Biomass and Bioenergy 90 (2016) 163–172

Contents lists available at ScienceDirect

Biomass and Bioenergy

journal homepage: http://www.elsevier.com/locate/biombioe

Research paper

Sugar beet as a biogas substrate? A discrete choice experiment for the design of substrate supply contracts for German farmers

Saramena Sauthoff*, Oliver Musshoff, Michael Danne, Friederike Anastassiadis

Georg-August-University of Goettingen, Faculty of Agricultural Sciences, Department of Agricultural Economics and Rural Development, Farm Management Group, Platz der Goettinger Sieben 5, D-37073 Goettingen, Germany

ARTICLE INFO

Article history:
Received 24 July 2015
Received in revised form
16 March 2016
Accepted 11 April 2016

Keywords:
Sugar beet
Alternative biogas substrate
Discrete choice experiment
Decision making
Supply contract design

ABSTRACT

Biogas production using biomass of agricultural origin plays a key role in Germany's energy transition process. As the main substrate, maize usage has been increasingly criticized in recent years leading to a reduction of this crop for the use in biogas plants by an adjustment of Germany's Renewable Energy Sources Act in 2012. Thus, at least 800 biogas plants are obliged by law to find suitable substrate alternatives to maize. This study explores German farmers' willingness to grow sugar beets for biogas production based upon the analysis of a discrete choice experiment conducted with 118 arable farmers. Models are estimated in terms of willingness to accept. Results reveal that at least two-thirds of the participating farmers assess biogas production from sugar beets as a suitable alternative to maize. However, with respect to their own farms, farmers are rather reluctant to choose a contract. Findings also indicate that experience with growing energy crops on contract does not enhance contract acceptance. Furthermore, risk-averse farmers are more likely to contract sugar beet as a biogas substrate than less risk-averse farmers, resulting in a lower price demand. However, risk-averse farmers prefer short contract periods and a small share of their arable land for contracted production, otherwise they demand a markup. Regarding a viable biogas production from agricultural biomass, our study is useful for biogas plant operators, farmers and policy makers to gain insight into the contract design for a possible substrate alternative from the perspective of farmers.

1. Introduction

While the global demand for energy is continuously rising [1], the availability of finite resources is decreasing. Additional energy-related challenges are to mitigate climate change and its consequences in order to minimize resource loss [2]. Therefore, the promotion and expansion of renewable energy sources has become a vital part of many countries' strategies to achieve a sustainable energy transition [3,4]. Against this background, the German government has laid the foundation for its energy transition process with the Renewable Energy Sources Act (RES Act) in 2000 [5]. By 2015, renewable energy sources already accounted for 30% of the gross electricity consumption [6]. However, the latest amendment of the law (2014) aims to continuously and cost-efficiently increase the share of electricity generated from renewable energy sources to at least 40% by 2025 [7].

Within various renewable energy sources, biogas production of agricultural origin has been greatly expanded in Germany due to a financially rewarding feed-in tariff system [5]. It is an attractive renewable energy source because of its applicability for heat and power generation, as well as for gaseous fuel [8]. The German Biogas Association estimates that the number of biogas plants in the country will reach 8928 by the end of 2015, which corresponds to more than an eightfold increase since 2000 [9]. Thus, Germany represents the largest biogas producer in the world [10].

Biogas of agricultural biomass origin is mainly obtained through the processing of energy crops [8]. This leads to a high demand for and an increased cultivation of energy crops such as maize and grains. Currently, maize accounts for nearly three-quarters of the biomass-based share of the substrate mix [11]. In 2015, energy crops produced for anaerobic digestion in German biogas plants were grown on a total surface area of 13,930 km^2 [12]; while the cultivation of energy maize alone accounts for 9000 km^2 of this area [13]. The rapid development of German biogas production has caused a public debate in Germany over many related features, with one substantial example being that of the negative influences of

* Corresponding author.
E-mail address: saramena.sauthoff@agr.uni-goettingen.de (S. Sauthoff).

http://dx.doi.org/10.1016/j.biombioe.2016.04.005
0961-9534/

maize monoculture cultivation on aspects of biodiversity [14]. There have also been complaints from citizens in some regions that high-growing maize plants block peoples' views and, thus, the landscape is affected negatively [15,16]. Similar findings are reported by Paulrud and Laitila [17] who showed that high growing energy crops "may cause visibility problems in the landscape and, unlike most conventional field crops, may block views." These among other reasons, e.g., pollution of ground water by nutrients or organic matter loss in farmland [14], gave the German government the necessary push to introduce the so-called "maize cap" through an amendment to the RES Act in the year 2012. The amendment limited the amount of maize or cereal grains that is allowed to be utilized in biogas plants to 60% mass fraction; moreover, the amendment affected approximately 800 biogas plants that were built from 2012 to 2014 [7,9,18]. In the summer of 2014, significant changes relevant for the biogas sector were implemented through another amendment. These include, for example, the elimination of the maize-cap, a narrow growth corridor for biomass-based energy of a maximum of 100 MW per year, and the elimination of bonuses for energy crops [7,18]. This amendment, however, only applies to newly built plants which are commissioned after August 1, 2014. Furthermore, it has to be considered that more than half of the currently operating plants will be in commission at least until 2029 since the minimum lifetime of a biogas plant is 20 years [7,9]. In order to generate energy from biomass with a less controversial substrate than maize, suitable alternatives become necessary, especially if a biogas plant is bounded to the amended RES Act of 2012 with its maize cap [7,14,18].

Alternative substrates should preferably provide a high land use efficiency, expressed as a high methane yield per hectare, to supplement or substitute maize [19,20]. Considering that the specific biogas yield depends on the composition of the substrate, sugar beet is a very interesting substrate alternative because its dry matter essentially consists of sugar that can be quickly and almost completely converted into biogas [21]. Starke and Hoffmann [20] and Gissén et al. [19] found that the yield of sugar beet, as well as the energy yield per hectare, exceeded that of maize. This is a crucial factor, since the energy production from agricultural biomass often competes with food production. It is therefore necessary to ensure that the scarce resource of land is used optimally [19]. Furthermore, compared to maize sugar beets can only be grown in crop rotation [22]. In current maize growing regions, sugar beet production could contribute to increased diversity by making crop rotations more flexible. Additionally, the low growth height of sugar beets could be advantageous for defusing the debate over a biogas production that is strongly reliant on high-growing maize [14]. From an economic point of view, the expiration of the EU sugar beet quota in 2017 increases the necessity to consider an alternative utilization of sugar beets as farmers are facing a decline in stable financial support for traditional sugar beet production [23]. From 2017 on, sugar beets will be traded at world market prices, which tend to vary greatly [24]. Bringing sugar beets intended for bioenergy production into farmers' focus could be one opportunity to provide farmers with more planning certainty [25].

As both sugar beet cultivation in the EU and biomass feedstock supply of biogas plants are almost entirely organized through contract farming [26,27], it is most suitable to establish future sugar beet cultivation efforts for biogas production with supply contracts. However, using sugar beet as a biogas substrate is a rather new endeavor, thus resulting in a lack of data regarding substrate supply contracts for this crop. Furthermore, supply contract data is sensitive information that cannot be easily collected, consequently requiring the development of an experimental design [28]. To date, there are no known studies which address farmers' supply contract preferences towards sugar beet as a biogas substrate. To investigate the preferences for the design of supply contracts for sugar beets prior to their implementation into the market, a discrete choice experiment (DCE) is a logical assessment instrument [29,30]. As the aim of this work is to achieve a realistic contract design that appeals to farmers to grow sugar beets for biogas, we pursue the following three objectives: (1) We examine whether farmers are principally willing to accept contracts for sugar beet as a biogas substrate. (2) Furthermore, we are interested in whether contract experience/no contract experience with growing energy crops on contract influences the decision of a farmer to opt for a contract. (3) Finally, we analyze whether there is an influence of the farmers' risk attitude on their contract choice, taking into consideration that sugar beet as a biogas substrate is a relatively new concept.

By closing the research gap on supply contract design for sugar beet as an alternative biogas substrate, the novelty of this paper lies in the transfer of the preference valuation technique of a DCE to the agricultural biomass sector for producing biogas from sugar beets. Furthermore, this study gives farmers, as well as biogas plant operators, the opportunity to gain important information about farmers' perceptions of sugar beet supply contracts. This information is especially valuable for those who are bound to the RES Act version of 2012 and are therefore obliged to reduce the maize share of the substrate mix. Moreover, this study allows policy makers to gain insight on how an alternative path of substrate supply may look from the farmers' perspective. This is particularly important because political support to increase adoption rates of sugar beet cultivation for biogas production could promote a more publically accepted biogas production, especially in regions with a high share of maize cultivation.

The following section deals with the hypotheses derivation. Section 3 provides information about the experiment, specifically regarding the experimental design. Based on the results, the hypotheses are tested and discussed (Section 4), while in Section 5 conclusions are drawn.

2. Hypotheses generation

2.1. Experience and knowledge

Goodwin and Schroeder [31] found that educational programs, as well as advisory services encourage farmers to adopt marketing contracts. Pennings and Leuthold [32] indicated that in the contract adoption phase, decision-makers evaluate to what extent, if any, a contract has an added value to them. Additionally, contracting knowledge is considered to have a positive influence on the adoption of future contracts [33]. Granoszewski and Spiller [26] revealed that farmers who have already accepted substrate supply contracts in the past are more likely to enter into contracts for biomass again. Therefore, the following hypothesis can be derived:

H1. Farmers who have experience with biogas substrate contracts are more willing to choose a supply contract for sugar beet as a biogas substrate.

2.2. Farmer's risk attitude

The statement "farming is a risky business" may result from the fact that income from farming depends to some extent on "unanticipated changes and unpredictable events" [34]. Furthermore, the literature gives evidence that farmers as a group are typically thought to be risk-averse [34–36]. This could lead to hesitant behavior, especially for entrepreneurial activities within the field of renewable energy, since future developments (e.g., changes in laws, political programs) are difficult to predict [37,38]. Uncertainty seems to be a key barrier to a widespread and successful uptake of