Energy Policy 76 (2015) 107–111

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Short Communication

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

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## HIGHLIGHTS

- Integrated SWOT–AHP analysis for agricultural biogas plants in Austria.
- Quantification of weighting factors based on expert judgments.
- Financial aspects dominate over technological and environmental aspects.
- Sophisticated and flexible subsidy schemes are crucial for the further diffusion of the technology.

## ARTICLE INFO

*Article history:*
Received 2 August 2014
Received in revised form
10 October 2014
Accepted 16 November 2014
Available online 26 November 2014

*Keywords:*
Decentralized energy generation
Analytic Hierarchy Process
SWOT
Small-scale electricity generation

## ABSTRACT

In this paper, 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.



## 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 and 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

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http://dx.doi.org/10.1016/j.enpol.2014.11.022
0301-4215/

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 operation.[1] 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 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.[2] In order to validate the SWOT analysis, and to identify the four most relevant factors per SWOT category, 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 plants.[3] Some of the experts were able to employ several perspectives simultaneously, e.g. a professional planner who deals with the planning of biogas plants and is also representative of a federal interest group. 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 factors.[4] In our case, the process of weighting and prioritization of factors via pairwise comparison was conducted independently by the experts involved. After the four most relevant factors per SWOT group had been identified based on the qualitative interviews, the involved experts received a questionnaire to make pairwise comparisons between the most relevant 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). With four factors per category, and four categories, experts had to make 30 pairwise comparisons in total (six pairwise comparisons per category, plus six pairwise comparisons of the four categories).[5] 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 et al., 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 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'). Each expert opinion was weighted equally. 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. Fig. 1 illustrates the results graphically.

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 , the consistency of the results was cross-checked. In all cases the calculated consistency

[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).

[2] The full list of SWOT factors is provided in Supplement 2.

[3] 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. Information on the background of the selected experts is given in Supplement 1.

[4] The underlying assumption is that it is cognitively easier to conduct relative than absolute assessments.

[5] The pairwise comparisons made by the experts are provided in Supplement 3.