Messy and technical governance of renewable energy: An institutional analysis of consenting biogas plants in Germany

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Abstract

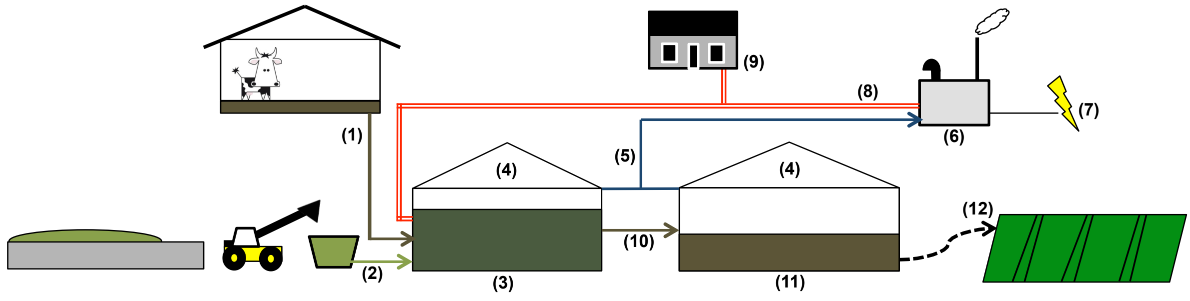
Biogas plants digesting agricultural resources have become notable contributors to renewable energy supplies in Germany. However, biogas is not without environmental problems. Environmental impacts and risks arising from the biogas plant itself can include noise, exhaust fumes and effluent run-off. Further impacts are associated with growing feedstock and with field application of digestate. Many of these impacts are addressed through planning consents for biogas plants, which can specify sites, technologies and operating practices. For the emerging agricultural biogas sector in Germany development planning regulation therefore is an important area of concern. This case study explores how institutions come into play from 1980 to 2008, when environmental impacts of biogas plants are governed as part of planning consents. It uncovers polycentric set-ups, including official, semi-official and in-official actors like engineering and business consultants. The implementation of legislation is influenced by the novelty of biogas technology and measurability of impacts. Planning officers pursue various arrangements, including adapted technical prescriptions and negotiated procedures, as they approach uniform implementation to prevent legal challenges from developers and the public. But there seems to remain scope for prescriptions according to officials' preferences and for voluntary measures. The findings suggest that accommodation of new demands on environmental regulation becomes more difficult, as institutional arrangements become more detailed.

Introduction

Globally renewable energy generation is on the rise. But with the exception of biofuels there is little attention to governance of environmental impacts. Germany is a country with comparatively long experience with modern renewable energy technologies, such as wind energy and photovoltaics, but also biogas, which is less popular in other countries. The numbers and installed electrical capacity of biogas plants digesting agricultural resources to increased greatly over the last decade and their contribution to renewable electricity production rose to three percent in 2011 (FvB, 2013). The growth coincides with increasing concerns about environmental impacts of biogas plants, growing feedstock and digestate management (e. g. Bringezu et al., 2008; Gawel and Ludwig, 2011; Neumann, Loges and Taube, 2009). In 2012 on about 800,000 hectares of the about 16.5 million hectares of farmland in Germany maize was grown as a biogas feedstock (FNR, 2013). Major associated concerns are nutrient leaching, biodiversity loss and soil carbon losses. The biogas plant itself can emit among others noise, exhaust fumes and effluent, while its buildings can be seen to alter landscape. Most of the environmental impacts are addressed through planning regulation, as planning consents can specify sites, technologies and operating practices. Some impacts are mitigated through technological changes. However, standards and procedures for monitoring implementation and compliance are generally required. For planning authorities this implies new tasks and regulation of novel technology, which is increasingly scrutinised. Moreover, there were periods, when planning authorities had to handle surges of planning applications for agricultural biogas plants. From the developers' and public policy perspective planning permission is occasionally identified as a barrier to uptake of on-farm biogas production (e. g. Tate, Mbzibain and Ali, 2012; Tranter, Swinbank, Jones, Banks and Salter, 2011), but it is unclear when and why. In addition, planning regulation appears critical for the shaping the biogas sector in terms of technologies and resources used, its environmental impacts and possibilities for further evolution of the sector. This suggests a need to look into the specificities of development planning. However, environmental impacts could also be governed outside official regulation. An investigation of environmental governance of the evolving biogas sector should therefore cover institutional arrangements of official planning and those associated with other policy areas and in-official arrangements. This case study explores how institutions come into play from 1980 to 2008 in Germany, when environmental impacts of biogas plants are governed as part of planning consents and other arrangements. It draws on data generated with qualitative interviews in an East and a West German county-level setting and uses an institutional analysis framework to generate insights into governance practices and strategies at this level, which is potentially influenced by legislation determined at higher levels. The findings presented are exploratory and further analysis of the data available is planned.

Background to planning regulation

Planning consent to biogas plants on farms is usually granted under privileged development on farms in non-development zones as stipulated in the Federal Building Code (Bundesbaugesetzbuch §35). Farms have to apply for development at a respective county or regional authority. The authority assesses the legality of the planned development following the state (Landes) building order and relating executive orders. It seeks comments from potentially affected statutory bodies, like the local parish council and various agencies. These comments and concerns of the responsible authority are worked into the planning consent, which can include further specifications of the development and compensation measures. Principally, if there are no legitimate concerns of statutory bodies and the development serves the farm, consent is granted within a legally specified period (usually three to four months). However, a biogas plant is an unclearly defined development from a legal planning perspective. Thus planning consent is only given to certain components, such as the combined heat and power unit and storage tanks (Kment, 2008; Niederstadt, 2011). There can also be uncertainties as to when a biogas plant serves a farm (Lampe, 2006). Farming itself is defined in § 201 of the Federal Building Code and privileged development is common practice. Figure 1 shows how a biogas plant can potentially integrate into a farm.



Liquid manure (1) and possibly also solid feedstock (2), such as energy crops and forage residues, are inserted into a digester (3), which is usually heated at 37 to 42°C to support anaerobic bacteria. In the airtight digester the bacteria break simple carbohydrates such as sugars, cellulose and fats and proteins down to acetic acid, hydrogen and carbon dioxide, which are then transformed into biogas. The feedstock is frequently mixed to ensure homogenous digestion over a period of about 30 to 100 days. Biogas is constantly released and trapped either under the roof of the digester (4) or in gas tanks, from where it flows through gas pipes (5) to a combined heat and power (CHP) unit (6). The biogas contains 50 to 75 percent of methane, which is used by a gas engine in the CHP unit to drive a generator to produce electricity (7). The engine also produces heat, which is fed into a small grid (8) to heat the digester and buildings, such as the farmhouse (9) or other buildings and heat consuming enterprises. The liquid digestate is frequently pumped into a digestate store (10, 11), which can be open or closed to capture remaining biogas (4) and volatile nitrous gases to prevent greenhouse gas emission. Sufficient storage volume ensures that the digestate can be applied on fields (12) as a fertiliser at optimal times using common slurry technology.

Figure 1: A typical biogas plant.

Alternatively designated zones can be proposed by parish councils with detailed specification of possible development according to the Federal Building Code in terms of types, sizes, area covered and infrastructure. Biogas plants could then be developed in certain industrial zones or specialist zones for energy production. Any developer can propose a zone to parish councils, who decide whether to plan a zone. County-level planning authorities or planning consultancies are developing plans of designated zones for a parish council, which is required to seek and acknowledge comments of potentially affected agencies and authorities (carriers of public concern), the public and neighbouring parishes. A designated zone needs to specify potential environmental impacts, monitoring and compensation measures and needs to reflect relating legislation *ex ante*. Usually objections are only considered, when they have a legal basis or reflect a higher-level zone. There may be a final hearing on the plan of a designated zone, which ultimately should reflect all concerns in its specifications. Planning consent has to be granted, if a planning application fulfils these specifications and any other legal requirements. The planning of such designated zones takes more than half a year and can be complex and uncertain in its outcomes. It can be appealed against the final plan of a designated zone and administrative courts can examine the planning procedures for correctness. Potential developers of biogas plants therefore tend to avoid siting biogas plants in such designated zones unless there is already a zone, which can accommodate biogas plants.

If a biogas plant exceeds a certain size, planning consent can only be given under the Federal Emission Regulation (BImSchG). It regulates the protection of humans, animals, plants, soils, water, air and cultural artefacts and implies more detailed planning applications than for a common planning consent. Even after development is granted, further measures can be imposed to implement the Federal Emission Regulation as technological advances could improve prevention of certain impacts. An array of federal executive orders and technical guidelines on air and noise pollution further specify implementation. However, there are problems to clearly define beyond what size threshold a biogas plant falls under the Federal Emission Regulation (Kment, 2008). If the size of a biogas is below the threshold, a common planning application is made on which the statutory bodies representing the Federal Emission Regulation will comment.

Analytical approach

The utilisation of agricultural biogas can be seen as an innovation, since for many farmers and other actors alike it is a novel practice. At the core to this innovation are technologies and transactions, which enable the use of energy that is initially subtracted from farm waste and agricultural land. Most of it occurs at local and regional levels, as the inputs are usually not transported over long distances and gas, electricity and heat outputs are usually not further transformed at distant places and either used close to production sites or locally fed into transmission grids. However, the technologies and transactions can change over time. As a consequence the biogas sector would have a different shape, using different resources or involving different actors, for example. The basic analytical framework needs to capture change in institutions, technologies, reasons for actions and transactions of farm-based biogas sectors at regional levels. It implies that the regional level has to be delineated and that the major sources of evidence would be located within regions or lower levels and relate to regional actors, institutions and transactions.

My analytical framework is based on the “Institutions of Sustainability” (IoS) framework (Hagedorn, Arzt and Peters, 2002). I considered the framework appropriate for studying the emergence of agricultural biogas utilisation and its institutions, including its environmental (biogeophysical) implications at regional levels, because it can accommodate my research questions and relating issues identified in the literature. The original IoS framework details what aspects of institutions, transactions, actors and governance structures should be considered (Hagedorn et al., 2002). While some of these suggestions may be of little relevance to this study, the basic concepts and relationships lend themselves to the research problem of this study and can all be further specified and be given different emphasis as the empirical analysis proceeds. However, to better capture core attributes of my research problem a few amendments to the original IoS framework are necessary and result in a basic analytical framework of institutions of regional biogas utilisation as depicted in Figure 2. Characteristics of actors, transactions, property rights and other institutions and the relating governance structures have implications for change and maintenance of institutions, which is indicated in Figure 2 as institutional innovation. In turn institutions, either determined internally in a region or externally at higher levels, guide actions of actors and frame properties of transactions, which is indicated as institutional performance. As a result biogeophysical, social and economic resources are mobilised and transactions with certain properties being undertaken at certain scales. This implies either maintenance or change of institutions and use of certain technologies.

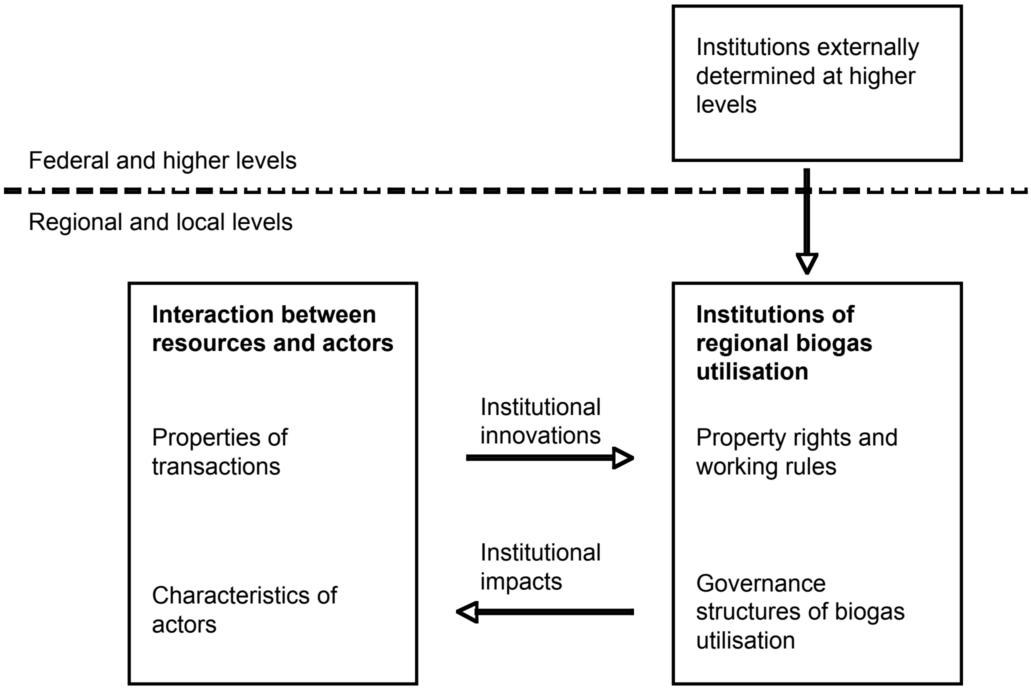


Figure 2: Institutions of agricultural biogas utilisation ((Hagedorn et al., 2002), own adaptations).

It is at this stage where theories about technological and institutional change come into play and institutions need to be defined. "Sets of conventions, norms and formally sanctioned rules that coordinate human interactions", would be defined as institutions (Vatn, 2005, 60.). But it may require closer investigation, what definition suits my purpose best. While the institutions can be observed as property rights (Bromley, 2006) and other regularised relations, associated transactions are co-ordinated through certain governance structures, such as networks or hierarchies (Hagedorn et al., 2002; Groenewegen, Spithoven and van den Berg, 2010).

All institutions, assigned at levels higher than regional are taken as given in this study, because the analytical framework aims to focus on properties of transactions, reasons for actions and institutional change at regional levels and below. However, some, like the Federal Building Code would impact on regional and local levels. I initially presume that they are determined outside regional levels as exogenous institutions. But they may change over time and their influence on phenomena at local and regional levels need to be accounted for along the timescale. For some the execution of such exogenous institutions at regional and lower levels may be seen imperfect, because of mismatches with lower level phenomena (Young, 2002). For others exogenous institutions would require intended and unintended amendment during implementation (Sabatier, 1986). The particularities and informalities of the institutions are therefore to be identified within the region. In any case, the framework takes into account of regional and lower level dynamics, which might be induced by exogenous institutions, as it allows for feedback among its four main components (actors, transactions, institutions and governance structures) and with the regional resources and technologies used. Analytically they are coupled to each other, with the transaction as the centrepiece.

Transactions

The principal unit of analysis is concerned with the transaction of energy from agricultural land and organic residues to the electricity grid. As shown in Figure 3, this principal transaction ties together all actors and biophysical flows from land use to outputs of utilisable energy and involves sub-transactions such as provision of biomass or organic waste, heating a house or environmental impacts such as noise and nutrient emissions or changes in landscape, biodiversity, environmental health and hygiene. The principal transaction is the unit of analysis of the research, which creates boundaries both at an analytical level and in terms of strategies for generating evidence. Many sub-transactions are part of actions of actors at local or regional level, like farmers, banks, developers of biogas plants or planning authorities, which may shape the institutions regularising these transactions and thus have an effect on development of the sector. The sub-transactions are sub-units of analysis and together form the principal unit of analysis. But the sum of sub-transactions is not simply the principal transaction, because there may be critical links between sub-transactions and closer analysis may reveal emergent properties of sets of sub-transactions. In addition, initially identified sub-transactions may be broken down further (Hagedorn, 2008). It follows that sub-transactions, which have no implications for the principal transaction can be ignored. But what sub-transactions are relevant and what linkages they have has to be established empirically.

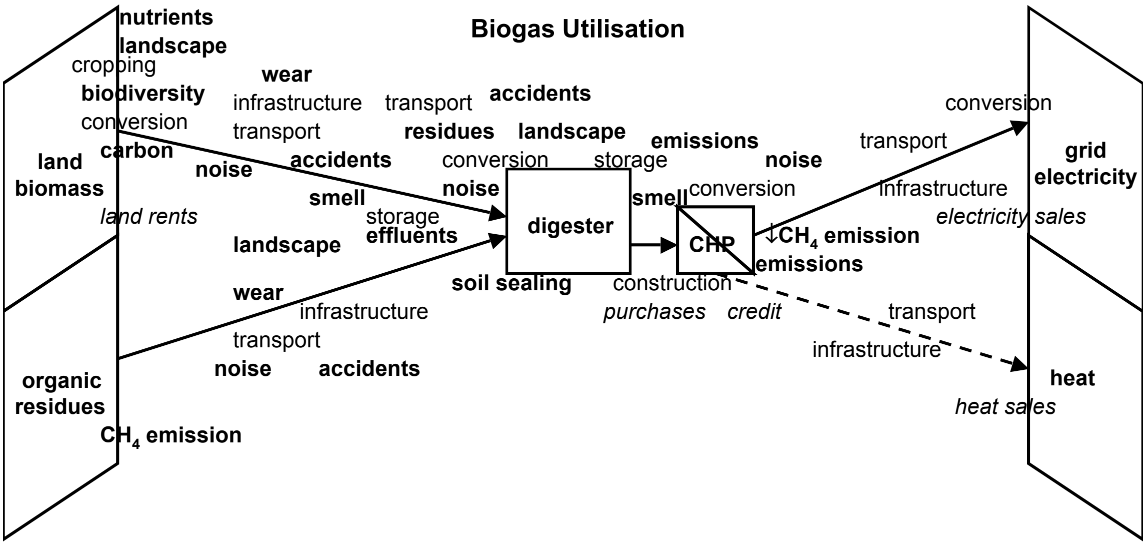


Figure 3: Concept of a principal regional biogas transaction (CHP = combined heat and power unit), own source.

The principal transaction ends with those actors who are at the border of the region in transactional terms. It implies that transactions, which come into effect only outside the region are ignored, while transactions extending into the region are being considered, such as payments for electricity sold into the grid. Example actors which extend a region are advisory services and planning authorities, which cover areas larger than a region and compare their transactions within these areas. Geographically, clear boundaries of a place can be drawn, as a region is determined in administrative and political terms constituting the county level. But from a social and biogeophysical perspective this is less clear-cut, because critical social relations and biophysical flows can extend a region. Thus instead of a spatial unit of analysis a principal transaction is used, which largely consists of regional and lower level transactions.

Agricultural biogas utilisation rests on technologies, which convert biomass and organic waste into energy. There are many definitions of technology offered. Technology may for example be defined as "…a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome" and it commonly consists of a material or physical part and the information base to operate the technology (Rogers, 2003, 13.). This is, however, only one aspect of the utilisation of agricultural biogas, as the use of these technologies is also involving transactions with biogeophysical effects which can be both, desired or not. Oliver Williamson's definition of a transaction rests on a circular logic in this context, because he defines transactions as the transfer of a good or service across a "technologically separable interface" (Williamson, 1985, 1.). The separating technology would itself involve at least some transaction to realise flows of matter and energy from one point to another and a transaction needs to be not observed to be able to identify a the "technologically separable interface". Hence, when a transaction is not specified further, this reasoning is circular. We need to be clear what particular transaction is analysed and where the analytical boundaries are drawn. In real terms we would only observe biogeophysical attributes of a transaction, if we have the means to establish the interface. These means would be technical, high or low tech. But even engineers may not be sure exactly what mechanisms are doing the separation, as they focus on what practically works. Hence, the separation of the two stages of activity may only be assumed or socially constructed (Pinch and Bijker, 1984). A natural activity or state ends, when human activity interferes, which is usually using technology of some sort and thus there would be technical separation of stages. One party to the transaction is interfering and in the subsequent stage the other party is experiencing the result of the interference for example as an economic good available or sees it as a negative externality of transacting an economic good (Vatn and Bromley, 1997), such as electricity from purposely grown biomass, which changes landscape amenities or emits noise. But if there is no other party experiencing the subsequent stage, we would not speak of transaction.

Social effects of transactions would usually be implied in biogeophysical effects of transactions, because they involve maintenance or change of a social relation (Emirbayer, 1997). Odour emissions from a biogas plant can affect the benefits a neighbour obtains from living at a site to which the odour is emitted. An institution would make sure that the first stage will be as anticipated in the second stage, meaning that social relations are not changed through a transaction. But if institutions regularising such a transaction break up, new social relations would be the result and they are not as anticipated.

Entrepreneurs can be seen as major contributors to novel social relations or novel states of nature, which are not as formerly anticipated and imply novel institutions regularising the novel transactions. Such entrepreneurial actors would be at the core of action theoretic concepts of institutional change (e.g. Challen, 2000; Lachmann, 1973; Ostrom, 1964). Entrepreneurial novelty would not necessarily be an attribute of property rights transactions. Property rights can be seen as institutionalised social relations and are concerned with what party can enjoy certain attributes of a biogeophysical entity, for example a plot of farmland (Bromley, 2006). A transaction would occur, if the property right to the entity is transferred from one party to another as part of an alienation of the right from one party and acquisition by the other party. A transaction would also occur if one party is altering the biogeophysical entity and another party is experiencing it as a change from stage to stage. In the first case the transacting parties would at least in some sense be aware of each other, while in the second case they may not be (Hagedorn, 2008). Indeed, transactions with biogeophysical effects can be "...intended or unintended, targeted or not targeted and predictable or non-predictable..." (Hagedorn, 2008, 362.). Although social attributes of transactions would be worked out by their parties, they can have unanticipated outcomes, when at least one party is not in full control of the transaction.

Several transactions may stick together because an interference has multiple effects, for which no technology is used to control them individually. This is common for biogeophysical transactions involving ecosystems, because there is insufficient technology to break all linkages between interferences and thus inflicting multiple transactions characterised such phenomena as "...jointness and lack of separability, coherence and complexity." (Hagedorn, 2008, 362.). The biogeophysical attributes of a transaction can be reflected in their social attributes. Institutions would need to acknowledge both biogeophysical and social attributes of a transaction when regularising transactions and there may be certain governance modes, which co-ordinate transactions with certain attributes best, such as markets or hierarchies (Coase, 1937; Hagedorn, 2008; Ménard, 2004; Williamson, 2000).

Further issues arise from the social relationships of the parties to a transaction and their social embeddedness (Granovetter, 1985). However, the parties should not be seen as atomised as they are being formed by their social environment when transacting, which consists of "networks of interpersonal relations" (Granovetter, 1985, 504.). These relations can be seen transactional themselves (Emirbayer, 1997), but have more import for the concept of the actor and agency than the general concept and typologies of transaction discussed here. An exception would be the transaction of less tangible services such as technical and financial advise, which are not created through immediate biogeophysical control and instead are an outcome speech and cognitive activity and understanding of the persons involved. While such transactions may be controlled through technologies, such as phones or printed text, communication between persons would still be essential when transacting for sophisticated technology (see Williamson, 1985, 293-4.). Basically the parties to a transaction should not be seen "...as acting under their own powers..." (Dewey and Bentley, 1960, 132.) be they norm following or rational entities (Emirbayer, 1997). Equally, the parties to a transaction should not be seen as entities, which create the action among themselves only when interacting, for example like billiard balls (Dewey and Bentley, 1960; Emirbayer, 1997). The interdependency of the transacting parties implies that they mutually have to make sense of each other, which would not be possible, when they are detached units, which can be detached from their relations. It is only through their relations within the transaction the parties to a transaction gain significance (Dewey and Bentley, 1960). It implies that the transaction is a "...dynamic, unfolding..." (Emirbayer, 1997, 287.) unit of analysis in which the (trans)actors are being formed over time and across contexts.

Non-entrepreneurial transactions may be called routine transactions and follow clearly institutionalised scripts. As long as the actors are not breaking away from them they would be rule or norm following. They may transact habitually, even when parts of the institution become obsolete or difficult to interpret. However, once they deviate from their institutions in some respect or act strategically in an institutional void, they would be entrepreneurs, if they create something new. The behavioural caveats of institutionalised transactions would be that the transacting parties (the actors) would be following the inscribed rules, norms and conventions, either habitually or as a rational response more or less perfectly. Even institutionalised transactions can gradually erode, when actors are not interpreting them perfectly in their actions (Lachmann, 1973). But the novelty of entrepreneurial transactions would imply at least some creativity on behalf of the transacting parties.

Actors, uncertainty and creativity

Creativity of actors is required, when they respond new situations or when they intend to bring about change (see Joas, 1996). In both cases the contexts of transactions are uncertain. The context would be unique to a transaction in which this context and the preferences and constraints need to be worked out (Whitford, 2002). Preferences would only be taking shape in relation to constraints and constraints would only be taking shape in relation to preferences (Beckert, 2009; Khalil, 2003). (Trans)Action, preferences and context are therefore emergent and interdependent. Such transaction can imply novelty and creativity and can accommodate Schumpeterian entrepreneurship, in which the specifics of an innovation are being worked out over time with flexible "ends-in-view" (Beckert, 2003) or "fictional expectations" (Beckert, 2011). Entrepreneurial transactions can be seen as "produced" through agency and non-entrepreneurial transactions as "reproduced" through agency (Emirbayer and Mische, 1998, 970.). Such agency is carried out through "iteration", projection and "practical evaluation" which would all come together in varying degrees as part of a certain action, while one of these elements may predominate (Emirbayer and Mische, 1998, 970-2.). Iteration implies "...the selective reactivation by actors of past patterns of thought and action, as routinely incorporated in practical activity, thereby giving stability and order to social universes and helping to sustain identities, interactions, and institutions over time." (Emirbayer and Mische, 1998, 971.), which relates to habitual norm following. Projection or "projectivity" implies "...the imaginative generation by actors of possible future trajectories of action, in which received structures of thought and action may be creatively reconfigured in relation to actors' hopes, fears, and desires for the future." (Emirbayer and Mische, 1998, 971.), which is particularly important for entrepreneurial transactions. Practical evaluation requires the "... capacity of actors to make practical and normative judgements among alternative possible trajectories of action, in response to the emerging demands, dilemmas, and ambiguities of presently evolving situations". (Emirbayer and Mische, 1998, 971.), which closely relates to Aristotle's "phronesis" (Flyvbjerg, 2001). This disaggregation of agency should help to identify reproductive and change-oriented elements of action as well as tendencies to institutionalisation and erosion of institutions. Moreover, it should illuminate how actors relate to past, present and future in their framings of contexts and actions, including mutual contingencies and transactions.

Institutions

The concepts of transactions and of actors used here consider both endogenous and exogenous institutions, which are interlinked in a particular point in time and sequentially as they are embedded in complex institutional arrangements. Institutions can be seen as exogenous, when they set the rules, norms and conventions prior to a transaction and when they are determined at a higher hierarchical level, which sets the context of a transaction carried out at a lower level. Endogenous institutions in turn are shaped and maintained when transactions are carried out (Aoki, 2007). While transactions can be analysed separately, they also imply coherence, interdependencies, overlap, complementation or conflict of its institutions with the institutions of other transactions (Aoki, 2007). Examples are the institutions at work at different administrative levels, when implementing a higher level law. Institutions of relevance to a particular transaction can therefore be transmitted to other transactions and vice versa. They might also become mutually reinforcing and thus complementing each other (Aoki, 2007). Such concepts of institutional networks share similarities with the concept of polycentricity (Ostrom, Tiebout and Warren, 1961), when shifting the emphasis to actors, which are transacting in such networks with fragmented and partly reinforced authority.

Institutions rest on a subjective ontology and therefore must be analysed from the perspective of its situated participants (Searle, 2005), which would be transacting actors. However, the transacting actors interpret their situations not only subjectively as they also consider a generalised other, which derives from general expectations on which actors react either in confirmation or surprise (Beckert, 2003). This generalised other can be seen as an institutional repository of possible interpretations and optional actions for the transacting actors, which is institutionally informed and socially constituted.

Externally sanctioned rules, norms, conventions, customs and habits are important contents of institutions, which can also relate to strategies used by actors. These parts of institutions extend into the concept of the actor, as they are usually seen as scripts for actors to pursue certain actions. But the norms, conventions, customs and habits, which matter to a transaction are being questioned in a transaction, if they are not shared by the transacting parties or do not match the situation of the transaction (see Bromley, 2006, 46-50; Ostrom, 2005, 104-13.). Once they are shared and match the situation as perceived by the parties, they are institutionalised and the parties follow them, no matter whether they are social norms and conventions shared by society at large beyond the specific transaction or whether they are customs and habits specific to the transacting parties.

Methods

The case study method (Yin, 1994) uses the concept of a principal biogas transaction (Figure 3) and the analytical framework to determine the potential content of the case analysed (Ragin, 1992) and the first steps of analysis (Dubois and Gadde, 2002). Only the distinction between nationally determined and regional and lower level institutions is initially important, because it implies that institutions determined above regional levels are exogenous to the case, although they may impact on the transactions, actors and other institutions internal to the case. The case study aims to capture empirical phenomena at regional levels from 1980 to 2008 in Germany, drawing on a county-level setting in East Germany (Ostprignitz-Ruppin) and in West Germany (Nordfriesland). The period considered sets chronological case boundaries and was selected because it includes legal, economic and technological changes of potential relevance to the research questions (Stoecker, 1991). The two settings could be seen as extreme cases or "maximum variation" cases (Flyvbjerg, 2006), although I had little information about potential cases before selection. The setting of Nordfriesland is characterised by early and later large uptake of agricultural biogas, while in Ostprignitz-Ruppin activities started later and there were fewer biogas plants. Farms are generally larger in Ostprignitz-Ruppin and yields lower, while types of farming enterprises are largely similar. The two different settings may be sub-cases, both with (partly) different contexts, but they are both contributing to the overall case and the understanding of the principal unit of analysis (Gerring, 2004). I discovered shared and unique properties of the settings during case analysis, which forced me to take the analysis to greater depth in iterative steps, as it is common practice in qualitative "within-case" analysis (Miles and Huberman, 1994, 29.). The two settings force me to reflect and re-consider the data and conclusions made on each single setting and on both settings together. Such reflection by design can contribute to the validity of the research and confidence my conclusions (Dubois and Gadde, 2002; Flyvbjerg, 2006).

Semi-structured in-depth interviews (Gillham, 2000; Warren, 2002) with actor representatives involved in biogas transactions at regional and lower levels form the main data sources. The interviews are structured according to themes and follow Rubin and Rubin's (2005) tree and branch model (see appendix A). The actors are purposely selected according to their involvement (Mason, 2002; Rubin and Rubin, 2005) in the two settings (see Figure 4). For the selection of farmers I used additional criteria to cover the full breath of farming types in the settings (see Appendix B for a summary of interviews). Before interviewing these actors, I conducted two exploratory expert interviews with official advisors (Bogner, Littig and Menz, 2009) to acquaint myself with terminologies and issues. In attempts to conduct a robust case study resting on multiple connected data sources (Yin, 1994) I also took notes of telephone conversations and after interviews on general reflections (Rubin and Rubin, 2005) and use statistical time series and documents as complementary sources and means for corroboration, where appropriate.

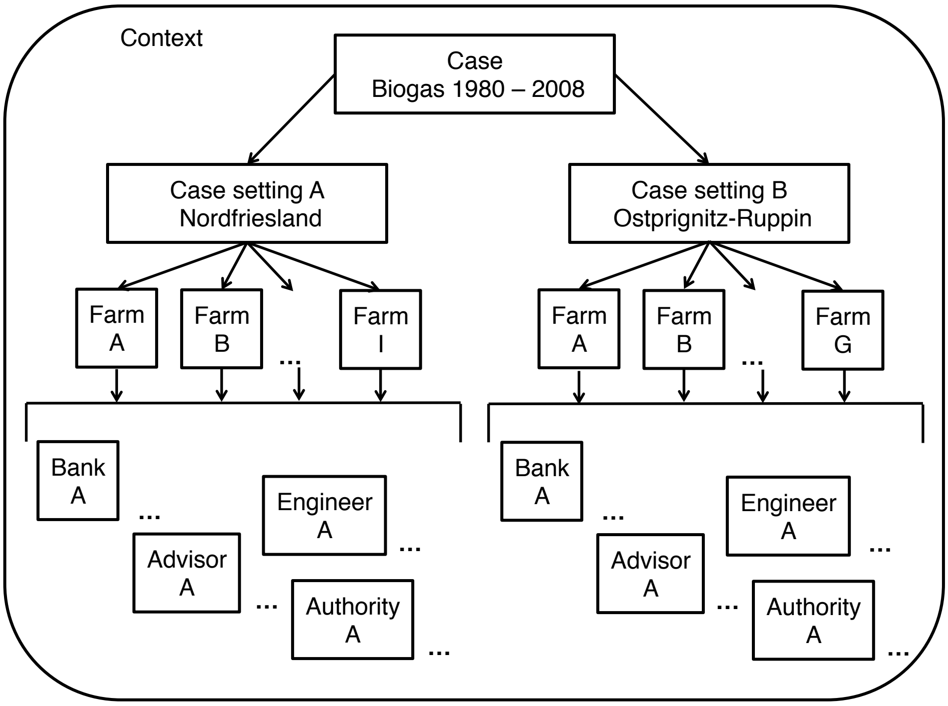


Figure 4: Summary of steps taken to sample actor representatives for interview.

The interviews are digitally recorded and transcribed verbatim (Gibbs, 2007). TAMS Analyzer (http://tamsys.sourceforge.net) is used for coding and memo management. In a first coding cycle short descriptive codes (Saldaña, 2009) are used to code for types of actors, technologies and biogeophysical attributes in the transcripts. Structural and longer descriptive codes are used to mark text relating to certain time periods and text touching on elements of the analytical framework. Before moving to more refined and targeted coding in second cycle (Saldaña, 2009) some of the first cycle codes are adjusted or discarded to improve consistency. In a intermediate cycle the codes are further refined to capture more detail. The codes of the second cycle capture nested analytical categories and form the basis for in-depth analysis together with relevant first cycle codes using targeted searches within TAMS Analyzer.

Preliminary findings

At the current stage the analysis just uncovered themes, which seem of importance. It is planned to focus on critical issues and transactions in greater depth. Planning consents for biogas plants address various issues, mainly relating to environmental impacts and construction standards of the storage and combined heat and power facilities of biogas plants. Generally not all components of biogas plants, including their interrelations are addressed. Early consents include prescriptions for construction, siting, technologies and access infrastructure. Later reporting and compensation and monitoring measures were added and prescriptions on feedstock and digestate management were given. However, planning authorities seem to have limited capacity for monitoring and control, especially at times, when they have to handle many planning applications. Still they aim to avoid legal challenges and see themselves as agents of the public and in parts also of those submitting planning applications.

Among the other actors involved, local parish councils appear to have little say on planning applications and can be of greater importance for local arrangements, which address local issues not covered in planning consents. Although such issues can be highly contextual for farmers engaged in biogas, arrangements among landowners and neighbours appear more decisive than those involving parish councils. Farmers make use of different strategies, when preparing and submitting planning applications, but commonly seek assistance from consultants, who typically have an engineering background. Some farmers are surprised about the effort and costs involved, while others find planning applications straightforward. Engineering and planning consultants tend to have their own firms, but can also be employed by firms constructing biogas plants or providing general planning and business advise on renewable energies and farming. Their expertise is growing over time and in parts they become able to standardise their services with respect to planning applications. This can reduce their costs, but can also attract competitors. Yet some consultants can develop a strong visibility and a large portfolio of biogas plants they advise. Planning authorities may engage with them to determine certain procedures and technological specifications. In addition, planning authorities and those submitting planning applications may see a need to or can be required to seek reports by chartered engineers and ecologists to determine the significance of certain environmental impacts or risks. These chartered engineers and ecologists are typically chartered for a larger geographical area. Finally, planning consents can have content, which has potential implications for viability of biogas projects. Therefore banks and other investors usually require planning consents, before drafting their contracts. The same banks can also use advise on investment proposals of biogas plants by the consultants, who assisted farmers and authorities with planning applications. In rare cases there can be organised local protests, which have to be recognised by the planning authorities, but they typically do not affect their decisions. The Association for Technical Monitoring (TÜV) makes a diversity of ex-ante impact assessments and measurements on the operating plants, mainly focusing on emission, especially exhaust fumes and safety standards. Some of the assessments are required for the planning application and content of the consent, although many can also be carried out by other chartered consultants. The occupational insurance association (Berufsgenossenschaft) examines health and safety implications relating predominantly to fire, explosion and electricity shock risks. Fire Fighters only examine access and potential strategies for containing run-off of harmful substances and extinguishing fires. All in all up to around fifteen authorities can participate in the final site acceptance test of a realised biogas plant.

Negotiations between planning applicants and authorities can take place before submission of a planning application, when the consent is drafted and after the consent is given. Planning applications are usually seen incomplete by the authorities, who then ask for further material. It is common practice to first ask for specification of the content of a planning application. Generally the planning authority has great authority, but farmers and consultants can sometimes steer them in directions desired by them and often negotiate solutions, with the aim to render them practicable and effective. Planning consents are site specific and the authorities usually have maps with great detail on the biophysical attributes of a site. The biogas plant has to fit the site requirements and either the technology of proposed plant may be altered or a different site may be negotiated, if there are planning conflicts or environmental impacts could potentially be mitigated this way. However, applicants may have different views of a site and can sometimes convince authorities to prescribe technology more appropriate in their view. During the drafting of a consent an authority can require further documentation and negotiate sites and technology in specific detail. After a planning consent is issued, there can be room for interpretation in the implementation of prescriptions. But for the site acceptance test of a realised biogas plant the consent needs to be followed. Smaller omissions discovered at a site acceptance test can be still required to be corrected, but authorities would not necessarily check. However, when operators do not comply they can charge them and ultimately shut down a biogas plant.

Monitoring and control can just be suggested, but then especially the strict authorities do not participate in the site acceptance visits. They could rely on liabilities of the operators of biogas plants, if disasters occur or impact thresholds are exceeded, which are the results of not following the technological prescriptions they made in the planning consent. Similarly the constructors and manufacturers of components would be liable when their work does not fulfil engineering standards or fails during warranty periods. However, some parts will undergo leak tests in regular intervals carried out by chartered consultants, with a first assessment immediately after the plant started operating. Thus the authority may see no need not check whether respective technologies are in place. Prescribed measures, which are integrated in the operation of a biogas plant can also be treated differently by operators, as measures, which do not interfere with operations, like compensation measures prescribed by the nature protection authority in particular.

Nature and habitat protection authorities are mainly dealing with compensation measures. The nature protection authority typically prescribes tree planting around a biogas plant, while farmers and consultants have other compensation measures in mind, which they see better locally adapted or of greater environmental value, than planting fast-growing trees to hide a biogas plant as quickly as possible.

Water authorities are seen the toughest authorities by the farmers and to some extent also by the consultants. The reasons could be manifold. As farms usually are not frequently developing farm buildings and infrastructure, planning applications can be seen a rare chance for authorities to implement water protection measures on farms. However, implementation of water protection measures may not be restricted to a biogas plant, as it can be a strategy of authorities to improve water management across a farm from their perspective, when a new development is planned. This seems typical in Ostprignitz-Ruppin, where the buildings often are of larger scale and date back to GDR times, which can imply that they do not fulfil standards of West German legislation. In such circumstances old storage facilities and surfaces may be prescribed to be extended and refurbished beyond the biogas plant. Moreover, farmers may be more critical of such prescriptions in East Germany, because usually their farms are seen simply as means of production and not as representative buildings, like they can be in West Germany. To large extents planning authorities pursue the precautionary principle, which can imply prescription of extensive surfacing to protect against spill and run-off, solid surfaces, pipes and valves, back-up measures, sensors for alerts and the like, which are more costly than simpler solutions the applicants had in mind. Technical standards can sometimes be seen redundant, if they are translated into multiple co-existing technical solutions by the authorities to achieve a standard, e.g. when a technical measures has to make a facility water proof and another measure slurry proof. Because most water protection measures relate to technology and buildings, there also appears limited scope to circumvent the measures. In addition, engineers and manufacturers might obtain higher margins from such measures and associated standards need to be followed as part of their professional code of conduct.

Emissions to air from combined heat and power units are not causing problems in planning applications, because the relating standards are built into the technology, are monitored by other bodies or certain impacts are ignored in legislation. Odour was a greater problem in early stages, which planning authorities feared. But technologies and feedstocks changed, which largely eradicated the sources of odour. Nevertheless, odour emissions are very difficult to measure and a challenge for monitoring and control authorities, if no technological solutions can be prescribed. Emissions from storage facilities appear to be of greater concern, because of conflicting views of impacts of methane, nitrous and sulphurous emissions on habitats around sites and because prescribed solutions can be comparatively expensive.

Engineering consultants would give implementation of engineering standards great attention. Such standards are developed by general engineering and issue-specific engineering associations. Planning authorities can be involved in determining such standards to some extent through membership in working groups at federal and lower levels. The authorities like to make use of the engineering standards, because they help them to specify technological measures, which can be used to implement legislation. Moreover, many such standards are agreed upon by a diverse group of actors, including engineers and engineering associations, manufacturers and manufacturing associations, authorities and legislators.

Planning applications according to the Federal Emission Regulation (BImSchG), require implementation of current technological best practice to prevent emissions. Planning authorities seem to aim for the most advanced technological best practice, but struggle to define it appropriately for prescriptions in planning consents, because engineering standards can take several years to be codified by German industrial norms or standards of the manufacturing or engineerings associations. The authorities are then often referring to the current drafts of norms and standard specifications, which can still change incrementally. In addition, existing standards and norms may be incrementally updated. If planning consent and realisation are more than a year apart and thus also the final site acceptance test by the authorities, they may ask for implementation of new standards before or as part of the acceptance test. Developers and investing farmers can find such prescriptions challenging and leading to greater costs. Yet, clear definitions of a biogas plant and its size categories in planning legislation and greater clarity, when biogas plants fall under privileged planning are welcomed by all of them.

The planning consents under the BImSchG are seen as more secure, because they imply consultation of all statutory authorities, whereas for common planning consents the leading authority decides what authorities to consult. A missed authority can later appeal against a realised biogas plant, which can imply decommissioning. Moreover, a planning application under BImSchG can be submitted, which already caters for an expansion of a biogas plant, thus giving investors more flexibility.

Farmers and consultants can find confused prescriptions in planning consents, which they trace back to insufficient communication between authorities, particularly in Ostprignitz-Ruppin. Usually perspectives of different statutory authorities within a jurisdiction can diverge and are mediated by the authority handling the planning consent and by a single office when it fulfils several statutory authorities. In addition, registered and non-registered consultants, exchange fora of neighbouring authorities, state ministry departments, federal working groups and federal engineering associations can mediate divergent perspectives within certain issue areas. When several planning authorities have difficulties with implementation of legislation, they would call for new executive orders and guidelines from higher levels to obtain clarity and legal certainty from their perspective. However, the consistency of the final planning consent greatly depends on the collaboration of desk officers, who can seek advice from colleagues, other authorities and the consultants of the applicants or the applicants themselves. If authorities are uncertain about procedures, consultants can refer to examples of how other applications were dealt with. Authorities can also consult certain planning consultants on applications which came through other consultants or on other issues.

Delayed processing for planning applications in authorities may be accepted by applicants, when they fear an intervention could jeopardise their plans. Legally the applicants have a right to a consent of rejection within fixed periods. Consultants appear to have greater leverage, enforcing this or to threaten credibly, if they cover several jurisdictions, have a history of helping planning officers and know the planning officers personally.

Experiences with cheating or failures lead authorities to caution in respective regulatory areas. One area, where authorities can feel cheated are cases when privileged planning consent is given and just after first operation the plant is sold to a non-farming investor. The public and farming communities are often very critical of such investors and may attempt to challenge the planning consent. However, the authorities themselves have limited means to prevent this. Incidences of technological failure, such as excessive odour emission in early years and breakage of digesters leading to methane or digestate release can also lead authorities to caution, especially when they led to court cases or public concern. Risks of gas explosion seem to worry authorities in particular, as such explosions are covered at wider scale by the media, although they are very rare.

Planning and other regulation concerning biogas is seen more complex and detailed as the sector grows, by all actors involved. However, those who are involved early on find is easier to navigate through the the regulations. Established consultants can therefore have an advantage compared to planning officers, who are new on the job. When both have long experience with biogas or planning on farms, negotiating a consent seems easier. In early stages of development of the German biogas sector, authorities appear uncertain what aspects of a biogas require planning consent. Greater clarity is achieved incrementally with new legislation, new executive orders and guidelines and with growing expertise of planning officers and consultants. However in some areas clarity is gained only slowly until shared understanding is facilitated with workshops and guidance documents. For example the Biogas Association managed to draw stakeholders together to produce guidance health and safety and operational risks, to which planning officers and consultants started to refer. However, generally engagement of planning and engineering consultants with the Biogas Association and regional groups of biogas practitioners seems to be more important in early stages of development of the sector, when there were few biogas plants in the jurisdictions of the planning authorities and technology was less standardised.

Several environmental concerns are not covered in planning consents and ineffectively accounted for in other legislations. These include fertiliser accounting of digestate applied on farmland, which was not covered by laws aiming to prevent excessive nitrate and phosphorous loading in water bodies. There are concerns about impacts of feedstock transport on road wear and risk of accidents. The actual energy and greenhouse balances of biogas plants can be questioned as not positive enough by some. There was also a period, where some uses of excess heat were seen inappropriate. As maize became the preferred feedstock for biogas plants, increased land area devoted to maize and conversion of grassland to maize plots is seen by many to reduce biodiversity and impact on birds populations. It is also claimed to lead to increased wild boar populations, hunters can no longer handle. Depending on topography maize cropping can also be seen to destroy landscape and views.

Voluntary mitigation or prevention of impacts of biogas plants can include noise and odour reduction through change of technology. Landscape effects of maize cropping are reduced through site selection of fields. Maize harvest and haulage can be coordinated in ways that roads where families live with small children are avoided and no activities take place close to houses during night and on weekends. Farms with large shares of rented land and farms close to villages seem particularly careful to mitigate impacts voluntarily.

Discussion

Changes over time in planning and environmental governance are difficult to explore, because especially the earlier biogas plants are rather unique. Farmers and one-time investors would typically not point at changes and comparisons between them are hampered by very contextual accounts. It seems easiest to identify institutional changes, when interviewing planning officers, because they worked on several biogas plants over time and had to devise new rules. But also this can have limitations, when officers started dealing with biogas only recently. Luckily there were a few officers, who dealt with biogas plants since more than fifteen years. Out of similar reasons, engineering and planning consultants, who are engaged since several years can also give useful insight. However, interviews tend to cover only what interviewees consider important. It could therefore be worthwhile to explore legal documents and administrative guidance in greater detail in conjunction with more in-depth analysis of the interviews. This could also lead to more detailed exposure of the analytical approach and should help to develop more general explanations, of why environmental governance of biogas unfolded in particularly ways.

Despite the caveats of the current stage of empirical analysis some observations may be of interest. A tendency towards standardisation of biogas plants can be identified, which comes along with greater detail and specificity of rules used in planning regulation. It implies that biogas plants become more recognised in planning regulation, gradually leading to more rules, conventions and customs specific to biogas plants. Potentially some of the underlying rules will be applied to other novel technologies, which have attributes in common with biogas. In addition, biogas plants may become more differentiated from a regulatory perspective, for example in terms of size and inputs and technologies used. Generally, institutional change in implementation and in legislation could be seen as incremental, which implies that the actors involved make reference to their experiences with comparable steps they made in the past, when determining their courses of action (Lindblom, 1959). Experts emerge, who can more convincingly navigate in the regulatory environment than newcomers, who have less contextual experience (Flyvbjerg, 2001). In parts, such expertise may be less important, because authorities gradually obtain clearer rules. However, environmental impacts are site specific and reflect public concerns, which change as the biogas sector develops. Planning authorities, applicants and consultants would have to attend to such context.

A planning consent would imply a transaction between the developer and the planning authority, which can be seen as an agent of the public. But there is polycentricity in the background. First, a range of statutory bodies, representing particular concerns is consulted. Second, authorities engage with neighbouring authorities and higher level administration and law-makers in attempts to clarify rules and to ensure equal treatment of planning consents. Third, authorities engage with private consultants to determine feasible application of rules and prescriptions for planning consents. The consultant can also act on behalf of the planning applicants and can be involved in developing industry and engineering standards, to which some planning officers also contribute. Planning officers seem therefore to make use of a polycentric actor environment, in attempts to draft planning consents that are triangulated across several sources of evidence and codes of conduct. This triangulation could imply that planning consents are generally seen appropriate and difficult to challenge legally.

Technology plays a great role in environmental governance of biogas plants. It is generally used as a means to control cause - effect relationships of environmental impacts and risks. The prescription to use certain technologies is seen to prevent environmental impacts and disasters, while it also appears to imply less pressure on monitoring and control, because once the technology is part of a biogas plant, it is assumed respective environmental impacts are controlled. Moreover, it is often easier to examine whether a certain technology is present, than measuring the scale of a certain environmental impact. However, challenges arise from technological change, which would need to be incorporated into implementation practices. Yet, for prescribing technology, standards are being devised, which appear to decrease risks of authorities of wrongdoing.

Theoretically many things can be prescribed in planning regulation concerning the operation of a biogas plant. It is more difficult for local and regional authorities to regulate digestate and feedstock cropping management, because there are limited links to planning legislation. As the biogas sector grows in size, calls to change legislation other than planning regulation emerge. These changes appear more drastic than the gradual adaption of planning regulation. A question would be, whether such drastic changes could actually be agreed, as they may greatly increase the costs for operators, for example in terms of digestate management and land use. In the meantime farmers and investors engage in some practices they see to prevent conflicts locally.

Generally governance of biogas plants focuses on technological measures. At least in early stages of development of the biogas sector their implementation appears to be messy. Later when biogas plants become more popular implementation becomes more formalised. This seems to imply more detailed sets of rules, which can imply greater implementation efforts. However, biogas is a renewable energy technology, which is still changing and involves many different environmental impacts. Some of them continue to be re-evaluated by stakeholders and the public. Official regulation seems to have to cater for emergent issues and at least on the short-run needs to rely on loosely approximate triangulation.

Appendix A

Basic interview guideline (more detailed versions were used in practice).

Interview topic	Sub-topics and questions
a) Reasons for own activities in biogas	1) What are you doing in the area of biogas?
	2) Why do you do the things you do?
	3) How do you decide about your activities?
	4) What is the role of certain points in time for your activities?
	5) What do you need to be able to undertake your activities?
b) Role of others in own biogas activities	1) What roles do other persons, organisations and firms play in your activities?
	2) Who do you address with your activities?*
	3) How do others impact on your activities?*
	4) How would you describe trust between you and the others?*
c) Rules and institutions that guide own biogas activities	1) What rules are relevant for your activities?
	2) Who determines what you are allowed to do?
	3) What customs/habits play a role?
	4) What discretionary powers do you have?*
	5) Can adherence to rules and customs incur inconveniences/costs?*
d) Changes in procedures in the area of biogas	1) What changes of rules, customs/habits did you observe? (in-house* and general)
	2) How can you contribute to changing rules?
	3) Are you active in committees?
e) Role of inputs, outputs and environment for biogas generation	1) What roles do soil and inputs play in biogas generation?
	2) What roles do technologies play in biogas generation?*
	3) What roles do environment, nature and wildlife play?
	4) What is sustainability?

*(initially) not considered relevant for farmers

Appendix B

Appendix B-1: Interviews in case setting Nordfriesland.

Interview code	Actor group (key attributes)	Interview together with	Interview mode and record	Date
Advisor-SH-early	advisor (public, Länder-level)	-	face-to-face, notes	13/03/2008
Advisor-SH-late	advisor (public, Länder-level)	Advisor-SH-early	face-to-face, notes	13/03/2008
Farmer-NF-A (Farm A)	farmer (biomass grower, shareholder of biogas plant, has other renewables)	-	face-to-face, audio transcript	17/03/2008
Farmer-NF-B (Farm B)	farmer (early plant operator, now has other renewables)	-	face-to-face, audio transcript	17/03/2008
Farmer-NF-C (Farm C)	farmer (plant operator after 2004, limited company, pigs and cereals, maize for biogas, has other renewables)	-	face-to-face, audio transcript	20/03/2008
Farmer-NF-D (Farm D)	farmer (plant operator after 2004, limited company, pigs, maize, grass and cereal biomass for biogas, small share in in other renewables)	-	face-to-face, audio transcript	25/03/2008
Farmer-NF-E (Farm E)	farmer (plant operator joint with neighbour after 2004, limited company, sows, pig fattening, potatoes, sugar beets, maize for biogas, no slurry used, now also shares in other renewables)	-	face-to-face, audio transcript	25/03/2008
Farmer-NF-F (Farm F)	farmer (plant operator before 2004, limited partnership, sows, dairy, cereals, maize and green rye for biogas and dairy, has other renewables)	-	face-to-face, audio transcript	26/03/2008
Farmer-NF-G (Farm G)	farmer (plant operator before 2004, sole proprietor, dairy, very diverse crop rotation, maize for biogas bought in)	-	face-to-face, audio transcript	26/03/2008
Farmer-NF-H (Farm H)	farmer (plant operator before 2004, family business, company under civil law and limited company, additional biogas plant without slurry, sows, cereals, maize for biogas, has share in other renewables)	-	face-to-face, audio transcript	27/03/2008

Farmer-NF-I (Farm I)	farmer (plant operator after 2004 together with neighbours, limited company, dairy, maize for biogas and dairy, cereals, has share in other renewables)	wife	face-to-face, audio transcript	27/03/2008
Bank-NF-A	Loan advisor for renewable energy (regional co-operative bank)	-	face-to-face, audio transcript	16/09/2008
Community-NF-A	Manager of community biogas plant (before 2004, limited company and commercial partnership, farmer, has other renewables)	-	face-to-face, audio record	16/09/2008
Community-NF-B	Manager of community biogas plant (before 2004, limited company and commercial partnership, early retired farmer)	-	face-to-face, audio record	17/09/2008
Bank-NF-B	Chief loan advisor for renewables and farming (small local bank under public law, recently retired)	-	face-to-face, audio transcript	27/10/2008
Bank-NF-C	Loan advisor for renewable energy (regional bank under public law)	-	face-to-face, audio transcript	27/10/2008
Engineer-NF-A	Engineer and planner of biogas plants (sole proprietor, freelancer)	-	face-to-face, audio transcript	27/10/2008
Engineer-NF-B	Engineer and planner of biogas plants (runs own company)	-	face-to-face, audio transcript	07/05/2009
Authority-NF-A	Officer responsible for larger biogas plants in regional (Länder-level) environmental authority (emission regulation, development planning, about to retire)	Authority-NF-B	face-to-face, audio transcript	14/05/2009
Authority-NF-B	Officer responsible for larger biogas plants in regional (Länder-level) environmental authority (emission regulation, development planning, new to job)	Authority-NF-A	face-to-face, audio transcript	14/05/2009
Authority-NF-C	Officer in county development planning authority (line manager of development planning)	Authority-NF-D, Authority-NF-E	face-to-face, audio transcript	28/05/2009
Authority-NF-D	Officer in county water protection authority (line manager)	Authority-NF-C, Authority-NF-E	face-to-face, audio transcript	28/05/2009
Authority-NF-E	Officer in county nature protection authority (line manager, biodiversity)	Authority-NF-C, Authority-NF-D	face-to-face, audio transcript	28/05/2009

Advisor-NF-A	Manager of regional farm business consultancy (personal specialisation in biogas)	-	face-to-face, audio transcript	09/06/2009

Appendix B-2: Interviews in case setting Ostprignitz-Ruppin.

Interview code	Actor group (attributes)	Interview together with	Interview mode and record	Date
Farmer-OPR-A (Farm A)	general manager of limited company and commercial partnership farm (farm A: dairy, cereals, maize, limited liability company)	Farmer-OPR-B, Farmer-OPR-C	face-to-face, audio transcript	08/07/2008
Farmer-OPR-B (Farm A)	technical manager of limited company and commercial partnership farm (farm A: dairy, cereals, maize, limited liability company)	Farmer-OPR-A, Farmer-OPR-C	face-to-face, audio transcript	08/07/2008
Farmer-OPR-C (Farm A)	accountant of limited company and commercial partnership farm (farm A: dairy, cereals, maize, limited liability company)	Farmer-OPR-A, Farmer-OPR-B	face-to-face, audio transcript	08/07/2008
Farmer-OPR-D (Farm B)	chief accountant of limited company farm, responsible for biogas plant (farm B: large dairy, cattle, cereals, maize, limited liability company, plant operator before 2004)	-	face-to-face, audio transcript	16/07/2008
Farmer-OPR-E (Farm C)	chairman of co-operative farm (farm C: dairy, cereals, maize, co-operative, land leased out for other renewables)	Farmer-OPR-F	face-to-face, audio transcript	17/07/2008
Farmer-OPR-F (Farm C)	deputy chairman of co-operative farm (farm C: dairy, cereals, maize, co-operative, land leased out for other renewables)	Farmer-OPR-E	face-to-face, audio transcript	17/07/2008
Farmer-OPR-G (Farm D)	part-time farmer (farm D: no slurry use for biogas, cattle, cereals, maize, pulses, sole proprietor)	Farmer-OPR-H	face-to-face, audio transcript	17/07/2008
Farmer-OPR-H (Farm D)	farmer, child of part-time farmer (farm D: no slurry use for biogas, cattle, cereals, maize, pulses, sole proprietor)	Farmer-OPR-G	face-to-face, audio transcript	17/07/2008

Farmer-OPR-I (Farm E)	manager of commercial partnership farm, bailiff for West-German owners (farm E: cattle, cereals, grain maize, maize for biogas, limited liability company, land leased out for other renewables)	-	face-to-face, audio transcript	09/02/2009
Farmer-OPR-J (Farm F)	chairman of co-operative farm (farm F: dairy, cattle, cereals, maize, co-operative, biogas from slurry and manure only, lessor of site and inputs, absentee owners of biogas plant, land and roofs leased out for other renewables)	-	face-to-face, audio transcript	09/02/2009
Farmer-OPR-K (Farm G)	farmer in company constituted under civil law (farm G: sows, cattle, dairy, cereals, maize, biogas plant before 2004, limited liability company, larger share in other renewables)	-	face-to-face, audio transcript	09/02/2009
Bank-OPR-A	Loan advisor for farm investment (regional bank)	Bank-OPR-B	face-to-face, audio transcript	09/04/2009
Bank-OPR-B	Loan advisor for renewable energy and environmental investment (regional bank)	Bank-OPR-A	face-to-face, audio transcript	09/04/2009
Engineer-OPR-A	Architect, construction engineer and planner of biogas plants and other farm buildings (runs own company)	Advisor-OPR-A	face-to-face, audio transcript	16/04/2009
Advisor-OPR-A	Farm business advisor (runs own company with partner)	Engineer-OPR-A	face-to-face, audio transcript	16/04/2009
Authority-OPR-A	Officer responsible for larger biogas plants in regional (Länder-level) environmental authority (emission monitoring, head of regional department)	Authority-OPR-B, Authority-OPR-C	face-to-face, audio transcript	12/05/2009
Authority-OPR-B	Officer responsible for larger biogas plants in regional (Länder-level) environmental authority (gaseous emission monitoring)	Authority-OPR-A, Authority-OPR-C	face-to-face, audio transcript	12/05/2009
Authority-OPR-C	Officer responsible for larger biogas plants in regional (Länder-level) environmental authority (emission monitoring, water protection)	Authority-OPR-A, Authority-OPR-B	face-to-face, audio transcript	12/05/2009

Authority-OPR-D	Officer responsible for development planning in county authority (group manager)	Authority-OPR-E, Authority-OPR-F	face-to-face, audio transcript	12/05/2009
Authority-OPR-E	Officer working in development planning in county authority	Authority-OPR-E, Authority-OPR-F	face-to-face, audio transcript	12/05/2009
Authority-OPR-F	Officer working on regional development planning in county authority	Authority-OPR-E, Authority-OPR-D	face-to-face, audio transcript	12/05/2009
Authority-OPR-G	Officer responsible for larger biogas plants in regional (Länder-level) environmental authority (planning consent, head of regional department)	Authority-OPR-H	face-to-face, audio transcript	19/05/2009
Authority-OPR-H	Officer responsible for larger biogas plants in regional (Länder-level) environmental authority (precaution and legal matters, waste regulation, head of regional department)	Authority-OPR-G	face-to-face, audio transcript	19/05/2009
Authority-OPR-I	Officer responsible for nature and biodiversity protection in regional (Länder-level) environmental authority (head of regional department)	-	face-to-face, audio transcript	22/05/2009
Authority-OPR-J	Officer in county environmental authority responsible for water protection	Authority-OPR-K, Authority-OPR-L	face-to-face, audio transcript	26/05/2009
Authority-OPR-K	Officer in county environmental authority responsible for habitat protection and biodiversity	Authority-OPR-J, Authority-OPR-L	face-to-face, audio transcript	26/05/2009
Authority-OPR-L	Officer in county environmental authority responsible for emissions and general environment	Authority-OPR-J, Authority-OPR-K	face-to-face, audio transcript	26/05/2009

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