Ensuring protection and competitiveness

Characteristics of market formation for biogas

Thomas Magnusson (corresponding author), Hans Andersson, Mikael Ottosson

Linköping University

Department of Management and Engineering

SE-581 83 Linköping

Sweden

☏ +46 13 28 89 98

✉ thomas.magnusson@liu.se

Abstract

Adopting a market constructivist perspective, this paper analyzes the shaping of markets for biogas in Sweden. The analysis shows how perceptions of the market offer have different implications for market shaping. Depicting biogas as a local system solution implies that the market offer is associated with several different environmental values that serve to qualify biogas. The realization of such a system depends on the bonding of various actors and once established, these bonds will protect the biogas system from competition. However, these bonds may also hamper system growth. The analysis suggests that although there is a tension between the local model and visions of significant growth, when used as a narrative, the local model makes it possible for actors to argue for institutional reforms to make biogas competitive and thus facilitate growth.

Introduction

The formation of markets for renewable technology alternatives is critical for sustainability transitions. Based on evolutionary models of technology diffusion, innovation systems literature typically depict market formation as a step-wise process from initial niche markets, via bridging markets, to mass markets (Hekkert, Suurs et al. 2007, Bergek, Jacobsson et al. 2008). Entry via policy-protected niche markets is often necessary to shield the technology from prevailing selection environments and nurture further development and diffusion (Kemp, Schot et al. 1998, Schot and Geels 2007, Schot and Geels 2008). A number of different policy instruments can support such a development. Hence policy makers will be central figures in the formation of protective spaces that allows initial market entry (Smith and Raven 2012). Whereas this early stage of market formation has been thoroughly elaborated in transitions literature, the critical step from protected niches to larger, more open and competitive markets has received less attention. In their studies of the development of biogas as socio-technical systems Wirth, Markard et al. (2013) pointed at the importance of informal institutios and Markard, Wirth et al. (2016) found that a rapid expansion can result in problems of legitimacy, defined as a misalignment with institutions. They conclude that studies of actor strategies are needed to understand how technology legitimacy evolves.

This paper explores the formation of markets for biogas in Sweden. Presenting possible solutions to environmental problems such as air quality, greenhouse gases, nutrient recirculation, organic wastes and wastewater (Lantz, Svensson et al. 2007), biogas is a highly relevant case for sustainability transitions. Besides biogas producers, the production and use of biogas engages actors from several sectors, including energy and gas distribution, waste and wastewater management, agriculture, vehicles and transport. The paper adopts a market constructivist perspective to analyze how these actors act to shape markets. The case study focuses on the Swedish context, which is different from other European countries in that policy makers have preferred to stimulate a demand, rather than subsidizing production and by encouraging use of biogas as a vehicle fuel rather than for electricity and/or heat generation (Magnusson and Berggren 2018).The following research question will guide the paper: What actors and what activities are shaping the market in this case and based on that, what is possible to learn about market formation in relation to sustainability transitions?

The paper proceeds with a theoretical framework, which builds on transitions and marketing literature to describe market formation. The framework emanates in a model that depict different actors as important linkages between technologies and institutions that facilitate market shaping. This is followed by a section on research methods. Thereafter a section outlines the Swedish biogas sector. The subsequent section then presents an analysis of actors and activities that shape markets for biogas in Sweden. A concluding section then summarizes the main findings and implications.

Market formation by multiple actors

To enable growth, it is necessary to enroll actors into the market for the new technology. The use of narratives is critical for the enrolment process (Smith and Raven 2012, Kern, Smith et al. 2014, Kern, Verhees et al. 2015). Narratives are stories with an underlying moral, which have a number of different functions. Firstly, narratives convey positive expectations about

the future, in which the technology plays a central part. In particular for technologies whose diffusion depend on large infrastructural investments, raised expectations is important to mobilize requisite resources for broader technology diffusion (Alkemade and Suurs 2012). Secondly, narratives make claims about the technology. To justify these claims, the narratives can refer to societal problems and those convening the narratives can engage in current political debates. Thirdly, narratives undermine the current socio-technical regime, stating that transition is necessary and emphasizing the transition opportunities that arise from the new alternatives. Existing institutional frameworks that are prevalent in the surrounding society will influence the ability for the narratives to succeed in their endeavor to enroll actors and enable market formation (Kern, Verhees et al. 2015).

Market formation involves different actors: buyers and sellers, as well as profit-making and non-profit organizations. The existence of a market implies some sort of competition, involving these actors (Ahrne, Aspers et al. 2015). Marketing scholars increasingly perceive market formation as an evolutionary phenomenon (Storbacka and Nenonen 2011, Kjellberg, Azimont et al. 2015, Ulkuniemi, Araujo et al. 2015). Inherent in this view is an emphasis on actors as co-creators of markets, as opposed to the historical image of companies merely targeting pre-defined, existing markets 'out there'. Hence, it is possible to discern a move away from the dominating image of markets as stable and pre-existing entities, to the construction of markets as an on-going process that actors influence through their strategies, activities and capabilities.

Markets are malleable and hence possible to influence as different actors engage in market interactions at different positions in the value stream (Finch and Geiger 2011, Vargo and Lusch 2011). Understanding market shaping includes analyzing activities aimed at a wider array of actors than merely direct customers (cf. Homburg et al., 2014). The importance of looking at such activities for understanding how markets are being shaped is emphasized in contemporary research (see e.g. Storbacka & Nenonen, 2011; Ulkuniemi et al., 2015). Drawing on literature on innovation systems, we may in this regard take into account at least three different elements – technology, actors, and institutions (Malerba 2002, Hekkert, Suurs et al. 2007, Bergek, Jacobsson et al. 2008).

Central to the technology element is the market offer. Callon et al. (2002) argue that qualification refer to the specific meanings attributed to the offer that create a boundary between different actors and the product. Finch and Acha (2008) discuss that different actors in a collaborative process need to define the market offer and that the potential value of the product might differ between actors. It emphasizes the close relationship between knowledge and technology, a perspective in which physical things can be perceived as embedded knowledge in products. Hence, without a clear view of what is being exchanged, i.e. the market offer, it will indeed be difficult to shape a market successfully (Callon et al., 2007; Harrison and Kjellberg, 2016). The perspective in this proposed research is that the technology, as a key part of the market offer, is a driving enabler in market shaping, and that this is especially pronounced in virgin markets, where the offer is yet far from fixed.

The actor element consists of "…actors, dyads, triads, complex networks…" (Chandler and Vargo 2011, p. 10). Focused on exchange practices this is typically represented by concrete activities, such as customer or supplier interaction, i.e. selling products and services or negotiating prices and delivery (Harrison and Kjellberg, 2007). It may also include

organizing actor networks and creating an infrastructure for sales, thus including interaction between actors in a market that goes wider than the traditional supplier-customer dyad. Homburg et al. (2014) suggest the inclusion of an array of actors, for example customers' customers (triads), to include downstream actors to a greater degree when trying to grow a market.

The institutional element consist of norms and regulations that set the boundaries and rules for an entire market (Edvardsson et al., 2014). Institutions have been defined as: "humanly devised rules, norms, and meanings that enable and constrain human action" (Vargo et al, 2015, p 64). Just as actors set up the market offer comprising the technology, institutions are neither static nor pre-conceived; instead, they are possible to shape and act upon (Koskela-Huotari et al., 2016). Vargo et al., (2015) has demonstrated that influencing institutions may be done through a dynamic institutionalization process, which can involve industry associations, the state, authorities as well as single firms. As institutions sets norms, standards, and rules they have a strong influence on single firms. Actors that has the ability to influence institutions affect the direction in which a market develops (cf. Edvardsson et al., 2014). Hence, institutions are essential in understanding the mechanisms of market shaping.

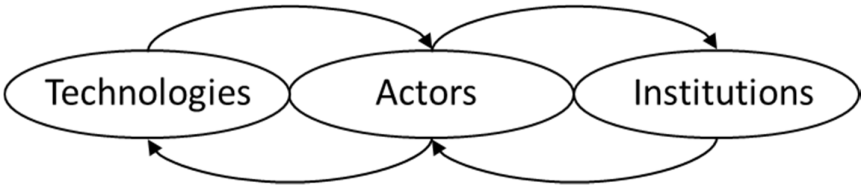

Figure 1 Market shaping through interaction

Consequently, one may distinguish three interacting elements that are important for market shaping: technologies, actors and institutions. Figure 1 describe how the actors' activities are central for this process. Deploying different strategies, actors engage in technological development and negotiate market offers based on the technology. These market shaping activities are influenced by technological restrictions and bottlenecks. Institutions also influence the market shaping activities and actors engage in associations and coalitions to align the technology, influencing established institutions and establishing new ones.

Research methods

The aim of the study is to explore key activities performed by multiple actors for shaping the Swedish biogas market, a complex and context bound process. Accordingly, multiple case study was chosen as the method appropriate for gathering the necessary data, since it is considered an effective means of gaining new knowledge about a specific phenomenon (Eisenhardt & Graebner, 2007). Specifically, multiple case analysis was expected to facilitate in-depth understanding of the contextual factors and underlying processes influencing the shaping of the biogas market. The focus is on activities performed by multiple actors on a biogas market in the making.

Three criteria were applied to the selection of appropriate cases from actors involved in the Swedish biogas market. First, a candidate had to be actively a part of shaping the Swedish biogas market. Second, for reasons of practicality, access to key informants had to be readily available. Third, the actors should yield qualitative richness and diversity of data, rather than delivering statistical representativeness, each one standing on its own merits as a unit of analysis (Eisenhardt & Graebner, 2007). Our case selection can be characterized as theoretical sampling rather than statistical sampling, since we are in pursuit of analytical generalizability of the findings rather than statistical generalizability (cf. Yin, 2018).

The paper combines quantitative and qualitative sources of data. It presents detailed data on production volumes and use of the produced biogas from Swedish biogas plants 2005-2016. The data also contains information about production technology and the substrates used. The data was received from the Swedish Energy Agency, which receive annual reports from the production units. This quantitative data is complemented by qualitative data from interviews with representatives from key actors on the Swedish biogas market.

We conducted twelve interviews with central stakeholders. This involves key personnel from organizations such as energy companies, suppliers of biogas equipment, biogas producers, vehicle manufacturers, gas grid owners, public users of biogas, biogas distributers, lobbyists and think tanks. The rationale for this sample profile was to minimize the scope for bias inherent in relying on answers of questions by a relatively small number of respondents or organizations. All interviews were semi-structured around the interview guides focusing on exploring key activities performed by the actors for shaping the Swedish biogas market (Yin, 2018). The interviews were generally audio-recorded and conducted at site face to face. One respondent asked to remain anonymous, so that interview could not be recorded on ethical grounds. The interviews were conducted during the 2015-2017 period and lasted for 1-2 hours. Moreover, we participated in several workshops and seminars, which gathered biogas stakeholders, and we used secondary data from reports and other written sources. The approach of the workshops had much in common with what Van de Ven and Johnson (2006, p. 803) calls "…engaged scholarship research…". Focus was on collaborative forms of coproduction of knowledge in which the researchers and the practitioners leverage their different perspectives and competencies around the biogas market.

Following Yin (2018), we carried out the analysis and interpretation as a pattern matching process guided by the theoretical framework. Analysis of the inputs from the depth interviews, workshop discussions and secondary sources identified a number of activities across the sample. A sequence of iterations, switching sequentially between empirical results and theoretical inputs, generated and developed our overarching conceptual activities. This process has been termed "abductive" (Dubois & Gadde, 2002).

The Swedish biogas market

Technologies

Biogas is a methane-rich gas, which is produced from organic substrates. It can be used as a substitute for natural gas or liquefied petroleum gas (LPG) in different applications such as generation of heat for industrial processes or domestic heating, electric power generation, or as a vehicle fuel. Use as a vehicle fuel requires upgrading to raise the methane-content.

Biogas production is based on different substrates such as organic wastes from households, food industries and forestry, manure, energy crops, and sewage sludge. The common way to produce biogas is through anaerobic digestion. Apart from the gas, this process results in a digestate that can be used as an organic soil nutrient in farming. Anaerobic digestion has for a long time had strong advocates on the Swedish market. In fact the very first versions of the Swedish biogas market was different local systems based on anaerobic digestion of sewage sludge. Later such local systems grew in size, often an important enabler of local biogas growth was the fact that it was perceived as a potential solution to the emission problem from diesel buses.

However gasification, producing synthetic gas (syn-gas) a promising alternative which may enable a significant expansion of the production volume, establishing larger units and making us of organic substrates that may be difficult to digest. This is a more immature technology, which may open up for use of a wider palette of substrates. Gasification however is met with skepticism from many actors on the biogas market since it is not associated with all the sustainability benefits associated to digestion. Rather it is associated with large-scale production sites and the absence of a local circular system. The large-scale production based on substrates such as forestry rest products means that returning of soil nutrients will be more problematic. There is also a fear among several actors that gasification may risk that biogas gets associated with the fossil natural gas. This would indeed affect the narrative of biogas and reduce it to just another energy market offer among others. The diagram below shows the overall development and its distribution across different types of production facilities.

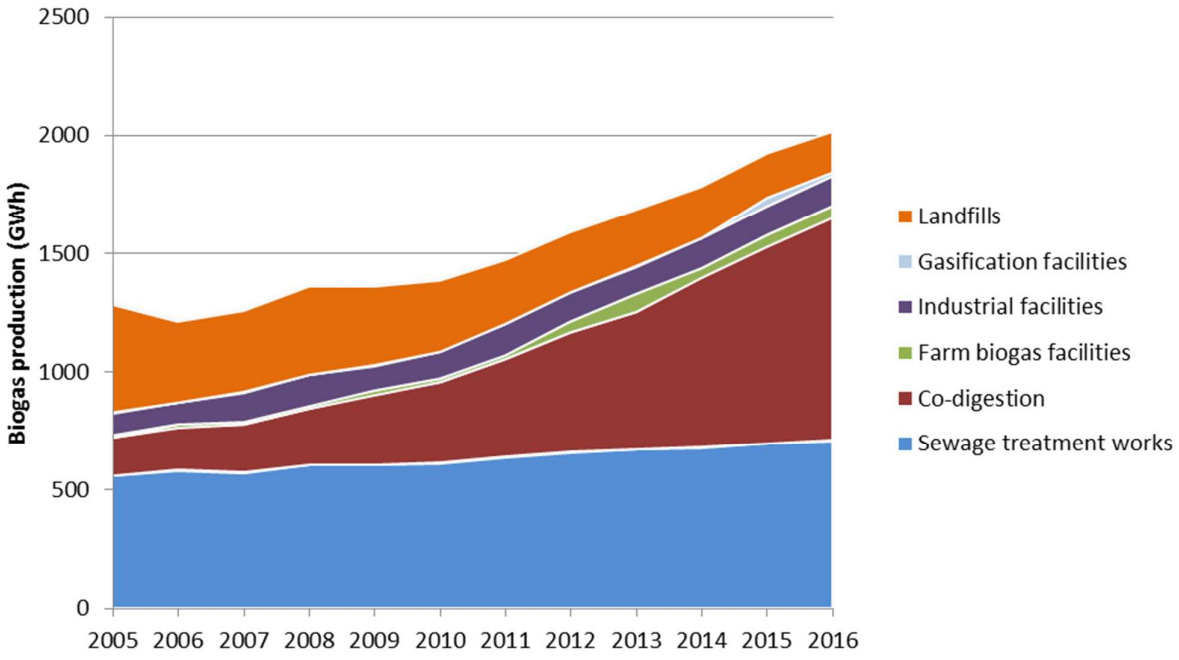

Diagram 1 Swedish biogas production per production facility category

In 2005, sewage treatment facilities accounted for 43 % of the total production of 1.3 TWh and landfills also had a significant share. Eleven years later, the total production was 2 TWh; co-digestion facilities accounted for almost 50 % of the total production and taken together, sewage treatment and co-digestion represented over 80 % of the production. 64 % or 1.3

TWh biogas was upgraded to vehicle fuel, 20% was used for local heat production, 3% for electric power generation and 9 % was flared (i.e. burnt for no use at all). As a comparison, the Swedish use of fossil natural gas was 13.1 TWh, out of which 52 % was industrial use and 32 % for heat and power generation.

Most Swedish biogas plants are located in the densely populated and agriculture intensive south. Half of the production is concentrated to regions surrounding Stockholm, Gothenburg and Malmö, which are the country's three largest cities. The biogas in the south-west has benefitted from the natural gas transmission grid that runs from Denmark, along the west coast up to the petro-chemistry industry cluster in Stenungsund, just north of Gothenburg. Injection of biogas into the grid simplifies distribution, and the availability of natural gas makes it relatively easy to blend in a higher percentage of natural gas when the demand is higher than the supply of biogas. Our interview respondents from gas grid owners argued that this is the most favorable method to increase the use of biogas long-term. The comparison is made with gasoline and diesel, which on many markets today are mixed with ethanol or biodiesel.

The natural gas transmission grid does not cover other parts of the country and therefore, cities in the central and eastern parts of Sweden have developed alternative solutions to enable distribution. The capital of Stockholm, for example, has used pressure bottle containers to transport biogas from neighboring regions and import of natural gas to compensate for shortages in biogas supply (Lönnqvist, Sanches-Pereira et al. 2015).

In a European comparison, the Swedish production of biogas is relatively small in absolute numbers and average in terms of production per capita. What makes Sweden a special case is its preference to use the produced biogas as a vehicle fuel. As noted above, in 2016, 64 % of the Swedish biogas was upgraded and used as a vehicle fuel. No other country comes close to this figure (EC, 2017). A number of measures have been necessary to reach this figure. Firstly, use of biogas as a vehicle fuel require investments in upgrading facilities at biogas production sites. A certain production quantity is required to justify the investments in such facilities and this is an important reason for the preference for co-digestion in fewer but larger units. Secondly, the upgraded biogas has to be made available to the vehicles. Thus investments in distribution systems and filling stations is required. Thirdly, there must be vehicles that use the biogas.

Upgraded biogas can be used for vehicles designed for natural gas. Vehicle manufacturers offer such cars, trucks and buses. In Sweden, biogas has primarily attained a strong position as an alternative for buses operating in public transport. According to Larsson & Wallmark (2016) public transport buses use about 37.5% of the upgraded biogas produced in Sweden. There are several reasons for this. Firstly, most public transport buses operate in city environments, where air quality is an important issue. Biogas has offered a less polluting alternative to diesel buses and public transport authorities have stipulated procurement requirements that have favored biogas buses. Secondly, fueling of public transport buses at centralized bus depots simplifies fuel distribution. Thirdly, whereas space for the biogas tanks is a problem in most other vehicles, these bulky tanks can easily be accommodated on city bus roofs. The percentage of public transport city buses that use biogas in Sweden is about 30%, while the percentage of biogas-fueled cars and trucks is about 1% (Magnusson & Berggren, 2018). A large portion of the biogas-fueled cars and trucks are vehicles that also are subject for public procurement, such as municipal company cars and refuse trucks.

Production of liquefied biogas (LBG) opens up possibilities for use of biogas in new applications such as long-haulage goods trucks. Liquefaction is made by cooling the gas so it condenses into liquid form. Thus the energy density becomes much higher and there is no need for bulky pressure tanks on the vehicles. Moreover, LBG production makes long range distribution of biogas viable even if there is no gas grid.

Actors

Starting in the 1990s there was an increasing public pressure to improve the air quality in several Swedish cities. The diesel-fueled public transport buses operating in the cities were an important source of urban air pollutants, and this problem justified initiatives in several cities. Municipal boards and public transport authorities in pioneering cities started to investigate, develop, implement and promote biogas solutions using organic solid wastes and wastewater as substrates for the production. The use of biogas as an alternative fuel for the city buses would not only reduce local emissions, but also help solving waste management problems and provide nearby farmers with organic fertilizers. The central actors were all local – the politicians, the energy company, the public transport authority, the local slaughterhouse and local farms. The market offer and its narrative have been framed as local circular flows and industrial symbiosis in order to qualify the biogas solutions.

The actors involved in substrate supply differ depending on the kind of substrate: municipal wastewater, municipal organic waste, organic waste from food production, crops or manure from animal farms. Often biogas production is executed by the same firm that supplies the substrate, such as municipal sewage plants, where biogas production is part of the wastewater treatment process or farms that use manure from their animals to produce biogas. In other cases, specialized biogas producers use a mixture of internally/externally supplied substrates in so called co-digestion plants.

In 2016, there were 279 biogas production facilities in Sweden. The 18 largest ones together accounted for slightly more than 50% of the total production. The size distribution is thus heavily skewed with a few relatively large units, mainly co-digestion and sewage treatment facilities, and many small ones. Diagram 2 shows the 30 largest facilities in falling order, omitting the almost 250 facilities representing the long tail of production plants.

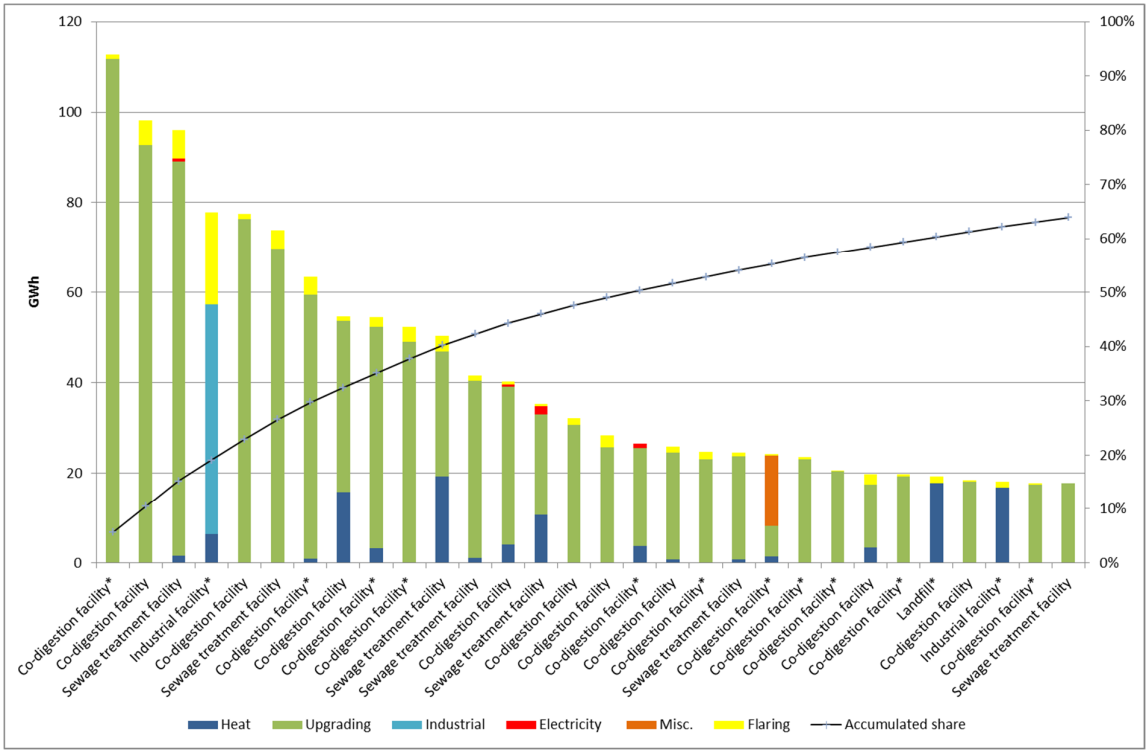

Diagram 2 Swedish biogas production and use for the 30 largest production facilities. An asterisk * indicates that the facility is privately owned.

In total, ca. 65% of the Swedish biogas was produced in publically owned, most often municipal, facilities. Sewage treatment facilities are completely in public hands while industrial and farm facilities are predominantly private. For co-digestion, the distribution was equal between 19 privately owned facilities that together produced 534 GWh, and 15 public facilities that produced 410 GWh. For the upgraded gas, the distribution is almost identical. 31% comes from privately owned facilities and 69% from public ones. This reflects the ownership structure in general and the facts that no biogas from industrial facilities and only a small share of the farm-based biogas is upgraded. Of the biogas from privately owned co-digestion facilities 87% was upgraded while the share for public ones was 89%.

In terms of distribution and recently also production, there is an active involvement from actors, whose main business is fossil gas. This includes the owner/operator of the CNG-pipe, and specialized gas distributors. For them, biogas offers a possibility to make their product "green", and to differentiate the gas product, selling different mixes of biogas and natural gas. There is currently over 170 public filling stations for vehicle fuel in the form of compressed biogas (CBG) in Sweden and 60 non-public ones, e.g. at bus depots. Three large multinational firms dominate the distribution. The energy group Eon operate as a biogas distributor in the southern parts of the country, the company Fordonsgas – a subsidiary of the gas supplier Air Liquide – operate in the western parts of the country, and the gas supplier AGA – part of the Linde group – operate in the region of Stockholm. Apart from these three large firms, there are few local distributors such as Svensk Biogas, which operate in the eastern part of the country. In 2017, Gasum – a large Finish energy company with focus on natural gas distribution – purchased several production plants, thus becoming the largest

biogas producing company in Sweden. One year later Gasum announced plans of a rapid establishment of a distribution network for liquid biogas/natural gas.

In recent years, the two major Swedish truck producers Volvo and Scania have released trucks with gas engines. These new models have sparked the enthusiasm on the biogas market since diesel today is the dominating fuel for trucks. However, our respondent at Volvo clarified that their truck primarily target the market in Southern Europe where there exist natural gas grids. By substituting these trucks from diesel to natural gas the CO_2 emissions can be reduced by 20%.

The Swedish Gas Association (Energigas Sverige) is the gas industry association in Sweden, and it is also the most prominent national advocacy coalition for biogas. This is a member-funded network, dedicated to promoting use of different types of gas, including biogas, natural gas, hydrogen, vehicle gas, and LPG. Moreover specific regional advocacy coalitions for biogas operate in different producing areas (Biogas west, Biogas East, Biogas South, Biogas Southeast, Biogas North). They gather municipal officers, producers, distributors, researchers and other stakeholders, informing about the benefits of biogas, coordinating activities to develop biogas systems, and promoting increased biogas production and use. According to the advocacy coalitions' rhetoric, biogas production can help solve virtually all sustainability problems associated with today's society. A research report from 2016, distributed by Biogas East stated that biogas produced by digestion "…can contribute to all of the 17 UN Sustainable Development Goals" (Hagman & Eklund 2016, p. 26). When qualifying biogas, it is also important to rule out competing process technologies: "As biogas solutions contribute with waste treatment, energy supply and nutrients in one process it is hard for technologies like aerobic waste water treatments, incineration or composting to compete, they only contribute with one aspect each." (Hagman & Eklund 2016, p. 26), and compete other alternative vehicle technologies: "The government has proposed a particular subsidy scheme to increase the use of electric buses. This subsidy scheme ought to include gas-fueled buses, since they also contribute to a better climate and cleaner air in the cities but also contribute to a closed circular flow" (Energigas Sverige, 2015:13-14).

Institutions

The prime justification for biogas the early 1990s when pioneering Swedish cities started building systems was local environmental problems, both related to waste management and air quality. Thus, it makes sense that municipalities took a prime responsibility to build systems, assigning the critical role as systems developers and integrators to municipal energy and waste management companies. Essential has been building local networks to protect the market from both external competitors and alternative products. Municipal officers have used formal arrangements, such as requirements and contracts that stipulate the use of biogas-fueled vehicles in procurement of public transport vehicles and vehicles used in public services. Moreover, they have created "informal contracts" with local citizens through marketing campaigns in order to change norms, visualizing biogas as an important part of a resource-efficient, recycling-oriented and sustainable society. This motivates the households to sort their organic wastes and it justifies public investments in systems for organic waste collection and sorting as well as biogas production. Thus, they put effort into constructing

and maintaining a norm in the local society of biogas as something good and worth supporting.

During the last decade, the focus of the sustainability discourse has moved towards climate change and greenhouse gas emissions. This has resulted in a broad political consensus in Sweden on the need to substitute fossil fuels with renewables. Thus the Swedish government has launched a vision to create "one of the world's first fossil-free welfare states" (Regeringskansliet, 2018). Since the energy sector already to a large extent is based on hydro, biomass and nuclear, transport is the most significant greenhouse gas emitting sector. In 2013, an investigation assigned by the government presented scenarios on how to make the Swedish transport system fossil-free by means of reduced need for transport, efficiency measures, electrification and increased use of biofuels (SOU, 2013). This has provided arguments for increased production of biogas.

Being both renewable and locally produced, biogas has enjoyed backing both among both national and local policy-makers. On the national level, several policy instruments support biogas, including waste management directives, vehicle subsidies and fuel tax exemptions, as well as investment grants for production and upgrading facilities (Larsson, Grönkvist et al. 2016). In particular, the tax exemptions for the use of upgraded biogas as a vehicle fuel has been important to make the biogas competitive with fossil fuels, which are exposed to heavy taxation. However, the tax exemption has repeatedly been disputed on an EU-level since it breaks with competition laws and the commission has only permitted tax exemptions on temporary basis, making them subject for repeated renegotiations.

The Swedish policy to provide tax exemptions for using biogas as a vehicle fuel differs from most other European countries, which instead support biogas production through production subsidies. These differences have resulted in skewed competition between Swedish and imported biogas. Whereas the Swedish biogas has only benefitted from domestic tax exemptions and investment support, the imported biogas have benefitted from production subsidies and investment support in their home countries as well as tax exemptions for vehicle fuel use in Sweden.

Activities shaping the market

Visions of growth

The governmental visions to create one of the world's first fossil-free welfare states and the make the transport system independent from fossil fuels have served to qualify plans for a rapid upscaling of national biogas production. As noted by Callon et al (2002, p. 200) "The qualification of goods is at the heart of economic competition and the organization of markets." In 2015, the Swedish Gas Association presented a national target of 15 TWh biogas production annually by 2030, an eight-fold increase compared to the production volume at that time (Energigas Sverige, 2015). Their prime agenda is to facilitate substitution of fossil liquid fuels; 80% of the targeted biogas is supposed to be used in the transport sector. High hopes are attached to LBG, which makes it possible to reach new fields of use, most notably long-haulage trucks and shipping. This depends on the establishment of an infrastructure with filling stations and to balance regional differences and limitations in production capacity, it also depends on extended imports of natural gas.

According to the Swedish Gas Association, the national annual potential for biogas production through digestion of different types of organic solid waste, wastewater and manure is 6.2 TWh. By using energy crops in accordance to EU restrictions on land use, there is a potential to increase this to 7 TWh (Energigas Sverige, 2018). Their vision of 15 TWh biogas production and use thus depends on a significantly increased use of forestry rest products, using thermal gasification technology to produce syn-gas. In 2018, Sweden has one syn-gas research and demonstration facility – Gobigas in Gothenburg – which is operated by the municipal energy company Göteborg Energi. The facility was inaugurated in 2014 and the fully operational, its production capacity is 160GWh. However, the Gobigas facility has met fierce criticism because of the heavy investments made by the municipal energy company, as well as significant operational losses because of declining biogas prices as a result of competition from imported biogas. In 2017, Göteborg Energi announced that they wanted to sell the facility. One year later, they still had not found any suitable buyer and therefore announced a stop of production.

Contrasting or complementary market shaping patterns

For biogas, networks of local actors and institutionalized local protection have made the technology less sensitive for competition. However, this reliance on local protection is associated with a number of problems. Firstly, it is difficult to isolate a local biogas market because the production and use will depend on input from specialized firms that operate beyond the local context. For instance, it is essential to have access to vehicles that are compatible with the fuel and the price of vehicle fuel is set by international price factors. Secondly, the local protection will focus on areas of application that is under public control. This can result in a bottleneck that restricts the possible market growth and it implies a dependency on stable local institutions. Changes in public support, entry of alternative technology options or shifting political governance are factors that may erode the stability of such institutional arrangements. Thirdly, the lack of competition may result in reduced incentives for efficiency improvements through specialization and run the risk of creating local sub-optimizations. The protection will never be perfect; the case of the imported biogas illustrates that even policies in support of biogas may have detrimental effects on biogas production.

Changing norms as well as building networks is essential for the expansion of the biogas market. As a product, biogas offers a renewable alternative to fossil fuels and fossil inputs in a wide range of applications, including different means of transport, energy and industrial processes. Rather than referring to local problems such as waste management and air quality, this market shaping focuses on CO_2-emissions, global warming and large-scale socio-technical transformation. Biogas offers an alternative that facilitates substitution of fossil fuels. For the actors involved, the adoption of biogas can support environmental profiling campaigns and claims of greening.

Whereas the use in city buses and municipal service vehicles have justified early expansion of biogas, liquid biogas provides additional opportunities to sell gas to a wider array of customers. To attract these customers, adaptations will be required to fit different needs and requirements. A significant proportion of the customers will not be subject for any public procurement. Hence, decisions to adopt biogas will to a larger extent be based on cost

rationality and decisions will be judged against other alternatives. In particular, it is important to overcome cost disadvantages that biogas has, both vis-à-vis established fossil fuels and other renewable alternatives. For this reason, proponents of biogas will plead for institutional reforms that favor biogas, claiming that it is "the most sustainable fuel" (a recurrent claim in our interviews). To avoid disadvantages vis-à-vis imports, they will also plead for of international harmonization.

A persistent narrative

In terms of qualifying the market offer, there are different perspectives on biogas. On the one hand, it is possible to view biogas as a discrete product. On the other hand, it is possible to view biogas as a systems solution. Proponents of biogas generally prefer the latter perspective, because the different values of biogas will be more explicit through this. As a systems solution, biogas includes several sectors and comprises a number of different activities, such as wastewater treatment, solid waste management, agriculture, forestry, energy and transport. The narrative is about the city where all citizens sort their organic wastes, which the biogas plant turns into useful fuels for the public city buses and bio-fertilizers for farmers who provide locally grown food for the citizens. This narrative is very visual and easy to sell in order to build credibility and support for biogas. It points at multiple societal and environmental benefits through circular flows and through symbiotic relationships between different local actors.

A wider substitution of fossil fuels depends on the enrolment of a number of additional actors; it entails a more pronounced element of competition, and a larger influence of private actors who will search for the most profitable alternatives. The most profitable way to use the biogas is not necessarily adjacent to the production site. Therefore, distribution will be a bigger issue, as illustrates with recent initiatives to produce LBG in order to simplify distribution. Possibilities for distribution will also influence localization of production and searching for economies of scale, production plants will most likely be larger and involve significant investments in gasification plants and the use of forestry rest products means that the returning of nutrients will be difficult. Therefore, in their argumentation in favor of biogas expansion, the biogas proponents persistently stick to the narrative of circular flows to the benefit of the surrounding society. This narrative is comprehendible when it is depicted locally and thus it is very useful as a means to attract public support.

Conclusions

The multitude of actors involved complicates market formation for biogas. Different meanings are attributed to the offer. Whereas it is possible to perceive biogas as a relatively simple product – a fuel – it is also possible to perceive it as a complex system that may help solving various societal and environmental problems. Depicting biogas as a complex system implies that the market offer will comprise a number of different qualifications. The realization of such a complex system depends on the bonding of various actors. Once established, these bonds may protect biogas from competition. However they may also hamper the possibilities for growth. Depicting biogas as a fuel means that the value of biogas will be assessed in relation to fuel prices. Qualification will thus depend on cost

competitiveness vis-a-vis other fuels. Our analysis suggests that although the contrasting perceptions of biogas cause tensions between the actors involved, the different qualifications complement each other in the market formation process. Presented as a narrative, the various environmental and societal benefits associated with the local system makes it possible for actors to argue for institutional reforms to help biogas become cost competitive. Increased competitiveness makes it attractive to establish new biogas production and it will also make it more attractive to use biogas.

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