Resources, Conservation and Recycling 104 (2015) 152–161

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

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

Biogas digestate marketing: Qualitative insights into the supply side

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ARTICLE INFO

Article history:
Received 24 April 2015
Received in revised form 26 August 2015
Accepted 26 August 2015
Available online 1 October 2015

Keywords:
Marketing
Biogas digestate
Organic fertilizer
Compost

ABSTRACT

Managing digestate output and developing a market for the product is a serious challenge for the biogas industry. Without effective strategies for sustainable management, the large volume of digestate produced by biogas plants may cripple the industry and its potential. Through interviews with diverse biogas stakeholders, we examine current approaches to digestate marketing to identify factors that support and those that inhibit its success. We find that marketing to regions with a nutrient demand or into the non-agricultural sector holds promise. Upgraded digestate products offer increased marketability due to their higher nutrient content and lower water content. Fertilizer and soil manufacturers, farmers, horticulturists and private customers all represent markets for digestate. Current disposal prices range from negative to strongly positive, depending on the regional nutrient availability, agricultural structure, season, feedstock and degree of upgrading. Marketers agree that concealing the biogas origin of digestate products is still necessary to avoid negative perceptions by customers. One implication of this is the need for better understanding by marketers of consumer concerns and preferences, and for better education of consumers regarding the safety and benefits of digestate. Overall, we find that opportunities for digestate marketing remain largely unexploited and marketing strategies remain immature. Our findings should prove helpful to current and future digestate marketers.

1. Introduction

Over the last decade, economic incentives, including feed-in tariffs, have led to a steady increase in the use of biogas technology. In 2013, more than 14,500 biogas plants were operating in Europe, including 9,035 plants in Germany (EBA, 2014). Produced through anaerobic digestion of organic feedstock and consisting mainly of methane and CO_2, biogas is used in Combined Heat and Power units (CHP) to generate electricity and heat. It can also be upgraded to biomethane and used as fuel for vehicles or heating. Biogas also offers more flexibility than other forms of renewable energy, as it can be stored for use at times of peak demand (Hahn et al., 2014).

Although biogas is a promising renewable energy alternative, its sustainable production also depends on the ability of plant operators to manage the digestate remaining after the anaerobic digestion of biodegradable feedstock. To date, 95% of the digestate produced in Europe is used as an organic fertilizer for field crops on agricultural land (Saveyn and Eder, 2014), where it substitutes for chemical fertilizers (Vaneeckhaute et al., 2013). Direct application on the plant operator's own land is usually the best option (Fuchs and Drosg, 2013), yielding the economic benefit of savings on nutrient purchases (Jones and Salter, 2013).

Other options for reusing the available nutrients include the marketing of digestate to third parties in the agricultural and non-agricultural sectors (e.g. private gardeners). Biogas plant operators may have to consider these alternatives if they have insufficient land of their own, or if there is a nutrient surplus in the region.

In Germany, the low public acceptance of biogas technology has been noted (Herbes et al., 2014), and the absence of broad public acceptance for bioenergy encumbers successful digestate marketing. Still, many questions remain worthy of research, from the effectiveness of different marketing approaches to the perceptions of different customer groups to even seemingly straightforward questions of digestate-related product requirements. Customer perceptions of different digestate feedstocks, of product forms and of the origin of biogas remain open issues. Since the digestate market is just developing, strategies for marketing have not yet been outlined. However, if the biogas industry is to mature into a sustainable energy production system, establishing marketing strategies for digestates and developing the digestate market will

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http://dx.doi.org/10.1016/j.resconrec.2015.08.013
0921-3449/

prove critical challenges, especially with the use of digestate in the agricultural sector facing imminent legislative restrictions.

Nutrient variability, pressure on available land (Huttunen et al., 2014; Riding et al., 2015), and insufficient knowledge of the use and fertilizing value of digestate among farmers are additional barriers for successful marketing (Schüsseler, 2009; Golkowska et al., 2014). These factors are discussed below.

1.1. Legal constraints

The use of digestate in the agricultural sector is strictly regulated (Huttunen et al., 2014). At the EU level the Nitrate Directive (91/676/EEC) provides the regulatory framework for protecting ground and surface water from nitrate pollution. It has to be implemented within the national law of all EU members. In Germany, this directive is implemented through a fertilizer ordinance that restricts the use of digestate as an alternative for chemical fertilizers (Düngeverordnung – DüV 10.01.2006). Upcoming changes in the fertilizer ordinance will pose further restrictions on using digestates in the agricultural sector. For example, the timeframe for digestate application after harvest will be further restricted (BMEL, 2014).

1.2. Pressure on available farmland

Several regions in Europe with intensive livestock farming suffer from excessive concentrations of nutrients in the land, which must be controlled to limit eutrophication of water bodies. As a result, only limited amounts of unprocessed digestate can be returned to agricultural land in such regions (Vaneeckhaute et al., 2013), leading to higher competition for available farmland and higher land rent prices in the affected areas (Emmann et al., 2011). Finding sufficient arable land for permissible digestate application is especially difficult for larger biogas plants (Döhler and Wulf, 2009) whose plant operators must often pay high prices for digestate transport over long distances to areas of application in need of nutrients. Resulting transportation costs reduce the overall profitability and hence economic viability of a biogas plant (Delzeit and Kellner, 2013).

1.3. Nutrient variability and properties

Complicating the marketing of digestate is the fact that digestate characteristics depend on the properties of the input biomass (Huttunen et al., 2014) and so are highly nonuniform. Nutrient contents of Nitrogen, Phosphorous and Potassium (NPK) varies widely (Nkoa, 2014), making the economic value of digestate as a substitute fertilizer highly variable. Similarly, dry matter content varies widely, with values around 7% being typical (FNR, 2010). The correspondingly high volume of liquid digestate impacts the economics of digestate marketing, as prohibitive transportation costs often preclude distribution over long distances (Huttunen et al., 2014). These and other factors make the optimal use of digestate as an alternative fertilizer for the agricultural and non-agricultural sector sometimes difficult to realize.

1.4. Approaches to facilitate digestate marketing

Treatment options that reduce the volume and therefore increase the fertilizing value of digestate can facilitate its export to areas where nutrient demand is high (Holm-Nielsen et al., 2009; Rehl and Müller, 2011; Delzeit and Kellner, 2013; Golkowska et al., 2014).

There are several treatment alternatives for digestate that produce different products with distinct physical characteristics and fertilizer values (Golkowska et al., 2014). Depending on the complexity of the technology used, these treatment options range from partial to complete upgrading (Fuchs and Drosg, 2013). Different upgrading technologies result in different nutrient contents in the products. When using a screw press for example, most of the nitrogen and potassium are extruded along with the liquid phase of the untreated product, while phosphorous is predominantly retained in the dry matter. Other upgrading technologies, such as evaporation and membrane processes, account for upgrading costs of up to 10 € per cubic meter and more. These costs for the treatment of digestate have to be counted against the estimated disposal costs (Fuchs and Drosg, 2010). In a Life Cycle Assessment of seven different treatment options, Rehl and Müller (2011) investigated the environmental performance of each but observed that profitability is a plant operator's primary criterion in selecting one over another. Indeed, less than 3% of the digestate in the European Union is currently being upgraded to products that could be more widely marketed. These products are, for instance, constituents for growing media and manufactured soils or pellets (Saveyn and Eder, 2014) suitable for the use in the non-agricultural sector.

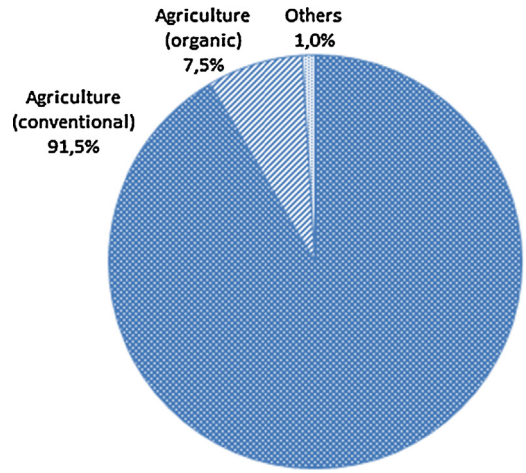

Fig. 1. Distribution channels for liquid digestate.
Source: Based on BGK (2015).

While such treatments can increase the market value of digestate, the price premia obtainable in existing, especially agricultural, markets may be insufficient to justify the investment in treatment technologies. There is therefore pressure to develop alternative markets outside of the agricultural sector where greater price premia might be obtainable. The horticultural and private gardening markets both have intriguing potential for further development (Döhler and Wulf, 2009; King et al., 2013). For example, from an agronomic point of view, digestate-based products such as potting media provide an acceptable alternative to peat-based products (Vaughn et al., 2014). Even the use of digestate pellets as a solid fuel has been explored technically and is already being practiced (Kratzeisen et al., 2010; García-Maroto et al., 2014). The possibility of expanding the market for liquid digestate products to domestic gardening applications as well as attempts to use digestate as a construction material are also being explored (Rigby and Smith, 2011).

Recent data from Germany shows, that liquid digestate is almost exclusively being used in the agricultural sector as Fig. 1 illustrates (BGK, 2015).

Solid digestate (e.g. pellets and compost) has more penetration of the non-agricultural sector, in contrast to liquid digestate. Fig. 2 illustrates that 17% of the solid digestate is marketed to private gardeners, soil manufacturers and others (BGK, 2015).

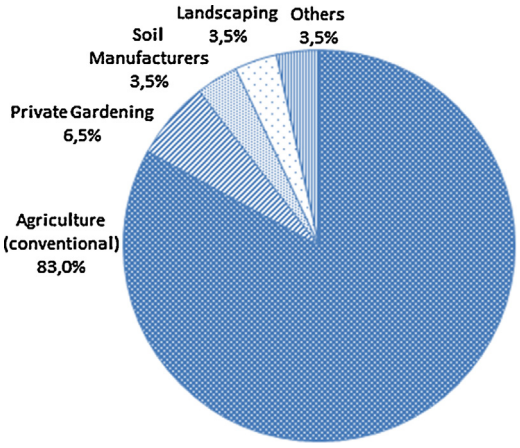

Fig. 2. Distribution channels for solid digestate.
Source: Based on BGK (2015).

1.5. Current state of digestate marketing research

It is noteworthy how little research has been done to date on the marketing of digestate-based products. However, some attention has been given to the marketing of compost, a product that is comparable to digestate in several ways. First, compost products are nonuniform, their characteristics depending largely on the input material (Alexander, 2010; Cesaro et al., 2015). Second, customers for compost cannot directly monitor the health and safety issues related to its application, so trust plays an important role in marketing (Borden et al., 2004). And third, the structure of producers is nearly as fragmented as that of biogas plants. Add to that the fact that some producers combine biogas and composting technology by processing solid biogas digestate products in composting plants (BMU, 2012) and the parallels between digestate marketing and compost marketing become even more compelling. However, the compost sector also differs from the biogas sector in several respects. First, the sector has been developing much slower than the biogas sector. Second, composting sites are mainly being owned by municipalities and have an established infrastructure. And third, many private gardeners are familiar with compost as a product and its application since they produce their own compost (Alexander, 2010; BMU, 2012).

Walker et al. (2006) pointed to the lack of knowledge of the advantages of compost as a major barrier for development of the compost market. Other studies have linked consumers' general knowledge of compost and their awareness of its health and safety aspects to their perceived satisfaction with compost products (Borden et al., 2004; Walker et al., 2006). Further, although market development, sales activities, limitations on its use and quality criteria for compost have been found to be decisive (Eggerth et al., 2007; Alexander, 2010), reported findings remain rather general. Specific insights can be found in a study by Probert et al. (2005), where price preferences of landscape contractors and retailers as well as preferred particle sizes, pH levels and standards for compost were evaluated. The actual preferences of the final customers, however, largely remain unknown to the composting industry.

1.6. Aim of this study

This study explores existing approaches to digestate marketing as well as the related marketing mix. Different product forms, quantities and qualities as well as customer groups are examined from the perspective of people with experience in marketing digestate-based products. We focus on issues such as the product, price, place and promotion and outline factors that support and those that inhibit successful digestate marketing. We anticipate that the results of this study will be helpful for all involved in marketing digestate and will serve as a point of departure for future research into consumers' perceptions of and preferences for digestate-based products. We regard this study as especially relevant for long-term development of the bioenergy industry, as marketing issues related to the critical question of digestate management have largely been ignored in the literature (Schüsseler, 2009).

2. Methodology

Owing to the open-ended nature of the research questions we sought to examine, we chose a qualitative research design for this study. When entering new or partially understood fields of research, an exploratory approach is an important preliminary foundation for further work (Creswell and Plano Clark, 2011; Sekaran and Bougie, 2013) and qualitative expert interviews are an appropriate method for the exploration of issues. Experts serve as representatives for their industry and can be characterized by their specific professional knowledge and their position in the marketing chain. For this study, all digestate marketers and consultants were considered to be experts.

We began by conducting an extensive literature review to gain an overview of the current issues in the field of digestate marketing. We then designed a semi-structured interview guide using principles established by Bogner et al. (2009), which was enlarged inductively through practice. The interview guide was structured as follows: section (1) dealt with the background and intentions of the marketers; section (2) investigated the regional context of the marketer, such as animal density and the agricultural structure in their vicinity; in section (3) questions were asked regarding production process and derived products; section (4) dealt with current marketing practices of the final digestate products such as price and distribution policies; in section (5) we explore communication activities; section (6) focussed on what is known about customer satisfaction and digestate marketing barriers; and the final section (7) focused on suggestions for further improvements concerning digestate marketing.

We next conducted an internet search for advertised digestate products, identifying a total of 48 suppliers throughout Europe. Their web presence ranged from entire websites dedicated to marketing digestate products to a short note on a related website announcing the availability of digestate for sale. Based on these results, we contacted 30 experts within reasonable travel distance by e-mail or telephone and asked them to participate in a personal interview. A total of 21 individuals agreed to do so. Table 1 summarizes pertinent details about the interviewees. Presumably, there are a lot more marketers of digestate that simply do not have a web presence.

The interviews took place between June and December 2014. They were held in four different countries (see Table 1). The stated prices are all in Euro (€).[1] The interviews ranged from 28 to 104 min, with an average of 57 min. All interviews were recorded and subsequently transcribed. The transcribed interviews then underwent a qualitative content analysis. We used MAXQDA, a common software tool to analyze qualitative data sets (Flick et al., 2013).

[1] Exchange rate for the Swiss Franc was applied at a rate of 1.2–1.0 € (January 13, 2015).

Table 1
List of interviewed companies.

Interviewed companies				
No.	Country	Interviewee	Feedstock	Form of interview
1	CH	Plant operator	Green and MSW waste	Face to face
2	CH	Plant operator	Green and MSW waste	Face to face
3	CH	Plant operator	Green and MSW waste	Face to face
4	CH	Plant operator	Green and MSW waste	Face to face
5	CH	Plant operator/soil amendment manufacturer	Green and MSW waste	Face to face
6	DE	Plant operator	Agricultural feedstock	Face to face
7	DE	Plant operator/soil amendment manufacturer	Green and MSW waste	Face to face
8	AT	Plant operator	Agricultural feedstock	Face to face
9	DE	Plant operator	Agricultural feedstock	Face to face
10	DE	Agricultural contractor	–	Face to face
11	DE	Agricultural contractor	–	Face to face
12	DE	Soil amendment manufacturer	Agricultural feedstock	Face to face
13	DE	Plant operator	Green and MSW waste	Face to face
14	DE	Plant operator	Green and MSW waste	Face to face
15	DE	Soil amendment manufacturer/upgrading technology manufacturer	Agricultural feedstock	Face to face
16	NL	Soil amendment manufacturer	Agricultural feedstock	Face to face
17	DE	Plant operator	Green and MSW waste	Face to face
18	FR	Consultant	–	Phone
19	DE	Soil amendment manufacturer	Agricultural feedstock	Face to face
20	DE	Plant operator	Agricultural feedstock	Face to face
21	DE	Plant operator	Agricultural feedstock	Face to face

(Key: CH, Switzerland; DE, Germany; FR, France; AT, Austria; NL, Netherlands; MSW, municipal solid waste).

3. Results

3.1. Digestate marketers

The interviewees varied considerably in their role in the digestate marketing chain. Broadly speaking, the following categories of market participation were observed:

1. Biogas plant operators with an agricultural, municipal or investor background;
2. Agricultural contractors, functioning mainly as intermediaries between digestate producers and customers in the agricultural sector;
3. Soil and organic fertilizer manufacturers;
4. Others, including manufacturers of digestate upgrading technologies and brokers working in nutrient exchange markets.

Some participants are active in multiple categories, i.e. these categories are not mutually exclusive.

3.2. Why is marketing of digestate necessary

The motives for marketing digestate are diverse and mainly depend on the regional context. In the following sections we present the primary motives that interviewees expressed.

3.2.1. Nutrient surplus region

One of the main marketing drivers is a nutrient surplus in the area where the biogas plant operates. This condition holds especially in regions such as Borken and Vechta in Northern Germany where the density of livestock farming is high, as is the number of biogas plants. The resulting scarcity of land for digestate spreading leads to high land rental prices, often exceeding 1.000 €/ha p.a. Further intensifying the pressure in these nutrient surplus regions is the manure and slurry disposal from bordering areas in the Netherlands. One interviewee stated that "manure disposal is a problem in our region – they come with 25 €/t across the border" (Stakeholder No. 9) indicating that payments are being offered to landowners to take slurry.

3.2.2. No available land on the plant operators' site

Some biogas plant operators with a non-agricultural background own no land for the application of digestate, and so have to either market their digestate through agricultural contractors or find distribution channels on their own. Due to limited storage capacities and a limited application timeframe for digestate, these plant operators depend heavily on uptake by local farmers. This dependency has led in some cases to severe pressures on the operators and increased rates of payment to landowners. By marketing upgraded products through longer chains, the distorting effects of local markets can be avoided.

3.2.3. Policy incentives and constraints

There are legal incentives that drive the marketing of upgraded digestate products. For example, the heat incentive bonus, paid by the German government under the renewable energy act (EEG 2004/2009), is applicable to the use of drying processes for the production of organic fertilizer from digestate. When biogas plants utilize the heat from their cogeneration unit and meet certain additional requirements, they are eligible for an extra bonus on the electricity produced that can amount to three cents per kWh of heat used, a considerable incentive (EEG 2009). For some interviewees, this bonus was the determining factor in deciding to treat digestate using exhaust heat.

Other legislative actions further influence the digestate market. For example, biogas plants that use household waste as feedstock have to comply with the German Biowaste Ordinance (BioAbfV), which prohibits the use of unprocessed digestate on grassland. Where this ordinance applies, alternative uses for the digestate have to be found, which may result in processing and marketing digestate to third parties. This is especially the case in regions with little arable farmland.

3.2.4. Evolving business niches

Emerging entrepreneurial activity has started to create added value from digestate through innovative services. Agricultural contractors, for example, offer extensive services around the feedstock and digestate supply chains such as finding suitable customers and the application of digestate. Other new players provide technology to upgrade unprocessed digestate to more widely marketable products. Some of these technology providers complement their service by assisting customers in marketing the final product. Manufacturers of organic fertilizers have also entered the digestate marketing field. They require inexpensive and abundant amounts of base material for their production, and they are turning to digestate as a source to complement their substrate mix.

3.3. Uses of digestate

While the main area of digestate application is as a soil fertilizer in the agricultural sector, digestate is being used by various groups for different applications, depending on the digestate properties and its degree of treatment. The following section deals with the use of digestate in both the agricultural and non-agricultural sectors.

3.3.1. Agricultural businesses

At least a part of the interviewed plant operators market a certain amount of digestate into the agricultural sector as substitute fertilizer. Organic farmers, for example, depend on organic fertilizers and especially favor using digestate when its use complies with the requirements of organic certification. Besides the common use of digestate as an organic fertilizer, it can also be used as animal litter. Separated digestate dry matter is being used as cattle bedding and refined dry matter pellets are being used as chicken litter.

3.3.2. Horticultural businesses

The horticultural sector is a large target market that ranges from nurseries to professional gardening and landscape construction businesses. Many of our interviewees began their businesses as composting sites and then later decided to expand their operations by installing biogas plants. These participants had already established contacts within the horticultural sector, which led to a ready-made channel for digestate-based products that could serve horticultural consumer needs. Such products vary widely in their configuration, from growing media for home gardeners to organic fertilizers for large-scale landscaping.

3.3.3. Other businesses

Other suitable sectors for marketing of digestate remain at the early stages of development. There are the hobby gardeners, for example, that require small amounts of organic fertilizers and compost for gardens and indoor plants. This is a market that could be much more widely served by digestate-based products. More intriguing possibilities exist outside the realm of fertilizer application, e.g. the marketing of digestate pellets as solid fuel to energy companies.

3.4. Marketing mix

3.4.1. Product forms

Several types of digestate product can be produced depending on their dry mass content, available upgrading technology and intended use, as shown in Fig. 3.'

3.4.2. Product processing technologies

Composting and belt drying were encountered most often in this study. Simple separation without further upgrading was often seen as unfavorable for the quality of the product because dividing the solid and liquid phases also separates the organic matter

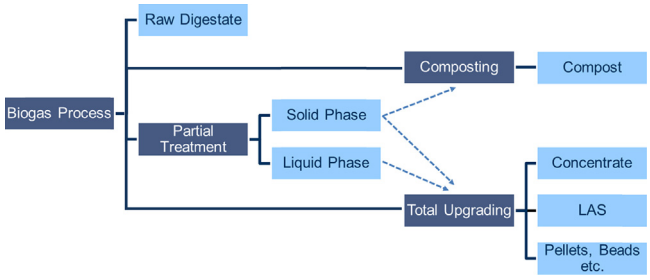

Fig. 3. Digestate varieties depending on the treatment method applied. (Key: LAS Liquid Ammonium Sulfate).

from the nutrient fraction. For example, because after separation the phosphorous largely remains in the dry matter, the liquor may be applied to land with an excess of phosphorous. The dry matter could further be marketed into regions with a phosphorus demand or into the non-agricultural sector. This example serves to illustrate that optimal application of upgrading technologies may need to account for local nutrient availability.

Besides the technical options for eliminating water and thus increasing the fertilizing value per unit of volume, additives can help to create a more marketable product. Interviewees mentioned adding organic and mineral substrates to create products with more desirable structural properties and nutrient concentrations. Additives include cocoa shells, malt, pumice, dry chicken dung, horn meal, feather meal, peat, sand, urea and nitrogen. Some providers have an assortment of up to 24 different products for various applications and one organic fertilizer producer offers over 200 recipes in their product mix.

3.4.3. Product quality and properties

Digestate quality can be assessed on three criteria: chemical, biological and physical. Chemical quality assesses the content of the essential plant nutrients Nitrogen, Phosphorous and Potassium (NPK). A suitable plant nutrient content should be complemented by a low content of heavy metals and salts. Consistency in nutrient content is regarded by producers as necessary to create a standardized product and so is an important quality goal. To achieve this, producers must exercise quality control of their biodegradable feedstock. Many operators also find it advisable to have the quality of their digestate products certified by an independent inspection agency. Such certification helps operators both in marketing and in resolving customer service issues.

The biological aspects of digestate quality control refer to the management of pathogens and diseases that may be present in organic waste. Elimination of germs and bacteria can be achieved through heat treatment, also called hygienisation.

The third important quality metric for digestate-based products concerns the presence of inert foreign materials such as plastics, glass and stones, with some operators reporting presence of up to 10% by volume. The presence of inert foreign materials not only impedes the use of digestate by some farmers and downstream processors, but their visibility can also remind users of digestate's origin in waste matter processing and so contribute to a negative public perception of the digestate product. To manage inert foreign materials, operators typically use sieving.

The physical standards of dried and upgraded products aimed specifically at private consumers also include odor and dust. Producers recognize that odor and dust must be controlled to make their products attractive to end-users and hence to retailers. Odor can be reduced by the use of an appropriate additive such as molasses. Structural materials can be added in some cases to control dust.

Critical quality metrics for dried products also include dry matter content and bulk weight. The dry matter content should be no less than 85% for a product to achieve a long shelf life, while the product's bulk weight affects its transportability and the accuracy with which it can be used as a fertilizer. Solid separated and dried digestate is very airy, an unfavorable property because it makes the product difficult to apply in a controlled way, particularly as it is susceptible to drifting with the wind. The airiness of dried digestate also shows up in bulk weights around 100 kg per cubic meter, in contrast to the 300 kg per cubic meter that interviewees indicated is the minimum bulk weight needed to make long distance transportation cost effective. Upgrading to pellets and granules can solve this problem, as these products have bulk weights of over 600 kg per cubic meter.

3.4.4. Product packaging and quantities

Digestate is sold in different unit sizes to meet different customer requirements. Bulk purchasers generally market large volumes of unpackaged digestate. Coming from the agricultural, horticultural and industrial soil manufacturing sectors, these distributors and purchasers transport their products in ton-sized quantities by truck or cargo ship. They work with large agricultural contractors, some of which market more than 200,000 tons of untreated digestate per year.

Smaller quantities of digestate-based products are marketed to gardening and landscaping customers through packaging options that range from big bags (1000 L) to small containers or buckets (0.2 L) with incremental sizes in between. None of the producers interviewed, however, market liquid products in packaged form, rather limiting their packaging efforts to solid products. The producers regard package design as a vital element in their marketing strategy because the product itself provides few visual cues to influence consumer purchases. As one respondent observed, "In the first place, many customers are overwhelmed in choosing a product; it is simply brown" (No. 5).

For digestate that has been processed into compost, but sometimes for pellets as well, producers usually choose bags. Offerings vary in size, with 5, 10, 15, 20 and 40 L bags being the most common. Bags provide producers with low-cost packaging options and also have the advantage of allowing easy imprinting and customization. Bags can also be made from recycled paper, adding to the packaged product's environmental appeal.

Higher-end packaging for upgraded digestate products such as pellets or beads tends to use plastic buckets. These range in size from 1 to 10 L. Interviewees acknowledged the higher expense of buckets, but said they chose them for their ability to lock out moisture and to prevent unpleasant odors from escaping. Plastic casks were reported as another option, as were paper retail boxes. Seeking to gain the advantages of buckets while avoiding the environmental stigma that accompanies the use of plastic, some producers indicated they were moving to paper bags laminated on the inside.

Finally, like the service provided on a pick-your-own fruit and vegetable farm, some producers provide shovel-your-own open sale of digestate, a self-serve option whereby customers fill bags onsite and then take home whatever amount of product they have chosen. For the producer, this option eliminates both packaging and transportation costs.

3.5. Price

The predominant factors that determine the price of digestate products are transportation costs to the area of application, season, product type, nutrient content and legislation.

3.5.1. Bulk marketing

Sale prices for raw (liquid) digestate from the biogas plant ranged from a positive 5 €/t to a negative 18 €/t. Untreated digestate already applied on a field reached a price of 60% of the fertilizing value in spring and 40% in autumn in an arable region in 2013. High negative prices, where the producer must carry the burden for biowaste disposal, prevail only during the winter, when there is no immediate use for fertilizer and when storage capacity is required. At these times double-digit negative prices may be encountered even in regions without high nutrient surpluses.

Upgraded digestate, such as pellets and beads achieve prices from 0 to almost 200 €/t. Pellets, made exclusively for chicken litter, achieve prices as high as 200 €/t. The demand for these high prices are driven in large part by the fact that these so-called "soft pellets" are more difficult to produce than the "harder pellets" used for fertilization. Fertilizer beads and pellets achieve prices between 0 and 100 €/t.[2]

The prices of digestate products used for fertilization do not fully capture the products' intrinsic nutrient value. The nutrients that most contribute to a product's fertilizing value are nitrogen, phosphorous and potassium; multiplying a product's available nutrient content by the actual prices for mineral fertilizers can thus serve to provide a notional market value for that product. That actual market conditions command a significant discount in digestate pricing – for instance pellets might sell for 20 €/t although their fertilizing value is over 90 €/t – may in part indicate that the agronomic and economic benefits of digestate use are not well known in the market. Regulatory obstacles might also be priced into the market.

When digestate pellets are sold as solid fuels, the market prices them as a substitute for fuel oil. In this scenario, valuations can be made based on the relative energy value or calorific value of the digestate product. For comparison, one ton of pellets has approximately the same calorific value as 400 L of fuel oil (Kratzeisen et al., 2010). However, associated with the use of these pellets are two end-user costs: the higher investment required for boilers suitable for burning these pellets and the cost for authorization. As reported by one vendor, these conditions lead to a discount of 25% to the replacement energy price.

Sales of compost achieve generally positive prices that can go as high as 80 €/t. Compost for agricultural purposes ranges between 0 and 7 €/t. The higher compost price of 80 €/t achieved by some marketers stems from their application of highly refined processes that allow them to target specific niches in the horticultural market.

Geography is a key driver of pricing for digestate products. Transportation costs, especially those associated with untreated liquid digestate, increase substantially as distance to the area of application increases. Some producers stated that in their regions, the transport distance for untreated liquid digestate has doubled over the past few years, with distances of up to 150 km reported. That transport costs play a dominant role in digestate distribution means that sound logistics planning and management are vital for the profitability of a biogas operation. Innovative approaches to transportation have started to emerge, including new trailer types that can be loaded with solid and liquid digestate in separate troughs. Some producers have even begun transporting digestate by inland water vessels.

The application costs for untreated digestate are an additional cost driver in digestate management. Producers reported application costs of liquid digestate to be less than for those of the solid separated or composted fraction.

[2] (N 3.7%; P_2O_5 2.1%; K_2O 5.2%; dry matter content 92.8%/N 2.1%; P_2O_5 2.3%; K_2O 3.6%; dry matter content 92.2%).

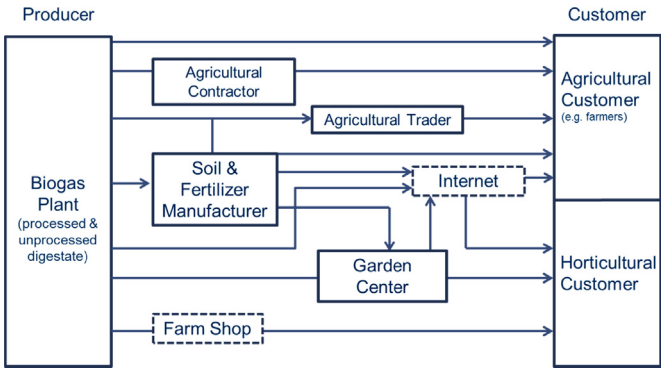

Fig. 4. Observed distribution channels for digestate.

3.5.2. Small scale marketing

Upgraded digestate products targeting private consumers achieve shelf prices of up to 9 €/L for a powder-like product. Pellets reach prices of up to 10 € for a 4.5 kg bucket.[3] Small beads are sold for 6 € for a 5 kg bucket.[4] Compost, marketed to private customers, achieves a price of 5.90 € for a 45 L bag. However, these higher prices do not necessarily mean higher margins. These products incur additional manufacturing, packaging and marketing costs and, in addition, up to 60% of the remaining margin may be taken by the retailer.

3.6. Distribution channels

Choices regarding the distribution of digestate can be critical to the viability of a biogas operation. Fig. 4 illustrates the variety of distribution channels that we observed, suggesting the need for creativity in devising new and more efficient marketing channels.

3.7. Promotion and communication

Marketers understand that promotion of digestate is key to greater public acceptance of the product. Consequently, some marketers carry out a range of promotional activities, including open days on their site with guided tours for the general public. Depending on their target group, they host special events for farmers, horticulturalists and private gardeners. During these events, farmers can inspect field trials and thus get an impression of the fertilizing effect of different digestate products. Even workshops on the proper use of composts are given to hobby gardeners or a free bag of organic fertilizer given to the local garden club, efforts that can result in articles in newspapers and journals.

Positive press is an important multiplier from the perspective of our interviewees. Awareness of the benefits of digestate remains relatively low, so education plays an important role in long-term marketing strategies. Reaching potential customers through presentations at regional agricultural and horticultural meetings as well as conventions and trade fairs serves this function. Key benefits that producers emphasize include the regional and organic origin of digestate, its safety, the advantages of a biofertilizer and its positive soil enhancing effect. Other efforts to bridge the knowledge gap in the public include brochures, pamphlets and educational seminars. One innovative approach to getting customers to regard digestate use as part of their daily life is a soil taxi, used to deliver small amounts of compost to customers. A clever strategy to convey the long-term ecological investment value of digestate is the distribution of compost gift certificates to the parents of newborn babies. Tried-and-true promotional strategies such as giveaways and sponsorships have also been applied. Of course, well-designed websites and product packaging complement these efforts.

At this stage of development of the digestate market, many products are advertised through personal contact and promoted through live demonstrations. Producers recognize that building trust is critically important, not only among consumers, but also with local authorities and agricultural consultants, as these exercise a multiplying effect.

3.7.1. Customer perception of digestate from the marketers' perspective

The customer perception of digestate is difficult to evaluate. In the following sections we present the views of active marketers, who naturally have limited objectivity regarding their products and can report feedback only from existing customers. However, these perceptions may be a good starting point for future consumer research.

3.7.2. Perception and experience of agricultural users

In the words of one respondent, "Farmers are creatures of habit – once they are convinced they are loyal toward the product" (No. 10). Long convinced of the value of mineral fertilizers, farmers have increasingly become convinced of the value of digestate fertilizers. Overall, they report high levels of satisfaction to marketers, both with the application of digestate products and the results obtained. Ease of application is particularly the case for granulated products, whose similarity to mineral fertilizers allows farmers to use their existing spreading machinery. The good yield results obtained from digestate use, together with the environmentally friendly properties of digestates, have also received positive press coverage, leading to further acceptance of the products. In the few cases where customers have expressed a lack of satisfaction with digestates, the issue has been improper application.

Conventional farmers are aware of the advantages of digestate, but largely use it as a complement to mineral fertilizers, seeing it as a way to reap the benefits of adding organic carbon to the soil. One conventional farmer, however, reported using digestate alone. He stated that although his yields were slightly lower, he nonetheless gained an overall economic advantage by avoiding the costs associated with the use of mineral fertilizers.

While local farmers in the regions surveyed seem to understand clearly the value of digestate-based products, the abundance of digestate in some regions has allowed them to exercise strong bargaining power. Marketers occasionally encountered skeptical statements by farmers toward compost from domestic waste. These statements may reflect lingering negative perceptions of digestate or may represent a time-tested bargaining ploy. Recognized as a good source of readily available crop nutrients, digestate has gained a strong following among organic farmers.

3.7.3. Perception among horticultural businesses and hobby gardeners

Marketers stated that their product was consistently perceived in positive terms by horticultural businesses and hobby gardeners. However, in most cases, the biogas origin of the product is not made visible. Marketers have learned that promoting the biogas or digestate origin of fertilizer products often backfires and generally does not help sales. There are two main factors that can account for this: first, a general resistance of the public to biogas resulting from public discussions about the excessive cultivation of maize for fuel; second, consumers concerns about product impurities such as inert foreign materials. Marketers have learned to keep a low profile concerning the product source and now design packaging accordingly. Many product packages simply state "from organic raw materials". This approach works because, as interviewees point out, customers

[3] (N 5.5%; P_2O_5 1.8%, K_2O 3.2%).
[4] (N 3.0%; P_2O_5 1.8%, K_2O 4.5%).

simply want a well-proven product that works and are not generally concerned to ask questions regarding the product's origin.

To hobby gardeners, digestate-based products are attractive because they are organic. These gardeners have become increasingly aware of environmental concerns, are interested in supporting regional farmers, and express skepticism about mineral fertilizers – all factors identified by the interviewees as supporting digestate marketing. Hobby gardeners also represent an opportunity for targeted niche marketing. They are not driven by the economics of commercial agriculture and will pay for fertilizer products specially designed to meet the nutritional needs of the plants they cultivate, whether that be roses, dwarf trees or other specialty plants. Even within a niche market like roses, perceptive marketers can find opportunities for further specialization of digestate products. The digestate market is only gradually learning to respond to these opportunities, but marketers do recognize that details about nutrient composition and information about product use need to appear on the packaging so that customers can see past the seemingly nondescript brownish material and instead get clear indications to help them make informed purchasing decisions.

Packaging plays a further important role, and not just among hobby gardeners, because purchasers act out of habit and usually buy established brands. New products and brands have a difficult time competing with these established products. To successfully position digestate products in the horticultural marketplace, compelling differentiators are needed.

When applying the product, most customers report satisfaction with its ease of use and the results. Under dry conditions, though, digestate pellets applied on the surface may remain visible and not assimilate into the soil. Marketers also recognize that the odor of some products may be perceived as strong and hence lead to unfavorable impressions. As with large agricultural customers, horticultural businesses and hobby gardeners may perceive powdery products as dusty and difficult to handle. These customers want a homogenous product that can be applied with existing tools and technology. Granulate is an attractive product form since it looks like mineral fertilizer and works well with existing dispersal devices. In any case, product offerings need to be available in a variety of packages sizes, as one size does not fit all.

3.8. Barriers to digestate marketing activities

In our study we encountered several barriers that impede the marketing of digestate. These barriers may occur in different steps along the supply chain and are outlined in the following.

3.8.1. Barriers from the plant operator's point of view

Operators of smaller biogas plants are generally farmers with limited human and financial resources. Due to these limitations, they mainly focus on their core competencies such as farming and biogas production. In contrast to these activities, the organic fertilizer and soil markets are not subsidized and thus pose greater uncertainty. Bureaucratic hurdles exist in France, where a type approval is needed to market fertilizer and soil amendment products. It was reported that the time required for the French Ministry of Agriculture to issue such approval is "very long". Beyond the investment in time, the costs for this approval process are said to be in the tens of thousands of Euros.

Larger industrial plant operators, who have the financial resources to hire additional staff to handle quality control and marketing activities, are often hesitant to do so. Many marketing activities are therefore tentative and often negligible. The further processing of various product streams in smaller quantities is felt to be too complex. For example, one interviewee reported that the liquid ammonium sulfate (LAS) produced by his plant, although a standardized and marketable product, was fed back to the digestate end-storage tank due to limited quantities.

3.8.2. Digestate marketing barriers to soil manufacturers and other institutional customers

Interviewees reported significant barriers that inhibit the marketing of intermediate digestate products to institutional customers such as soil manufacturers. First, biogas operators do not look beyond a 200 km radius distance from their plants for markets for upgraded and dried digestate because of transport costs. Second, smaller quantities of upgraded digestate are often not considered in the purchasing decisions of larger companies. Alternative substrates are more convenient to use, such as peat for which higher quantities with consistent and approved properties are available. And third, when exporting to other countries, regional preferences have to be considered. For example, products derived from digestate containing pig slurry cannot be marketed to Islamic countries.

3.8.3. Barriers to retailers, traders and private customers

Manufacturers of digestate-based products find it difficult to establish themselves in competition with existing soil and organic fertilizer manufacturers that already command shelf space with retailers. Providers of digestate products often do not have a wide range of products due to the size of their company. But retailers and garden centers prefer suppliers that can deliver large quantities and prefer to be able to purchase a wide range of products from a single source. In addition, larger and already established suppliers commonly offer extra services tailored to retailer needs, such as a free stocking service, as well as warranties that facilitate sales for the retailer. Further, corporate retailers and distributors often receive up to 60% of the shelf price of their products, and the resulting deep discounts on the producer side are not attractive to many digestate producers. Private customers also prefer established brands and specialized products, such as rose fertilizer, over general-purpose products. For many private customers, it is difficult to assess the quality of a new product, making pre-sales services for these customers very important.

3.9. Success factors from the interviewees' perspective

General suggestions are difficult to make since the biogas sector is vastly heterogeneous and local conditions differ significantly. Not surprisingly, however, a recognizable, well-proven and high-quality product is considered a prerequisite for marketing success. Specialization of function within the marketing chain is often advisable, so that the involved parties can focus on their core competencies, e.g. digestate production and marketing. Smaller biogas plants are advised to limit their focus to the production of simple digestate products such as pellets or compost, while downstream actors handle the further processing and marketing of these products. This enables the plant operator to focus on the production process and quality of the product without dissipating further resources into marketing efforts.

An important success factor for downstream processors and marketers is the availability of a wide product range. Through provision of a larger variety of products, customer requirements for specific products can be addressed more easily. Larger companies have the advantage of established brands and recognized product branding. From the interviewees' perspective, digestate branding should downplay the origin of the products to avoid association with negative perceptions that still exist. Anything associated with the hotly contested fuel-versus-food debate works against positive positioning of digestate-based products. Local applications still remain the easiest markets to serve: where an agricultural demand

for digestate exists in the immediate vicinity of a plant, operators concur that it is advisable to apply it there.

4. Discussion and conclusion

The purpose of this study was to examine existing approaches to distributing digestate-based products with the overarching goal of identifying factors that support and those that inhibit successful digestate marketing. We interviewed a range of biogas stakeholders, including plant operators in different EU countries working under diverse local conditions. It is not surprising, therefore, that we found a wide range of products, prices, marketing strategies and distribution channels.

One general observation that can be made is that to date most biogas plant operators have focused on the input side of their business, concentrating their resources on energy production and sometimes regarding digestate as waste. The legal status of digestate is inconsistent, even among EU member states (Saveyn and Eder, 2014). As a result, the digestate side of biogas production has largely been neglected: viable outlets for digestate have not been analyzed; market opportunities have been overlooked; and revenue potentials have not been exploited. Given that these outlets, opportunities and potentials can be economically decisive for a plant operator, such shortcomings impact the long-term viability of the biogas industry and hence of bioenergy's promise as a sustainable resource.

However, we also found signs that the digestate market is developing in a positive direction. New players such as agricultural contractors and providers of upgrading technology are entering the field, offering services that should help bring the output of digestate producers closer to markets where these products have commercial value. As a sign that future digestate marketing strategies will rely on more than the notion of fertilizer substitution, new applications have emerged, such as digestate as a bedding material for cows and chickens.

Several factors could lead to increased pressure to develop alternative marketing approaches. First, tighter regulations on the use of fertilizers in EU states. Couple this with the fact that in some regions high nutrient surpluses restrict the agricultural use of digestate and a strong driver emerges for marketing digestates outside the agricultural sector. Second, further development of upgrading technologies is underway and should facilitate the further processing and transportation of digestate. Third, the possibility exists in the future of further restrictions on peat-cutting, as seen in Switzerland (Schweizerische Bundeskanzlei, 1987) – a development that would provide an opportunity for solid digestate to replace peat as a soil amendment.

Finally, the fact that digestate comes from a renewable energy system and makes use of recycled nutrients that would otherwise be lost, while mineral fertilizers rely on nonrenewable mining practices, means that the economic value of digestate as an alternative nutrient source is likely to increase going forward. It is unlikely that the costs of mineral extraction will decline in the future, so increased prices for mineral fertilizer can be anticipated. For example, Morocco is a major supplier of phosphate rock to the world, but the critical role it plays as a phosphate exporter makes the phosphate supply chain highly susceptible to political and social crises (Cooper et al., 2011; Walan et al., 2014). And while other large deposits of phosphate do exist in deep-sea reserves, recovering these deposits is prohibitively expensive. So global economic forces may well play a role in driving digestate-based products into broader markets (Reijnders, 2014).

Another general observation that can be made from this study concerns the disparity between the relatively small digestate producers with their uneven supply and fledgling distribution channels and the unquestionably and the large-scale manufacturers of shelf-ready fertilizers and soil amendments with their army of established retailers. Aware of the lack of marketing power of smaller producers, a number of our interviewees discussed establishing cooperative efforts involving several biogas plants. These efforts could lead to shared marketing costs, shared investment capital, and reduced risk. Larger cooperatives would also enjoy an improved negotiating position with larger purchasers.

Another promising approach mentioned in the interviews is the franchise model, similar to that already established for compost marketing. This approach would facilitate building a visible brand name with uniform standards and so help create consumer trust and loyalty.

If further opportunities for digestate marketing in the non-agricultural sector are to be realized, the consumer attitude toward renewable and sustainable products such as digestate-based fertilizers will be key. This leads to our final general observation, that marketers need to make greater efforts to better understand and respond to consumer preferences and concerns. The digestate market is still immature; as a consequence, effective and long-term marketing strategies have yet to be developed. These will be necessary if digestate marketing is to utilize its full potential. Only in doing so will the bioenergy industry be able to play a decisive and transformative role in providing for the world's future energy needs.

5. Limitations and further research

This study reflects the experience of digestate providers and their perception of customers. The neutrality and objectivity of these providers is difficult to assess and the answers that were given might be biased. Therefore, further research into consumer attitudes and preferences toward digestate-based products could assist plant operators and manufacturers of soil amendments to develop a better understanding of their markets. Examining the behavior of horticultural and private customers could also contribute to increasing the share of digestate in the non-agricultural sector and thus help to mitigate the pressure created by restrictions on agricultural use. In order to get a more comprehensive view of the market, the whole digestate supply chain from the plant operator to the final customer should be evaluated in rigorous detail to identify further options and barriers for digestate marketing.

Acknowledgements

This research was conducted within the framework of the research project GAERWERT (no. 22402312). The project is supported by Fachagentur Nachwachsende Rohstoffe e.V. (FNR) on behalf of the German Federal Ministry of Food and Agriculture.

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