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Energy Production from Biogas: Analysing the Management

Strategies of Supply Chain Actors

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Abstract

While stocks of fossil fuels decline, the search for renewable energy options has been intensified in recent years. Thereby energy production via biogas could be regarded as a promising approach which helps preserve non-renewable resources, contributes to energy supply security, and mitigates the greenhouse effect.

The objective of this PhD project is to conduct a strategic management-based analysis of actors in the biogas supply chain. A multi-tier approach encompassing the whole relevant chain / network is chosen. A SWOT analysis (internal strengths and weaknesses, external opportunities and threats) fed with theory from strategic management and adjacent disciplines is applied as analytical tool. It is operationalised principally by Porter's five forces model of environmental threats, as well as the resource-based view as intra-firm, and the relational view as inter-firm or network perspective for analysing the generation of (sustained) competitive advantage. The aim is to contribute to strategic supply chain management (SCM) by analysing the single strategic positions as well as their interrelation. It is proposed that SCM helps generate inter-firm-based competitive advantage. This assumption is tested by relating constructs of the framework of SCM by Chen and Paulraj (2004) to the sources of specific inter-firm-based competitive advantage proposed by Duschek (2004).

Empirical research is to be conducted as integrated case study and survey research. In terms of case study research, multiple cases are to be developed referring to several supply chains / networks which comprise, as embedded units, farmers, forwarders, power plant operators, power plant technology suppliers. Data will be gathered initially via oral in-depth interviews with few selected actors for exploring the field, and subsequently via a written survey for broader field coverage. Results are mirrored back to selected actors by in-depth interviews. Data is analysed

by methods of qualitative content analysis for the interviews as well as quantitative tools for the survey.

This work aims at making a contribution to the testing as well as elaboration and refinement of theoretical concepts at the interface between SCM and strategic management, on the empirical ground of supply chains producing biogas.

Keywords: Strategic management, supply chain management, SCM, biogas, renewable energy

Energy Production from Biogas: Analysing the Management Strategies of Supply Chain Actors

Introduction

While stocks of fossil fuels decline, the search for renewable energy options has been intensified in recent years. Following the concept of sustainable development as defined by the Brundtland Commission, energy systems should be ecologically, socially, and economically sustainable, so that the present generation is able to meet its energy needs without compromising the ability of future generations to meet their energy and other needs (WCED, 1987). Thereby energy production via biomass could be generally regarded as a promising approach which helps preserve non-renewable resources, improves energy security, mitigates the greenhouse effect, and promotes regional development (McComick & Kåberger, 2007; ecosense, 2007).

A review of studies comparing bio-ethanol systems to conventional fuels on a life cycle basis reaches the conclusion that the balance of environmental impacts of current liquid fuels from biomass is ambiguous. Apart from the definite advantage of biofuels to reduce resource use and global warming, their impacts e.g. on acidification, human and ecological toxicity, and eutrophication have been evaluated more often unfavorably than favorably (von Blottnitz & Curran, 2007). Moreover, energy efficiency of biofuels vary strongly according to plant species, climate, and production technique: Bioethanol from Brazilian sugar cane yields 8 units bioenergy output from one unit fossil fuel input into the production process. Biodiesel produced from rapeseed in the EU has a ratio of 1:2.5, while bioethanol from US corn merely holds an efficiency of 1:1.5 (Böttinger, Leschus, & Vöpel, 2008; GTZ, 2006). The net energy yield per hectare as the difference between the total energy gain from biofuel and biogas minus the fossil fuel input into the production process is 178 GJ (1 Gigajoule = 278kWh) in the case of biogas

and thus more favorable in comparison to liquid fuels. Plant oil (35 GJ), sugarbeet (88GJ), grain (30 GJ), and lignocellulose (18 GJ) are less efficient with regard to the area under cultivation. Even the biomass-to-liquid (BtL) technology generating the so-called second generation biofuels, which is not yet applicable to series production, yields just 135 GJ net energy per hectare. BtL technique makes use of the whole plant, while first generation biofuels only use the starchy and oleic parts of the feedstock (Elz, 2007).

These findings indicate in certain respects environmental and economic advantageousness of biogas, although the researcher is obliged to draw prudent conclusions from comparing input materials with technologies, neglecting furthermore variations from different cultivation climates. When evaluating bioenergy production, a system perspective has to be taken comprehending the components biomass resources, supply systems, conversion technologies, and energy services. In practice many idiosyncratic combinations of these components are possible, which makes direct comparisons between different bioenergy systems difficult (McComick & Kåberger, 2007). Berglund (2006) states that, in general, anaerobic digestion can serve more purpose than only the production of energy: (1) compliance with legal requirements like a ban on land filling organic waste, (2) mitigation of environmental impacts of extant waste management strategies or agricultural activities, (3) provision of fertiliser and thus closing the nutrient cycle in agriculture. While biogas systems have the potential to provide environmentally friendly energy and, at the same time, address several environmental problems, the actual environmental impact of establishing biogas systems depends largely on the raw material input, the energy services provided, and the fuels and handling systems for the raw material that are replaced (Berglund, 2006).

The extant dissertation project deals with energy supply through converting biomass consisting of predominantly energy crops into biogas. Variable parameters are the specific energy crops used and further input like waste and manure, the supply network, as well as the final use of biogas for heat production, combined heat and power (CHP) generation, for upgrading into natural gas, or as vehicle fuel.

The ability of biogas supply chain actors to survive and prosper hinges critically on choosing and implementing successful business and corporate strategies (Barney & Hesterly, 2006). Factors to be considered when developing a firm's strategy are for example external environment, sector, internal capabilities, and relational resources, which are generated by non-market transactions between companies. Objective of this PhD project is to conduct an external and internal strategic management-based analysis of supply chain actors involved in biogas production. Furthermore, the interrelation between supply chain management (SCM) and the generation of interorganisational competitive advantage are tested. The research subject is the biogas supply chain and network respectively, while strategic management and SCM serve as theoretical background and analytical tool. The study analyses actors on various tiers of the supply chain, who are identified beforehand. They may include, for instance, farmers, forwarding and logistics companies, power plant operators, as well as producers and suppliers of power plant technology or of fertilisers.

The structure of the paper is the following: First, characteristics of biogas energy production are delineated. Subsequently, the theoretical framework of the analysis is explained. Afterwards, the research objective is presented, and the research questions are formulated and operationalised. Finally, the planned empirical research design is depicted and a brief outlook is given.

Characteristics of biogas production

Important characteristics of biogas production in terms of raw materials, supply chain, and outputs are outlined briefly below.

Raw materials

Biogas is produced by anaerobic digestion or intensive fermentation of organic matter. Feedstock of this process are energy crops, but also manure, sewage sludge, municipal solid and biodegradable waste (Elz, 2007). Savola (2006) classifies the raw materials (1) into urban waste (including waste water, industrial waste, household waste, restaurant and catering waste, park and garden waste), (2) agricultural by-products (including manure and harvest residues), and (3) dedicated energy crops (for example grasses, grain, maize, sugar beet) (cf. Berglund, 2006; Linné & Jönsson, 2005).

Supply chain

Generally, biogas supply chains and networks are manifold in terms of size, design, and functioning. Supply chain management and co-ordination is most important when introducing bioenergy systems. The whole supply network has to be actively integrated thus realising synergies and meeting the needs of all supply chain actors. McComick and Kåberger (2007) identify energy companies and biomass suppliers as crucial actors within the supply chains. Investing in biomass resources implies energy producers' demand for biomass, and providing conversion technologies premises secured supply of biomass. In terms of activities, harvesting, refining and transporting of biomass are key issues, which must be facilitated by supply chain and operations management as well as most adequate technologies. Berglund (2006) points to costly transport to centralised biogas plants and high costs for cultivating energy crops as

possible barriers for realising the full potential of biogas energy production. Functioning SCM systems, proactively managed relationships, and long-term contracts may turn out to be essential for encouraging farmers to invest in energy crops (McComick & Kåberger, 2007). The supply chain may be either directed by one focal company (like an energy company) in the case of hierarchical structures, or by several actors throughout the chain in the case of heterarchical chains (Westhaus, 2007).

Allan et al. (1998) splits the supply of biomass from its point of production to the power station into following steps: (1) Harvesting of the biomass; (2) in-field handling and transport to the next road; (3) storage of the biomass (particularly energy crops with specific harvest periods); (4) loading and unloading road transport vehicles; (5) transport; (6) processing of the biomass to increase shipping volume and handling efficiency. These activities are carried out by a different number of actors depending on the supply chain / network structure. The activities are highly interconnected. Therefore a total supply chain perspective has to be taken when planning any single activity. Most cost-effective harvesting systems may entail expensive storage systems or even delivery bottlenecks. Hence the choice of the harvesting system largely determines storage, handling and transport systems in the supply chain. In contrast to other activities like harvesting, where there is rather little scope for easy environmental benefits through reorganisation of the supply chain, the activities transport and storage offer various opportunities to reduce environmental impacts through planning and managing the supply chain. Improvements may be reached, for instance, by optimisations in terms of vehicle selection, vehicle routing and scheduling, storage and depot positioning, landscaping and load safety (Allan et al., 1998).

Applications of anaerobic digestion outputs

Anaerobic digestion produces (1) biogas, (2) digestate, which is mostly used as fertiliser on arable lands, and (3) process liquor, which is fed back to the digestion process, the rest being used as liquid fertilizer or disposed as waste water (Savola, 2006; Berglund, 2006).

The simplest energy application of biogas is heat production through natural gas boilers modified for raw biogas. Cleaned biogas can also be inserted into municipal gas pipeline grids for cooking use (Savola, 2006). Currently biogas is mainly used for power generation through combined heat and power units with gaseous fuel engines, or for feeding biogas grids (Hacker, Rabenstein, & Baumgartner, 2007). If sufficiently cleaned of water, hydrogen sulphide and carbon dioxide, biogas acquires the same characteristics as natural gas and can be fed into the local gas distribution grid (Elz, 2007; Schulz & Hille, 2003). In Sweden biogas is also increasingly used as vehicle fuel, contrary to other countries like Denmark and Germany (Berglund, 2006; Savola, 2006). Power generation from biogas with even higher efficiency may offer the fuel cell technology in the future (Hacker et al., 2007). Table 1 gives an overview of currently feasible end applications of biogas and their respectively required processing steps. Each processing step adds value to the final product (Savola, 2006).

Table 1: End applications of biogas

End application:	Required process steps:		
	Pre-treatment	Upgrading	Compression and storage
Flare	Very simple		> 0,1 bar
Town gas for heat	Simple		2 – 4 bar
CHP	Advanced		2 – 4 bar
Natural gas grid	Advanced	Remove CO ₂	Compr. required 4 – 50 bar
Vehicle fuel	Advanced	Remove CO ₂	Compr. & storage 200 – 250 bar



Source: Savola, 2006, p. 17

Theoretical Background

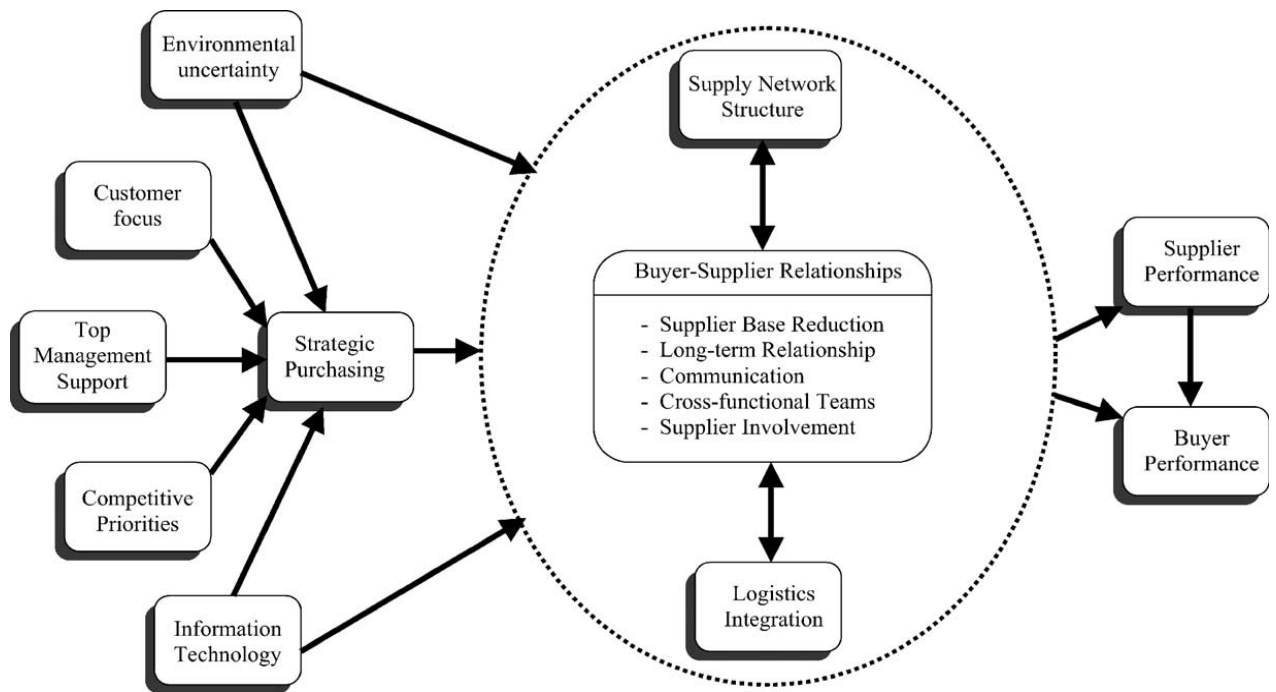
The research subject of the extant PhD project is the supply chain and the SCM respectively. Mentzer et al. (2001, p. 4f.) define the supply chain as “a set of three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer”. They identify three degrees of supply chain complexity: Direct supply chain, extended supply chain, and ultimate supply chain. SCM means „the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole” (Mentzer et al., 2001, p. 18). Various activities are considered necessary for successfully implementing a SCM philosophy within a company: (1) Integrated behaviour incorporating customers and suppliers (Bowersox & Closs, 1996); (2) mutually sharing information, particularly for planning and monitoring processes (Cooper et al., 1997); (3) mutually sharing risks and rewards, particularly

when jointly generating competitive advantage (Cooper & Ellram, 1993); (4) cooperation at several management levels, involving cross-functional coordination across the supply chain (Cooper et al., 1997); (5) harmonising goal and focus on serving customers as a form of policy integration among the supply chain members (LaLonde & Masters, 1994); (6) integration of sourcing, manufacturing, and distribution processes across the supply chain; (7) building and maintaining long-term relationships among supply chain members while limiting the number of partners (Cooper et al., 1997).

Chen and Paulraj (2004) develop a framework of SCM by elaborating a set of reliable, valid, and unidimensional constructs and their appropriate measurements. As Figure 1 indicates, special attention is drawn to the buyer-supplier dyadic relationships, which several studies have recognised to be of outstanding importance to effective SCM (e.g., Anderson, Hakansson, & Johanson, 1994). Pivotal aspects of this relationship are included into the framework: supply base reduction, long-term relationships, communication, cross-functional teams, and supplier involvement. Key driving forces of fostering and maintaining superior dyadic relationships are considered to be environmental uncertainty, competitive priorities, top management support, and strategic purchasing. The construct supply network structure refers to decentralised, horizontal and non-power based links among the supply chain actors. For studying the integration of information and materials along the supply chain, the constructs of logistics integration and information technology are incorporated. Since satisfying customer needs is the basis of any business, customer focus is seen as further component of effective SCM. As the paradigm shift towards SCM implies the conception that it is entire supply chains rather than autonomous businesses which compete on the markets (Lambert & Cooper, 2000), both supplier performance

and buyer performance are incorporated in the theoretical framework of Chen and Paulraj (2004).

Figure 1: A research framework of SCM



Source: Chen & Paulraj, 2004, p. 121

As main analytical tool the extant project applies the SWOT analysis (internal strengths and weaknesses, external opportunities and threats), which is part of the organising framework of the strategic management process according to Barney and Hesterly (2006). This analytical framework is based on Andrews (1971), who “defined strategy as the match between what a company can do (organisational strengths and weaknesses) within the universe of what it might do (environmental opportunities and threats)” (Collis & Montgomery, 1995, p. 121). Porter’s five forces model of environmental threats (Barney & Hesterly, 2006) was the first concept systematically assessing the firm’s environment (Porter, 1979, 1980, 1981). Porter (1979, p. 137) identifies five forces shaping an industry: “the threat of new entrants, the bargaining power of

customers, the bargaining power of suppliers, the threat of substitute products and services [...], and the jockeying among current contestants.” Brandenburger and Nalebuff (1996) suggest as additional force the benefits of complementors. Their complementary products enhance the value of a firm’s products in the customers’ eyes. Thus complementors help increase the size of a firm’s market, instead of competing for a certain market as competitors do (Barney & Hesterly, 2006; Brandenburger & Nalebuff, 1995).

With the emergence of the concepts of core competences and competing on capabilities the perspective changed radically from outside to inside the company (Stalk, Evans, & Shulman, 1992). The resource-based view (RBV) helps reconcile these seemingly disparate approaches by acknowledging the importance of company-specific resources and competencies, yet placing them in the context of the competitive environment (Collis & Montgomery, 1995). Barney (1991) refutes the assumption of perfectly mobile and thus homogeneously distributed resources within an industry or a group of companies, on which the environmental models of competitive advantage are based (Rumelt, 1984; Porter, 1981). The article formulates four attributes a firm resource must have to hold the potential of generating sustained competitive advantage: “(1) it must be valuable, in the sense that it exploits opportunities and/or neutralises threats in a firm’s environment, (2) it must be rare among a firm’s current and potential competition, (3) it must be imperfectly imitable, and (4) there cannot be strategically equivalent substitutes for this resource that are valuable but neither rare or imperfectly imitable” (Barney, 1991, p. 105). Firm resources may be imperfectly imitable due to unique historical conditions, causal ambiguity, and/or social complexity (Barney, 1991). Other so-called isolating mechanisms preserving competitive advantage are, for example, legal preclusion or tacit knowledge (Schneider, 1997; Freiling, 2001). Newbert (2007) analyses a sample of RBV-grounded empirical articles and comes to the

conclusion that the RBV has received only modest support overall (53%). Moreover, the independent variable and theoretical approach employed has substantial impact on the degree of support. Future empirical analyses are recommended to abstain from testing early concepts of the RBV, but to test those that incorporate its more recent theoretical extensions. Analysing cluster-specific resources and capabilities, Hervás-Oliver and Albors-Garrigós (2007) apply the RBV at the meso-economic level, thus extending the perspective of the RBV beyond the firm or micro-level.

As another thread of strategic management theory the relational view emerged. The approach says that critical resources are not solely housed within a single firm, but may span firm boundaries and be embedded in inter-firm routines and processes. Therefore, the relationships between firms are an important unit of analysis when discussing competitive advantage. Dyer and Singh (1998) identify four determinants of interorganisational competitive advantage: (1) relation-specific assets; (2) knowledge-sharing routines; (3) complementary resources and capabilities; (4) effective governance (cf. also Duschek, 2004). Causal ambiguity (Porter, 1981; Reed & DeFillippi, 1990) and time compression diseconomies (Dierickx & Cool, 1989), identified as factors for sustaining competitive advantage on a firm level by the RBV, also do apply on a dyadic or network level. Additionally, Dyer and Singh (1998) define four mechanisms of preserving relational rents: Interorganisational asset interconnectedness, partner scarcity (rareness), resource indivisibility and institutional environment. Although the relational view can be considered complementary to the RBV, these two theories differ in terms of unit of analysis, sources of rent, as well as control and ownership of the rent-generating resources. Consequently, the relational view may recommend firm strategies for achieving sustainable

profits diverging from the prescriptions offered by the RBV (Dyer & Singh, 1998; Duschek, 2004).

Duschek (2004) regards the relational view as a complementary extension of the RBV, since both theories focus on resources as their primary object of analysis. The former aims at conceptually anchoring sustained competitive advantage in network resources (Duschek, 2004).

Research objective and research questions

The objective of this PhD project is to conduct integrated case study and survey research regarding the strategies of biogas supply chain actors. The analysis is theoretically based on strategic management and adjacent disciplines as well as SCM. Biogas supply chains represent the subject matter of the analysis. The following research questions are proposed: (1) Which influence does the environment exert on the strategies of biogas supply chain actors? (2) Which firm-based resources are identified as important for corporate performance? (3) How do interactions between supply network actors contribute to the generation of sustainable competitive advantage? (4) What impact does SCM have on the creation of interorganisational competitive advantage?

Operationalisation of the research questions

(1) For assessing the organisation's environment the extended Porter's five forces model of environmental threats (Porter, 1979, 1980, 1981) is employed. Here, the question is posed: How do the threat of new entrants, the bargaining power of customers and suppliers, the threat of substitute products and services, the fight with current contestants, and the benefits of complementors impact the situation of the organisation under examination?

(2) For identifying the firm's internal resources the three categories value, rareness, as well as imperfect imitability and substitutability are checked (Barney, 1991). Thus the following questions are asked: Does a firm's resource create value – i.e. increase customer's benefits or reduce costs (Porter, 1992) – on the marketplace? Is a specific valuable resource rare among the competitors? Are those resources which are valuable and rare difficult to be imitated or substituted by competitors?

(3) Interorganisational resources generating competitive advantage are assessed by checking the sources of specific inter-firm-based competitive advantage: relation-specific assets, knowledge-sharing routines, complementary resources and capabilities, effective governance (cf. Duschek, 2004). Hereby these questions are posed: Do partners invest specifically in co-specialised resources, thus to establish site specificity, physical asset specificity, or human asset specificity (Duschek, 2004; Williamson, 1985)? Are there specific and institutionalised patterns and mechanisms of knowledge transfer, combination and creation? Are there interorganisational complementary resources which create competitive advantage through cooperation that is larger than the potential sum of advantage stemming from the individual organisations' use of these

resources? Are there effective interorganisational institutions which minimise transaction costs and simultaneously generate incentives for maximising transaction values?

(4) The concept of SCM is based on the notion that firms are links in a networked supply chain. Hence, SCM implies “the challenge of designing and managing a network of interdependent relationships developed and fostered through strategic collaboration” (Chen & Paulraj, 2004, p. 119) and thus generating collaborative advantage (Kanter, 1994). The research framework of SCM of Chen and Paulraj (2004) explicitly draws on the relational view. This thread of strategic management theory focuses on interorganisational competitive advantage (Dyer & Singh, 1998; Duschek, 2004), which represents an extension to the RBV (Barney, 1991; Teece, Pisano, & Shuen, 1997) shifting the unit of analysis from the individual firm to the dyad and network respectively. With this in mind, the conclusion is proposed that SCM helps generate inter-firm-based competitive advantage. In order to test such a relation, constructs of the framework of SCM by Chen and Paulraj (2004) are assigned to the sources of specific inter-firm-based competitive advantage presented above. On this basis the following hypotheses are proposed:

Effective SCM suggests close, long-term relationships between partners who depend on one another for much of their business (Spekman, Kamauff, & Myhr, 1998). The strong role of top management dedicating time, personnel and financial resources to develop key suppliers who are willing to engage in long-term partnerships is emphasised in the literature (Monczka, Trent, & Callahan; Chen & Paulraj, 2004). These considerations lead to the assumption that the likelihood of partners investing specifically in co-specialised resources – for example, suppliers engaging in re-use activities of their customers (Carter & Carter, 1998; Carter & Rogers, 2008) – and hence heightening the dependence on supply chain partners grows when relationships are designed to be long-term and when top management support is provided.

Hypothesis 1: Long-term relationships and top-management support are positively related to relation specific assets.

Grant (1996) considers knowledge as the most strategically important of the firm's resources. Access to valuable information is a major incentive for firms to build up partnerships characterised by trust and information exchange (Gulati, 1999). Learning between supply chain members may be resource-consuming, but is in many ways less transparent than learning within a single firm and thus more difficult to imitate (Carter & Rogers, 2008). Simatupang and Sridharan (2005) state that due to advances in information technology information sharing has become a main feature of supply chain collaboration. Two-way communication, facilitated by various forms of information technology and even extended to sensitive design information and crucial project and planning processes (Krause & Ellram, 1997; Chen & Paulraj, 2004) may be assumed prerequisites of transferring and combining knowledge and hence initiating interorganisational learning processes.

Hypothesis 2: Supplier involvement, information technology, and communication are positively related to knowledge sharing routines.

SCM offers the opportunity to gain access to other firms' core competencies through interorganisational cooperation as an alternative to building such competencies in-house (Halldorsson et al., 2007). Thus complementary assets can be developed among entities of a supply chain. Collaboration leading to mutual completion of resources requires a high degree of trust, commitment and information sharing among supply chain partners (Spekman et al., 1998). It may be assumed that such collaboration is facilitated by a supply network structure emphasising non-power based relationships and inter-firm coordination, by long-term relationships and by the use of information technology.

Hypothesis 3: Supply network structure, information technology, and long-term relationships are positively related to complementary resources and capabilities.

Minimising opportunistic behaviour within a supply chain lowers costs and hence improves the supply chain’s economic performance (Carter & Rogers, 2008). On the other hand supply chains can only yield the full potential of revenue-enhancing benefits when the risks for the single supply chain member associated with its heightened dependence are minimised. Trust, commitment and a common vision of the future are prerequisites that supply chain members engage in interorganisational collaboration (Spekman et al., 1998). Hence, it can be assumed that effective governance structure minimising transaction costs and maximising transaction values are facilitated by a supply network structure emphasising non-power based relationships and inter-firm coordination and by the long-term nature of these relationships.

Hypothesis 4: Long-term relationships and supply network structure are positively related to effective governance structure.

The constructs of the framework of SCM by Chen and Paulraj (2004) – long term relationships, top-management support, supplier involvement, information technology, communication, and supply network structure – represent the independent variables. They can be operationalised by the measurements provided by the authors presented below.

Table 2: Operationalisation of constructs of the framework of SCM

Information technology
There are direct computer-to-computer links with key suppliers. Interorganisational coordination is achieved using electronic links. We have electronic mailing capabilities with our key suppliers.
Supply network structure
We have a permeable organisational boundary that facilitates better communication and/or relationship with our key suppliers. Our relation with the suppliers is based on interdependence rather than power. We have few management levels in our relationship with suppliers.
Long-term relationship

<p>We expect our relationship with key suppliers to last a long time. The suppliers see our relationship as a long-term alliance. We view our suppliers as an extension of our company. We give a fair profit share to key suppliers.</p>
<p>Communication</p> <p>We share sensitive information (financial, production, design, research, and/or competition). Exchange of information takes place frequently, informally and/or in a timely manner. We keep each other informed about events or changes that may affect the other party. We have frequent face-to-face planning/communication.</p>
<p>Supplier involvement</p> <p>We involve key suppliers in the product design and development stage. There is a strong consensus in our firm that supplier involvement is needed in product design/development. We involve our key suppliers in business and strategy planning.</p>
<p>Top management support</p> <p>Top management considers purchasing to be a vital part of our corporate strategy. Top management emphasises the purchasing function's strategic role. Top management supports the need for interorganisational information systems.</p>

Source: Chen & Paulraj (2004)

A starting point for operationalising the sources of specific inter-firm-based competitive advantage which represent the dependent variables, are the questions presented above under subsection (3), following Duschek (2004). A further-reaching concretion of these four constructs still has to be developed.

Empirical research design

The extant project aims at selecting, applying, and testing theoretical models based on strategic management, SCM, and adjacent disciplines. Case study and survey research are chosen as empirical research methods.

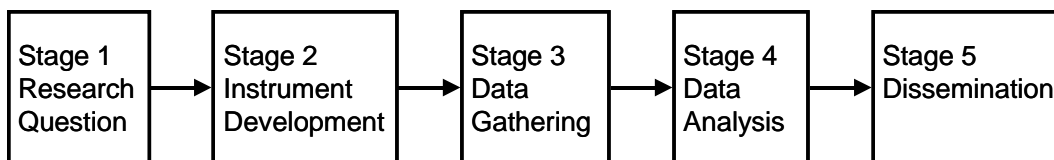
According to Yin (2003, p. 13) “a case study is an empirical enquiry that (1) investigates a contemporary phenomenon within its real life context, especially when (2) the boundaries between phenomenon and context are not clearly evident”. Seuring (2008) points to the fact that the opportunity of applying a flexible research strategy is one of the major strengths of case

studies. However, this may also turn into a major weakness, in particular, if the research process is insufficiently documented. Siggelkow (2007) underlines the importance of filtering the total of information gained by case research so that only these details are presented which are related to the conceptual arguments.

Survey research is an important and frequently used research method for collecting primary data in the social sciences (Zikmund, 2000). It allows for collecting large amounts of data in a rather efficient way (Kotzab, 2005). Hereby, questionnaires are most often applied. Questionnaires as data collection tool, however, are not solely used in survey strategies, but also, for example, within case study research. A questionnaire includes “all techniques of data collection in which each person is asked to respond to the same set of questions in a predetermined order” (Saunders, Lewis, & Thornhill, 2007, p. 354f.). One may differentiate between self-administered questionnaires – such as internet-mediated, postal, as well as delivery and collection questionnaires – and interviewer-administered questionnaires – such as telephone questionnaire and structured interview (Saunders, Lewis, & Thornhill, 2007).

Stuart et al. (2002) suggest a five stage research process, which serves as model for presenting the research design of the extant project.

Figure 2: The five stage research process model



Source: Stuart et al., 2002, p. 420

(1) Theory-based definition of the research objective: The project aims at selecting, applying, and testing models of strategic management, SCM, and adjacent disciplines. The biogas supply chain represents the subject matter of the analysis.

(2) Instrument development: The extant research project applies an integrated multi-case and survey design.

The case study research intends to analyse several supply networks dealing with energy production via biogas. Opting for a multi-case design allows generalising beyond the single case (Eisenhardt, 1989), while still allowing in-depth insight into the individual case (van Donk & van der Vaart, 2005).

Actors on various tiers of the supply chain are analysed. This complies with the call for empirical research designs looking into multi-tier supply chains, which was repeatedly claimed in business economics supply chain literature (Fettke, 2007; Seuring, 2008). Actors relevant for our enquiry are identified by a preceding supply chain mapping. The assessment comprises the complex structure of the “ultimate supply chain” (Mentzer et al., 2001, p. 4f.) which considers all actors involved into the value creation process and which may be better denominated by the term “network”. Moreover, it distinguishes between main lines and side lines of the supply chain. The latter marks value creation activities conducted by actors of side lines before products and services are provided to the tiers of the main line (Enquete-Kommission, 1994). In the extant study actors of the main line may be the following: Farmers, forwarding and logistics companies, power plant operators. Relevant actors of side lines may be producers and suppliers of power plant technology or of fertilisers.

At least one supply chain shall be based on organic farming and at least one on conventional farming. When analysing and interpreting data, these two types may be compared and contrasted among each other.

The supply networks shall preferably represent regional clusters in order to delimit time and costs for data collection. The individual supply chain actors are regarded as embedded units of the case studies.

Survey research is applied for testing the hypotheses of positive correlations between the constructs of the framework of SCM by Chen and Paulraj (2004) and the sources of specific inter-firm-based competitive advantage (Dyer & Singh, 1998; Duschek, 2004). Naturally, the analyzed sample is considerably broader than the one addressed by the case studies.

The project pursues a multi-national approach. Data collected in Germany is complemented by data collected in another European country.

(3) Data gathering techniques: Data is gathered by means of oral semi-structured interviews as well as written questionnaires, both addressing experts.

Experts are defined as “people who possess special knowledge about social issues” (Gläser & Laudel, 2004, p. 10, own translation). The selection of experts is made according to the specific research objective. A person is considered an expert when s/he holds at least one of these two characteristics: (1) The expert is responsible for conceiving, enforcing, and controlling a problem solving. (2) The expert possesses privileged access to information about groups of people or decision processes (Meuser & Nagel, 1991). In the extant project experts are people who are responsible for managing and strategically steering their organisation or hold special knowledge about these matters.

The empirical work is opened by personal or telephonic depth interviews with selected companies, aiming at exploring the field of study and preparing a broader questionnaire survey which consists of open and closed questions. Open questions are mainly used for gathering data for the case studies. Closed questions are used for testing the hypotheses of positive correlations

between SCM and inter-firm-based competitive advantage. In addition, complementary information concerning the companies under examination is gained through web research and further accessible information material. Concluding the empirical work, issues that turned out to be of special interest can be studied in even greater depth by means of oral expert interviews. Such a combination of different empirical approaches – the so-called triangulation (Webb et al., 1966) – contributes to checking and complementing the collected data and thus help secure high research quality.

(4) Data analysis: The collected data are analysed following one of the qualitative approaches below. Meuser and Nagel (1991) suggest proceeding according to these modules: transcription, paraphrasing, captioning, comparison of topics, conceptualisation, and theoretic generalisation. Mayring (2005) classifies techniques of qualitative content analysis as follows: (a) Summary and inductive category building; (b) explication (narrow and broad context analysis); (c) structuring as regards form, content, types, and scales.

In addition, quantitative tools apply when testing the hypothesis of interconnection between SCM and the generation of interorganisational competitive advantage by analysing correlations between theoretical constructs of these two fields.

On the one hand the study wants to gain practical insights into the strategies of biogas supply chain actors and biogas supply chains as a whole. On the other hand, it proves empirically the explanatory power of the theoretical models applied, combines frameworks from different disciplines, and elaborates, if applicable, starting points for the enhancement of these models.

(5) Dissemination / overall process: Quality of research results is guaranteed by a comprehensive and detailed documentation of the whole research process. Besides, quality-securing mechanisms inhering in the research design apply, like empirical triangulation mentioned above.

Outlook

This research project analyses the single strategic positions of various actors of the biogas supply chain, as well as their interrelation. It shows how external factors, organisation-specific resources and interorganisational resources have impact on strategy considerations of the entities involved in biogas production. Moreover, the interrelation between SCM and the generation of interorganisational competitive advantage is assessed. Thus, factors determining the performance of single actors and of entire supply chains in this rather young sector, which may evolve to a substantial pillar of renewable energy supply, are depicted. They determine the viable paths the sector can take in the future for expanding both its absolute energy output and its market share of the total energy market.

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