Learning and Interaction within the Bio Energy for Heating Purposes Industry -
A Comparative Study of Hadeland and Buskerud

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Abstract

This thesis is a comparative study on learning and interaction in regional systems of innovation within the bio energy for heating purposes industry at Hadeland and Buskerud. The systemic perspective on innovation has been employed as an analytical framework in order to grasp all aspects of initiatives and activities in its social, institutional and cultural context. The context is to a certain degree path dependent and therefore regional-specific. The comparative approach enables the identification of strengths and weaknesses in the two regional efforts.

Whereas learning and interaction were characterized by co-shaping and an including bottom-up strategy in Buskerud, there were traces of a non-relational top-down attitude in the Hadeland region. The failure of an abrupt creation of an industry cluster indicate that the path creation effort at Hadeland where largely path dependent while the to a great extent successful path creation almost “from scratch” in Buskerud proved not to be. Although there has been former, successful attempts of bio energy efforts in the Hadeland region, inner rivalry and the absence of outside-regional relationships at Hadeland seems to be the main obstacles to new and continued activity in the region. The lack of system openness may have contributed to a diminishing intensity of activity and initiatives in general. There is also a need to reduce uncertainty in order to stabilize the institutional set-up. In Buskerud the public project functions as a hub for relational know-who and technological know-how. There is thus a more pro-relational-friendly climate within the region. There are also established several outside-regional relationships that might be beneficial to new and continued activity. Nevertheless, the growing tendency of division of actors according to size and significance due to fierce competition and decreasing returns may hamper the established system of openness. Another hindrance might be the lack of a downstream perspective.
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List of keywords

Bio energy; interaction; learning; regional innovation system; path creation; path dependency; systemic
1 Introduction
Both the regions examined in this thesis are located in what is called the eastern part of Norway (Østlandet). Hadeland is the southern part of the County of Oppland. The region of Hadeland is made up of the three municipalities Gran, Jevnaker and Lunner, which are the home of 28 000 inhabitants\(^1\). Hadeland is seen as a traditional forest and agriculture region, but there are also some examples of industrial activity, primarily within glass works. The region is considered a pioneer in terms of bio energy efforts. Already in 1986 the local authorities drew up a heating plan for one of the villages at Hadeland, and the 1990s witnessed the establishment of several bio energy firms\(^2\). The public Bioreg project\(^3\) was initiated in 2003. Eidsalm Energy Farm\(^4\) (Energigården) located at Hadeland has been appointed a national bio energy information and competence center by the national government\(^5\).

The County of Buskerud shares a south western border with Hadeland. There are nearly 250,000 inhabitants\(^6\), and many of them live in the cities\(^7\). Trade and industry in the county is rather technology intensive and international oriented compared to many other counties\(^8\). The centralization tendency and the technology intensity notwithstanding, parts of the county are seen as traditional forest and agriculture regions in which the population is relatively wide-spread. These parts are to a great extent also home to the largest forest areas in the county, which is 10%

\(^{1}\) The Hadeland regional council website: http://www.regionhadeland.no/
\(^{2}\) The Bioreg project plan: http://www.bioreg.no/mikpublish/media/prosjektbeskrivelse.pdf
\(^{3}\) The Bioreg project: http://www.bioreg.no
\(^{4}\) The Energigården website: http://www.energigarden.no
\(^{5}\) The Hadeland newspaper online: http://www.hadeland.net/Nyheter/lokale_nyheter/article2612005.ece
\(^{6}\) Statistics Norway: http://www.ssb.no/aarbok/tab/tab-048.html
\(^{7}\) Statistics Norway: http://www.ssb.no/aarbok/tab/tab-055.html
of the total national area\(^9\). Significant bio fuel producers and heat entrepreneurs are located in
the region, but there were no coherent efforts as in the case of Hadeland until the county
authorities initiated the Increased use of bio energy project\(^{10}\) (Økt bruk av bioenergi i Buskerud)
in 2005. According to Innovation Norway\(^{11}\) Buskerud was the county investing most in bio
energy in 2006 through the bio energy program\(^{12}\) administered by the former.

The world has witnessed an increasing awareness of the environmental condition of the Earth,
and the need to reduce CO\(_2\) emissions is crucial. One effort in the right direction is the
replacement of fossil fuel like coal and oil with renewable energy sources. According to NoBio\(^{13}\)
bio energy is one of the most effective means in reducing emissions as it can replace fossil fuel,
which causes the majority of the emissions. Use of bio energy may also free valuable electricity
that is utilized for heating purposes today. In terms of economy, bio energy may be a significant
contributor as it is one of the cheapest efforts in reducing the emissions; the technology is
already known and implemented several places, and the implementations can be made locally.

There is a vast literature on renewable energy policy, but there has been a strong focus on wind
states that policy measures, targets and choices prove to be of vital importance for the success of

\[___\]

\(^{9}\) Statistics from State of the Environment Norway (Miljøstatus), a public initiative web site
maintained by the Norwegian Pollution Control Authority (SFT): http://buskerud.miljostatus.no/msf_theme
page.aspx?m=2648

\(^{10}\) The project website: http://www.e-plan.no/app/WebFormPhasesEdit.aspx?CustomerID=8&PlanID=276

\(^{11}\) The Innovation Norway website: http://www.invanor.no

\(^{12}\) The bio energy program website: http://www.invanor.no/templates/Page____49889.aspx

\(^{13}\) The Norwegian bio energy association: http://www.nobio.no
the bio energy industry development. Bjørnstad (2003a, 2003b) states that there are few studies devoted to knowledge development in the bio energy sector in an innovation system perspective. Most studies are seen from a reductionist point of view, i.e. their focus has been more or less isolated studies of the raw material situation, different technical solution, costs and policy. In his case study of a Norwegian region, he finds that fragmented and non-present vertical industry links hinder innovation and diffusion.

The Scandinavian countries are among the most prominent producers and users of bio energy. By 2000 bio energy had become a larger primary energy source than water (Hohle 2005). Sweden (91 TWh\(^{14}\)) and Finland (91 TWh) have implemented use of bio energy on a large scale, whilst Denmark has managed to incorporate 18 TWh despite its scarce forestry resources. Norway is the definite laggard with only 15 TWh per year. Christiansen (2002) gives an overview of the Norwegian renewable energy political climate in general, and concludes that there exist weak demand-side policies and fluctuating patterns in public priorities. Skagestad (2005) agrees and adds that Norway may be in a carbon lock-in situation in terms of our huge economical gains in fossil fuel and poor implementation of bio energy system infrastructure.

Similar to Bjørnstad I have chosen to employ a *systemic* approach to innovation, more specific a regional innovation system framework. A regional emphasize is preferred due to the geographical distinct areas examined (Asheim and Gertler 2005). It must however be stressed that systems are open in that activity and relationships may cross regions or national borders (ibid). Lundvall (1992) points out that systems of innovation are social systems, and a central

\(^{14}\) Watt hour is a unit of energy. 1 TWh = 10\(^3\) GWh = 10\(^6\) MWh = 10\(^9\) kWh.
activity in such a system is learning, which involves interaction between people. The degree of learning and interaction may be promoted or hindered by the institutional set-up, which can be both formal laws and informal codes of behavior, norms, routines etc. Hence, in order to compare the two regions, it is not only important to map the actors, but also investigate what shapes and regulates the interaction.

As mentioned above the technology utilized in bio energy for heating purposes is known and there are several examples of implementation. Therefore, this thesis regards not so much innovation in terms of new products or processes, but rather how to build up a new system of heating replacing the old. I seek to examine whether there are any differences in the two regions that can cause a more systemic interaction or different path in one or the other region, to what degree there is a different composition of actors and the extent to which they emphasize different aspects related to learning and interaction.

I have chosen to divide the thesis in two parts, one in which I map the actors, and another in which I look at how the interaction takes place. This does not imply that there are two separate fields of investigation, on the contrary.

The research questions intended to direct the thesis are therefore the following:

1. *Mapping the actors – are there any differences in composition of actors?*
2. *How does learning and interaction take place in the two regions?*

In the following chapter I will present the methodology of the thesis. Chapter 3 provides an
introduction to bio energy and bio energy for heating purposes in particular. Chapter 4 elaborates on the theories of the systemic perspective on innovation: regional systems of innovation and related theories of learning and interaction. The concept of the institutional set-up is explained, followed by a discussion on the interrelated concepts of path dependency and path creation. Chapter 5 maps the actors in the two regions and is thus a part of and a prerequisite for the more detailed analysis presented in chapter 6. This chapter aims to understand how learning and interaction in the two regions takes place and discusses opportunities for continued and new activity. The analysis also focuses on what policy implications can be derived from the identification of strengths and weaknesses. Chapter 7 summarizes the main points and identifies areas for further studies.

2 Methodology

2.1 The case study approach

The method chosen for this task is to conduct a qualitative cross-region comparative interview study. In addition to the interviews, I have made use of textual analysis of central documents, lists of grants regarding the national bio energy program administered by Innovation Norway, and participation at a seminar and demonstration held by the information and competence center, The Energy Farm.

Yin (2003, p.5) recommends a case study approach when three conditions are met; the form of research question is how/why, one focus on contemporary events and one does not require control of behavioral events. My aim was to understand how the network formation was built in the two regions and how the learning- and network effects might differ in the two regions. I was
investigating contemporary events, that are the current bio energy activities in the two regions, and my study did not require control of behavioral events. On the contrary, I wanted to find out how the actors were actually working and to what extent there existed a vibrant bio energy milieu within the two regions.

Although my aim was to map activity and see if such activity made up a system on a macro level - a regional level - interviews with people in the business on a micro level, is necessary to get the whole picture and to understand the dynamics between the actors, people who actually make up the system.

Skagestad (2005) refers to Flyvbjerg (2001) who argues that the choice of case is decided upon the anticipation of information content, based on already existing knowledge. Skagestad also refers to Ragin (2004) who points out that comparing two cases gives a more comprehensive insight when focusing on the differences and similarities than just one case.

I have chosen to utilize a comparative case study of the region of Hadeland and the County of Buskerud. It might seem strange to compare a region, Hadeland, with a whole county, Buskerud. I have nevertheless chosen these two units because I saw an opportunity to investigate and compare a region that commenced its bio energy efforts as early as the mid 1980s and has proven tracks of bio energy activity with a county that tops the statistics for investments in bio energy in 2006 according to the Innovation Norway bio energy program and seemingly recently started their bio energy efforts. It made me curious how Buskerud, that does not have any proven track record for bio energy (at least no written sources that can tell of the county's bio energy efforts) almost suddenly climbed to the top of the list, and if this has something to do with how the local
government and actors in the county behave and stake out the path. Are there any differences that can cause a more systemic interaction or different path in one of the units of analysis? Do they go in different directions, is there a difference in the composition of actors operating in the two regions, do they emphasize different aspects of bio energy etc.

There are some problems and pitfalls related to a case study approach. To what extent the results can be generalized, how to ensure the consistency of the research process and to what degree observations reflect the phenomena investigated. Kvale (2001) approaches these problems under the heading of generalizability, reliability and validity.

As to the issue of generalizability, there are different opinions to what degree the findings can be generalized from the study sample to the entire population. Kvale suggests the term analytical generalization, which regards use of an assertive logic, similar to the reasoning used by barristers in the court of law. It is based on an extensive examination as to what degree the findings can be used as guidance for what can happen in another situation. The researcher must be regarded as sufficiently convincing, and one must make the arguments explicit and specify the evidence. In this way, the researcher allows the reader to judge whether or not the findings can be generalized.

I am utilizing Kvale's definition of generalizability. This thesis is not an effort to present a definite finding that can be generalized, but an effort to present one of several possible perspectives on the subject matter, that is to understand learning and interaction in differing institutional set-ups.

Strong reliability ensures that the reader can easily trace and follow the steps in the research
process. The whole chapter on methodology is meant to ease the reader's understanding of my approach. Again, the reader is allowed to judge in this matter. As in a court room the question of guilt will be decided by looking at preferably all the possible sides of a case. I suggest that certain theories may be suitable for my findings and assert my conclusions on the basis of the findings.

Kvale notes that validity should not be understood as doing one check at the end of the research project. Instead, one should run through several quality controls during the process and maybe also reconsider focus along the way. As I talked to the informants and generally gained more insight into the field of research, I felt the need to reevaluate my initial plans. Furthermore, Kvale sees validity as a skill to counteract the possibility of a biased presentation. I hope I have managed to present the material as objectively as possible.

2.2 Selecting the informants

I started using an interview method called snowballing. The approach and the concept were introduced to me by my supervisor, Olav Wicken. As pointed out by Grønmo (2004), snowballing is a method of selection happening in accordance with the actors themselves. The first actor selected is asked to suggest a smaller number of other actors who can be included in the sampling. These are in turn asked to suggest further actors. The process goes on until the sampling is considered big enough. From the initial actor, the number of actors increases, just like a snowball getting bigger when rolled downhill. Bjornstad (2003b) also uses this method in his case study of bio energy actor formation, activity and learning links. He writes that he would “go out in the field and identify the actors one by one. The initial contact with the relevant actors
will result in that they refer to each other. Hence, they will contribute to identify the system, to
the extent it exists such a system”.

I started out with contacting the project managers for bio energy projects at Hadeland and
Buskerud, respectively Helge Midttun and Tom Christensen. In light of their position and
knowledge, I hoped they would help me identify actors and give me valuable information about
bio energy work in the two regions as well as elaborate on their daily work. Hence, I contacted
people and organizations they mentioned as important for the bio energy activity and whose
activity has led to bio energy use in practical life. I also met with Ole Bertil Grennæs, responsible
for the Innovation Norway bio energy program in the counties of Buskerud and Vestfold. In
addition to helping me identify actors, he gave me a list of all actors in Buskerud who had
received monetary help in connection with the bio energy program in 2005 and 2006. Syver
Aasberg, Innovation Norway division Oppland, gave me a similar list for Oppland County. These
lists and talking to the above mentioned people have been of invaluable help in identifying
activity and actors in the two regions.

Bryman (2004) argues that the problem with snowball sampling is that it is unlikely that the
sample will be representative of the population. One reason might be that the actors referring to
each other represent the same world view. Another might be that the actors contacted do not wish
to participate. The former is clearly a problem as I might risk ending up with only small or large
actors, a specific part of the value chain or a certain consortium of actors cooperating. Most of
my informants referred to people with whom their relationship was good, but some also
mentioned their competitors or persons with whom they had no contact. As to the latter, the vast
majority of the actors I contacted were more than willing to let me steal between half an hour and an hour and a half of their time for an interview.

Although one might never be able to capture and understand all the links and activity, I feel that I spoke to enough people to create a picture of the activity in the two regions in terms of types of projects, types of actors, and future and past paths of action.

All in all I interviewed 18 people involved in bio energy activities in the two regions, 10 informants from Buskerud and 8 located at Hadeland. The bio energy industry for heating purposes is rather small, and even on a cross-regional- or national basis, people know each other and may be easily identified. Except the initial key persons, the informant’s name, type of work and function is not revealed. The source of quotes and other information is therefore referred to by the anonymous word “informant”. An example would be that “one informant pointed out that....” For the same reason, I have not included a list of informants in this thesis.

2.3 Conducting the interviews

The initial interviews with key informants were conducted by meeting personally with the informants. This because it is easier to talk face-to-face to people as facial expressions are a big part of communication, because I brought an actor scheme for them to help me fill in, and because these interviews took just about 1 ½ hour. It was simply more convenient to meet them in person. The subsequent interviews were conducted by phone, and lasted around ½ hour. When asking for an interview, I referred to the person who had recommended him/her and presented my objective and general focus of my research task. I had already worked out an interview
guide, but this guide turned out to be more of a structure for the interviews in order to initiate a conversation. I soon learned that many interesting topics and answers came up as a consequence of letting the informants speak freely, and most of the interviews are conducted according to this loosely, but guiding strategy, which let people reflect and elaborate on their own perceptions and daily work. Some times, it was natural to ask additional questions, which again helped me to clarify my objective and refine my understanding of my research. The interview guide for the key informants differs from the other informant's interview guide because I asked them to help me map activity in addition to their daily work. All quotes have been approved by the informants.

3 On bio energy

3.1 Use and potential

Bio energy is the largest of the renewable sources, and the global use of bio energy is over 14 PWh, which is 15% of the total global energy consumption, this includes the use of non-processed wood as utilized in ordinary wood stoves\textsuperscript{15}. The total bio mass growth on land equals an energy amount of 660 000 TWh/year\textsuperscript{16}

\textsuperscript{15} Hohle (2001), p. 13
\textsuperscript{16} Kan Energi (consultancy company), report:
The Scandinavian countries are among the most prominent producers and users of bio energy. By 2000 bio energy had become a larger energy source than water. The Scandinavian production of bio energy amounts to 215 TWh/year whereas the capacity of water power production in a normal year is estimated to 205 TWh/year\textsuperscript{17}. Sweden (91 TWh) and Finland (91 TWh) have implemented use of bio energy on a large scale, whilst Denmark has managed to incorporate 18 TWh despite its scarce forestry resources\textsuperscript{18}. Norway is the definite laggard with only 15 TWh per year\textsuperscript{19}.

\textsuperscript{17} Hohle (2001), p.16
\textsuperscript{18} Ibid.
\textsuperscript{19} Ibid.
The total growth of bio mass in Norway equals an energy amount of 425 TWh/year, of which 325 TWh is land-based and 100 TWh water-based\(^\text{20}\). Use of bio mass in terms of energy purposes competes with other utilization areas like food for humans and animals, timber and industry commodities. Hence, the usable energy potential accounts for 15-20% of the total growth, which is 64-85 TWh\(^\text{21}\). The total energy consumption in Norway is roughly 120 TWh/year\(^\text{22}\).

### 3.2 Classification of bio energy

Bio energy is the common denominator for all forms of energy that are derived from bio mass,
which in itself is a common denominator for organic material onshore and offshore. The energy is released upon combustion of organic material in terms of solid fuel, gas or liquids, either for heat production or as fuel for transport. Below is a list of typical material used as biomass, but it is not an exhaustive list as all biological material in principle can be used for energy purposes.

I have chosen to concentrate on bio energy for heating purposes, more exactly on pellets, briquettes and wood chips. These products all derive from the forestry sector, and are the most utilized in heating systems in Norway. When not explicitly mentioning the specific names, I will refer to them under the common heading of bio fuel.

Table 1: Type of bio mass and utilization

<table>
<thead>
<tr>
<th>Industry</th>
<th>Type of bio mass</th>
<th>Processed products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forestry</td>
<td>Wood</td>
<td>Pellets, briquettes, wood powder, wood coal, bark, wood chips, bio ethanol, bio methanol</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Grain with straw (wheat), grass, oil plants (raps, soy, peanut, sunflower, ryps), potatoes, sugar, manure</td>
<td>Pellets, briquettes, bio gas, bio ethanol</td>
</tr>
<tr>
<td>Agro</td>
<td>Corn residues, bone flour, deep fat, destruction fat, oil/fat from food waste</td>
<td>Bio diesel, pellets, bio gas</td>
</tr>
<tr>
<td>Aqua</td>
<td>Micro and macro algae, seed plants</td>
<td>Bio metan, bio ethanol</td>
</tr>
</tbody>
</table>

Source: Hohle (2001), my table.

### 3.3 An example of bio energy for heating purposes

The process from bio mass to heat starts with harvesting of the bio mass. This can be tree felling or harvesting growths in the fields. Bio mass may also derive from waste collected by the refuse
disposal service or surplus materials primarily being used for other purposes. The raw material is then transported to saw mills, farms or other places for processing into bio fuel in terms of briquettes, pellets, wood chips etc. The refinement process requires special equipment like wood chippers, compressors and drying facilities. The next step consists of transporting the bio fuel to the boilers and heating plants, usually by trucks with containers.

In the literature regarding bio energy for heating purposes, the term *district heating* refers both to *large-scale* heating systems implemented in cities and *small-scale* systems utilized for heating smaller areas of buildings and houses. One also speaks of *single-unit* heating systems which provide heat for one building. This might be a market garden or a cowshed at a farm. Whereas farmers may utilize and process wood from their own forest, the market gardens might have an agreement with a local farmer or a larger bio fuel vendor.

The figure below illustrates how a large-scale bio energy heating system operates in practice. The water is heated by combustion of bio fuel and the heat is then distributed to the customers.
From the block heating station which is owned and operated by the heat supplier, water is pumped into the network (primary net) and distributed to the customers through isolated pipes underground. The pipes are dug down in ditches, often together with other types of infrastructure like phone and power cables, and they have an average heat loss of maximum 5-10%\textsuperscript{23}. Hot water of up till 120 degrees is pumped through one pipe, and cooled water which holds around

\textsuperscript{23} Norwegian district heating association, Norsk Fjernvarme: http://www.fjernvarme.no/hvaerfjern/index.html
40 degrees is circulated back into the block heating station. The temperature is regulated according to the seasons. The water distributed into the network exchanges through one or more heat exchangers implemented into the customers internal network, which is build into a subscriber central located with the customer. Hence, the supplier network and the customer network are two separate systems. The heat is distributed to each customer via a water-based heating system entailing radiators, floor heat or ventilation systems.

3.4 Type of sector

According to Von Tunzelmann and Acha (2005) there are several ways to categorize type of sectors, for instance according to product range (OECD 1994), technology characteristics (Pavitt 1984) and marketing expenditures versus technology development (Sutton 1991, 1998). It is not my aim to discuss whether bio energy for heating purposes fits one or the other category, rather to comment on the current status in Norway. Innovation and activities related to bio energy for heating purposes can be both highly technical and science-based or so-called “low-tech”. Activities spans from production of filter systems in order to lower the emissions from firing systems, process innovations of bio fuel drying methods to the implementation of small-scale firing systems and boilers. Activities can also be service-related as many heat entrepreneurs seek to expand their product range in terms of equipment maintenance and helping customers with financial planning and other information (Hillring 2002).

Utilization of bio mass for heating purposes and its related technology are not new phenomena. The industries connected to bio energy as discussed in this thesis already exist, and the production of bio fuel and for example boilers specialized for certain types of bio fuel derive
from or intertwine with existing sectors and value chains. Hence, one can speak of merging paths, continuation of paths or creating side-paths. Production of bio fuel as discussed in this thesis has its roots in the agriculture and forestry sector, including industrial wood refinement. The production of equipment derives from industrial machinery, especially electricity, power and hydraulics. People within the Sanitary Plumbing and Heating sector (VVS-sektoren) might acquire competence for installing and maintenance of systems.

Whereas Norway is endowed with a considerable amount of forest and thus has a good starting point in terms of bio fuel production, there has been no production of equipment needed for bio energy heating systems. Norway is world leading within wood stove manufacturing\(^{24}\), and has an industrial base that could act as a prerequisite for the heating systems in question. The interest in producing such equipment might have been low due to the dominant oil-based energy system. Hence, Norway needs to import the technology, especially from countries like Sweden, Denmark, Finland and Germany, in which the implementation of such heating systems are extensive compared to other countries. Both equipment utilized in harvesting and processing of bio fuel and the heat supply part are imported. Examples of the former could be wood choppers, specialized storing facilities, and compressors. Heating block stations, bio fuel feed-in systems, pipes, boilers, and stoves are examples of the latter.

Implicit in such a technology transfer is acquisition of knowledge (Bruland 1988, 1989), which can be directly related to how to install systems and boilers and what types of equipment are needed for a specific implementation. It can however also regard non-technological knowledge

\(^{24}\) See for instance Jøtul: http://www.jotul.no
as to how to develop a market, planning of infrastructure, and how to establish advantageous relationships either within the industry or with the public. The transfer of technology and knowledge is discussed further in chapter 6.4.

Unless one employs Schumpeter's definition of innovation as to “the exploitation of new markets” (Fagerberg 2005, p.6), there are very few examples of innovation related to bio energy for heating purposes in the two regions. One notable exception is a company which has developed a new drying method and is the first in the world to utilize timber directly from the forest in pellets production 25. Hence, the activity in Norway is primarily focused on the implementation and transfer of technology, not just purely technical, but also in terms of social, cultural and economical aspects.

4 The systemic perspective on innovation
In this chapter I will try to provide a deeper understanding of the systemic perspective on innovation by presenting the analytical framework employed in this thesis, the regional system of innovation. Not only the actors are important parts of the system, but also the institutional set-up which regulates and shape interaction between actors. There is a constant interplay between actors and the institutional set-up. The role of the institutions influences the way learning and interaction takes place. The institutional set-up in different regions can differ due to cultural, social, economic or technological variations. In discussing how the regional system and the institutional set-up are built up and renewed over time, I will employ the interrelated terms path

dependency and path creation.

4.1 The regional innovation system

The systemic perspective on innovation is an analytical framework. As Edquist (2005, p.186) puts it: “systems of innovations” should be labeled an approach or a conceptual framework rather than a theory”. I have utilized the regional innovation system approach in this thesis. A regional innovation system approach is by many scholars (e.g. Asheim and Isaksen 1997, Asheim and Gertler 2005) similar to the national system of innovation framework as first coined by Freeman (Edquist 2005). There are two different understandings of a national innovation system; a broad understanding as suggested by Lundvall and a narrow one as advocated by Nelson (ibid). As my focus is systemic activity, I have utilized the former, which is oriented towards the structure of production and the institutional set-up in which economic production takes place. The latter focuses more strictly on research and development processes, and hence is more in line with the linear model of innovation.

As national and regional innovation systems to a certain degree overlap, I see a need of clarifying the concept of the former before I narrow down to the latter. National systems of innovation have been defined by Lundvall in the following manner:

The national system of innovation is a social system. A central activity in the system of innovation is learning, and learning is a social activity, which involves interaction between people. It is also a dynamic system, characterized both by positive feedback and by reproduction. Often, the elements of the system of innovation either reinforce each other in promoting processes of learning and innovation or, conversely, combine into constellations blocking such processes (Lundvall, 1992, p.2).
It is imperative to understand the type, quality and strength or weakness of the interactions between organizations and between organizations and the institutional set-up. One must not only concentrate solely on the economic activity, but also the social and cultural characteristics of the subject matter. Such an understanding assumes that organizations do not innovate in isolation (Edquist 2005).

In their approach to the regional system of innovation, Asheim and Isaksen (1997) states that organizations or actors equals firms, universities and colleges, R&D organizations, in addition to public and private specialized industry training units. Further, they emphasize the role of the institutional infrastructure and the importance of learning and interaction. Apart from the fact that there is a spatial or geographical dimension that differentiates a regional and a national system of innovation (Asheim and Gertler 2005), the significance of the co-localization of organizations, area specific cultural and social aspects, and local learning processes imperative to local innovation activity are stressed by many scholars. Such a view might include the attitude towards entrepreneurial activity in the region, mutual trust between leaders in the regions, or locally acquired competence. Other commonly recognized characteristics of a regional innovation system are the existence of a technological trajectory based on sticky knowledge and localized learning and presence of knowledge creation organizations (Ibid.)

Bjørnstad (2003b) builds on several innovation theories in his regional innovation system approach regarding his bio energy case study of a region. He has a similar list of organizations as mentioned by Asheim and Isaksen, he includes the learning and interaction aspect, but differ in the sense that he to a certain degree build his analysis on the triple helix approach (Leydesdorff


and Etzkowitz 2000). Moreover, he utilizes the concept *green innovation that* is defined as a circular and environmental-friendly economy. The goal is two folded; to pursue continued innovation and to do it in a way that sustains or preserves our surroundings. The concept as defined by Bjørnstad means that there is a turn from large-scale, centralized units to small-scale, decentralized units with a great degree of flexibility. Hence, the question of green innovation may be interpreted as a sort of regional and district politics. To a great extent, Bjørnstad founds his analysis on the concept *vision*, which to me is an extension of the institutional set-up (Lundvall) and the regional attitude (Asheim and Isaksen). Bjørnstad puts it in the following manner:

“The concept of vision is thus a kind of socialization of the actors by the development of a common and maybe self reinforcing logic as to what solutions and actions that are in coherence with the “system's” vision. In those cases a broad innovation oriented cooperation between different actors is based on an existing “objects clause”, one can measure the concrete activities performed by the actors against the vision” (Bjørnstad 2003b, p.21) (Author's translation)

According to Wiig (1997) there is a vast literature on regions scrutinized utilizing the region innovation system approach. However, these are often dynamic regions with many firms and employees in the dominant sectors. Hence, this empirical material might not be directly transferable to Norwegian conditions, resulting in the same conclusion for the regional innovation system approach. In their comparative study on innovation activity in two counties in Norway, Wiig utilizes a regional innovation system framework upon the criteria of spatial or geographical boundaries and the fact that important parts of the public support system are administered on a regional basis. Thus, there can be said to be uncertainty in regard to what
constitutes and limits a “Norwegian regional system of innovation”. I have chosen the regional approach based on my wish to examine and compare two different regions in terms of geographical location.

This is not to say that all activity, interaction and the structure of production in general are restricted to regional borders, on the contrary. Lundvall (1992) stresses that systems of innovation are open and heterogeneous. Activity and processes do not necessarily take place within national borders, or regional borders as is the case in my thesis. Organizations may be established on a national level as a national policy, but operate regionally. The Innovation Norway bio energy program serves as an illustration due to its local subsidiaries administering loans and grants for local projects. Firm relationships may transcend regional borders, both in terms of knowledge and technology acquisition. As I will elaborate later on in this thesis, technology utilized for local implementation is imported from abroad and both technical and other forms of knowledge are part of a so-called “technology transfer package”. Research and development activities in bio energy for heating purposes are often national or international rather than local. Most actors within the bio energy for heating purposes sector are small in size and scope, and do not have the necessary financial means or motivation for developing for instance new efficient processes or products.

4.2 The institutional set-up

According to Johnson (1992, p.26) institutions can be defined as:

“sets of habits, routines, rules, norms and laws, which regulate the relations between people and shape human interaction. By reducing uncertainty and, thus, the amount of information needed for individual and collective action, institutions are fundamental
Hence, institutions can be both formal laws or more informal codes encouraging or dis-encouraging a certain type of behavior. The institutions may be of a tacit or explicit nature, and they function as informational signpost. Without institutions, innovation and learning would be difficult to pursue, since one would have to navigate following an empty map (Ras-Vidal 2006).

The institutional set-up is important as learning and interaction takes place between actors or organizations. To clarify the distinction, Edquist (2005) points out that organizations are formal structures that are consciously created and have an explicit purpose. They are players or actors as opposed to the rules of the game, the institutions. There is a constant interplay between organizations and the institutions in a country's or region's institutional set-up, and this is one of the reasons why one can find different structures of production and interaction activity in different places. An example can be the interplay between the public bio energy projects and the private actors. Both the bio energy projects in the two regions are politicized as they are initiated and founded by the public authorities. However, in one of them the lack of a commercial focus affect the way the project is perceived and has altered the channels of learning and interaction. In Buskerud the commercial aspect is more prominent, and learning and knowledge acquisition go to a great extent via the public project.

The element of uncertainty reduction plays a great role as to the effort actors need to exert in order to realize their purpose. This might be stable and long-term policies given by the authorities, or predictability in terms of stable relationships between organizations. An example
might be that the political attitude regarding financial incentives promoting a conversion from oil to bio fuel friendly heating remains the same despite change of political government. As to the information aspect, the degree of openness in a system determines how easy/difficult it is to obtain the wanted knowledge and to influence the rules of the game, for instance lobby organizations trying to influence and change the existing institutional set-up by stating their view in public hearing documents.

4.3 Path dependency and path creation

Path dependency has been used as a core factor in explaining successful path creation (David 1985, Arthur 1988). In this view, the emergence of novelty is a path dependent phenomenon. One follows a certain trajectory influenced by prior experience, knowledge base and background. Our present and future choices are conditioned by choices we have made in the past. According to Munch Andersen (2006) trajectory change is seen as taken place merely through selection processes as understood in biology. As a result of this innovation economics mainly addresses incremental change within existing paths while radical change and path creation remains unexplained, meaning that new paths may only be realized ex post. Departing from path dependency, Garud and Karnøe (2001) consider the cognitive aspects of path creation offering a contrasting perspective:

“In our view, entrepreneurs meaningfully navigate a flow of events even as they constitute them. Rather than exist as passive observers within a stream of events, entrepreneurs are knowledgeable agents with capacity to reflect and act in ways other than those prescribes by existing social rules and taken-for-granted technological artifacts.” (p.2)

Hence, entrepreneurs are shaping paths in real-time, in the making and as they go. They may of
course shape a path based on the past, but this is due to a logical exercising of option, a screening of information.

Referring to Wicken (2005), Ras-Vidal (2006) suggests that path dependency and path creation are *interrelated* processes; new paths interacts with old paths, and that such processes may transform old sectors or paths and shape paths in its emergence.

A path may reflect the development of the institutional set-up over time. New laws may be passed or changed, habits or common codes may change, and relationships may be altered as a result of a changing economic, social, cultural or technological situation. Altering conditions may or may not result in uncertainty and in some cases lead to a change of path. Karnøe (1991) describes how the wind turbine industry developed in Denmark. The oil crisis in the 1970s forced Denmark to look for other alternatives as they were not self-sufficient like Norway. Danish companies formed small and informal networks and the government supported creation of a path in many ways. In short, the rules of the game contributed to development of a new path.

### 4.4 Learning and Interaction

It is important to find out how learning takes place as learning is imperative for all innovation, including diffusion. The institutional set-up says something about how relations are regulated between people and what factors shape interaction, implying that how learning takes place may be affected by the institutional set-up. Thus, there is no exhaustive distinction between learning, interaction and the institutional set-up. Almost all learning is interactive, but it may be useful to take into account that there are different kinds of learning, which involve different amounts of social interaction (Johnson, 1992).
Lundvall and Johnson (1994, p.24) refer to learning as “both to those processes which lead to new knowledge and those which spread old knowledge to new persons”. This regard individuals or organizations. As accounted for above, this thesis emphasizes to a great extent the implementation of already introduced technology and the utilization of bio mass fuel for heating purposes rather than what is typical referred to as innovation, although there are a couple of examples of product and process innovations in the two regions. Furthermore, Lundvall and Johnson suggest different kinds of learning which refer to the possibilities to carry through transactions with economically relevant knowledge. These four categories are know-what, know-why, know-who, and know-how. The examples in the table below are fitted according to the subject matter and represent respectively knowledge within equipment or hardware utilized for heating purposes, and processing of bio mass fuel to a ready product, for example pellets.
Table 2: Learning taxonomy

<table>
<thead>
<tr>
<th>Types of knowledge</th>
<th>Know-what: Refers to the knowledge about 'facts'. Knowledge is close to what is normally called information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Know-what</td>
<td>● What is the maximum effect measured in Watt of a certain boiler</td>
</tr>
<tr>
<td></td>
<td>● What are the different drying methods for pellets</td>
</tr>
<tr>
<td>Know-why:</td>
<td>Refers to scientific knowledge of principles of laws of motion in nature, in the human mind and in society.</td>
</tr>
<tr>
<td>Know-why:</td>
<td>● Why should the boiler be constructed in a certain way in order to give a certain effect</td>
</tr>
<tr>
<td></td>
<td>● Why should one dry biomass according to certain drying principles</td>
</tr>
<tr>
<td>Know-how:</td>
<td>Refers to skills, ie. the capability to do different kinds of things on a practical level. The need for organizations to be able to share and combine elements of know-how is one of the most important rationales for participating in networks or inter-organizational relationships.</td>
</tr>
<tr>
<td>Know-how:</td>
<td>● How to operate or install a boiler or a firing system</td>
</tr>
<tr>
<td>Know-how:</td>
<td>● How to dry the biomass</td>
</tr>
<tr>
<td>Know-who:</td>
<td>Social skills involving knowledge of who knows what and who knows how to do what. The competency involved in forming special social relationships, utilizing common codes of information, can be characterized as relational knowledge or learning.</td>
</tr>
<tr>
<td>Know-who:</td>
<td>● Knowing who who might know what the effect of a certain boiler is, and how to install it to fit ones needs</td>
</tr>
<tr>
<td>Know-who:</td>
<td>● Knowing who who might know the different drying methods, and how to dry it to fit ones needs.</td>
</tr>
</tbody>
</table>

Source: Lundvall and Johnson (1994)

In order to understand the processes which lead to new knowledge and those processes which spread old knowledge to new persons, one need to study how knowledge flows or is transferred.

The spread of district heating in for instance Sweden, suggests that technical equipment used in bio energy heating is not new. Bruland (1989) describes the transfer of technology from Britain to Norway in the textile industry in the mid nineteenth century. In addition to a physical transfer of machinery and equipment, is was also a transfer of knowledge in terms of specific skills input,
technical information and advice, contacts with British firms, skill transmission, and supervision and management. As no technology utilized for bio energy for heating purposes is produced in Norway, such a transfer is highly relevant to the topic investigated in this thesis. As will be elaborated in section 6.4, the importers of technology often possess the role of diffusers of technical know-how and relational know-who both within their home region or other regions in the country.

*User-producer relationships* is according to Lundvall (1992) one of the cornerstones in a system of innovation. Sometimes, the relationship between users and producers will involve direct cooperation. For example, a user might invite a producer to take part in solving a specific problem within the organization. Cooperation might also take place at different stages; while defining the problem, while developing the solution or while introducing it to the users. The user in this thesis is the technology importer situated in Norway whereas the producer is the foreign manufacturer of technology. The importer is also a producer in that he tailors heating systems uniquely for each customer in Norway. Integrating a producer will give a user more direct access to technological know-how. At the same time, the integrated producer will get more direct access to knowledge about the changing needs of this particular user. But the price paid for these intimate relationships might be high in the long run. Users and producers not integrated will be reluctant to give away sensitive information to the pair of integrated units. Thus, there is a trade off between the integrated units, and the short term advantages of closer interaction between the integrated units, and the long term cost of their isolation from the broader process of interactive learning involving several, formally independent, users and producers. This is however not a huge problem to Norwegian importers as they are bound to each manufacturer exclusively. They
are therefore limited room for other channels of interaction and learning outside the
manufacturer network. Lundvall also stresses that a cultural distance between users and
producers will affect the processes of interactive learning involved. Norwegian importers usually
do business with Danish and Swedish firms as many of them are leading actors within bio energy
for heating purposes technology manufacturing. These countries are closely related to Norway in
terms of language and norms and codes representing the context for communication.

Mapping the actors and initiatives

As pointed out in the introduction chapter, mapping the actors is one of the two research
questions guiding this thesis. The mapping is a prerequisite for the subsequent analysis of
learning and interaction in the two regions, and it is imperative in an analysis employing the
system of innovation approach as the interactions between the organizations are scrutinized. The
lists regarding funded projects in the Innovation Norway bio energy program and the industry
index at the NoBio website have proved valuable in mapping the actors and initiatives. The
former gives an insight into all applications granted by the bio energy program, which are
primarily small-scale farm heating projects, and the latter probably lists all members of the
association. The association did not answer my inquiry regarding this issue. Hence, the list and
the index do not represent an exhaustive and complete mapping. Searches on the Internet and
epecially the informants have therefore been of great significance.

26 All information in this chapter is provided by the informants or retrieved from the public project web sites. Other
information is provided in own footnotes. The Bioreg website: http://www.bioreg.no. The increase use of bio
The mapping is not an effort to describe all actors by name and in detail and present a list in terms of quantity. My aim is rather to present a list of actors that are relevant in bio energy for heating purposes and identify their place and function. Similar to Bjørnstad (2003b) I have chosen to divide the actors into three categories; public initiatives, education and R&D, and private actors. He further divides the latter category into three subsequent ones; bio fuel producers, market segment, and architectural and construction technical aspects, which can be firms within the Sanitary Plumbing and Heating sector, the construction sector, importers of technology, and consultants. I have also adopted this categorizing. The two main public projects, private organizations and education and R&D institutes are described for each region. Other public initiatives are described in an own section as these are more national in scope, but nonetheless important to the regional system of innovation.

4.5 Buskerud

The country of Buskerud occupies a geographical area of 14.927 square kilometers, and is the mother of 21 municipalities. There are nearly 250,000 inhabitants (per 31.12.2006)\(^{27}\). The county is located in the southeast of Norway, and it has borders to eight other counties. One of these is Oppland in which Hadeland is situated. Trade and industry in the county is rather technology intensive and international oriented compared to many other counties\(^{28}\). Forest-based products, industrial equipment and electric/optic products are the larges industries. Buskerud is the fourth biggest within offshore, with the marine technology cluster in Kongsberg as the leading locomotive within all industries in Buskerud. The tourist and travel business is


considerable, especially in the upper part of the county. Agriculture tends to be concentrated in smaller farms, but there is a tendency of rationalizing into bigger units. Measured by productive forest, Buskerud is the third largest forest county.

4.5.1 The increased use of bio energy project
The increased use of bio energy project is a co-operation between the County of Buskerud, the chief administrative officer of Buskerud and Innovation Norway Buskerud. This program is primarily an information project to increase the knowledge on bio energy for potential producers in the forestry industry and users of bio energy, but it has granted financial support to a handful of pilot heating systems. The goal of the project is two folded, a result-orientated goal stating a decision within 2007 of building ten bio energy plants, and an efficiency goal divided in four sub targets. These are:

- Local and regional industrial development through networking and innovation in the bio energy industry
- Increased sale of equipment and services among the actors in the value chain, in particular increase the turnover in agricultural industry related to bio energy
- Reduce the utilization of fossil fuel and reduce climate gas emission
- Increase the share of stationary energy use based on bio energy and release of electrical power

The project is organized through a project leader, a management and a project group. The practical work is carried out by the project group and is organized by the project leader. The project owners participate when called upon. The project leader is a full-time employee in the county administration and has been working with renewable energy issues prior to this project. He is also a part of the management and the project group. In addition to the project leader, the
management and project group respectively consist of the chief administrative officer of Buskerud and the leader of Innovation Norway Buskerud, and two external consultants.

Figure 4: Organizational map for the Increased use of bio energy project

The project is the first bio energy effort in the county, and it complements other renewable energy initiatives. Politically, the county takes part in cross-county co-operations through the BTV (Buskerud, Telemark, Vestfold) and the Oslo region (Oslo, Akershus and Buskerud).

Technologically, they were involved in three projects; ProBioEnergy, Green Energy Clusters and Bioenergy in Hallingdal. The two first mentioned were international in scale and regarded a possible establishment of a bio fuel market. The county does not longer participate. The latter regards the implementation of a value chain and industrial development in the Hallingdal region, and is still on-going.

4.5.2 Private actors
The County of Buskerud is home to several firms producing bio fuel on a large-scale. There is
one producer of pellets which is relatively international oriented as most of the pellets are exported abroad. The production has also given birth to a subsidiary firm that is marketing and trading their product. The firm has a broad and solid base as it is owned by local power suppliers, a waste management firm, and a prominent forest association who provides the raw material. Saw mills and the wood residue industry produce significant amounts of wood chips and briquettes. Production of bio fuel is a side-activity of their main work and commenced on the basis of wanting to exploit what was regarded as waste. When these firms cannot utilize the residues themselves, they often sell to other actors. Some firms have made a living of buying residues from firms, both regional and in neighbor regions, generating wood residues. One informant conveys that the entire production is sold to a big, local heat supplier who utilizes the briquettes in its own plants. Hence, the acquisition of raw material is non-local and the market is local. There are also farmers who process raw material from their own forest and sell to customers heating a single-unit building within the region. This is mainly wood chips which are relatively easy to produce.

As Buskerud has many densely populated areas, the presence of several heat suppliers or the market segment for bio fuel is not a surprise. Infrastructure and physical piping restricts the use of such heating methods in rural or scarcely populated areas. The publicly owned power companies are in general heavily influencing the establishment of district heating firms as many establish subsidiaries for the purpose of offering “green heat”. They are already supplying heat and may have a comparative advantage as they have stable and relatively good financial muscles, extended network and contacts after many years of business. Most important, they are assigned by the public to supply heat in different areas. However, the presence of public subsidiaries does
not hinder the entrepreneurial activity of private actors. These firms may not have the same advantages as described above, but they have found their niche in the market supplying heat to small- and medium-scale clusters of buildings or single units. Some of them also enter into agreements in terms of technical operation of public plants, which is an example of so-called public-private-partnerships. Households utilizing pellets stoves are also part of the market segment. According to Bjørnstad and Sand (2007) Buskerud is not represented among the regions in which the utilization of pellets stoves is above the national average.

Architectural and construction technical aspects can be firms within the Sanitary Plumbing and Heating sector, the construction sector, importers of technology, and consultants. According to my informants there are no efforts of integrating the Sanitary Plumbing and Heating sector into the bio energy for heating purposes. One informant conveys that there is a need for additional competence specific to bio energy related heating equipment and techniques, but that it is not his job to educate professionals within this sector. There is no indication that the construction sector is an integrated part of the bio energy for heating purposes regional innovation system. There are several importers and vendors of equipment for bio heating systems in Buskerud. Together they offer a range of solutions for pellets stoves in private houses to small-scale single-unit systems and large-scale solutions for district heating. Due to the fact that technology vendors import a certain brand, they cannot restrict themselves to only one region. As their customers are spread around the country, importers also function as consultants and thus diffusers of knowledge. I will describe such activity further in section 6.4.
4.5.3 Education and R&D institutes
There are no specific bio energy educations or institutes performing R&D within bio energy for
heating purposes in Buskerud. As to renewable energy techniques, the College of Buskerud
focuses on fuel cells and hydrogen-related energy carriers. However, some informants have
participated in courses offered by local subsidiaries of national associations, for instance the
National Association of Forest Owners (Skogeierforbundet) and The Norwegian Agricultural
Extension Service (Landbrukets Forsøksringer). These courses function more as information
meetings and eye-openers for possible entrepreneurial activity than concrete advice on technical
implementation and operation.

Only one of the informants state that they perform R&D activities. This firm has developed a
low-temperature drying method, and is the first company in the world to utilize raw timber
directly from the forest in the production of pellets. The process innovation has been developed
single-handed by the firm itself; no outside R&D institutes were involved.

4.6 Hadeland
Hadeland is situated in Oppland County, which has just over 180.000 citizens and occupies an
area of 25.192 square kilometers. There are 26 municipalities and three cities. It has borders to
seven counties. The Hadeland region, with its three municipalities, Gran, Lunner and Jevnaker, is
part of the county. The bio energy project Bioreg has its main focus here. The three
municipalities are traditional agriculture and forest areas.

29 http://www.oppland.no/ncms.aspx?id=97fd8712-a033-47b0-8bf4-440a199aab96&menuid=2722&menuobj=18014db1-047d-4b76-a362-097742177907
4.6.1 The Bioreg project

Bioreg Hadeland was initiated in 2003 as a three year project aiming to motivate facilitate and inspire increased bio energy activity in the Hadeland region. However, there has been activity in the region prior to the Bioreg project. A specific bio energy committee was initiated in 1986, which drew up a heating plan of the village of Brandbu. The 1990s witnessed the establishment of several bio energy firms. In 2002 the municipality of Gran/the regional council and the owner of the Energy Farm initiated a pre-project on Hadeland as a pioneering region for production and use of bio energy, and as a competence and development region. At the same time, the county of Oppland, in which Gran is situated, contacted the three municipalities that constitute the Bioreg project in addition to itself, and invited them to collaborate. In 2003 the regional council of Hadeland established the Bioreg project with a time frame of three years. It has now been extended for three new years. There has also been computed a climate estimation showing that the CO2 emissions stayed on the same level in 1986 and 2000 in the Hadeland region due to the relatively high share of bio energy use, 12% against 6% on average in the rest of the country.30

The Energy Farm has been a cornerstone for the project due to its considerable competence on bio energy. The farm was initiated in 1990 by Erik Eid Hohle, and it has become the leading bio energy information and competence center in Norway, as well as recognition abroad. The center has had visitors from more than 60 nationalities, and several prominent politicians have paid the center a visit. Hohle's effort has started to pay off; in addition to the plans of making the center a national bio energy information and competence center, Hohle received the Nordic Council of

30 http://www.bioreg.no/bioreg.php#bakgrunn
Ministers Bio energy award 2007. Although the center focus primarily on agriculture, it has often been employed in governmental hearings regarding all aspects of bio energy.

The Bioreg project is owned by the municipalities of Jevnaker, Lunner and Gran, the County of Oppland, and the department of agriculture and forestry with the chief administrative officer. The organizational map shows all levels and sub groups.

Figure 5: Organizational map of Bioreg

![Organizational map of Bioreg](image)

Source: Stubberud & Vagland (2005)

The management group consists of the chief administrative officers in the three municipalities, a representative for Oppland County and the chief administrative officers’ agriculture department respectively. The chairmen of the municipalities meet as observers. The present project leader is

The Industry Network (Industrilauget) is an information and competence network for the bio energy industry in the Hadeland region. Different firms and industries cooperate in order to increase the value creation related to bio energy. Bioreg is the secretariat whose task is to identify and present new products and projects to the network members. If a member wishes to take part in a project presented, Bioreg assists in the initial phase. Bioreg is also a connector between the industrial network and national and international competence centers.

According to Stubberud and Vaagland (2005) the two competence groups drawn up at the organizational map were never realized. The technical expertise was however present in the project from day one, first and foremost represented by Hohle. He has now resigned from the project, but is hired on a time-basis as a consultant. The region has formerly participated in networks and R&D development. It was the Norwegian representative in a three year project, Interreg, Bio Energy Technology Transfer Network (BTN), which was cooperation between regions in Germany, Finland, Sweden and Norway. It has also co-administered a project with Norwegian University of Life Sciences (UMB) and Norwegian University of Science and Technology (NTNU) mapping the bio energy education at college and university level. The aim was to coordinate the educations in order to offer a more comprehensive education. Such a study would probably be owned by UMB, and the field work, practice and administration would be located at Hadeland. Norwegian research institutes have been connected via Bioreg to firms at Hadeland.
4.6.2 Private actors

Hadeland is a smaller region than Buskerud, and the number of bio fuel producers is lower. There are two saw mills and wood residue industry firms producing respectively pellets and wood chips. An association of forest owners, disposing of a relatively large forest area, produces wood chips. In difference to Buskerud, no-one buys raw material neither locally nor from other parts of the country. One firm initiated by a group of farmers produces bio fuel taken from their own land.

This farmer initiative also operates as a heating supplier. Hence, it aims to control more of the value chain and not restrict itself to being solely a bio fuel producer. As the farmers’ total production of bio fuel is less than needed for their heating supply, they need to buy additional bio fuel which is bought strictly according to a price aspect rather than from a regional development point of view. The company has a broad and solid basis as it is co-owned by people within the wood residue industry, the Energy farm and other farmers. Whereas the firm mostly supplies heat for single-unit or medium-scale areas, other actors focus on the future large-scale district heating implementation in the centers. One local company has been established for the purpose of winning the on-going concession round for heating the centers, and another outside-region company has partnered with a local forest association. The market for utilization of pellets in private households is relatively large at Hadeland, there are two stoves for every stove in Norway on average\(^\text{32}\). There is also a market for equipment and technology as many farmers and owners of industry buildings have installed green heating systems.

**Architectural and construction technical aspects** can be firms within the Sanitary Plumbing and Heating sector, the construction sector, importers of technology, and consultants. The public Bioreg project reports that there have been efforts of incorporating the first mentioned sector into the bio energy for heating purposes industry. In difference to Buskerud, an actor within the sector is listed on the NoBio industry index. Only one heat supplier states that he has cooperated with the construction sector. Questions related to technical integration of the bio energy heating system in a new housing area raised on part of the supplier's land were addressed. There is one importer of heating system equipment, which is a subsidiary of a non-local firm. As the vast majority of the heat suppliers in the region choose outside-regional vendors, the impact on the local activity seems insignificant. Local consultants restrict itself to the Energy Farm, whose customers are mostly national or international. Hence, technology and knowledge acquisition seems to be of non-local character. This is elaborated in section 6.4.

### 4.6.3 Education and R&D institutes

Similar to Buskerud, there are no specific bio energy education or institutes performing R&D within bio energy for heating purposes. The College of Gjøvik used to offer a one-year bio energy class at Brandbu located at Hadeland, but the course has been put to an end due to lack of applicants and organizational restructuring. In difference to informants in Buskerud, none of the informants state that they have participated in courses given by interest organizations, except excursions organized by the Bioreg project in the seminal years of the project. However, the offer has ceased to exist.

Whereas no firm reports of R&D activity solely within the firm, a couple of companies
participate in cross-regional R&D efforts. A wood refiner functions as a test site for the
development of a stove filter aiming to reduce emissions and another firm develops a longterm
burning stove. Both projects were initiated during the first period of the Bioreg project, and the
relationships to national R&D institutes and firms located in other part of Norway are now
maintained without the public project as a middleman.

4.7 Other public actors and initiatives

Enova\textsuperscript{33} was established in 2001 by the Ministry of Petroleum and Energy. It is a national
governmental initiative for change in energy production in Norway. They provide financial,
technical and administrative support. They currently offer two programs in regard to bio energy
for heating purposes; “Heat” (Varme) and “Heat – Processing of bio mass fuel” (Varme –
Foredling av biobrensel). The former regards support for construction and implementation of
heating systems/plants and infrastructure. The latter addresses actors who aim to develop a
business within the value chain of processing and trade of biomass fuel.

Innovation Norway is a central actor within the Norwegian innovation system. Their goal is to
back up and promote entrepreneurial initiatives. The national effort on bio energy is administered
by Innovation Norway through the \textit{bio energy program}. The program is realized through the
regional sub units of Innovation Norway, in this thesis Oppland and Buskerud/Vestfold (co-
administration of two counties). The overall aim is to stimulate actors within forestry or
agriculture to produce, utilize and sell biomass fuel for heating purposes and/or become heat

\textsuperscript{33} All facts taken from the Enova website: http://www.enova.no
suppliers. Their target group is farmers and forest owners. The local aspect is emphasized by a “should” clause of utilizing locally produced bio fuel in local heating systems. The program has its roots in the Ministry of Agriculture and Food's industry strategy, which states the following goals:

1. Developing innovation systems and value chains
2. Realizing the potential for increased use of bio energy through investments in biomass fuel production for heating and transport purposes and district heating systems.
3. Marketing and communicating the opportunities related to bio energy use
4. Improving the conditions for the industry
5. Increasing R&D activity

Another governmental effort is the Green Energy Municipality project (Grønne energikommuner), which is co-administered by the Ministry of Local Government and Regional Development and the Ministry of Petroleum and Energy. This project was initiated in the beginning of 2007 and will run until 2009. 10-12 municipalities throughout the country are invited to participate. These municipalities have a proven track of “green energy” implementations and are to state great examples for their local and neighbor environment. Each municipality will receive monetary support for hiring an energy advisor and will be prioritized with Enova. All the municipalities in the Hadeland region, Gran, Jevnaker and Lunner, are included, in addition to the county itself, Oppland. The County of Buskerud is represented by the municipality of Ringerike.

http://www.invanor.no/templates/Page____49889.aspx
5 The analysis

5.1 Specific national institutional set-up relevant to the regional set-ups

There are certain institutions that are national specific rather than regionally determined. Such institutions may be laws. There are some already established laws and some suggestions from the current administration that are significant to the bio energy industry. All new public buildings over 1000 m² must install energy flexible heating systems, which are systems based not only on fossil energy sources but also green energy sources like pellets and wood chips. The current administration has suggested narrowing this limit to 500 m². Another suggestion was presented in the Norwegian Climate Policy regulation and recommends prohibiting oil boilers in new buildings, both public and private. The administration also considers prohibiting a substitution of old oil boilers with new in existing buildings. Financial support through Enova is suggested to reach this goal. Such formal institutions may reduce uncertainty for the actors, but may also contribute to the opposite depending on how long time it will take implement such efforts.

Another governmental effort is the Green Energy Municipality project. As accounted for above, the participants will receive monetary support in order to hire an energy advisor in the council, and they are to be prioritized with Enova regarding financial funding for the implementation of

specific district heating projects applied for. One of my informants told a story of how he felt the project was carried out in practice:

“Theory turns out to be different than practice... [A district heating supplier] applied for funding regarding a district heating project, but the application was refused based on the presupposition that the project would have lower profit than similar projects. Enova would not prioritize it, even though it took place in a green energy council. When the council decided to contribute a certain amount, Enova granted 25% of the total costs. In the end the project management could still not defend the project economically, and it was rejected. Nevertheless, this is an example of how one is not prioritized despite the promises. They [Enova] keep strictly to their granting rules.”

The same informant stated explicitly that the rules of the game are changed. This is not the way for the authorities to reduce uncertainty for the actors.

“She [The Minister of Local Government and Regional Development] also promised support for hiring an energy advisor in each council, but she has not had the opportunity to make that promise come true. The councils included felt there were high expectations related to the project, but rather few direct and financial instruments to meet the anticipations. The councils are currently deciding whether they want to continue their participation or not. They have a “wait and see” attitude as they feel the promises are not kept, and when something happens it turns out to differ from the original directives. The Norwegian Association of Local and Regional Authorities38 (KS) is said to administer the arrangement. Hence, the rules of the game are changed.”

38 Kommunenes Sentralforbund: http://www.ks.no
There are not only problems in terms of risk reduction but also obstacles in regard to a lack of interaction between public organizations. Innovation Norway administers the national bio energy program, the most important national strategy on bio energy, but the grants are allocated by sub divisions in each county. Whereas an applicant must be given a statement from the local office of agriculture and forestry before applying for funds in other agricultural programs provided by Innovation Norway, there is no need to go through the local office when applying for the bio energy program. However, there is an established contact between the local office of agriculture and forestry and the Innovation Norway sub divisions. One informant expressed worries related to this practice:

“It is unfortunate that we [the local office] are not involved in such projects [applications through the bio energy program]. We might have acquired competence via a more extensive cooperation with Innovation Norway in regard to the diffusion and use of bio energy, and they might benefit from our knowledge related to what projects in the region are worth supporting or not.”

5.2 The institutional set-up at Hadeland

As accounted for above, the Hadeland region has a long track of bio energy activity compared to the rest of Norway. Upon the initiation of the Bioreg project, there were plans of creating a new industrial cluster, including technology production. The first project leader was headhunted from outside the region, and brought with him an extensive network and contacts within the research and development milieu as a result of working with commercialization of R&D. The ambitions
for the project were three fold:

- Industrial development and value creation
- Develop a national bio energy competence- and development region
- Organize and arrange an increase of use of bio energy

In order to achieve the goals, several activities were put to life, e.g. relationships with external R&D institutes were established, the establishment of the Industry Network, distribution of an information pamphlet to all households twice a year, identification of new business opportunities, marketing and lobbying towards external organizations, and arranging of a bio energy fair at Hadeland.

Despite the diversity of activities, the majority regarded relationships outside the region. Industrial partners were identified and were tried to match actors at Hadeland, and the activity was linked to R&D and the hope that there would be an inward knowledge flow. They wanted to create an industrial and technological region. As one informant puts it: “We had ambitions of putting Hadeland on the map. The Energy Farm was already an important actor and factor. We wanted to keep going down that path and envisioned ourselves as a governmental center similar to the “gas center” at Haugaland”. However, according to the same informant there was one element missing imperative to the realization of an industrial region:

“Keep in mind that we are talking about a small region. One wishes and dreams of establishing both one thing and another, but there needs to be a pre-existing industrial and technological environment. An *abrupt and sudden creation* [author's italic] of such
an environment can not be done without certain pre-existing conditions. Such conditions were to a small extent present at Hadeland.”

This might resemble a path that Garud and Karnøe (2003) labeled *breakthrough*. The term is used to evoke an image of actors attempting to generate dramatic outcomes as opposed to *bricolage* which is characterized by co-shaping of a path. These terms were coined in their description of the different paths taken by respectively Denmark and the US in regard to the wind turbine industry. Although the terms are subject to a specific product, they also describe the institutional set-up of the industry as a whole.

It turned out that the vast majority of the actors at Hadeland did not follow up the public strategy, and the *public-private relationship* was weakened. In a way, one might call it a co-shaping of a path as the actors were included in projects, but they did not see the need for the relationships and opportunities offered to them. Hence, the shaping was more of a top-bottom than of a bottom-up strategy. They were now cooperating more with each other than with the public project. One reason for this might be the fact that almost all actors at Hadeland were working with bio energy on a part-time or spare-time basis. They did not have the time or financial opportunities to involve themselves more with bio energy related activities. As a consequence of the experiences in the first project period, the second phase embodies a more inward and regional attitude. The efforts are now more focused on the actual implementation and diffusion of bio energy for heating purposes on a local level and to utilize the resources within the region, rather than connecting to national and international specific R&D and industrial milieus.

Not only the creation of a path is important, but also to what degree there is a coherent and
common vision behind a certain trajectory, a certain socialization of the actors and a goal upon which one can measure the practical and actual activities. The Bioreg project has stated their vision as “Hadeland – best at bio energy”\(^{39}\) (“Hadeland – best på bioenergi”). This slogan is based on the goal of confirming Hadeland as the number one bio energy region and to work towards a sustainable and green energy society. There seems to be no disagreement among the informants in relation to this publicly defined vision, neither among people working in the public nor private sector. They are nevertheless divided in the view to what extent the actors are actually pulling in the same direction. One informant states that:

“There is a positive common understanding among the actors here [Hadeland] that it is important both for the regional development and the environment that we work together and support each other likewise. [...] I believe that the local public initiatives are good. The politicians provide financial support to the Bioreg project, and the chairmen of the councils stand up and take responsibility. We have seen the implementation of many heating systems of all sizes.”

However, another informant who represent the general attitude, convey a more disappointed attitude:

“The Bioreg project has shifted focus from the commercial to the idealistic. It has become more politicized [author's italics]. There are plenty of visions, wishes and will, but the ability to accomplish and implement is not present. The number of implementations are far from what could have been. This goes for the regional development as well. I miss the early commercialization attitude”

\(^{39}\) The Bioreg project strategy document: http://www.bioreg.no/mikpublish/media/prosjektbeskrivelse.pdf
Not only the public-private relationship has been reduced in intensity, the regional private-private relations have also been altered. The Energy Farm has always been one of the most important primary sources of information and competence in regard to bio energy issues for actors in the region. However, as a consequence of the owner's partnership and presence in one of the companies, some other actors say they no longer are in the position to ask the center for help. Such an attitude grows out of two motives; they do not want to address a competitor and they do not want to reveal their own business “secrets” or plans. Hence, the relational climate might be said to be colder, and there is a tendency of rivalry, in particular within the bigger firms.

In terms of regional public cooperation, there has been a more or less tacit discontent at Hadeland due to the fact that their region has been promoted as the primary bio energy region. The anticipations of monetary and political support from the County of Oppland has proved to be vague and even competition-like as the county has established an own bio energy office. This is nevertheless not a comprehensive project as the Bioreg project, but one informant suggests that the county initiative may weaken the position of the Bioreg project in terms of political will and financing.

5.3 The institutional set-up in Buskerud

As in the case of Hadeland, there were occurrences of bio energy activities in the region before the public administration commenced its official project in 2005, even if in a small scale and rather widely distributed in the county. Although the use of bio energy for heating purposes was primarily individual driven for private purposes, there were initiatives related to either bio mass
production or heat supply. At Hadeland, there was an effort initiated by the local authorities represented by the Bioreg project to create an industrial cluster almost “from scratch”. In Buskerud, there has been an effort from individual actors to start up as e.g. heat entrepreneurs, consultants or biomass fuel vendors without having a background in forestry, agriculture or wood processing, which can be said to be a common background for people within the bio energy industry. There are of course actors rooted in such industries, but some of my informants revealed a diversity in original occupation and education; electricity, marketing, civil engineering, and industrial mechanics. They saw an opportunity in the bio energy industry and took it. This might be path creation in a sense according to Garud and Karnøe (2001) as their introduction to the industry is not a result of the past but rather an attempt to shape one for themselves in real time.

In difference to Hadeland, the private actors are in general more content with their relation to the public project. My informants do not feel there is a top-bottom attitude, on the contrary they say that the people involved in the project works with them and not against them, in other words the project was established to accommodate their needs, not the other way around. Hence, there might be a sense of a co-shaping of activities, a more bricolage-like approach. One industry informant stresses the establishment of the project as an important presupposition for bio energy activity in the county and a unit that has helped shaping interaction among the actors:

“I believe that the project has been almost a cornerstone for the diffusion of the use of bio energy within the county. The project management has contributed by actively working towards actors and ask them what they need and what are the daily obstacles. They have also introduced us to other actors who may help both financially and/or
technically, and hence I for instance, consult people within the project in many questions related to my business.”

Even though the Increased use of bio energy project is politicized as it was initiated by the regional authorities, the project has to a great extent proved to live up to the more commercial goals stated.

According to the project strategy, extensive networking and innovation are the keys to local and regional business development. The importance of increasing sale of equipment and services among actors in the value chain, and thus increase the turnover is emphasized. The project has also helped finance a handful of pilot projects, of which some of them are flourishing today. The informants in general convey a content attitude towards the business and market focus, as one of them states:

“...It is price worthy that they [people in the public project] manage to balance the commercial aspect and the pure political. It is always a question of money and prioritizing, but they have proven that the establishing of the project is not just a political show off in these times of increasing environmental awareness”

In the strategy document, the project has stated a vision; making the county a leading region within bio energy. Whereas the vision was embraced by all actors at Hadeland but not reflected the daily activities, the opposite seems to be the trend in Buskerud. There is no unison opinion about the importance of becoming a leading county, the emphasis is on the actual implementation, regardless of where, geographically speaking, it takes place. Such an attitude
may be because of the fact that Buskerud is a larger area; there are more vendors of equipment which is sold not only within the county etc. Nevertheless, the actors seem to be content with the implementation rate and to what degree and how the public is working towards its goal.

In terms of inter-firm relationships there is a tendency of division between small and larger actors. Many in the latter category are district heating suppliers and subsidiaries of publicly owned power and electricity firms. These have a solid economy in comparison to the former group, an extensive network and years of experience. There are also some significant private actors. Interaction takes place horizontally rather than vertically, and hence the opportunity for entering into networks or mutual learning relations for small actors are not the best.

The composition of the project management, the public-public relationship, seems to reduce rivalry and communication problems. The County of Buskerud and the chief administrative officer in Buskerud form the management together with Innovation Norway. This might have lead to a closer cooperation between the county, the municipalities and the organization administrating financial support. They perform different tasks in the cooperation and can therefore complement each other and are of better help to actors seeking their advice. In 2005, there were granted eight applications through the Innovation Norway bio energy program and in 2006 Buskerud topped the list with 43 applications granted\(^4\). As one informant puts its:

> “I had heard of the public project and contacted them. They thought my plans had potential and put me in touch with Innovation Norway, which helped me in regard

\(^4\) Information retrieved from lists provided by the Innovation Norway informants
to the application and other documentation. However, the financial help was secondary to other forms of help. What actually meant something turned out to be that there was someone by my side through the application process, that they “bothered” to sit down and listen to me and my plans.”

The main points of both institutional set-ups may be summarized as follows:

Table 3: Comparison of institutional set-up in the two regions

<table>
<thead>
<tr>
<th></th>
<th>Hadeland</th>
<th>Buskerud</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path</td>
<td>Effort of abrupt path creation of an industrial cluster, breakthrough, top-down</td>
<td>Path creation by individuals, private-public co-shaping of a path, bricolage, bottom-up.</td>
</tr>
<tr>
<td>Public-private cooperation</td>
<td>Private actors cooperate more with each other than with the public project</td>
<td>Public project acts as a hub which convey information and bring actors together</td>
</tr>
<tr>
<td>Vision</td>
<td>Coherent vision, recently low implementation rate</td>
<td>Non-coherent vision, recently high implementation rate</td>
</tr>
<tr>
<td>Public project</td>
<td>Public project becomes more politicized, less commercial</td>
<td>Public project is politicized, but not less commercial</td>
</tr>
<tr>
<td>Inter-firm cooperation</td>
<td>Altering of regional interaction caused by prominent actor</td>
<td>Tendency of division of small and large firms</td>
</tr>
<tr>
<td>Public-public relation</td>
<td>Uncertainty in regard to the Oppland County initiative</td>
<td>Public project owner composition gives stability</td>
</tr>
</tbody>
</table>

5.4 Technology and knowledge transfer

There are no producers of bio fuel firing system equipment in either of the regions, nor elsewhere in Norway. There is however firms producing wood stoves, which are sold and marketed both nationally and internationally⁴¹. The fact that Norway is a laggard in utilizing bio energy for

⁴¹ For example Jøtul: http://www.jotul.no
heating purposes compared to other Scandinavian countries, might be a reason why the 
Norwegian industry has not found it interesting (read: profitable) enough to produce such 
equipment. There has until recently not been a market. Hence, the equipment is imported from 
countries like Sweden, Denmark, Germany and Austria. This point of view is shared by 
Skagestad (2005) who examined the bio energy industry within a technological system approach. 
She concludes that Norway is between a technology transfer phase and a system growth phase.

Heating entrepreneurs in either of the regions had in general no prior experience with bio fuel 
heating equipment. They reveal that their introduction to such equipment were either based on an 
interest in installing a small-scale “green solution” at home or/and they saw a market 
opportunity. There were already a few equipment importers in Norway, but these did not, 
according to my informants, provide the knowledge or service required in terms of how to 
operate the equipment and how to install it. They may provide manuals and other codified 
knowledge, but as one informant puts it:

“I buy my equipment strictly from abroad. This is of course due to the fact that there 
are no producers in Norway, but it is also due to the fact that my Danish supplier has 
a long time experience with such equipment. [...] They also know “stuff” that are not 
written in the manuals. There is a certain knowledge that you can only acquire by 
doing it over a long period, if you understand what I mean, for instance how and when 
to adjust the equipment and what components should be used under different 
circumstances.”

Bruland (1989) denotes such learning *skill transmission* which defined the tacit knowledge
transfer from British workers employed by British producers to Norwegian producers and factory owners in the textile industry. Further, the knowledge transfer inherit in the technology transfer did not only regard purely operative aspect, there was also an element of technical information and advice in that the Norwegian actors acquired knowledge of pricing of equipment, market information and administrative issues. The history repeats itself, as one informant puts it: “They [the foreign supplier] provide us with insights in how to position ourselves in the market, the possibilities of adding further services to our product, and in general extend our business.”

In the case of Buskerud there are firms who are purely importers, but many also serve as heat suppliers and hence control more of the value chain. The common characteristic is that they operate as diffusers of technical know-how and relational know-who. Although there is an emerging market for bio fuel heating solutions, there are not enough projects and work in their home region. The customers are spread around the country, and they see no reason why they should restrict themselves to one region. Hence, when implementing a heating system, potential heat entrepreneurs in the region often visit another plant in order to acquire initial knowledge of how to operate such a system. In that way, they will acquire knowledge of consultants. Already established in the industry, the consultants also have an extended network and may convey valuable information in terms of who to contact and what services they offer. However, the initial contact between potential heat entrepreneurs and established suppliers is in many cases initiated by people in the county public project, which according to one informant has been a significant help to the majority of the projects and implementations within the county. The project is thus of vital importance for future suppliers in that it acts as a relational hub. One of the reasons why the
knowledge flows via the public is the fact that loans and investments are granted by public organizations, for instance the bio energy program administered by Innovation Norway, which is also one of the coordinators in the public county project. In this process the future heat entrepreneurs are introduced to existing plants, suppliers and consultants. The project has also hired an energy advisor who is one of the most experienced consultants in the region, and he is contributing further to the diffusion of both technical and relational knowledge.

There are relatively many importers of technology in Buskerud, and some have strong administrative and working relationship to the foreign producer. One in particular has a user-producer interaction that has resulted in a niche of specially tailored heating systems for each customer. Such tailoring may be different ways of the feed-in of bio fuel, equipment able to handle different types of fuel, and additional measuring systems. The user in this relationship is thus the importer and the foreign manufacturer is the producer. However, the importer also acts as a producer in his relationship to his customers. The idea of niche production was born out of the tight relationship to the foreign producer who had informed the firm about the increasing demand-side for special designed systems in the producers’ home country. The producer had experienced a boost in the sale. This may thus also be part of the technical information and advice (market information) as advocated by Bruland. The importer either leaves it to the foreign manufacturer to make the fitting, but he is also doing it himself to a great extent. The technical part of it is a result of their relationship that gives the importer direct access to the original manufacturer's technological know-how. The importer reveals to have acquired the technical insights through extensive on-site training, numerous phone calls and additional contact with the manufacturer's network. The cultural aspect was also imperative to this relationship. The
producer is Danish and is therefore closely related to Norway in terms of language and norms and codes representing the context for communication. The learning aspect and the comprehensive interaction were not an issue with the past manufacturer from Germany. Language barriers and the cultural code of conduct owing to the fact that Germany has more hierarchical and formal ways of doing business were the main obstacles.

The same process of applying for investment loans via the public finance organizations do of course apply to actors at Hadeland. However, the regional project and Innovation Norway do not collaborate to the same extent as in Buskerud, neither are there energy advisors or consultants connected to the public project who might possess the role as objective diffusers of relational know-who or technical know-how. Hence, there is a low intensity in the public-private relationship, and the public project does not function as a hub as in the case of Buskerud. There is of course interaction between private actors, but it mainly takes place between small-scale actors. The region is small in terms of area and number of inhabitants, and according to my informants most people know each other on a personal level, at least among those in agriculture and forestry who are in the group most likely to implement a heating system at their own farm. Hence, learning and information among these actors often go via informal channels, for example by paying a neighbor farm a friendly visit. Other types of relational linkages have decreased caused by rivalry and competition. The consequence is that technology importers doubling as consultants are hired by each and every firm. There are therefore many simultaneous but separate connections to outside consultants who are eligible to introduce the needed competence and network. The result is that each of the actors increase their competence level and extend their network outside the region, but the common regional knowledge base does not accumulate.
Actors also to a great extent become dependent on the external in-flow of expertise, and small actors with scarce financial means, low capacity to enter into beneficial networks or choosing the right consultant or equipment supplier might have difficulties in entering the market.

5.5 Opportunities for new and continued activity at Hadeland

In the case of Hadeland, the implementation rate of bio energy for heating purposes compared to other regions in Norway has proved to be successful. Whereas the share of bio energy use amounts to 12% at Hadeland, the average in Norway is 6%. Hadeland was one of the first regions in Norway to promote itself as a bio energy region, and to initiate a comprehensive public effort solely devoted to bio energy. Hence, there is already a path of green energy utilization. Whereas the first project period was concentrated towards the creation of a cluster significant in a national scale with outward relationships and networks, the second period focuses inward and locally.

If the aim of the bio energy effort is solely to increase the utilization within regional borders, then Hadeland has come a long way. The constellation of actors suggests that most organizations that comprise an optimal system of innovation are present in the region, except education and R&D institutes and technology producers. For the sole purpose of supplying bio fuel and heat, these elements might not be of imperative importance, which was also underlined by the informants. There are actors within bio fuel production, heat supply, and vendors of technology both for large- and small-scale heating solutions. The Energy Farm is a valuable asset in terms of competence, information and network building, and the public Bioreg project has not only focused on the upstream part of the sector but also established relationships to the important Sanitary Plumbing and Heating sector and promoted the advantages and possibilities of green
energy to the inhabitants in the region in terms of informational brochures, fares and school visits.

However, there are some pitfalls and possible hindrances. Most people work part-time on activities related to bio energy production and supply, insecure and unstable work conditions in terms of threats of price competition and over production may lower the existing initiatives, and non-local actors may be ready to penetrate the local market. It is relatively easy to switch to another supplier of fuel or service maintenance provider. Most of the actors at Hadeland say that price is the first element they consider, and the local development aspect is then unfortunately suffering. Thus, the intended regional aspect and aim of business development, regional solutions and decentralization may flop. Hillring (2002) points out that the Swedish public strategy of small-scale, local fuel production has not been as successful as assumed 20 years ago, a strategy that is adopted by the national and local Norwegian policy makers. This has changed the ideas about the strategies in Sweden that have been drawn up to face the development of the market, and Sweden is regarded as one of the most prominent countries in the world in terms of bio energy production and utilization. Furthermore Hillring notes that those who will survive in the future are those who apply system-thinking, possess relational competence and are capable of penetrating not only their level in the value chain but vertically as well. The tendencies of rationalization and internationalization of the market are also adequate. So, what are the opportunities for new and continued activity at Hadeland?
Hadeland is home to 0.69% of the total productive forest area in Norway. Half of the area is owned by two forest associations and two large private owners; the rest is shared among 1000 small-scale family farms. The latter properties are 1416 acre (350 dekar) on average, which is below the national average. Due to the fact that the majority of the forest owners dispose of relatively small area, few of them have an economical incentive to buy their own machinery and tools for harvesting and realizing the wood. The cost of investing in such equipment does not match the gains. The interest in the forest decreases together with the investments. Therefore, most of the forests areas are not utilized for either bio energy or other purposes. Also for those who actually produce bio fuel on a small scale, the production of bio fuel constitutes only a small part of a farmers daily work load and income. There are tendencies of rationalization in that farmers establish firms together, but there is a need for a generally more relational climate in order to become significant producers of bio fuel. The big forest owners may excel in establishing outside region relationships to other forest owners or the wood residue industry. No firm at Hadeland is currently importing significant amounts of wood residues, and the outside links are generally weak. This may be an obstacle in addressing the important question of relational competence and outside networks.

Another obstacle to further production may be that the medium- and large-scale heating systems are relatively old as Hadeland was one of the first regions in Norway to install such systems which can only support certain types of bio fuel, mostly wood chips and briquettes. There are thus weak incentives for production of for example pellets, which contains more energy per unit

that the two former mentioned bio fuels, for local utilization and sale. As most firms are dependent on a local market that can serve as an entrance to other market opportunities, start up may seem to be difficult at Hadeland, and actors may not be able to take part in the increasing internationalization of the bio fuel market.

As to the technology and knowledge transfer, knowledge seems to flow directly from outside region firms and consultants to separate actors at Hadeland. There are thus many simultaneous streams of knowledge in terms of know-how and operational skills, but limited rates of diffusion within the region. Many actors are too small or they do not wish to become importers of technology or they may have difficulties in supplying additional services and technical maintenance themselves. As a consequence of the limited diffusion of know-how, the important asset of know-who and outside relations suffers. The tendencies of inner region rivalry do not contribute to an advantageous climate for knowledge sharing or cooperation. Such rivalry may to a certain extent limit the possibilities of vertical integration and system-thinking. Especially the strong position held by the Energy Farm in terms of both technical knowledge, national and international networks and overall industry knowledge. People behind the information and competence center have interests in one of the firms at Hadeland, and competing actors find it unnatural to ask a direct competitor for help and advice. An important factor for further activity at Hadeland is thus to what extent the Energy Farm manages to find a solution in sitting on both sides of the table.

5.6 **Opportunities for new and continued activity in Buskerud**

In contrast to Hadeland, the general bio energy effort in Buskerud started relatively late. There
was no significant path of green energy, but the strategy of co-shaping and inclusion of private actors has proved to be successful. This is also the case for the composition of project owner participants; Innovation Norway, the County of Buskerud and the chief administrator in Buskerud.

If one looks purely at the regional share of bio energy already implemented, then Buskerud lags behind Hadeland. But the project has been a helper for many projects initiated but not yet executed or put to life. The projects has good support in the local communities, the inclusion aspect is adopted from the mother project. The future of realizing the projects are promising because people in the local projects draw experience from local projects already realized, they get technical help from people connected to the mother project and other relations they need, and they have established connections to organizations within the forestry industry providing courses and education. The people within the communities are positive because there is an implicit thought of utilizing local bio fuel. Buskerud also have more densely populated areas, and it is therefore easier to supply green heat to many people at once. District heating is already implemented in many cities, to which the technology equipment industry in Buskerud has benefited.

The overall actor composition in Buskerud is satisfying, but similar to Hadeland there are no education or R&D institutes in the region. The county has an advantage in the strong presence of technology vendors and services, which may lead to a flourishing activity as their market is cross-regional. The biggest threat does not lie within the county, but outside; slow public national administration, and equally slow implementation of incentives to increase the demand-side.
There is a national political will, but the ability to take action is low. According to the informants financial support is less than needed, low electricity prices restrict the willingness for new investments in bio energy heat solutions, and laws must be changed to favor renewable energy. Again similar to Hadeland, there is a threat of outside competition that can increase the potential for local activity and also hinder further activity heading outwards. So what are the possibilities for new and continued activity in Buskerud?

10% of the forest area in Norway is located in Buskerud, that means 60 700 500 acre (15 million dekar)⁴³. In difference to Hadeland, the large owners have their hands on most of the area, 93% versus 7% owned by the small. However, the small properties are on average bigger units than Hadeland. The obstacles for owners of small forest area are the same as for those situated at Hadeland. Hence, it might be difficult to become a bio fuel supplier. The larger units are a good starting point for rationalization and export of bio fuel as a high volume can compete with international price levels. The challenge is to readjust to become a bio fuel producer, to establish cooperation and relationships to other forest owners, and to access the market. Thus, the obstacles are not technological, but more organizational and marketing related. There is one firm that has specialized in selling and marketing pellets, which was established as an extension of a large-scale pellets producer in the vicinity. They mostly sell abroad and have established several international contacts. And they have succeeded. This shows that one of the success factors to further activity is to gain competence outside the pure production-wise operations or relate to actors that already possess such competence.

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⁴³ Statistics from State of the Environment Norway (Miljøstatus) that is a public initiative web site maintained by the Norwegian Pollution Control Authority (SFT) : http://buskerud.miljostatus.no/msf_themepage.aspx?m=2648
Many actors integrating vertically into the bio energy for heating value chain starts as technology importers and vendors. There are already some examples in Buskerud. As there are relatively many actors at this level in the chain in Buskerud, it may be a good expansion opportunity for these firms. As shown in section 6.4 technology sale, implementation and maintenance does not restrict itself to the regional borders. It takes place across borders and the possessors of know-how thus get an important position. As their customers are both people working in bio fuel production and heat supply, they acquire knowledge of these areas as well and the whole chain. It might then be easier to enter into relations with actors within other parts of the chain and extend their own business by offering bio fuel either from own production or buy from other producers and heat supply, in addition to technical maintenance and service.

In difference to Hadeland there has been little focus on the downstream perspective, which can be a hindrance to further activity. Whereas the Bioreg project made great effort to integrate the important Sanitary Plumbing and Heating sector, no efforts are done in Buskerud, neither by the public project nor the private actors. The general view is that actors within bio energy for heating purposes do not regard it as their job to “educate” the above mentioned sector. Such a view is supported by the fact that no firm located in Buskerud within the sector is listed in the NoBio industry index as in contrast to the case of Hadeland. Another obstacle might be the weak links to the construction sector, which is imperative to increase the rate of implementation of bio energy solutions in new buildings and housing areas. This might be a problem particularly to the
more densely populated areas in the region as statistics show that people move to the cities\textsuperscript{44} and many new buildings are raised there.

5.7 Implications for policy makers at Hadeland

The bio energy effort and strategy has changed a lot during the life of the Bioreg project. Such abrupt and volatile conditions may contribute to \textit{uncertainty} among private actors. There has been a shift in policy from favoring an almost breakthrough-like attempt of creating a bio energy cluster to focusing solely on local small-scale activity. It seems like the project management needs to stabilize a coherent strategy that includes elements both of co-shaping and room for individual efforts. The difficult second phase of the project can be compared to an artist working on the hard second album after publishing a great first album. The challenge for the Bioreg project will be to take care of the first-mover advantage gained through the early start up.

The path has \textit{reflected the institutional set-up} over time. The lack of public presence has contributed to a fading of the aspiring bio energy efforts in the region. According to McCormick and Kåberger (2005) who described a successful regional bio energy innovation system in Sweden, well-defined and good working relationships between public authorities and private actors were significant factors in the blooming bio energy activities. Therefore, the project should strive to involve itself more into the daily work of the private actors and actively seek to establish relationships both in early periods of start-ups and with current businesses. Now, there are two diverging paths, one for the private actors and one for the project.

\textsuperscript{44} Aftenposten, Norwegian newspaper: http://www.aftenposten.no/nyheter/iriks/article1859735.ece
Such diverging paths may also be a sign of lack of system openness. Many informants reveal their frustration at the missing opportunities of getting investment loans on leased equipment as opposed to the current requirements of buying in regard to the Innovation Norway bio energy program. As a consequence many potential bio fuel producers, particularly small actors, are not financially able to start up harvesting and production. Closing the gap implies a certain awareness of the private actors’ situation, and the public project to acquire first-hand knowledge of obstacles to further activity that can be forwarded to both national and regional policy makers. Hence, actors may have a possibility to change the rules of the game.

The Bioreg project might also benefit from letting go of the second phase inward and local focus and open itself up for outside impulses, a more outside-regional attitude that can serve to support the inside region relational climate. This is not to say that they should re-establish all relationships to national and international R&D organizations, but by serving as a 'gatekeeper' to outside region technical know-how and in particular relational know-how knowledge, which will probably be imperative to market access vertical integration opportunities and the lack of significant technology importers located in the region. Thus, they might re-create their position as a hub in which such knowledge passes through on the way to the private actors. Such a position can to some degree help in the current state of unwillingness to share information among private actors and contribute to more diffusion, especially important for new start-ups without strong connections or market segment. An indirect effect of such a recommendation is a shift towards a more commercial attitude and not merely political administration, which was also expressed by the vast majority of the private actors interviewed. A shared vision of commercial market penetration may be a good starting point for a re-establishment of the competence groups
originally sketched on the organizational map. It may also help in addressing problems of organizational and marketing related character, which is a must in future outside region expansion.

5.8 Implications for policy makers in Buskerud

The public project has been successful in many ways due to its composition of relevant actors in the owner group. Many actors at Hadeland point to the constellation as a successful one. It has been easier for actors to relate to financial sources which are national in scope. There has been a bricolage-like attitude and co-shaping of path, but larger actors can hamper the efforts of further opening up the system and make it an including one. The public project functions in many ways as a hub in that technological know-how and relational know-who is diffused. There is nevertheless a tendency of segregation into small and large actors due to immense competition. The big heat suppliers are for example reluctant to cooperate with many, small bio fuel producers due to their limited product range and generally increased administration costs. There is thus no incentive for larger actors to collaborate with smaller ones. The value of participating in or stay in touch with the public project decreases, and the formers networks and willingness to share their experience with the latter might reduce the position of the public project. It is therefore imperative to discuss this potential problem when authoring the strategy for the next project period.

The international network efforts must continue as a part of an outside-relational competence building. The public project has been a participant in international networks and cooperation that aimed to establish an international market for bio fuel. In my consideration, my informants
underestimate the importance of the participation when they say that little came of out it and that the time and money spent were wasted. An actor with strong ties to the public project was introduced to the networks, saw an opportunity to enter into beneficial relationships and is now an established part in one of the project groups. This shows that the public project may be important for outside impulses and a diffuser of relational know-who.

As the main obstacle to bio fuel production is not of a technical character but rather organizational and marketing related, the public project might help the producers in acquiring such competence or helping them identify potential buyers or markets. The firm mentioned above that established important relationships to actors with knowledge of foreign bio fuel markets is a marketing organ solely for pellets produced by a firm closely related to it both in terms of geography and relational ties. There are no other market organs for bio fuel distribution in the region in which all producers can sell their commodities. Neither regional nor national policy makers pay much attention to this problem, which deserves to be addressed. Many of the informants point out that the demand for bio fuel, and pellets in particular, increases abroad and many countries have already well established markets and are familiar with buying from all kinds of suppliers, not only domestic.

As a consequence of the inability of private actors to pay attention to the downstream perspective, the public project might help the actors in trying to integrate the Sanitary Plumbing and Heating and construction sector in order to open their eyes to the market opportunities of bio energy for heating purposes and maybe benefit from their expertise valuable to further implementation. For instance the Association of Plumbers (Rørleggerlauget) in Drammen, the
largest city in Buskerud has a strong position, and trying to make them a natural part of the green heat value chain might prove to be a smart move. The population centralization tendency and the recent increase in new buildings raised indicate that there are possibilities of implementing bio energy district heating systems. The first housing area designed for bio heating in the entire country is located in Buskerud\textsuperscript{45}. It utilizes bio gas as energy source and not the type of bio fuel discussed in this thesis, but the main point is that the construction firm was willing to realize an environmental friendly project, and the feedback from the house buyers proved to be very positive.

There are relatively many technology importers in Buskerud, and many of them also operate as consultants. \textit{Niche} application and special tailoring of heating systems have proven to be a successful source of income and expansion in more developed market in which production of equipment takes place. Bjørnstad (2003b) points out that flexibility and product diversity might be an advantage that makes one stand out from the crowd. Hence, the public project management should consider a strategy of helping the actors identifying new possibilities and needs within the bio energy for heating purposes sector. People working in the public project should also market the opportunity and advantages of tailoring to actors who contact them, both inside-regional and external actors, and in that way contribute to an awareness of the opportunity and the potential long term cost-reduction as they will save money on investing in generic and scalable equipment.

6 Conclusion
The goal of this thesis has been twofold; to identify actors in the two regional innovation systems and thus primarily to examine how learning and interaction takes place within the two systems.

\textsuperscript{45} http://www.enova.no/?itemid=3964
The focus has been opportunities for new or continued activity in the two regions. The comparative approach has made possible insights on how particular regional institutional set-ups influence learning and interaction by hindering or supporting different efforts.

The constellation of actors in the two regions is rather similar. There is a public bio energy initiative in both regions, and both regions are home to bio fuel producers, heat suppliers and technology importers. Neither of the regions have education and R&D institutes. Whereas the sanitary plumbing and heating sector is part of the regional innovation system at Hadeland, the non-presence of this sector is noteworthy in Buskerud. The construction sector was not identified as a part of the bio energy for heating purposes industry in neither of the cases scrutinized. As systems of innovation are open and heterogeneous, actors outside the regions are also parts of the geographically limited regional system of innovation. For actors in both regions, the hesitation to implement laws and alter efforts meant to reduce uncertainty has recalled the opposite reaction. The lack of interaction between public administrations has proved to be an obstacle to competence acquisition.

Similarities in the actor constellation notwithstanding, the differences revealed in the thesis were caused by the different institutional set-ups in the two regions. Both regions have made efforts of a path creation in their own way; Hadeland with its abrupt attempt to form an industrial cluster without the necessary industrial base, and actors in Buskerud by embarking on a career in the industry without any prior knowledge of it. Whereas the public project in the latter region has been characterized by co-shaping, a bottom-up strategy and a bricolage-like approach, the former has been differently characterized by a top-down and breakthrough-like method. As a result there
has been a general division between private actors and the public project at Hadeland, and a more relational climate in Buskerud in which the public project functions like a hub and diffuser of learning and interaction. The limited inter-regional cooperation at Hadeland has utterly diminished due to inter-firm rivalry.

Actors neither at Hadeland nor in Buskerud say that the lack of technology producers in their home region is an obstacle, but their relationship to the technology importers seems to be very important for the diffusion of many types of knowledge originally acquired from foreign manufacturers. The main difference is that Buskerud has several technology importers, many of them also functioning as consultants. As these operate not only within their own region, they function as diffusers of relational know-who and technological know-how. In Buskerud such knowledge often flows via the public project, and at Hadeland it flows into the region in many simultaneous and separate connections.

Hence, the location of technology importers in the region is one of the promising facts for new and continued activity in Buskerud as there probably will be a market for niche applications. The existing outside-regional relationships might also be beneficial. Nevertheless, the growing tendency of division of actors according to size and significance due to fierce competition and decreasing returns may hamper the established system of openness. Other hindrances might be the lack of a downstream perspective and organizational and marketing-related competence. In the case of Hadeland, inner rivalry and the non-presence of outside-regional relationships at Hadeland seems to be the main obstacles to new and continued activity in the region. The lack of system openness may have contributed to a diminishing intensity of activity and initiatives in
general. There is also a need to reduce uncertainty in order to stabilize the institutional set-up.

From the differences found in the two regions, there are no general conclusions to draw in terms of learning and interaction in regional systems of innovation with the bio energy for heating purposes industry. There is therefore a need for further empirical studies of other regions, for example the County of Hedmark which many of my informants point out as an interesting research case, in order to understand more of the actual situation.
References


