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Suvi Huttunen

Sustainability and Meanings of Farm-Based Bioenergy Production in Rural Finland

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ABSTRACT

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Rural bioenergy production has accrued interest in recent years. EU pressure for climate change abatement and energy political concerns regarding the availability of fossil fuels, have increased bioenergy production objectives in Finland. In addition, rural regions in Finland have encountered structural changes following EU inclusion, including an emergent interest in auxiliary production lines of which bioenergy production is an example. Local bioenergy production has the potential to increase rural sustainability and provide a model for sustainable rural development and energy production. Focusing on the recent emergence of small-scale farm-related bioenergy production: heat provision from wood fuels and biogas and biodiesel production, this study aims to discover if and how farm-based bioenergy production contributes to sustainable rural development. The study derives from the field of rural studies and evaluates sustainable rural development via the concepts of multifunctionality, embeddedness, ecological modernization and sustainable livelihoods, with a particular focus on social sustainability. The empirical portion of the study is comprised of thematic qualitative interviews of bioenergy producing farmers, and on newspaper and periodical article material. The results demonstrate how rural small-scale bioenergy production can have important positive developmental effects that ameliorate and sustain livelihoods in remote areas. This occurs via the multifunctional benefits of bioenergy production to the producers and local communities. The positive effects include social, economical and environmental aspects and rural bioenergy production can present traits of sustainable rural development, predominantly manifested in the social aspects of increased capabilities and reinforced social networks. There are, however, important differences between the examined production models. As an example of achieving sustainable rural development and livelihoods, heat entrepreneurship presents the best option. Biogas and biodiesel production provide more complex cases and even exhibit some negative developmental effects related to economic profitability. Biogas and biodiesel production could benefit from greater reliance on peripheral resources, enhanced networking and the realization of community benefits via improved cooperation.

Keywords: sustainable development, bioenergy, biofuels, rural development, livelihoods, multifunctionality, ecological modernization, eco-economy, Finland

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FOREWORD

The journey to this point has been longer and included more sideways than I ever could have imagined in the beginning. However, looking back, I would not change a thing. I have learned much. There are many people who have taken part to the journey at some point or another, or even during the whole trip. Without them this dissertation would have looked a lot different or would not even have been finished at all. So, let the thanking begin:

Starting from the beginning, I wish to thank people in the Renewable Energy Programme in the University of Jyväskylä for providing me with the topic of my master's thesis, which eventually led to the subject of my dissertation – the rural bioenergy pioneers. And obviously the next big thanks goes to the pioneers themselves who have shown an incredible courage and interest in doing something new and who did not hesitate to be interviewed.

The research work for this thesis was carried out in the Department of Social Sciences and Philosophy, University of Jyväskylä. There, my supervisor Professor Marja Järvelä has been irreplaceable. She has guided me through the entire process from a vague idea to this finished thesis, helping with both practical matters starting from funding to more theoretical questions. Most importantly she has believed in this thesis even when I have not. Kiitos Marja.

During the most part of preparing this thesis I worked in different teaching positions in the Unit of Social and Public Policy. Thanks to all the people there and the entire department for a pleasant working environment. In addition to teaching posts, I had a change to take part in a research project *Sustainable Development and Pioneering Small-Scale Rural Entrepreneurs* (SUSMARU), funded by the Academy of Finland. Thank you all the susmaru people, especially Dr Antti Puupponen, Professor Pekka Jokinen and Dr Ari Paloviita.

I'm grateful to all the people who have commented my work in different seminars and conferences at home and abroad. A special thanks goes to Professor Raimo Lovio and Docent Taru Peltola for reviewing the entire thesis and for their encouraging comments and suggestions for improvements.

During the past year I have been working with new projects at the Finnish Environment Institute. There I wish to thank Docent Paula Kivimaa and Professor Mikael Hildén for new insights, contacts and engouragement during the finishing of the dissertation. Thanks also for the other crew.

From the more practical side of making this thesis I wish to thank Lari Tirkkonen for helping with the interviews. I'm also indebted to Anna and Lisa Jokivirta for proofreading the language of this thesis. In addition, I wish to thank all the people in Viheri for the unforgettable year of not doing research – a year without which I don't believe this thesis would have ever been finished.

The final thanks is for family and friends, most of all Jaakko and Mai for just being there.

Käpylä, December 2012

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LIST OF ORIGINAL ARTICLES

Article I Huttunen, S. 2009. Ecological modernization and discourses on rural non-wood bioenergy production in Finland from 1980 to 2005. Journal of Rural Studies 25, 239-247.

Article II Huttunen, S. 2011. Bioenergy production and social sustainability in Finnish farms. In Järvelä, M. and Juhola, S. (eds.) Energy, policy and the environment. Modeling sustainable development for the North. New York: Springer. pp. 173-192. (Originally published in Finnish in Maaseudun uusi aika 3/2009.)

Article III Huttunen, S. 2011. Embeddedness in local farm-scale bioenergy production. AGER Journal of Depopulation and Rural Development. Special issue on private entrepreneurs in rural areas 11, 107-127.

Article IV Huttunen, S. 2012. Wood energy production, sustainable farming livelihood and multifunctionality in Finland. Journal of Rural Studies 28, 249-258.

1 INTRODUCTION

1.1 Rural bioenergy production and diversification on Finnish farms

Finland is often considered to be a frontrunner in global bioenergy production. For decades, the share of bioenergy in Finland's energy palette has been the highest or among the highest, in the developed world. Bioenergy resources are usually located in rural areas in the form of forests and fields. Hence, one would assume that extensive experiences and established patterns for rural energy production exist in Finland. Surprisingly however, such is not the case. Finnish bioenergy production is largely based on the utilization of forest industry by-products, like black liquor (Figure 1), and the whole field is characterized by large-scale centralized production with modest opportunities for local diversification.

Aside from the obvious, rapid growth in the utilization of forest industry by-products during the 1980's and 1990's (Figure 1), other important changes are also apparent. First, the utilization of solid wood fuels in heating and their consumption by power plants has continually increased from the early 1990's. Additionally, new forms of bioenergy, namely biogas and liquid biofuels in traffic[1] also emerged. Finally, the small-scale combustion of wood in small buildings and households is slowly increasing. Part of this diversification is occurring at the rural and farm levels

The agricultural sector in Finland has experienced structural changes, which were accelerated by EU inclusion in 1995. Although the number of farms has steadily decreased, their respective size has increased. In 2010 there were approximately 20% fewer farms compared to 2000 and almost 35% less than in 1995. The average area of arable land cultivated by single farms has increased about 60% from 1995 to 2011 (Niemi and Ahlsted 2011). Traditionally, rural

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1 Their emergence is partially statistical, as they have not been part of official bioenergy statistics prior to the 2000's, but the mere inclusion in the statistics signifies their increasing importance.

townships in Finland have been founded on small-scale family farms but the increasing numbers of specialized large-scale industrial farms with professional management structures now challenge the family farming concept (see e.g Hildenbrand and Hennon 2005, Vesala and Vesala 2010). Another development trend is towards an increasing reliance on diversification activities.

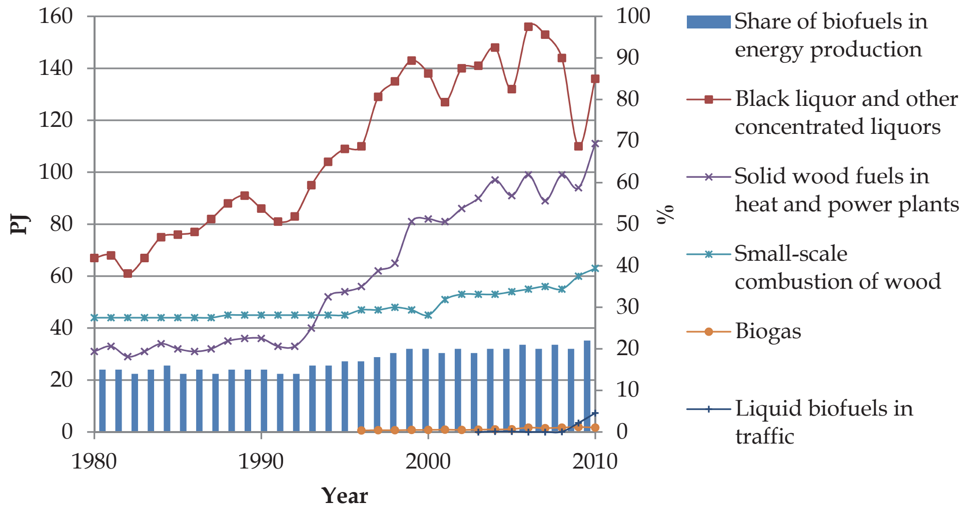

FIGURE 1 Biofuel varieties (lines) used in energy production in Finland between 1980-2010 and their combined share of total energy production (bars). (FFRI 2011)

The traditional Finnish family farm obtained its livelihood from the combination of forestry and agriculture (Niemelä 2008: 153). The mechanization of forestry practices was primarily to blame for the destruction of the occupational integration between forestry and farming that occurred in the 1960's (Rannikko 1999). What connection to forestry remained was maintained via forest ownership. An important share of a farm's income can still originate from forestry, in the form of timber sales. Hence, in Finland, forestry is not regarded as a diversification branch, but rather as one possible farming production line. The modernization of many forestry practices have contributed to diversification strategies on Finnish farms. Developments in forest and farm machinery contracting, in addition to familiarity with forestry work and farm-based utilization of forest resources in heating form the foundation of bioenergy production. Forests and forestry have particular importance in the area of Central Finland, where nearly 60% of farms cited forestry as either the primary or auxiliary production line in 2005 (Niemelä et al. 2005).

In 2010, approximately 30% of Finnish farms were engaged with at least one diversification branch. The most popular branch consisted of different services, with various forms of machinery contracting being the most common (approximately 45% of diversifying farms). As a diversification branch, renewable energy production is increasingly becoming a significant option (Table 1).

In 2010, it was the most common industrial diversification farming form, exceeding such options as food and other agricultural product processing. In 2010, nearly 5% of farms were engaged in energy production, the majority of which was related to wood bioenergy. While other renewable energy production remains marginal, some increases have occurred since 2000. (Tike 2011)

TABLE 1 Number of diversified farms engaged in energy production activities and their share of all diversified farms in 2000, 2005 and 2010 (Tike 2011).

Year	2000	2005	2010
Wood energy production and fuelwood	640 (3,0%)	745 (3,5%)	621 (3,2%)*
Other renewable energy	8 (0%)	79 (0,4%)	47 (0,2%)
Peat production	311 (1,4%)	217 (1,0%)	237 (1,2%)
Energy production (total)	959 (4,4%)	1037 (4,9%)	907 (4,7%)
All diversified farms (total)	21832 (100%)	21244 (100%)	19530 (100%)

* additionally, there were 57 farms diversified in bioenergy contracting, increasing the share to 3,5% and the share of total energy production in all diversifying activities to 5 %.

Part of the diversification in wood energy production includes a practice called "heat entrepreneurship". Heat entrepreneurship simply denotes the production of wood-based heat for retail purposes, on a small-scale. Typically, such entrepreneurs heat large municipal buildings, like schools, in areas where district heating is unavailable. Occasionally, they may even be employed to heat a small district-heating network. For the farmers, this has resulted in a shift from mere raw material provision to the production of a refined energy product, and a new utilization of their forest resources (Peltola 2007). Heat entrepreneurship is becoming increasingly popular in Finland. The first heat entrepreneurs began operating in the early 1990's. At the time of the data collection for this study (2006-2007), there were approximately 200 heat entrepreneurs and over 300 heat plants operated by heat entrepreneurs in Finland (Alanen 2007). By the end of 2010, the figure had risen to include 490 heat plants in operation (Solmio 2011).

A small portion of diversified farms also have a role in the development of the emerging biogas and liquid biofuels energy sector (Figure 1). At the time the interviews for this study took place, there were about 8 farms producing biogas and several were in the process of building a biogas reactor (Kuittinen et al. 2007). In 2011, the number of biogas producing farms had increased to 10 and 14 plants were in the planning or building process (Huttunen and Kuittinen 2012). In addition, there was one large unit managed co-operatively by several farms (Huttunen and Kuittinen 2012). Biodiesel production on farms is unaccounted for in statistics but 20 to 50 farms are estimated to be involved in its production. The biogas and biodiesel farmers interviewed for this study were primarily producing energy to satisfy the farm's individual energy requirements in the form of heat, electricity and traffic fuels (see original articles II and III). Thus, contrary to heat entrepreneurship, the production of biogas or biodiesel on farms can seldom be considered an auxiliary production line in the sense of producing externally sold products. Rather, it is an addition to food production that increases the farm's self-sufficiency.

Diversification will serve as the focal point of this thesis - particularly how rural energy production is conceptualized, how energy producers understand their activity, how it has emerged, what it looks like and essentially: what it means in relation to sustainability and rural development.

1.2 The question of sustainable rural development

The surge and increase in farm-scale energy production reflects its potential and the need for a more diversified view on both bioenergy production and farming related activities in Finland. The apparent drivers for rural energy production are climate change mitigation and the urgency to develop new energy sources as traditional ones become exhausted (Flavin 2008). Focusing on rural energy production in relation to local energy broadens the perspective. Local energy production can be understood as energy created from regional resources, combined with locally based consumption. It represents a distributed energy production pathway that is rooted in the "soft energy path" proposed by Amory Lovins in the 1970's (Lovins 1977). Currently, in the European context, it can be paralleled with various emerging farm diversification options, including local food, agro-tourism and small-scale industries, as previously discussed.

These alternate production forms have emerged as a response to various societal and rural changes related to globalization and trade liberalization, resulting in cost-price squeeze on farms in the form of rising expenses and simultaneous decreases in product prices. In parallel to this development, food security and environmental concerns and demands related to agricultural production have become increasingly important issues (Marsden and Sonnino 2008, Marsden 2009, Snäkin et al. 2010). These changes have been partially diffused to Finland via the EU's Common Agricultural Policy, which determines farm subsidies and conditions. Rather than responding to the cost-prize squeeze by further specialization and enlargement of the scale, the farms engaged in new types of production have taken the environmental and social challenge earnestly and opted for value addition in terms of re-localization, quality production and the maintenance of cultural heritage (e.g. Marsden and Smith 2005, Fleskens et al. 2009, Järvelä et al. 2009).

As such, diversified production represents a new path in rural development by challenging the primarily food-based, raw material production function of farms and rural areas (van der Ploeg et al. 2000, Knickel and Renting 2000). It may even be suggested that it has the potential to increase rural sustainability and provide a model for sustainable rural development (see Marsden 2003, 2009) and energy production (see Elliott 2000). The utilization of endogenous rural resources in the creation of local value addition for the emergence of more sustainable rurality has recently also been conceptualized in terms of eco-economy (Marsden 2010, Kitchen and Marsden 2009). This concept emphasizes local processes in striving towards sustainable development and challenges the increasingly popular term bio-economy, which focuses more on globally oriented technological solutions for the sustainability challenge and nonrenewable resource depletion (Marsden 2010). Bio-economy is seen as representing important potential for attaining sustainable growth and improving global competitiveness via innovative utilization of bio- and nanotechnologies in producing and refining biomass for health, food, energy and industrial processes (Jordan et al. 2007, OECD 2009, Sheppard et al. 2011).

Connecting farm based bioenergy production to sustainability is simple to make on a general level: bioenergy production has definite potential for environmental, social and economic benefits (e.g. Domac et al. 2005). However, sustainable and reasonable utilization of rural resources is not simple, nor is the actual assessment of sustainability. There are several studies relating bioenergy and renewable energy production to sustainable development (e.g. del Río and Burguillo 2008, Bucholz et al. 2007, Elghali et al. 2007). All suggest variations on concepts to analyze sustainability, exemplifying the importance of case specific assessments and also potential trade-offs between the environmental, economic and social dimensions of sustainable development (see also Mol 2007, van der Horst and Evans 2010).

In this study, sustainable development is analyzed through the utilization of the concepts of multifunctionality, embeddedness, ecological modernization and sustainable livelihoods, with a special focus on social sustainability. The core concepts are closely connected to one another. Ecological modernization refers to the integration of ecological concerns into different societal sectors via the creation of win-win situations, where ecologically compatible innovations create economic growth (Hajer 1996, Buttel 2000, Mol and Spaargaren 2000, Dryzek 2005). Ecological modernization is often characterized by a differentiation between weak and strong forms, where weak ecological modernization focuses on technological solutions for environmental problems and strong versions imply profound changes in the way we live (Dryzek 2005: 173-4, Hajer 1996). Sustainable rural development is connected to strong ecological modernization (Horlings and Marsden 2010). Multifunctionality is the core concept behind the observed rural change, where farms and rural regions are perceived to fulfill functions other than mere raw material production for agricultural or forest industries - hence being multifunctional (Knickel and Renting 2000). These functions are essentially ecological and social, thus multifunctionality potentially leads rural development to a more sustainable direction (Marsden and Sonnino 2008, Wilson 2008). Multifunctionality can be understood as incorporating local and regional embeddedness (Wilson 2008), where personal ties, mutual knowledge and trust are central in the formation and sustainability of economic relations (Hinrichs 2000, Sage 2003, Sonnino 2007). Sustainable livelihoods place the encompassing focus on local actors and their assets in the creation of livelihood outcomes that have the potential of enhancing sustainability (Scoones 1998, 2009).

The rural sustainability approach to bioenergy production differs from other emerging approaches to bioenergy and renewable energy in general among social sciences. These include transition and innovation studies using for example the conceptualizations around multi-level perspective or strategic niche management (e.g. Ulmanen et al. 2009, Raven and Geels 2010) and more general policy analysis (e.g. Kivimaa and Mickwitz 2011). The advantage of the rural sustainability approach lies in the attempt to reveal the actual effects of the transitions and in providing local perspective to the conditions of emerging innovations.

1.3 Research questions and original articles

This study focuses on the bioenergy-producing farmers themselves and their perceptions regarding their energy production activity. The primary focus of the research is to reveal the ways farm based bioenergy production contributes to sustainable development and more specifically, to sustainable rural livelihoods. This is achieved by examining the experiences, perceptions and visions the farmers attribute to their bioenergy production. The aim is to uncover the farmers' understanding of the meaning of their bioenergy production and the impacts of farm based bioenergy production to rural areas and to society in general.

Of further interest is the examination of what the emerging bioenergy production activity reveals about rural development and how it relates to the discussion on bio- and eco-economies? In the analysis, the characteristics of social sustainability, multifunctionality, embeddedness and ecological modernization are examined in relation to the various bioenergy production types. In addition, the functioning and evolution of farm-related bioenergy production systems are examined from the viewpoint of the rural actors.

The thesis is founded upon four original research papers and this summary article. The original papers are available at the end of the thesis. The research questions and their relation to the original articles are presented in Figure 2. The first paper, *Ecological modernization and discourses on rural non-wood bioenergy production in Finland from 1980 to 2005*, concentrates on the historical development of non-wood bioenergy production in rural discourses and compiles its data from newspaper articles. The theoretical focus is ecological modernization, and the central question is: are non-wood bioenergy production options presented in terms of ecological modernization?

The second paper, *Bioenergy production and social sustainability in Finnish farms*, explores social sustainability in rural energy production and maps bioenergy producing farmers' conceptions regarding their activity. The empirical material is based on 31 interviews of bioenergy producing farmers. Social sustainability is assessed by examining the energy producing farmers' lives, their farms and projected futures and the localities surrounding the farms.

The third paper, *Embeddedness in local farm-scale bioenergy production*, utilizes the same empirical material as the second paper. It follows the concept of embeddedness - commonly used in local food studies and applies it to the analysis of farm-based energy production. Its primary focus is on the extent that locality and quality in bioenergy production influence the conceptions of the energy-producing farmers.

The fourth paper, *Wood energy production, sustainable farming livelihood and multifunctionality in Finland*, focuses on the analysis of 15 interviews of heat entrepreneurs and the multifunctionality of their heating activity. The article's central claim is that multifunctionality provides a useful steppingstone in the analysis of sustainable rural livelihoods as increasing multifunctionality tends to lead to fortifying sustainability.

This summary integrates the main conclusions from the original articles and develops them further by introducing some new article material and theoretical considerations. The novelty of the summary is in its ability to apply the concept of eco-economy to combine the central concepts in the analysis of sustainable rural development. This offers a more dynamic perspective to the interrelated nature of the central concepts and provides insight into the potential of energy production activity in creating more sustainable outcomes.

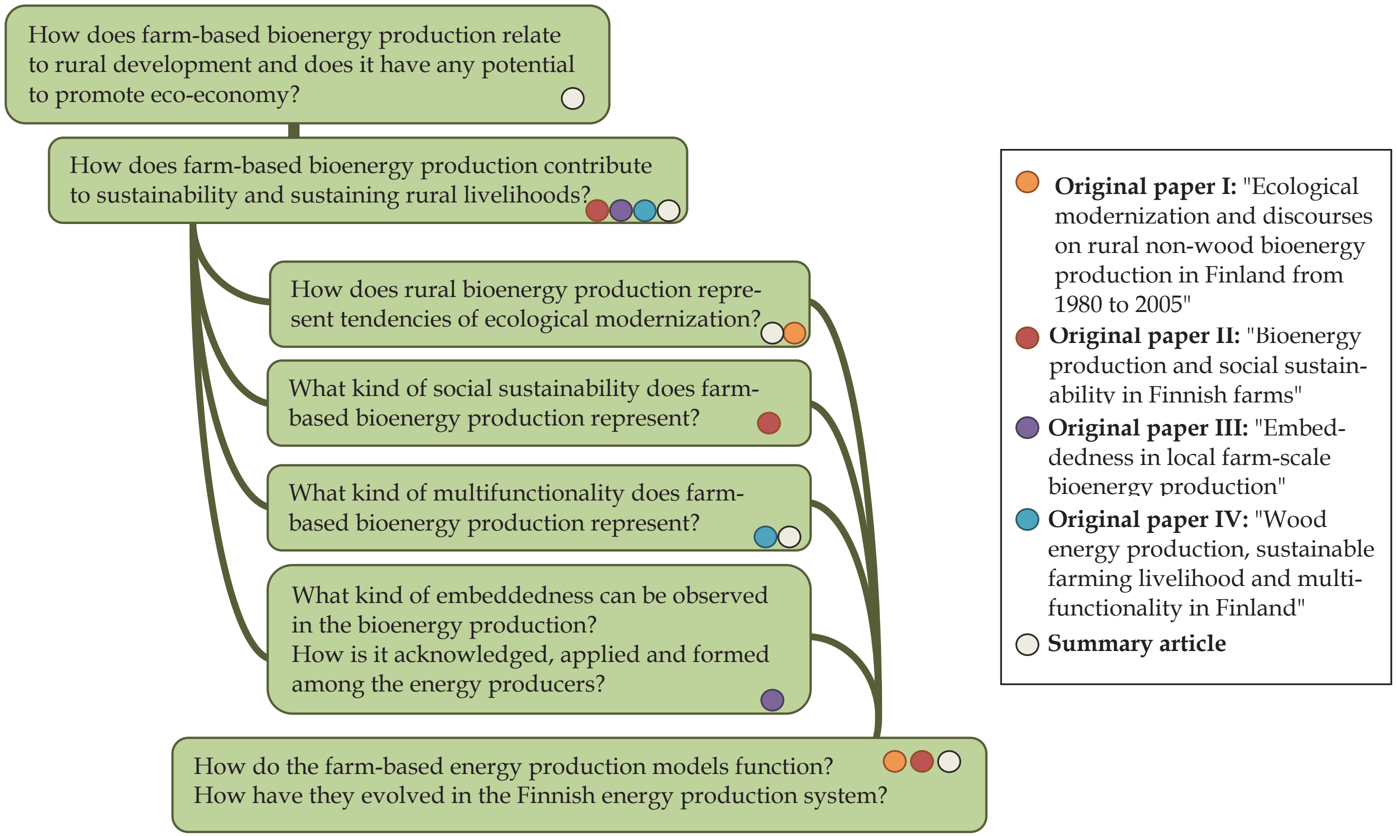

FIGURE 2 Research questions with the original papers and summary article. The papers addressing each question are marked accordingly. The summary article addresses all questions. New data or theory relating to the questions that is presented in the summary article has been indicated.

2 THEORETICAL BACKGROUND

2.1 Sustainable development and social sustainability

Sustainable development is a rather paradoxical term (Giddens 2011:61). How can something simultaneously be developed and sustained? The paradox is figurative for the concept, as it has been interpreted for controversial purposes, with claims that sustainable development could be used as a justification for practically any policy (for a discussion see Jacobs 1999, Meadowcroft 2000). However, the paradoxical nature of the concept can also be seen as its strength as it provides a platform for discussion for individuals with different aims to assimilate and try to unite their goals (Hermans et al. 2010). Moreover, the contrasting and contesting interpretations of sustainable development form the essence of the political struggle over the direction of the presumed development, keeping different interests on the agenda (Jacobs 1999).

In defining sustainable development, the essential questions are: what should be sustained, what should be developed and how? (Meadowcroft 2000). In the most common definition for sustainable development, stated in the Bruntlandt commission's report "Our common future," the concept is defined as: "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED 1987: 43).

The report elaborates on the definition further and a few central deductions can be discerned. The emphasis is on fulfilling human needs, particularly those of the world's underprivileged. The fulfillment of present needs is limited by the needs of future generations and fundamentally the degree of present development or economic growth should not override environmental preservation (WCED 1987: 43). The concept leaves room for different interpretations related to what and how to sustain and develop. There have been numerous attempts to redefine the concept in order to render it more relevant analytically (see e.g. Elliott 2006:10, Connelly 2007) but the concept seems to have escaped the margin where an agreeable analytical definition is possible, or even desirable (Jacobs 1999). However, some elaboration into the vagueness of sustainable development is inevitably needed.

Usually, sustainable development is divided into three or four dimensions: environmental, economic, social and sometimes, cultural. Here, the cultural dimension is included in the social dimension and the term 'socio-cultural dimension' could also be applied (Munasignhe 1993, Chiu 2004). The interconnectedness of the social and cultural dimensions is based on the culture-specificity of the understanding of social sustainability, for example, in terms of quality of life (Chiu 2004). Most often, the dimensions are considered to overlap and bear equal importance (Figure 3a), demonstrating how the dimensions cannot be completely separated and how "real" sustainability can be achieved only when all dimensions are combined, as in the intersection of the spheres (Conelly 2007, Elliott 2006:13).

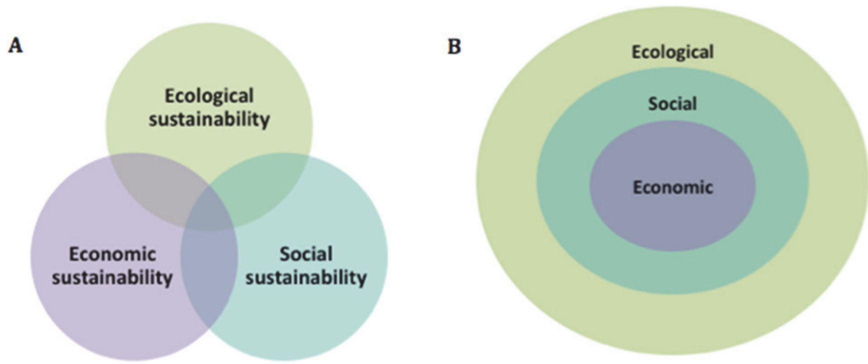

FIGURE 3 Three dimensions of sustainability presented as overlapping and equal (A) and as hierarchical (B) (modified from Juurola and Karppinen 2003).

The dimensions of sustainable development can be contradictory, proposing a need to make value judgments between the different dimensions. Juurola and Karppinen (2003)[2] have suggested an alternate model for the description of the dimensions of sustainable development, where opinions between the various dimensions are taken into account (Figure 3b). According to this model, ecological considerations are considered to be primary, followed by social, then economic considerations. The claim is that social sustainability cannot be achieved without ecological sustainability and economic sustainability requires ecological and social sustainability as a prerequisite, reaffirming the need for the dimensions to be assessed collectively (Juurola and Karppinen 2003). Whether combining the dimensions is analytically beneficial has been questioned (see e.g. original article II, Conelly 2007). However, the normative principle related to the order of the dimensions is well grounded and can even be derived from "Our common future". The underlying concept is that the ecological and to

[2] According to Lehtonen (2004) a similar depiction has also been proposed by French authors Passet (1996) in his book ”L'economique et le vivant” and Maréchal (2000) in ”Humaniser l'economie”.

some extent, social factors form preconditions that permit economic development to be sustainable (Baker 2007). However, problems can also arise as the limiting environmental factors are changing due to scientific and technological development (Hukkinen 2003).

The division of sustainable development into different dimensions has also been criticized. The main difficulty relates to the inseparability of the dimensions in practical situations, which is contrasted by the false legitimization of their separate treatment given by the separate labels. Thus, the dimensions of sustainable development reinforce the administrative separation and serve to fortify the productivistic, economic growth-seeking characters of modern societies (Lehtonen 2004).

Attaining a balance between the ecological and economic dimensions has traditionally been focused upon in discussions around sustainable development. More recently, interest around the social dimension has also evolved (Lehtonen 2004, Littig and Grieβler 2005). In this study, sustainability is assessed via individual perceptions. The focus is on social sustainability and its contents will be elaborated upon further. Environmental and economic sustainability are reduced to considerations regarding environmental effects and income. They are not assessed in monetary terms or in measures of pollution but merely in relation to how they are perceived by local actors.

Social sustainability is a very broad, yet site-specific term, which lacks a robust conceptual definition. There is a common understanding concerning the issues social sustainability comprises on a general level but great variation exists in the application of concepts and indicators. Littig and Grieβler (2005) offer a good foundation in their three core ideas for the assessment of social sustainability. These are: 1) satisfaction of basic needs and quality of life, 2) social justice, and 3) social coherence (ibid.). The first is related to wellbeing, which is unanimously identified to be central to social sustainability (e.g. Elliott 2006:13). Initially, wellbeing refers to material comfort, related to issues like income, housing conditions and health. In addition, it encompasses the subjective satisfaction with one's life and individual autonomy. This can be further justified by the concept of capabilities. The concept is usually attributed to Amartya Sen (1999), who defines capabilities in terms of freedom to achieve alternative functionings. The functionings essentially encompass everything valuable for being or doing, like eating, being happy, having a job, etc. (Sen 1999). Central to this is the ability to choose and have power to lead one's life in a desirable manner. In relation to social sustainability, capabilities have been referred to as the ability to control changes (Saastamoinen et al. 2006), control one's own life (Rannikko 1999) or the enlargement of capacity to act (Leskinen et al. 2006).

The concept of social justice is also partially encompassed in the capabilities theory. It is concerned with the equal distribution of economic goods but also with equal participation opportunities (Littig and Grieβler 2005). The embodiment of social justice is most apparent in the economic divide between northern and southern countries but it is also relevant at the local, community level. There, it appears in matters of democracy and power-distribution, campaigning for individual rights. Social justice seeks to determine the extent that individuals can influence their own wellbeing. A specific interest is on acknowledging cultural differences and rights of minorities (Littig and Grieβler 2005).

Social coherence brings a more community-centered view to social sustainability. It can be related to social networks, solidarity and involvement (Littig and Grieβler 2005). These may contribute to a sense of belonging and potentially positive reflections on social justice, presuming that the coherence is non-exclusive and comprises all community members (Bijl 2011). Social coherence is intertwined to social capital - a concept that is also often associated with social sustainability (Lehtonen 2004). Social capital comprises inherent social values that are manifested in reciprocity and trust and provide added worth to community members (Putnam 2000). Social capital can also be related back to capabilities as community or compiled social capital clearly adds to individual capability.

In summation, the core idea of social sustainability is understood as follows: social sustainability aims at providing individuals with opportunities to live good lives as defined by each individual, while considering cultural diversity, equity and justice (see also Elliott 2006: 13, Rannikko 1999, Rantala et al. 2006). Hence, social sustainability is essentially a process, with goals that are continually revised (Bijl 2011).

There are two central problems related to the assessment of social sustainability: time and scale. In relation to time, the core questions are: what do we want to sustain and how long should we sustain them? Also, what if development that appears to be sustainable today is no longer sustainable in the future? By ignoring the concept of time, the notion of social sustainability is merely reduced to discussions about social impacts (Leskinen et al. 2006, Juurola and Karppinen 2003). Understanding social sustainability as a chronologically evolving process aids to develop and reinforce individual capabilities in order to attain and increase wellbeing. Thus, the main objective is not any stable, sustained condition but rather the ability to cope successfully as societal and environmental conditions change within limits where coping is possible.

The second obstacle related to sustainable development and social sustainability is scale. What may be sustainable locally is not always sustainable globally. In this study, the scope of locally collected data limits the possibility of global assessment. The focus is on the energy producing farmers and their personal views regarding social sustainability in their lives. The potential for increasing their capabilities and the subsequent consequences were analyzed. Generational assessment is not feasible using this data, since the possible effects on future generations can only be speculated. Furthermore, the research assessments are compiled on individuals residing in Finland and thus the scope of the study remains local.

2.2 Bioenergy and social sustainability

There is an increasing body of literature related to the social aspects of bioenergy production. Two broad divisions can be made. The first concerns the scale of bioenergy production and the second is related to the geographic area of biomass procurement and energy production contrasted to the locale of the energy utilization. Milder et al. (2008) present three models of bioenergy production systems. These include: 1) small-scale energy production with household utilization; 2) small-scale energy production or raw material provision with energy distributed externally; and 3) medium and large-scale energy production with energy distributed primarily for external markets. The models could be expanded to include ownership structure, since it has been argued that local versus external energy production ownership is related to social consequences (Bain 2011, Selfa et al. 2011, Worldwatch institute 2006). Small-scale production is generally locally owned, whereas large-scale production can be owned locally or externally.

The model does not define small-scale production, thus there is some obvious ambiguity in defining whether the production is small or middle to large-scale. However, the rough dichotomy, occasionally referred to as the division between distributed and centralized production, is useful in this context and it is rather widely applied in bioenergy literature (Mol 2007, Milder et al. 2008, van der Horst and Vermeylen 2011, Mangoyana and Smith 2011). The typification excludes cases where large-scale energy production utilizes imported biomass, such as crude palm oil from Indonesia in biodiesel production. This type of production is argued to have serious damaging effects in the raw material producing areas both environmentally and socially (Mol 2007, White and Dasgupta 2010, van der Horst and Vermeylen 2011). This type of bioenergy production is excluded from this study, since the interest is on the utilization of local raw material for energy production.

Bioenergy production includes various technologies with different phases and impacts. Thus, the assessment of social aspects is always site specific and considers the entire production chain, starting from raw material procurement and ending with energy distribution and utilization (Buchholz et al. 2007). Despite case-specificity, it is useful to examine identified social effects within relevant literature. Bioenergy production is assessed both in specific empirical studies and in broader reviews, which are occasionally limited to certain bioenergy production systems or concern bioenergy production in general. The majority of the existing literature concerning potential social aspects of bioenergy production can be derived from the review studies, pertaining to more detailed examinations of observed social consequences of bioenergy production in assorted production types. The potential and observed social consequences are summarized in Tables 2 and 3 respectively.

TABLE 2 Summary of potential social impacts for producers of bioenergy, according to recent literature-based review studies.

	General (small- and large-scale)	Small-scale production	Large-scale production
Material wellbeing	• Increased income (Domac et al. 2005, del Río and Burguillo, 2008) • Positive employment effects (Domac et al. 2005, del Río and Burguillo, 2008)	• Increased income (van der Horst and Vermeylen 2011, Milder et al. 2008) • Positive employment effects (van der Horst and Vermeylen 2011)	• Local income generating effects including employment are poor (van der Horst and Vermeylen 2011, Milder et al. 2008)
Capabilities	• Learning, new skills, new utilization for local resources (del Río and Burguillo, 2008) • Reinforced social relationships (del Río and Burguillo, 2008)	• Learning, new skills (Mangoyana and Smith 2011)	• Risk for reduced capabilities if control over local resources diminishes (del Río and Burguillo, 2008) • Risk for dependence of changing state subsidies (van der Horst and Evans 2010)
Social justice	• Poorly justified income transfer to farming sector in the form of subsidies (van der Horst and Vermeylen 2011)	• Potential benefit for low-income producers, in terms of less expensive fuel (van der Horst and Vermeylen 2011, Milder et al. 2008)	• Risk for the local community to be treated simply as a resource base, with little resource control (del Río and Burguillo, 2008)
Coherence	• Decreased migration (Domac et al. 2005, del Río and Burguillo, 2008) • Increased quality and quantity of social relations (del Río and Burguillo, 2008)	• Decreased migration (van der Horst and Vermeylen 2011) • Personal relationships in production-consumption chain (van der Horst and Vermeylen 2011) • Enhanced community cooperation (Mangoyana and Smith 2011)	• Risk for isolated production from the community and reduced community coherence (del Río and Burguillo, 2008)

TABLE 3 Summary of identified social impacts for producers of bioenergy, according to recent empirical studies.

	Small-scale production with utilization by the producer (community)	Small-scale production with external utilization	Large-scale production
Material wellbeing	• Monetary gain in terms of reduced energy costs and improved energy availability (Cook 2008, Dhliwayo 2010, UNDESA 2007) • Positive employment effects (Dhliwayo 2010, Cook 2008)	• Increased income (Åkerman and Jänis 2005, Madlener 2007) • Positive employment effects (Åkerman and Jänis 2005, Madlener 2007)	• Some local benefits, although perhaps debatable (Rossi and Hinrichs 2011, Bain 2011, Selfa et al 2011)
Capabilities	• Improved knowledge and skills (Dhliwayo 2010, UNDESA 2007)	• Improved opportunities for livelihood (Åkerman and Jänis 2005) • Learning, new skills (Åkerman and Jänis 2005, Peltola 2007) • Institutional learning (Leskinen et al. 2006)	• Pride in association with energy production (Rossi and Hinrichs 2011) • Learning, new skills (Rossi and Hinrichs 2011)
Social justice	• Improved access to modern energy for low-income rural populations (Cook 2008, Dhliwayo 2010) • Empowering women (UNDESA 2007)	• Local actors gain greater influence over the utilization of local resources (Åkerman and Jänis 2005, Peltola 2007) • New livelihood opportunities in remote areas where other opportunities are scarce (Åkerman and Jänis 2005)	• Concern over the treatment of local actors simply as resource providers with little control over resources (Rossi and Hinrichs 2011)
Coherence	• Improved trust between village members and officials (Dhliwayo 2010) • Increased sense of association with a social group (Dhliwayo 2010) • Exposed existing discrepancies within the community (Romijn et al. 2010)	• Fortified social networks (Åkerman and Jänis 2005) • Positive boost within the community (Åkerman and Jänis 2005) • Trust building between actors (Peltola 2007)	• Doubts regarding local benefits (Rossi and Hinrichs 2011, Bain 2011) • Positive boost on the community (Selfa et al. 2011)

Literature based studies on the social aspects of bioenergy production

In consideration of material well-being and quality of life, the review literature suggests that bioenergy production can contribute to the general improvement of material consumption levels of households, promoted by increased income (Domac et al. 2005, del Río and Burguillo, 2008, Milder et al. 2008). In addition to increased revenue from energy sales, income may also be obtained via increased employment opportunities or from forestry or other resource utilization (del Río and Burguillo, 2008). Furthermore, bioenergy production can enhance other small enterprises (Milder et al 2008). The income earned from rural bioenergy production can also be partially based on subsidies related to agriculture, energy or forestry (e.g. Helby et al. 2006, Panontsou 2008). Farming is often heavily subsidized, hence the subsidies related to bioenergy production only add to or change the subsidies based income to involve different subsidies. The general dependency on subsidies remains. The new subsidies obtained via energy production make the farmers' income more vulnerable to policy changes (e.g. changes in the levels and availability of subsidies) in different sectors, but less dependent on policy changes on only one sector (e.g. Helby et al. 2006).

In bioenergy production, employment effects are often considered to be significant (del Río and Burguillo, 2008). Even following the development phase, workers are necessary in fuel processing and transport and in the management of the power or heating plant. The employment effects of bioenergy production are often most evident in remote areas, where employment opportunities are scarce and under-employment is common. Thus, bioenergy production has the potential to equalize employment opportunities between different regions (Del Río and Burguillo 2008). Similarly, the revenue generated through bioenergy production may also level income discrepancies between regions. This phenomenon can be reflected in migration between regions, for example (Domac et al. 2005). However, it is also argued that for the positive effects to emerge, production should occur in small, decentralized plants as centralized plants concentrate on rare sites and are presumably less significant (van der Horst and Vermeylen 2011).

Bioenergy production can present learning opportunities and the chance to acquire new skills for local inhabitants (Mangoyana and Smith 2011, del Río and Burguillo 2008), thus enhancing their capabilities. Of special importance is the ability to utilize and benefit from local resources by using new approaches (del Río and Burguillo, 2008). However, this requires integration of the production activities into the local community (del Río and Burguillo 2008).

At the community level, bioenergy production is expected to contribute to social cohesion and stability by reducing migration from rural areas as a result of improved employment opportunities (Domac et al. 2005). It can also benefit local development on a larger scale as the entire community may ultimately profit from the increased economic activities and rural diversification. In addition, the quality and quantity of social relations can be amplified with increased activities and community cooperation (del Río and Burguillo 2008, Mangoyana and Smith 2011). However, these aspects can also be less manifested or even negatively affected if the local resource base is being exploited for externally occurring, large-scale production (del Río and Burguillo, 2008), as is the case for pulp and paper production in Finland (Rannikko 2010). This can also occur if the energy production occurs in the locality but is isolated from the local economy (del Río and Burguillo, 2008).

Empirical studies on the social aspects of bioenergy production

Both similarities and differences can be found in the empirical studies of societal aspects of bioenergy production. Producer-focused, small-scale bioenergy production and utilization has primarily been studied in the context of developing countries and even then, existing academic studies on social aspects are scarce[3]. The studies conducted on small-scale bioenergy production in developed nations mostly concentrate on the environment-economic nexus and social interest chiefly concerns finding barriers for the implementation and not on the actual effects (e.g. Walker 2008). Examples of small-scale energy production for external utilization can be found within the developed world. In addition, there is an interesting stream of literature on the social acceptance of both small- and large-scale bioenergy production, reviewed below. But first, a look at the social effects of bioenergy production as observed in empirical studies:

Within developing countries, there is a particular interest on biogas production at the community and household level. Although the social aspects are not wholly comparable to developed countries, interesting insights and even lessons can be extracted from these studies (see e.g. Yadoo et al. 2011). The clearest benefits from household or community level bioenergy production come from increased savings and energy availability (Cook 2008, Dhliwayo 2010, UNDESA 2007). In addition, cooperation in energy production has improved trust among village members and this trust has even extended to village members and officials and contributed to an increased sense of communal belonging (Dhliwayo 2010). Bioenergy production has also lead to improvements in knowledge and skills (Dhliwayo 2010), although occupations related to bioenergy are generally considered to be low-skill jobs (Cook 2008). The empowerment of women is a special feature of local bioenergy production specific to developing nations. Due to more readily accessible energy, women are relieved from wood collection and require less time for cooking (UNDESA 2007). However, bioenergy projects are not always successful and problems related to cooperation among village members often arise. These problems may stem from power structures, vested interests and even from political, religious and other division within the community (Romijn et al. 2010).

In Finland, small-scale bioenergy production by local entrepreneurs, using forest-based fuels, has been studied. These systems contribute to local, material wellbeing in the form of increased income from forestry and by offering new employment and business opportunities (Peltola 2007, Leskinen et al. 2006,

3 For example, Bond and Templeton (2011) review the impacts and applications of household-based biogas plants in developing countries but do not remark on social effects aside from those related to health and potential cost savings.

Åkerman and Jänis 2005). These opportunities are important regarding social justice, as the opportunities develop in remote areas, where the livelihood options are scarce (Åkerman and Jänis 2005). In addition, the energy production offers new forms of forest utilization of municipal resources, thus improving the local actors' control over the resource (Peltola 2007, Åkerman and Jänis 2005). Similar findings related to income, employment and forest resources have also been reported in an Austrian case (Madlener 2007).

In Finland, bioenergy production provides local actors opportunities to gain knowledge and learn new skills related for example to the management of bioenergy production plant (Peltola 2007, Åkerman and Jänis 2005). In addition, learning has occurred at the institutional level, where new counseling services to guide the entrepreneurs and forest owners in energy-wood and energy production have been established (Leskinen et al. 2006). As energy production requires co-operation between various local stakeholders and the heating activity itself can even be performed in a co-operation, social networks are fortified (Åkerman and Jänis 2005) and trust among the stakeholders plays a pivotal role (Peltola 2007). Overall, small-scale energy production activity has provided a positive boost for the locality of production (Åkerman and Jänis 2005).

In a large-scale context, Rossi and Hinrichs (2011) studied local stakeholders' perceptions regarding their switchgrass production activity for large-scale electricity production in the US. They found scepticism regarding the local benefits, both in terms of improved material wellbeing and coherence. The uncertainty primarily stemmed from concerns that the local actors would become disengaged from the large, albeit locally situated, energy firms and simply be regarded as raw material providers with little resource control (Rossi and Hinrichs 2011). Similar results have already been observed on a fuel ethanol plant in the US (Bain 2011). Additionally, in the UK, van der Horst and Evans (2010) raised concerns over the dependency on state subsidies for energy plant cultivation and the vulnerability resulting from changing policies. However, positive results regarding community benefits of large-scale ethanol production have also been observed (Selfa et al. 2011). These were related to the prevention of local emigration, creation of new jobs and establishing a positive atmosphere and boost for the locality (Ibid.). Furthermore, Rossi and Hinrichs (2011) found positive insights related to the pride stakeholders felt regarding their contribution to energy production and to the new skills and knowledge gained.

Studies also indicate that the ownership structure of large-scale energy production does not significantly influence local social effects (Selfa et al. 2011, Bain 2011). Certainly, increased economic activity has importance (Selfa et al. 2011) but local ownership alone does not seem to offer the enterprise any additional community value. The local farmer proprietors themselves benefit but evidence of additional benefits to the community due to local ownership alone are scarce (Bain 2011).

An understanding of the effects of bioenergy production contributes to the acceptance of the various related technologies. Social sustainability in bioenergy production, especially when considered as a process, includes acceptance of the technology required in all of the production phases (del Río and Burguillo, 2008). The acceptability relates to both; those affected by bioenergy development and those involved in its production. One should not assume that farmers or forest owners are necessarily willing to produce biofuels or raw materials required in biofuel production (Rämö et al. 2009, Paulrud and Laitila 2010, van der Horst and Evans 2010) or that neighbors and other community members view the production activity in positive terms (Upreti 2004). Without (local) acceptance, the project cannot be considered socially sustainable. However, acceptability can be influenced and community ownership of wind power turbines, for example, has been proven to increase the acceptability of renewable energy technologies in general, exemplifying the connection of familiarity and personal benefit to acceptance (Warren and McFayden 2010, Musall and Kuik 2011). Such findings suggest that acceptability can be influenced by various aspects of social sustainability, such as increasing (community) participation and participatory decision-making and through public education (Bergmann et al. 2008). Appreciation is directly related to acceptability. If positive effects outweigh negative ones in the general opinion, the technology may be considered acceptable. However, acceptability does not necessarily imply that the activity is without adverse effects (Elghali et al. 2007, Bergmann et al. 2008).

A few general remarks should be made regarding the differences between the assumed social consequences of bioenergy production and those actually observed. First, large-scale applications appear to be rather troublesome and more benefits are generally associated with small-scale applications. Second, there are few empirical studies concerning the social aspects of small-scale applications and hence, further proof needs to be obtained for the assumed beneficial social consequences proposed in the more general studies. This study partially aims to seal this gap, although it should be emphasized that the social aspects in this study are very much site-specific.

2.3 Achieving sustainable rural development

Productivism, post productivism or another alternative?

In the European context and within the developed world more generally, a new model of rural development has been emerging, contesting the modernization paradigm (van der Ploeg et al. 2000, OECD 2006). Marsden (2003) identifies three characteristic paradigms for rural development. These are: productivism, post-productivism and sustainable rural development (Marsden 2003). According to this model, rural areas are, at least to some extent, shifting away from intensive agricultural production (productivism) towards a more holistic existence, where rural regions are producing various commodities and non-commodities for society (post-productivism). In parallel to the post-productivist model, a model of sustainable rural development is simultaneously emerging (van der Ploeg et al. 2000, Marsden 2003). Dissimilar to post-productivism, sustainable rural development reinforces the role of farmers and peasants as the primary actors in rural regions and converts agricultural practices, as well as other rural industries into more sustainable activities in economic, social, as well as ecological terms (Marsden 2003).

The extent to which post-productionism and sustainable rural development are actually occurring and their exact definitions are still uncertain (Evans et al. 2002, Evans 2010). Whether it is feasible to separate post-productionism from sustainable rural development is questionable, as the two seem to be occurring simultaneously and partially overlap. Perhaps only the distinction between the productionist paradigm and new rural development might suffice (OECD 2006). However, the more pronounced sustainability and the understanding of rural districts primarily as productive spaces, renders the concept of sustainable rural development useful for the purpose of this study.

The focus of this study is to discern whether sustainable rural development can be identified in rural Finland and more specifically, in local bioenergy production. Sustainable rural development has been assessed with the application of different analytical concepts (e.g. Wilson 2008, Sonnino 2007, Kitchen and Marsden 2009). The theories used in this study include ecological modernization, multifunctionality and sustainable livelihoods and eco-economy.

Ecological modernization

Ecological modernization can be dated back to the 1980's and to the work of Joseph Huber and Martin Jänicke (Mol and Spaargaren 2000). It can be understood as a theory of social change or as a more practical strategy of ecological reform (Baker 2007). The central idea in ecological modernization is to some extent the same as in sustainable development: to enable economic growth without environmental degradation. This is achieved by integrating environmental concerns into different societal sectors without profoundly altering existing institutions and production structures. Central to its success is assuring that markets are sensitive to environmental costs of production and the development of more environmentally benign technologies. This leads to win-win situations, where both the economy and environment benefit as the development of environmentally benign solutions becomes profitable and impels economic growth (see e.g. Hajer 1996, Buttel 2000, Mol and Spaargaren 2000, Dryzek 2005). The theory's appeal lies in its promise to continuing modernization, with a confidence on our present science, politics, governance and capitalist economic systems to help resolve the environmental crisis (Baker 2007).

Contradictory to sustainable development, ecological modernization can be criticized for being primarily concerned in reconciliations between environmental and economic dimensions, as being applicable only in industrialized countries and in regards to local environmental problems, not global ones (Langhelle 2000). Thus, it disregards such issues as social justice and society-nature relations that are essential to sustainable development. Sustainable development can be understood to encompass a "limits to growth" approach, whereas ecological modernization aims to maintain economic growth and the relationship with nature exists primarily through natures role as a resource base (Baker 2007). In integrating ecology and economy, ecological modernization has been criticized for ignoring environmental issues that lack economic prospects or whose economic value is difficult to calculate (Barry 2003).

However, there are variations in the understanding of what ecological modernization stands for. For some, it approaches sustainable development, understood as a reflexive process where ecological values are increasingly integrated into our practices at all levels of society, resulting in profound changes in the way we live. Analogical to sustainable development, ecological modernization can be perceived as a process with weak and strong variations (Dryzek, 2005: 173-4, Hajer, 1996). However, some also criticize that strong ecological modernization does not necessarily coincide with the original concept of ecological modernization (Langhelle 2000). The process-nature and reflexivity of ecological modernization may provide an opportunity to overcome some of its weaknesses and ecological modernization can develop even to a point where the process of modernization itself is questioned (see also Christoff 2000).

Here, ecological modernization is considered as a process that directs development towards a more sustainable society in relation to economic and environmental dimensions. As this study considers local level developments in rural Finland, ecological modernization has analytical relevance in relation to the assessment of sustainability (see also Marsden 2004, Kitchen and Marsden 2009). At the local level, ecological modernization can be observed both in discourse and in practice. The essential characteristics include: 1) utilizing technology and science to solve environmental problems, 2) emphasizing the economic sector and markets as the carriers of social change, 3) increasingly important role of environmental movements and 4) new discursive practices, where environmental considerations are self-evident (Mol 2003, see also original article I).

Rural bioenergy production encompasses many characteristics central to ecological modernization. It represents technological solutions to environmental problems. It is usually compatible with existing energy production and consumption patterns, and allows the continuation of current lifestyle, despite the promise of looming climate change. It also provides profitable business opportunities. The role of environmental movements can be seen as twofold: on one hand, climate change mitigation is central to environmental movements and bioenergy may be considered one alleviatory option (e.g. Greenpeace 2010). On the other hand, there are significant environmental concerns related to bioenergy, particularly concerning international trade (Mol 2007, Oxfam 2008, Greenpeace 2011). Although the matter is sensitive, it offers support for local, decentralized bioenergy production (Oxfam 2008, Greenpeace 2010). Often, many local solutions also emerge from the bottom-up. In matters concerning rural development, ecological modernization prioritizes the environment and may be beneficial in determining if and how environmental considerations are integrated into local activities (see also Marsden 2004). Considering the theory as a process, weak ecological modernization is attributed to productivism, while strong ecological modernization is related to sustainable rural development (Horlings and Marsden 2010).

Multifunctionality

Recent developments in the utilization of rural resources can be characterized as multifunctional (van der Ploeg et al. 2000). Multifunctionality encompasses an understanding of rural activities, like farming and includes the utilization of rural areas more generally to fulfill various functions besides the mere production of raw material for agriculture or forestry (Knickel and Renting 2000). These functions include such aspects as the protection of landscape and local traditions, value addition to rural life and even pollution minimization (e.g. Barbieri and Valdivia 2010, Fleskens et al. 2009, Iorio and Corsale 2010).

Multifunctionality has been applied in policy context and in local, farm level analyses. In the policy context, Marsden and Sonnino (2008) have identified three ways of understanding what multifunctional agriculture encompasses. These are: 1) encouraging pluriactivity and diversification as a survival strategy for unprofitable farms; 2) focusing on non-agricultural utilization of agricultural land and 3) promotion of sustainable rural development more broadly. Thus, the term multifunctionality can be connected to all paradigms of rural development, although it is clear that the second and third strategies, connected to post-productivism and sustainable rural development are the prevailing themes (Marsden and Sonnino 2008). Within EU policy-making, the term developed and became popular in relation to trade liberalization (Potter and Burney 2002). As such, it is also criticized for being a mere justification for protectionist policies, with poor substantiation on the actual multiple functions of agriculture (Potter and Burney 2002).

In this study, multifunctionality is used in a local context. At the farm level, multifunctionality is applied in describing and explaining changes in farming practices and in the utilization of rural areas (Wilson 2008, Knickel and Renting 2000). Wilson (2008) provides a useful description of the characteristics of multifunctionality. Multifunctionality can be characterized by social, economic, cultural, moral and environmental capital. These are observable in:

- Local and regional embeddedness
- High environmental sustainability
- Relocalized agro-food networks
- Low farming intensity and productivity
- Improved food quality
- Diversification pathways where farming serves purposes other than solely food production
- Re-evaluation of existing farm household knowledge

(Wilson 2008, original article IV)

The combination of these characteristics represents multifunctionality that is related to sustainable rural development (see also Marsden 2009). Wilson (2008) also presents multifunctionality as a continuum ranging from weak to strong, where an increasing number of characteristics indicate stronger multifunctionality. Thus his approach combines the various interpretations of multifunctionality presented in the policy context and allows for the extent of multifunctionality present in different local contexts to be measured (Hollander 2004, Wilson 2008). Consequently, there may be weak multifunctionalism even in a very productivistically managed farm, whereas strong multifunctionality is connected to sustainable rural development. This is certainly a tentative generalization but for a local case-study, the characteristics are useful in examining the degree of multifunctionality as an embodiment of sustainable rural development. Multifunctionality is not automatically assumed to insinuate greater sustainable development but rather multifunctionality broadens the goals of rural activities that involve more than mere commodity production and these goals are comparable to sustainable rural development (see also Marsden 2009, Bessant 2006).

The concept of multifunctionality also helps to widen the view provided by ecological modernization on how to attain more sustainable outcomes. This occurs especially by paying attention to local and regional embeddedness. Embeddedness refers to the special characteristics, alleged to be inherent in local economic interactions and often absent in global or national enterprises. These characteristics include, for example, mutual knowledge, personal ties and trust (Sage 2003, Hinrichs 2000). Embeddedness is commonly applied in analyses of rural development within local food production. There, the core characteristics revolve around quality and locality (e.g. Sonnino 2007, more discussion in original article III), which provoke the positive consequences of embedded production. It is alleged that embeddedness can enable viability in remote areas by the utilization of endogenous resources, offer a competitive advantage in special markets and even more holistically incorporate sustainability into the food production process (Kirwan 2004). Some argue embeddedness incorporates the beneficial utilization of local ecological processes, as the production activities are presumably more ecologically compatible and thus embedded in natural processes (Murdoch et al. 2000). In this study however, the emphasis is on embeddedness within the regional social community. There, the informal relations and local knowledge inherent in economic activities initiate positive cycles, promoting coherence and local capabilities (Sage 2003, Floysand and Sjoholt 2007).

Within local food studies, the concept of embeddedness has been accused of being overly simplistic. Quality production, ecological sustainability, local food and embeddedness are almost automatically combined and placed in opposition of global food-chains that are categorized as disembedded and undesirable (Winter 2003, Goodman 2004). However, the regional origin of local food production does not necessarily make it more embedded in the local ecology or social networks when compared to conventional food production. Nor is local embedded food production necessarily more sustainable (Goodman 2004).

Another criticism can be derived from excessive focus on the rural locality, without proper consideration on the importance of extra-rural networks (see e.g. Philipson et al. 2006).

To make the concept of embeddedness more analytical and holistic, Sonnino and Marsden (2006) have suggested that embeddedness be considered as a process. The resulting focus then shifts to how a system becomes embedded. Embeddedness itself is understood as involving the active utilization and reconstruction of space, social economy and nature to create the embedded systems (see also Sonnino 2007). This approach is also useful in identifying the importance of extrinsic factors. Embeddedness as a process is developed further (albeit not using the embeddedness word) in local webs of eco-economy (Marsden 2010) (see chapter 2.4).

Sustainable livelihoods

Sustainable livelihoods has evolved as a useful concept in assessing and obtaining sustainable development in rural areas. It has its roots in the late 1980's and has since been further developed mostly in the context of developing countries and poverty reduction. It may be simply defined as people and communities being able to maintain and ameliorate their means of living while not undermining the natural resource base (Scoones 1998, 2009). Sustainable livelihoods can be assessed using various approaches (Carney 2002) but they all focus on individual livelihood assets. The assets culminate to social, economical, human, physical and natural capital and the ability to apply them. They are shaped by features that include: policies, legislation, institutions, vulnerability and personal interest (Carney 2002). Hence, striving towards a more sustainable livelihood is essentially a process where individual assets are weighed against wider societal structures and processes that together determine the livelihood outcome and continuously influence the available assets (Figure 4) (Kinsella et al. 2000).

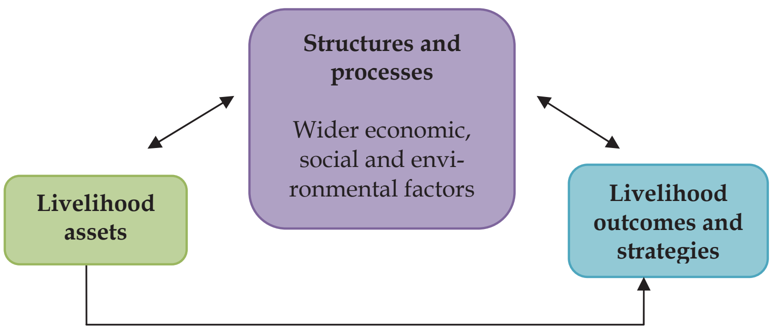

FIGURE 4 Sustainable rural livelihoods process (modified from Kinsella et al 2000).

The concept of sustainable livelihoods encompasses all three dimensions of sustainable development: economical, social and environmental. It applies an actor and community-orientated approach that considers the context in which people live. The sustainable livelihoods approach has been faulted for focusing solely on short-term prerogatives and failing to properly account for the overall picture of global environmental change and the broader structural context of the actors, including policy and power (Scoones 2009). However, once removed from the context of development programs, the approach can also be interpreted in a more holistic manner, with multiple policy sectors, institutions and actors. Micro-macro linkages from the global to local perspective are important, yet the focus remains on local populations (Hall, 2004: 100-106). In a broader sense, the sustainable livelihoods concept provides the necessary tools to understand circumstances specific to rural regions, from the local actors' perspective. It concentrates on local resources and aims to develop rural livelihoods towards a more sustainable future. The livelihoods approach can be advantageous when studying rural areas in developed countries, where local employment is largely based on available natural resources, the standard of living is lower than in urban areas and the regions are often in need of development programs and action. Therefore, it is very pertinent to consider how people could live in accordance with sustainable development from the local perspective.

Sustainable rural development can be combined with the concept of sustainable (or sustaining) rural livelihoods, as both can be regarded as processes with similar means and outcomes. Both emphasize the role of local actors, their unique traditions and capabilities, combat their vulnerabilities and build on the sustainable utilization of local resources, be it in the form of local food production, agro-tourism or renewable energy (Kinsella et al. 2000).

2.4 Towards eco-economy?

Ecological modernization, multifunctionality with special attention to embeddedness and sustainable livelihoods, comprise the foundation in the analysis of sustainability in farm-based bioenergy production. Each concept has been analyzed and discussed in relation to all or a portion of the empirical data in the original articles. Here, a more holistic approach to the issue is applied and the separate analyses are unified with the help of the emerging concept of eco-economy.

According to Kitchen and Marsden (2009), eco-economy is the central feature of the new rural development paradigm. It encapsulates the localized webs of economic activities, where natural resources are employed in a sustainable and value adding manner. The concept of eco-economy can be useful in explaining how new production-consumption chains, networks and relationships are established in rural areas at the micro-economic scale, promoting new understanding on the role and meaning of rural areas (Horlings et al. 2010, Kitchen and Marsden 2009). Central to this feature is the new kind of utilization and appreciation of local resources, both natural and human. Some key issues related to eco-economy include ecosystem services, relocalized food-webs and local energy production (Horlings and Marsden 2010).

Kitchen and Marsden (2009) present the concept of eco-economy as opposing the more generally utilized concept of bio-economy or biobased economy (OECD 2009, EC 2010). Bio-economy is also associated to sustainability but in somewhat different terms. Bio-economy refers to the sustainable utilization of natural resources via advanced technologies, with a special emphasis on biotechnology and its applications. The main actors are globalized corporations and production activities at the local level are directed to globalized consumption. In contrast to eco-economy, bio-economy essentially focuses on the global level with little consideration of local communities and their sustainability (Kitchen and Marsden 2009, Horlings et al. 2010, Sheppard et al. 2011, see also CREPE 2011).

TABLE 4 Comparisons between eco- and bio-economies [a].

Strategy	Eco-economy	Bio-economy
General	• Sustainable resource utilization • Diversity, small-scale • Regionalism, localism • Local networks – embeddedness	• Sustainable resource utilization • Large-scale efficiency • Technological innovation • Global biotech and bioenergy • Green clusters
Bioenergy production	• Ecological modernization (strong) • Multifunctionality (strong) • Small- and micro-scale distributed systems • Production-consumption networks at the regional scale • Value capture at local and regional level	• Ecological modernization (weak) • Multifunctionality (weak) • Technical innovation • Large scale, even global systems • Corporate control

[a] The table is strongly influenced by Horlings et al. (2010), although modifications have been made, including a change from the examination of agri-food to energy production.

The global orientation of bio-economy suggests potential threats in terms of marginalization of rural populations (Rossi and Hinrichs 2011) and exploitation of local resources - especially in relation to developing countries (van der Horst and Vermeylen 2011). These threats were previously summarized in Tables 2 and 3, where the social consequences of large- and small-scale production were compared. In addition, claims have been made suggesting bio-economy poses environmental threats due to crop production intensification and biosecurity related risks (Jordan et al. 2007, Sheppard et al. 2011). Although presented as opposing concepts, bio-economy and eco-economy can be regarded as simultaneously occurring pathways, as demonstrated by the Finnish Innovation Fund, Sitra (Luoma et al. 2011). Recognizing the existence of these two pathways and determining which pathway becomes dominant is fundamental for directing our future (Horlings et al. 2010). Table 4 summarizes the key differences of bioand eco-economy in general and in relation to bioenergy production more specifically.

The evolvement of rural eco-economic activity is presented in Figure 5. The figure is slightly modified from Marsden's (2010) figure on the rural web model, which is applied in analyzing the emergence of local eco-economies. Here, the figure is used to analyze the emergence and sustainability of bioenergy production activities and it has been modified to better suit the purpose. The figure is intended as an analytical tool to identify development and change or lack thereof, at the local level. On a conceptual level, it unifies the central concepts used in this study.

The top of the figure displays different change-triggering factors that contribute to the rural actors need to find novel solutions for the amelioration of their lives. These factors include: 1) *cost-price squeeze* of agricultural production or increasing production costs versus decreasing output prices. This results in increasing difficulties in sustaining family farms without investments in large-scale production (Marsden 2010). 2) On one hand, *environmental change* refers to climate change and the related adaptation and mitigation responses and on the other hand, to further response requiring environmental issues, such as water and air pollution and biodiversity degradation. 3) Finally, *new demands* concern the utilization of rural areas and increasing competition over natural resources. The new demands are partially the consequence of increased recreational use of rural areas, in the form of summer cottages and rural tourism, for example. Additionally, while the share of people residing in urban areas in Finland is growing, rural areas are also increasingly exploited and even owned by city dwellers, with new ideas regarding the utilization of the land. The new stipulations also relate to consumer demands on rural products and services (Hienonen 2011). The most recent, additional demand is the result of the necessity for more efficient and sustainable utilization of natural rural resources, due to their increasing scarcity and need to respond to environmental change (Nieminen-Sundell 2011).

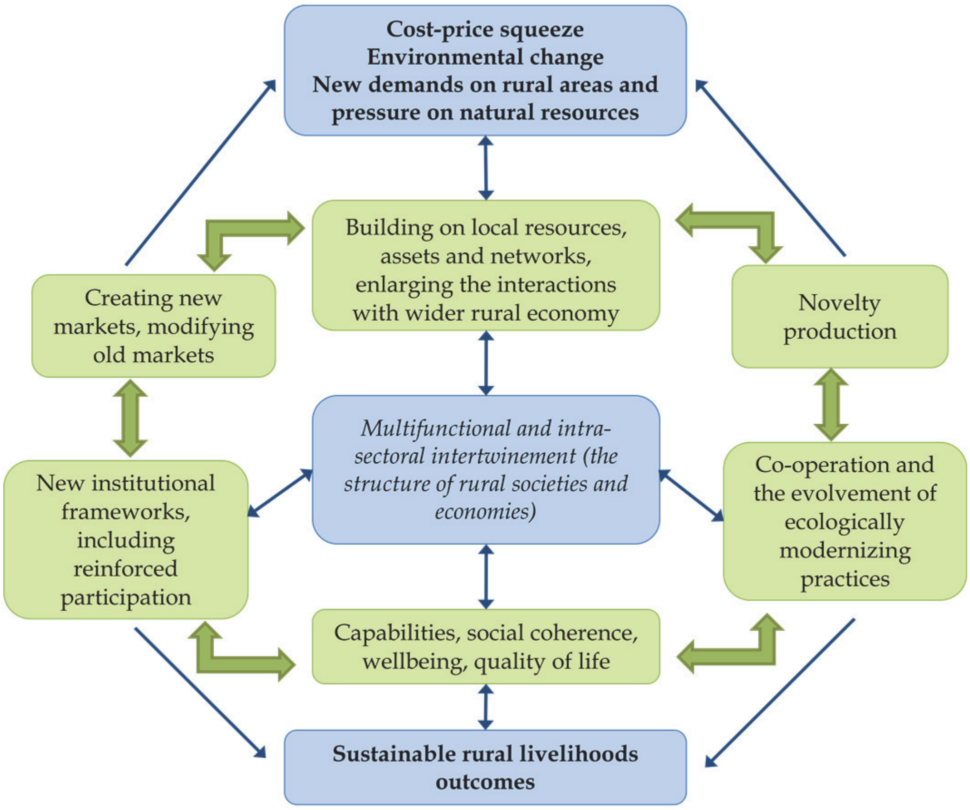

FIGURE 5 Dynamics contributing to the potential development of eco-economies. The prevailing state policies remain in the background. (Modified from Marsden (2010)

In the central circle, marked with thicker arrows and green boxes, are the different building blocks of eco-economy. These incorporate what the various aspects; multifunctionality, ecological modernization and embeddedness have to offer, contributing to sustainable rural livelihoods as a response to the change-triggering factors previously described. The building blocks are derived and modified from Marsden's (2010) ideas and also presented by Horlings and Marsden (2010). Multifunctionality emerges as the central response, both on a conceptual level, as the perception of rural areas shifts towards the various functions and also on a more practical level, as the functions are developed into new ideas and production solutions. The key to uncovering these novelties lies in the embedded nature of local economic relations as they occur via developing local resources, assets and networks. This may occur by implementing new types of sustainable utilization for local natural resources that are created from regional, trust-based networks and other available assets. The new production leads to increased co-operation within the community and fortifies trends of ecological modernization, as environmental considerations become increasingly embedded in economic activities, creating both environmental and economic benefits. Simultaneously, the new products create new markets that could potentially modify existing ones. Thus, the embedded characteristics of local value, as well as the environmental value may be beneficial. By supporting the emerging new activities and development of ideas, new institutional frameworks are created. These are advantageous to networking, information provision and communication with society and may contribute to establishing trust between different actors and reinforcing participation. Together, developments lead to and are fortified by the key dimensions of social sustainability: reinforced capabilities, increasing social coherence, and quality of life.

Sustainable rural livelihoods can be optimistically hypothesized to be the outcome of advancing multifunctionality, derived from local embeddedness and the creation of ecologically modern practices. The purpose of the presented case study is to examine to what extent this system functions in small-scale bioenergy production in rural Finland. The degree of sustainability visible in the outcome depends on the extent the building blocks are applicable and manage to create positive synergies. Thus, the outcome may also itself be unsustainable.

Echoing the criticisms of embeddedness, the eco-economy approach can be accused of being overly idealistic and having naïve assumptions of local and small-scale production leading to increased sustainability (see e.g. Goodman 2004). The model itself is complex and suggests the interplay and revalorization of various local assets. The claim is not that the mere local-based nature of an activity leads to sustainability but the empirical examination of the functioning of local systems is vitally important (Horlings and Marsden 2010).

As a system, which examines the emergence of bioenergy system, eco-economic rural web approach comes close to sustainability transition studies, where the case of bioenergy production seems to be occurring often (e.g. Raven and Geels 2010, Lovio and Kivimaa 2012). These studies focus on analyzing the emergence of presumably sustainable innovations, without actually assessing the sustainability. In the rural web approach, the center of the analysis is on local developments and their perceived sustainability, hence this model could also aid in deepening the transition studies perspectives.

3 RESEARCH METHODOLOGY

3.1 Qualitative case study

This study concerns sustainable development in rural areas, where farm-scale bioenergy production provides a unique opportunity to observe the possible transitions towards sustainability on Finnish farms. The intent is to gain a comprehensive understanding of farm-scale energy production and attempt to illustrate the case within the theoretical framework presented in chapter 2. Hence, the chosen methodology for this study is a qualitative case study methodology (e.g. Yin 2003). The case in this study is farm-scale energy production in Finland, which is further divided into three sub-cases: 1) heat entrepreneurship, 2) biogas production and 3) biodiesel production.

Case study is a term that is used in various contexts, sometimes even in contradictory ways and there is no fixed description for case study methodology within the social sciences (Gomm et al. 2009, Platt 2007). In fact, case study is best understood as a research paradigm that offers a broad strategy for a more detailed research design. However, there are broad characteristics that embody the central ideas of a case study. A case study can be understood as the study of one single event, person or phenomena. It can also be a study of a community or a nation, the important aspect being that it is a study of an identifiable case or few cases. The aim of the case study is to gain an inclusive understanding of the case(s) at hand. This represents an opposing method to the survey study, where a relatively small amount of information is gathered from a large number of research units (Gomm et al. 2009).

A case study can be used as a preliminary pilot study in generating a hypothesis. Some contend that this is the most suitable, if not the only legitimate way of applying case study methodology (Platt 2007). However, case studies have also been successfully used in other stages of research, including testing or in the illustration of a theoretical point (Flyvbjerg 2006). A good example of theory testing using case study methodology is falsification, where one single case can prove an entire theory wrong. More generally, it is maintained that even a single case study can contribute to theory by using logical instead of statistical inference and by the analytical accuracy of the underlying theory and whole corpus of knowledge (Mitchell 1983/2009). In summation, case study methodology can be legitimately used in various kinds of studies with different objectives. However, it is important to consider the particular choice of case and the study design in order to obtain unbiased results.

This is not a conventional case study in a manner where one case of farm-scale energy production was studied in depth. Rather, a deeper understanding was sought by selecting a broad case or entire phenomenon and then selecting particular sub-cases with several informants, for further analysis. The three sub-cases present the three principal ways for a farmer to produce commercial energy for markets in Finland[4], hence they offer a more expanse representation of farm-based energy production than any one single energy-producing farmer or one production type could have offered. This is relevant to the main purpose of the study: to discern how farm-based bioenergy production contributes to sustainable development. This kind of broader case selection is often used in innovation studies (e.g. Hillman et al. 2008, Raven and Verbong 2009, Ulmanen et al. 2009). Furthermore, the selection of case study methodology assisted in illustrating the theoretical concepts presented in chapter 2 and of sustainable rural development more generally.

The generalizability and role of theory in case studies are widely discussed matters (Gomm et al. 2009). According to some, the aim of case studies is to produce an understanding of the case at hand, with no need for generalization or even theoretical inference. In these types of studies, the increased knowledge regarding the studied phenomena is valued as such (Flyvbjerg 2006). Some claim that it is even impossible to generalize case studies as the results are biased and that case studies are useless in proving or developing theories, as they only represent one particular case. This is true to some extent. It is obvious that not all case studies can be generalized nor does the lack of generalizability diminish the value of the studies. However, to claim that this applies to all case studies is an overstatement. Case studies can also be generalized. This is related to the careful selection of a case or cases (for more discussion see Flyvbjerg 2006) or to the type of generalizations made (e.g. Stake's (1995) "naturalistic generalization"). Generalizability is not a concern in this context, as this study does not allege to be generalizable to other countries or other rural development phenomena. What is significant however, is what this particular case reveals about developments in rural Finland and how they relate to the wider theoretical framework. According to Mitchell (1983/2009), embedding case studies in appropriate theory also gives them generalized value.

Usually case studies are conducted using unstructured data with qualitative analysis, although quantitative approaches can also be used (Yin 2003). Data collection comprises various forms, including interviews, observation and

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4 Conventional firewood production and energy plant cultivation were excluded from the scope of this study, as the interest was on new forms of energy entrepreneurship involving energy sales in the form of heat, electricity or vehicle fuel.

written material, such as government documents and newspaper articles. Frequently, several forms of data are used simultaneously (ibid.). Obtaining an in-depth picture of the case at hand and collecting high quality, data are of utmost importance.

In this study, the case is approached from the viewpoint of the energy-producing farmers. Thus, the farmers' perceptions and experiences on their energy production activity primarily comprised the data for the case. Data collection was twofold. First, written material in the form of newspaper and journal articles was collected, followed by the conduction of qualitative interviews of energy producing farmers. This approach to data collection was selected because during the initial stages of the study, additional information on the background of the phenomena was required in order to conduct the data collection among the farmers in an appropriate manner. The article material provided a suitable starting point for the study and it facilitated the planning of interviews, which were the most suitable form of data collection among the farmers.

3.2 Newspaper articles and discourse analysis

The newspaper data was collected using a Finnish newspaper called *Rural Future* (Maaseudun tulevaisuus) and a professional agricultural journal called, *Practical Farmer* (Käytännön maamies). *Rural Future* is primarily distributed in rural areas and contains a wide variety of topics, from international news to domestic curiosities although it predominantly concentrates on issues related to rural regions and farming. It is published three times each week, by the Central Union of Agricultural Producers and Forest Owners in Finland (MTK). *Practical Farmer* is a monthly journal. It contains articles discussing recent farming technologies and trends, as well as topics related to rural development and agricultural politics. These particular journals were selected as they are considered to be the most common printed media regarding agriculture and rural interests in Finland. They are also widely read among farmers. Consequently, they were regarded as a suitable means to gain insight into how bioenergy production is discussed and conceptualized in a rural context. The selection of these particular publications also allows for the observation of discourses surrounding farmers and does not necessarily represent the general public's view regarding bioenergy production in Finland.

The entire body of data consisted of approximately 1000 articles published between the years 1980 and 2005. The articles were searched manually collecting all articles concerning bioenergy production. From *Rural Future*, only opinion pieces, editorials and columns were used. The article selection was based primarily on content pertaining to opinions surrounding farmers in Finland. The chosen criteria reduced the quantity of analyzed articles considerably, making the analysis more convenient. From *Practical Farmer*, all articles concerning bioenergy production were considered. However, only the article material concerning biogas, biodiesel and other non-wood material related bioenergy production was analyzed systematically (original article I), reducing the number of applicable articles to 200 (115 articles from *Rural Future* and 78 articles from *Practical Farmer*). The articles related to wood-energy production were used as background material for the interviews and analysis. Later however, the wood-energy related articles published in *Practical Farmer* (150 articles) were also used to formulate wood-story (Chapter 4).

Assessment of the article material was based on critical discourse analysis combined with more traditional elements of content analysis. Critical discourse analysis focuses on the text, discourses and social practices (Fairclough 1992: 73). It attains that social life is essentially comprised of social practices that on one hand are constrained by social structures but on the other hand are constantly transforming them (Chouliaraki and Fairchlough, 1999: 21). This kind of outlook on social life as practices allows for mediation between structures and events (action) and thus combines the perspectives of structure and agency. Discourses are moments of social practices that are represented as semiotic elements, thus social practices are partly discursive and also discursively represented (Chouliaraki and Fairclough 1999: 21, 38). Through practices and action, discourse attains a dialectical relationship with social structures. A discourse has the potential to become hegemonic when it defines the ways the related phenomena is discussed and understood, thereby simultaneously defining suitable practices and actions. In this manner, the hegemonic discourse eventually affects social structures (See e.g. Hajer 1996).

The analytical interest in the non-wood articles was to identify the ways bioenergy production was presented in the articles and especially to discern whether an identifiable discourse on ecological modernization existed. The analysis of the literature was initiated by seeking out identifiable discourses. This was accomplished by searching the data for answers to the following questions: 1) How is rural non-wood energy production represented? 2) What arguments are used? 3) How and when are these arguments used? And 4) How are environmental arguments related to other arguments? Following identification of the discourses, their order was examined: which have been hegemonic and when? The aim was to uncover the central ideas behind the discourses and their effect on the development of non-wood bioenergy production and its role in environmental problem solving. The wood related articles were analyzed in an analogical manner, albeit the discourses are not reported in similar manner to original article I (See chapter 4.1).

In practice, the analysis began with close examination of the article material. The articles were roughly grouped according to their content: wood energy production, other energy production and combinations of these. The combination articles were analyzed in accordance to both wood and other production. A short description including main points and key phrases were written on each article. The descriptions were compared and related to the questions above and to the theory of ecological modernization. During the preliminary stages of data analysis, the storylines and main arguments of the articles were categorized into chronological periods. During later stages, more holistic discourses related to non-wood articles were identified. The results pertaining to discourses are reported in original article I. In this summary article, the discursive elements are used as a background for the summarizing analysis of the interview material.

3.3 Qualitative interviews and content analysis

Qualitative interviews were conducted between fall 2006 and 2007. In total, 31 bioenergy producing rural entrepreneurs were interviewed. The majority (29) was full or part-time farmers engaged in dairy, beef or crop production or combinations of these. Although two of the participants were not farmers, they were engaged with forestry in other ways. The part-time farmers had secondary employment outside the farm or were engaged in other entrepreneurial ventures besides farming or energy production. The participants included 15 heat entrepreneurs, 10 biogas producers and 6 biodiesel producers. Some of the participants were engaged in the same energy production cooperatives or consortiums or were cooperating with one another in other ways. Farming, especially farming-related energy production, is typically a male occupation in Finland, thus due to the lack of female farmers in the energy branch, all interviewees were male.

The general information collected from the article material aided in the selection of the energy production types and also in the identification of the possible research participants. Initially, the aim of the study was to concentrate on the area of Central Finland. This was based on the study's inclusion within a larger project with such areal boundaries. The focus on Central Finland was suitable for heat entrepreneurs, as it is a relatively common activity and a suitable number of heat entrepreneurs residing in the selected area were willing to participate in the study. However, the scarcity of biogas and biodiesel production did not allow for their inclusion to Central Finland alone. For these activities, interviewees from around Finland were accepted. The heat entrepreneurs were located with the help of the regional Forestry Center, who maintain a list of heat plants operated by heat entrepreneurs. Biogas producers were mainly identified using the register of Finnish biogas plants (Kuittinen et al. 2006), from information in the article material and tips from the interviewees themselves. All Finnish biogas producing farmers that could be reached were interviewed. Biodiesel producers were the most difficult group to locate as no registers were available. They were primarily identified using the collected article material and from an accumulation of tips given by other interviewees. Overall, the energy producers that were contacted and asked to participate in the research had a positive attitude regarding the interview and only a few declined. The reason given by respondents for declining participation was difficulties in finding suitable time for the interview.

The interviews were conducted at the subjects' homes or at their energy production plants. The interviews are best described as semi-structured (see

Silverman 2006: 110), as the structure of the interviews was tentatively planned prior to the meetings but room for variation was permitted. The interviews were comprised of a set of open-ended questions, structured into four themes. The order of the questions varied from one interview to the next and additional questions were also posed, depending on issues that arose during each dialogue. The themes included: 1) Farm and energy production in practice, 2) Drivers and barriers for energy production, 3) Possibilities for farm-scale energy production in general and 4) Relationship of energy production to the environment. The respondents were also asked to draw an operational diagram of their energy production activity. The interviews were recorded and transcribed.

Qualitative interviews were selected as the main method of data collection as it was best suited to the research purpose. The aim was to expose the respondents understanding regarding their energy production activity, as related to predetermined themes and to establish any common patterns between the two (cf. Warren 2001). As there are various ways of using qualitative interviews in research and significant debate exists regarding their application (e.g. Hammersley 2008, Miller and Glasner 2004, Roulston 2010), a brief glance at the debate follows, combined with an explanation on how qualitative interviews were used in this study.

Hammersley (2008: 89-100) has summarized the main criticism concerning qualitative interviews. In the context of this thesis, the most relevant censure concerns the claimed inability of qualitative interviews to provide information beyond the scope of the interview. This is founded on the belief that the interview scenario itself influences the direction of the interview and respondent's narrative, rendering the authenticity and reliability of the accounts questionable. The critique derives from radical social constructionist and post-modern thinking related to the epistemological understanding of reality (see e.g. Roulston 2010). However, as argued by Miller and Glassner (2004) and Hammersley (2008), the constructed nature of interview accounts does not necessarily implicate that the interview is incapable of deriving information on the social world outside the interview situation. It only means that the interview process should be planned with care and reflection, starting with consideration on the suitability of interview method for data collection considering the particular research questions (Miller and Glassner 2004, Roulston 2010, Silverman 2006).

When conducting qualitative interviews, it is important to be aware of factors that might influence the interview process and the analysis. These matters can be related to the respondent's or researcher's individual perspectives or issues related to gender, race or social status (Warren 2001). More problematic to assess is the interview process itself. It is essentially an unnatural form of communication and the interactional dynamics of the discussion, as well as the style of questions in relation to the answers should be reflected upon (Hammersley 2008).

A less constructivist approach was adapted to the analysis of interview transcripts in this study, than with the written material examined using discourse analysis. By applying Silverman's (2006: 118) divisions, the utilization of interview data in this study can be placed somewhere between emotionalism and constructionism or Roulston's (2010) romantic and constructionist conception of the interview. The interviews were not analyzed for discourse but rather for the content they provided on the research topic. However, also used language, tone and inferences the respondents made were considered. The interviews provided a representation of the respondents' views regarding their energy production activity - an impression that was constructed in the interview situation. Still, as the emotionalist/romantic conception promotes, such representations is taken to be somewhat accurate picture of the views the interviewed individual has chosen or wished to reveal.

The rationale for the interview approach lies partly in the subject of the study and partly in the purpose. The subject or entrepreneurial activity of the farmers was common to all interviews. It was a topic the farmers were accustomed to discussing and describing and they were mostly eager and willing to speak openly about their activity. Certainly, the farmers might have been inclined to embellish their production activity or exaggerate the success of their venture during the course of the interviews. However, they also addressed negative issues, even spontaneously and often expressed a more general interest in improving the political and societal conditions related to their entrepreneurship. Thus, the accounts were multi-faceted. The actual purpose was to attain a picture of energy production activity as depicted by the farmers. It is therefore rather irrelevant whether the portrayal actually represents the farmer's "real" or circumstantial views.

The interview data was analyzed by a method best described as qualitative content analysis. The analysis was commenced by careful review of the interview transcripts. The material was inspected for commonalities: typical ways of describing the activity and similar views on the meaning of energy production, etc. At the same time, disparities were also revealed. These were used in assessing how the three different energy production systems functioned from the energy producers' perspective (see chapter 4.2).

Following classification, the data was reflected to the theoretical concepts of social sustainability and sustainable rural livelihoods (original article 2), embeddedness (original article 3) and multifunctionality and sustainable rural livelihoods (original article 4). Finally, these findings were synthesized using the concept of eco-economy, benefitting from Marsden's (2010) notion regarding rural webs. In contrast to Marsden's research, the focus in this study is on locally-based bioenergy production activity and not in a more holistic assessment of the evolvement of eco- and/or bio-economy in the locality. Small-scale bioenergy production may be regarded as an example of an eco-economic activity. Although locally based, it can be considered to have rather uniform conditions for emerging. In addition, the data enables observation of differences between the various local cases.

4 FARM-SCALE BIOENERGY PRODUCTION IN FINLAND

4.1 Development and current situation

In this chapter, the development of farm-scale energy production from 1980 to 2005 is explained. The development has previously been described in the first original article. Here, that description is augmented to include wood energy production, using printed material from *Practical Farmer*. The chapter is primarily based on the analysis of the newspaper material, thus it represents the general farming sector view on bioenergy production. The material has also been related to official documents and existing research.

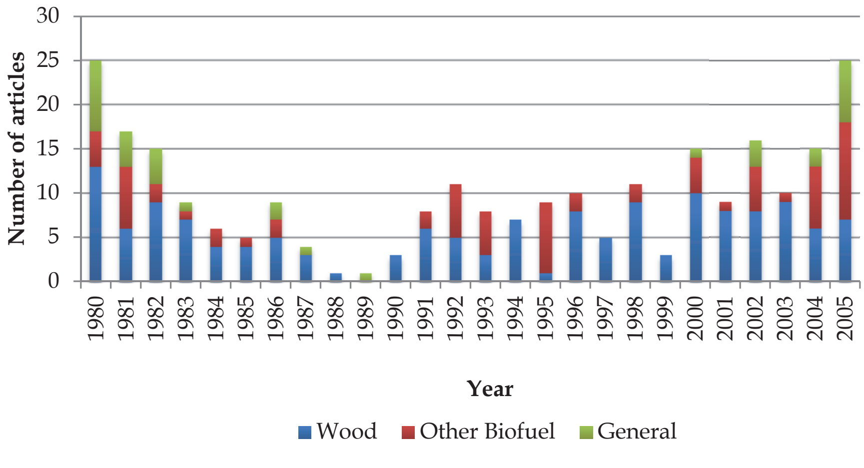

FIGURE 6 The number of analyzed articles in *Practical Farmer* from 1980-2005. The general articles pertain to both, wood-energy and other biofuels.

The number of articles analyzed and the corresponding bioenergy production type varied with time. The variation in *Practical Farmer* is presented in Figure 6 (for *Rural Futures*, see original article I). There, the articles are categorized into wood energy articles, articles concerning other biofuels and general articles that concern both wood biomass and other biofuels.

In original article I, non-wood energy production was categorized into four periods: 1) Pre-biofuel; 2) Biofuel learning; 3) Wood chips; and 4) Bioenergy entrepreneurs. Analogically to this, the wood energy articles in *Practical Farmer* were categorized into periods with slightly different time frames. These periods were: 1) Wood heating boom; 2) Slowing down and getting ideas; 3) Emerging heat entrepreneurs; and 4) Normal wood energy production (Figure 7).

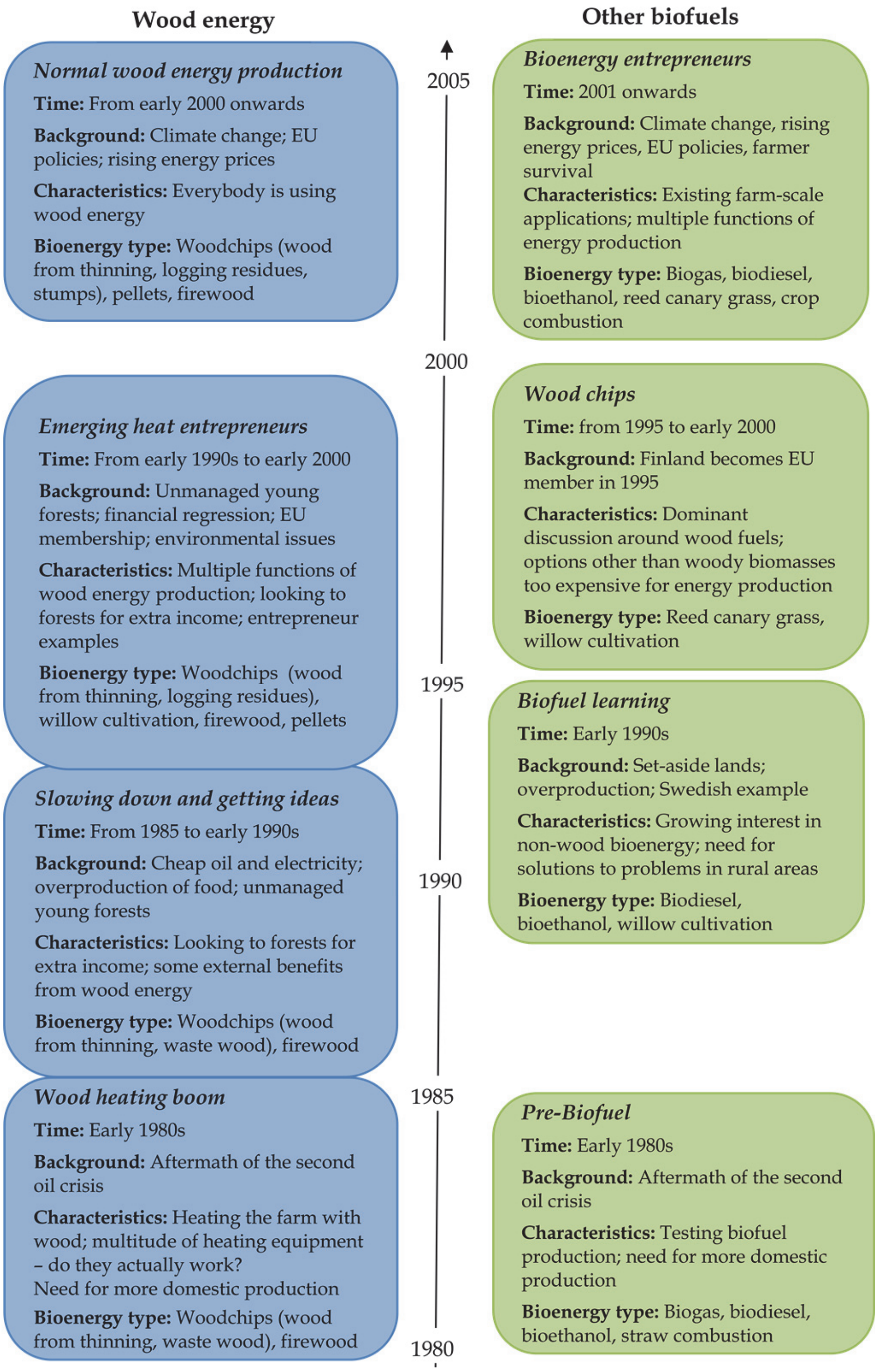

FIGURE 7 Periods of wood and other bioenergy production from 1980-2005, based on article material from *Practical Farmer*.

During the early 1980's, the *Pre-biofuel* and *Wood heating boom* periods related to the aftermath of the second oil crisis. The price of oil had, for the second time in a relatively short period, increased rapidly and its availability had become an issue of concern. As a consequence, domestic fuels that had mostly been neglected during the 1960's and 1970's enjoyed a revival of interest (Hakkila et al. 2001). The revival was reflected in the national energy policy, where the main goals included energy preservation and increasing domestic energy production (MTI 1979). At the time, domestic energy production focused on wood and peat, although other options were also briefly mentioned (MTI 1979) and studied (e.g. MTI 1983). At this stage, policy instruments related to domestic energy sources included investment subsidies, research funding and later also an exemption from electricity tax for electricity produced from bioenergy was introduced (Kivimaa and Mickwitz 2011).

On farms, traditional wood energy based heating had commonly been replaced with central heating systems and boilers functioning mainly on oil (Mutikainen and Jouhiaho 2005) and the utilization of firewood was steadily declining (FFRI 2011). The success of oil in the 1960's and early 70's was based largely in maintenance free, automatic heating systems, combined with cheap price of oil. However, traditional stove-based heating persisted on the side of central heating systems and many farms had wood resources available for energy use. As oil prices skyrocketed and its future availability became questionable, interest in the utilization of wood resource increased once again (Hakkila 2005).

The articles in *Practical Farmer* portray a real wood energy surge on farms. Multiple novel heating systems are presented with many farm-based examples of utilization. The articles emphasize the simplicity and profitability of wood-based heating on farms. Wood chips are presented as the preferred fuel for wood-heating systems that offer increased automation but more traditional logs and firewood are also used. The profitability is founded on the utilization of wood from farmer-owned forests where labor costs and the need to purchase external energy are avoided. Although wood energy heating is presented in a positive light in the farm-based example-stories, the articles addressing technical solutions reveal problems in boiler development and point out that wood heating is not without negative implications. During this period wood energy is most often related to the desire to increase domestic energy production in order to regulate energy prices and supply, although reasons related to forest management in the form of unutilized wood resources and rural employment also appear.

Other biofuels also appeared frequently in the published material but their role remained minor compared to wood. The articles presented various sources for bioenergy production, ranging from wastes to energy crops. They also suggested different fuels that could be refined, including biogas, biodiesel and bioethanol. The articles were either concerned with testing different production types or illustrating the potential of these technologies. Biogas, in particular, emerged as a promising energy production type for farms. The reasoning behind the surge in popularity of other biofuels was similar to wood energy: the need to find domestic energy sources to replace oil. After oil prices started to decrease in the mid 1980's, mention of other biofuels widely disappeared from the articles as did references on wood energy. The related time frame corresponding to wood energy production is called *Slowing down and getting ideas* and it lasted from about 1985 until the early 1990's.

During the *Slowing down and getting ideas* period, wood-heating encountered difficulties. Aside from decreasing oil prices, low-cost (nuclear) electricity and negative experiences regarding unskilled heating with wood chips were also contributing factors. The articles continued to portray wood energy in the same positive manner. However, the motivation for wood energy production was now more emphasized and even included some environmental concerns related to sulfur emissions from fossil fuels, as the reasons for considering wood energy as an option needed defending. More importantly, new ideas emerged as farms were faced with the overproduction of food and a growing reserve of young forests that required thinning became an issue that needed to be addressed. As increasing food production was not an option, farmers began considering provision of wood for energy production to simultaneously provide additional income and solve their silvicultural problems. Thus, the primary reasons for the future interest in wood fuels were already identified in late 1980's (see also Åkerman et al. 2010).

The agricultural over-production dilemma was also tackled by remerging discussions on alternate biofuels in early 1990's, termed the *Biofuel learning* phase. By this time, alternate biofuels included biodiesel from rapeseed and bioethanol (in addition willow cultivation on fields was discussed). Biogas did not emerge during this period. Energy crop cultivation was considered to be a potential solution to cut food production while still maintaining farmers' incomes. Other potential for rural job creation, as well as additional benefits of domestic production were also identified. Overall, biofuels were seen as an expensive alternative to imported fuels, requiring state subsidies for feasible production.

In early 1990's, biofuels were on the national agenda as the Ministry of Trade and Industry had comprised a working group to investigate the potential of biofuel production in Finland. Weighting costs and benefits, the committee found biofuel production to be unfeasible (MTI 1993). The results were contested and another working group was assembled, arriving at rather opposite conclusions. It recommended experimental production and utilization in order to test the options in practice (MTI 1995). Despite all efforts however, biofuel production disappeared from the agenda once more. Gradually, analyzed media discussions on biofuels ceased whereas support for forest based wood fuels continued on, even increasing from the mid 1990's onwards. The *Wood chips* period is a reflection of the *Emerging heat entrepreneurs* -period in wood energy. Two energy crops: willow and reed canary grass are considered, probably due to their potential utilization in CHP or heat production, analogically to the utilization of woody biomasses. Otherwise, the emphasis is on wood energy production.

The *Emerging heat entrepreneurs* period is a continuum of the "getting ideas" portion of the previous wood-related period. The support for wood energy production presented in the articles was fortified. Finland faced a serious economic regression in the early 1990's, resulting in high unemployment rates. The over-production problem shifted to a more holistic concern of the survival of the farming livelihood, as the implications of Finland's forecasted EU-membership were discussed and again as the membership became reality in 1995. The unmanaged young forests became increasingly problematic and the climate change -related environmental effects of fossil energy emerged public knowledge.

These issues were also relevant in forestry and energy politics. Within forestry, there was a shift towards the management of young forests, as subsidies for their thinning became available in the early 1990's (Åkerman et al. 2010). Regional Forestry Centers began active promotion of the possibilities related to heat entrepreneurship, connecting the problematic unmanaged young forests to rural livelihoods and political energy goals (Leskinen 2006). In energy politics, taxation based on carbon dioxide emissions was already introduced in 1990. According to Vehmas (2005), its introduction was based more on fiscal reasons, rather than environmental ones. Renewed policy goals for increased bioenergy production were introduced in 1992 and 1997, identifying such factors as emission reductions, renewability and regional employment as the rationale behind such development. Major research programs related to forest-based bioenergy were launched in the 1990's and according to Hakkila (2006), they had an important role in increasing bioenergy production. However, research efforts were mainly directed to the development of large-scale bioenergy production (ibid.).

The analyzed material reveals that this produced an increase in wood energy utilization on farms, as there was a need to reduce expenditure by using farm labor to produce energy internally instead of purchasing it externally. Additionally, forests were considered as a source of extra income in energy production. As a consequence, heat entrepreneurship was the manifested example. The articles managed to combine all the reasons for wood energy production and portray it as a multifunctional activity that is good for forests, rural communities, the climate and the national economy. The presentation of positive entrepreneurial examples in the articles contributed to the portrayal of energy production as a concrete option for income generation.

At the turn of the millennium, rising energy prices, international commitments to reduce carbon dioxide emissions, EU targets for renewable energy utilization and to some extent, rising awareness of climate change itself, triggered the emergence of bioenergy in both, wood and other biofuels. The *Bioenergy entrepreneurs* period for biofuels is strongly comparable to the *Emerging heat entrepreneurs* period in wood energy. Existing farm-scale examples of energy production were positively presented in the printed media, optimistically portraying the energy production potential and multiple beneficial functions for rural areas specifically but also for Finland more generally. The bioenergy types included biogas, liquid biofuels and energy crops that could be either refined into gas or liquid fuels or combusted. Politics had acquired a central role, as new supportive mechanisms for bioenergy production were demanded. In practice, these were not realized until 2011 (Kivimaa and Mickwitz 2011).

The turn of the millennium appeared as an era of normalization for wood energy production. During the *Normal wood energy production* period, wood energy had become self-evident, and was considered to be the most "natural" bioenergy option. Articles on wood-energy production were published at a stabilized rate and covered issues ranging from heating of the farm to heat entrepreneurship and the possibilities in selling wood for energy production. The arguments in favor of wood energy production during this time are similar to those presented previously. Curiously however, some negative impacts were discussed. The impacts were related to the collection of stumps and harvesting residues and their impacts on future forest growth. The discussion centered less on environmental values like biodiversity and more on the potentially decreasing economic value of forestland. Stumps and harvesting residues were primarily utilized by forest industries or large energy companies and not by local small-scale heating plants or individual farmers. The large-scale users were unwilling to pay the forest owners for this biomass, thus, the concern was used as an argument for payment.

This discussion reflects the juxtaposition between forest owning farmers and forest industries in the provision and utilization of forest resources throughout the studied timeframe. The price and demand for wood set by forest industries is generally not considered to be adequate by the forest owners. Therefore, the general concern expressed by forest industries on the sufficiency of wood material for pulp production due to increasing wood energy production, seems exaggerated from the perspective of forest owners. When new possibilities on the utilization of forest resources are introduced by heat entrepreneurship and other small-scale energy production, they are generally embraced by forest owning farmers. They attain a profitable solution for the utilization of wood not wanted by the industry and perhaps force the forest industries to pay an increased price for their product. This, in turn, increases the control that forest owners have over their resources (see also Åkerman et al. 2010). Other sources of biomass face similar issue in terms of finding alternatives for raw material provision for food production in the utilization of fields. The same also applies to localized food production.

The media material exhibits a tension between various scales of bioenergy production, as also suggested by Åkerman et al. (2005). To generalize, there is tension between the different scales utilizing rural resources. For bioenergy, the division also intersects policy sectors. According to Kivimaa and Mickwitz (2011), the framing of bioenergy in Finnish energy and climate policies since the late 1970's has related to wood-energy and large-scale industrial production, with only a minor role reserved for small-scale energy production and the utilization of resources other than woody biomasses. The role of small-scale production and rural alternatives has been more emphasized in the agricultural and forestry sector than within energy politics (Åkerman et al. 2005).

4.2 Policy instruments related to farm-based bioenergy

Farm-level bioenergy production intersects three policy domains: agriculture, forestry and energy. All domains have an interest in bioenergy production activity, and all influence it in forms of policies and policy instruments. Finnish agricultural policy is closely connected to EU's Common Agricultural Policy, CAP. The primary forms of support, like Single Farm Payment and Aid for Less Favored Areas (LFA), are allocated to farms, independent of the actual production (Niemi and Ahlsted 2011). This means that support is available for energy crop cultivation but the production is not specially promoted. Between the years 2005 and 2009, an additional grant for energy crop cultivation was available but this subsidy ended in 2010.

The agricultural sector provides investment and entrepreneurship subsidies intended for farm-scale bioenergy production and for small rural enterprises (Mavi 2012). These subsidies are partially funded by the EU via the Rural Development Program for Mainland Finland (MAF 2011). The investment support systems have improved since the empirical part of this study was conducted. Previously, the investment subsidies were mainly directed towards wood energy production but currently, investments related to biogas and biodiesel production are also supported, although the emphasis is on large, rather than single farm facilities (MAF 2007). Additionally, the energy sector provides investment subsidies for bioenergy production although these subsidies are not available for farms (statute 1313/2007).

The energy sector supports bioenergy production by taxing the use of fossil fuels in heat production. In the past, electricity production from biomass and other renewable energy sources received taxation support. In 2011, new legislation concerning feed-in tariffs and production support for energy produced using various renewable energy sources was implemented (Act 1396/2010). In principle, these new support forms are not applicable to farm-scale production due to minimum production capacity requirements. However, energy production facilities operated by several farmers could be large enough to obtain these subsidies in the future. Farm-scale energy production is not included in the EU's carbon emission trade.

During the time of the empirical portion of this study, biofuels used in the traffic sector were subject to equivalent or even higher taxes as those imposed on fossil fuels. Only biogas has enjoyed tax relief since 2004 (Lampinen 2008). However, some improvements have occurred. Since 2011, all biofuels have received partial tax reductions based on their carbon dioxide emissions (Act 1399/2010). Since 2008, biofuels produced on farms have been tax exempt when utilized in heating and machine-related usage (MAF 2008).

In forest policy, bioenergy has become increasingly important in the utilization of forest resources. There are subsidies available for energy wood harvesting from young forests, for the thinning of young forests and for energy wood chipping (MAF 2008). Originally, the subsidies were used as incentives to encourage forest owners to improve the management of young forests but they have since become important in increasing the profitability of energy wood collection (Åkerman et al. 2010).

In adjunction to financial instruments, information and guidance on bioenergy production is also provided. The guidance has predominantly been provided by forestry officials[5] and to some extent, by rural and energy-related agencies (MAF 2008). The bioenergy related policy instruments have not been particularly favorable for farm-scale energy production. The emphasis has been on larger scale facilities, although some minor amendments have occurred in the past five years. The most heavily subsidized production type relevant for farms is wood-based heating. Also, information and guidance on wood heating is most readily available, compared to other bioenergy production forms (See also Snäkin et al. 2010).

4.3 Bioenergy production systems on Finnish farms

The functioning of farm-related bioenergy production was more thoroughly examined via the farmer-interviews. The farmers were asked to draw a schematic figure outlining their energy production system, including all relevant actors, materials and production locations in the system. Based on these drawings and the interview accounts, a general representation of farm-related bioenergy production was generated (Figure 8). Separate figures detailing the various actors related to heat entrepreneurship, biogas production and biodiesel production are presented in original article II.

Common to all the production systems is the utilization of previously underexploited natural resources, available on the farm or within the immediate locality. The manufactured energy is either sold externally or utilized on the farm (theoretically, at least, it is possible to do both). Another commonality concerns the possibility for local networking.

The following section describes the energy production systems and their significance to the energy producers as based on the interviews - thus from the farmers' perspectives.

5 In Finland, forest management activities are supervised by two main organizations, Regional Forestry Centers (RFC) and Local Forest Management Associations (FMA). RFCs form the official local body for regional forestry planning and advising. Most RFCs have energy advisors specialized in bioenergy production. FMAs are forest owners' associations. Each forest owner is a member of the local FMA and pays membership fees, which entitle the owner to forestry related services from the FMA. FMAs are governed by the Forest Management Association Act, thus their status is semi-official. FMAs may also employ energy advisors and the associations form the central body of timber and energy wood sales organizations (FFC 2012, FMA 2012).

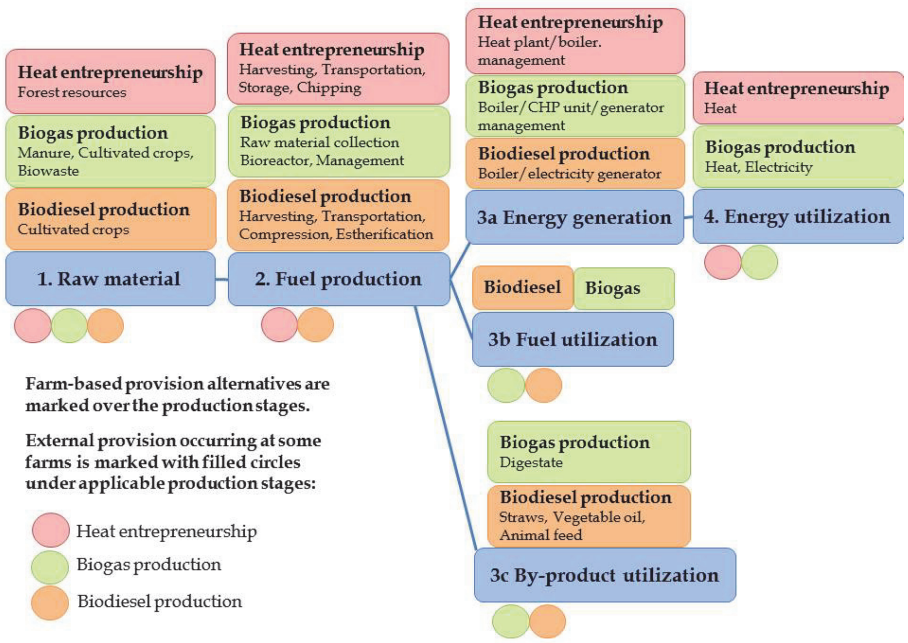

FIGURE 8 Summary of farm-based bioenergy production systems

Heat entrepreneurship

Heat entrepreneurs sell heat that is produced using wood-based fuels - most commonly wood chips. Generally, the wood is collected from the entrepreneur's own property or from other local forests. Stems resulting from the thinning of immature forests comprise the most commonly used biomass but other types of wood residues may also be used. Most of the heat plants operated by entrepreneurs are quite particular to the fuel required and harvesting residues from clear-cuts or stumps cannot be used, for example. Additionally, the wood must have low moisture content. The fuel procurement, chipping, storage and transportation require a considerable amount of labor that can be performed by the heat entrepreneurs themselves or by external contractors.

Due to the marketable nature of heat, it is produced directly at the consumption site or at a larger heating plant connected to a district-heating network. The plant can be owned by the heat entrepreneur(s) or by the customer. The plant is managed by the heat entrepreneurs and the customer commits to purchasing the heat for a given price. The operation of the heating plant is in itself another stage of work. The heating systems are automated but somebody must always be available on an on-call basis, should a problem arise.

In a business sense, heat entrepreneurship is entirely contingent on the customer base from the initial stage onward. This means that a farmer cannot just decide to become a heat entrepreneur before he has secured a heating site.

Potential heating sites are usually owned by municipalities and occasionally by the state or local companies. Municipal-owned heat plants are desirable to heat entrepreneurs, as initial investments are made by the municipalities, thus reducing the financial risks for the entrepreneurs. The sites become available as owners decide to change heating from oil to bioenergy and invite tenders for the heating contract. Thus, in order to become a heat entrepreneur, the tender must be won. Frequently however, the decision behind the fuel shift has been initiated by suggestions of willing heat entrepreneurs or by forestry officials who have greatly facilitated the emergence of heat entrepreneurship.

Heat entrepreneurs operate as single entrepreneurs, as members of a small entrepreneur's consortia or in cooperatives. The operational model affects the heat entrepreneur's role and responsibilities, as well as his conceptualization of the activity. The responsibility, workload and earned income are more considerable for a single entrepreneur than for an entrepreneur in a shared business. Furthermore, single entrepreneurs commonly have partners outside the realm of the heating business. In cooperatives or consortia, the members can be responsible for different phases in the fuel procurement process, such as heating or other business related tasks like accounting, depending on their respective resources and skills. Thus, the majority of the workload can be accomplished by the members themselves. The members' particular skill sets may also influence the formation of the consortia or cooperatives in the first place. Besides the cooperating partners, contractors and customers, heat entrepreneurs are also involved with organizations and individuals that provide advice or otherwise facilitate the entrepreneurs' activities. These include Local Forestry Associations and Regional Forestry Centers, heating plant manufacturers and other heat entrepreneurs. Sometimes the proprietor of the heat plant, manufacturers and even local forestry associations may be members in heat entrepreneurship cooperatives.

Heat entrepreneurship means different things to each entrepreneur, depending on the entrepreneurship model being followed and the role the entrepreneur assumes[6]. Single entrepreneurs can earn significant additional income to augment other farming activities that could even sustain a farm that would otherwise have been endangered. In consortiums and cooperatives, significant income can be attained if the entrepreneur can provide a large share of fuel and/or contribute to chipping and logistics. Nevertheless, the entrepreneurs do not generally consider the additional revenue to be significant or crucial. More importantly, heat entrepreneurship provides farmers with a diversification option, allowing for less dependence on one income source and an expansion of economic capital.

Heat entrepreneurship offers more than mere economic benefits. For many farmers, it presents an important new personal challenge. A number of farmers found it rewarding to challenge themselves with a new project or to broaden their understanding of wood heating, which was previously only used

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6 For a more detailed account on different heat entrepreneur types, see original article IV.

on a small scale. Socially, farmers gained important relationships or fortified existing ones. For farmers typically accustomed to working alone, the opportunity to collaborate with others and share responsibilities was a welcome change. The development of strong networks with other cooperatives or consortia members and dealings with other business partners also increased social interactions outside of work. As a downside, the heavy workload frequently associated with heat entrepreneurship was sometimes the causative factor of stress in family relationships.

The farmers view heat entrepreneurship in positive terms and are proud of their activity. Compared to farming, heat entrepreneurship is perceived as "real" work that is independently profitable, without substantial subsidies. In addition, wood- energy production is appreciated by the local community. Public opinion regarding production is very positive, although farmers often encountered many challenges during the early phases of development. General community appreciation increases the farmer's pride in their production activity. They also consider their work as benefitting the entire locality by generating additional employment opportunities in forestry, by utilizing wood that would otherwise have no market and by amplifying the (aesthetic and recreational) value of municipal forests and landscapes. This is largely attributed to the increased management of young forests and to the clearing of roadside brush and other thickets. According to the farmers, the municipality also benefits, as local fuel is less expensive and consumers are able to purchase heat at a lower price than oil heating can offer. In addition, heat entrepreneurship has supported and even created new local manufacturers related to heating equipment, especially when the manufacturer is a co-owner in a heat enterprise.

Biogas production

In biogas production, farmers use available farm-generated biowaste material to generate biogas that is further refined into heat, electricity and even purified biogas that can be used as traffic fuel. Biogas is produced by a process of microbial anaerobic digestion in a bioreactor. The raw material used is usually either cow or pig manure. Also, waste material from plants or "energy plants" cultivated on the farm specifically for biogas production can be used. Sometimes, industrial or other biowaste is imported to the farm, in which case, the farmer may potentially gain additional income from waste management.

Biogas is customarily generated on single farms and the resulting energy is used directly on the farms. Among the interviews, there was one case where several farmers cooperated in biogas production and mainly sold the energy externally. Most frequently, only heat was produced, followed by a combination of electricity and heat production and one farm was actively refining biogas for traffic fuel. Several of the interviewed farmers were planning to use biogas in electricity and traffic fuel production in the future. The major constraint inhibiting electricity and traffic fuel production was the availability and cost of the required technology. Electricity and traffic fuel are potentially marketable energy products and presented farmers with an appealing opportunity to earn additional income. The main objective, however, remained meeting the farm's energy requirements. Besides energy production, biogas manufacture also provides farms with a waste management system, where manure and other biowastes are converted into fertilizer as the solid remnant of the digestion process. This fertilizer is more compressed, less odorous and the nutrients are more readily utilizable than untreated manure. Thus, in its simplest form, biogas production offers a solution to the farm's manure management problems, while simultaneously producing heat. No connections outside the farm are necessarily required.

Biogas production can be commenced at any time, as no clientele or partners are required. However, the investment costs are high for single farms and much of the older biogas equipment in existence has been obtained for use as pilot projects in cooperation with a university or polytechnic. Investment in biogas manufacture restricts other development options on the farm. In the future, investment costs might not appear so devastating, as the option of selling electricity and traffic fuels may prove profitable if energy prices continue to increase and legislation is amended to support small-scale bioenergy production.

For the farmers, biogas production primarily provides a challenge and possibility to develop oneself and the farm. Also, the future potential and novelty of biogas in Finland is intriguing. Being actively involved in biogas development and managing the biogas production process adds important value to the farmer's skills. In fact, if farming suddenly became unprofitable for a biogas-producing farmer, he would have gained significant skills that could be applied in another sector, such as waste management. Additionally, some farmers, who had been involved in the development of biogas production related equipment, were selling similar equipment to other farmers.

Partnerships in biogas production are rare if the co-operation with research and education institutions is excluded. Sometimes experiences are shared with other biogas producers. Some may have a customer base and external raw material providers. Compared to heat entrepreneurship, the networks are sparse. Some farmers expressed disappointment towards their biogas production, especially in regards to profitability. This was particularly common with producers who had only recently commenced their production. Biogas production can be regarded as a pioneering endeavor that requires the producer to be enthusiastic and passionate about technological development work.

Biodiesel production

Biodiesel production on Finnish farms occurs mainly by rapeseed compression into vegetable oil, followed by further estherification into biodiesel. The farms primarily utilize rapeseed cultivated on the farm. Compression into vegetable oil occurs at the farm, but the estherification process is sometimes performed externally. The biodiesel produced is mainly used as fuel for farming equipment and vehicles. In some cases, the biodiesel can also be utilized in heat production and there is even potential for electricity generation, although this did not occur on any of the farms surveyed in this study. The manufactured biodiesel is primarily intended for farm consumption, but a portion may also be sold peripherally.

The process of rapeseed cultivation into biodiesel generates various by-products, including straw, glycerol, protein-rich animal feed and in some cases, vegetable oil that is not processed into product. Hypothetically, all by-products can be used profitably, thus providing additional income for the farm. In practice, not all by-products are necessarily used commercially but they can nevertheless be utilized on the farm. Biodiesel production occurs primarily on a single farm basis, although cooperatives of several farms also exist. The interviewed biodiesel producers were well connected with each other, equipment manufacturers and the surrounding community, as there are various collaborations relating to the acquirement of raw materials and the utilization of by-products.

Similarly to biogas, biodiesel production is in general not profitable for farmers. In biodiesel production the investment costs are not as significant in determining the profitability as in biogas production. Rather, the unprofitability is caused by cultivation costs and the alternative utilization possibilities for rapeseed. In some cases, the production expenses exceed earnings, while in other cases the costs are barely overcome by profits. While farmers mostly strive for fuel self-sufficiency, some have considered heat and electricity production. Hopes for the future importance and profitability of biodiesel production remain high. Part of the value can be attained via the by-products, especially animal feed, and ensuing networks that result from biodiesel production.

Presently, however, biodiesel production is a hobby: an interesting project in which to immerse oneself. As such, the perceived value of biodiesel production comes via the acquired ability to produce fuel: biodiesel producers feel a sense of pride when driving cars or machinery powered by energy they have produced themselves. Biodiesel production introduces farmers to new skills that may prove to be beneficial outside the agricultural sector. Some biodiesel producers have even partaken in development projects that have directed them to further interesting projects and contacts. Also the assumed environmental friendliness of the fuel is valued.

5 MEANINGS OF SUSTAINABILITY

5.1 Heat entrepreneurship

The contribution to sustainability by each farm-scale bioenergy production model is assessed using the dynamics of the evolvement of eco-economy presented in chapter 2.4 and Figure 6. Heat entrepreneurship portrays the most natural case, clearly presenting all of the aforementioned building blocks. The factors influencing the farmer's decision to start a heating business stem from the intertwinement of factors related to energy, forestry and rural development (see also Åkerman et al. 2010). The central reasoning arises from abundant local forest resources, especially in the form of non-marketable wood. This includes, for example, stems procured from the thinning of young forests or dry standing wood left over from final felling. The abundance of available wood material was reflected against the rising price of oil and the quantity of oil used in local heating systems. For farmers, heat entrepreneurship appears as a suitable additional activity to farming, as it provides work during the wintertime, when time is more readily available and provides a potential method for earning much needed additional income. Heat entrepreneurship is often initiated or at least facilitated by local forestry officials, usually employed in Regional Forestry Centers or in Local Forestry Associations. Local contacts also play an important role in the recruitment of heat entrepreneurs. Ecological reasons do not rank highly among factors initiating heat entrepreneurship.

When examining the dynamics of the development of heat entrepreneurship (Figure 9), consideration of the local community and material resources are essential. These may be manifested in the form of forest resources, social networks and local knowledge but the availability of existing equipment and machinery related to farming and forestry is also beneficial. Heat entrepreneurs construct their activity as essentially local production. This is accomplished by emphasizing the regional economic significance of heat entrepreneurship, which results in three factors: 1) The more efficient utilization of forest resources, contributing to improved forest management; 2) The locally produced heat retains money and employment within the locality, as there is no need to purchase imported fuels, allowing heating costs to remain relatively low; 3) new small-scale local businesses are created in the development and management of heating plants. In addition, locally produced energy provides a heating service with superior quality, endowed with trustworthy management that also contributes to a more aesthetic landscape. The entrepreneurs reflect personal pride in their energy production and claim it is also a source of pride more widely in the locality (see also original article III).

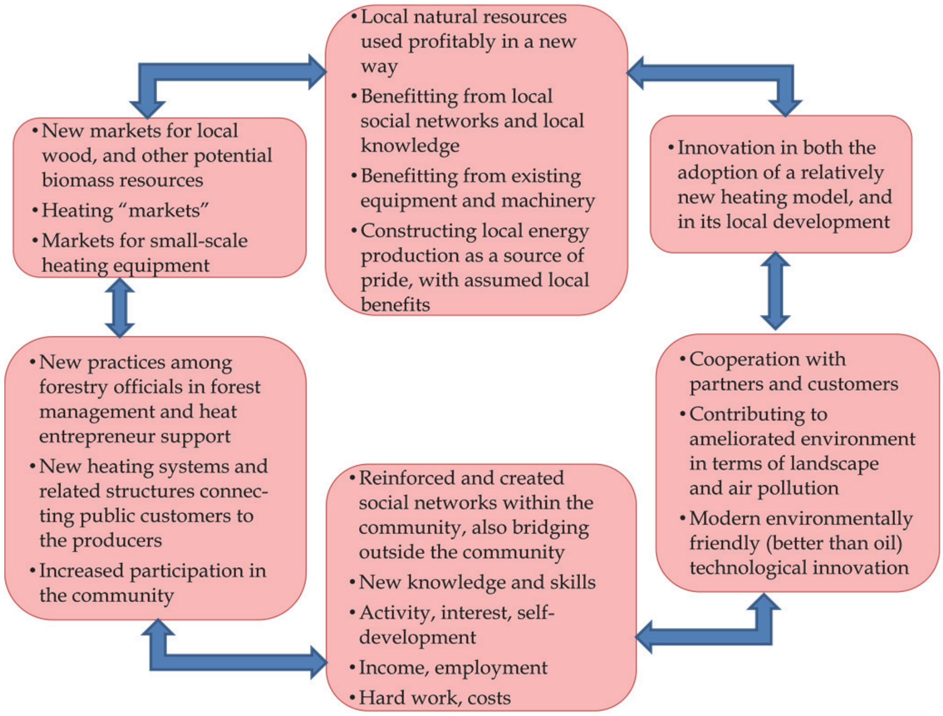

FIGURE 9 Dynamics influencing the development of heat entrepreneurship.

Heat entrepreneurship is closely intertwined with the development of new markets. A central innovation is the new utilization of forest resources that contributes to improved forest growth in terms of forest management and augments the more conventional ways of utilizing forests. In addition, the creation of new markets for forest resources that were previously not marketable, allow forest owners alternative ways of utilizing their resources. By embarking in heat entrepreneurship, forest owners can further refine forest resources into energy, hence decreasing dependence on the global forest industry. Thus, the farmers are regaining partial control over the resources and the financial benefits available from their utilization (see also Peltola 2007).

Heating systems are developed further in the local context where manufacturing businesses for heating equipment have developed in conjunction with heat production. The novelty aspect is further reinforced by interested visitors, both local and international who wish to familiarize themselves with the new technology and heat provision model. The novelty is interestingly intertwined with older traditions, reflecting the connection between locality and innovative production. Heat entrepreneurship ensues the farming tradition in Finland, where forestry has been an important aspect of farming livelihoods (Niemelä 2008). Most farms possess at least some forestlands and a tradition of wood-fuel based heating still exists. This is evidenced by the fact that most of the interviewed farmers were heating their farms with wood fuels. Thus, heat entrepreneurship offers a continuum for the utilization of forestry skills and resources on farms.

In addition to forest resources, heat entrepreneurship has created new markets in terms of heat and heating equipment. In some cases, the building of a heating plant has also lead to the construction or expansion of a local district heating network. This has enabled the local inhabitants to choose between a detached heating system and the district-heating network. The heat markets are unique in that the actual customer is most often the municipality, which then "re-sells" heat to the actual consumers. In some cases, however, heat entrepreneurs may sell the heat directly to customers. Previously, the municipality produced the majority of heat required for its buildings and district heating, but the emergence of heat entrepreneurship has initiated a new kind of public-private partnership in heat provision. The partnership offers the heat entrepreneur security and eases the investment burden. Direct municipal involvement has also contributed to the emphasis of the local community benefits of heat entrepreneurship. This idea has been fostered both in the minds of heat entrepreneurs and in the community mentality, increasing the entrepreneurs' personal and professional participation in the community.

An important relationship in heat entrepreneurship is formed between the business and local forestry organizations. The utilization of stems from the thinning of immature forests has contributed to increased forest growth and improved forest quality: both primary goals of forestry organizations (Leskinen 2006, Åkerman et al. 2010). As heat entrepreneurship is seen to support forestry, the forestry organizations in both regional forestry centers and in some local forestry associations employ energy advisors that assist heat entrepreneurs. In addition, the emergence of heat entrepreneurship has paved the way for new practices in forest management that support the wood procurement of heat entrepreneurs.

From the heat entrepreneurs´ perspective, the environmental benefit of heat entrepreneurship is essentially manifested in local small-scale environmental issues. The activity of heat entrepreneurs contributes to sustainable and efficient utilization of forest resources. This is discernable in improved aesthetic value of landscapes and forest growth, as a consequence of the improved management of young forests within the boundaries of rotation-based forestry. This is intertwined with the economic benefits that can be obtained from more economically feasible thinning practices, as small-sized timber may be used in heat plants. In addition, the thinned forests without harvest residues can be considered to yield more recreational value (see also Kuusinen and Ilvesniemi 2008, Barbieri and Valdivia 2010). Whether the rotation-based forestry, or increased collection of biomass for energy production actually is environmentally beneficial in terms of biodiversity was no concern for the heat entrepreneurs. Heat entrepreneurs value the utilization of local, renewable resources in heat production instead of imported oil, which they consider to be a more polluting energy source. However, they also acknowledged smog and particulate emissions from wood heating as potential environmental problems that they wished to diminish.

Climate change and carbon dioxide emissions related to energy production were issues that had little relevance for heat entrepreneurs in their daily lives. They expressed concern about climate change on a general level but did not acknowledge an association between their bioenergy production and climate change, nor did they consider environmental factors to be influential motivators in their entrepreneurial activity. Interestingly enough however, some had used environmental arguments in their applications for government funding (see also original articles IV and I).

In terms of ecological modernization, heat entrepreneurship utilizes environmentally friendly technology, not to solve environmental problems but rather to attain economic or social benefits. The environmental benefits are more of a bonus and local level benefits are usually more appreciated than global ones. What is important is that the economic benefits are essentially the carriers of change in heating practices. Involvement in heat entrepreneurship might also provide for improved knowledge on environmental issues and hence provide fortification for the environmental dimension of the activity, allowing environmental considerations to become more self-evident.

The innovative application of forests and heating occurs through local networks, where cooperation is based on existing relationships, personal ties and trust. Such networks contribute to the overall achievement of the business, as farmers must be considered trustworthy and respected members of the community to ensure entrepreneurial success. Additionally, new relationships are formed and existing ones reinforced, strengthening community coherence and contributing to the capabilities of the heat entrepreneurs. For example, some heat entrepreneurs have found that their business endeavor has produced valuable professional, political and authoritative contacts. Their capabilities are also reinforced by their increased knowledgebase and skills on heating with wood fuels, enabling them to expand upon and profit from their knowledge. During the study, different groups of heat entrepreneurs were identified (original article IV). For one group, heat entrepreneurship signified improved material wellbeing, with increased income and employment, as well as reduced dependence on one income source. For another group, wellbeing had been increased due to new activity and cooperation. For the final group, wellbeing was increased more on a community level by increased employment and more efficient forest management. The identified downsides included a heavy workload and sometimes, financial burdens that reduced capabilities and wellbeing. The heat entrepreneurs´ views regarding their activity may be summarized as multifunctional due to the various benefits it offers both to the entrepreneurs themselves and for the surrounding community (also see original article IV).

To recapitulate, the dynamics of eco-economy in heat entrepreneurship illustrate how the production activity has managed to create a positive circuit based on local value-addition. The strengths result from the embedding of the production activity within surrounding social and environmental structures and from enhanced cooperation and forestry related benefits combined with potential economic advantages. The supporting structures provided by forestry organizations and partnerships with the municipality are important in strengthening the activity. It is also evident that national politics have been helpful in providing support for fuel collection and sometimes, investments, in addition to funding for research and development programs (Åkerman et al. 2010). Supportive policies, partnerships and collaboration with different local and regional actors and developing know-how, have also been found to be important for bioenergy development in other countries (McCormick and Kåberger 2005, McCormick 2011, Laborgne 2011). The weaknesses of heat entrepreneurship are manifested in relatively poor profitability compared to workload and also in the rather poor acknowledgement of the production activity's global climate benefits as well as potential local biodiversity loss.

5.2 Biogas production

Biogas production has fundamentally emerged from the initiative of individual farmers. Both environmental and energy related reasons exist in the background. The energy related reasons are associated with rising oil and electricity prices, as was the case with heat entrepreneurship. This has prompted the entrepreneurs to use their own resources in energy production. The environmentally related reasons chiefly include manure management problems, to which biogas production offers a solution (see chapter 4). In addition, some biogas producers have deliberately searched for a new endeavor to delve into, seeing interesting possibilities in the field of biogas production. In this aspect, direct involvement and interest by research organizations, universities and polytechnics has been beneficial.

The evolvement of biogas production systems is presented in Figure 10 Here, biogas production is examined by reflecting on the interviews of the single farm based producers. The exceptional case of the cooperative biogas production is discussed later, in chapter 5.4. Biogas production derives from local resources in a somewhat different manner from heat entrepreneurship. At the core of the production lies the farm's underutilized biomass resources in the form of manure or less frequently, plants. Local social networks play a minor role, as production is mainly based on individual farms and their resources.

Hence, the role of innovative individuals, in this context the biogas-producing farmers, is vital. In some instances, the local community even acted in a counter-productive manner towards production by expressing disbelief and ridicule towards biogas-producing farmers. Despite the initially discouraging attitudes of the local community, the farmer's belief in the value of the energy production has been strong. Fortification has been obtained from beyond the scope of the local community - primarily from research organizations. Hence, the biogas producers also tend to consider the value of their energy production activity in broader terms: the production of domestic, rather than local energy. Nevertheless, they also have a sort of micro-local pride in their energy production (see original article III).

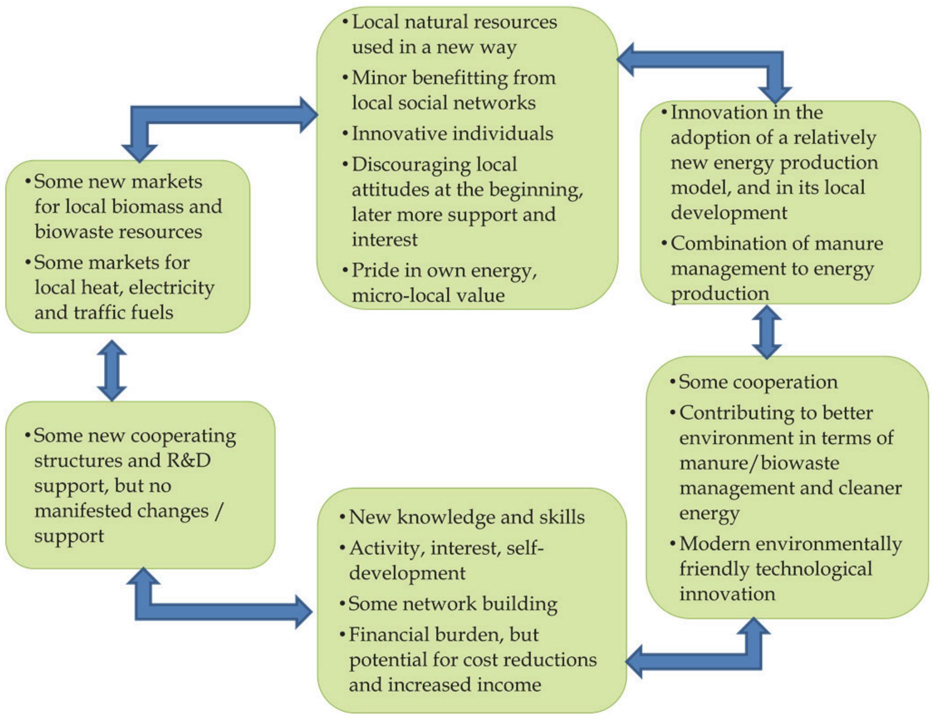

FIGURE 10 Dynamics contributing to the development of farm-based biogas production.

The novelty of biogas production comes in part from its rarity as a practice on Finnish farms and partly from the combination of manure management and energy production. The technology itself is old: farm based biogas production was discussed in Finland as early as the 1980's (original article I) and practiced in countries like Denmark, Germany and the Netherlands (Raven and Verbong 2004, Raven and Geels 2010). However, local innovation is also required when adapting the technology to the farm locale, creating another aspect of novelty. This results from the desire to attain a fully functioning system and from interest to develop the system further, often with the help of external organizations. This development work has led to patented innovations and entrepreneurial activity related to the provision and design of biogas systems. If successful, biogas production could create new kinds of rural business opportunities, including consulting. As with heat entrepreneurship, biogas farms have attracted interested visitors, further reinforcing the novelty of biogas production.

The production activity has led to minor developments in biomass and energy related markets. Some farmers sell electricity or heat to neighbors and some purchase or receive biowaste and other biomass material for the digestion process. This happens mostly via informal connections, hence to consider new market creation or real development of existing markets would be an exaggeration. Perhaps a more significant market is being created by the farmers who are developing biogas production systems and marketing them further. However, presently their activity is occurring on a very minor scale.

Biogas production is not supported by institutional frameworks to any measurable extent. Some minor support can be observed in the form of established relationships to research organizations and support from other biogas-producing farmers, providing an informal network for assistance. At the time of the interviews, the existing official organizations were rather ignorant regarding biogas systems and their requirements, thus hindering the adoption of biogas systems at the farm-level. This was demonstrated for example as inadequate regulation of biogas systems causing difficulties in what kind of environmental permits were needed, or in obtaining financial protection for the system from insurance companies.

Biogas production exemplifies ecological modernization, as it is clearly an environmentally beneficial innovation. Modern technology is applied to solve problems related to manure management, while simultaneously reducing carbon dioxide emissions from energy production. However, for most of the biogas-producing farmers, the cleaner energy aspect and contribution to climate change mitigation were secondary to the benefits associated with manure management. The technology was considered to be innovative, unique and something to be proud of. For most, the initial hope had been to obtain economic gain from the biogas system, primarily by reducing energy expenses and by eventually achieving self-sufficient energy production. These hopes had not materialized and the energy production was not economically viable in a revenue generating sense. Hence, the economic aspect inherent in ecological modernization is not fulfilled by biogas production. The farmers have become increasingly aware of environmental issues (also related to climate change) due to their involvement in biogas production. The increasing knowledge also has potential to increasingly internalize environmental considerations.

From a social point of view, biogas production has fortified the farmers' capabilities by providing them with new knowledge and skills that expand their livelihood options. The creation of additional new contacts also increases the farmers' social networks. Generally, the farmers' quality of life is improved by the new activity and development opportunities provided by biogas production. Yet, the production also yields a workload and occasionally a financial burden that counteract some of the positive aspects regarding capabilities and quality of life. Thus, distinct to heat entrepreneurship, multifunctionality in biogas production primarily manifests through environmental benefits and via personal and professional development. The multifunctionality of the locality is not enhanced significantly and no considerable community benefits are attained.

To summarize, the dynamics of eco-economy in biogas production are rather poorly reinforced. Strengths present themselves via strong, innovative individuals and in innovative technology combining environmental problem management (manure) with potential cost reductions (energy). Weaknesses are more manifested. They relate to market creation, institutional structures, weak local embedding and poor profitability. The non-existing support structures reveal the instable position of biogas producers in Finnish agricultural and energy production fields. The emergence of farm-based biogas production has been examined extensively in Denmark and the Netherlands (Raven and Gregersen 2007, Negro et al. 2007, Raven and Geels 2010). There, observed problems are similar to those in Finland: a weak institutional framework and the inability of local actors to improve it (Negro et al. 2007, Raven and Geels 2010). In the Danish case, a more positive outcome was reached as the biogas production was developed with farmer cooperation, using a more community-centered approach that promoted learning, new practices and was supported by the authorities (Raven and Gegersen 2007, Raven and Geels 2010).

5.3 Biodiesel production

Farmers embark on biodiesel production due to various reasons that provide a mixture of the motives presented by heat entrepreneurs and biogas producers. The main initiator has been increasing energy prices and an interest to find a solution via self-generated resources. In addition, social networks of friends and family have in some cases provoked interest in the biodiesel production activity. Similarly to biogas production, biodiesel manufacture also requires strong personal commitment and interest to develop new production activity that is clearly outside the scope of conventional farming.

Dynamics impacting the development of biodiesel production are presented in Figure 11. The locality aspect is mostly manifested in the innovative utilization of local biomass resources, similarly to biogas production. In biodiesel production however, local social networks have a more influential role, as partnerships are more common in the production activity itself and in the procurement and distribution of raw-material, by-products and fuel. These networks are embedded in nature, based on existing relationships, trust and local knowledge. Like biogas producers, farmers embarking in biodiesel-related activities also faced some initial discouragement. Thus, the local community influence was not entirely positive. The biodiesel producers appreciate the fuel they produce and regard that their customers also value it. This value is essentially based in the locality of the product but not in any community or regional level, as might be the case in heat entrepreneurship. The biodiesel is independently produced, micro-local and associated to the farm.

Biodiesel production has created some new products with separate micro-markets or production networks. Those farmers that market biodiesel externally have accumulated clientele through informal connections and by word of mouth. The same can be said about the sale of related by-products and raw material for biodiesel production. The micro-markets occur on such a minor scale and are available to such a limited number of people, that they do not represent any real challenge to existing fuel markets. Biodiesel production has not managed to create supporting structures to fortify production activities or their local importance. Similar to biogas production, local officials are frequently unaware of the production requirements.

The novelty in biodiesel production exists in the production of valuable by-products, mainly protein-rich animal feed, and the production of fuel. The producers have found new ways of utilizing different types of biomass that originate from the process. Also, some farmers have further developed the technology itself and local adaptations have been made. Hence, innovation is occurring.

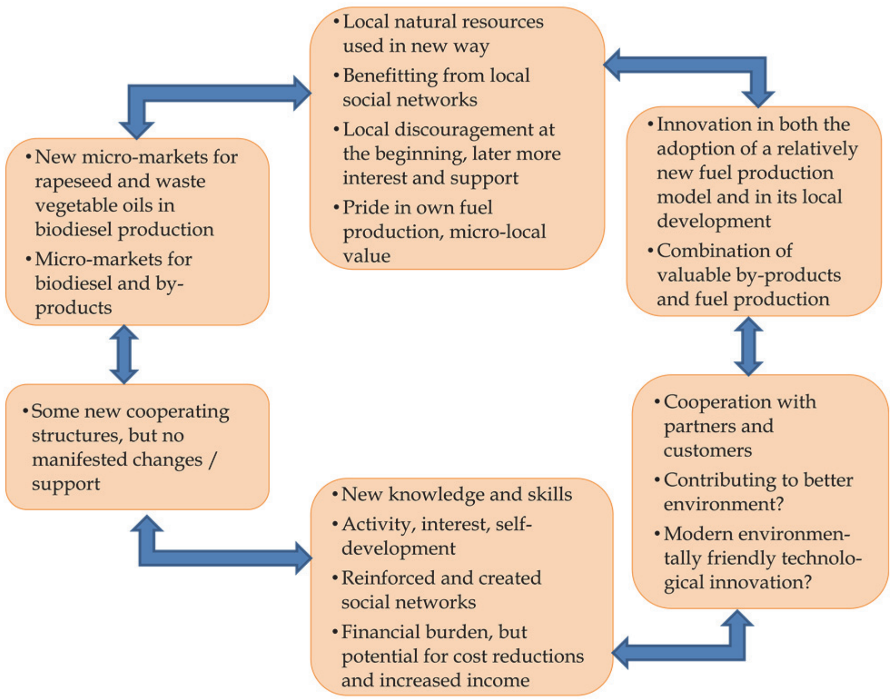

FIGURE 11 Dynamics influencing the development of farm-based biodiesel production.

Ecological modernization in relation to biodiesel production is less straightforward compared to biogas production. The new technology is not intentionally used for solving environmental problems. Rather, the original aim was to solve economic problems or prevent them from actualizing. The environmental benefits of biodiesel production are not very imperative for the producers and they are simply regarded as a potential auxiliary benefit that may add value for some customers. However, the environmental benefits contribute to the pride felt by producers regarding their self-generated fuel. It should be noted that the environmental benefits in terms of carbon dioxide emissions are somewhat questionable based on research (see e.g. Soimakallio et al. 2009, Malça and Freire 2011). This, combined with the poor profitability of biodiesel production undermines the ecologically modernizing character of biodiesel production. However, similar to biogas production, biodiesel production has increased the environmental and climate change related awareness of the farmers. In addition, biodiesel production involves cooperation, contributing to community benefits. If by-products are considered in profitability and environmental assessments, then biodiesel production becomes more profitable and environmentally beneficial (see also Pierre 2009). Hence, the combination of these features reveal more about the potential of local ecologically modernizing practice. Biodiesel production should be considered as a multifunctional activity with slight positive functions on social, environmental and economic aspects.

The social aspect of biodiesel production is more important than with biogas but less manifested than in heat entrepreneurship. As in biogas production, the most important features of production activity for farmers include new knowledge and skills, and the acquirement of a new interesting project to embark upon. In addition, the biodiesel itself is a source of pride, providing for increased job satisfaction and value. Biodiesel production also reinforces existing social networks and creates some new ones. These provide for capabilities, although the poor profitability partially undermines them. The farmers were positive regarding the future potential of their biodiesel production activity and remained optimistic in regards to future cost reductions and increased income. These were projected to manifest essentially via the by-products and social networks.

In the case of biodiesel production, the dynamics of eco-economy are rather poorly manifested. Its forte is in the magnitude of products or by-products that exhibit potential to generate new markets. In addition, the emerging networks and cooperative partnerships have promise in contributing to more effective local value addition. Weaknesses are similar to those in biogas production and essentially relate to almost non-existent institutional structures and profitability. The potential in biodiesel production is clear but the producers have not managed to successfully actualize it in their activity. In France, biodiesel production originated from local farmer's associations, who collaborated in the acquirement of oil presses and other machinery. Hence, the biodiesel production was immediately intertwined with existing structures, easing the development of know-how and access to biodiesel production (Pierre 2009). This allowed biodiesel production to become a viable option, compared to the rather curious image it is still associated with in Finland. However, the problems with low profitability also exist in France (Pierre 2009).

5.4 Sustainable livelihoods and sustainable development

The examples of rural bioenergy production exhibit varied results in terms of sustainable livelihoods. The central concept is the same: new utilization for local biomass resources, contributing in more environmentally friendly energy production. All methods increased livelihoods assets for the producers in terms of gained skills and knowledge and also in increased work-related pride, improving self-esteem. Other aspects relating to sustainable livelihoods displayed greater variation.

Differences in improving economic assets

Improving economic assets is central to the concept of sustainable livelihoods. In this study, the bioenergy production options differed both between and within groups. Material wellbeing was primarily enhanced in the case of heat entrepreneurship but even the heat entrepreneurs included farmers for whom economic benefits were unimportant (original article IV). In biodiesel and biogas production, the economic benefits remained minor to even non-existent, although there were hopes for future economic benefits.

The economic importance of bioenergy production observed in this study can be compared to the economic significance of energy production as a diversification option for Finnish farms more generally and to the economic importance of all diversification branches (Table 5). On average, energy production represents a smaller income addition compared to all diversification branches. About half of the farms earn 10 000 € or less by diversifying in energy production. In this study, the focus was on the energy producing farmer's perception regarding the economic importance of their bioenergy production activity. Hence, direct comparisons to the monetary values are difficult. However, the results indicate variance and emphasis on smaller incomes. Only in heat entrepreneurship can the income from energy production form more than half of the farmer’s total income. In economic terms, increased income may be more easily attainable via other diversification pathways.

TABLE 5 Income obtained from diversification in 2010 on Finnish farms (Tike 2011).

Income	< 10 000 €	10-50 000 €	50-100 000 €	100-200 000 €	> 200 000 €
Energy producing farms	51 %	30 %	7 %	5 %	7 %
All diversification branches	42 %	36 %	10 %	6 %	6 %

The lack of economic benefits is partially problematic with sustaining rural livelihoods. However, there were examples of farmers who attained enhanced material wellbeing from heat entrepreneurship and in this sense, their livelihood assets were improved. In addition, the other heat entrepreneurs were relatively content with their economic situation as heat entrepreneurship provided other assets contributing to their livelihood. The biogas and biodiesel producers were also generally content with their financial situations, although for most the expectations regarding the profitability of their bioenergy production had initially been somewhat higher than what was actually realized at the time of the interviews. The main problem associated with sustainable livelihoods seems to arise from the limitations energy production poses on alternative livelihood options.

In this regard, it should be considered whether the other assets provided by the energy production activity can compensate (and essentially overcompensate) for the losses in economic assets. The majority of farmers surveyed for this study would have answered that they do indeed compensate. This finding agrees with the findings of Kinsella et al. (2000), for example, who observed pluriactive strategies on Irish farms and emphasized the need to consider diversification activities via their multiple functions, not merely through economic profitability. This also reflects the concept of moving from productionist rural development towards sustainable rural development in terms of increasing multifunctionality (van der Ploeg et al. 2000, Marsden 2009).

Strengthening social sustainability

Perhaps the clearest variation between the production models is exhibited by the magnitude of benefits and development of local social resources. Heat entrepreneurs and to some extent, biodiesel producers managed to efficiently utilize the existing local social networks in their production activity, whereas biogas producers were more isolated. By utilizing social contacts, the networks were fortified, creating positive effects in terms of local coherence and social capital and contributing to the assets of the energy producers by creating collective capabilities (cf. Floysand and Sjoholt 2007, Chiffoleau 2009). In original article III, the social networks were examined in terms of horizontal embeddedness. This revealed that the networks in heat entrepreneurship are essentially comprised of the cooperation between producers and their partners and less between producers and customers, as is the case in local food production (e.g. Sage 2003). In biogas and biodiesel production, the few producer cooperatives and business partnerships that existed were also embedded in a manner similar to heat entrepreneurship.

The positive social consequences gained from local bioenergy production confirm many of the expectations theorized by both review and empirical studies (Tables 2 and 3), contributing empirical evidence for the social benefits of small-scale bioenergy production in a developed country. However, the results also suggest that social benefits are not guaranteed by production activity alone but rather they emerge via the manner in which the activity is initiated (see also del Río and Burguillo 2008, Mangoyana and Smith 2011). In cases of isolated farm bioenergy production, where resources originate mainly or solely from the farm and energy production is solely to fulfill the farm's needs, the social benefits are less manifested and relate only to the increased knowledge and skills gained. Relying on cooperation and networking contributed to wider community benefits and also improved livelihood assets for the energy producers.

The isolation can be partially attributed to social acceptability of the novel energy production models. In heat entrepreneurship, the functioning of the heating systems and the ability of the farmers to provide heat in a reliable manner was initially questioned by many municipalities. However, by presenting arguments on community benefits related to local heat production and by initiating community involvement in the production, attitudes have changed and the heating ventures have gained support. Similar cases have been observed with community wind energy projects (Warren and McFayden 2010, Musall and Kuik 2011) and in German "bioenergy villages" (Laborgne 2011). In addition, cultural familiarity of the wood-based heating has contributed to the acceptability of heat entrepreneurship. The case for biogas and biodiesel is somewhat different. Production occurs on separate farms with relatively little cooperation and the technology is unfamiliar. The farmers did not actively seek to change the curious image of their energy production by emphasizing its locality or potential community benefits. The production activities became more widely embraced only after bioenergy production became the focus of national policy interest, where its potential benefits on rural areas and to society more generally were acknowledged (see also original article I).

In all production models, the social networks could be expanded via local and external cooperation and by seeking external advice from agencies such as regional forestry centers or research organizations. These relationships were often embedded in heat entrepreneurship. As an energy production system, heat entrepreneurship was also quite nicely embedded in the tradition of energy production in Finland and it had supporting administrative and even financial systems in place. Hence, heat entrepreneurship can be considered more widely in terms of vertical embeddedness (Sonnino and Marsden 2006, see also original article III). Biogas and biodiesel production were lacking similar structures and instead faced problems with assimilating into the energy and agricultural production systems. Circumstances may have improved after the interviews, due to new supporting instruments (MAF 2008), presented in chapter 4.2.

One important feature of on-farm energy production relates to energy security and autonomy. In developing countries, the central driver behind and benefit from local energy production was increased availability of energy (e.g. Cook 2008, Dhliwayo 2010). In the Finnish context, energy availability is not an issue as such but the centralized nature of energy production and maintenance systems for power-lines, have made rural areas increasingly vulnerable to interruptions in electricity distribution. Simultaneously, farmers are increasingly dependent on electricity, forcing them to invest in diesel-generators in order to avoid disturbances caused by sudden electrical shortages. The interruptions in electricity distribution were problematic for heat entrepreneurs. With self-generated electricity production, the interruptions can be avoided. In addition, the availability of self-generated fuel for biogas and biodiesel producers diminishes the dependence on imported oil and increases the farm's self-sufficiency and autonomy. These reasons have also been found to be important for French farmers commencing in biodiesel production (Pierre 2009). By investing resources in biofuel production, the farmer chooses increased fuel and feed autonomy over increased production (ibid.).

Recognizing the importance of environmental benefits

The bioenergy producers in each production model presented claims on environmental sustainability. For heat entrepreneurs, this occurred in terms of forestry practices and in comparing oil to wood as an energy source. For biogas producers the claim was more efficient manure management and biodiesel producers maintained improved fuel quality. However, in the majority of cases, the ecological values played a minor role compared to the social and economic factors related to bioenergy production. The bioenergy producers' relationship with nature can be considered typical for Finnish farmers (cf. Silvasti 2003). In general, they acknowledge the environmental importance, claiming that environmental considerations are self-evident for them. They work with nature, thus they must respect its boundaries. This may also be related to generational considerations regarding farming. Some bioenergy producers stated that the farm and nature are "borrowed" from their children. Others expressed rather strong attitudes against environmental protection and rejected any association to being labeled "green" or "environmentalists." Rather, the farmers maintain that they are sustainably utilizing natural resources as they are "intended" to be used, even if the scientific basis of their sustainability can be questioned. This is typical for Finnish farmers, who are even inclined to regard productionist agriculture as environmentally sound (Silvasti 2003).

The discourse analysis based on the published material presented in original article I also revealed that environmental aspects were not prioritized in arguments supporting agriculture-related bioenergy production. Rather, rural development and energy security were more emphasized. The environmental dimension can be regarded as the cornerstone of sustainable development and it is impossible to discuss sustainable livelihoods exclusive of environmental sustainability. The question then arises: must the actors be environmentally aware or is it sufficient that environmental benefits exist at a general level? Theoretically, it can be argued that the mere environmental benefits are adequate, as the physical environment is at least improved. However, ecological modernization also connotes the internalization of environmental considerations deeper and deeper into practices, so that they become self-evident to the actors (Mol 2003). Hence, strong ecological modernization includes the actor's understanding of environmental functions (cf. Hajer 1996, Dryzek 2005:173-4).

On one hand, the farmers' environmental knowledge was somewhat improved by the bioenergy production. The implications suggest that although environmental considerations may be initially unimportant, they can gain relevance via the production activity and contribute to stronger ecological modernization and hence more sustainable rural development over time. This can be related to practicing "learning by doing" and social learning, which are also attributed to improving environmental knowledge and environmentally beneficial behavior (Wals 2007, Dueren and Witt 2010).

Furthermore, in a study on agroforestry, Barbieri and Valdivia (2010) observed that their respondents did not necessarily connect the term "agroforestry" with the practices it involved, resulting in a poor association between the actual action and environmental values. Hence, the bioenergy producers might also benefit from more concrete information regarding the environmental effects of their production activity. Tailoring information to better suit the purposes and needs of farmers is important in implementing better practices (Barbieri and Valdivia 2010).

Multifunctional bioenergy production

Original article IV argues that strong multifunctionality is the essential character of sustainable rural livelihood and hence, also of sustainable rural development. Based on the assertions above, the multiple functions in rural bioenergy production from the producer's perspective are summarized in Table 6. The multiple functions are most strongly manifested in heat entrepreneurship and appear weaker in the other production models.

Many farmers understand bioenergy production to be a multifunctional activity and are quite competent to present the associated characteristics when challenged with opposing views on the suitability of bioenergy production. For heat entrepreneurs, this occurred essentially in terms of local viability and forestry, for biogas and biodiesel producers, it was more in terms of personal skills and knowledge, with the inclusion of some environmental benefits. In general, Finnish farmers tend to regard farming as multifunctional in regards to the viability of rural areas (Kaljonen and Rikkonen 2004). Thus, bioenergy production exposes the multiple functions of their activity, perhaps eventually exposing the views of the potential multifunctionality of farming itself.

Unfortunately, the connection between multifunctional diversification activity and multifunctional agriculture is not straightforward. For example, while observing farmers diversifying in non-food production activities, Morgan et al. (2010) identified strong multifunctionality due to the diversification activities. However, when analyzing their farming practices, it was apparent that these farmers tended not to be multifunctionally oriented. Hence, the mere diversification of multifunctional activities may not result in multifunctional agriculture, although it does result in a more multifunctional farm. The assessment of the multifunctionality inherent in the farming activities of bioenergy producing farmers was beyond the scope of this study but it deserves further analysis in the future.

TABLE 6 Farm-based bioenergy production and multifunctionality.

Heat entrepreneurship	Biogas production	Biodiesel production
Reinforced assets: • Increased knowledge, skills and self-esteem of producer • Reinforced social networks, new contacts • Potentially increased income	**Reinforced assets**: • Increased knowledge, skills and self-esteem of producer • Self-produced/generated energy • Some contacts and reinforced social networks	**Reinforced assets**: • Increased knowledge, skills and self-esteem of producer • Self-produced/generated energy • Some contacts and reinforced social networks
Environmental benefits: • Landscape, forestry • Superior product (compared to oil)	**Environmental benefits**: • Manure management • CO2-emission reductions for some	**Environmental benefits**: • Superior product (compared to oil)
Community benefits: • Increased revenue from forestry, Employment • Better energy security and maintenance • Independence from imported oil, better utilization of local resources • More activity in the community • Creation of new manufacturing businesses	**Community benefits**: • Possibility to utilize biowaste for some • Creation of new businesses on biogas technology	**Community benefits**: • Possibility to buy biodiesel/obtain by-products/ sell raw material for some • Creation of new businesses on biodiesel technology

Examples of sustainable rural livelihood and sustainable rural development are best portrayed in heat entrepreneurship. Biogas and biodiesel production exemplify some traits inherent of sustainable rural development but presently they do not represent manifested changes. The dynamics of eco-economy surrounding the different production models were helpful in discerning reasons for the variances. The dynamics derive from the utilization of local resources, creation of new markets and reshaping of existing ones and from new institutional frameworks. Heat entrepreneurs managed to brand their energy as local and relied on diverse local resources, including personal networks. The new practices were connected to existing structures and institutional support was gained. In this regard, the regional forestry centers and local forest management associations were important. An additional special feature included the role of public-private partnerships in heat entrepreneurship (also found to be important by Mangoyana and Smith 2011). They reduced the need for personal investments in energy plants and rendered the energy production a safe and reliable option.

With biogas and biodiesel production, social networking and a broader utilization of local resources were largely missing. In addition and perhaps most importantly, these production models were lacking in the creation or modification of institutional frameworks and markets, implying weak supporting structures. This, combined with the fact that the technologies and production models themselves were new and unestablished, resulted in various hindrances during production, construction, operation and in communicating with officials. With the addition of weak economic viability, it is no wonder that these production models have remained relatively rare and are facing difficulties in Finland.

Among the biogas producers, there was one special case where a cooperative of several farmers produced biogas together in a larger facility. The fuel was produced from manure collected from all participating farms. The biogas production was initiated with the aim to collectively solve manure management problems and aspirations of economic profit were not expressed. The considerable potential of biogas production in energy production was taken into consideration, however. The cooperative has since managed to expand their biogas production (in regards to waste management) and are now managing municipal biowastes in the city of Turku, with plans to expand to other cities. In addition, they are cooperating with a natural gas corporation, Gasum, to expand their endeavor to the field of traffic fuel production.[7] During the time their operation has expanded, the Finnish policy environment has become more favorable for these types of larger multiple farm biogas plants, due to improved availability of investment support and feed-in-tariffs (MAF 2007, 2008, MEE 2011). This example demonstrates how innovative cooperation and active embedding to a relevant sector (waste management), can overcome the barriers for biogas production. Here, the development also parallels the positive example of Danish biogas cooperatives (Raven and Gegersen 2007, Raven and Geels 2010) and even that of heat entrepreneurs in Finland.

Each farmer's circumstances are unique and the positive portrayal of heat entrepreneurship versus more uncertain biogas and biodiesel production can also be questioned. Every farmer has unique circumstances to consider when contemplating whether to undertake a new multifunctional business endeavor, which impacts the degree of success the new venture attains (Knickel and Renting 2000, Meert et al. 2005, Grande 2011). Issues such as farm location, financial circumstances, line of agricultural production practiced, area of field and forestland possessed by the farm and existing relationships play a crucial role in influencing the decision to start bioenergy production (see also Snäkin et al. 2010). These factors also influence the role bioenergy production plays in the farming livelihood: whether the main function is the survival or improved financial position of the farm, enhanced social relations and community benefits or development of the farmer's assets in terms of new skills and knowledge.

The role of supporting policies and governance

Finally, the role of supporting politics seems to be essential in the creation of eco-economies (Marsden 2010), both in clearing governance-related barriers but

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7 For additional information regarding their activities, see www.biovakka.fi.

also in promoting economic viability in bioenergy production. The original circumstances for heat entrepreneurs, biogas and biodiesel producers were the same. Relevant differences arose related to opinions regarding what was considered to be normal farm-related activity, and how they were reflected upon by the relevant policy sectors: energy, agriculture and forestry sectors and to some extent, rural and environmental policies. Finnish energy policy tends to favor large-scale production systems, whereas regional and agricultural policies have been more receptive to small-scale solutions (Snäkin et al. 2010, Åkerman et al. 2005). In the heat entrepreneurs' case, the unique combination of forestry-related benefits and energy production enabled the producers to gain support for their small-scale energy production. Financial support primarily arose from fuel wood collection and chipping: essentially in terms of forest management (Åkerman et al. 2010). More directly, research and development support and investment subsidies were also available for the small-scale energy production, although they were chiefly directed to the development of large-scale energy production (Hakkila 2006).

In the case of biogas and biodiesel production, despite the boom on biofuels that was observable in the newspaper material in mid 2000 (original article I), the producers largely felt excluded from policy measures, both in energy and agricultural politics, although they remained optimistic regarding future changes. As the cooperative biogas production example showcased, waste management has perhaps functioned better as a reference for bioenergy production than agriculture alone. For the energy policy field, agricultural biogas and biodiesel production seem to be too small-scale to be of real interest (see also Kivimaa and Mickwitz 2011). In addition, according to Kivimaa and Mickwitz (2011), agricultural politics have framed bioenergy production in terms of rural viability, whereas energy policy considers bioenergy more in terms of climate change. This difference suggests an interesting value consideration: rural support or encouragement of climate change mitigation? Perhaps climate change mitigation could raise more stakeholder interest. Currently, large-scale energy production is maintaining and even reinforcing its position as the preferred energy production model in Finland, as small-scale production was excluded from feed-in-tariff (production support) for renewable electricity in 2011 (Snäkin et al. 2010, see also Huttunen 2012).

To an extent, the emergence of eco-economy and the actualization of the related positive consequences appear to be a matter of political choice. In the Finnish heat entrepreneur case (this study and Åkerman et al. 2010) and in the Danish biogas production example (Raven and Gegersen 2007), active policies supporting grass-root level developments have helped establish local bioenergy businesses. In Great Britain, community energy projects (Walker and Devine-Wright 2008) and in Germany, bioenergy villages (Laborgne 2011), have exemplified how local projects, supported by local governing bodies, can be successful and create more sustainable outcomes - especially in terms of social sustainability. Hence, it can be questioned whether developments in Finnish small-scale biogas and biodiesel production would have been more favorable with more manifested sustainability, if the policies had been more supportive?

The key policy recommendation that can be derived from this study relates to placing more emphasis on the role of local networks and communities in bioenergy production. A more holistic perspective on sustainability should be taken, where not only the environmental and economical functions matter, but also the social function is taken into account. Further the emphasis is not so much on financial instruments but rather on information and knowledge enabling structures to facilitate local developments.

6 CONCLUSIONS

Farm-related bioenergy production has evolved as a curious tangent alongside the wider spectrum of Finnish bioenergy development. The potential it has in relation to rural viability and to society more generally has been recognized for decades. However, only wood-based heating in the form of heat entrepreneurship has emerged as an eminent option in national energy production schemes, whereas biogas and biodiesel production have remained rare alternatives.

The existing production models demonstrate how rural small-scale bioenergy production can have important positive developmental consequences that ameliorate and sustain livelihoods in remote areas. This essentially occurs via acknowledgement of the multiple functions of bioenergy production by the energy producers and general community. The positive effects include social, economical and environmental aspects and rural bioenergy production can be interpreted as presenting traits of sustainable rural development.

However, the examined production models differ. It can be stated that heat entrepreneurship most clearly contributes to sustainable livelihoods, whereas biogas and biodiesel production provide more complex cases, with some negative developmental effects and less manifested community benefits. The dynamics of eco-economies aided in the identification of variances between the bioenergy production models. These are presented in the form of market and institutional creation and social networking.

A disparity in the appreciation of the community benefits available via bioenergy production is also distinguishable. This suggests that biogas and biodiesel production could benefit from greater reliance on external resources, increased networking and exploitation of available community benefits via increased cooperation. This could be one method to attain more sustainable production models and create eco-economies.

The concept of eco-economy was useful in connecting the various concepts describing rural development under one umbrella and in highlighting the general dynamics related to the potential of particular activities to promote more sustainable development in a community and even societal level. For all researched cases, the eco-economical potential is greater than currently realized.

In every case, the ecological functions of bioenergy production could be further acknowledged, although it is clear that rural viability related issues are easily more pertinent for the local actors. Greater appreciation of the production's ecological value could create more attention to these production models and hence facilitate their political situation. A clear illustration of this direction is gained by the example of heat entrepreneurship, where forestry was the key for facilitated development. Furthermore, in the case of the large biogas cooperative, their expansion into waste management facilitated progress.

On the other hand, the ecological value of bioenergy production is far from simple. Wood based bioenergy production raises questions from the viewpoint of carbon sinks and biodiversity losses. Biodiesel production uses fields for energy production instead of food and the actual emission reductions are questioned. Biogas production, when waste materials are used, seems like the only option with no environmental uncertainties. Thus if the ecological functions are to be more embraced by the producers, there should be more certainty on how and under what conditions bioenergy production actually has environmental benefits. Certainly the problem with the environmental benefits is related to both small- and large-scale production, with often even larger problems attached to larger scale production.

Changing the perspective from bioenergy producing farmers to the society more widely suggest another type of approach. The social aspects related to rural viability and wellbeing manifested especially in the case of heat entrepreneurs should gain more prominence. This is the central factor separating bioeconomy from eco-economy. Bio-economy, with its popular relatives such as green growth, or green economy, searches for large solutions promising high economic profits by the combination of economic and environmental benefits. In a welfare state the following economic growth has the potential to lead to increased wellbeing via e.g. jobs, increased tax revenue and ameliorated public services. The social benefits come after the economic growth, if necessary political decisions to support them are made. In the eco-economy approach the social effects are at a central role from the beginning, allowing for socially sustainable development in the locality as a prerequisite. This might mean less economic growth, but more socially sustainable being. As this study also shows, the social effects might be more valued than the economic ones. Hence, it might be worth to explore the eco-economic alternative.

The potential in promoting eco-economic development is closely connected to politics. Part of the success of heat entrepreneurship is related to the existing support structures and policy instruments, whereas biogas and biodiesel alternatives have been forced to proceed without support. In the end, it boils down to values: is support for local level developments encouraged or is the promotion of large-scale efficiency preferred? Could the attainment of both be viable? At the very least, a level playing field should be available to both options. At the moment, it seems that large-scale options are more politically appealing than the development of eco-economies.

YHTEENVETO (FINNISH SUMMARY)

Maatilaperustaisen bioenergiantuotannon merkitykset ja kestävä kehitys

Maatilaperustainen bioenergiantuotanto on herättänyt kiinnostusta toisaalta maa- ja metsätalouden kehittämisen ja toisaalta ilmastonmuutoksen näkökulmista. Suomalainen maaseutu ja maatalous ovat olleet kiihtyvän rakennemuutoksen kourissa EU jäsenyydestä asti. Käytännössä tämä on tarkoittanut kasvavia tilakokoja, maatilojen kokonaislukumäärän laskua ja lisääntyvää kiinnostusta perinteisen maa- ja metsätalouden ulkopuolisiin tuotantosuuntiin. Tässä suhteessa bioenergian tuotanto on yksi esimerkki tilojen erikoistumismahdollisuuksista. Bioenergian tuotannon lisääminen on Suomessa noussut myös keskeiseksi keinoksi ilmastonmuutoksen hillitsemiseksi sekä keinoksi energiaomavaraisuuden lisäämiseen.

Suomessa bioenergiantuotannon päähuomio on keskittynyt suuriin metsäteollisuuden yhteydessä oleviin tuotantolaitoksiin ja toisaalta suuren mittaluokan aluelämpölaitoksiin sekä yhdistettyyn sähkön ja lämmön tuotantoon. Tämän kehityksen ohella myös pienemmän mittaluokan ratkaisuja on syntynyt erityisesti maatilatoiminnan yhteyteen. Näistä ratkaisuista yleisin on lämpöyrittäjyys. Siinä yksittäinen yrittäjä, useamman yrittäjän muodostama yrittäjärengas tai osuuskunta tuottaa lämmityspalveluja käyttäen puuperäisiä polttoaineita, lähinnä metsähaketta. Lämmityspalvelun asiakkaina ovat yksittäiset, usein kuntien tai yritysten omistamat rakennukset tai kokonaiset kaukolämpöverkot.

Harvinaisempia maatiloihin liittyviä energiantuotantomuotoja edustavat biokaasun ja biodieselin tuotanto. Biokaasun tuotannossa hyödynnetään tilalta saatavissa olevia raaka-aineita, yleensä eläinten lantaa ja myös kasvinosia. Näistä saadaan anaerobisen mädätyksen seurauksena biokaasua, jota voidaan hyödyntää lämmön- ja/tai sähkön tuotannossa sekä jatkojalostaa polttoaineeksi liikenne tai työkonekäyttöön. Biodieselin tuotanto maatiloilla perustuu yleisimmin tilalla kasvatetun rypsin käyttöön. Rypsi puristetaan ja esteröidään diesel-polttoaineeksi, minkä jälkeen sitä voidaan käyttää työkoneissa, liikennepolttoaineena tai lämmön tuotannossa.

Maatilamittakaavan bioenergiantuotanto voidaan liittää laajempiin maasedun kehityskulkuihin Länsi-Euroopassa. Tällöin voidaan ajatella niiden edustavan uutta maaseudun kehityksen polkua, jossa maataloustuotannon maksimoinnin sijaan pyritäänkin kokonaisvaltaisempaan näkemykseen maaseudun tuotannosta ja merkityksestä yhteiskunnalle. Näin bioenergian tuotannon voidaan osaltaan nähdä vahvistavan maaseudun kestävää kehitystä. Samalla sillä on mahdollisuuksia tuottaa eväitä kestävän energiantuotannon ja kestävän maaseudun malleihin.

Tämän väitöskirjan tarkoituksena on tutkia missä määrin ja millä tavoilla maatilaperustainen bioenergiantuotanto edistää maaseudun kestävää kehitystä. Tutkimuksen keskiössä ovat bioenergiaa tuottavat maanviljelijät ja heidän bioenergiatuotannolle antamansa merkitykset. Kestävän kehityksen käsitteeseen pureudutaan hyödyntämällä monivaikutteisuuden, juurtuneisuuden, ekologisen modernisaation sekä kestävän toimeentulon käsitteitä.

Tutkimuksessa hyödynnetään kahdentyyppisiä empiirisiä aineistoja: haastatteluja ja lehtiaineistoa. Pääpaino on bioenergiaa tuottavien viljelijöiden teemahaastatteluissa. Yhteensä haastateltavina oli 31 maaseudun bioenergiantuottajaa. Heistä 15 oli lämpöyrittäjiä, 10 biokaasun tuottajia ja 6 biodieselin tuottajia. Haastattelut toteutettiin vuosina 2006 ja 2007. Lehtiaineisto koostui Maaseudun tulevaisuus ja Käytännön maamies -lehdissä julkaistuista bioenergiaa käsittelevistä artikkeleista vuosilta 1980–2005. Maaseudun tulevaisuudesta hyödynnettiin ainoastaan pääkirjoitukset, kolumnit ja mielipidekirjoitukset, Käytännön maamiehestä kerättiin kaikki bioenergia-artikkelit. Aineistojen analyysissä käytettiin sisällönanalyysin ja diskurssianalyysin menetelmiä.

Tutkimuksessa käydään läpi maaseudun bioenergiantuotannon kehitys 1980-luvun alusta tutkimusajankohtaan. Haastatteluaineiston pohjalta osoitetaan kuinka maatilamittakaavan bioenergiantuotannolla voi olla merkittäviä maaseudun kestävyyttä ja kestävää toimeentuloa edistäviä vaikutuksia. Vaikutukset tulevat näkyviin ennen kaikkea tunnistamalla bioenergiantuotannon monivaikutteisuus energian tuottajille ja heitä ympäröivälle yhteisölle. Vaikutukset liittyvät kaikkiin kestävän kehityksen ulottuvuuksiin, taloudelliseen, sosiaaliseen ja ympäristöön. Kuitenkin niin että bioenergiantuottajille merkityksellisimmiksi nousi sosiaalinen ulottuvuus lisääntyvinä voimavaroina ja kykyinä sekä sosiaalisten verkostojen vahvistumisen muodossa.

Bioenergiantuotantotavat erosivat kuitenkin toisistaan. Lämpöyrittäjyys nousi esiin selkeästi muita vaihtoehtoja vahvempana kestävän kehityksen edistäjänä. Biokaasun ja biodieselin tuotanto osoittautuivat vaikutuksiltaan moninaisemmiksi ja osin myös negatiivisia vaikutuksia sisältäviksi. Suurimpina ongelmina näillä tuotantomuodoilla olivat taloudellisen kannattavuuden heikkous sekä osin myös ympäröivään yhteisöön kytkeytyminen.

Bioenergiantuotantomuodot ovat vahvasti kytköksissä historialliseen taustaansa. Lämpöyrittäjät ovat onnistuneet kytkeytymään osaksi metsänhoidon ja metsäbioenergian tuotannon laajempia järjestelmiä, kun biokaasun ja biodieselin tuottajat ovat jääneet enemmän yksittäistapauksiksi. Niinpä biokaasun ja biodieselin tuotanto voisivat hyötyä vahvemmasta tilan ulkopuolisten resurssien hyödyntämisestä ja yhteistoimintamahdollisuuksien etsimisestä. Esimerkiksi biokaasun tuotannolle luonteva reitti voisi löytyä jätehuoltojärjestelmän kautta. Kaikkien tuotantomuotojen osalta kehitettävää löytyy ympäristövaikutuksen arvostamisessa.

Yleisemmällä tasolla olisi tärkeää että pienen mittakaavan paikallisen energiantuotannon mahdollistamat sosiaaliset hyödyt otetaan paremmin huomioon pohdittaessa energiajärjestelmien tulevaisuutta.

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