SURPLUS GRASSLAND - A NEW SOURCE OF BIO-ENERGY?

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ABSTRACT: Today, in many regions of Germany the landscape is characterised by meadows and pasture. Despite the high appreciation among the general public, the decline in grassland use by cattle farming seems inevitable. Essentially, this is a result of progress in breeding and production technology and of structural adjustments in agriculture leading to a further increase of milk production per cow and to a decreasing demand of (less productive) grassland for roughage production. Against this background, the article assesses the surplus grassland no longer needed for animal feed production today and in the medium-term future for the rural districts of the federal state of Baden-Württemberg. The calculations show that at present around 135,000 ha or 21 % of the permanent grassland is not needed for livestock feeding. Until 2015, the area of surplus grassland increases to 167,000 ha or 26 %. Today, mainly the rural districts with low stocking rates are characterised by significant surplus grassland. In the future, however, an increasing number of rural districts with intensive dairy cattle farming will be affected by this development. From the technical and economic point of view the use of grass silage from surplus grassland as a co-substrate in local biogas plants seems a promising production alternative for farmers. A biogas plant with over 500 kW_{el} can be run profitably with a substrate mixture of grass and maize silage over the whole operation time of 20 years. With the same mixture, biogas farm plants with 100 kW_{el} can be operated almost economically if the infrastructure and farm machines can be used and if the existing buildings can be supplied with the incidentally produced heat. In a 100 kW_{el} farm biogas plant considerable bulks of grass silage (from 90 ha grasslands) exclusively can be converted profitable into electricity if substantial volumes of cattle manure are available exempt from charges. If the operation of these biogas plants is calculated without regard of working salaries, the achievable wage compensation for the farmers vary between 11 and 30 EUR per working hour. This is relatively high compared to other agricultural production processes. If the complete surplus grassland would be used to produce grass silage for biogas generation, around 830 GWh of electricity could be generated. This compares to almost 1.3 % of the electricity consumption in Baden-Württemberg today.

Keywords: grassland, biogas, economic aspects

1 INTRODUCTION

Grassland forms a substantial part of cultural landscapes in Central Europe and in some regions of Germany respectively. Almost 30 % of the agricultural area in Germany is permanent grassland; in the federal state of Baden-Württemberg in the south-west of Germany around 39 % are grassland. Thus, the cultural landscape here is especially characterised by meadows and pasture.

Because of dramatic changes in production technology and of structural adjustments in agriculture, the traditional ways of using grassland by cattle farming are vanishing for years already. Large areas are nowadays used for high intensity grassland farming while sites with less favorable conditions (soil, climate, slopes) for dairy farming become fallow. Many of the latter will be afforested, especially mountainous grasslands.

The decline of meadows and pasture will have negative consequences, not only for the cultural landscape and rural and agricultural economies, but also for nature and environmental protection, tourism and regional economy.

The political and social intention to stop the decline of grassland has found its reflection in the German translation of the agricultural reform. In the future, the payment entitlements are based on areas. Also for grassland premiums of around 300 €/ha will be paid by the year 2013 in Baden-Württemberg. Furthermore, the conversion of grassland will be limited by law to a level of not more than 5 % of the existing permanent grassland (compared to 2003). If more than 8 % of the grassland is converted, reseeding of grassland can be instructed [1].

The chances to preserve grassland with alternative and extensive methods of animal husbandry (e.g. suckler cows) have already been analysed in different research projects. The results indicate that these alternative production systems can in certain regions be economically feasible. However, this is not a solution for the complete surplus grassland because in many parts of Baden-Württemberg the appropriate requirements for alternative animal husbandry are missing.

Against this background, the Institute for Technology Assessment and Systems Analysis (ITAS) at the Research Centre Karlsruhe analyses different technologies and methods to use surplus grassland in a sustainable way for the production of bio-energy. In this paper first the results of the assessment of the surplus grassland in Baden-Württemberg are presented. Then the profitability of using grass silage of surplus grassland as co-substrate for local biogas plants is analysed.

2 APPROACH

For the calculation of the surplus grassland a method was developed to assess and allocate the surplus grassland on the basis of different statistical data on land use, live stock and agricultural yields in Baden-Württemberg. Further data needed for the calculation such as the energy content of grass silages were raised by a special two-step survey among the local agricultural offices.

Based on these data, first the roughage demand of cattle, horses and sheep was calculated. Then, the production volume of the different types of grassland (meadows, pasture) as well as other fodder crops was calculated in relation to the average yield and energy content on district level. Finally, the production volume was balanced with the estimated roughage demand of the live stock. This was done for the present situation and for the medium term future.

For the development up to the target year 2015 different assumptions were made about the development of live stock, the area devoted to organic farming and the sealing of soils due to the construction of roads and settlement. Changes in the demand of grassland due to structural adjustments in dairy farming have been projected based on analyses of the actual trend in the trade of milk quota in Baden-Württemberg.

3 RESULTS

In this chapter, first the area of surplus grassland which is theoretically available for bio-energy production and the distribution on district level are presented. Then, the supply costs of grass silages from surplus grassland and the achievable electricity yields by converting these grass silages into biogas are outlined. Finally, the profitability of the utilisation of grass silage as co-substrate in biogas plants is discussed.

3.1 Area of surplus grassland

In Baden-Württemberg, at present around 132,000 ha or 21 % of the permanent grassland are not needed any more as roughage production land for cattle, horses and sheep. By the year 2015, the surplus grassland area will add up to 167,000 ha or 26 % of the total grassland in Baden-Württemberg. Then, in a number of districts more than half of the grassland is not needed anymore for roughage production (Figure 1).

If the complete surplus grassland would be used to produce grass silages for biogas plants, around 830 GWh of electricity could be generated. This compares to almost 1.3 % of the electricity consumption in Baden-Württemberg today.

3.2 Supply costs and electricity yields of grass and maize silage feed in biogas plants

The energetic use of grass in biogas plants is of relatively great interest compared to other technologies to convert grass or hay into energy. At the one side this is due to the technical challenges related to the combustion or gasification of the growth from grassland. On the other side, the economical incentives to use grass for electricity production are appealing because of the higher reimbursement for feed-in-electricity if especially produced biomass is used exclusively for electricity production according to the Renewable Energy Sources Act [2].

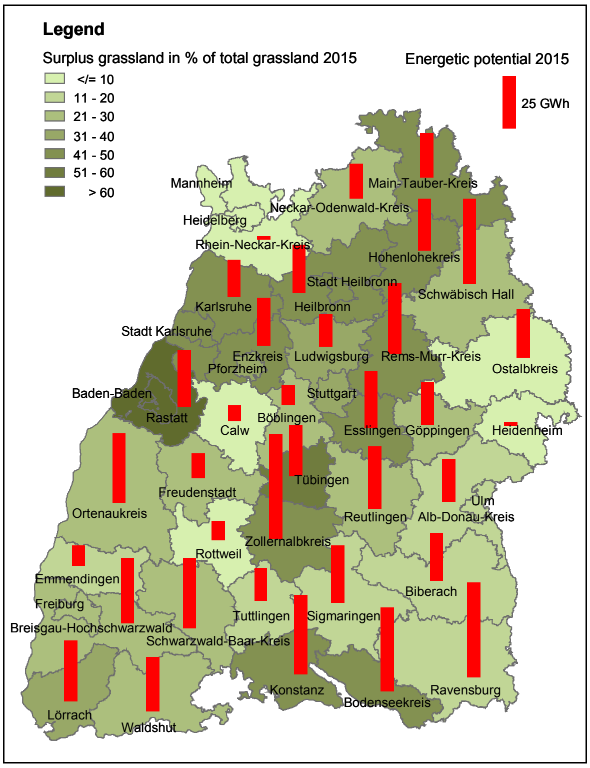

Figure 1: Surplus grassland areas and their energetic potential of Baden-Württemberg on district level

Fresh grasses as well as hay and grass silage are suitable feedstock for biogas plants. The biogas yields which can be achieved with the different feedstock types from grassland vary only slightly. In this paper, however, only electricity production from grass silage is analysed due to advantages in operation and costs. The biogas yields which can be achieved with different types of grass silages range between 540 and 580 m³/t dry organic matter (according to [3]). For grass silage from meadows with two cuts a only slightly smaller biogas yield is assumed. Thereby the assumption is made that on locations with favorable soil and climate conditions still good quality grass silage can be produced.

The results are indicating that the supply costs of grass silage are mainly depending on the yield and the number of cuts (Table 1). In the calculation, the average yield was varied between 5.75 and 9.0 tons dry matter per hectare and year, the number of cuts between two and four. Additionally, a meadow with only three cuts but a high yield was exemplarily calculated. For comparison, the supply costs and electricity yields of maize silage are presented. The results show that the electricity yield per ton dry matter of grass silage is only 13 to 19 % lower than those of maize silage (Table 1). However, related to the production area, with grass silage from one hectare only between 42 and 65 % of the electricity yield can be achieved compared to one hectare of maize.

Table I: Biogas and electricity yields of grass and maize silages

Cutting frequency		Grass silages from meadows				Maize silage
		Two cuts	Three cuts	Three cuts, high yield	Four cuts	
Net yield	t dm/ha	5.75	7.3	9.0	9.0	13.5
dom content	%	89	89	89	89	94
Biogas yield	m³/t dom	540	560	560	580	620
CH_4 content	%	53	53	53	53	54
Electricity yield[1)]	kWh/t dom	866	898	898	930	1,070
	kWh/ha	4,980	6,511	8,083	8,372	14,445

dom = dry organic matter; dm = dry matter
[1)] Efficiency of the block heat and power plant: 34 %

The feedstock supply costs (full costs) of grass and maize silage were calculated (according to [4]) or the following conditions: field size: 5 ha, distance field to farm: 3 km, self mechanization, harvesting with private contractor. Furthermore, it was assumed that the digester residues are used as organic fertilizer and that therefore only the costs of spreading have to be considered. A fertilizing value, however, was not included because a closed loop nutrient recycling is assumed.

In the calculation included are the EU payment entitlements based on areas, the EU compensatory allowances, the German grants for the cultivation of energy crops (if a yield of more than 40 m³ per hectare can be achieved) and the federal grants for extensively used meadows and pasture. The last-mentioned grant is an EU co-financed program of federal state of Baden-Württemberg with the aim to disburden the agricultural markets and to sustain the cultural landscape (MEKA).

Under these conditions, at present, maize silage can be provided for 7.8 Ct/kWh_{el} and thus with 13 % lower costs than the most inexpensive grass silage for 9.0 Ct/kWh_{el} deriving from a meadow of three cuts with high yield (Figure 2). Grass silage from a meadow of three cuts with an average yield score the highest substrate supply costs with almost 10.0 Ct/kWh_{el}.

In the calculation it is assumed that the biogas plant investments are amortised over 20 years due to the fact that the higher feed-in prices for renewable energy are guaranteed over that period of time. Whereas the feed-in-reimbursement for electricity from biogas plants is kept constant over 20 years, the supply costs of the biogas substrates are rising significantly even if moderate assumptions for the price increase are made.

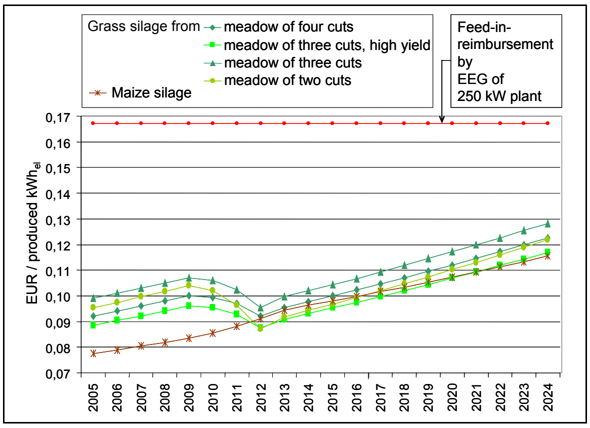

Figure 2: Feedstock supply costs of grass and maize silage over 20 years (inclusive the agricultural EU-premiums, but without increase of yields)

Depending on the matter of expense regarded, it is assumed that every year the prices rise between 1 and 2 % and for fuel about 4.3 %. Against this background, in 20 years the substrate supply costs of grass silages will be around 30 % higher and of maize silage 50 % higher than today (Figure 2).

By the increase of the payment entitlements based on areas for grassland on the same level as the premium for arable land, the supply substrate costs of grass silage decrease from 2009 to 2012. Then, they range on a similar level as those of maize silage. This happens despite the assumed abolition of the federal state grant for extensively used grassland by the year 2012.

By the increase of the substrate supply costs in the year 2024, around three-fourths (70 to 77 %) of the feed-in-reimbursement for the produced electricity has to be spent for the supply of the biogas substrate. In the year 2005, this value still ranges around 46 to 59 %. However, yield increases by maize which could compensate the cost increases are not taken into account in this calculation.

3.3 Profitability of biogas plants fed with grass silage as co-substrate

At the present state of research and development the exclusively fermentation of grass silage in biogas plants is critical, respectively because of the nitrogen content and the pH-value. Therefore, in this study only the input of grass silage as a co-substrate of cattle manure or maize silage is considered.

The full cost calculation for a 500 kW_{el} biogas plant fed with grass and maize silage show that in this case the average electricity production costs are below the feed-in-reimbursement (Figure 3). Thus, this biogas plant can be run economically over the whole operation time of 20 years.

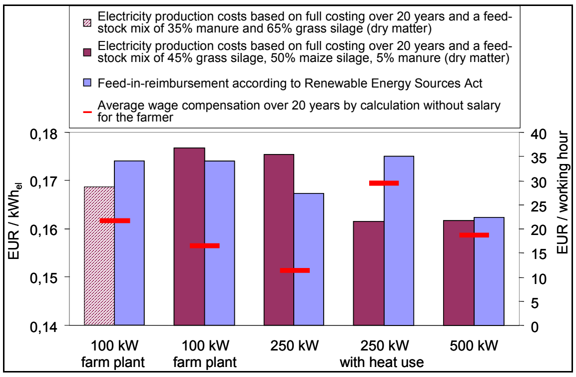

Figure 3: Profitability and wage compensation of biogas plants fed with grass silage

Smaller biogas plants with only 250 kW_{el} but fed with the same substrate mixture of grass and maize silage, however, are only profitable if major volumes of the produced heat can be used.

Biogas plants with 100 kW_{el} can almost be operated economically if the existing infrastructure (such as the farm area, silo, water and electricity connection) and farm machines can be used and if the existing residential and farm buildings can be supplied with the incidentally produced heat.

In such a 100 kW_{el} biogas farm plant also considerable bulks of grass silage (from 90 ha grasslands) can be converted economically into electricity. Therefore, however, substantial volumes of cattle manure (from 300 animals) have to be available exempt from charge. The operation of a 100 kW_{el} biogas plant exclusively with cattle manure would cause a high demand of cattle manure relating to around 1,000 animals. In the federal state of Baden-Württemberg, farms with such high numbers of cattle can hardly be found. This is due to the small size agricultural structures of cattle breeding, which is characterised by family farms with an average number of 23 cows. The utilisation of grass silage as co-substrate with maize can thus improve the profitability of biogas plants respectively at locations with limited numbers of cattle or limited arable land for the production of energy maize.

The operation costs of biogas plants can be calculated without regard of working salaries for the supply of the feedstock and for managing the biogas plant. In this case, the achievable wage compensation varies between 11 and 30 EUR per working hour. This is relatively high compared to other agricultural production processes which lead partially to a wage compensation under 10 EUR per working hour.

4 CONCLUSIONS

The calculation presented in this paper show that the use of surplus grassland to substitute fossil energy can make a small contribution to satisfy our energy demand with renewable and locally available resources. Furthermore the conversion of grass silage from surplus grassland in biogas plants to bio-electricity can provide a relatively high salary for the farmer compared to other agricultural production processes.

However, at present the co-fermentation of grass silage is very rarely adapted in practice. This is due to the lack of information, but also to questions which can not be answered by science at the moment. Therefore, at the moment the farmers are faced with a number of technical challenges correlated with the quality and quantities of the grass silages. Research and development is urgently needed to solve the existing technical and biological restraints and to support the diffusion of this promising technology process. If these endeavors will be successful, biogas production from grass can contribute to preserve grassland.

5 THANKS

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