Regional bioenergy supply and demand and some implications for rural development

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***Abstract* - Pellets for heating, combined heat and power (CHP) and methanol production plants are promising technologies for energy production from forest woods. The spatial distribution of bioenergy demands is one of the factors that determines efficient plant locations. Locating bioenergy plants in rural areas can create employment and income opportunities for local communities. In this study, the determination of optimal plant locations considering three alternative biomass conversion technologies and implications for rural development are analysed with respect to optimal plant locations. A spatially explicit optimization model, integrating a Monte Carlo simulation approach to account for model parameter uncertainty, is used to seek optimal locations of bioenergy plants in Lower Austria. Model results indicate that pellets production is most appropriately located in rural areas, competitive to fossil fuels, and allows substituting the highest amount of fossil fuels when compared to methanol and CHP production.**

INTRODUCTION

Pellets for heating, combined heat and power (CHP) and second generation methanol production plants are promising technologies for energy production from woody feedstock. Besides offsetting greenhouse gas emissions and increasing energy security through substitution of fossil fuels, bioenergy plants are also considered to contribute to rural development (BERNDES und HANSSON, 2007). Different energy commodities can be produced with the plants. The spatial distribution of demands for these commodities is one of the factors that determines efficient plant locations. Employment in the plants as well as in up-stream and down-stream industries can be significant (HILLRING, 2002). Consequently, locating bioenergy plants in biomass rich rural areas could be a measure to foster economic development. In this study, the optimal locations of bioenergy plants considering three biomass conversion technologies i.e. pellets, CHP and methanol production are assessed as well as their implications for rural development. The model is performed for the region Lower Austria including the city of Vienna. A clear characterization of rural and other areas is necessary to assign plant locations. The definition of rural areas according to Palme (1995) is used for this purpose. The distinction of regions is based on the primary economic activity in the district, differentiating between human capital intensive, physical capital intensive and rural regions.

METHODS

A spatially explicit optimization model (LEDUC et al., 2008) is used to seek optimal locations of bioenergy plants in the region of Lower Austria. In the model, bioenergy plants are supplied by domestic forest wood. It is assumed that forests can be harvested up to the maximum sustainable yield. The spatial distribution of biomass supply as well as the spatial distribution of energy demand for transportation fuels and heat is taken into account. Investment costs for district heating networks which are necessary to distribute surplus heat in the bioenergy production and the distribution costs of pellets and methanol are considered as well. The plants compete with fossil fuels. It is assumed that pellets can substitute heating oil in private buildings, district heating can substitute the heating fuels currently in use, power can substitute electricity generated in fossil plants and methanol can substitute fossil gasoline.

Many of the input parameters are uncertain because CHP gasification and methanol plants are currently not available on commercial level and costs are therefore estimates with high uncertainties. Additionally, prices of fossil fuels and CO_2-emissions are highly volatile. Therefore, a Monte Carlo simulation approach is applied to account for uncertainties (SCHMIDT et al., 2009). The optimal location of the plants is derived for each technology separately. Two different sizes (250 MW and 50 MW) are assumed to show the effect of plant size on the optimal locations and on the costs of bioenergy plants.

Table 1. Model results by plant size and technology.

Technology	Parameter	250 MW Plant	50 MW Plant
Methanol	Plants in Rural Areas (%)	0	80
	Costs (% of fossil)	128	150
	Fossil Substitution (TWh)	0.57	0.57
CHP	Plants in Rural Areas (%)	0	9
	Costs (% of fossil)	100	95
	Fossil Substitution (TWh)	1.05	1.05
Pellets	Plants in Rural Areas (%)	33	50
	Costs (% of fossil)	102	97
	Fossil Substitution (TWh)	1.09	1.12

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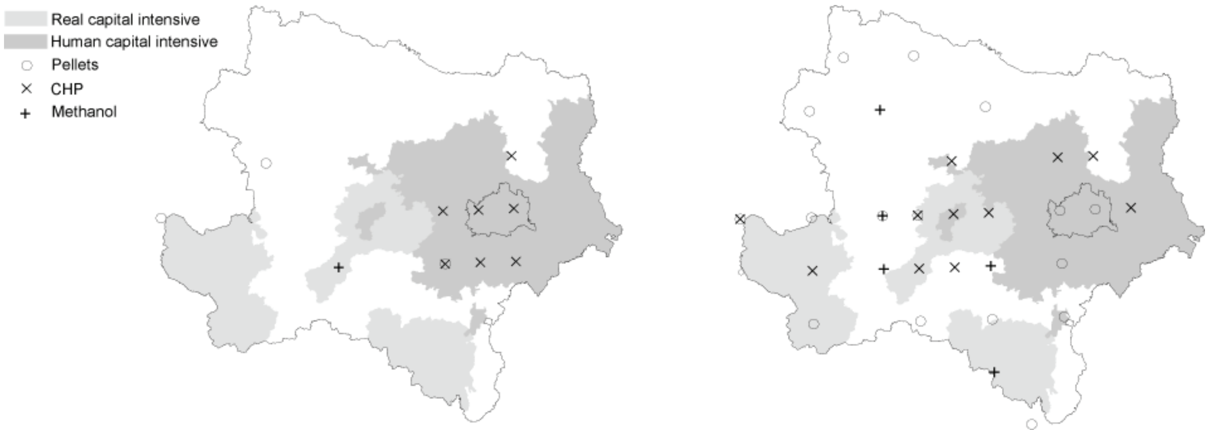

Figure 1. Optimal plant locations for big bioenergy plants (left) and small plants (right) in Lower Austria.

The investment costs per production unit decrease with increasing plant sizes due to economies of scale. The model is setup in a way that at least 50% of the available biomass is used for bioenergy production.

RESULTS & DISCUSSION

Optimal plant locations are reported in Figure 1. Table 1 lists the percentage of plants that are located in rural areas, the production costs in comparison with fossil fuels and the amount of fossil fuels substituted for each technology and plant size. The means of the results of the Monte Carlo Simulation are reported. Small methanol and small pellets plants are more likely to be found in rural areas than bigger plants and CHP plants. Both methanol and pellets plants produce less surplus heat than CHP plants. They therefore do not need to be located close to bigger cities where district heating networks can be built efficiently. The costs for distributing pellets and methanol to end consumers are not as relevant as biomass transportation costs, rural areas are therefore more suitable for these bioenergy systems. Smaller plants produce even less heat and are therefore more likely to be located close to the supply of feedstock than bigger plants. Methanol is not competitive to fossil fuels because investment costs are high for this technology and total conversion efficiencies are low. Pellets plants as well as CHP plants of both sizes are, however, able to produce energy commodities at the costs of fossil fuels. For both technologies smaller plants are slightly cheaper because higher plant investment costs are compensated by lower transportation costs. Regarding the capacity of fossil fuel substitution, CHP and pellets plants are a lot more effective than methanol production because conversion efficiencies are higher. The amount of employment created by bioenergy projects is hard to quantify. It can be, however, assumed that the three technologies have similar demands for working labour and that plants of smaller capacity need relatively more jobs than big plants (BERNDES und HANSSON, 2007).

The results show that locating pellets plants in rural areas is economically viable. Pellets production allows the substitution of more fossil fuels than any of the other technologies. It is also competitive to fossil fuels at current prices. Pellets can be produced in small production units. A wide spread distribution of plants is therefore possible. Especially the North-West of Lower Austria ("Waldviertel") is well suited for low scale pellets production, which can create employment and income opportunities for the local communities as well as promote competitive local energy systems.

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