Agricultural biogas plants – a systematic analysis of strengths, weaknesses, opportunities and threats

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Important Note

This is a preprint version of the following paper:

Brudermann T, Mitterhuber C & Posch A (2014). Agricultural biogas plants - a systematic analysis of strengths, weaknesses, opportunities and threats. *Energy Policy*, doi:10.1016/j.enpol.2014.11.022

Original version: <http://www.sciencedirect.com/science/article/pii/S0301421514006302>

Abstract

In this communication, we discuss the prospects of agricultural biogas plants. We conducted an integrated SWOT-AHP analysis for such plants in Austria in order to identify strengths, weaknesses, opportunities and threats (SWOT factors), and to weight the factors identified based on expert judgments, calculated according to the Analytic Hierarchy Process (AHP) method. The results show that financial aspects are dominant in three of the four SWOT categories. Technological aspects and issues regarding utilization seem to play a relatively minor role. Factors that are not directly under the control of plant operators are currently perceived as crucial for the success of agricultural biogas plants. We conclude that such plants will only succeed in contributing to sustainable energy supply goals when economic and political conditions are favorable over the long term.

Keywords: Decentralized energy generation; Analytic Hierarchy Process; SWOT; small-scale electricity generation

1. Introduction

The agricultural sector plays a crucial role in the transition towards a sustainable energy system. It is a source of large land areas for wind plant construction, it offers plenty of large flat roofs for mounting PV modules, and natural resources such as biomass are readily available for biofuel and biogas production (Brudermann et al., 2013). Judging by the number of papers published, agricultural biogas projects are becoming an increasing point of focus in the scientific literature. At present, existing research appears to focus on the economic, ecological and technical aspects of agricultural biogas plants (e.g. Buysman & Mol, 2013; Djatkov et al., 2012; Srirangan et al., 2012), or on the social aspects of agricultural biogas production and use (e.g. Bluemling et al., 2013; Carrosio, 2013). This has often been accompanied by, or has initiated, intense debate on the advantages and disadvantages of agricultural biogas: For example, the use of regionally grown natural resources as input is seen as a main advantage. Biogas plants are considered to have the potential to significantly contribute to the reduction of greenhouse gases (Djatkov et al., 2012). From an economic point of view it is argued that biogas plants can provide farmers with an additional source of income and therefore help them preserve the long-run viability of their farms. Following the recent decades of ever-intensifying specialization, there are even signs that biogas plants may at some point contribute to a re-diversification of agriculture (Mautz et al., 2008). One potential drawback associated with biogas production is related to ethical concerns, namely the food vs. fuel dilemma – i.e., if energy crops oust feed crops. Here it is argued, that in order to resolve or minimize this area of conflict, biogas plants need to be operated with resources which are not part of the food chain, i.e. with resources which would otherwise remain unused, such as liquid manure.

Despite all these arguments, no systematic analysis of the strengths, weaknesses, opportunities, and threats (SWOT analysis) of agricultural biogas production has been carried out. Thus, it is our intention here to add to the existing literature by providing an integrated SWOT-AHP (Analytic Hierarchy Process) analysis in order to identify SWOT factors and, based on expert judgments, to quantify their relative importance. Our analysis focusses on the situation in Austria.

In Austria, currently around 500 biogas plants are in operation¹. In general, electricity generation from renewables is subsidized via a feed-in-tariff scheme. The level and nature of these tariffs is determined in the Austrian eco-electricity feed-in-tariff act ÖSET-VO 2012 (BMWFJ, 2012). For biogas plants, feed-in-tariffs are only granted where energy cycle efficiency is at least 60%, and where at least 30% animal manure is utilized. The tariffs are fixed and are guaranteed for 15 years. The tariff levels depend on plant capacity; small plants with a maximum capacity of 250 kW receive the highest tariffs (~ € 0.20 per kWh), and plants with a maximum capacity of over 750 kW receive the lowest tariffs (~ € 0.13 per kWh). Tariffs are slightly reduced where substrates other than those derived from agricultural are also utilized. When compared to Australia or the US, agriculture in Austria can be characterized by rather small structures,. The

¹ This number is taken from the official website of the Austrian biogas umbrella organization ‘ARGE Kompost & Biogas’ – see <http://www.kompost-biogas.info> (accessed July 30, 2014).

average size of the agricultural area per farm is 42.4 ha, and most farms are a family business. At present, over two thirds of 173,317 registered farms are farming less than 30 ha, and 54% are run as side-business. Only 39% of farms are run by full-time farmers, and as few as 7% of farms are joint ventures or legal entities (Statistik Austria, 2010).

We address the following research questions: Given the relatively small-scale nature of agriculture in Austria, what are the internal strengths and weaknesses of agricultural biogas plants? What are the respective external opportunities and threats? And what is the relative importance of the factors identified?

Based on the SWOT/AHP analysis, and taking into account the aggregated judgments derived from expert interviews, we derive the related policy implications concerning the use of agricultural biogas for electricity generation in Austria.

2. Method: SWOT and AHP

As a first step we conducted a standard SWOT analysis to identify the strengths and weaknesses (internal factors) and the opportunities and threats (external factors) for such plants. In order to validate the SWOT analysis, we conducted semi-structured face-to-face interviews with a diverse group of seven experts. These experts comprised both representatives from academia and from the field. Among them were regional policy makers, representatives from interest groups, energy planning experts, and operators of biogas plants². Some of the experts were able to employ several perspectives simultaneously, e.g. regional policy makers who were also farmers and operated an agricultural biogas plant. The experts were contacted via email or phone, and, conditionally on agreement, questioned concerning several aspects of agricultural biogas plants, e.g. operating modes, resources, tariffs, subsidies, and future prospects.

One shortcoming of SWOT is that it merely represents a qualitative analysis. While it is helpful in pinpointing relevant factors, it provides little, or no information on their relative importance. We thus combined SWOT with the AHP method developed by Saaty (1980). In principle, this approach demands a pairwise comparison and weighting of the SWOT factors³. In our case, the process of weighting and prioritization of factors via pairwise comparison was conducted independently by the experts involved. Experts were asked to make pairwise comparisons between all factors within a group and additionally to produce overall comparisons between the four SWOT groups on the basis of a 9 point scale, as recommended by Saaty (1986). Combining SWOT with AHP adds value in that it helps improve the quantitative information available for strategic planning, i.e. the AHP results in a systematic priority ranking of factors (Kurttila, Pesonen, Kangas, & Kajanus, 2000). AHP is based on the eigenvalue method, and as a result of the calculations, each of the SWOT factors is associated with a certain relative priority level p ($0 < p < 1$, $\sum_{i=1}^n p_i = 1$) in a group of n factors. We first calculated the relative priority of each factor

² The representatives of interest groups and the energy planning experts had been identified via web research, and biogas plant operators had been selected randomly from a public directory.

³ The underlying assumption is that it is cognitively easier to conduct relative than absolute assessments.

based on the average values of the expert comparisons between the factors in the same SWOT category ('local factor priority'). Secondly, we calculated the relative priority of the four SWOT groups, based on the average of the expert comparisons between all groups ('group priority'). Thirdly, we calculated the 'global factor priority' of all SWOT factors by multiplying the local factor priority by the respective group priority. One limitation here is that the selection of SWOT factors is to a certain degree subjective, since it depends on the experts consulted, and not all possible factors can be included. However, the chosen factors can still be ranked on a quantitative basis. Our analysis focusses on agricultural biogas plants in Austria in general, and not on individual plants. While we assume no universal validity for our results, we do believe that we have been able to spot relevant propensities in the field.

3. Results and Discussion

In our SWOT analysis, we identified eight potential strengths, seven potential weaknesses, nine potential opportunities and eleven potential threats. Based on a consideration of the existing scientific literature and reports, as well as on expert statements, we were able to reduce the number of factors to four in each SWOT category. These factors were then made the basis for the expert pairwise comparisons and for further processing via AHP. Table 1 shows the factors and their resulting AHP rankings. Figure 1 illustrates the results graphically.

Table 1: Priority of SWOT factors

	SWOT Factors	Local Priority		Global Priority	
Strengths [Priority: 0.245]	S _a : Additional source of income*	0.477	(1.)	0.117	(3.)
	S _b : Reduced energy costs through self-provision	0.128	(3.)	0.031	(11.)
	S _c : Utilization of available resources	0.278	(2.)	0.068	(6.)
	S _d : Recovery of fermentation residuals in agriculture	0.117	(4.)	0.029	(13.)
Weaknesses [Priority: 0.103]	W _a : Low financial strength*	0.519	(1.)	0.053	(7.)
	W _b : Potential underutilization of plant capacity	0.200	(3.)	0.021	(14.)
	W _c : Lack of use for heat generated	0.202	(2.)	0.021	(14.)
	W _d : Lack of technology know-how	0.079	(4.)	0.008	(16.)
Opportunities [Priority: 0.343]	O _a : Climate change	0.201	(3.)	0.069	(5.)
	O _b : Reduced dependency on energy imports	0.271	(2.)	0.093	(4.)
	O _c : Multi-functionality of biogas*	0.375	(1.)	0.129	(2.)
	O _d : Development projects for rural areas	0.152	(4.)	0.052	(8.)
Threats [Priority: 0.309]	T _a : Feed-in-tariff depends on policy**	0.650	(1.)	0.201	(1.)
	T _b : Food vs. fuel dilemma	0.142	(2.)	0.044	(9.)
	T _c : Low acceptance rate among neighbors	0.108	(3.)	0.033	(10.)
	T _d : Small-scale agriculture	0.101	(4.)	0.031	(11.)

* Factor with highest local priority in respective SWOT group

** Factor with highest local and global priority

Figure 1: Results of integrated SWOT/AHP analysis

Experts assigned the highest priority to opportunities ($p=0.343$) and threats ($p=0.309$), while strengths ($p=0.245$) and weaknesses ($p=0.103$) are viewed as being relatively less important. Thus external factors, i.e. those not directly under the control of plant operators, are currently perceived as having a higher impact on the success of agricultural biogas plants than internal factors.

As a subsequent step, we then looked at the SWOT categories separately, and at the specific priorities calculated for the factors within the categories. As suggested by Saaty (1986), the consistency of the results was cross-checked. In all cases the calculated consistency ratio indicated that the experts made consistent judgments ($CR < 0.1$).

Regarding the perceived strengths of agricultural biogas plants, the most significant appears to be the additional source of income it represents for farmers ($p=0.477$). The fragile economics of agricultural enterprises often require that additional income streams be generated wherever possible. Austrian eco-electricity legislation represents an important basis for planning in this respect as it regulates the feed-in tariffs for energy generated from renewables. In addition,

revenues can also be generated through heat provision, e.g. for residential estates, through the sale of digested residues, utilization of animal and plant manures, etc. The second-most important strength of biogas found in our analysis relates to the potential it offers for the utilization of resources which would otherwise remain idle; e.g. manures, agricultural residues and self-grown renewables. In contrast, the reduced energy costs resulting from self-provision and utilization of fermentation residuals are considered to be only of relatively little importance.

‘Weak financial strength’ ($p=0.519$) of potential and existing plant operators is perceived as being the main weakness associated with extending the use of agricultural biogas plants. Especially agricultural enterprises which depend on buying in substrates may frequently face liquidity shortages. Investment costs in new plants are often covered by loans. Moreover, as operating costs have increased in recent years, the current level of guaranteed tariffs no longer covers associated expenditures. This lowers profitability, and thus makes necessary re-investment and up-grading of older facilities either unattractive, or impossible. The financial leeway for operators is even more constrained when heat is not properly utilized and/or the utilization capacity of the plants is low.

In the category opportunities, the highest priority is seen to be the multi-functionality of biogas ($p=0.375$), and the reduction of dependency on energy imports is ranked second ($p=0.271$). Climate change issues are seen as the third most important opportunity, and the fifth-most important global factor, not least because biogas production is perceived to be basically CO₂-neutral. Rural development projects and public policies targeted at increasing regional economic value added are considered to be rather insignificant in this context.

The dependence of feed-in-tariffs on political circumstances is rated highest ($p=0.650$) among threats, and also in terms of global priorities. Thus, governmental policies will clearly exert a substantial influence on the further development of the entire sector, at least in the mid-term. Other perceived threats (food vs. fuel debate, public acceptance, small-structured agriculture) are all considered to be rather insignificant.

We have to note that the relatively low acceptance of biogas plants by residents has repeatedly been seen as a problem. In a couple of cases, residents complained about expected high levels of smell, noise and traffic, and indeed a couple of planned projects have had to be shut down, or scaled down, as a result of public protests. This is not entirely reflected in the rather low relative ranking found for this issue ($p=0.108$). However, despite the low relative threat level reported here, it is important to take the concerns of residents seriously. The use of participatory approaches in planning and implementation is likely to be one means of preempting any buildup of resistance: More scope needs to be made available for residents to become involved in projects, e.g. in the planning process or as co-owners or customers.

The global ranking of priorities emphasizes that agricultural biogas plants are strongly driven by external factors – four of the top five factors are of an external nature. Although opportunities, such as the multi-functionality of biogas and the potential to reduce dependency on energy imports, appear strong in this ranking, the results indicate that in the end it is up to policy makers

to decide which direction the development of renewables is to take, and which specific role is to be played by agricultural biogas.

4. Conclusions and Policy Implications

The results of our analysis indicate that agricultural biogas production and its further development are primarily dependent on external factors, i.e. those not in the direct sphere of influence of farmers and plant operators. Assuming that the main external barriers can be overcome, the experts interviewed see considerable growth potential for small-scale agricultural biogas plants.

In general, lack of goodwill on the part of farmers does not appear to be an issue. However, at the current stage of development, farmers' willingness to invest still depends strongly on the availability of subsidies. The current feed-in-tariff system in Austria is regarded as being insufficient with respect to the support offered for biogas, and thus overall willingness appears to be decreasing. However, the experts all agree that simply increasing feed-in-tariffs will not solve this problem. Currently, the price volatilities related to input material are not considered in the fixed feed-in-tariff system. Thus, plants which rely on buying in substrates remain high-risk undertakings. Alternative and/or more suitable policy options need to be devised. These could include index-linked feed-in-tariffs, hybrid tariffs with a fixed and a variable component, or a more sophisticated feed-in system which differentiates between electricity and gas generation. Bonuses for utilizing liquid manure could also generate positive side-effects (e.g. increased ground water protection), and attractive follow-up-tariffs would support re-investments in plants that otherwise would be shut down. Investment and operating costs are still rather high, but these are expected to decrease once plants become more standardized. However, a policy of maximizing operational efficiency should not be pursued to the extent that no room is left for customized planning. Experience will dictate the correct balance of objectives in practice.

To conclude, political and technical impulses are still necessary in order to make agricultural biogas plants attractive to potential operators. Currently, profitable operation is difficult, particularly for small-scale plants. Consequently, no significant increase in plant numbers is to be expected in the mid-term. In the long-term, however, the need to optimize the utilization of agricultural resources and to improve operational efficiencies means that biogas is very likely to become established as one small, but significant, component of the energy system.

Acknowledgements

We cordially thank the experts who participated in this study.

5. References

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