

Article

Identifying Challenges and Drivers for Deployment of Centralized Biogas Plants in Denmark

Mark Booker Nielsen 

Institute of People and Technology (IMT), Roskilde University (RUC), Universitetsvej 1, 4000 Roskilde, Denmark; mebn@ruc.dk

Abstract: There is an increasing need to accelerate the diffusion of biogas technology, to contribute to handling grand societal challenges. It is thus concerning that around 30% of all biogas projects are abandoned. Previous studies have found that challenges for deployment of bioenergy technology are mainly economic and financial challenges, market and infrastructure challenges, regulatory and administrative challenges, local opposition, site selection challenges and ecological aspects. Very few studies have however tried to understand how these different types of challenges specifically affect individual biogas projects. Also, no previous studies have identified where these challenges occur in the different phases of a project's lifecycle (conceptualization, planning, and execution). A lack of understanding that limits the ability of both public institutions and project owners to ensure the success of biogas projects. The aim of this study is to fill this knowledge gap and provide a unique insight into the often very complex and long project lifecycle for the realization of centralized biogas projects. Results based on five comprehensive longitudinal case studies of attempts to realize centralized biogas projects, all taking place between 2008–2020 in Denmark, provide insight into how projects are specially affected by these different types of challenges, and shows that both successful and abandoned projects typically faced an array of challenges that project owners need to overcome. The study also from a bottom-up perspective provides insight into the implementation of national policies and initiatives assigned to the accelerated deployment of biogas technology in Denmark between 2008–2020 as well as critical factors at the local level driving the development.

Keywords: renewable energy; biogas production; longitudinal case study; challenges; drivers



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1. Introduction

Biogas production is a versatile technology that offer solutions for several societal sustainability challenges: first, handling increasing amounts of organic waste streams; second, producing renewable energy so as to reduce greenhouse gas (GHG) emissions and contribute to climate mitigation; third, the need to increase energy security; fourth, recycling hard degradable carbon and nutrients to agricultural land; and fifth, avoiding or reducing eutrophication of local waterbodies [1,2].

With the Russian invasion of Ukraine in February 2022, the need to accelerate biogas production is currently high on the political agenda, both in Denmark and in the EU, but before that biogas production was already expected to increase rapidly and to play a key role in the transition to a climate-neutral energy system and a circular bioeconomy [1–6].

Biogas production in Denmark has a long history going back to the oil crisis in 1973, with the first farm-scale biogas plants having been implemented by entrepreneurial farmers, folk high schools, and grassroots organizations. In the early 1980s, the focus shifted away from farm-scale biogas plants to centralized ones, and between 1984 and 1998 a total of 21 centralized biogas plants were implemented in Denmark as part of the Biogas Action Plan and follow-up program. In the late 1990s, however, the development stagnated due to liberalization of the energy market and uncertainty about the economic support scheme.

Only one centralized biogas plant (Biokraft Bornhom) was thus implemented between 1998 and 2008 [7–9].

However, between 2008 and 2012, new political goals and initiatives were launched to again accelerate biogas production in Denmark. First came the energy deal in 2008, which aimed at 30 percent of all animal manure being digested by 2025, corresponding to 12 PJ/year, and was supported by an enhanced feed-in tariff for direct use. The following year, 2009, saw the start of the Green Growth agreement, in which the aim was increased to 50 percent of all animal manure being digested, corresponding to 20 PJ/year. To support this, an investment grant scheme with a budget of 240 million DKK was set up. Further, the Planning Act was changed, making it mandatory for all municipalities to pinpoint suitable sites for biogas plants, and a national biogas “flying squad” was established to support the municipalities. Finally, in 2012, the feed-in tariff was again enhanced and support for direct use, upgrading, transport, and industrial processes equalized, and furthermore a Biogas Taskforce was established to support project owners [9,10]. In 2018, a new energy act was agreed by a majority in the Danish Folketing (parliament); it decreed that new biogas plants put into operation after 2020 would no longer be eligible for support under the current support scheme, and instead an investment grant scheme would be set up assigning funds to new project in a tender with a price ceiling. Also, it was agreed to put a general limit on public support for biogas production that would be continuously evaluated. In April 2019, an amendment was made to the 2018 agreement that meant that biogas projects that had already made irreversible investment could still be eligible for the enhanced support if this was approved by the Danish Energy Agency and if biogas plants had begun operation before the end of 2022. This article focuses on this policy circle between 2008 and 2020 [11,12].

The policy changes between 2008 and 2012 resulted in a rapid increase in biogas production from 3.9 PJ/year in 2008 to 21.3 PJ/year in 2020 in Denmark. The period between 2016 and 2021 in particular saw biogas production in Denmark accelerate very quickly, from 6.2 PJ/year to 21.3 PJ/year. At the end of 2020, 34 large-scale centralized biogas plants and 63 farm-scale biogas plants were in operation in Denmark. The centralized biogas plants that are the focus of this article in 2020 contributed with 60.4% of the total biogas production, while farm-scale biogas plants contributed with 28.9%, landfill biogas plant 0.6%, industrial biogas plants 4%, and waste water treatment plants 6.1% [13–15].

All centralized biogas plants in Denmark use a continuous stirred-tank reactor (CSTR) that is well suited for treating animal manure and organic waste [16]. Since 2008 a total of 16 centralized biogas plants have been successfully implemented in Denmark (not including Morsø Bioenergi, which started operation in 2009), and several of the centralized biogas plants implemented between 1984 and 2008 have also expanded their capacity [13].

Overall, the policy that aimed to accelerate biogas production between 2008 and 2012 must be evaluated as successful, but gaining the momentum for this accelerated deployment was not without challenges; in 2015, biogas production had only increased to 5 PJ/year and it was still unclear if the target of 20 PJ/year by 2020 would be reached. Also, during this time a minimum of 14 biogas projects aimed at implementing centralized biogas plants were abandoned or put on indefinite standby—most after considerable resources and several years of work had already been invested by project owners and on regulatory approval process by local government, and in several cases leaving local communities deeply frustrated about the process.

By analyzing the project lifecycle of five selected cases (three successful projects, one abandoned project, and one partly successful one) that all took place during the policy cycle between 2008 and 2020, this article hopes to provide new valuable insight in three ways. First, it aims to identify the challenges influencing the development of centralized biogas projects in Denmark, using a longitudinal analysis approach to link them to the three phases of a project’s lifecycle (conceptualization, planning, and execution). According to the review (see below) there is a knowledge gap in the literature on deployment of bioenergy technology and biogas technology regarding what challenges influence the

different phases of a project's lifecycle. This lack of understanding limits the ability both of public institutions to support biogas projects and of project managers to ensure their success. Second, the study also identifies drivers at both the local and the national level that have contributed to project owners successfully navigating the identified challenges, and thus provides insight into how the accelerated deployment of biogas production in Denmark gained momentum. Third, the study provides recommendations on how biogas production generally can be accelerated to support transition to a climate-neutral energy system and sustainable resource use in the future.

Research Question

The research question for this article is: What challenges and drivers influenced the different phases of the project lifecycle of biogas projects during the 2008–2020 policy cycle, and what recommendations can be drawn from these lessons learned to help accelerate biogas deployment in the future?

2. Materials and Methods

2.1. Analytical Framework

2.1.1. Literature Review of Challenges in the Deployment of Biogas Plants

This section summarizes findings from previous studies on challenges for diffusion of biogas technology, supplemented by studies on challenges for bioenergy technology and renewable energy technology (RETs) in general.

Economic and financing issues have been identified as a challenge for diffusion of bioenergy technology. Several studies have found that bioenergy was not competitive with fossil fuels in most cases in the market place [17–20]. One reason for this lack of competitiveness was found to be the complications involved in supply of feedstock for bioenergy plants [17]. Roos et al. (1999) also pointed out that bioenergy plants need to compete both with other local biomass buyers and in the consumer market with oil and natural gas [18]. Related to this, McCormick and Käberger (2007) found that competition was distorted as fossil and nuclear energy continue to receive subsidies [19].

Another reason for the lack of competitiveness found in several studies was the relatively high Investment costs required by RETs [20–22]. Finally, Rösch and Kaltschmitt (1999) pointed to the challenge of obtaining private financing, due to the technical and non-technical uncertainties of RETs, compared to fossil fuel technologies and also the early stage of development of some non-proven bioenergy technologies [17].

Administrative and institutional challenges related to regulatory approvals and permissions have also been identified as a challenge in several studies. For example, Rösch and Kaltschmitt (1999) found that there is often a lack of clarity about the requirements and standards that bioenergy plants need to meet, especially for novel bioenergy technologies using unusual feedstocks. In these instances, authorities might have difficulty evaluating the impact of new bioenergy concepts because they have no experience from previous processes [17]. Rösch and Kaltschmitt (1999) pointed to three overall types of administrative challenge that might hinder or prolong a project's lifecycle: (1) absence of a clear regulatory framework; (2) lack of a common interpretation of the existing regulatory framework due to unclear specifications and an absence of guidelines; and (3) thirdly, existing regulation frameworks for similar technology that do not fit [17]. Also, they stressed the complexity of the task of addressing or clarifying these matters, as it will often require the involvement of other administrative branches of government. Similarly, Mignon and Bergek (2016), in an international comparison of challenges inherent in the diffusion of RETs in Sweden and France, found that RETs adopters often experienced a lack of institutional transparency [21]. Adopters claimed that it was often unclear why permits were rejected and that they experienced different results from regulatory approval processes in different municipalities even though the context was very similar. Also, they found that some municipalities required very detailed and expensive applications, while other municipalities accepted applications that followed only the basic requirements [21]. The reason for this lack of institutional

transparency has been found by Mignon and Bergek (2016) to be largely due to inexperience at the municipality level [21]. Also, Seetharaman, Moorthy, Patwa, Saravanan, and Gupta (2019) pointed to a lack of coordination between different branches of government as a reason for administrative and bureaucratic challenges, resulting in prolonged deployment of RETs [23].

Market and infrastructure have also been found to pose a challenge for deployment of bioenergy technologies. It was found by one study that the lack of physical infrastructure could be a critical challenge for market introduction of bioenergy technology, especially if the necessary infrastructure had not been implemented [17]. Mignon and Bergek (2016) pointed out that a lack of grid connection was a challenge both in Sweden and in France [21].

Local perception and attitude issues have also been found to influence deployment of biogas technology in several studies. In one such study it was proposed that three factors—(1) perceived benefits, (2) perceived cost and (3) trust in operators—strongly influenced the acceptance of biogas plants, and that these three factors are directly influenced negatively or positively by other factors such as information reception, participation options, and smell perception, as well as a general level of trust in the plant operator [24].

Trust in the neutrality, competence, and fairness of local authorities has also been found to play an important role in local acceptance of biogas plants in several studies [25–27]. This is closely linked to the concepts of procedural and distributive justice. Here, procedural justice refers to the transparency and fairness of the decision-making process, which are demonstrated by providing appropriate information and participation opportunities, while distributive justice refers to the distribution of costs, benefits and risks by the involved stakeholders [25]. In a study by Upreti (2004), mistrust in local authorities was identified as a major challenge for bioenergy development. The study stressed the need to start with an open dialogue among all stakeholders to establish mutual trust and win public support [28].

General advocacy for renewable energies or lack of this, e.g., by local authorities, has also been found to be highly influential on local acceptance of biogas plants [25,29].

Proximity is also an important factor. In a survey carried by Schumacher and Schultmann (2017) only a minority of respondents accepted having a biogas plant closer than 1 km from their home, while a majority accepted a distance of 3 km [25]. In another study by Bourdin (2019), proximity theory was combined with the exit-voice model developed by Hirschman to try to explain public opposition to biogas plants [30]. A third study looked at place attachment as a factor influencing local acceptance of biogas plants but found no significant effects [31].

Site selection can also be seen as a separate challenge for deployment of biogas plants. When selecting a suitable site for a biogas plant, many different factors need to be considered. In a recent study by Feiz, Metson, Wretman, and Ammenberg (2022), 12 factors were identified as influencing site selection for biogas plants in Sweden. The factors were categorized into four groups: (1) supply and demand (feedstock supply, biogas demand, digestate demand, CO₂ demand); (2) synergies and infrastructure (available infrastructure, adjacent industries); (3) land use and zoning (nearby housing, zoning, historic preservation sites); and (4) socio-political (political strategies and goals, organizational capability, local social acceptance). The authors suggested that these could help regional and national policymakers in expanding biogas solutions [32]. Another recent study explored constraints regarding suitable site selection for biogas plants also in Sweden using a GIS-analysis approach. It found lack of road infrastructure with high bearing capacity to be the biggest constraint for site selection, followed by zoning requirements, and proximity of buildings in the three different regions [33].

Finally, environmental sustainability aspects might also be a challenge for deployment of biogas plants. Another study by Turkenburg (2000) found that arable land available for energy crops might become a limitation for bioenergy production in various regions, and that biomass for energy use should not compete with food production [34]. A study by Thrän D et al. (2020) on the governance of sustainability in the German biogas sector

showed that the increased use of energy crops especially between 2004 and 2012 created a risk to sustainability, by amplifying land prices and rents [35]. Another study of the German biogas sector by Britz W (2013) found that the use of non-waste feedstock could impact global agricultural markets and quantities and lead to land-use change outside Germany [36].

2.1.2. Analytical Framework for This Article

In this study the following framework will be used to identify the various challenges during the project lifecycle of the five cases.

- Economy challenges (A);
- Site selection challenges (B);
- Market and infrastructure (C);
- Administrative and regulatory challenges (D);
- Local perception and attitude (E);
- Environmental sustainability aspects (F);
- Financial challenges (G).

Combining the analytical framework with a longitudinal analysis will give novel insight into where these challenges occur during the different phases of a project's lifecycle (conceptualization, planning, and execution).

2.2. Methodology

2.2.1. Multiple Case Studies

For this study, the project lifecycles for five cases were selected: (1) Sønderjysk Bio-gas Bevtøft, (2) Nature Energy Midtfyn (Faaborg-Midtfyn Biogas) (3) Bio-Center Gudenå, (4) Bioenergi Vest and (5) Nature Energy Nordfyn (Nordfyn Biogas). All five project lifecycles were within the policy cycle between 2008 and 2020, a period where biogas production in Denmark was greatly accelerated. This happened after a duration of around ten years, between 1998 and 2008, when deployment of centralized biogas plants stagnated in Denmark and almost no new noncentralized biogas plants were established, except for Biokraft Bornhorn, which began operation in 2007, and Morsø Bioenergi, which started operation in 2009. Between 2008 and 2018 a minimum of 32 centralized biogas projects were initiated across the country; of these, 17 were successfully deployed by 2021 (not including Morsø Bioenergi) while the rest were abandoned, put on standby, or are still pursuing implementation. The five cases were selected for three main reasons [37]. Firstly, they were all initiated around the same time in 2008 and 2009, and thus took place under the same policy context, hereby providing insight into the rapid diffusion of biogas plants between 2008–2020 in Denmark from a bottom-up perspective. Secondly, the cases collectively represent both the share of projects that were successful and the projects that were abandoned or put on standby. Thirdly, the five cases are overall quite common examples of the project lifecycle for centralized biogas projects initiated between 2008 and 2020 [37].

2.2.2. Longitudinal Study

To identify the challenges and drivers in the project lifecycle (conceptualization, planning, and execution phases), a longitudinal analysis was applied [38,39]. Here, events identified through the document analysis and semi-structured interviews were listed chronologically in an event database. An event can here be defined as an instance where a change takes place in the project idea, involved stakeholders, transactions, relationships, context, or outcome. In the event database, the time of an identified event (month/year) was registered, together with a short description a listing of the stakeholders involved, and the data sources [38,39]. Building of the event databases was a very time-consuming and iterative process that continued until a coherent understanding of the project lifecycle for the five projects had been obtained. Following completion of the event databases, narratives for the project lifecycle of the five cases could be constructed and the analytical framework used to identify challenges and drivers.

2.2.3. Document Collection and Analysis

For this study, an extensive and very time-consuming document-collection process was carried out for the five cases [37]. Documents were primarily obtained through archives, websites, newspapers, social media, and participants in the process. In total, 199 documents were collected for the Sønderjysk Biogas Bevtøft case, 510 documents for the Nature Energy Midtfyn Biogas case, 1138 documents for the Bio-Center Gudenå case, 237 documents for the Bioenergi Vest case, and 405 documents for the Nature Energy Nordfyn case. After the documents were collected, they were uploaded into Mendeley. Following this the documents were used for identification of events during the project lifecycle, together with the data from the semi-structured interviews.

2.2.4. Semi-Structured Interviews

In-depth semi-structured interviews were also conducted as part of the study, with selected informants that had been involved in the five cases [40]. A total of nine interviews were conducted with municipal planners, project owners and consultants. Each interview typically lasted between 1–1.5 h. In the first part of the interview the participants on their recollection of the project lifecycle and the challenges they faced along the way. This happened with offset in the preliminary event databases, which had been sent beforehand. This way, the interviews were used not only to verify the event databases but also to provide extra insight into events, identify new events, and correct any misunderstandings. In the second part of the interview the participants were asked to talk more generally about, e.g., the challenges, drivers, best practices, and critical success factors linked with deployment of the biogas plants. After the interviews had been finalized, summaries were made using both the notes taken during the interviews and audio recordings; these summaries were used to further develop the event database.

3. Results

3.1. Case Studies

3.1.1. Case 1: Sønderjysk Biogas Bevtøft

Phase 1—Conceptualization 2008–2011

At the beginning of 2008, a collaboration agreement was signed between farming organization Sønderjysk Landbosforening and technology provider Nordic Bioenergy about implementing between one and four biogas plants in the Southern Region of Jutland. In May 2008, the project consortium invited the mayor of Haderslev Municipality to a meeting, where he gave his preliminary support to the idea of implementing a biogas plant in the municipality. In September 2008, the first meeting was held between the Haderslev Municipality administration and the project consortium about how to move the project forward. It was agreed that the project consortium should approach the local district heating companies in the towns of Vojens and Tøftlund, and parallel to this the administration in Haderslev Municipality would approach the regional office of the Danish Environmental Agency (Miljøcenter Odense) for guidance about the process for gaining the needed regulatory approvals. Also, the project consortium would initiate the work needed for environmental impact assessment (EIA) screening including finding a suitable site for the biogas plant. By December 2008, five sites had been pinpointed and one of the locations, near the town of Nustrup, looked very promising. Sites close to the national gas grid were also considered as the district heating companies in Vojens and Tøftlund were so far not that interested in the direct use of biogas. The project consortium thus started looking for other options. At this point in time there was still no support for upgrading biogas and injecting it into the national gas grid in Denmark; therefore, in January 2009, the project consortium, together with energy company DONG (now Ørsted), approached the Committee for Energy Policy in the Danish Parliament (Det Energipolitiske Udvalg), advocating that upgraded biogas should receive a level of governmental support (feed-in tariff) that was equal to that given to direct use of biogas for production of CHP (combined heat and power). In March 2009, another meeting was held between the project consortium

and Haderslev Municipality, to discuss the project development. The regional office of the Danish Environmental Agency (Miljøcenter Odense) was also invited to the meeting. Sønderjysk Landboforening informed those present that it had not been able to reach an agreement with the district heating companies in Vojens and Tofthund about the price for the biogas; it had therefore contacted DONG about a potential collaboration on upgrading the biogas. The five suitable sites that had been pinpointed were also discussed, and the regional office of the Danish Environmental Agency (Miljøcenter Odense) stressed that biogas plants were first and foremost to be situated in industrial zones; strong arguments were needed if they were to be situated in rural zones. It was therefore agreed that a new site analysis should be elaborated. In June 2009, the company Sønderjysk Biogas A.M.B.A. was established by Sønderjysk Landbosforening and local farmers—Nordic Bioenergy had left the project consortium as it was very close to bankruptcy. In December 2009, the consulting company NIRAS was hired to elaborate a report analyzing different business scenarios for implementation of a biogas plant. In October 2009, the first version of the updated site analysis was ready—the only possible location for implementing the biogas plant was in an industrial zone at Marstrup near a local incineration plant, but the project consortium did not find this location very attractive because the proximity to feedstock and to the national natural gas grid was not optimal. At the beginning of 2010, NIRAS finalized its analysis of the different business scenarios and contact was made between the project developers in Sønderjysk Landbosforening and the German energy company E.ON, which was interested in entering the Danish biogas market, but at this point there was no official collaboration agreements between them. At the start of May 2010, Sønderjysk Landbosforening sent the final version of its site analysis to Haderslev Municipality, having narrowed it down to two sites—the first in the industrial zone in Marstrup and the second, the choice preferred by Sønderjysk Landbosforening, in a rural zone near the town of Bevtøft. During May 2010, the newly established national biogas flying squad (Biogas Rejsehold) gave its advisory input on the potential spatial planning conflicts, together with Haderslev Municipality, and at the start of June the location analysis was sent to the regional office of the Danish Environmental Agency (Miljøcenter Odense) by Haderslev Municipality. After several months of waiting, the regional office of the Danish Environmental Agency finally declared in October 2010 that it no longer opposed locating the biogas plant in a rural zone. A new matter, however, had arisen—the location near Bevtøft was situated in a nitrate-vulnerable area—and the Danish Environmental Agency (Miljøcenter Odense) was unsure whether the biogas plant could be implemented there. It informed Haderslev Municipality that it would investigate the issue further. Despite all this, the project slowly gained momentum and in the beginning of 2011 collaboration with E.ON started to be strengthened with joint elaboration on feasibility studies of different potential project concepts. All focus was now on the location at Bevtøft and upgrading the biogas. In September 2011, E.ON declared that it was ready to pay 50 percent of the planning and development costs and to own 49 percent of the shares in the biogas plant if it was established. On 8 November 2011, the around 90 farmers who were members of Sønderjysk Biogas A.M.B.A. voted yes to this proposal to include E.ON in the project consortium, and the same day the company Sønderjysk Biogas produktion I/S was established. Things were now really moving forward.

Phase 2—Planning 2011–2015

At the end of March 2012, the project consortium applied to the administration in Haderslev Municipality for an EIA screening. Earlier in March 2012, a majority in the Danish Parliament had agreed on a new energy act—including equalization of the subsidies (feed-in tariffs) for direct use of biogas for CHP and for upgrading. After a couple of months, in June 2012, the administration informed that it had found that an EIA was needed for the project. Soon after, the administration announced a call for ideas and suggestions from the public as the first step in scoping of the EIA. The first public meeting about the project was scheduled for 30 August 2012 in Bested community hall near Bevtøft. Around 50 interested local citizens turned up for the meeting and brought with them a wide range

of questions. Before the meeting, the project consortium had held a separate meeting with those neighbors that lived closest to the selected site. At the meeting in Bested, the planners from the administration in Haderslev Municipality wore green shirts while the members of the project consortium wore grey shirts to clearly signal that they belonged to two different delegations—with different roles in the process. Also, as part of the meeting, a bus tour was arranged to Ribe Biogas—so the citizens that wanted to could see a centralized co-digestion biogas plant in operation. Around the same time, in September 2012, a majority in the Danish Parliament agreed on an amendment to the new energy act from March, putting a limit on the input of energy crops to biogas plants in Denmark to increase sustainability. The agreement meant that a maximum of 18 percent of the total input (wet weight) could be energy crops between 2015 and 2018 and a maximum of 12 percent from 2018 to 2020. This was a setback as maize silage as feedstock played an essential role in the project's economic viability—the project consortium thus started exploring the availability and use of alternative feedstock. Quickly, its focus turned to cereal straw and deep litter, and it began testing equipment for pretreating this feedstock; that work continued into 2013. Around the same time, in August 2012, the project consortium submitted an application to the Danish Nature Agency that was administering the investment grant scheme setup as part of the Green Growth agreement in 2009, providing investment grants equal to 30 percent of the total investment cost for selected projects. In December 2012, the Nature Agency informed the project consortium that its application had been declined, probably due to the amount of maize silage in the project concept. It was another setback for the project. The project consortium was, however, not deterred, and continued work to establish the biogas plant. In February 2013, responsibility for the EIA process was transferred from Haderslev Municipality to the Danish Nature Agency; the municipality had been informed by Energinet.dk that it was not the correct authority for handling the approval process as the project included an extension of the national gas grid. The Danish Nature Agency quickly took over the process of preparing the EIA report together with the project consortium and in August 2013 the final version was ready. The process for obtaining regulatory approval for the new local district plan and an amendment to the municipal plan were initiated in the same month. Around the same time, in mid 2013, the issue concerning siting the biogas plant in a nitrate-vulnerable area was finally clarified by the legal department of the Danish Nature Agency—it found that a biogas plant could be sited there after a specific assessment. Also, in mid 2013, the prequalification of building contracts for implementation of the Sønderjysk biogas Bevtoft plant was initiated as part of the procurement process. From 27 September to 25 November 2013 there was a public hearing process for the proposed new local district plan and amendment to the municipal plan. During this period the Danish Nature Agency and Haderslev Municipality received only three objections to the plans from the public. Following the hearing, both the new local district plan and the amendment to the municipal plan were approved by the mayor, in January 2013, and the City Council was informed. The last challenge for the project was to ensure adequate financing for the 51 percent of the biogas plant that would be owned by local farmers. Thus, in mid 2014, the project consortium was in luck as the investment grant initially awarded to Bio-Center Gudenå was transferred to Sønderjysk Biogas Bevtoft; the reason was that Bio-Center Gudenå would not be able to meet the 2016 operation deadline that was a condition of receiving the funding. By the end of 2014, the last contract for supply of manure and cereal straw to the biogas plant was signed and in March 2015, the project consortium signed the turnkey contract with the building companies FARMATIC Anlagenbau GmbH and Jacobsen og Blindkilde A/S.

Phase 3—Execution 2015–2016

In April 2015, construction of Sønderjysk Biogas Bevtoft began. The biogas plant was designed to have a capacity of 600,000 tons/annually of biomass and an expected biomethane production of 21 million Nm³. After around 1.5 years of construction and upstart the official inauguration took place in September 2016 [41]. Here, several hundred

guests attended, and the Danish Ministry for Energy, Supply and Climate Lars Chr. Lilholt was the guest of honor.

3.1.2. Case 2: Nature Energy Midtfyn (Faaborg-Midtfyn Biogas)

Phase 1—Conceptualization 2008–2010

In May 2008, the City Council in Faaborg-Midtfyn Municipality decided to assemble a temporary climate committee whose primary task would be developing a white book for local climate mitigation, including suggestions for a vision, aims and actions. In January 2009, a public meeting was held in the town of Ringe as part of the work of the climate committee; here, the idea of implementing a biogas plant was discussed as one of the key actions that should be part of the vision for local climate mitigation. Local farming association Centrovic shortly hereafter declared that it supported the idea of implementing a biogas plant; communal waste-handling company FAKS also backed the idea. In May 2009, the work on the white book was finalized; establishing a local biogas plant was top of the list of suggested actions. A suitable site was pinpointed by the climate committee—at a former landfill area near Sandholt-Lyndelse that was partly owned by FAKS. The City Council of Faaborg-Midtfyn Municipality approved the white book at a meeting on 12 May 2009 and decided that all future work on implementing the actions and on local climate mitigation would continue under the Technical and Environmental Council. Following finalization of the climate mitigation white book, Centrovic took full ownership of the project idea of implementing a biogas plant in the municipality. In August 2009, a request was submitted to the City Council for a small grant of 50,000 DKK for elaboration of a pre-feasibility study for implementing a biogas plant at Sandholt-Lyndelse. The biogas was to be supplied to the district heating company FFV in the city of Faaborg and used for CHP production. The request was approved by the City Council and supported with funds set aside for implementation of actions suggested in the local climate mitigation strategy. In November 2009, Centrovic arranged an information meeting for local farmers to clarify whether they were interested in being part of the project. At the meeting, 45 farmers declared that they were interested, and each invested a small sum of 5000 DKK into the company Faaborg-Midtfyn Biogas A.m.b.a, which was created shortly after, so that work on establishing the biogas plant could continue. At the beginning of 2010, the prequalification part of the procurement process for implementing a biogas plant at Sandholt-Lyndelse was initiated and in October 2010 it was announced that three companies had been selected to enter negotiations. Shortly hereafter, the regulatory approval process was initiated.

Phase 2—Planning 2010–2015

In November 2010, the City Council in Faaborg-Midtfyn Municipality approved initiation of the regulatory approval process, including an amendment to the municipal plan and a new local district plan for the selected location at Sandholt-Lyndelse. From 16 November 2010 to 10 January 2011, the public hearing for the proposed plans took place. During this period four comments were received—from the Danish Road Directorate, FFV Varme, Odense Museum and the Danish Nature Agency—and there were two objections from neighbors living close to the coming biogas plant. In FFV's comment, dated 21 February 2011—more than a month after the end of the official hearing period—it declared that it was not interested in any binding contract with Faaborg-Midtfyn Biogas on supply of biogas as this would mean an investment of 40 million DKK in gas storage capacity to be able to use the biogas—also, it was very happy with its current use of natural gas as it found that this solution was the most attractive for its consumers. This was a setback for Faaborg-Midtfyn Biogas, which thus started investigating other options for use of the biogas, while at the same time continuing with the plan of supplying biogas to FFV Varme. One alternative option for use of the biogas that emerged was upgrading the biogas; the company contacted Naturgas Fyn (Natural gas Funen) in February 2011 about a potential collaboration. Naturgas Fyn declared that it would be interested if the feed-in tariff for upgrading biogas was made equal to the feed-in tariff for direct use—but

the regulation had not yet been changed at this point. In March 2011, Faaborg-Midtfyn Biogas submitted a request for a municipal guarantee for a loan from KommuneKredit of 113 million DKK to finance the original project idea of supplying biogas to FFV Varde. The request was approved by the City Council and in May 2011 the City Council also approved the amendment to the municipal plan and the new local district plan. The following year the project was however put on standby after its application for an investment grant from the Danish Nature Agency was declined. Also, a new problem had arisen—the farmer who owned the land where the biogas plant was to be located was not willing to sell. According to the legal consultants for Faaborg-Midtfyn Municipality, expropriation was not possible as Faaborg-Midtfyn Biogas was a privately owned company. At the beginning of 2012, attempts to reach an agreement with the landowner were abandoned and work to find a new location was initiated. In mid 2012, the project was reactivated, and district heating company Fjernvarme Fyn joined the project consortium and took over the project coordination from Centrovic. Fjernvarme Fyn was and is the largest district heating company on Funen, supplying heating for the city of Odense, the third biggest city in Denmark. The project concept now was that Faaborg-Midtfyn Biogas would supply biogas to Fjernvarme Fyn to be used for CHP production. In September 2012, Faaborg-Midtfyn Biogas, together with its consulting firm WH-PlanAction, submitted another application for an investment grant to the Danish Nature Agency. In December 2012, Faaborg-Midtfyn Biogas was notified that it was one of the eight centralized co-digestion biogas projects that had been approved for support. This meant that the project would receive 39 million DKK on the condition that the biogas plant was in full operation by August 2015. Things were now really moving forward again, but a new suitable location still needed to be found. In December 2012, a new municipal plan was approved by the City Council of Faaborg-Midtfyn Municipality. Another part of the 2009 Green Growth agreement was that it had become mandatory for all Danish municipalities to identify suitable sites for deployment of biogas plants in new municipal plans. Faaborg-Midtfyn had received support from the national biogas flying squad (Biogas Rejseholdet) and had identified a central area near the towns of Sallinge, Lyndelse and Højrup as a prospective home for a new biogas plant within the municipality. In February 2013, a location at Sallinglunde/Sallinge Ås was selected, and a request to initiate the regulatory approval process was submitted to Faaborg-Midtfyn Municipality, but for reasons unknown the location was quickly abandoned. Even though a suitable site had not yet been found, the prequalification part of the procurement process was initiated in March 2013. The procurement information also included the option to implement another centralized biogas plant—Nordfyn Biogas—a biogas project that had been running parallel to the one in Faaborg-Midtfyn Municipality since 2008 and also had Fjernvarme Fyn engaged as the project coordinator. In June 2013, a new suitable location was finally found at Heden and a request to initiate the regulatory approval process was again submitted. The main regulatory approvals needed at this point were, as before, the new local district plan and the amendment to the municipal, including an EIA, but this time also an approval of the project proposal under the Danish heating regulation, as the biogas was to be used for CHP and the heating supplied to new district heating networks that were planned to be established in Nr. Lyndelse and Nr. Søby. Naturgas Fyn objected to this project proposal as natural gas was currently used for individual heating in Nr. Lyndelse and Nr. Søby—the planned district heating networks would thus mean a decline in demand for natural gas and their overall business. They thus argued that the project proposal was not favorable if looked upon in socioeconomic terms using the method developed by the Danish Energy Agency to prioritize societal resources in the heating sector. In October 2013, the public hearing part of the regulatory approval process for the new district plan and amendment to the municipal plan took place—again, Natural Gas Funen complained about the project both to Faaborg-Midtfyn Municipality and to the Danish Energy Complaints Board. Despite these complaints, the district heating project was approved by the City Council in Faaborg-Midtfyn Municipality after consulting with its legal adviser and getting an impartial assessment from the company Rambøll. At the

end of 2013, a radical change happened in the project's development. Naturgas Fyn, which by now had changed its name to NGF Nature Energy, and which had been objecting to the project proposal all this time, now took over Fjernvarme Fyn's share and became project coordinator. The main reason for this, according to Fjernvarme Fyn, was that using biogas to supply heating to the greater metropolitan district heating network near Odense would not be in accordance with the requirements for receiving the Green Growth investment grant, as that was focused on rural development and helping farmers. The reason given by NGF Nature Energy was that too few inhabitants Nr. Lyndelse and Nr. Søby had signed up to be part of the district heating project. As a first step by NGF Nature Energy, at the beginning of 2014, the project concept was changed so that the biogas would be upgraded and injected into the natural gas grid instead of being used for production of CHP. Things were now really moving forward. In March 2014, it was announced that construction company Xergi had been selected to build NGF Nature Energy Midtfyn, as the project was now called. During mid 2014, work was initiated to update the regulatory approval to cover the new concept of including an upgrading facility and a pretreatment facility for handling food waste, which would be operated by N.C. Miljø. The company N.C. Miljø had until then been located in the town of Ørbæk in Nyborg Municipality, where the food waste had been planned for use as feedstock in another biogas project, Ørbæk Biogas, also coordinated by Nature Energy. That project had encountered many objections from the nearby community and mistakes had been made during the EIA process, resulting in delays. When N.C. Miljø then moved, the Ørbæk biogas project was first put on standby and later abandoned.

Phase 3—Execution 2015–2016

In July 2014, construction of Nature Energy Midtfyn was initiated by Xergi. The biogas plant was designed to have a capacity of 360,000 tons/annually and expected biomethane production of 11 million Nm³. In June 2015, the construction process was midway through and at the end of 2016 the construction was finalized. After several months of upstarting the biogas production, the official inauguration was held in April 2016.

3.1.3. Case 3: Bio-Center Gudenå

Phase 1—Conceptualization 2009–2013

In June 2009, an initial meeting was held between the project leader from Bio-Center Gudenå and the administrative planning staff from Viborg Municipality. The project leader from Bio-Center Gudenå was the chairman for the district heating company in Rødkjærsbro that had initiated the project, together with a group of local farmers. At the meeting, Bio-Center Gudenå informed the municipality about the project idea and in return the administrative staff from Viborg Municipality informed the project leader about the regulatory approval process. In the following month the project leader for Bio-Center Gudenå arranged several townhall meetings with local farmers—and slowly gained their support. Also, the consulting firm NIRAS was hired to elaborate a feasibility report. In October 2009, a second meeting was held with Viborg Municipality. The project had now gained support from around 50 farmers wanting to supply manure to the proposed biogas plant. At the meeting, the project leader informed that they had pinpointed an optimal site west of the town of Bjerringbro and that they expected that biogas would be used for production of CHP and the heating used in the district heating networks of the towns Bjerringbro, Rødkjærsbro and Ans, but that they would also investigate the possibilities for upgrading the biogas. In January 2010, the feasibility report prepared by NIRAS was finalized. In the report, two main scenarios were assessed—one where the biogas was used directly for CHP and the other where it was upgraded. The assessment showed that the scenario where the biogas was used directly for CHP was the only one that was viable at the time. Also, several optimal locations were pinpointed based on a transport analysis—one of them the location west of Bjerringbro. Two months later, in March 2010, Viborg Municipality finalized a preliminary conflict screening of the west of Bjerringbro and a collaboration

agreement was made between the municipality and the new established biogas flying squad for assistance during the regulatory approval phase. Things were slowly moving forward. In May 2010, another meeting was held between Viborg Municipality and the project leader from Bio-Center Gudenå. Here, the project leader stressed the importance of finding the “right location” in the first go—because of the resources needed for the regulatory approval process. Also, he requested a time schedule from the municipality. The municipality staff informed him that they first needed to elaborate an overall analysis of suitable locations for biogas plants within the municipality in collaboration with the national biogas flying squad—and thus could not promise the “right location”; also, several locations would need to be considered. At the end of the meeting, however, it was agreed that Viborg Municipality would assess the locations pointed out in the feasibility report from NIRAS. In November 2010, a new meeting was held and staff from Viborg Municipality informed that they were still working on the Geographic Information System (GIS) analysis aimed at finding the optimal location for biogas plants within the municipality—but it underlined that the results were only preliminary. The project leader from Bio-Center Gudenå informed that they were in contact with Thorsø Biogas, which was working on an expansion, and that they were considering being part of that process instead of establishing this new biogas plant, as it would probably be much faster and easier. Later the same month in 2010, the Bio-Center Gudenå project was put on standby. Already in April 2011 the Bio-Center Gudenå project was relaunched as it had not been possible to reach an agreement with Thorsø Biogas about the organization structure. The following month, in May 2011, the first meeting after the reactivation was held between the project leader of Bio-Center Gudenå, the project’s newly assigned project adviser from the company PlanEnergi, and the administrative staff from Viborg Municipality. Here, the project leader from Bio-Center Gudenå informed the municipality that they had decided to arrange two public information meetings for local citizens. The administrative staff from the municipality informed that they would not take part in these public information meetings arranged by Bio-Center Gudenå as they first would need an application for an EIA screening, after which they would initiate a call for ideas and proposals if an EIA was needed and initiate the public hearings part of the regulatory approval process for a new local district plan and amendment to the municipal plan. Later the same month in 2011, the two public meetings were held at Bjerring Forsamlingshus and Naturvidenskabernes Hus (community houses) in Bjerringbro. In Bjerring, 35 local citizens took part and in Bjerringbro 80, and in both places people were quite critical about the project idea; they were especially concerned about potential odor from the proposed biogas plant. The mood, however, became a little better after the project team from Bio-Center Gudenå expressed that they understood their concerns. As a result of the meetings, a monitoring group was established with people interested in the project. At the first meeting of the monitoring group in July 2011, local citizens expressed that they felt that the location west of Bjerringbro (Location 1a) was too close to the town and preferred an alternative location farther west. Following the meeting, the project leader from Bio-Center Gudenå approached the municipality and inquired about two locations farther west of the city location (Locations 1b and 1c) and later, in October 2011, finalized the preliminary spatial conflict assessment of the two locations. During the same time, in July 2011, an application was submitted to the Danish Nature Agency and philanthropical organization Realdania requesting to be a case in the project called Biogas Plant and Landscape—aiming at better architectural integration of biogas plants into the landscape. Later, in December 2011, the application was accepted. In March 2012, the Bio-Center Gudenå project submitted a request for EIA screening to Viborg Municipality—the project consortium had during this period decided to maintain the location west of Bjerringbro (Location 1a) as was economically optimal from a project perspective. After several months of waiting, Viborg Municipality finalized an internal hearing for implementation of the biogas plant at the location west of Bjerringbro (Location 1a) as part of the EIA screening— and had a long list of questions it wanted to be clarified. Until around 2012 it had been normal procedure in Denmark that typically only an EIA

screening was needed for biogas plants, but from 2012 the Danish Complaints Board for Planning started interpreting the EU EIA directive in a new way such that an EIA was now typically obligatory for centralized biogas plants with a capacity over 100 tons/day. The Bio-Center Gudenå project consortium thus informed Viborg Municipality in July 2012 that it expected that an EIA report would be needed to fast-track the EIA screening process. In August 2012, a new request for an EIA screening was submitted to the municipality as the project consortium had decided to double the amount of biomass feedstock annually, which meant a new internal screening by the municipality. Also, at that time an application for an investment grant was submitted to the Danish Nature Agency. A month later, at the end of September 2012, a radical change happened in the project's development—also sometimes referred to as the Gudenå coup. During 2011 and 2012, public concerns about the project had been growing among the local community in Bjerringbro, and on 28 September 2012, when districting heating company Bjerringbro Heating Plant held its annual general assembly, around 320 local citizens turned up that were also consumers and shareholders in Bjerringbro Heating Plant, and thus were entitled to vote and make proposals at the general assembly. Here, a proposal was put forward that Bjerringbro Heating Plant could only continue the collaboration with Bio-Center Gudenå if the biogas plant was located a minimum 5 km from Bjerringbro. After heated discussion during the general assembly, the proposal was passed with 237 for and 83 against. The project had been under development for more than three years—and would now need to find a new location. This development was a very big setback for the Bio-Center Gudenå project consortium. The directive board of Bio-Center Gudenå, however, decided a few days afterwards to continue the project development and pursue a new location at Middelhede (Location 2). In December 2012, the Bio-Center Gudenå project consortium received the answer on the application for an investment grant it had submitted back at the start of September 2012. This was another big change in the project's development—the project had been approved for an investment grant of 48.8 million DKK, if the biogas plant was in operation by August 2015. After several months of preparation and meetings with Viborg Municipality to ensure a fast regulatory approval process, in May 2013, the Bio-Center Gudenå project submitted a new application for initiation of the regulatory approval process for the new location at Middelhede/Kjellerupvej (Location 2). The new location meant that the project concept had changed a little so the biogas would now be used both for CHP production by the district heating companies in Bjerringbro and Rødkjærsbro and for industrial processes by the dairy company Arla Foods in Rødkjærsbro. At the same time, Bio-Center Gudenå submitted a request to Viborg Municipality for a municipal guarantee for a loan from Kommunekredit.

Phase 2—Planning 2013–2014

This time, the EIA screening went very fast and in June 2013 the City Council in Viborg Municipality approved initiation of the regulatory approval process. The first step in this process was a call for ideas and proposals over 4 weeks as part of the EIA process. Again, the project was met with heavy objections from the public; Viborg Municipality in total received 78 ideas and proposals, most of them concerns about potential heavy transport, noise, odor, and appealing for an alternative location. Due to the many objections, the City Council in Viborg Municipality decided to stop the regulatory approval process for the location at Middelhede/Kjellerupvej (Location 2) even though the administrative staff had recommended continuation. This was yet again a big setback for the Bio-Center Gudenå project; it would once again need to find a new location for the biogas plant. Also, time was ticking if the project was to be in operation by August 2015 and receive the investment grant. By now the Bio-Center Gudenå project consortium had lost patience with Viborg Municipality and decided in December 2013 to approach Silkeborg Municipality about a location near the town of Thorning (Location 3)—not that far from the location at Middelhede/Kjellerupvej (Location 2). The project concept, however, stayed the same, with supply of biogas to the district heating companies in Bjerringbro and Rødkjærsbro and for

industrial processes at Arla Food. At the end of January 2014, for the third time a request for initiation of the regulatory approval process was submitted to Silkeborg Municipality, together with a request for a municipal guarantee for loan from Kommunekredit. Silkeborg Municipality handled the request quickly; already by the start of February 2014 the City Council had approved initiation of the regulatory approval process for the location at Thorning (Location 3), again with a call for ideas and proposals as part of the EIA process. Again, the Bio-Center Gudenå project was met with objections from the public, and at a public hearing on March 1 at Knudstrup Kro in Thorning, around 250 local citizens participated. Here, a central question became why Silkeborg Municipality should provide a municipal guarantee for a loan from KommuneKredit, when the biogas was to be used in Viborg Municipality, and what was the legality of this as Danish municipalities are only allowed to make investments in the interests of their own inhabitants. At the end of March 2014, the administration decided to contact the Danish State Administration to get an answer on this legal matter; the Planning, Climate and Environmental Council in Silkeborg Municipality decided to put the regulatory approval process on standby until it was resolved. The Bio-Center Gudenå consortium, after nearly five years of attempting to realize its project idea, abandoned the project as it realized that it would not be able to meet the deadline for receiving the investment grant. Instead, the investment grant was transferred to Sønderjysk Biogas Bevtøft during 2014, as already mentioned. In October 2014, the Economic and Business Council of Silkeborg Municipality decided to stop the regulatory approval process. The legal interpretation by Silkeborg Municipality of the answer from the Danish State Administration was that the interests of the municipality depended on the amount of biomass input from within the municipality territory to the biogas plant as Silkeborg Municipality had no interest in the biogas use. As the Silkeborg Municipality had no information about suppliers of feedstock within the municipality, the regulatory approval was stopped, but at this time Bio-Center Gudenå had already stopped work on the project.

Epilogue

Two farmers involved in Bio-Center Gudenå, shortly after the project was abandoned, initiated the deployment of two farm-scale biogas plants I/S Kuhr Hedegård Gårdbiogasanlæg and Vestergaard Bioenergi ApS. Both these biogas plants were successfully implemented.

3.1.4. Case 4: Bioenergi Vest

Phase 1—Conceptualization 2007–2012

On 1 January 2007, five municipalities were joined together and became Ringkøbing-Skjern Municipalities as part of a national structural reform. In June 2007, a proposal for a plan strategy for the new Ringkøbing-Skjern Municipality was presented. The plan strategy encompassed overall visions, strategies, and initiatives for future planning within the new municipality and laid the foundation for the upcoming work on a municipal plan. One of the central visions in the plan strategy was that Ringkøbing-Skjern Municipality should become self-sufficient with renewable energy in 2020. As one of the initiatives to accomplish this vision, it was proposed to establish a renewable energy advisory board. In February 2008, the advisory board was established and composed of local businesses and organizations involved in the energy sector. An energy team was also established in the municipal administration; it was responsible for facilitating the work of the advisory board and one of its first tasks was to arrange an energy conference. In May 2008, the energy conference was held with bioenergy as one of the three main topics. During the conference, several of the participants raised questions about the possibility of local biogas production. In September 2008, the first meeting of the advisory board was held; here, the preliminary work for the upcoming municipal plan was presented. In the municipal plan 2009–2021 that was being prepared, bioenergy was highlighted as one of five focus areas to achieve the goal of becoming self-sufficient with renewable energy in 2020. In

April 2009, the second meeting of the advisory board was held; this time the members were informed that Vestjysk Landboforening (a farming association) had shown interest in implementing local biogas plants. In the beginning of 2009, a feasibility study was elaborated by the consulting firm WH-PlanAction. The feasibility study focused on establishing a decentralized biogas transmission network that would link 40–90 small, centralized biogas plants and, through the transmission network, distribute biogas to nearby district heating companies. Later in 2009, the results of the feasibility study were presented to local farmers and utilities that had also shown interest in the project idea and encourage work on implementing the centralized biogas network, called the RKSK-model for biogas, to continue. At the end of 2009, an application was prepared for the regional development fund (Vækstforum) administered by Central Region Denmark. The aim of the project was to provide the foundation for deployment of the first stage of the RKSK-model that would include implementation of between three and four biogas plants and a 15 km transmission network that would distribute biogas to one or two CHPs. In December 2009, the project application was accepted. The project was now starting to move forward. In May 2010, the company Bioenergi Vest was officially established, with Ringkøbing-Skjern Municipality owning half of the shares and Vestjysk Landboforening and other local businesses each owning one-quarter. Work continued on fine-tuning the project concept and preparing the organizational setup. Another project application was prepared for the energy research and development program (EUDP) that would provide economic funding for establishing the first stage of the RKSK-model. In March 2011, the application was accepted by EUDP, and 16 million DKK was provided in public funding. A few months later, in May 2011, the City Council of Ringkøbing-Skjern Municipality approved an application for a municipal guarantee for a loan from KommuneKredit. In May 2011, the first strategic energy plan was approved by the City Council of Ringkøbing-Skjern Municipality. One of the focus areas in the plan was bioenergy and biogas. The goal was that 80 percent of all manure in the municipality would be utilized in biogas plants in 2020 and that bioenergy would contribute 25–35 percent of the total energy consumption. In mid 2011, an application was prepared to be a case in the project Biogas Plant and Landscape and later in 2011 Bioenergi Vest was notified that the application had been accepted. In February 2012, an amendment to the municipal plan was presented pinpointing seven suitable sites for implementation within the municipality territory, with support from the national biogas flying squad (Biogas Rejsehold), hereby fulfilling the municipality's obligations regarding the spatial planning regulation. Besides, the five biogas plants that were expected to be part of the Bioenergi Vest project, the amendment to the municipal plan pinpointed suitable sites for other biogas plants at Viftrup Biogas and Videbæk Biogas, which were also under development at this time in the municipality.

Phase 2—Planning 2012–2016

In August 2012, WH-PlanAction, the consulting firm for Bioenergi Vest, submitted an application to Ringkøbing-Skjern Municipality for initiation of the regulatory approval process for the first stage of the RKSK-model. At this point, the first stage included implementation of the biogas transmission network and the four biogas plants: (1) Strømmesbølvej, (2) Østergårdevej, (3) Sdr. Vium, and (4) Borris. The Economic and Business Council of Ringkøbing-Skjern Municipality approved the initiation of the process. In September 2012 individual applications were submitted to the Danish Nature Agency administering the Green Growth funds providing investment grants. A couple of months later, in December 2012, Bioenergi Vest was notified that the applications for Strømmesbølvej and Borris had been approved. This was, however, also a setback for the project, which was hoping for investment grants for all four biogas plants. In December 2012 another big change happened in the project. The utility company Ringkøbing-Skjern Forsyning acquired a majority of the shares in Bioenergi Vest from Ringkøbing-Skjern Municipality. Vestjysk Landboforening was the only other company that also still had ownership. The project was now really starting to move toward realization. In April 2013, a project proposal was submitted to

Ringkøbing-Skjern by WH-PlanAction, linked to the regulatory approval required by the Danish Heat Supply Act (Varmeforsyningsloven). It was, however, agreed that the approval should wait until the spatial planning permissions was in place. In June 2013, the administration in Ringkøbing-Skjern Municipality prepared an EIA screening of the transmission network providing biogas to Skjern Fjernvarme (Skjern district heating company) and Skjern Papirfabrik and each of the three biogas plants. The number of biogas plants had now been reduced to three—(1) Strømmesbølvej, (2) Sdr. Vium, and (3) Borris—as the one on Østergårdsvej have been put on standby. The result of the EIA screening was that an EIA was not needed for the three biogas plants. On 20 August 2013, the City Council approved initiation of the regulatory approval process for an amendment to the municipal plan and the new local district plans for the sites where each of the three biogas plants was located. During the public hearing that took place between 6 September and 1 November 2013, only very few complaints were received from the local community for the aforementioned plans. However, during this period a complaint was made to the National Complaint Board for Nature and Environment (Natur- og Miljøklagenævnet) about the Ringkøbing-Skjern Municipality's administrative assessment that an EIA was not required for the three plants and the transmission network. In February 2014, the complaint board made its ruling and found that an EIA was needed. In 2013, the complaint board had altered its practice so that an EIA was obligatory for biogas plants with a capacity over 100 tons/day; before that it had depended on an EIA screening (Natur-og Miljøklagenævnet, 2014). Parallel to this, at the end of 2013 the Bioenergi Vest project received 1.9 million euros in support from the EEEF (European Energy Efficiency Fund) for the first stage project and prequalification of companies to deliver three turnkey biogas plants had also been initiated as part of the procurement process. At the beginning of 2014, the project encountered another major setback. It became definitively clear in the negotiations with Skjern Fjernvarme (district heating company) and Skjern Papirfabrik (papermill), the main customers for the biogas produced at the three biogas plants, that it would not be possible to enter into a contract as the price they were willing pay would not make the project profitable for Bioenergi Vest. Instead, Skjern Fjernvarme and Skjern Papirfabrik chose to implement a wood-chip boilers as they perceived that this solution was the most attractive after energy distribution tax for fossil fuels and biomass was removed in 2014. With the regulatory approval process needing to start over and a new biogas customer needing to be found, the project was up in the air. Ringkøbing-Skjern Forsyning was, however, persistent and dedicated to the project's success. The following month, in March 2014, Ringkøbing-Skjern Forsyning took over coordination of the project and made a contract with new consulting firm, Rambøll. Already in May 2014 the project was back on track and a new project concept had been found. Instead of using the biogas for CHP in the town of Skjern, the transmission network would be extended, and the biogas distributed to the dairy company Arla, which would use it for industrial processes, like in the Videbæk Biogas project previously mentioned. On 7 May 2014, Ringkøbing-Skjern Forsyning submitted a new request for initiation of a new regulatory approval process for the Bioenergi Vest project. Ringkøbing-Skjern Municipality promptly found that an EIA was needed, based on the ruling from the National Complaint Board for Nature and Environment, and initiated a call for ideas and suggestions as part of the EIA process between 9 May and 23 May 2014—no remarks were received from the local communities living close to the three biogas plants. Based on the pre-hearing, the City Council decided to continue the planning process and Rambøll, between June and November 2014, elaborated a joint EIA report for the three biogas plants and transmission network. Parallel to this, in September 2014, a contract was signed with Arla about supply of biogas. In November 2014, the City Council approved the initiation of the regulatory approval for the three proposals for local plans and the amendment to the municipal plan with the attached joint EIA report. Between 21 November 2014 and 31 January 2015, the plans were in public hearing; only a handful of objections were received from the local communities living close to the three biogas plants. In April 2015, the plans were thus approved. Two major setbacks were, however, still to come. First, parallel to the regulatory

approval process, the farmers supplying biomass to the biogas plant in Sdr. Vium at the beginning of 2015 announced that they could not wait any longer for the Bioenergi Vest project; they instead started their own project—Sdr. Vium Biogas. Only the two biogas plants at Strømmesbølvej and Borris were thus at this point part of the Bioenergi Vest project. Second, because the biogas was now to be distributed to Arla to be used for industrial processes instead of being used for CHP production at Skjern Fjernvarme, the project had encountered unclear regulation that needed to be clarified with the Danish Energy Agency. For Ringkøbing-Skjern Forsyning, as a public utility company owned by the municipality and governed by the Heat Supply Act and rules governing municipality government (kommunalfuldmagten), to be able to engage in the Bioenergi Vest project, it would have to be classified as a public heating plant (Kollektiv varmforsyningsanlæg), which requires that more than half the gas be used for room heating. The Danish Energy Agency, however, at the beginning of 2015, informed that it was not willing to approve the Bioenergi Vest project in accordance with the Heat Supply Act (Ringkøbing-Skjern Forsyning, 2016). The result of this was that supply of biogas from Bioenergi Vest to Arla was abandoned at the end of 2015. At the same time, a final attempt was made to realize a new version of the Bioenergi Vest project, this time with supply of biogas to Ringkøbing Fjernvarme (a district heating company), which had shown interest. It was thus agreed that Bioenergi Vest should prepare an offer by the first quarter of 2016. The new version of the project, however, required a new suitable site to be found closer to Ringkøbing; the locations at Strømmesbølvej and Borris were abandoned as they were too far away. In February 2016, an offer was presented to Ringkøbing Fjernvarme; it was, however, declined in April 2016, after which it was decided to put the Bioenergi Vest project on standby [42].

Phase 3—Execution/Epilogue 2016–2017

In November 2015, the Sdr. Vium Biogas project (classified as a farm-scale biogas plant) submitted a request for EIA screening to Ringkøbing-Skjern Municipality. As the Sdr. Vium Biogas project was an adapted version of the Bioenergi Vest project at the same location, for which a local plan and amendment to the municipal plan with EIA had already been approved, the EIA screening only focused on whether the alterations would cause an increased environmental impact. The biggest alteration of the project was that the biogas would be upgraded and injected into the natural gas grid in a collaboration with Hemmet Biogas; Ringkøbing-Skjern Municipality thus found in March 2016 that it would not cause an increased environmental impact, and an EIA approval was issued. Construction of Sdr. Vium Biogas was thus ready to start already in mid 2016; by the end of 2017 Sdr. Vium Biogas was in operation. Some of the farmers located near the site at Borris decided the same thing and formed the Vestjysk Biogas project (classified as a farm-scale biogas plant). In September 2016, a request for an EIA screening of this adapted version of the Bioenergi Vest project was submitted to Ringkøbing-Skjern Municipality. Again, the biggest alteration of the project was that the biogas would be upgraded; Ringkøbing-Skjern Municipality thus again found in November 2016 that the project would not cause an increased environmental impact. Construction of Vestjysk Biogas started at the end of 2016 and started operation in September 2017.

3.1.5. Case 5: Nature Energy Nordfyn (Nordfyn Biogas)

Phase 1—Conceptualization 2008–2010

In April 2008, a first meeting was held between the project reference group of the emerging Nordfyn Biogas project and Nordfyns Municipality. The reference group at this point comprised Centrovice, Bogense Fjernvarme (a district heating company), Udviklingsforum Odense, and the consulting firm WH-PlanAction. In the following half-year, several meetings were held, where the main topics on the agenda were site selection and financing options for the pre-feasibility study. In September 2008, a suitable site was selected south of Bogense, and Nordfyns Municipality quickly elaborated a pre-screening of the location to ensure that there were no spatial planning conflicts. In October 2008 a request for initia-

tion of the regulatory approval process for Nordfyns Biogas was submitted to Nordfyns Municipality. In January 2009, Nordfyns Municipality completed an EIA screening of the project, where the administration found that EIA was not required as the project would not have a significant impact on the environment. It also found that an amendment of the municipal plan was not needed as a new municipal plan was under preparation wherein the project could be included. The Nordfyns Biogas project was thus very quickly well on the way and on 1 July 2009 the company Nordfyns Biogas was established. In November 2009, the new municipal plan was approved by the City Council of Nordfyns Municipality, where the selected site south of Bogense was dedicated for biogas production. A couple of months later, the City Council also approved initiation of the regulatory approval process for the new local district plan for the selected site. Between 1 May and 7 July 2010, the new proposed local district plan was in public hearing—only one proposal was received from the local community during this time. In September 2010 the new local plan was thus approved by the City Council, and Nordfyn Biogas was thus very close to having all the required regulatory permits and being able to initiate the execution phase.

Phase 2—Planning 2012–2014

At the end of 2010, the Nordfyn Biogas project, however, encountered a setback as Bogense Fjernvarme, the only buyer of the biogas, decided to leave the project. Bogense Fjernvarme highlighted the price of the biogas as the main reason, perceiving it as not being able to compete with other types of biomass at this time; instead, the company chose to expand its wood-chip boiler capacity. With no buyer for the biogas, and no support for biogas upgrading at this point, the project was put on standby at the end of 2010 until better economic framework conditions were available. In mid 2012 the project was reactivated as the framework conditions had now been improved with the energy agreement from March 2012. Also, the district heating company Fjernvarme Fyn had joined the project consortium and taken over the project coordination from Centrovic, like in the Faaborg-Midtfyn Biogas case. Fjernvarme Fyn wanted to buy the biogas from Nordfyn Biogas and use it for a district heating project in the town of Sønderød. In September 2012 an application was submitted to the Danish Nature Agency administering the Green Growth funds by the consulting firm WH-PlanAction, and a couple of months later, in December 2012, the project consortium was notified that the project application had been approved and that the project was eligible for an investment grant of 29.7 million DKK provided it entered the operation by August 2015. Things were now back on track again and the project was really moving forward. In January 2013, a project proposal, as required by the Heat Supply Act, was submitted to Nordfyns Municipality aimed at converting Sønderød from individual natural gas boilers to district heating provided Fjernvarme Fyn. This, like in the Faaborg-Midtfyn Biogas case, was heavily contested by Naturgas Fyn, which was supplying the natural gas. In March 2013, the prequalification was initiated as part of the procurement process. The procurement information also included an option for implementation of the Faaborg-Midtfyn Biogas project that Fjernvarme Fyn was also engaged in. In June 2013, Fjernvarme Fyn submitted an application for implementation of a biogas and CHP plant as required in the Danish Heat Act. In October 2013, the City Council approved the application for converting Sønderød and in December 2013 it also approved the application for implementation of biogas and CHP production, despite the complaints from Naturgas Fyn, like in the Faaborg-Midtfyn case. Parallel to this, the administration in Nordfyn Municipality also issued an environmental approval in September 2013. Like in the Faaborg-Midtfyn case, a radical change however happened at the end of 2013, where Naturgas Fyn suddenly took over the project from Fjernvarme Fyn, which was otherwise well on the way. Things did not start that well for the new project owner Naturgas Fyn. In January 2014, the Danish Society for Nature Conservation (DN) and nearby neighbors to the biogas plant submitted a complaint to the Danish Nature and Environmental Complaints Board (Natur-og Miljøklagenævnet). The complaint was twofold: first, DN argued that an EIA should have been elaborated for the centralized biogas plants; and second, the

neighbors were worried about noise and odor from the biogas plant and linked to this, decrease of property values. In April 2014, the complaints board made its ruling. Firstly, it found that it could not process the complaint regarding the EIA screening as the complaint had been made after the complaint duration had expired. The complaint board was thus not able to process this part of the complaint but noted that municipal approval was in line with the practice at the time. Secondly, regarding the complaint over the environmental approval, it ratified the approval issued by Nordfyns Municipality. The project could thus continue without any alterations. Parallel to this, the construction company Xergi was, in March 2014, selected for implementation of a turnkey biogas plant as the result of the procurement process started by District Heating Funen one year earlier. In June 2014 Naturgas Fyn, that had now changed its name to NGF Nature Energy, and also remade the biogas project Nature Eneergy Nordfyn submitted an application for an amendment to the environmental approval to include an upgrading facility, as the biogas was now to be upgraded and injected into the natural gas grid. In December 2014, the amendment was approved by the City Council and thus all permits were now in place to start construction.

Phase 3—Execution 2014–2016

In September 2014, the groundbreaking ceremony with turning the first sod was held. The biogas was designed for 300,000 tons/annually and an expected production of 10 million Nm³. In April 2015, construction was midway and in January 2016 the official inauguration was held for Nature Energy Nordfyn, with the current Danish Ministry for Energy, Distribution and Climate Lars Chr. Lilleholt, as the guest of honor.

4. Identified Challenges

4.1. Economic Challenges (A)

Economic challenges was encountered during the project lifecycle of of Sønderjysk Biogas Bevtøft, but also to a lesser degree in the case of Nature Energy Midtfyn and Nature Energy Nordfyn (See Figure 1). Between 2010 and 2012, project development continued in the Sønderjysk Biogas Bevtøft case even though there was still no feed-in tariff for upgrading biogas at this time and there was uncertainty as to whether it would be implemented. Also, the project application for a governmental investment grant that was important for the business case was declined in December 2012 in contrast to the two other cases—this, however, did not deter the project owners. In the Nature Energy Midtfyn case, an application for an investment grant was also declined in 2011, resulting in the project being put on standby for nearly a year, as was essential for the business case of the project.

4.2. Site Selection Challenges (B)

In all five cases the project consortium managed to make an agreement with biomass suppliers and pinpointed a site with a viable business case—i.e., a good balance between operation costs (transport costs and price of feedstock) on one hand and revenues from biogas production on the other hand. The lack of gas boosters (e.g., energy crops, slaughterhouse by-products) can, however, still be seen as a challenge for all five cases as it limits the potential biogas production and thus the biogas plant profitability. In the Sønderjysk Biogas case, this challenge was addressed by use of cereal straw and deep litter, and in the Faaborg-Midtfyn Biogas case by establishing a close collaboration with the company N.C. Miljø, which recycles food waste from supermarkets.

4.3. Market and Infrastructure Challenges (C)

For the cases of Sønderjysk Biogas Bevtøft, Nature Energy Midtfyn, Bioenergi Vest, and Nature Energy Nordfyn, market and infrastructure challenges played a role. In the case of Sønderjysk Biogas Bevtøft, it was not possible to reach an agreement with local district heating companies in Vojens and Tøftlund about the price of the biogas even though the heating demand matched the potential biogas production very well. In the Nature Energy Midtfyn case, the district heating company Faaborg Varme was not interested in biogas

use even though heat demand again was a good match with biogas production; instead, it preferred the use of natural gas. In the Bioenergi Vest case, the project consortium and Skjern Fjernvarme were also not able to reach an agreement about the price of the biogas; instead, Skjern Fjernvarme ended up implementing a wood-chip boiler. In the Nature Energy Nordfyn case, Bogense Fjernvarme also decided to leave the project as it did not find the price competitive; it implemented a wood-chip boiler, too. In the cases of Nature Energy Midtfyn Biogas, Nature Energy Nordfyn, and Sønderjysk Biogas Bevføft, the project concept ended up being adapted from direct use of the biogas to upgrading.

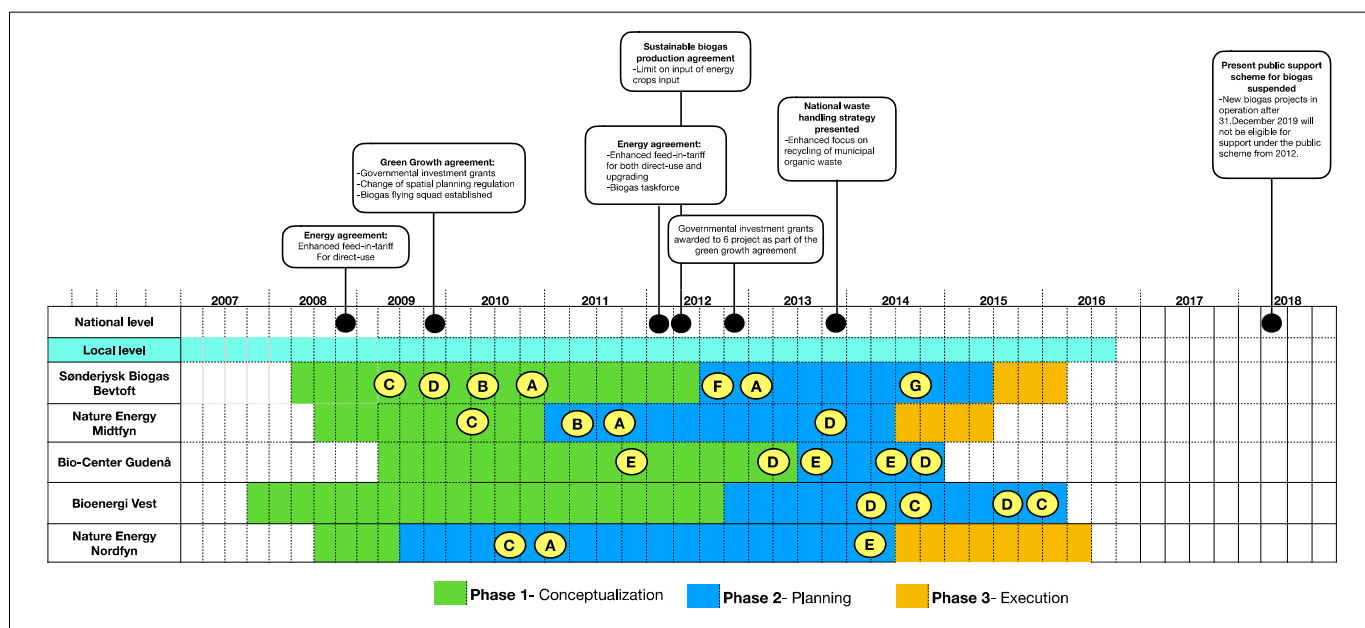


Figure 1. Duration of project lifecycle for the five case, and indication of types of challenges they encountered using the analytical framework A–G. Also, key event in the policy lifecycle at the national level is included.

4.4. Administrative and Regulatory Challenges (D)

The Sønderjysk Biogas Bevføft, Nature Energy Midtfyn, Bio-Center Gudenå, and Bioenergi Vest cases encountered different kinds of administrative and regulatory challenges. In the Sønderjysk Biogas Bevføft case, there was a good collaboration between the municipality and the project owners, but, due to unclear regulation and absence of guidelines, it took over a year to clarify whether the biogas plant could be sited in rural zones instead of industrial zones. Furthermore, it took several years to clarify whether the biogas plant could be sited within a nitrate-vulnerable area. Another unclear element arose in the Sønderjysk Biogas Bevføft case about who was the correct authority for handling the regulatory approval. Haderslev Municipality started, but midway the regulatory approval was transferred to the Danish Nature Agency because the project included an extension of the natural gas grid. In the Bio-Center Gudenå case, administrative and regulatory challenges seem to have been rooted in a lack of experience in handling the regulatory approval of biogas plants in Viborg Municipality. This resulted in only very little progress being made in the first two years of the project conceptualization. Also, it took almost a year to clarify whether the project could obtain a municipal guarantee for a loan from KommuneKredit if a majority of the biogas would be used for industrial processes (also see financing challenges). In the Bio-Center Gudenå and Nature Energy Midtfyn cases, where the applications for governmental investment grant were approved on condition that the biogas plants were in operation by August 2015, this created a time pressure that meant that hasty decisions needed to be made and little time was left for overcoming unexpected challenges. Also, because the investment grant was partly financed through

the EU Programme for Rural Development, the heating could not be used in urban areas, which prompted Fjernvarme Fyn to abandon the project, with project ownership being transferred to Nature Energy in the Nature Energy Midtfyn case. The Bioenergi Vest case also encountered a lack of clarity regarding the Heat Supply Act and whether Ringkøbing-Skjern Forsyning could be the project owner of a project where over half of the biogas was used for industrial processes. The Danish Energy Agency in the end found that this could not be approved, which was the main reason why the Bioenergi Vest project was eventually abandoned. Also, the regulatory approval process had to be started again because the National Complaint Board for Nature and Environment in 2012 changed its position on when an EIA was necessary for a biogas plant. Before 2012, it almost entirely depended on the specific assessment by the municipality, but following 2012, it in practice became obligatory for biogas plants with an input of over 100 tons/day to elaborate an EIA [43]. In the Nature Energy Nord case, where a similar complaint was made, the complaint board found that it could not process the complaint as the complaint deadline had passed, but it noted that it had no remarks on the Nordfyn Municipality EIA screening from 2009, as it had followed the present practice. This shows some of the lack of transparency in the regulation that project owners were faced with.

4.5. Local Perception and Attitude (E)

In the Bio-Center Gudenå case, there was deep public concern about the location of the biogas plant. Attempts were made to implement the biogas plant at three different sites. At all three sites there were strong objections from the surrounding local communities, especially about potential odor problems and heavy transport. It is here interesting to note that in the other four cases there were only very few objections during the public hearing. The Bio-Center Gudenå project seems to have entered a spiral of mistrust affecting the general attitude of the local community. In the Bio-Center Gudenå case in Bjeerringbro, a small group of citizens formed a protest group that mobilized the rest of the community. This was done, e.g., by delivering leaflets, putting up large banners in the town, and establishing a Facebook group through which activities were organized. The administrator of the Facebook group wrote that they were not against biogas in general but believed that the location west of Bjeerringbro was too close to the city. Also, they felt that the project owners of Bio-Center Gudenå had failed to listen to their concerns, even though they had been put forward both in the monitoring group and in the public meetings held in 2011. Also, in the Bio-Center Gudenå case, it seems that even though Viborg Municipality followed all procedures correctly, it had a non-proactive approach to the project. This is indicated by the long administrative processing time in finding a suitable site and the non-facilitating approach of the administrative staff. Overall, the municipality seems to have seen its role as being only a regulatory approval authority and not a facilitator trying to ensure the project's success and promote renewable energy production.

4.6. Sustainability and Ecological Aspects (F)

In the Sønderjysk Biogas Bevtøft case, the sustainable supply of biomass posed a challenge. A majority in the Danish Parliament in 2012 set a limit of 25 percent on the input of energy crops to biogas plants between 2015 and 2018; this limit was decreased to 12 percent between 2018 and 2021 to enhance the sustainability of biogas production. When this regulation was passed it meant that the Sønderjysk Biogas Bevtøft project concept needed to be changed. Until 2012 maize had been expected to account for 25 percent of the total biomass input to the biogas plant, but in the following years the Sønderjysk Biogas Bevtøft project needed to find an alternative feedstock, driving innovation into utilization of cereal straw as feedstock in biogas production.

4.7. Financing Challenges (G)

Financing can also be a challenge for biogas projects. In the Sønderjysk Biogas Bevtøft case, it was difficult for local farmers to acquire sufficient financing from banks to cover

their part of the investment. Luckily, the investment grant from Bio-Center Gudenå ended up being transferred to them at the end of 2014. Also, the involvement of NGF Nature Energy in the Nature Energy Midtfyn case and E. ON in the Sønderjysk Biogas Bevtøftcase was essential for realization of the projects. In the Sønderjysk Biogas Bevtøft case, E. ON ended up owning 49 percent of the biogas plant, while local farmers and other investors owned 51 percent. In the Nature Energy Midtfyn case, NGF Nature Energy ended up owning 87 percent of the biogas plant and local farmers only 13 percent, even though the farmers for a long time hoped they could be the main investors. Before the equalization of the feed-in tariff between direct use and upgrading in March 2012, all centralized biogas projects in Denmark were reliant on municipal guaranteed loans typically combined with a governmental investment grant. This financing approach, however, put a limit on investment returns due to the Danish heating regulation. As can be observed in the Bio-Center Gudenå case, the regulatory framework was and still is unclear as to whether municipal guaranteed loans can be provided for electricity production or only for heating, and it is unclear whether municipal guaranteed loans can be provided for projects where the heating is primarily used in another municipality.

5. Identified Drivers

5.1. National Level

5.1.1. Enhanced Policies

Public support schemes are still essential for deployment of centralized biogas plants. Enhancement of the renewable energy feed-in tariff for direct use of biogas for production of electricity in December 2008 was thus the first step in re-sparking interest in biogas production in Denmark. This was supplemented by a governmental investment grant program that was part of the Green Growth agreements. It also made it mandatory for municipalities to pinpoint suitable areas for deployment of biogas plant in their municipal plans. In March 2012, a majority in the Danish Parliament reached an agreement about a new energy act that meant that the feed-in tariff would be further enhanced and the subsidies for direct use and upgrading equalized. This portfolio of public support schemes combined re-sparked the initiation of the biogas projects across Denmark.

5.1.2. Access to the National Gas Infrastructure

In the Danish Energy Agency there had for many years been reluctance toward upgrading biogas because of enhanced costs, lower energy efficiency, and enhanced methane slipping. Equalization of the subsidies between biogas for direct use at CHP plants and biogas upgrading and injecting into the natural gas grid, however meant that a new infrastructure was made available for the biogas sector in Denmark. Until then, biogas production had been dependent on a match between heat demand and manure concentration. Biogas producers were thus in a weak negotiating position with local CHP plants, as can be seen in the Sønderjysk Biogas Bevtøft, Nature Energy Midtfyn, Nature Energy Nordfyn, and Bioenergi Vest cases.

5.1.3. Initiatives Supporting Local Government and Projects Owners

As part of the Green Growth agreement in 2009, a national biogas flying squad was established to support Danish municipalities in identifying sites for implementation of biogas plants. As mentioned above, it had been made a requirement to pinpoint suitable areas for biogas plants in all municipalities' upcoming municipal plans for 2013–2025. The national biogas flying squad supported this work, but it also guided the municipalities in specific planning processes even though it did not have any actual authority. In all the cases presented here, the municipalities had contact with the national biogas flying squad, but it seems that the projects had already pinpointed suitable sites before their involvement, and the biogas flying squad mostly helped with clarification regarding regulatory requirements. In the Sønderjysk Biogas Bevtøft case, the involvement seems to have played a part in

the regional office of the Danish Environmental Agency resigning its objections against locating the biogas plant in a rural zone, and in the unclear regulation being clarified.

5.1.4. Involvement of Well-Established Energy Companies in the Biogas Sector

In the successful cases, well-established energy companies were included in the ownership structure. In the Sønderjysk Biogas Bevtøft case, E. ON was involved relatively early in the project conceptualization, while NGF Nature Energy became involved during the project planning in the Nature Energy Midtfyn and Nature Energy Nordfyn. In all three cases, the involvement of these energy companies was a critical factor for the project's success, as they had access to finances and were willing to invest in the biogas sector. Involvement of well-established energy companies also meant a professionalization of the project management, as they sometimes had more experience in implementation of bioenergy plants than the local project initiators.

5.2. Local Level

5.2.1. Bottom-Up Approach, Vision of Change Agents and Project Management Style

In all cases, the projects were initiated bottom-up by farming associations, utility companies, and municipalities. This bottom-up approach meant that it was easy to get the support of local farmers, and in the Bio-Center Gudenå case also to get the support of local district heating companies in Bjerringsbro and Ans. In all cases the project leaders seem to have had a clear project vision and been persistent in their belief that it would be realized. Also, they seem to have had a solution-oriented project management approach, which meant that they were not deterred by the setbacks that they encountered but tried to find solutions and include stakeholders that could help them. This was probably due to the previous project management experience of the project leaders with deployment of RET projects. The bottom-up work done by the project initiators also meant that the large-sized energy companies could see an attractive business case that they could engage in relatively easily because the project planning was already well underway.

5.2.2. Gaining Trust of Local Communities

In contrast to Bio-Center Gudenå, both the Sønderjysk Biogas Bevtøft and the Nature Energy Midtfyn cases were met with very few objections from the local communities. Especially Sønderjysk Biogas Bevtøft seems to have had a strategy for engaging with the local community near the site at Bevtøft, so problems were solved before they spiraled out of control. This was done, e.g., by having separate meetings with neighbors that would be closest to the biogas plant, before the public hearing meeting arranged by the municipality. Also, a bus tour to Ribe Biogas was included in the public meeting so that all who wanted to, could experience a biogas plant in operation. Finally, the municipality and the project owners decided to wear different-colored T-shirts at the public hearing meeting to clearly signal that they had different roles in the process. In the Nature Energy Midtfyn Biogas case, the public hearing seems to a large extent to have gone unnoticed by the public, maybe since the site was a long distance from any large towns.

5.2.3. Facilitating Role of Municipalities

It is apparent from the five case studies that the municipalities handling the regulatory approval approached this task differently and with different dispositions. In the Nature Energy Midtfyn case, the project was initiated by the municipality through the work on a white book for local climate mitigation, and further the municipality supported the elaboration of a pre-feasibility study in the conceptualization phase, thereby facilitating the project development. Also, in the Bioenergi Vest case, Ringkøbing-Skjern Municipality played a leading role in facilitating and coordinating the project in the conceptualization phase, as one of several initiatives in its strategy to become self-sufficient with renewable energy by 2020. In the Sønderjysk Biogas Bevtøft and Nature Energy Nordfyn cases, Haderslev Municipality and Nordfyns Municipality also had proactive approaches to the

biogas, trying to identify solutions that would help ensure the success of the projects. In the Bio-Center Gudenå case, however, it seems that Viborg Municipality had a more nonproactive approach, seeing its role merely as the regulatory approval authority and not as a facilitator trying to ensure that the biogas plant was implemented.

6. Discussion

The deployment of biogas plants is not an easy task, as this study indicates. Many challenges need to be overcome both for projects that are successful and for projects that are abandoned. The challenges identified in this study overall correspond with previous studies, but also give some interesting new insights (See Figure 2).

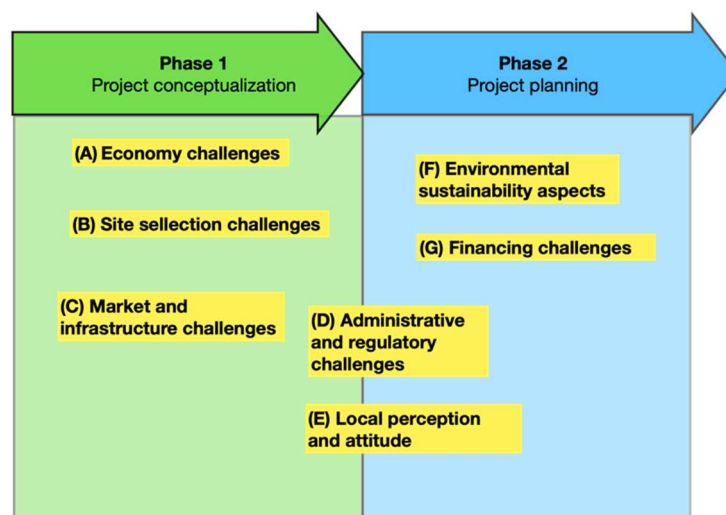


Figure 2. Pattern in identified challenges in the five cases linked to phase 1 and 2 in the project lifecycle.

The interest in deployment of biogas plants in Denmark re-sparked with, first, an enhanced feed-in tariff for direct use of biogas in 2008 and, second, an agreement about a governmental investment grant scheme the following year, in 2009. The economy challenge that had almost completely stopped deployment of centralized biogas in Denmark since 1998—with two exceptions—was thus overcome and around 30 centralized biogas projects were initiated across the country between 2008 and 2010.

As can be seen from the five cases, the project lifecycle for deployment of centralized biogas plants was typically very long; even though viable project concepts had been identified early in the conceptualization phase, the projects met an array of different challenges. For the Sønderjysk Biogas Bevtøft, Nature Energy Nordfyn, and Nature Energy Midtfyn cases, this resulted in a project lifecycle lasting around eight years, and in the Bio-Center Gudenå case around four and a half years were spent before the project was abandoned. In the Bioenergi Vest case, about seven to eight years were spent before the project was abandoned (See Figure 1). In Denmark, breaking the local monopoly of district heating companies for use of biogas by giving the biogas sector access to the national gas grid infrastructure through equalization of the feed-in tariff for direct use of biogas and upgrading in March 2012 seems to have been a key driver for accelerating deployment.

This policy change opened new business opportunities and enhanced the interests of well-established energy companies like E. ON and NGF Nature Energy to enter the biogas sector. Four of the cases encountered administrative and regulatory challenges especially related to spatial planning zoning during the site selection for the biogas plant and to the Heat Supply Act. National spatial planning requirements and guidelines made it quite hard to find a suitable site for a medium-sized industrial plant in a rural zone. As part of the Green Growth agreement in 2009 it was made mandatory for Danish municipalities to identify suitable sites for biogas plants in their municipal plans. This policy change was,

however, too slowly implemented to play a role in the five cases. In the Bio-Center Gudenå case, where it could have played a role, Viborg Municipality did not pinpoint specific areas; it gave only vague overall guidelines in its municipal plan, instead of specific locations. Overall, this can be seen as an example of the lack of coordination and motoring between different levels of government, but also of the lack of timing in policy implementation. The unclear regulation framework and lack of a common interpretation due to an absence of national specifications and guidelines prolonged the projects considerably. In the end, the persistence and experience of the project team were essential in clarifying unclear regulation, but it was often a very time-consuming task that involved different levels of government and sometimes led to different interpretations of the regulation framework. Also, the project consortium played an important role in lobbying for policy change, as can be observed in the Sønderjysk Biogas Bevtøft case, which already in January 2009 approached the Committee for Energy Policy in the Danish Parliament for equalization of the feed-in tariff between direct use and upgrading of biogas. This can be seen as an example of the important role of local stakeholders in policy formation. Also, it is interesting to find big differences in local perceptions and attitudes related to the five biogas projects. Bio-Center Gudenå, on one hand, entered a negative spiral in its collaboration with both the local communities and the municipality, while the rest of the cases, on the other hand, were met with very few objections and had a very good collaboration with the municipalities. Here, the critical success factors for not entering this negative spiral need to be better understood, but, as previous studies have shown, distributive justice, procedural justice, and trust in local government and project developers are key factors. Furthermore, an interesting finding related to sustainability and other environmental aspects was the effect of the regulation limiting the use of energy crops, which resulted in enhanced focus on utilization of cereal straw and deep litter as feedstock for biogas production. As an example of how regulation can drive sustainable innovation, even though it was a challenge for the Sønderjysk Biogas Bevtøft project to overcome at the time, it can over time be turned into business advantage in the future. Finally, still with attractive support schemes and the engagement of well-established energy companies, biogas projects still need to obtain financing through private banks or municipal guaranteed loans. Here the experience of bank staff with similar projects is of course important, but the critical success factors for overcoming the challenges also need to be better understood.

These findings have policy implications that could support accelerated deployment of biogas production both in Denmark and in the EU. First and foremost, a portfolio of policy instruments and actions is needed to spark or re-spark deployment of RETs. Here are four recommendations to decision-makers:

- In the Danish case, an enhanced feed-in tariff for both direct use and a governmental investment grant program created the spark among local initiators. Equalization and enhancement of the feed-in tariff for both direct use and upgrading biogas a couple of years after meant that the biogas sector gained access to a new infrastructure, which sparked the interest of well-established energy companies. The combination can thus be recommended. A special incentive should, however, still be put in place for direct use of biogas, which is more energy-efficient than upgrading. In the Danish context, the direct use of biogas for CHP has almost completely been abandoned since 2012. Here, easier access to national guaranteed financing with low interest rates for renewable energy projects is recommendable. Alternatively, they could remove the regulatory limitation on municipality guaranteed loans for renewable energy projects.
- When accelerating the deployment of biogas plants, it would also be a good idea to establish a national legal office that can support project developers and municipalities with interpretation and guidelines related to the sometimes very complex regulation framework surrounding biogas production and coordinate efforts between different governmental branches. This could be supplemented with spatial planning support and project development support like the national biogas flying squad and the Biogas Taskforce provided in Denmark.

- Also, in terms of fast-tracking the regulatory approval of biogas plants, it is recommended to establish educational courses for both local project developers and municipal planners, to create a common understanding of the regulatory requirement that the project is expected to meet, and to ensure that the administration is handled efficiently, without being prolonged. This could help share best practices related to gaining the trust of local communities. Also, it would be a good idea for climate mitigation action to be made a mandatory task for municipalities, as the general advocacy of renewable energy as shown is a key factor in successful deployment.
- Finally, a last recommendation is to enhance research and development into optimizing the operations cost for utilization of deep litter and cereal straw for biogas production as this will be essential for accelerating sustainable biogas production and ensuring the future development of the biogas sector.

7. Conclusions

The main purpose of this article has been to investigate where in the project lifecycle of biogas projects different kinds of challenges are encountered and to evaluate and analyze the drivers put in place for overcoming them in Denmark since 2007. Based on these findings, the article has provided recommendations for accelerated deployment of biogas production. By applying a longitudinal progress analysis of five cases, the challenges the biogas projects encountered were identified and linked to the different phases of the project lifecycle (See Figure 2). Also, the study provides insight into the drivers that were implemented for overcoming these challenges in the Danish context.

At the national level, a portfolio of policies was used for re-sparking interest in deployment of centralized biogas plants. This included an enhanced feed-in tariff for both direct use and upgrading of biogas, combined with a governmental investment grants program. The equalization of support between direct use and upgrading of biogas meant that biogas projects gained access to the national gas infrastructure. This opened new business opportunities that attracted the attention of well-established energy companies. Also, initiatives were put in place to try to support municipalities and local project owners.

At the local level, drivers for success were also identified. The first was the role of local ownership and change agents, the second gaining of public trust, and the third was the facilitating role of municipalities. Overall, there is a need for further research into the critical factors influencing successful deployment of centralized biogas plants, together with research into the opportunities for accelerating deployment of biogas production.

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