers have almost two times higher fuel costs (1.9x) and the most expensive option is the electric boiler (fuel costs are 3.1 times higher); (2) the substitution of outdated coal boilers either for a modern one or for other types of boilers requires high costs (typically between 1900 and 3800 EUR) – for details see Ref. [3]. The cheapest option is to substitute coal boilers either for wood boilers, or pellet and gas boilers (fuel costs are app. by 20% higher). And in many smaller villages (where natural gas is not available), biomass (pellets, briquettes and firewood) and heat pumps are by far the most important substitutes for coal boilers or individual stoves. Heat pumps are characterized by very high initial purchase and installation costs (2–3 times higher compared with wood or pellet boilers), which reduces their competitiveness, esp. in rural areas, where household incomes are below the country average.

The substitution or reduction of massively used coal boilers started to be not only an environmental problem, but it also gained political and social aspects in the last decade [4]. Available resources of cheap domestic brown coal, mostly used as fuel in boilers for individual space heating (heating value app. 16–17 MJ/kg), are limited and quickly running out, in the contrary to the “energetic” coal which is used in big coal-fired power and cogeneration plants (here, the heating value typically ranges from 10.5 MJ/kg to 12 MJ/kg). Therefore, the substitution of local coal boilers started to be more and more urgent problem to solve – see Ref. [4].

There are two main support programs of Ministry of the Environment, which are aimed at promotion of biomass for individual heating in households. New Green Savings Programme is opened in the horizon of 2014–2021 and is financed from the sell of emission allowances. This program supports energy savings (e.g. installation of new windows, recuperation, facades isolation), building of new low energy or passive houses and exchange of low effective heating devices (typically old coal and gas boilers) with heat pumps, condensation gas boilers, biomass boilers and modern coal boilers. In case of exchange of coal boiler with modern biomass boiler the subsidy is 50% of eligible cost (similar support is also for other modern devices). Total allocated finances are 454 mil. EUR in Axis II aimed at improvement of air quality incl. the exchange of heating devices in households [5]. Second support program, so called “boiler subsidies” is directly aimed at replacement of old “non ecological” boilers used for individual space heating (mostly old coal boilers). This program gives preference to most polluted regions and also to the biomass boilers and heat pumps where subsidy amounts up to 80% of eligible cost. Total amount of financial sources for the call in the year 2017 is 126 mil. EUR. It is expected that around 35 ths. old boilers will be replaced with the new ones until 2019 [6].

Locally available biomass is thus one of the possibilities in the portfolio for substituting coal used for individual space heating in villages and areas with unavailable natural gas. The substitution of coal for biomass and other technologies (e.g., heat pumps) can significantly improve air quality in villages and reduce the threat of the lack of coal in the future.

2. Material and methods

In making decision how to substitute coal for locally available biomass for space heating successfully, the decision makers should consider the following important aspects:

a) Availability of biomass in a given site (the surroundings of the village or town), i.e., the absolute biomass volumes and the structure of available biomass
b) Price of biomass available at a given site
c) Biomass processing and its logistics – cost, energy losses during the storage and biomass processing itself
d) Costs on a current way of space heating – the price of 1 GJ effectively used for space heating
e) Cost of heating technology substitution (e.g., the cost of the coal-to-biomass substitution, including indirect costs such as fuel storage, etc.)

2.1. BICOM – Biomass competitiveness model

2.1.1. Model BICOM consists of four modules

- Module A: Modelling available biomass potential in the analyzed area
- Module B: Modelling raw biomass price
- Module C: Cost of raw biomass conversion into solid fuels (briquettes and pellets) and complete logistic chain of biomass
- Module D: Evaluation of competitiveness of solid biofuels with domestic brown coal

Structure of the BICOM model is presented in Fig. 1.

2.2. Potential of available biomass

A crucial aspect of the successful development of biomass utilization for space heating of family houses and other buildings in smaller villages and towns is an appropriate identification of a biomass potential for energy purposes. In this type of task, the biomass transportation for longer distances (typically more than 10 km) is not considered. The transportation of raw biomass (which has typically relatively low heating values) would significantly increase its cost of production.

Biomass utilization for energy purposes, namely for power generation and heat production, has been boosted with the start of a systematic support of the RES utilization. In the Czech Republic, similarly to other EU countries, a massive development of the biomass utilization started in the middle of the last decade (one of the reasons was targeting the share of the RES electricity defined by the EU Directive 2001/77 in the year 2010). In many cases, biomass was one of the cheapest options to generate “green” electricity. Biomass can be, for instance, relatively easily added into coal used in coal-fired power plants, where the biomass content is usually between 5 and 20%, depending on the burning technology. Fast introduction of this technology resulted in a rapid growth of biomass utilization, namely, the utilization of the biomass wastes from wood processing industry. Further, it resulted in quick

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