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Potential for bioenergy development in Latvia: future trend analysis

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Abstract. The paper discusses development trends of bioenergy production and use in Latvia. A methodology for the assessment of biomass potential was developed and applied to a Latvian case study. Four scenarios were built to analyse the potential of biomass supply for energy needs and energy costs. The biomass resources considered are forestry residues and by-products, energy crops, and agricultural residues.
The evaluation is performed on the basis of historical data analysis and literature review applying indicators with sufficient levels of information aggregation and adequacy. Future bioenergy development patterns are assessed from technological, ecological and environmental points of view. The analysis focuses on currently initiated cogeneration plant and boiler house projects (planned to be finished in two years' time) and maximum available bioenergy resources in country.
The analysis indicates the biomass potential available for energy needs in the range of 25–30 TWh per year in 2020, of which circa 15 TWh were used in 2011.

Key words: bioenergy, biomass potential, wood fuel.

INTRODUCTION

Biomass is the most developed renewable energy source with a large number of applications starting with direct heating for industrial or domestic purposes and ending with electricity generation or production of gaseous and liquid fuels. The flexibility of biomass as an energy carrier has led to development of a wide range of biomass conversion technologies and growing biomass share within the global energy balance. According to Eurostat bioenergy makes up over two thirds of the European Union's primary renewable energy production. However, the potential of biomass is not fully harnessed. Furthermore Voivontas et al. (2001) argue that the share of biomass in regional energy balances is rather low.

Published estimates of the potential of bioenergy differ from source to source mainly due to the application of various methodologies, assumptions and datasets. The Special Report on the Renewable Energy Sources and Climate Mitigation (SRREN) of the Intergovernmental Panel on Climate Change recently concluded that the total bioenergy potential in 2050 is to be in the range of 50–500 EJ per year depending on the scenario. Also a number of other studies point out the potential of bioenergy to fall within the given range, e.g. Haberl et al. (2010) estimated the global technological biomass potential to be 162–267 EJ in 2050 and Thran et al. (2010) expected to have 96 EJ of energy crop potential in 2050.

Previous studies (Voivontas et al., 2001; Batidzirai et al., 2012) outline four types of bioenergy potential indicators: (1) theoretical potential, (2) available potential, (3) technical potential, and (4) market or economic potential.

The theoretical biomass potential is defined as the maximum amount of terrestrial biomass (agricultural, forestry and other residues) which can be considered theoretically available for bioenergy production in a certain region. It depends on the type of crops and the area of cultivated land as well as limitations that result from the temperature, solar radiation and rainfall in the particular area.

The available biomass potential is defined as the energy content of biomass that can be technically and economically harvested and used for energy production. It is derived from the theoretical potential by subtracting the fraction of biomass which cannot be collected or is used for other purposes (bedding or fertiliser).

The technical biomass potential indicates the amount of energy that can be produced. It depends on the technology applied (e.g. direct biomass incineration for steam production, integrated biomass gasification in a combined cycle or co-firing with fossil fuels). The technological potential is assessed as well through the identification of potential sites for biomass installations.

The economical biomass potential is defined as the energy that can be economically exploited in the region with respect to alternative solutions. The feasibility of a biomass plant can be determined based on the energy production costs or the internal rate of return and the net present value.

Numerous authors have focused on the estimation of biomass potential at different levels. Voivontas et al. (2001) developed a GIS based method to estimate the economically feasible potential for power production from agricultural residues stressing the importance of geographical characteristics of regions and states. Van Dam et al. (2007) developed a methodology for the assessment of biomass potential in Central and Eastern European countries (CEEC) to find out whether the bioenergy potential in the CEEC is indeed large enough to supply biofuels to the European market and under what conditions such potential can be developed. German authors (Simon & Wiegman, 2009) presented a model for analysing the sustainability potential of agricultural biomass for energy production in Germany, Poland, the Czech Republic and Hungary. Authors concluded that different environmental goals, e.g. climate protection and nature conservation, can come into conflict regarding land use and that the land competition can be eased by intensifying the use of residues. Meanwhile De Wit & Faai (2010) and Havlickova et al. (2011) have paid attention to the economic aspects of bioenergy potential. In their study on European biomass resource potential and costs De Wit & Faai (2010) concluded that large variations exist in biomass production potential and costs between European regions. Authors outlined large parts of Poland, the Baltic States, Romania, Bulgaria and Ukraine as high biomass potential regions and indicated that the total available land for bioenergy crop production in Europe could amount to 900,000 km^2 by 2030. On a narrower level Havlickova et al. (2011) developed an economic model for biomass price calculation in the Czech Republic and concluded that the price of biomass is mainly affected by harvesting and processing costs.

The aim of this study is to assess the future development trends of bioenergy in Latvia from a technical, environmental and economic point of view.

MATERIALS AND METHODS

Energy systems in Latvia are characterised by various types of energy resources. Both the imported (natural gas, petroleum products, coke, etc.) and local primary energy resources (biomass, agricultural residues, hydropower, wind energy, etc.) are used to supply fuel, power and heat to different end-user sectors including transportation, industry, residential and commercial sectors. The total consumption of primary energy resources in Latvia amounted to 188.7 PJ in 2011. Fossil fuels – natural gas and oil products – play the dominant role in the Latvian energy balance leaving bioenergy with a 26.3% share of the total energy consumption. Wood fuel (wood chips, pellets, and logs) make up 94.4% of bioenergy consumed in the country. The rest is agricultural crops and residue used for first generation biofuel and biogas production.

Despite the relatively high share of wood fuel in the national energy balance, the share of biomass in the energy sector (heat and power production) is rather low (i.e. less than 20%). Wood fuel is mainly consumed for heat supply in the residential sector meanwhile the energy sector including boiler houses and high efficient CHPs is mostly dependant on imported natural gas resources (Fig. 1). There are various reasons explaining the slow growth in the number of wood-chip-fuelled cogeneration plants relevant to engineering, economic and environmental aspects as well as marketing activities whereas the high consumption of natural gas in boiler houses seems to be more favoured due to political rather than economic obstacles.

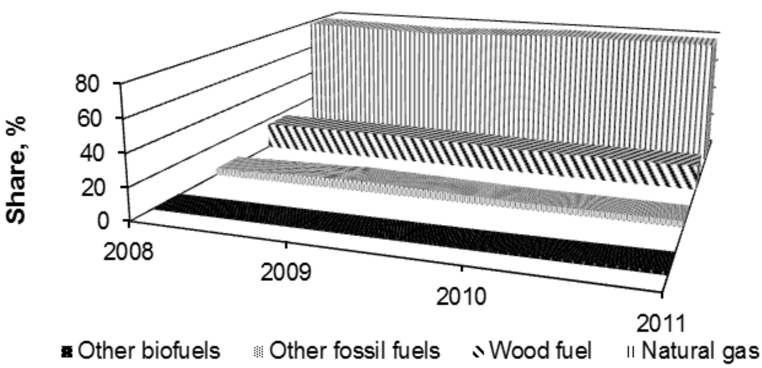


Figure 1. Energy consumption in the energy sector (Central Statistical Bureau of Latvia, CSB).

Authors of this paper have therefore tried to model possible scenarios for the future development of bioenergy resources in Latvia. Evaluation is done on the basis of historical data analysis and the literature review applying indicators with sufficient level of information aggregation and adequacy, and assessment of future bioenergy development prospects from a technological, economic and environmental point of view. A general overview of the methodology for the assessment of the biomass potential is given in Fig. 2.

The first step of the algorithm estimates the present biomass availability for energy production in the region. The theoretical potential of biomass is assessed for three sources: (1) biomass from forestry; (2) biomass from energy crops, and (3) biomass from agricultural residues corresponding to the defined scenarios. Estimates are done based on data of present land use pattern and future development trends, energy crop production yields, and availability of forestry and agriculture residue.

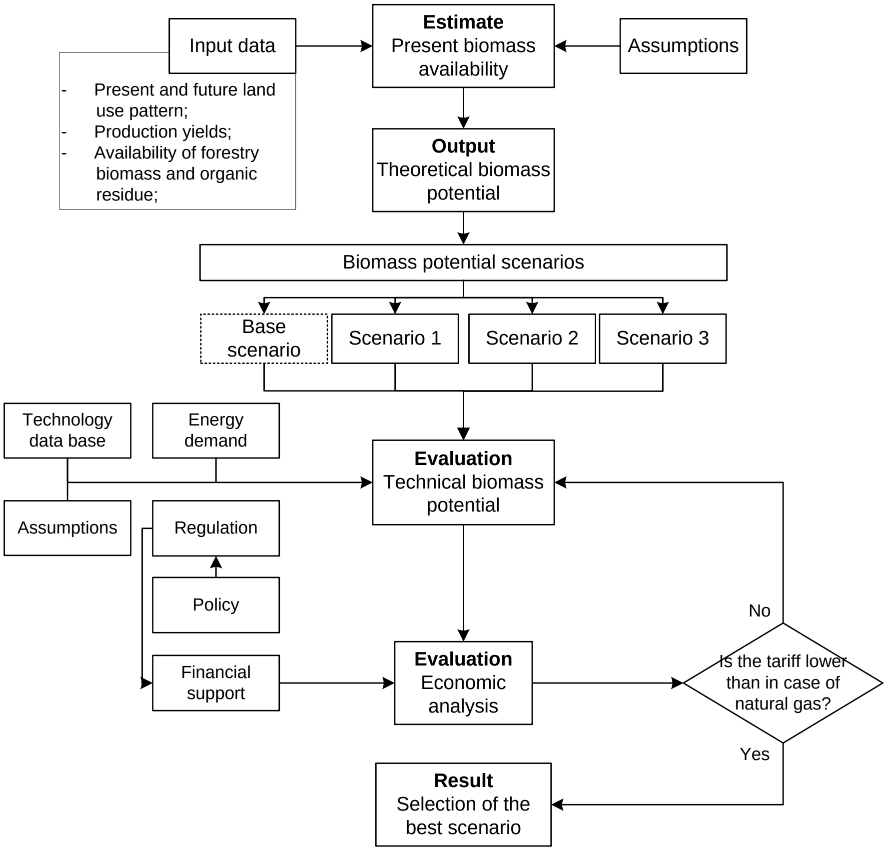


Figure 2. An algorithm for scenario evaluation.

In the subsequent step, the method estimates the technological potential of each of the predefined biomass potential scenarios taking into account available biomass conversion technologies and energy demand. The following economic analysis is performed and energy production costs of the selected alternatives are estimated. In this step the current and planned state energy policy and support mechanisms are taken into account as one of the economic motivators of biomass business development. Energy production tariffs in the case of biomass and natural gas based generation are compared to find the best scenario of biomass utilisation in line with national renewable energy targets.

RESULTS AND DISCUSSION

Four scenarios were built to analyse biomass fuel potential and utilisation patterns in Latvia. Base scenario illustrates the actual situation and assumes the Latvian energy system follow a business as usual scenario. Scenario 1 assumes utilisation of locally available forest biomass potential. Scenario 2 adds growing energy cultures on available agricultural lands and Scenario 3 includes utilisation of available organic residues for biogas production. Further each scenario is described in more detail and a comparison of all scenarios is given.

Base (business as usual) scenario

The business as usual scenario represents the baseline situation that is used as a threshold reference for comparing the results with the defined scenarios. This scenario assumes a situation where both main energy resources – wood fuel and natural gas – maintain their dominant role in the energy sector. An historical consumption pattern was used to model the possible future development trend (Fig. 3).

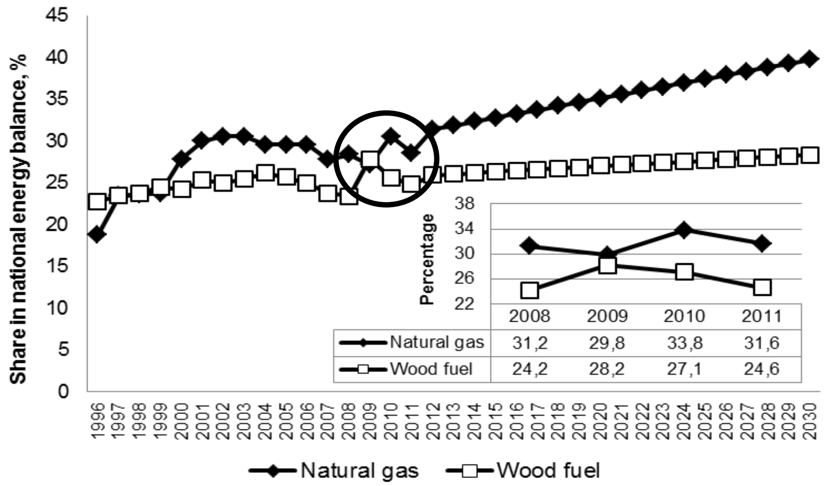


Figure 3. Wood fuel consumption in baseline scenario.

Fig. 3 illustrates the historical pattern of wood fuel and natural gas consumption in Latvia. It shows a gradual increase in the share of both energy resources over time with natural gas consumption increasing more rapidly (two-fold growth compared to wood fuel during the period 1996–2009). The most recent data demonstrates decreasing demand for biomass in the post-crisis period. However the authors assume that the future development trend will follow the observed historical pattern with a gradual increase of natural gas and wood fuel share in the energy balance. A linear trendline is applied to model this forecast.

Scenario 1: Biomass potential from forestry

Forest lands in Latvia cover nearly 3.5 mil. ha or 54.1% of the State territory with a total forest stock around 630 mil. m^3. Consequently it has made the timber industry a significant contributor to the national economy. The average forest processing rate in

Latvia reaches 12 mil. m^3 $year^{-1}$. Around half of these resources reach the energy sector in terms of low value harvested wood, logging residues and wood-processing by-products (chips, sawdust, and bark) from which circa 40% are exported (CSB, 2011).

Previous studies have indicated the possibility to increase the level of utilisation of biomass potential from forestry. Available biomass potential is assessed around 25–30 TWh $year^{-1}$ (Dubrovskis, 2011). The biomass assumed in this section includes logging residues from forests, biomass growing alongside trenches, and manufacturing residues recoverable for energy use.

The sustainability of forest resource utilisation in the proposed scenario was assessed with the help of a system dynamics model developed by the authors (Romagnoli et al., 2012). The model confirmed that the biomass potential can be exploited in the long term (2050) without causing damage to local timber resources.

Scenario 2: Biomass potential from energy crops

Energy crops can be generally categorised as conventional agricultural crops such as rape and maize that can be used for energy purposes and dedicated energy crops such as willow, poplar, miscanthus and others, which maximise the yield of dry matter per unit area. This investigation focuses on the second type of energy crops and assumes the potential for short-rotation woody crops production on available agricultural lands.

So far, short-rotation woody energy crops have not achieved any outstanding proportion in the Latvian cropping area. To assess the land areas available for production of biomass for energy use, the future demand of land for food and fodder production has to be estimated (Hoogwijk et al., 2003). Data collected by the Latvian Rural Support Service (2011) on situation on agricultural lands in Latvia indicates that 13.4% of all agricultural lands (circa 314,000 ha) are left untended resulting in increasing areas of farmlands overgrown by trees and shrubs. Lazdins et al. (2010) estimated that the total area of naturally afforested farmlands in Latvia equals 257,850 ± 3,606 ha. Taking into account the observed tendency of annually increasing areas of naturally afforested agricultural lands and projected population decrease, the authors assume that production of energy crops in Latvia does not compete with food production and untended agricultural lands can thus be used for short-rotation woody biomass planting.

Productivity of energy crops firstly depends on the type of culture chosen. Further the aspects of environmental conditions (climate, soil, etc.) and management (nutrient supply, irrigation, etc.) influence the productivity and can vary considerably among different areas (Hoogwijk et al., 2003). Adamovics et al. (2009) suggested two species of short-growing woody energy crops appropriate for Latvian conditions – willow and grey alder sprout – with the total technically available biomass stock in the range of 140,000–830,000 tons of dry mass per year equal to 485–1,685 GWh $year^{-1}$. Calculation is done taking into account the availability of fertilisers (municipal sewage sludge) limiting the possible amounts of energy crop cultivation.

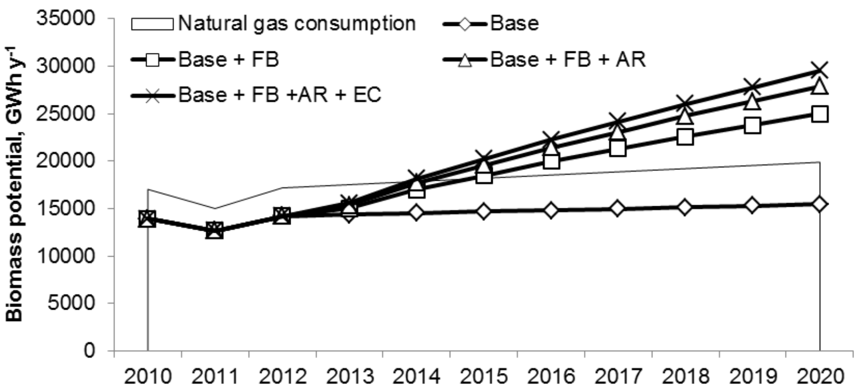
Scenario 3: Biomass potential from agricultural residues

Latvian biogas market is characterised by a high number of small-scale power plants where agricultural crops, mainly maize, in co-fermentation with animal waste are used for biogas production. Proximity to raw materials has been used as the key indicator in assessing the prospects for biogas production. As a result maize farming has increased from 2.9 million ha in 2005 to 11.3 million ha in 2011, according to the Central Statistical Bureau of Latvia. This has led to an energetically unreasonable solution – low efficient power generation from biogas (efficiency in range of 25–35%). The development of the future biogas sector in Latvia should be associated with residue-based biogas production and valuable utilisation for heat, power and transport.

The theoretical availability of biomass for biogas production in Latvia is considered to be 3,000 GWh $year^{-1}$. This includes the use of animal waste, agricultural and green residues, as well as organic residues and by-products from the food industry. However, there is a question of how the recently introduced changes in national legislation aimed at discontinuing existing support measures for renewable electricity will affect the development of the biogas sector. This will have an influence on economic indicators, from which the unit cost of one megawatt hour of electricity and the end-tariff are key.

Comparison of scenarios

In Fig. 4 the four biomass potential scenarios are compared with the forecasted natural gas consumption from the baseline scenario.



Base = Biomass consumption in business as usual scenario
FB = Biomass potential from forestry
AR = Biomass potential from agricultural residues
EC = Biomass potential from energy crops

Figure 4. Evaluation of biomass potential in Latvia.

Authors have assumed that utilisation of the annual available biomass potential will increase gradually reaching a maximum by 2020. One can see that the business as usual scenario is characterised by a continuous dominance of natural gas in the national energy balance. Meanwhile simultaneous use of available biomass potential described in other scenarios allows replacing natural gas imports with local biomass resources already in 2015. The largest biomass potential is associated with the use of forest logging residues and timber processing by-products. Total bioenergy potential in 2020 is approved to be twice the current biomass utilisation rate.

CONCLUSIONS

This study aimed to explore the range of the potential of biomass energy production in Latvia on the medium term up to 2020. Four biomass supply options were identified.

Results of the study have shown that following the business as usual scenario will lead to negligible increase in wood fuel consumption for energy production in Latvia. The share of biomass in the national energy balance can be increased by the use of available biomass potential from forestry, agriculture and energy crop plantations. Utilisation of local biomass resources at the same time would enable numerous direct and indirect societal, economic, and environmental benefits.

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