Energy Policy 62 (2013) 372–378

Contents lists available at ScienceDirect

Energy Policy

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

Individual acceptance of the biogas innovation: A structural equation model

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HIGHLIGHTS

- Strong expansion of biogas production based on renewable resources in Germany since 2004.
- Low acceptance of biogas production in some regions.
- Identification of influencing factors that determine the individual acceptance of the biogas innovation among German farmers.
- Compared to existing studies, personal innovativeness was taken into account in the causal model.
- Results are important for the further expansion of biogas production in Germany as well as in other countries.

ARTICLE INFO

Article history:
Received 7 December 2011
Accepted 20 July 2013
Available online 15 August 2013

Keywords:
Personal innovativeness
Renewable energy
Structural equation model

ABSTRACT

The rapid spread of biogas production in Germany has resulted in an increased public debate over this new business branch. Today the production of biogas is much more controversially debated than several years ago. At the same time it could be proven that even among farmers themselves the acceptance of biogas production in some regions is somewhat dampened due to accompanying “collateral damages”. Therefore, the goal of this paper is to identify relevant influencing factors that determine the acceptance of the innovation “biogas” among farmers by applying a causal analysis. Initial results among the five investigated determinants show that not only an individual attitude toward biogas but also the farmers' personal innovativeness strongly and significantly influences an individual's acceptance of the innovation “biogas”.

1. Introduction

Over the years the European Union (EU) has launched various elements of its renewable energies strategy. According to the EU Directive 2009/28/EC, the EU has formulated three ambitious energy and climate protection goals for the period leading up to 2020: reducing greenhouse gas emissions by 20%, increasing the share of renewable energy to 20% and improving energy efficiency by 20%. The overall objective of the EU's strategy is to stop climate change and to reduce global warming accordingly.

Against this background, Germany has seen great expansion in its production of renewable energies in the past few years. In 2010 renewable energies already contributed 9.3% to Germany's supply of total primary energy (IEA, 2011). One German specialty in the field of bioenergy production is the implementation of numerous plants producing biogas from agricultural sources (including, but not restricted to, manure, energy maize and grass silage) (FNR, 2010). A similar development elsewhere in the EU, although to a much lesser degree, can be observed only in the Netherlands, Austria, Belgium, Italy and Denmark (Eurobserver, 2010). Due to the generally concordant energy concepts of the various political parties in Germany, the growth in the biogas sector will rapidly continue in the near future (Bode et al., 2010). In this manner, renewable energies will play a central role in Germany's future energy supply, in accordance with the German government's 2010 energy concept (BMU and BMWi, 2010).

From an agricultural perspective, the decentralized production of biogas from renewable resources has gained greatly in importance in the area of renewable energies in recent years. In fact, between 2004 and 2011, the number of German biogas plants for production of electricity and heat has more than tripled, from 2050 to ~7000 (FVB, 2011) This can be seen as a result of the first amendment of the German Renewable Energy Act (REA), which particularly supported the use of renewable resources in biogas production. The majority of these plants operate on the basis of renewable resources from agricultural production, in most cases energy maize. Therefore, biogas production has turned out to be very land intensive. In 2010, 650,000 ha (or about 3.9% of Germany's agricultural farmland) were used for the production of

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0301-4215/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enpol.2013.07.083

inputs for biogas plants. Most biogas plants are currently operated by farmers who, in accordance with the requirements of the REA, have committed themselves for at least twenty years to the biogas innovation (EEG, 2009). In addition, farmers can benefit indirectly from biogas production and its promotion by supplying energy crops to nearby biogas plants.

With the strong development of biogas production, public discourse about this new and financially often interesting industry has likewise increased. Today, biogas production is considerably more controversial among the wider public (including the mass media) than it was just a few years ago (Zschache et al., 2010). At the same time, it has become obvious that in some regions, even among farmers themselves, the acceptance of biogas production and the accompanying "collateral damage" (e.g., increased competition with animal husbandry, rising land lease prices, crowding-out effects, nutrient problems) is low (Emmann and Theuvsen, 2012). For example, it was observed that some farmers invested in the biogas innovation relatively early, whereas other farmers—despite the attractive governmental incentives—still have not joined this new industry (Granoszewski et al., 2009).

This paper will use a causal analysis to identify influencing factors that determine acceptance of the biogas innovation among German farmers. To this end, an empirical study was conducted in 2010 using a standardized questionnaire. The study was carried out in an area comprising five regions in the state of Lower Saxony that are characterized by a high concentration of biogas plants (ML, 2010). In these regions, early (and late) adopters often live side by side with farmers who are still refraining from investing in biogas plants. The empirical data will be used to identify factors influencing farmers' acceptance of the biogas innovation. Knowledge about the causal relationship and properties of these factors can be used to increase farmers' acceptance of the biogas innovation and thus guarantee the politically desired continued development of decentralized biogas production as an important contribution to Germany's energy turnaround (BMU and BMWi, 2010).

This paper is divided into five sections. The next section will develop the model and formulate the research hypotheses that will serve as the basis for the empirical study. The third section deals with the methodology and describes the sample. The focus of the fourth section is the causal analysis of farmers' acceptance (or lack thereof) of the biogas innovation. The paper concludes with a discussion of the results and managerial implications as well as some suggestions for future research.

2. Model and hypotheses

Farmers' investments in biogas plants can be interpreted as the outcomes of their acceptance of a new technology (Heyder et al., 2012). In the agricultural and food industry, various models have tried in the past years to identify determinants of acceptance. Areas of investigation include, for instance, the acceptance of agricultural technologies like new storage and processing technologies (Rhoades and Booth, 1982), the adoption of agricultural innovations like modern environmental technology and high yield hybrids (Feder and Umali, 1993) and the acceptance of IT-based information systems by pig farmers (Arens et al., 2012). These studies have identified various determinants of farmers' acceptance of new technologies, for instance, behavioral intention, performance expectancy and facilitating conditions.

During its short existence, biogas technology has not been the subject of many academic studies on acceptance. This is not surprising, especially when considering that biogas production from renewable resources (when seen from a global perspective) is primarily a German development (Eurobserver, 2010). Until now, only a few authors have investigated the acceptance of the biogas innovation. For example, Wüstenhagen, et al. (2007) examined the social acceptance of renewable energies and Ahrer et al. (2007) analyzed the regional acceptance of biogas plants by the public, but none of them among farmers. Granoszewski et al. (2011) analyzed the investment behavior of farmers active in renewable energies (including biogas). The regression model focused more on the determinants of the investment decision than on acceptance of the biogas innovation. Therefore, it is still an open question which factors influence German farmers' acceptance of the biogas innovation.

With this in mind, a work done by Frambach and Schillewaert (2002) was used to derive an acceptance model that integrates the problems discussed above. The model includes a total of five constructs to describe the individual acceptance of the biogas innovation. Frambach and Schillewaert (2002) themselves suggested that, in subsequent studies, the determinants presented as the basis for their acceptance model should be adjusted to fit the innovation, situation and environment. There are five constructs in the present model: attitude towards biogas, personal innovativeness, externalities, individual land lease conditions and facilitating conditions (cf. Fig. 1). The derived model seems to be especially appropriate in the present context to describe the acceptance of the biogas innovation since, in contrast to previous research, personal innovativeness is explicitly considered (see also Scott and Bruce, 1994). This allows individual differences between farmers investing or not investing in biogas production to be taken into account.

An individual's **attitude towards biogas** is based on cognitive beliefs and affects that individual perceives concerning the particular innovation (Venkatesh et al., 2003). According to various studies, these two aspects are important for the explanation of individual acceptance of an innovation (Fishbein and Ajzen, 1975). For example, in this manner the Technology Acceptance Model (TAM) (Davis et al., 1989) shows that the user's beliefs about a technology—namely its "perceived usefulness" and "perceived ease of use"—as well as individual affects can be key elements of acceptance. In addition, it can be derived from the TAM that attitude is influenced by external determinants (hypotheses 2b, 3b and 5) and thus can experience change (Frambach and Schillewaert, 2002). Especially in the case of biogas production, Granoszewski et al. (2011) were able to show that strongly perceived external effects exert a negative influence on the individual business's investment behavior.

These considerations lead to the first hypothesis:

Hypothesis 1. A farmer's attitude towards biogas influences that farmer's acceptance of the biogas innovation.

Personal innovativeness is related to the willingness of a person to accept an innovation, regardless of others' opinions. Until now, only few acceptance studies have considered personal

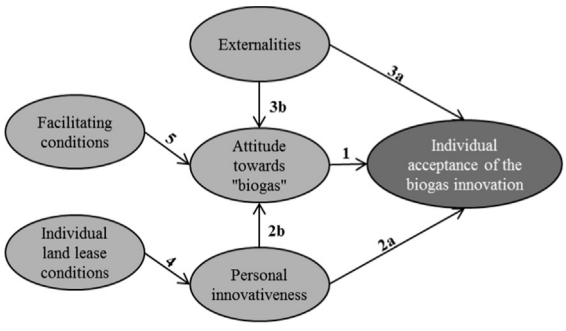

Fig. 1. Conceptual Model.
Source: Authors' adaption of Frambach and Schillewaert (2002).