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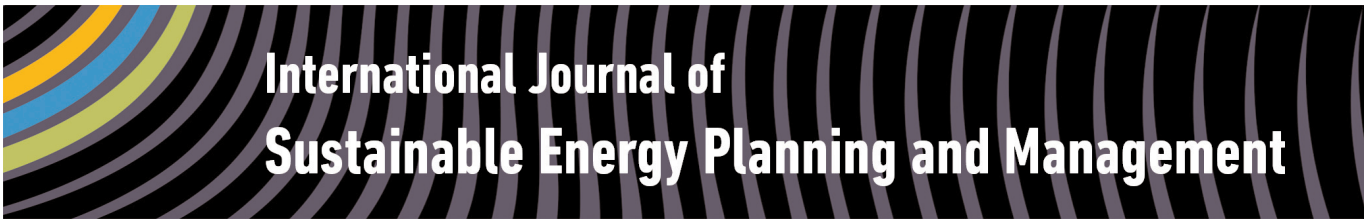

Paving the way for heat. Local government policies for developing bioenergy in Norway

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ABSTRACT

Local governments play dual roles in developing renewable energy projects. They are the targets of many goals concerning energy and climate, set by national and international actors, and they are important actors in energy planning, regulation setting, and the development of infrastructure and residential areas. In this paper, I study how local governments' technology policies affect the actual outcome of project development based on experiences from 14 local governments. Technology policies are studied from the perspective of Sørensen's [1] four areas of concern:direct support of innovation, infrastructure, regulation (protection and standards) and public engagement. I find that local governments use policy instruments within all four areas, and that the way local governments involves in the process of bioenergy development are surprisingly similar despite differences in location and size of both the local government and the project.

Keywords:

technology policy,
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1. Introduction

There seems to be a common understanding that local and regional levels of government do not engage in development of new technology [2]. However, many technological innovations do happen at the local or regional level [3], and local governments play an important part in them [4, 5]. In fact, local knowledge often provides a major advantage in the development of projects, because local actors have better knowledge of the local factors that might influence the development of the project [6].

According to Hielscher [7] and Hielscher et al. [8], there are two ways of looking at local and regional innovation: with a focus on the local community as a unit (including the area's residents and other actors) or with a focus on the local government and its role as a political and administrative unit. In this paper, I have chosen the latter approach to focus on local governments' role in harnessing the development of sustainable bioenergy. In turn, this means to explore what I will call local governments' technology policy, which is a broad term meant to cover the strategies employed to develop and embed technologies for public and industrial purposes in the municipality.

Potentially, local governments may support the development of renewable energy in their community as developers, regulators, planners, providers of knowledge, managers and initiators [9]. As owners of a large number of buildings–a role that challenges many local governments–they buy energy and are responsible for local government plans and regulations concerning emissions, energy efficiency, development of trade, and residential areas.

Local energy plans map local governments' current status concerning energy use, emissions, and potential for energy savings and use of more renewable energy. Further, they propose strategies to increase sustainability [10]. Similar planning regimes are found

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in other countries, but their effects remain unclear [11, 12]. Do such plans contribute to increased use of renewables? Sweden has a long history of fairly successful energy plans, but Swedish local governments concentrate on energy supply, not energy efficiency [13]. Energy plans can also be seen as a tool for local governments when they develop local energy systems. However, Nilsson and Mårtensson [12] found considerable variations in the use of energy plans. Many plans were vague and their major objective was often merely to describe the local energy system. In Denmark, it has been observed that local governments have the most developed goals for areas in which national authorities impose specific tasks [14]. The Danish local governments' main objective is energy savings, particularly in buildings that they own [14]. Still, the progress is slow [15].

This paper examines Norwegian local governments' technology policies in stimulating innovation in sustainable energy using examples from bioenergy developments. What strategies do local governments pursue? What kind of policy instruments do they use? What is achieved? I first introduce the concept of local technology policy as a backdrop to analysing these issues, before I present the findings from a study of 14 local governments.

2. Understanding local technology policy

Local governments, whatever the size of the local community, play an important role in local innovation processes. Their role seems to be affected by their developmental capacities and the financial instruments available to support innovative actions [4]. Local conditions are important because innovation processes are based on context-specific conditions [16]. The advantages of the local level include a specialized local labour market and close cooperation between the involved actors [17]. Local actors can take advantage of this. There are also important differences, which may be crucial for the success of a project in how developers cooperate and involve citizens [18]. Mangoyana and Smith [19] find that the main criteria for development of small-scale bioenergy are the participation and involvement of an active community. Good local market conditions have also proved to be important for local bioenergy development [20]. Local community participation helps secure a market for bioenergy, which is necessary for innovations to succeed.

Local, regional and national innovation contexts are fundamentally different [21], and the actors respond differently to national and international directions. Those who respond fast will, in many cases, act as beacons for others. According to Cooke [22], system initiatives often precede regional or local policies. At other times, local and regional conditions prompt local innovation processes before national and international policies are made [22]; local actors see a need or opportunity, and they act.

Hielscher, Seyfang et al. [8] show that local community projects seem to be more effective in promoting renewable energy and behaviour changes compared to top-down initiated projects. That is, local projects can address social, cultural and economic barriers more effectively [23]. Still, their success depends on informed and engaged citizens [24]. Thus, when local governments want to support local innovation, they face challenges to be addressed through the development of local technology policy. Sørensen [1] proposes that technology policies should be studied broadly by analysing not only the direct support of innovation but also efforts with respect to infrastructure, regulations (protection and standards), and public engagement.

Currently, at the national level, technology policy tends to focus on innovation, because innovation is considered key to economic growth. However, innovations need to be socially integrated in acceptable ways. As Sørensen [1] argues, infrastructure is itself a concern because structures like roads, railways, grids, and pipelines are preconditions of a well-functioning society. At the same time, infrastructure may be a prerequisite for innovation; for example, the production of heat from bioenergy usually depends on the existence of a heat grid. Regulations are needed, not only to protect against technological risks, but also to set standards that facilitate the interaction of various forms of technologies and make demands in terms of, e.g., what heating systems to introduce in new buildings. Innovations might be spurred by regulations, such as more stringent requirements regarding the emission of climate gases. Public engagement is important to secure democratic decision-making and to develop interest in, support of and demand for new technologies.

All four of Sørensen's areas may be addressed by local governments. Innovation support tends to be seen as the task of national governments and often includes public investment in research and development (R&D).

This is probably less relevant at the local level, even though some communities might benefit from hosting R&D institutions. Still, local governments can offer advice, encouragement and economic support. Large local governments, mostly cities, have access to a larger variety of policy instruments than smaller ones. Moreover, it has been argued that policy instruments specifically designed for local governments are needed, particularly increased funding for local governments to promote local innovation [25].

With respect to infrastructure, local governments are responsible for municipal roads, water supply, waste management and similar services. Summerton [20] shows that the development of district heating involves considerable local infrastructure developments. Historically, local governments have also played an important role in supplying electricity [26]. Actually, local governments have many options for regulating land use and construction, including making demands about the energy systems being implemented in new buildings. Not the least, local communities are important arenas for public engagement with new technology and technological development. For example, involving local inhabitants in the construction of wind farms has resulted in less controversial decision-making [27].

We know little about the shaping of technology policy in Norwegian municipalities and the ensuing practices. To what extent do the local governments actually develop policies to engage with innovation, infrastructure, regulations, and public engagement to support local development of renewable energy? Although there is little theory or research that allows for well-grounded expectations, it seems reasonable to assume that direct support of local innovation is difficult for most local governments and that building infrastructure and making regulation might be more pertinent to facilitate local innovation. In this respect, we assume that the previously mentioned energy and climate plans play an important role. Public engagement may be legally required, at least when innovation is linked to large construction efforts, but this can be achieved in different ways [27]. So what might we learn when studying how local governments engage with bioenergy developments?

To answer this question, I pursue a strategy inspired by Bruno Latour (2005) [28 p. 249] to re-assemble the activities by the local governments into what I consider to be a local technology policy. This means to be sensitive to controversies and uncertainties regarding the content of actions and the interaction of human and non-human objects, to analyse how actors work to stabilize uncertainties and what policy instruments that consequently come to be employed.

3. Methodology

This paper explores the development of bioenergy projects in Norwegian local communities and the local communities' experiences with this process. Who initiated the projects, and who developed them? What kind of technology policy has been exercised by the local governments?

To gain insight into these issues, qualitative interviews and document analysis have been used. Many local governments are involved in bioenergy projects in some respect. I chose to examine a limited number of cases. Since there is no existing database from which relevant cases could be identified, I developed my own. I started with the Retriever database (www.retriever-info.com\no), where I searched for newspaper articles concerning local governments and bioenergy projects. The newspaper articles provided information about projects, actors, technologies and size of the local government involved in the projects. With this as a point of departure, I selected local governments and projects I found interesting. I wanted local governments with varying involvement in bioenergy projects using different technologies. I have also tried to select cases from different geographical areas, with varying levels of population. The local governments are located in different parts of Norway, and include both cities and small local governments in rural areas. Thus, the aim was to provide for variation to facilitate the identification of different technology policies.

The cases are not a representative selection of local governments, but comprise a strategic sample to study variations with respect to technology policy. When I found interesting cases, I studied the local government energy and climate plan to see how they have described the actual situation concerning energy and climate, and how related goals for energy use, including energy efficiency, emissions, and transportation have been reviewed.

The paper is mainly based on interviews with representatives of 14 local governments that have established bioenergy plants: Averøy, Bergen, Harstad, Levanger, Nord Odal, Rissa, Røros, Stryn, Sunndal, Trondheim, Trysil, Ullensaker, Vik and Åsnes. They are

located in different parts of Norway and differ with respect to size, the initiative of the project, the local government's role in the process and type of plant. Bergen and Trondheim are among the largest cities in Norway, while the municipality of Vik only has twenty-seven hundred inhabitants.

The interviews took place during spring 2011 and were conducted by telephone. The interviews have been semi-structured. I have used an open list of questions to be covered, not a strict interview guide. I asked for instance about who had participated in the local project, who initiated it, the development process and what problems the project had met during the process. I also inquired about the local governments' relation to renewable energy. In most of the cases, I interviewed one person, usually the mayor, the project manager, the trade counsellor or the environmental counsellor. They were selected because they had worked closely with the bioenergy projects and could give information about them since their conception. In total, 16 persons have been interviewed.

All interviewees were party to the development of a local bioenergy project. This is likely to have made them positively biased in their assessment of the process, possibly neglecting problems and disagreements. Another potential weakness of the study is the fact that I interviewed only one or two persons from each local government. However, my main interests have been to collect information about motives and policy measures, information that is fairly robust with respect to the positive bias. Furthermore, this information has been checked against news media coverage and the local energy and climate plans. In addition, possible conflicts with respect to the development projects have not been the focus of the paper. Thus, I believe the data underlying the paper to be sufficient to address the research questions.

The interviews lasted on average 30 minutes and were transcribed in verbatim. They have been analysed, inspired by grounded theory, through the writing of summaries and notes based on the interviews [29]. The purpose has been to discover new and interesting aspects of the development process, with a focus on innovation, infrastructure, regulation and public engagement as a point of departure. The interviews were conducted in Norwegian, and I have translated the quotes used in the paper.

In addition to the interviews, the paper is based on qualitative content analysis of local government energy and climate plans. Energy and climate plans have been imposed on local governments by national authorities (with a 2010 deadline). Today, most local governments have such plans, but there are large differences with respect to the specification of the goals and the degree to which the plans are actually followed through and used in the local governments' renewable-energy work. Energy and climate plans are one of the most important documents in order to describe the status of local energy and climate issues. They outline the current energy situation in the local community, and what plans the local government has to increase use of renewable energy and promote energy efficiency. In the content analysis, I have gone through the plans in detail, studying the goals they have, how they plan to achieve their goals and who they are going to cooperate with. I have used the plans both as an important document of information, and as a second source where I can compare the information given in the interviews.

In the following, I will present an overview of the information collected about the 14 local governments and their projects, including the technology employed, the role of the local governments, and their motivation for participating in the projects. I then continue with a more detailed analysis of the local governments' technology policies. This analysis has been structured using Sørensens [1] four dimensions of technology policies.

3.1. Local government enacting bioenergy development

As noted, an important part of Norway's efforts to support sustainable energy and climate mitigation has been to require local governments to develop so-called energy and climate plans. By November 2014, 412 of 431 local governments had passed such plans [30]. Thus, in theory, nearly all local governments in Norway have adopted some kind of technology policy that focuses on sustainable energy and climate mitigation. In this paper, I analyse 14 cases concerned with bioenergy developments to study the content of such policies.

Table 1 provides a brief overview of the 14 local governments studied, with an emphasis on the technologies and policy instruments used, the role of the local government and its motives, and the importance attached to local resources as a reason for the engagement. The idea underlying the national government's initiative to make local governments produce energy and climate plans was that these plans

Table 1: Overview of the bioenergy initiatives of the 14 surveyed local governments.

Local gov. population	Technology in focus	Policy instruments applied	Role of the local government	Motives of the local government	Use of local resources
Averøy[1] 5600	Production of wood chippings	LG plans, easy case handling. Info. about renewable energy, energy efficiency, phasing out fossil fuel.	Facilitator	Employment, climate. Using local resources in long-term.	Long-term goal
Bergen, city 263 000	Garbage incineration producing heat	LG plans and regulations. Area planning. Environmental requests in purchasing.	Establisher in coop. with private comp.	Reduce climate emissions and solve garbage problem.	Local garbage
Harstad, city 23 700	District heating	Planning and building act. Area and transport planning, district heating, coalescing.	Facilitator and customer	Increased local activity, employment. Climate.	Local farmers involved
Levanger, city 19 000	District heating	Support local farmers. Help develop a local bioenergy company. Area planning, alt. transport.	Customer and supporter of local actors.	Pol. interest in bioenergy on local resources. Increased activity, employment.	Local farmers involved
Nord-Odal 5000	District heating	Use district heating. Emphasizing environment in area planning and in case handling.	Initiator and customer	Energy efficiency, energy alteration, reduce emissions. Reduce expenses to heating.	Not today, but future goal
Rissa 6500	District heating	Area planning and regulations. Cooperation with other LG concerning energy efficiency.	Initiator and customer	Reduce emissions. Alternative use of the forest, new industry. Income.	Local splinters
Røros 5600	District heating	Planning and building act. Transport planning. Produce more renewable energy.	Initiator together with Røros Energy	Alternative ways of using local resources. Produce renewable energy	Future goal
Stryn 7000	District heating. Biofuel gas station for use in LG cars.	Planning and building act, regulation plans.	Initiator	Local resources, employment. Sustain. dev. Climate changes.	Main goal
Sunndal 7200 inhabitants	District heating from surplus heat	Establish expertise. Area planning, transport planning. Produce hydro power, develop power stations.	Initiator	Environmental and climate focus.	Local surplus heating
Trondheim, city 177 000	District heating	Using area, parking and transport planning. Green tax to support environmentally friendly transport.	Mainly involved in the area plan. .	Environment and emissions. Focus on climate and energy.	Raw materials from Sweden
Trysil 6600	District heating. Gas station for biofuel.	Planning and building act. Cooperation with other local governments.	Initiator.	Use excess heat. Climate neutrality for stationary energy use. Develop trade.	Local resources and contractors
Ullensaker, city 31 000	District heating	Transport planning. LG as ECO-lighthouse certifier.	No particular.	Climate neutral energy for heating.	Partly use of local resources.
Vik 2700	District heating + splinter prod.	LG involvement and support of local actors. LG use of district heating in buildings.	Initiator, later participator.	Reduced emissions. Climate change. Increased local activity.	Use of local resources
Åsnes 7600	District heating	Energy and climate plan. Transport and area planning.	Initiator and owner	Reduce emissions combined with carbon binding. Financial savings.	No plan of using local resources

could be instrumental in encouraging local initiatives to achieve climate mitigation in the area of energy. That is, the main motive was related to climate change concerns. However, previous studies of local governments' activities with respect to innovation and the use of new technologies highlighted economic motives, mainly related to local employment and income [19, 31]. While climate concerns would make reduced emission of CO2 the main motive, worries related to local economy could be expected to be the main shaping force of the choice of projects to pursue. In the latter case, we should observe that local governments' initiatives to help develop bioenergy in their community would reflect interests like use of local resources, increased income for farmers and other land owners, and increased local employment. So what did we find?

First, Table 1 shows that in most cases, the choice of technology to produce bioenergy seems rather standardised. Most of the projects focused on district heating, and the bioenergy innovations seem to be about exploiting local conditions for the production of heat. The gradual development of the projects and in accordance with local resources enabled the participation of local actors. This was often vital, especially in smaller communities. Also, the concept of district heating offers particularly good options for local governments to play a decisive role in preparing effectively for the development, since they may exercise control of the infrastructure – the heat grid – and to some extent also with respect to the demand for heat as a large building owner and as a regulator that may demand other building owners to use heat.

Second, most of these local governments have themselves taken the initiative to develop bioenergy, either on their own or in cooperation with other actors. This means that they actively chose to engage with a particular technology based on available resources. This contrasts with national governments, which tend to offer general support schemes for innovation, rather than becoming directly involved with concrete technological developments.

Third, the most important policy instrument for these local governments seems to be local government plans (mainly zoning plans) that are used to establish profitable district-heating markets. Through housing and industry development that emphasizes density, the district heating net will have more customers within a smaller radius. Local governments are also able to require connections to the district heating net for all new buildings or buildings over a certain size. These actions will in many cases be deciding for the cost-benefit of district-heating development. This means that the innovation activity mainly is related to making a new local market for heat as well as utilizing local bioenergy resources. In addition, the applied technology policy involves measures with respect to infrastructure development and regulatory actions.

Fourth, the motives of these local governments for developing their bioenergy projects were two-fold. The larger (often urban) local governments seem to have had a relatively strong environmental focus. Their main motive was to reduce emissions and promote climate and environmental concerns. On the other hand, the smaller local governments seem mainly to have been concerned with developing local trade, employment, and increased economic activity, even though some of them also claimed to have had a clear climate focus.

Fifth and related to the fourth point, is the use of local resources. This was considered important, especially by the smaller local governments since the development of trade and employment related to bioenergy was seen to be intimately linked to putting local resources to use in a way that would benefit landowners as well as local industry. Typically, local farmers and wood owners often want to deliver raw materials to the production of splinters, or actually themselves produce splinters to district heating. In most cases this is seen as an alternative use of forests and forest residues, and it does not require a lot of labour. Still, it may be an important income for small farms. Some of the local farmers and forest owners responded to the new market and demand for raw materials from forest residues by forming small companies either on their own or with the local government as a coordinator.

In the next section, I analyse in greater detail these local governments' technology policies to engage with bioenergy innovations and developments. I use quotes and examples from the interviews to illustrate the involvement of local governments in these four areas, and how their technology policies may look in practice. I start by addressing the local governments' technology policy: I study their support of innovation and see if they contribute in developing infrastructure and how they act concerning regulations, then I study their participation in developing local bioenergy projects.

3.2. Technology policies to support innovation

National and local technology policies have some distinct differences. At the national level, policies are technology neutral. Thus, they are not specifically aimed at supporting particular projects or technologies. At the local level, there is more room for directing policies toward particular areas that the local government want to ensure further development.

Table 1 shows that the analysed local governments have technology policies; this is evident in how they support innovation. Still, it is challenging to identify the different elements of their support, not the least because of the low level of deliberation with respect to such policies. To begin with, it seems that the most commonly used policy instrument was local government plans (or regulations). These policies instruments were used to ease the transition of the new technology and to make the projects more profitable for the innovators by establishing a market, for instance in passing mandatory affiliation to the district heating net.

It is not clear how innovation happens locally, but it has been stated that it does [3]. We know that local-government innovation differs substantially from that of the national level [21] which often focuses on financial support as well as R&D; innovation in local governments has a different focus and more limited financial and human resources. So how does local innovation happen? Who are the main actors and how do they act?

In the case of Levanger, the local government had for a long time wanted to replace the 1950s oil boilers in the community with environmentally friendly district heating. To do so, it established agreements with local actors to provide the local government's buildings with district heat. Further, Levanger's local government had a strong focus on using local contractors and raw materials and required the biomass used for the district heating to be delivered from local sources. This has been important to the politicians and has had a positive side effect: increased local activity. The manager at Levanger's Department of construction and building stated that: "It has been one of the main concerns of our politicians that we are going to be able to build some local trade here, based on bioenergy."[2]

Today, the local government buys district heating from three different actors. Together, they heat five buildings owned by the local government. The manager went on to say that bioenergy: "was part of the action list in the energy and climate plan from 2001. It says very clearly that the local government is going to place a priority on bioenergy, among other things. But also … the heat pump technology we are also going to start using, and we do that now in one building. We who work in the administration use the politically adopted climate and energy plan".[3]

Because the investment was too large for Levanger's local government to handle on its own, it was important for them to refrain from getting involved financially. Instead, their strategy was to buy district heating by requesting bids from interested suppliers. In this phase of the process, all who wanted to deliver district heating was invited to take part. Thus, the local government stimulated local bioenergy developments by buying district heating, but without any further involvement. The supplier is expected to take care of the delivery, maintenance, etc.

The municipality of Vik shares some of Levanger's background. This local government was one of the first in Norway to establish a local bioenergy pilot project—15 years ago (in the mid1990s). The project started because Vik had been selected as a reference local government in a national waste-sorting project. Vik's project leader disagreed with the local government's waste treatment, in which all the waste was sorted and shipped out of the region. The suggestion was to use some of the waste locally, particularly paper, pasteboard, and some wood and production remnants from the furniture industry, to produce fire briquettes. At that time, this idea was rather innovative, and the establishment of the district heating plant was difficult politically, due to a constant shifting of the political majority.

Vik's district heating plant was built, as well as the piping, and the electrical heating elements in the ventilation system were replaced with water-based heating. Today, some of the local farmers have taken the initiative to develop a new bioenergy industry: producing wood chips or splinters from trees harvested from the local forest. After the farmers contacted their local government, there was a meeting of all interested parties, including representatives from the county administration who contributed information. After the meeting, a work group was established to explore the possibilities for small-scale production of wood chips or splinters. The already established wood-chips plant in the local community centre is the basis for the initiative and a customer of local wood chips and splinters.

Local governments have been shown to be a major actor in local innovation, either alone or in cooperation with others, such as farmers, local trade and business. As

well as financial support, they offer information and encouragement and they help establish markets for new industry. Typically, this would be via a mandatory connection to the district heating net or a political resolution to use district heating in local government buildings.

Local innovation is also characterised by its more "hands-on" approach towards local initiatives and innovation. Often, in spite of limited resources, local governments are able to help actors who have a business idea; they have opportunities to contribute with information and employees who can help them further in the innovation process.

3.3. Construction of infrastructure

The construction of infrastructure is one of local governments' most challenging tasks, both financially and politically. Infrastructure development, both the development of the net and the related large changes to the landscape, affects substantial parts of the population. Table 1 shows that the technologies used by local governments are diverse but usually they require fairly large infrastructure developments. How was this solved by the local governments?

The cost of a net to distribute the heat to all users is expensive and can be difficult for any developer to handle financially, whether the developer is a private actor, local government, or public-private partnership. Let us consider some examples and start by considering a district heating project started in the municipality of Sunndal in 2004. For a long time, there had been discussions between the local government and Hydro Aluminium [a large factory producing aluminium] concerning cooperation, and both parties were interested in using the waste-heat from Hydro to heat buildings in Sunndalsøra. Usually, a project like this would have been too expensive, but when Hydro was ready to modernize its aluminium plant, the timing was opportune. The district heating net is between six and seven kilometres long, and today 30% of the district's heating needs is covered by waste-heat, a percentage that is one of the highest in Norway.

The project received an investment grant from the Norwegian energy directorate Enova totalling about 12–13 % in 2004, approximately 7 mill NOK of the total investment of 60 mill NOK. The next step in the development is to connect the existing buildings, and to do this, financial support will be necessary, from either the local government energy fund or Enova.

In a second case, the municipality of Åsnes, the district heating net has been extended gradually. Its local government has established a district-heating company in partnership with two relatively large private actors: Eidsiva District Heating (33 %) and Solør Bioenergy (41 %). The company's main purpose is to supply district heating to public buildings owned by the local government and the buildings of the county administration.

Further development of the project and the district heating net is planned; the licensing area is quite large, and the project's cost-benefit ratio will determine how much of the licensing area that will be developed. Åsnes' project manager explained that the project will start with local government buildings and county administration buildings:

"So public buildings, but also private buildings in what we call proximity, close to the city centre. In the more peripheral areas, farther from the city centre … characterized by single family homes … they will be involved in a later stage of the development. The economy of this is constantly considered, but the licensing area (at NVE) is quite large and ambiguous. It's not expected to be [fully] developed from day one. Those who bring in most money, accordingly the big actors first; the nursing home, the city hall, junior high school, high school and so on".[4]

It is obvious that infrastructure development to cater for local use of bioenergy is one of the most practically and financially challenging tasks for all local governments. Infrastructure development often depends on cooperation with developers or on financial support from external actors such as national authorities. Still, we have seen that many local governments have managed to develop the infrastructure needed to establish bioenergy production.

4. Regulations

Local governments have several technology policy tools available, including local government plans, support in terms of financial grants or information, and direct involvement in projects. Do they use these tools, and if so, which ones? Table 1 shows that the policy tool most commonly used by the local governments in this study is regulations, exploiting local government regulation plans to their fullest extent to promote bioenergy development. How do they act to make it easier for bioenergy actors to establish in the local community?

The local government of the municipality of Stryn decided not to pass mandatory connection to the heat grid but demanded that all the buildings used or rented by the local government should have environmentally friendly heating. While Stryn's local government and the work group were planning bioenergy production, much of the bioenergy mass in the municipality disappeared because some lumber companies had started to use the biomass themselves for splinter production. A local company in Stryn, The Olav Tenden Company, decided to produce splinters with the necessary degree of dryness themselves, which turned out to be a good solution. Because the splinters had to go through a drying process to get the optimal humidity, the price of the district-heating energy was higher than the price of electricity. Still, according to the local government, a surprisingly large number of companies chose to connect to the district heating net.

A third case is the small city of Røros, where large parts of the centre already were covered by its district heating net. Recently, however, a new multipurpose hall was connected; the church, hotels, schools, nursing homes, other large buildings, and private industry were already linked to the heat net. Røros's district heating net also delivers some heat to the neighbouring local community. The mayor was very happy with the role the local energy company has taken on: "I have to brag about the local energy company, which our local government owns by two-thirds. It has its own wood-chippings factory. Unfortunately, we are not able to use our own birch trees in the plant, but research is being done to make this possible".[5]

Still, developing a large district-heating net can be a considerable challenge. In the municipality of Trysil, a fourth case, the development of the net required a lot of work from its local government. As Trysil's mayor said: "When there is 10 kilometres of district-heating pipes, it is evident that it's a case in itself. It has to be planned."[6]

In addition to the cost, the district-heating project has faced other start-up challenges that the mayor commented on: "It has been a mix of idealism, using local resources and of course, making money. The district-heating company does make money, but we keep the money in the company for further development. We don't pay out any profits".[7]

The main policy tools of local governments with respect to regulations were the area and regulation plans of the local government. By using these, they could to a large degree develop both infrastructure and housing in a way that maximizes the profits from district heating development and reduces emissions. In addition, to secure the market for the district heating developers, some local governments have passed regulations for mandatory connection to the district heating net for new or rehabilitated buildings over a certain size.

5. Public engagement

Several of the bioenergy developments in this study involve local actors (see Table 1). Did this result from a conscious strategy to secure local support for these projects? In some cases, involving local inhabitants has been important to building acceptance for the project; increased employment or business income for local actors seems to have had a positive effect on the attitudes.

In the municipality of Levanger, the bioenergy developers were invited to several public meetings during the process. Besides involving the inhabitants in general, the local government set a condition that local farmers should have opportunities to deliver raw materials to the district-heating plant. As a result, several of Levanger's local farmers have established companies or cooperatives to deliver wood splinters or bricks to the companies that deliver district heating in the area. This meant a positive level of engagement.

In the city of Harstad, there was according to the interviewed mayor much debate concerning its district heating plant, both about the establishment itself and more practical problems like the excavation of ditches. A major focus of this debate was on the anticipated effect on air quality and the fear that the district heating plant would produce air pollution that exceeded the legal level, but there were other issues, too. The mayor said further that the plant was located in Harstadbotn just outside Harstad's city centre, and this had also been an issue. A lot of people thought that the plant should have been located further from the city centre and were sceptic for this reason.

A third example, the municipality of Stryn, had a strong focus on using local resources and has involved its local inhabitants, in particular, local farmers, in the process of developing bioenergy. Stryn's energy and environment plan targets increasing the use, production and trading of biofuel or biogas, with an emphasis on local projects. One of its goals was the establishment of a pilot project with Fjordane Bioenergy to produce bioenergy from the forest in Stryn.

With respect to local trade development, the effect had not been great. According to the interviewee from Stryn's local government, the companies involved in the project would have existed anyway. But there has been increased employment at the Olav Tenden Company; the local splinter producer. This company had used the opportunity to produce more splinters and now also serves the neighbouring county, Møre og Romsdal.

The city of Trondheim is probably the local government analysed in this paper that has had the greatest challenges regarding public engagement with respect to bioenergy developments. A large district heating plant has been under construction in a densely populated area with several other projects under development at the same time. Local inhabitants have been critical to the lack of a coherent plan for the whole area, which in turn led to worries about further developments. The local government planner had also noticed the skepticism of the inhabitants:

"We have had two or three public meetings with many attendees and high temperature. I was not surprised by the temperature. It was as I expected; people didn't come to the meeting to get information about the plant, they came to let us know that this is something they didn't want to be studied.[8]*… Their worries concern several issues, for example, how the traffic flow will develop. The raw materials need to be transported to the plant …. People are worried about increased traffic, noise and the potential emissions and pollution from the plant. They are also worried about the aesthetics; it's a large plant and even though there is a factory there already … they are insecure, they think it will be a foreign element".*[9]

The public can participate in bioenergy development in several ways. Some of the larger developments inform citizens via public meetings; this is often a condition in the license needed for large constructions. The smaller projects in this study, which often develop gradually, have not held any public information meetings.

5.1. Conclusion: Re-assembling local technology policy

In this paper, I started out with a hypothesis that most local governments did not support innovation like national governments through R&D and market-based instruments. Rather, I assumed local governments to build infrastructure and make regulations to facilitate local innovation, partly based on energy and climate plans. Both these expectations have been confirmed.

More generally, the paper has explored the strategies and policy instruments that were used to promote bioenergy by local governments. Previous research has shown that local governments play an important role in local innovation processes, but also that this role seems to be restricted by their financial and developmental capacities. In addition, other, more specific local conditions like engagement of the community [19] and cooperation with local actors were expected to influence the outcome of the innovation process [18]. This has also been confirmed. Further, all the 14 local governments studied is seen to exercise technology policy in the sense that they take steps to help bioenergy initiatives succeed. A striking feature of this policy is that it is direct in the sense that it supports specific technologies and actors. More concretely, nearly all projects analysed were concerned with developing district heating.

Perhaps unsurprisingly, given the findings of previous studies, none of the climate and energy plans passed by the analysed local governments was based on an articulated technology policy. Thus, the technology policies implicitly used had to be re-assembled. The result is presented in Figure 1. It shows that local governments apply measures along all the dimensions proposed by Sørensen (2002): innovation support, infrastructure development, regulation, and public participation. Further, the main overall instrument is to create local demand for heat in a way that secures a stable market and thus considerably reduce the risks involved in the innovation process. Thus, Figure 1 proposes a general model of the technology policy of local governments based on the empirical analysis of their engagement with bioenergy in the local community. Clearly, it extends the reviewed literature with respect to how local governments engage with renewable energy

Figure 1 departs from Sørensen's [1] four areas of technology policy. However, his point of departure was national policies. Still, the paper shows that his framework is fruitful also for analysis of local governments' efforts even if national policies have a different emphasis through their use of general – usually market based – instruments. This is a contrast to local governments' technology policy which is particular in terms of technologies and actors. This is evident from the prevalent effort to promote district heating. However, it should be noted that the findings in this paper emphasise that all four areas are important to local

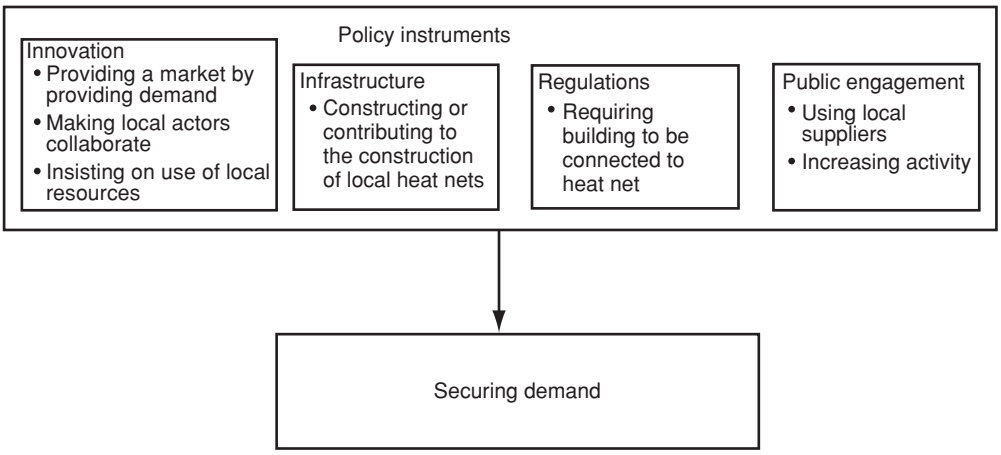

Figure 1: Model of local governments' technology policy.

governments' technology policy, even if the content is different from what is observed with respect to national governments.

Does this reflect the policies of the Norwegian government? Only in a general way. The main instrument offered to local governments is contained in the Planning and Building Act, which offers possibilities to regulate local construction efforts. The required local energy and climate plans are expected mainly to make local governments become more concerned with climate and energy issues, not to provide any substantial guidance about what to do. The national energy agency Enova provides more advice but still at a general level. Thus, local governments are given some important instruments with respect to local infrastructure and building projects, but not much direction. Further, they do not have any effective financial instruments at their disposal, beyond the possibility of providing some economic support to projects.

To some extent, this may explain the prevalent choice of supporting bioenergy for district heating. First, such initiatives utilize local resources. Thus, they generate local income, maybe also employment. Second, district heating is an objective that may be pursued by the regulation tools given to local governments by the Planning and Building Act. This act allows the local government to require new building projects to make use of such a particular source of heat. Further, since local governments own a lot of local buildings, it may itself decide to change the supply of heat to district heating. Another common feature of all the district heating projects studied is the potential these projects have to make the local government involve local actors, a potential less obviously available to other kinds of bioenergy initiatives

The model in this paper is based on data from Norwegian local governments. We have seen that local governments analysed have had a "hands on" approach with respect to bioenergy developments, targeting particular technologies and actors. This form of technology policy may be as a result of the fairly autonomous role of local governments in Norway, where considerable room for decision-making is delegated to the local community. If such autonomy of decision-making is present, there are good reasons to believe that the model in Figure 1 is valid. This is because local governments usually lack access to non-specific market-based instruments. Such instruments are normally only available to large regions or nation states.

References

1. Sørensen, K.H., *Providing, pushing and policing. Towards a new architecture of technology policy.*, in *Technology studies and sustainable development.*, A. Jamison and H. Rohracher, Editors. 2002, Profil: München, Germany. p. 65–94.
2. Seyfang, G. and A. Smith, *Grassroots innovations for sustainable development: Towards a new research and policy agenda.* Environmental Politics, 2007. **16**(4): p. 584–603 *http://www.tandfonline.com/doi/pdf/10.1080/09644010701419121*.
3. Lundvall, B.-Å. and S. Borrás, *The globalising learning economy: Implications for innovation policy*. 1997: Aalborg and Copenhagen. p. *http://www.globelicsacademy.org/2011_pdf/Lundvall%20Borras%201997.pdf*.

4. Aarsæther, N., *Innovations in the Nordic Periphery*, in *Nordregio Report*, N. Aarsæther, Editor. 2004, Nordregio: Stockholm, Sweden. p. *http://www.diva-portal.org/smash/get/diva2:700448/FULLTEXT01.pdf*.
5. Ringholm, T., H. Teigen, and N. Aarsæther, *Innovative local governments [Innovative kommuner]*, ed. T.R. (ed), H.T. (ed), and N.A. (ed). 2013: Cappelen Damm akademisk.
6. White, R. and A. Stirling, *Sustaining trajectories towards Sustainability: Dynamics and diversity in UK communal growing activities.* Global Environmental Change, 2013. **23**: p. 838-846 *http://ac.els-cdn.com/S0959378013001039/1-s2.0-S0959378013001039-main.pdf?_tid=2ba18f7a-a098-11e4-ac01-00000aab0f6c&acdnat=1421753795_5531523a01a29503bd08d790df9487a1*.
7. Hielscher, S., *Community Energy in the UK. A Review of the Research Literature.* 2011. p. *https://grassrootsinnovations.files.wordpress.com/2012/03/cise-literature-review.pdf*.
8. Hielscher, S., G. Seyfang, and A. Smith, *Community Innovation for Sustainable Energy*, in *CSERGE Working Paper 2011-03*. 2011, CSERGE (Centre for Social and Economic Research on the Global Environment). p. *http://www.cserge.ac.uk/sites/default/files/2011–03.pdf*.
9. Enova, *All local governments should have an energy and climate plan. Here you get to know why - and how it is formulated [Alle kommuner bør ha en energi og klimaplan. Her får du vite hvorfor - og hvordan den utarbeides]*. 2007, Enova SF. p. *http://www2.enova.no/minas27/publicationdetails.aspx?publicationID=259*.
10. Harevold, K. and L.C. Risan, *Local government climate and energy planning [Kommunal klima og energiplanlegging]*, in *Climate-environment and sustainable development [Klima- miljø og bærekraftig utvikling]*. 2010, NIBR Norwegian Institue for Urban and Regional Research. p. *http://www.nibr.no/filer/2010-107.pdf*.
11. Denis, G.S. and P. Parker, *Community energy planning in Canada: The role of renewable energy.* Renewable and Sustainable Energy Reviews, 2009. **13**(8): p. 2088-2095 *http://ac.els-cdn.com/S1364032108001767/1-s2.0-S1364032108001767-main.pdf?_tid=65721d70-a09b-11e4-99c5-00000aacb35e&acdnat=1421755181_94dd3d4c7f42ffde38f98abe71758a69*.
12. Nilsson, J.S. and A. Mårtensson, *Municipal energy-planning and development of local energy-systems.* Applied Energy, 2003. **76**(1-3): p. 179-187 *http://ac.els-cdn.com/S030626190300062X/1-s2.0-S030626190300062X-main.pdf?_tid=90833e7c-a09b-11e4-b964-00000aab0f27&acdnat=1421755253_cc1f56d65fcf3a3f8b9f9221af6f1d2a*.
13. Palm, J., *Development of sustainable energy systems in Swedish municipalities: A matter of path dependency and power relations.* Local Environment, 2006. **11**(4): p. 445–457 *http://www.tandfonline.com/doi/pdf/10.1080/13549830600785613*.
14. Sperling, K., F. Hvelpelund, and B.V. Mathiesen, *Centralisation and decentralisation in strategic municipal energy planning in Denmark.* Energy Policy, 2011. **39**(3): p. 1338–1351.
15. Meyer, N.I., B.V. Mathiesen, and F. Hvelplund, *Barriers and Potential Solutions of Energy Renovation of Buildings in Denmark.* International journal of Sustainable Energy Planning and Management, 2014. **1**: p. 59–66 *http://journals.aau.dk/index.php/sepm/article/view/549/480*.
16. Solomon, B.D. and K. Krishna, *The coming sustainable energy transition: History, strategies and outlook.* Energy Policy, 2011. **39**: p. 7422-7431 *http://ac.els-cdn.com/S0301421511006987/1-s2.0-S0301421511006987-main.pdf?_tid=2b999fbe-a09c-11e4-9014-00000aab0f27&acdnat=1421755514_3a245cdafddc4434eb825e07f49685c5*.
17. Asheim, B.T. and A. Isaksen, *Regional Innovation Systems: The Integration of Local "Sticky" and Global "Ubiquitous" Knowledge.* . Journal of Technology Transfer, 2002. **27**: p. 77–86.
18. Walker, G.P., et al., *Harnessing Community Energies: Explaining and Evaluating Community-Based Localism in Renewable Energy Policy in the UK.* Global Environmental Politics, 2007. **7**(2): p. 64–82.
19. Mangoyana, R.B. and T.F. Smith, *Dectralized bioenergy systems: A review of opportunities and threats.* Energy Policy, 2011. **39**(3): p. 1286-1295 *http://ac.els-cdn.com/S0301421510008815/1-s2.0-S0301421510008815-main.pdf?_tid=e7160c00-a09c-11e4-a7b2-00000aab0f01&acdnat=1421755828_8edde52323b79d8e19ca19ab5d05f4e6*.
20. Summerton, J., *District heating comes to town: The social shaping of an energy system*, in *Faculty of philosophy, Technology and Social Change*. 1992, Lindköpings universitet: Lindköping. p. 319.
21. Asheim, B.T. and L. Coenen, *Knowledge bases and regional innovation systems: Comparing Nordic Clusters.* Research Policy, 2005. **34**: p. 1173-1190 *http://ac.els-cdn.com/S0048733305001101/1-s2.0-S0048733305001101-main.pdf?_tid=0cd8704a-a09d-11e4-99f4-00000aacb35d&acdnat=1421755891_29c076e217b4491d562cce6a3b58f4e1*.
22. Cooke, P., *Transition regions: Regional-national eco-innovation systems and strategies.* Progress in Planning, 2011. **76**(3): p. 105-146 *http://ac.els-cdn.com/S030590061100050X/1-s2.0-S030590061100050X-main.pdf?_tid=46db4998-a09d-11e4-99d3-00000aacb362&acdnat=1421755988_4696f1aaada5dbbefe751c72e0217dc5*.
23. Khan, J., *The importance of local context in the planning of environmental projects: examples from two biogas cases.* Local Environment, 2005. **10**(2): p. 125-140 *http://www.tandfonline.com/doi/pdf/10.1080/1354983052000330815*.

24. Peters, M., S. Fudge, and P. Sinclair, *Mobilising community action towards a low-carbon future: Opportunities and challenges for local government in the UK*. Energy Policy, 2010. **38**(12): p. 7596-7603 *http://ac.els-cdn.com/S0301421510000728/1-s2.0-S0301421510000728-main.pdf?_tid=963b36a6-a09d-11e4-af90-00000aacb361&acdnat=1421756121_0a21f67ed49405cb6af918868c27b6d5*.

25. Teigen, H., T. Skjeggedal, and A. Skålholt, *Local governments work on innovation - an analysis of policy instruments and policy instrument actors [Kommunesektorens innovasjonsarbeid - ein analyse av verkemidlar og verkemiddelaktørar]*. 2010, Østlandsforskning: Lillehammer, Norway. p. *http://www.ks.no/PageFiles/ 14427/ 104017%20Den%20innovative%20kommune%20-%20rapport.pdf*.

26. Hughes, T.P., *The Evolution of Large Technical Systems*, in *The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology.*, W.E. Bijker, T.p. Hughes, and T. Pinch, Editors. 1984, Massachusetts Institue of Technology: Massachusetts

27. Rygg, B.J., *Wind power-An assault on local landscapes or an opportunity for modernization?* Energy Policy, 2012. **48**: p. 167–175 *http://ac.els-cdn.com/S0301421512004016/1-s2.0-S0301421512004016-main.pdf?_tid=d2656e94-a09d-11e4-9af4-00000aacb35f&acdnat=1421756222_2bdcc6fe5c0691e34aeb9302206a39ea*.

28. Latour, B., *Reassembling the Social. An introduction to Actor-Network Theory*. 2005, Oxford: Oxford University Press.

29. Strauss, A. and J. Corbin, *Basics of Qualitative Research. Grounded Theory Procedures and Techniques*. 1990, US: Sage Publications Inc.

30. Enova. *Local governments work concerning climate and energy [Kommunenes arbeid med klima og energi]*. 2013 [cited 2013 November 21st.]; Available from: *http://www.klimakommune.enova.no/sitepageview.aspx?sitepageid=1416*.

31. McCormick, K. *Sustainable Bioenergy Systems: Experiences from Sweden*. in *Sustainable Consumption and Production*. 2005. Melbourne, Australia: International Institute for Industrial Environmental Economics (IIIEE).

Notes

[1]The plant is now closed due to lack of profit and technical problems.
[2]Manager at the department of construction and building, Levanger, p. 3.
[3]Manager at the department of construction and building, Levanger, p. 2.
[4]Project leader, Åsnes p. 2.
[5]Mayor, Røros. p. 1.
[6]Mayor, Trysil, p. 7.
[7]Mayor, Trysil, p. 4.
[8]Local government planner, Trondheim, p. 3–4.
[9]Local government planner, Trondheim, p. 3.