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Institutionalization of Agricultural Biogas: A Question of Normative and Cultural Embedding

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Abstract

The enigmatic term 'institutions' has cumulatively become relevant and have been pushed to the center of the analysis of innovation processes. In this paper, we follow the general conceptualization that institutions are or can be comprised of regulative, normative, and cultural-cognitive elements. We want to empirically illustrate the usefulness of such a comprehensive understanding of institutions with evidence from the agricultural biogas technology. The empirical investigation focuses on biogas innovation histories in two Austrian federal states. Regarding these two subsystems, we can find different rates of biogas diffusion and partly also different socio-technological designs which can be explained – to a certain extent – by differences in institutional context structures. It is shown that the negligence of regionally rooted normative and cultural elements can hinder a broad implementation of biogas in agriculture.

1. Introduction

A sustainable supply of energy for societal needs is nowadays one of the top issues in human societies. It is argued that the diffusion of renewable energy sources (RE) is necessary to reach environmental and climate-related objectives and to reduce emissions of green-house gases. The use of RE has also been regarded as an opportunity to reduce the dependence on fossil fuels and to secure energy supplies in the future. Since the early 2000s, biogas technology has become one of the significant technologies for the production of renewable energies throughout Europe (Wellinger 2007). Biogas had a share of one percent with regard to the primary energy produced in 2009 in the European Union (cf. EUROB-SERV'ER 2010, Energy Statistics for EU-27 2011). Besides the digestion of sewage

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sludge (wastewater sector) and organic residues such as municipal household waste or organic industrial waste (waste disposal sector), the generation of biogas from agricultural residues and energy crops has become prominent.

The digestion of wet biomass can happen within a broad range of applications. The technology per se facilitates a variation regarding, for example, the feedstock mix, the plant site and scale, and the main emphasis concerning the energy output. Hence, the plant concept must be defined. Biogas plants have been developing differently in different countries and regions.

Several papers with a socio-technical perspective have thoroughly addressed empirical insight into the field of agricultural biogas (Decker 2007; Geels and Raven 2006, 2007; Markard et al. 2009; Negro et al. 2007; Negro and Hekkert 2008; Raven 2004; Raven and Geels 2010; Raven and Gregersen 2007). With regard to the biogas development in Denmark, the Netherlands, Germany, and Switzerland, most of these papers emphasized "formal institutions" like subsidy schemes, investment grants, and feed-in tariffs as the or one of the key factors (Decker et al. 2007; Markard et al. 2009; Negro et al. 2007; Negro and Hekkert 2008; Raven and Geels 2010; Raven and Gregersen 2007). In addition, the need of a rather long-lasting support system was emphasized in these studies, in order to sustain the formation of a biogas system (or biogas subsystems). In some of the papers mentioned above (Geels and Raven 2006, 2007; Raven 2004), different influences are underlined as being the key factors for the development paths of agricultural biogas. Therein, the relevant influences are (collective) learning processes, the formation of networks, the development of expectations and mismatches with existing regimes (electricity, waste, agriculture).

The aspect of matches and mismatches hints at the circumstance that different contextualizations of the biogas technology also mean different challenges. The implementation of "farm-scale" biogas plants from the mid-1970s on typically resulted from the rise of energy prices (linked to the oil crisis). In contrast to that, taking the examples of Denmark and the Netherlands (Geels and Raven 2006, 2007), biogas plants in the mid- and late 1980s were mainly realized in order to process too large

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manure streams and to handle the problem of overfertilization. These so-called centralized plants treated manure from multiple farms and were mostly organized and run by farmers' cooperatives (in Denmark) or firms with competencies in chemistry (in the Netherlands).

Agricultural biogas plants are to be embedded in already existing structures and have to be literally implanted into a consisting sector. Thus, our paper contributes to the research question of how different institutional elements influence a technology's trajectory.

Relying on institutional theory, institutional environments shape, mediate and channel social choices (Wooten and Hoffman 2008). According to organizational institutionalism, actions of organizations are regarded as reflections and representations of the perspectives approved by (a group of) organizations that embody the institutional environment. Out of this environment, regulative, normative, and cultural-cognitive interrelations emerge that provide meaning to organizations (Scott 2008, 2001). The interplay of regulative, normative and/or cultural-cognitive elements, which factually influence the implementation of biogas plants, is substantially important in order to understand empirical phenomena more explicitly.

This paper relies on the different developments of biogas technology in the two Austrian federal states of Vorarlberg and Styria. The case of Vorarlberg stands for an institutionally converging situation, while Styria represents a development with a disregard of institutional setting (chapter 3). Next, chapter 2 briefly introduces our principle understanding of how to handle 'institutions'.

2. Perspective on a technology-specific analysis of institutions

In this paper, we follow the general concept that institutions are potentially comprised of regulative, normative, and cultural-cognitive elements. An institution is not a single, stand-alone entity but an amalgam of elements, which are interrelated. Accordingly, the "logic" behind the three pillars of institutions is different: regulative elements are assigned to

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instrumentality, normative to appropriateness, and cultural-cognitive to orthodoxy (Scott 2008, 51). Institutions have a causal and regulating power for actions and are everything, which leads to binding and rule-abiding actions (Scott 2008). We distinguish institutions from organizations and acknowledge that institutions are socially constructed and not primarily instrumental. Furthermore, we concentrate on the impact of institutions on existing actors but we do not exclude the possibility that institutions may bring about new / distinct organizations or organizational modes (e.g. Thornton 2004; Thornton and Ocasio 2008).

In the understanding of modern institutionalism of social sciences, actors are embedded in overall rule systems (institutions) or comprehensive patterns. Consequently, an analysis of institutional effects should encompass the factors, which generate patterns as well as the implications these patterns have for actors. An institutionalized structure represents an interrelation of elements, which are not actors. These elements congeal to organized and established procedures (cf. e.g. Jepperson 1991). Institutions clarify what kinds of actions and decisions are adequate.

To define the term 'institution', some concretion is still needed. Scott (1995, 2008) made a very strong effort and reviewed institutional theories in sociology, political sciences and economics. From that, he drew his three-pillar model and an institution-specific framework. Numerous empirical studies refer to this framework and it has become well-established in sociological neo-institutionalism. Even though this framework delivers substantial differentiation for an elaborated analysis of institutions, it does not include a concrete definition. With respect to the overall focus of this body of literature, the interest is on societal institutions, which influence organizational activity decisively (Jepperson 1991). In this case, 'decisively' means that social rules really influence organizational processes (Senge 2005) in three senses: First, the influence takes place in a time-related perspective. That means that the influence is durable, permanent, and stable (for the duration of observation). Accordingly, recurrences can be regarded as a premise for institutions. Second, the institutional influence happens in social regard, which means that a social rule is binding for specific actors (actors 'stick to it'). Thus, institutions/social rules lay out the spectrum of typical possibilities of action (Barley and

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Tolbert 1997; Oliver 1991). Third, institutions have to be relevant and significant for an empirical phenomenon under study (factual regard).

3. Biogas case study

The generation of biogas means the conversion of wet biomass through anaerobic decomposition into biogas (raw biogas: mostly methane and carbon dioxide) and a digestate. The produced biogas can be used for the generation of electricity and heat as well as vehicle fuel or as a substitute for natural gas, which is fed into the existing natural gas network. Besides these attributions that the anaerobic digestion and biogas generation technology has undergone through time, it is also regarded as an all-rounder in terms of treating different feedstock materials like sewage sludge (waster water), organic industrial or municipal household waste (waste), and manure, farm residues, or energy crops (farm products). For our empirical illustration, we want to concentrate on agricultural biogas. Besides Germany, the Netherlands, or Denmark, Austria belongs to the classic agricultural biogas countries in Europe. Austria had experienced quite a high diffusion dynamic in the field of agricultural biogas plants. The amount of production had increased sixfold between 2003 and 2007 (Energie-Control 2010; EUROBSERVER 2010). This dynamic led to a total number of agricultural biogas plants of about 350 (Braun 2008, 2009, 2010). The national feed-in law was central for the regulation of rewards for "renewable electricity" (Ökostromgesetz). Biogas plants had to get their construction approval before December 31, 2004. After that, the approved plants were obliged to be built before December 31, 2007, in order to be eligible for getting the guaranteed feed-in tariff.

The spatial distribution of biogas plants is heterogeneous among the nine Austrian federal states and interesting to study. The highest concentration in relative terms can be detected in the smallest federal state, Vorarlberg (Tragner et al. 2008, 17), even though the larger part of this state is clearly affected by the physical topography of the higher Alps.

In the following, we present empirical findings that we have attained on the basis of an interview series (27 interviews plus 6 follow-up con-

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versations) and the evaluation of several studies, reports, documents of legislation, and unpublished plant-related data. The latter we could get confidential access to by requesting to the respective authorities and the Austrian compost and biogas association.

3.1. Biogas in Vorarlberg and Styria

Vorarlberg is, with regard to its population and area, the smallest federal state in Austria (Vienna excluded). As an alpine territory, Vorarlberg is dominated by grassland, mountain farming and very small farms. Dairy farming makes up the largest part of the farming activities in Vorarlberg (Bösch et al. 2010). Even though the largest part of Vorarlberg is affected by the physical topography of the Alps, here one can find the relatively highest plant concentration in Austria. The biogas plants in Vorarlberg are primarily based on manure. These manure-dominated plants are in a complementary way fed with approximately 20 percent of organic waste (e.g. cooking oil, fat separator, waste from fruits and vegetables, residues from mowing, residues from harvest etc.) and very small quantities of energy crops. In accordance with the agricultural structure, the average plant size is ≤100 kW_{el}. The prevailing organizational mode for the operation of a biogas plant is a single-farm mode. In Vorarlberg, it was managed to implement approximately 80 percent of the biogas plants before the national feed-in law came into force in 2003 (Scheibler 2006a).

The physical conditions in the federal state of Styria are characterized with two-thirds grassland in the alpine territory (northwest and north) and one-third farmland where cultivation takes place (southeast and south) (Lindner et al. 2010; Ulz et al. 2005). The biogas plants in Styria are mostly bound to the cultivation area. That is why a clear plant concentration can be spotted in the southeastern part. Here, biogas plants show an average plant size of around 400 kW_{el}. Even though the plant sizes are that big, the dominant organizational form for the operation of a biogas plant only reached that of a single-farm mode, which is not enough for supplying the plants out of farm-own feedstock. The plants' dominant feedstock is renewable raw materials and 75 % of them were implemented after 2003 (Puchas 2008).

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Table 1 summarizes what the two Austrian provinces have reached in the field of agricultural biogas.

Table 1. Biogas realization in Vorarlberg and Styria

Region	Land use (in ha)	Biogas production	Plants per 1,000 ha intensive use (Cultivation of land and intensive grassland)
Vorarlberg	Cultivation: 2.929 Intensive grassland: 32.228 Extensive grassland: 63.092	Number of plants: 30 Average scale: <100 kWel Total production capacity ~3 MW	0.85
Styria	Cultivation: 149.255 Intensive grassland: 168.451 Extensive grassland: 123.973	Number of plants: 41 Average scale: ~380 kWel Total production capacity ~16 MW	0.13

3.2. Institutionalization of biogas

In both federal states, Vorarlberg and Styria, it seems that most of farmers can be characterized by the following shared logic of action: (1) First, farmers substantially tend to differentiate between MY and YOUR. That means that there is a strong concern of delineation. Farmers want to

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make clear which facilities (e.g. the farm itself, tractors, agricultural machines, etc.) belong to them and which to others. This strong need of demarcation supports them in gaining a concept of themselves and their identity. They do not like to collaborate with other farmers. Rather, they prefer to "Do-it-myself-the-way-I-think-one-should-do-it". Thus, the collective use of biogas facilities is limited. (2) Second, there is a constitutive schema to identify, which can be described as "be bigger than your neighbor". Both the first and second aspect shows that they tend to do something different. (3) Third, in terms of assumptions taken for granted, the majority of farmers consider themselves in the first place a farmer (dairy farmer, crop farmer, etc.). Hence, the typical self-conception in a taken-for-granted sense is responsible for that generally, farmers rather fiddle about with making the core procedures on the farm better than extending the activity profile, for example towards biogas. Additionally, farmers often want to get advice ("recipes"), which is an indication for that the majority of farmers take receiving guidelines, for example from the chamber of agriculture, for granted. These cultural-cognitive elements have, most of time, institutional effects on farmers' decisions and substantially influence the pros and cons of biogas in general and, especially (1) and (2), get in the way of biogas plants with a collaboration-oriented business model.

3.3. How institutional elements converged in Vorarlberg

From 1999 on, the federal states in Austria were permitted to define feed-in tariffs by a decree. Even tough Vorarlberg was rather late in taking advantage of this opportunity (September 25, 2001), the federal state managed to create supportive conditions anyhow and, consequently, a permanent increase of incentives led to a substantial rise of the installation of biogas plants in Vorarlberg. Then, Vorarlberg realized that too much incentive risks resulting in a loss of quality regarding the generation of biogas (the profit motive may come to the foreground, less examination of the technical process). That is why the investment support and feed-in tariff were tied to a six-day course of instruction.

The original concept of an appropriate (normative) biogas plant was exclusively based on the idea of fitting the plant into existing structures.

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Actors who can be considered responsible for this conceptualization saw a high value in the design of plants closely adapted to the agricultural structure. Strong and clearly expressed normative elements that guided the biogas-related activities in Vorarlberg are the following: First, biogas plants should be integrated into the existing and agriculture-/farm-specific structures and procedures (e.g., related to typical live stock). Second, farms should not be dependent upon feedstock supply from other farms. Third, energy production on the farm is explicitly regarded as an additional income source for farmers. Thus, farming is regarded as the key purpose of a farm. This normative setting is supported by federal state's authorities, the 'Energieinstitut' and the chamber of agriculture of Vorarlberg and is in harmony with the federal state's agricultural policy-related goals. The overall end was to design plants on available organic material. In this case, 'availability of organic material' meant using feedstock, which originated from procedures that happened on the farm anyway. This was literally an approach with a strong focus on locality and the explicit consideration of existing, established, and proven agricultural practice.

Here, the quest is to find an additional income source for farms, which complements the existing agricultural business ("integrated pillar"). A biogas plant was, and still partly is, considered appropriate if the design of the plant (scale, feedstock) matches the prevailing situation and agricultural practice on the farm. This approach is the quest of finding an additional source of income for the existing agricultural business coupled with the aim of a high degree of integration of the biogas plant in the established farm structure. We want to qualify this approach to agricultural biogas generation as an approach that is developed out of the sector, which is at the same time the target sector (agricultural approach to agricultural biogas).

Before 2003 and entry-into-force of the nationwide feed-in law, Vorarlberg had already reached about 80 % of today's number of biogas plants (currently, there are 30). This goal was reached in accordance with the normative concept of a regionally appropriate biogas plant (technological design: „integrated main pillar on the farm"). Therefore, the plants that were put into operation before 2003 started with different

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"rules of the game" than the ones after 2003. Generally, the problematic aspect here was that these "rules of the game" were superimposed by the national law and that the legal situation has been changing in the years since then. However before the enactment of the Ökostromgesetz, Vorarlberg had managed in negotiations with authorities from the national government to get the federal states' rules integrated into the national law by defining an interim arrangement. That means that the biogas plants, which had been already approved, could keep the feed-in tariffs assigned to them (this interim arrangement was also applied to photovoltaics). After 2003, only five more biogas plants were implemented in Vorarlberg under the scope of the national feed-in law (one in 2004, two in 2005, and two in 2006).

To sum up the development in Vorarlberg, we can say that there is a favorable interplay between normative (e.g. farms should not be to a greater extent dependent upon external feedstock) and already existing agriculture-specific cultural-cognitive elements (e.g. my- and your-mentality). The federal state-peculiar support for agricultural biogas plants was brought into being on the basis of these well-interrelated elements. The prevailing single-farm mode for the operation of a biogas plant fits the normative goal that "farms should not be dependent upon feedstock supply from other farms" and the cultural-cognitive situation that farmers tend to delineate themselves, for example. Thus, we can clearly trace back the empirical situation to institutional effects and show that the implemented biogas plants largely represent these institutional influences. All in all, we find a good match between the different institutional elements.

3.4. How institutional elements were disregarded in Styria

In principal, as already mentioned before, the cultural-cognitive structures in Styria's agricultural sector are comparable with those identified for Vorarlberg (at least, no fundamentally different cultural-cognitive structures have been detected). The biogas development course ran differently in Styria. The main reasons can be encapsulated like this: Both the design of the feed-in tariff law at the national level and the normative foundation of this law did not have an anchoring in the region itself. Consequently,

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the interrelation between institutional elements shows a mismatch. To put it differently, the eventual design of the 'Ökostromgesetz' led to the situation that biogas plants were only implemented under specific circumstances. The public support through this feed-in tariff law has not reached an implementation of biogas technology in a broader sense, but merely pushed forward a uniform type of biogas plants, which do not blend in with the original approach in this region to implement biogas plants that are adjusted to the site (e.g. feedstock related to pig breeding: manure from pigs and maize as a feeding stuff for pigs).

The transfer of the feed-in tariff to the national level in 2002/2003 led to an altered legal situation. The so-called 'Ökostromgesetz' had an overall dominant influence on the types of biogas plants, which were installed in the federal state of Styria. With the national decree for guaranteed feed-in tariffs for green power (Ökostromverordnung 2002), that became effective in 2003, larger biogas plants occurred. These "new" plants primarily produced electricity to be fed into the public power network. From an economic point of view, the use of heat was suddenly not important anymore. This led to plants that show overall insufficient energy efficiencies. In the federal state of Styria, the plant categories defined in the 2002-decree (<100 kW_{el}, 100-500 kW_{el}, >500-1000 kW_{el}) pushed the emergence of homogeneous plants in terms of scale. The absolute majority of the plants was designed or redesigned to optimally meet the categories defined in the law from a revenue point of view. More and more, large biogas plants had appeared and the typical plant size, from 2003 on, had accounted for 500 kW_{el}. Almost exclusively all plants were installed in Styria's southwest, the farmland area. Here, we can speak of structural isomorphism. 75 % of the 42 biogas plants in the region of Styria were implemented after 2003.

Even the plants that were planned, constructed, and installed before the enactment of the 'Ökostromgesetz' in the federal state of Styria, were later "optimized" to get as much payment for the generation of biogas-based power as possible. This substantial increase in plant size led to a higher feedstock need, which could not be met only by the use of farm-own material resources. One consequence was that maize became the most important feedstock for biogas plants. At that time, the generation

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of biogas was also seen as an opportunity to relieve farm products markets due to overproduction. In a situation of low grain prices, the use of maize as a feedstock for biogas plants allegedly created a further or new economic pillar for the agricultural sector. A quite rapid change toward higher grain prices worldwide then made the cultivation of grain as feed- and foodstuff attractive again. The production of energy on the basis of grain, here maize, is competing with food production. Agricultural waste, that almost vanished into oblivion due to the euphoria related to the digestion of energy crops, has now again become interesting as a feedstock for the generation of biogas.

In order to reach a performance scale of 500 kW, all farmers had to procure additional feedstock for the digestion in the biogas reactor. Farmers either purchased additional organic material from other farmers or they leased more land. Because the average farm in Styria was too small to steadily supply a 500 kW plant, farmers became increasingly dependent upon outside suppliers and thus more exposed to fluctuations in the prices of organic material. The farmers in Styria went beyond the concept of self-supply. Thus, most of Styria's plants appear in a feed-in law-related optimized version.

4. Conclusions

In the introduction, we plugged in the topic of the paper by emphasizing that a normative (appropriate) and cultural (orthodox) embedding of biogas is needed to create a robust formation of biogas technology in agriculture. Even though the comparison between the Austrian federal states of Vorarlberg and Styria already shows differences in terms of physical and consequently of agricultural conditions, the two institutionalization processes nevertheless bring to mind that only an alignment of different institutional elements leads to a broader technological integration into existing structures.

In the case of Vorarlberg, it was easier to find an explicit coordination and consideration of a regionally important normative and cultural structure. Nevertheless, Vorarlberg only managed to take these conditions

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into account because the province actively created the track to develop biogas on. As a result, the various potentially institutional influences converged in a productive manner. In contrast to that, the development of agricultural biogas in Styria could not be realized on the basis of a broader integration into already existent structures (normative and cultural). Admittedly, the challenge to do so was substantially higher due to the different prerequisites in terms of physical landscape and agriculture. But, the reason why Styria was so obviously pushed into one direction by the national feed-in tariff law can be linked to the fact that the province of Styria had not shaped a regionally anchored technological subsystem before. In sum, on the one hand, we can qualify Vorarlberg's approach as "fit to existing agricultural structures" ("complementary"), and on the other hand, the implementation of biogas in Styria can be labeled as a development with a one-sided focus on a high electricity output. While a farmer in the first case could remain the one he or she had been before (no change of roles), most of the farmers in Styria realized that a biogas plant had to change their professional role and they would exclusively become an energy producer. Against this background, plants in the federal state of Styria, compared to those in Vorarlberg, actually comply with the categories of biogas plants defined in the 'Ökostromgesetz'. Or, to put it differently, the national feed-in tariff law took effect in the region of Styria and nearly did not in Vorarlberg. Thus, this case can be labeled as 'institutionalization from the bottom of the region'.

Due to the institutional convergence, biogas technology is generally legitimized in Vorarlberg. This succeeded because of the early and consistent path creation with an explicit coordination of normative and cultural influences and that plants had been adapted to the agricultural structure. Therefore, the admission of organic wastes as complementing substrates was a helpful move.

Against the background that existing institutional elements (e.g. the norm that farming is regarded as a farm's key purpose) could not be regarded sufficiently, the biogas issue lacks legitimacy in Styria. That is because most plants, above all the ones with an installed production capacity of 500 kW_{el}, suffered on economic losses, depend on external substrates (energy crops), and simply have a poor or even missing con-

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cept for the use of the generated heat. To resume, the low degree of institutionalization of biogas before the 'Ökostromgesetz' had taken effect, forced the province of Styria to implement it mostly in advantageous locations. Thus, the diffusion of the biogas technology was totally driven by this 'Ökostromgesetz' and resulted in homogeneous and oversized plants. Consequently, the biogas story in Styria is rather an institutionalization coming from the 'top of the national balance of power'.

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