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## Advancing Bioenergy in Europe: Exploring bioenergy systems and socio-political issues

McCormick, Kes

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# **Advancing Bioenergy in Europe**

Exploring bioenergy systems  
and socio-political issues

Doctoral Dissertation, September 2007

Kes  
**McCORMICK**



**LUND**  
UNIVERSITY

The images on the front cover represent the 12 case studies developed and analysed in this research work. The images show the diversity of bioenergy systems across 8 countries in Europe, and highlight the fieldwork conducted by the author and research colleagues.

<p><b>Kristianstad, Sweden</b> Picture: Kes McCormick Biogas production, stations and vehicles.</p>	<p><b>Berlin, Germany</b> Picture: Kes McCormick Presentations at a CHP plant on biomass supply and demand.</p>	<p><b>Lviv, Ukraine</b> Picture: Kes McCormick At a waste management facility with potential for biogas production.</p>
<p><b>Gubin, Poland</b> Picture: Kes McCormick Researchers and industry leaders meet in some fields of energy crops.</p>	<p><b>Winkleigh, UK</b> Picture: Kes McCormick Waste wood as an opportunity for biomass supply.</p>	<p><b>Umbertide, Italy</b> Picture: Åke Thidell Typical landscape and farm land with possibilities for energy crops.</p>
<p><b>Vansbro, Sweden</b> Picture: Murat Mirata Forests for wood and residues for energy purposes.</p>	<p><b>Enköping, Sweden</b> Picture: Ian Hamilton Researchers at some plantations of energy crops.</p>	<p><b>Lahti, Finland</b> Picture: Murat Mirata Waste from households for combustion in a CHP plant.</p>
<p><b>Växjö, Sweden</b> Picture: Kes McCormick Wood chips for combustion in a CHP plant.</p>	<p><b>Grudziadz, Poland</b> Picture: Luule Sinnisov Farm land with potential for energy crops.</p>	<p><b>Mureck, Austria</b> Picture: Mihai Tomescu Biodiesel production and supply for conventional vehicles.</p>

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*Kes McCormick*

Lund, August 2007



# Executive Summary

## Background and Purpose

This thesis concentrates on bioenergy as a renewable energy with significant potentials and options. Biomass can be considered as ‘stored’ solar energy because the process of photosynthesis ‘captures’ energy from the sun in growing plants. Utilising biomass for energy purposes is in fact tapping into the vast energy available from the sun.

The opportunities for exploiting bioenergy in Europe are considerable. However, a major challenge confronting the European Union and Member States is how to expand bioenergy utilisation to meet targets, policy goals, and international commitments on renewable energy, climate mitigation, energy security, and sustainable development.

This research work explores the implementation of bioenergy systems in Europe focusing on socio-political issues (see Key Definitions below). The purpose is to improve understanding of key drivers and barriers for bioenergy, and experiences of supportive (and disruptive) policies and actions.

### *Key Definitions*

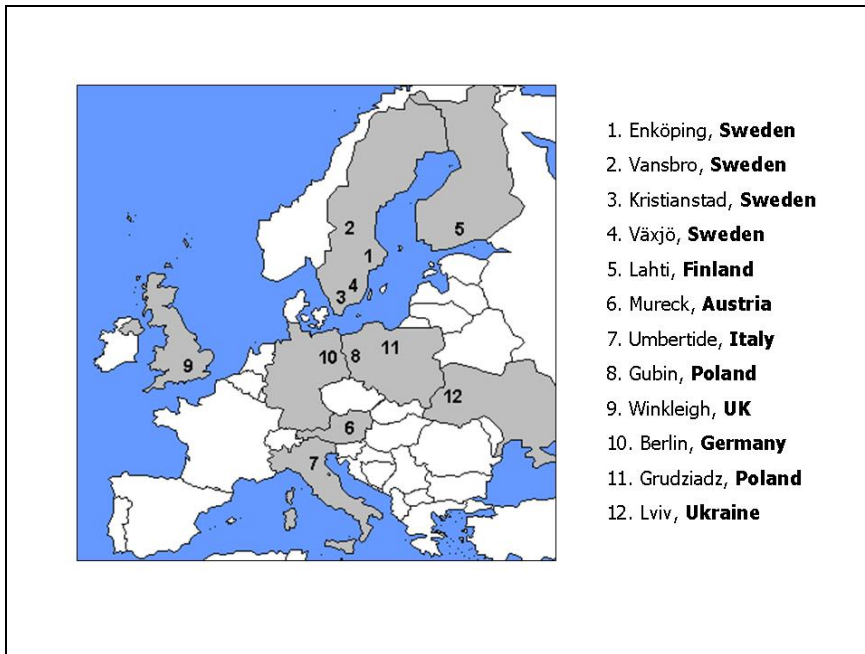
Terms	Descriptions
Bioenergy Systems	Bioenergy systems comprise both the technical aspects of bioenergy, such as conversion technologies and biomass resources, and the overarching social aspects of bioenergy, such as policies and actors. This research explores bioenergy systems, which shifts the emphasis to whole systems rather than specific parts.
Socio-political Issues	Socio-political issues can be defined simply as a combination of social and political factors. More specifically this research explores the process of how actors (individuals and organisations) make decisions, resolve conflicts, form partnerships, respond to government policies, and engage with public issues.

## Methodology

This thesis is based on a combination of research methods and a range of informants. The author conducted literature reviews, case studies, site visits, stakeholder interviews, industry interactions, and research workshops. The

research process also involved extensive fieldwork and the development of 12 case studies from 8 countries in Europe (see Case Studies below).

### Case Studies



### Drivers and Barriers

The first research objective for this thesis is to identify and analyse key drivers and barriers for the implementation of bioenergy systems in different contexts in Europe. The main findings include:

**Key drivers for bioenergy systems:** Combating climate change and enhancing energy security are identified in the literature as key drivers for bioenergy. Promoting regional development is also often mentioned although it is not well explored by empirical studies. This thesis analyses regional development activity associated with the implementation of bioenergy systems in 4 case studies from Sweden. The case studies suggest there are at least 4 benefits that can flow from bioenergy systems. These benefits can be key drivers for local and regional actors (particularly when recognised through supportive policy measures). The key drivers include:

*Distribution and diversification:* Bioenergy systems can promote distributed and diversified energy systems based on locally available biomass resources and

investments in both small-scale and large-scale conversion technologies. Expanding bioenergy can therefore improve the resilience of energy systems and assist in breaking dependence on fossil fuels, particularly imported oil.

*Partnerships and synergies:* Bioenergy systems can stimulate partnerships to exploit synergies between industries thereby strengthening local networks (and economies). This is particularly the case for industries that produce waste or by-products, which can be transformed into co-products of value when coupled with bioenergy.

*Business and employment:* Bioenergy systems can generate (direct and indirect) employment and business opportunities all along the bioenergy chain from biomass resources to energy services. The utilisation of local biomass resources implies that expenditure on energy provision is retained in the local community and re-circulated.

*Environment and landscape:* Bioenergy systems can support environment and landscape goals. The health and productivity of forests relies on thinning and management, which can be directly linked to (and supported by) bioenergy systems. Furthermore, energy crops can help to prevent erosion and soil degradation, restore degraded land, and enhance biodiversity.

**Key barriers for bioenergy systems:** Studies on barriers obstructing the development of bioenergy often adopt different analytical perspectives and produce lists of many types of obstacles. Based on case studies, research workshops, and industry interactions, this thesis work attempted to identify key barriers for bioenergy in Europe. The case studies from Sweden, Finland, Austria, Italy, Poland, the Ukraine, Germany and the UK illustrate how these barriers affect ‘real-life’ bioenergy systems. The key barriers include:

*Economic conditions:* Bioenergy systems, as with all renewable energy, must compete with fossil fuels and nuclear power, which have received and continue to benefit from energy subsidies and externalised costs. Furthermore, bioenergy often produces positive impacts that are not compensated by energy markets. Overcoming unfavourable economic conditions through effective and efficient policy measures (that recognise externalised benefits and/or charge for externalised costs) is vital to the success of bioenergy systems.

*Know-how and institutional capacity:* When establishing bioenergy systems a combination of know-how (knowledge and skills) and institutional capacity is needed to shift from unrealised potential to success. For example, a lack of understanding of the bioenergy industry by the finance sector may be an obstacle as well as a lack of experienced maintenance staff. Furthermore, learning processes and altering perceptions of both the public and politicians about bioenergy is often required to build up legitimacy for the bioenergy industry.

*Supply chain co-ordination:* Bioenergy systems require functioning and organised supply chains that overcome the ‘chicken and egg’ problem. Put simply, investing in biomass resources is generally only possible if there are energy companies purchasing biomass, and establishing conversion technologies is generally only possible if biomass suppliers exist to provide biomass. In particular, agreements on biomass supply appear to be crucial for farmers to harvest energy crops. There is also emerging competition for biomass resources and potentially land use conflicts.

## **Policies and Actions**

The second research objective for this thesis is to investigate and discuss experiences of supportive (and disruptive) policies and actions for the implementation of bioenergy systems in Europe. The main findings include:

**Bioenergy systems:** While there are key barriers hindering bioenergy systems, this research identifies no absolute barriers to realising the targets on bioenergy utilisation defined by the European Union. Interestingly, there are some consistent policies and actions evident in the case studies that are employed to overcome key barriers, including: investment grants; policy measures; pilot projects; local initiatives; local champions; and supply contracts. Not surprisingly, supportive economic policies and partnerships between the public and private sectors are observed as influential in the development of bioenergy systems.

**Energy crops:** This research investigates the perspective of farmers on energy crops. The Common Agricultural Policy reforms that aim to facilitate investments in energy crops, include: the introduction of the single payment scheme; the aid of 45 €/ha for energy crops on agricultural land; and the permission to harvest energy crops on set aside land. However, farmers and agricultural associations in the case studies from Sweden, Italy and Austria

communicate a range of obstacles for shifting agricultural land to energy crops. These include:

- Supporting the construction of conversion technologies (and agreements on biomass supply) is as important as stimulating the development of biomass resources in order to overcome the ‘chicken and egg’ problem.
- The amount of compulsory set aside land changes and there are rotations of set aside land in some instances. Focusing on set aside land therefore presents energy crops as a marginal activity rather than a mainstream development.
- There are tensions between energy policy and agricultural policy, which is evident in that agricultural associations prefer annual crops (more labour and higher costs) and energy companies prefer perennial crops (less labour and lower costs).
- Shifting from food crops to energy crops is a risk for farmers in terms of changes in both work practices and economic flows. Reducing and spreading risk is paramount to stimulate farmers to cultivate energy crops.

It is difficult to generalize for Europe from a selection of case studies. However, there are valuable insights from the case studies into the ‘real-life’ issues confronting farmers and agricultural associations. Clearly, shifting from food crops to energy crops is a significant economic and psychological risk for farmers (as opposed to standard crop shifts). Agricultural cooperatives appear to demonstrate that collaboration between many farmers is a way to share the risk and facilitate the diffusion of energy crops. However, further support is necessary.

Responsibilities for the promotion of energy crops are currently scattered across different policy sectors. To accelerate the diffusion of energy crops, the author proposes that the Common Agricultural Policy could act as the main policy framework to co-ordinate support for farmers on a number of fronts, including: introduce establishment subsidies; expand information campaigns; initiate demonstration projects; support agricultural cooperatives; subsidise (small-scale) conversion technologies; evaluate landscape changes; and promote multiple benefits.

**Liquid biofuels:** The widespread cultivation of energy crops is closely linked to the demand for liquid biofuels for transport. The introduction of bioethanol and biodiesel in Germany and the UK provide contrasting pictures and many insights into markets in Europe. These include:

*Experiences from Germany:* The main driver for liquid biofuels in Germany has been the excise duty exemption, at the beginning in 1993 for biodiesel and since 2004 also for low-level blends of biodiesel and bioethanol (although the situation has changed with the newly introduced Biofuels Quota Act in 2007). The National Government has played an active role in the market development for liquid biofuels. Trade associations have also been important for supporting the domestic industry. The main barriers that liquid biofuels face in Germany are higher production costs (as compared to fossil fuels) and the uncertainty created for the domestic industry by the Biofuels Quota Act.

*Experiences from the UK:* The main driver in the UK has been the excise duty reduction since 2002. The main barriers are the higher production costs of liquid biofuels, which – except for the cheapest feedstocks – are not sufficiently compensated by the excise duty reduction to induce blending in the UK. National Government signals on support for liquid biofuels have so far been ambiguous. Furthermore, the domestic industry for liquid biofuels is undeveloped and inexperienced. Biofuels producers and suppliers (especially for bioethanol) are waiting for strong signals from the National Government. The limited support for the domestic industry is also connected to weak trade associations.

This research work has derived general conclusions from the assessment of the German and British experiences with biodiesel and bioethanol that are particularly relevant for the early stages of a biofuels industry. These include:

- Consumers purchase cheap rather than green. Not surprisingly, most consumers only purchase liquid biofuels if they are price competitive with petrol and diesel.
- Excise duty exemptions or reductions can ensure liquid biofuels are price competitive, and thereby stimulate investments in a domestic industry.
- National Government commitment to liquid biofuels (particularly through clear and strong signals) is the foundation for building up a biofuels industry.

- Low-level blends of 5 percent bioethanol and/or biodiesel are the easiest and cheapest way for marketing liquid biofuels but not sufficient to meet targets in the European Union. Introducing 10 percent bioethanol and/or biodiesel in blends with petrol and diesel, along with high-level blends is most likely required.
- An opportunity for promoting and expanding bioethanol and biodiesel is through niche markets, such as bus fleets for public transport, truck operators, and farmers.
- Oil companies are generally more supportive of biodiesel than bioethanol. If policy-makers aim to diffuse bioethanol on the market, they will have to exert more pressure on oil companies.
- Environmental impacts and carbon balances of liquid biofuels vary. The uncertainty around ‘good’ and ‘bad’ liquid biofuels has significant implications for policy-makers.
- The introduction of a sustainability certification scheme for liquid biofuels is necessary to maintain confidence in the performance of liquid biofuels from both environmental and social perspectives.
- Support for first generation liquid biofuels is not expected to ‘lock-in’ or ‘lock-out’ any technologies. However, it is important to promote technologies for second generation liquid biofuels to expand opportunities and improve performance.

## **Contributions**

This thesis work contributes to knowledge on bioenergy and it has value for the research community, policy-makers (and/or policy advisors), local municipalities, and industrial actors in the European Union and Member States. While the contributions merge into each other, they can be classified under 5 themes. These include:

**Fieldwork:** This thesis work has been based on extensive fieldwork involving the development of 12 case studies in 8 countries. The overall data collection (and analysis) activities represent an empirical contribution to the body of knowledge on bioenergy systems in Europe.

**Approach:** This research work adds to the movement of researchers focusing on whole bioenergy systems rather than only specific parts. The

systems approach opens up ‘new’ insights that are particularly relevant for a better understanding of implementation challenges for bioenergy.

**Methodology:** Based on a combination of research methods and a range of informants, this thesis work tests assumptions in the field and against industry knowledge. The author participated in several projects under investigation thereby directly influencing actors in the field.

**Knowledge:** There is a relatively strong knowledge base on technical issues related to bioenergy systems. This research work responds to calls in the literature and political circles for a greater understanding of non-technical issues by focusing on socio-political issues.

**Diffusion:** The author has presented this research at a number of major conferences with international audiences in an effort to diffuse findings and results to relevant actors. The author argues that research may be of little or no value to actors if the findings are not made directly available to them.

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- Article I      Johansson, T.B., McCormick, K., Neij, L., & Turkenburg, W.C. (2006). The Potentials of Renewable Energy. In D. Abmann, U. Laumanns & D. Uh (Eds.) *Renewable Energy: A Global Review of Technologies, Policies, and Markets*. London: Earthscan.
- Article II      McCormick, K., & Kåberger, T. (2005). Exploring a Pioneering Bioenergy System: The Case of Enköping in Sweden. *Journal of Cleaner Production*, 13(10-11), 1003-1014.
- Article III     McCormick, K. (2005). *Sustainable Bioenergy Systems: Experiences from Sweden*. Paper presented at the Asia Pacific Roundtable on Sustainable Consumption and Production, Melbourne, Australia.
- Article IV     McCormick, K., & Kåberger, T. (2007). Key Barriers for Bioenergy in Europe: Economic Conditions, Know-how and Institutional Capacity, and Supply Chain Co-ordination. *Biomass and Bioenergy*, 31(7), 443-452.
- Article V      McCormick, K., Nilsson, H., & Tomescu, M. (2006). *Energy Crops and the Common Agricultural Policy*. Paper presented at the World Bioenergy Conference, Jönköping, Sweden.
- Article VI     Bomb, C., McCormick, K., Deurwaarder, E., & Kåberger, T. (2007). Biofuels for Transport in Europe: Lessons from Germany and the UK. *Energy Policy*, 35(4), 2256-2267.

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## **Abbreviations**

BAP	Biomass Action Plan
B100	Biodiesel 100 percent
B5	Biodiesel 5 percent
CAP	Common Agricultural Policy
CHP	Combined Heat and Power
EU	European Union
E85	Bioethanol 85 percent
E5	Bioethanol 5 percent
FFF	Fossil Fuel Free
IIIIEE	International Institute for Industrial Environmental Economics
MSW	Municipal Solid Waste
Mtoe	Million Tonnes of Oil Equivalent
NoE	Network of Excellence
PPPs	Public-Private Partnerships
UFO	Used Frying Oil
WVO	Waste Vegetable Oil

# CHAPTER ONE

## 1. Introduction and Background

A major challenge confronting the European Union (EU) and its Member States is how to expand bioenergy utilisation to meet targets, policy goals, and international commitments on renewable energy, climate mitigation, energy security, and sustainable development.<sup>1</sup> This thesis explores the implementation of bioenergy systems in Europe focusing on socio-political issues (see Table 1-1).<sup>2</sup> The purpose is to improve understanding of key drivers and barriers for bioenergy, and experiences of supportive (and disruptive) policies and actions. This chapter outlines the background of this thesis.

*Table 1-1. Key Definitions*

Terms	Descriptions
Bioenergy Systems	Bioenergy systems comprise both the technical aspects of bioenergy, such as conversion technologies and biomass resources, and the overarching social aspects of bioenergy, such as policies and actors (Geels, 2004; Meadows, 2002). This research explores bioenergy systems, which shifts the emphasis to whole systems rather than specific parts.
Socio-political Issues	Socio-political issues can be defined simply as a combination of social and political factors (Carter, 2001; Considine, 1994; Miller, 2005). More specifically this research explores the process of how actors (individuals and organisations) make decisions, resolve conflicts, form partnerships, respond to government policies, and engage with public issues.

<sup>1</sup> In this thesis the EU is broadly interpreted as a political body comprising 27 Member States. The EU is governed by a number of political institutions, primarily the European Commission, Council of the EU, and the European Parliament.

<sup>2</sup> While socio-economics is well-known, socio-politics is not a widely used concept. Socio-economics is the study of the relationship between economic activity and social life. Socio-politics on the other hand concentrates on political activity and social issues.

## ***1.1 Energy for Sustainable Development***

Energy is vital to modern industrialised society. The availability of affordable and reliable energy allows many people to experience unparalleled comfort, mobility and productivity (World Energy Assessment, 2000). Without such a supply of energy, our everyday lives would be very different. Energy is often understood simply as energy supply (Reddy, Williams, & Johansson, 1997). But this is a narrow view, which does not encompass the many dimensions of energy systems from resources to services or the social, economic and environmental implications (Holdren & Smith, 2000; Reddy, 2000).

Unfortunately, conventional energy systems based on fossil fuels and nuclear power are not conducive to sustainable development (Reddy et al., 1997).<sup>3</sup> In fact, they are linked to significant environmental, social, and health problems for people alive today and, in many cases, pose even greater threats to future generations (World Energy Assessment, 2004). Access to affordable and modern forms of energy is crucial to achieving sustainable development. The challenge is to shape energy systems to act as drivers for sustainable development rather than ‘roadblocks’ (Geller, 2003; Jefferson, 2000).

Energy access, health impacts, energy security and climate change are all major challenges for achieving sustainable development, which are directly linked to energy systems (Geller, 2003). The key strategies and technologies identified in the literature as the foundations for sustainable energy systems include enhancing energy efficiency, expanding renewable energy, improving fossil fuel technologies, and advancing novel energy technologies (World Energy Assessment, 2004).<sup>4</sup> There are also a number of significant transitions linked to the implementation of new energy systems and technologies (see Table 1-2).

---

<sup>3</sup> While there is no single agreed definition of sustainable development, the concept has stimulated a broad and global debate about the responsibility of present generations for future conditions; the relationship between social issues, the health of the environment, and economic development; and the role of government, industry, academic institutions, and civil society in bringing about change (Miller, 2005).

<sup>4</sup> In a broad sense, renewable energy includes hydro energy, biomass energy, solar energy, wind energy, geothermal energy and ocean energy. See Article I for discussion and background information on renewable energy markets, technologies and resources, and in particular bioenergy systems.

*Table 1-2. Energy for Sustainable Development*

<b>Areas</b>	<b>Topics</b>	<b>Comments</b>
Challenges	Energy Access	Over 2 billion people are without access to electricity, and a further 2 billion continue to use traditional fuels. This dramatically affects standards of living.
	Health Impacts	Conventional energy systems are closely linked to environmental degradation, which threatens human health and the integrity of ecosystems.
	Energy Security	The availability of energy at all times, in sufficient quantities and at affordable prices, is necessary over the long-term if energy systems are to contribute to sustainability.
	Climate Change	The combustion of fossil fuels for energy purposes is the largest source of anthropogenic greenhouse gas emissions, which is changing the global climate system.
Strategies	Enhancing energy efficiency	Numerous and varied opportunities exist for energy efficiency improvements.
	Expanding renewable energy	Renewable energy sources have the potential to meet considerable demands.
	Improving fossil fuel technologies	Cleaner technologies for the use of fossil fuels remain imperative.
	Developing novel energy technologies	Research and development on new technologies and systems is important.
Transitions	Distributed and diversified energy systems	A shift from centralised and concentrated energy systems towards distributed and diversified energy systems.
	Energy services	A greater emphasis on energy services rather than energy supply.
	Active management	A greater emphasis on active management of energy rather than passive consumption.
	Internalised costs and benefits	A shift away from externalised costs and benefits towards internalised costs and benefits.

Source: Jefferson (2000); Geller (2003); World Energy Assessment (2000)

Most discussions in political circles focus almost entirely on how to increase conventional energy supply rather than on how to obtain the desired energy

services, enhance innovation processes, and invest into new systems that ensure the efficient use of energy based on renewable resources (Geller, 2003; Vaitheeswaran, 2005). Bringing about a fundamental change in systems and organisations focused on the expansion of conventional energy supply to strategies that emphasise energy services and new technologies will demand great efforts on the part of governments, industry, academic intuitions, and civil society (Reddy et al., 1997).

Ultimately, there is no ‘silver bullet’ to transform present energy systems. Rather, a combination of resources, technologies and policies will be needed to shift the design of energy systems towards sustainable development (World Energy Assessment, 2000). However, it is clear that enhancing energy efficiency and expanding renewable energy remain at the forefront of any sustainable energy strategy (Geller, 2003; Jefferson, 2000). Additionally, a transition away from highly centralised energy systems to a greater share of distributed energy technologies is closely linked to utilising renewable energy (Vaitheeswaran, 2005).

## *1.2 Bioenergy*

Humans exploit biomass (plant and animal matter) for many purposes. When it is utilised to produce heat, electricity or fuels for transport it is commonly called bioenergy.<sup>5</sup> Of the range of renewable energy options available, bioenergy offers the greatest potential both in the short-term and overall as it cannot only supply a considerable proportion of renewable energy, but it offers the widest possible range of energy products, and provides significant direct and indirect benefits (Berndes, Hoogwijk, & van den Broek, 2003; Domac & Richards, 2002; International Energy Agency, 2007a; Rogner, 2000; Turkenburg, 2000). These include:

- Contribution to climate mitigation strategies by replacing fossil fuels, and benefits related to other major environmental concerns (Sims, 2002).

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<sup>5</sup> Biomass can be considered as ‘stored’ solar energy because the process of photosynthesis ‘captures’ energy from sun in growing plants. Utilising biomass for energy purposes is in fact tapping into the vast energy available from the sun.

- Improvement of energy security from more indigenous energy supply, and reduction of energy imports, particularly oil (European Renewable Energy Council, 2004).
- Maintenance of a robust agricultural and forestry economy through the production of biomass with socio-economic benefits, such as employment opportunities (European Commission, 2005b).
- Potential for innovative scientific and technological developments that can provide industrial growth and security, and opportunities for greater exports (Boyle, 2004).

### **1.2.1 Biomass Resources**

The availability of biomass resources is important for high shares of bioenergy to penetrate energy markets. Extensive energy modelling work on the potentials of global biomass production for energy purposes is documented in the literature (Berndes et al., 2003; Hoogwijk, Faaij, Eickhout, de Vries, & Turkenburg, 2005). In a review of 17 studies on bioenergy potentials in 2050 by Berndes et al. (2003), the estimates range from 100 EJ/yr to above 400 EJ/yr.<sup>6</sup> The main reason for the differences is that land availability and yields for energy crops remain very uncertain.<sup>7</sup>

Energy crops are attracting considerable attention as a long-term source of biomass resources. Hoogwijk et al. (2005) have investigated the global potential of energy crops under different land use scenarios for 2050-2100. In 2050 the estimates are 311-657 EJ/yr, and in 2100 they are 395-1115 EJ/yr. Technically speaking, these estimates suggest that energy crops can play a significant role in global energy supply. However, more in-depth research is needed on the implications of large-scale plantations of crops for energy purposes (Hall & Scrase, 1998).

Shifting the focus to Europe (which is the geographical area addressed by this thesis), Ericsson & Nilsson (2006) have analysed biomass supply in the

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<sup>6</sup> For reference, the total global energy use in 2004 was approximately 470 EJ (Johansson, McCormick, Neij, & Turkenburg, 2006).

<sup>7</sup> Energy crops refer to crops grown on agricultural land for energy purposes. They may be dedicated energy crops, such as willow, or they can be conventional crops, such as rapeseed (Boyle, 2004).

Member States of the EU as well as Belarus and the Ukraine. Scenarios were developed to describe short-term (10-20 years), medium-term (20-40 years) and long-term (40 years) potentials. Additionally, low and high biomass harvests for forest residues and energy crops were estimated. The scenarios range from approximately 4 EJ/yr in the short-term to 23 EJ/yr in the long-term (Ericsson & Nilsson, 2006).<sup>8</sup>

Research on bioenergy potentials in the EU confirms several points. First, the current biomass supply can be considerably increased in the near-term and over the long-term (Ericsson & Nilsson, 2006; European Commission, 2005b). Second, bioenergy is only part of a sustainable energy strategy for Europe (Boyle, 2004). It cannot meet all energy demands (unless there are very large imports of solid and liquid biofuels). Third, the Member States in the EU have different resources and opportunities for exploiting bioenergy. Fourth, Poland, the Ukraine, France and Germany hold the largest potentials, primarily in terms of energy crops (Ericsson & Nilsson, 2006).

## **1.2.2 Conversion Technologies**

There are a large variety of raw materials and treatment procedures for the use of biomass (European Commission, 2005b; Turkenburg, 2000). It is not always possible to utilize raw materials directly for bioenergy. Instead, the raw materials have to be converted to solid, liquid or gaseous fuels, which can then be used for heat, electricity or fuels for transport. Conversion is generally achieved through mechanical, thermochemical or biochemical processes. The different conversion pathways allow many alternative structures for bioenergy systems with a range of inputs and outputs (see Figure 1-1).

Many biomass conversion technologies to generate heat and electricity can be considered mature (European Commission, 2005b; European Renewable Energy Council, 2004). For example, biomass-fired heating systems are widespread in many parts of Europe, especially in colder climates. Furthermore, combustion of biomass to produce electricity and heat is applied commercially in a number of Member States of the EU (International Energy Agency, 2003). Co-firing of biomass with other fuels

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<sup>8</sup> Total energy use in the EU in 2004 was approximately 73 EJ/yr (European Commission, 2006a).

(such as coal) is also a well-established practice, which allows the utilisation of existing conversion technologies (World Energy Assessment, 2000).

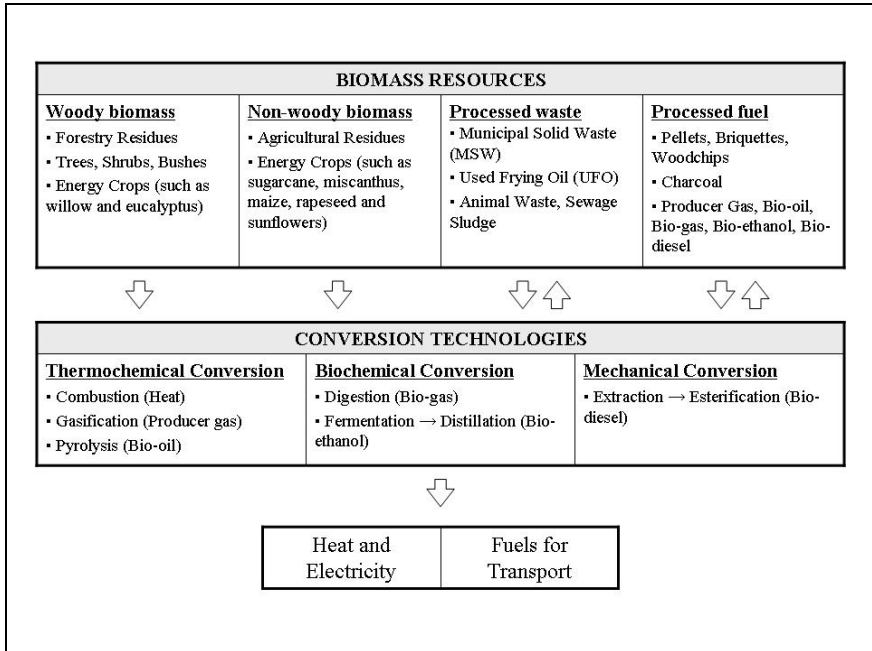


Figure 1-1. Bioenergy Pathways

Internationally and in Europe, the production of first generation liquid biofuels is growing and the commercialisation of conversion technologies to produce second generation liquid biofuels is expected in the near future (International Energy Agency, 2004).<sup>9</sup> What makes liquid biofuels for transport so interesting is that they can be easily integrated into current infrastructure and technology based on oil (Biofuels Research Advisory Council, 2006). Bioethanol can be blended at low-levels with petrol for use in conventional vehicles, and with minor alternations for mixes of high-levels. Biodiesel can be used directly (Abmann, Sieber, & Kulheim, 2006).

The overall scenario for bioenergy systems in Europe is that conversion technologies are not a barrier to the widespread expansion of bioenergy

<sup>9</sup> First generation biofuels are manufactured mainly from agricultural resources, such as grain, sugar and oil crops. Second generation biofuels can utilise lignocellulosic material, which is the various compounds of lignin and cellulose comprising the essential part of woody cell walls (European Commission, 2005b).

(European Commission, 2005b; European Renewable Energy Council, 2004). On the contrary, the array of commercially available and mature technologies suggests a bright future for bioenergy systems (Sims, 2002). Furthermore, research and development activities are expected to bring new technologies to the market, particularly for liquid biofuels (European Commission, 2005b; Turkenburg, 2000).

### **1.2.3 Political Support**

In the EU, there is a range of supportive policy measures relevant for bioenergy (see Table 1-3).<sup>10</sup> These policy measures are spread across energy, agriculture and climate policy fields. Additionally, the policy goals are related to many topics, including liquid biofuels for transport, electricity and heat from renewable energy, greenhouse gas emissions, and energy crops. The types of policy measures range from the Kyoto Protocol to the Common Agricultural Policy (CAP) and the EU Directive on the Promotion of Biofuels for Transport.

The recent commitments by the EU – to reduce greenhouse gas emissions, to increase the share of renewable energy, and to expand the level of liquid biofuels for transport – show growing political leadership on these issues. Global climate change is a dominant issue on the EU political agenda, and bioenergy is firmly identified as a main energy source to replace fossil fuels and reduce greenhouse gas emissions in Europe (European Commission, 2007a). The established targets by the EU represent a roadmap for the expansion of renewable energy and bioenergy.

In 2005, the European Commission (2005a) released the Biomass Action Plan (BAP) for Europe to accelerate the development of bioenergy, and identify potentials and targets for biomass resources in terms of wood from forests, organic wastes, wood industry residues, agricultural and food processing manure, and energy crops from agriculture. Furthermore, the European Environment Agency (2005) states that realising the targets for bioenergy as indicated in the BAP can be (under proper management)

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<sup>10</sup> Policy measures refer to all kinds of policies and actions, principally adopted and implemented by governments and/or authorities. The specific types of policy measures can be categorised as regulatory (e.g. mandates or quota systems), economic (e.g. subsidies or incentives), procurement (e.g. green purchasing), collaborative (e.g. voluntary agreements or networking) and communication (e.g. awareness campaigns).

compatible with protecting and maintaining biodiversity, soil and water resources.

*Table 1-3. Selection of Policy Measures Relevant for Bioenergy in the European Union*

<b>Policy Fields</b>	<b>Key Policy Measures</b>	<b>Key Policy Goals</b>
Energy	An Energy Policy for Europe: The Need for Action	To reduce greenhouse gas emissions by 20% by 2020; to increase the share of renewable energy by 20% by 2020; and to expand the level of liquid biofuels for transport by 10% by 2020.
	Biomass Action Plan (BAP)	To increase biomass use to 149 Mtoe by 2010 from the 69 Mtoe in 2003.
	Directive on the promotion of liquid biofuels for transport and alternative fuels	To achieve a 2% share of liquid biofuels for transport and alternative fuels by 2005 and a further increase to 5.75% by 2010.
	Directive on the promotion of electricity from renewable energy sources	To achieve a 22% share of electricity from renewable energy in terms of electricity consumption by 2010.
	Green Paper on Energy Security	To reduce energy imports and improve security of energy supply.
	White Paper on Renewable Energy Sources	To expand the share of renewable energy in the energy supply from 6% to 12% by 2010.
Agriculture	Common Agricultural Policy (CAP)	To define mechanisms to regulate agriculture in the EU. The CAP reforms aim to promote sustainability, rural and regional development, employment creation, multi-functional agriculture, and energy crops.
Climate	Directive on establishing a scheme for greenhouse gas emission allowance trading	To establish a market for greenhouse gas emission allowance trading to meet the targets in the Kyoto Protocol.
	Kyoto Protocol	To reduce EU greenhouse gas emissions to 8% under 1990 levels by 2008-2012.

Source: European Commission (2007a)

The supportive policy measures established by the EU and some Member States indicate a political willingness to bring about change in current energy systems. The increased use of bioenergy in particular remains at the forefront of the EU strategy to respond to climate change and improve energy security (European Commission, 2005a). However, achieving the many stipulated targets will require the development and implementation of effective policy measures that can stimulate innovation processes and engage key stakeholders.

### ***1.3 Research Design***

Connel (1985) argues that a thesis is not a flawless and definitive piece of work. It is in fact research training. At the centre of the training is the research design, which is a strategic plan that guides the learning process, the research methodology, and the overall development of the thesis (Perry, 1998). The plan for this thesis encompasses a significant research problem, a research aim and specific research objectives.<sup>11</sup> Furthermore, there are clear justifications for this research work on the basis of contributions to the field and value for actors.

#### **1.3.1 Research Problem**

Bioenergy systems under the ‘right’ conditions are expected to greatly contribute to climate mitigation, improved energy security conditions, maintenance of robust agricultural and forestry sectors, and support industrial growth and greater exports (Sims, 2002). The evidence presented in this thesis shows that the opportunities for exploiting biomass resources in Europe are considerable and a range of conversion technologies exist. There is also political support from the EU (and some Member States) in the form of supportive policy measures.

Unfortunately, the current projections show that the EU is lagging behind the widely accepted BAP targets, which are based on utilising existing technologies and systems (see Figure 1-2). The scenario defined in the BAP suggests that bioenergy can be increased from 69 Mtoe in 2003 to 149 Mtoe

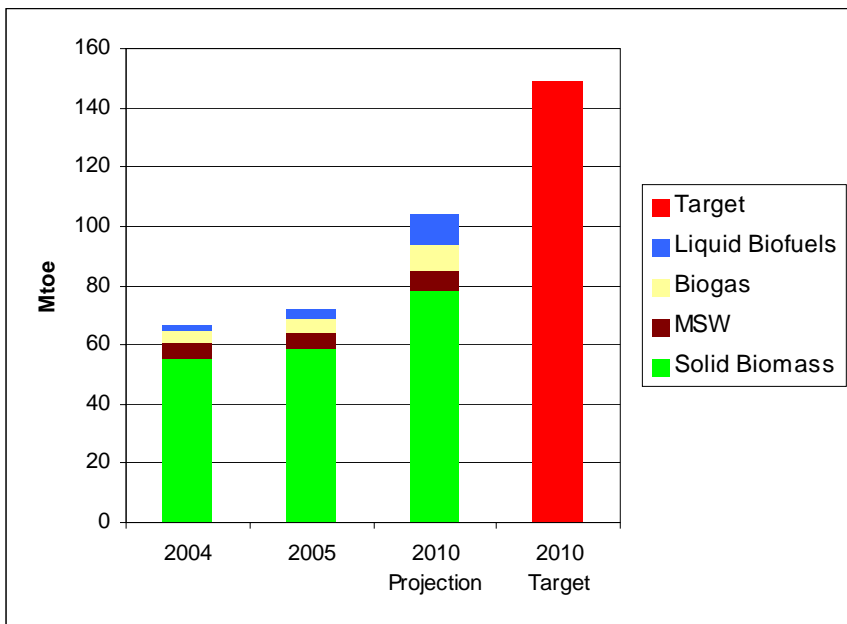
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<sup>11</sup> A research problem is a broad issue of significance that requires research and thinking by the researcher. A research aim is the general direction and/or target of the research activities. Research objectives are concrete statements about what the researcher is trying to achieve (Perry, 1998; Teitelbaum, 2003).

in 2010 (European Commission, 2005a). It is connected to (and compatible with) a range of targets, policy goals and international commitments on renewable energy, climate mitigation, energy security, and sustainable development. The likely failure to achieve the BAP targets indicates that the EU and Member States need to intensify efforts to expand bioenergy.

The research problem for this thesis is therefore as follows:

**Despite considerable potentials for expanding bioenergy across the European Union and Member States, the implementation of bioenergy systems is lagging behind targets.**



*Figure 1-2. Bioenergy Projections for the European Union (Mtoe)*

Source: European Commission (2007b)

### **1.3.2 Research Aim**

This thesis explores the implementation of bioenergy systems in Europe focusing on socio-political issues (see Figure 1-3). The research aim highlights the implementation stage of bioenergy systems. It is at the implementation stage when social and political factors (or socio-political issues) often arise and confront actors engaged in (or affected by) bioenergy

systems (Roos, Graham, Hektor, & Rakos, 1999). Exploring socio-political issues, this research concentrates on how actors make decisions, resolve conflicts, form partnerships, respond to government policies, and engage with public issues.

The research aim for this thesis is therefore as follows:

**To explore the implementation of bioenergy systems in Europe focusing on socio-political issues.**

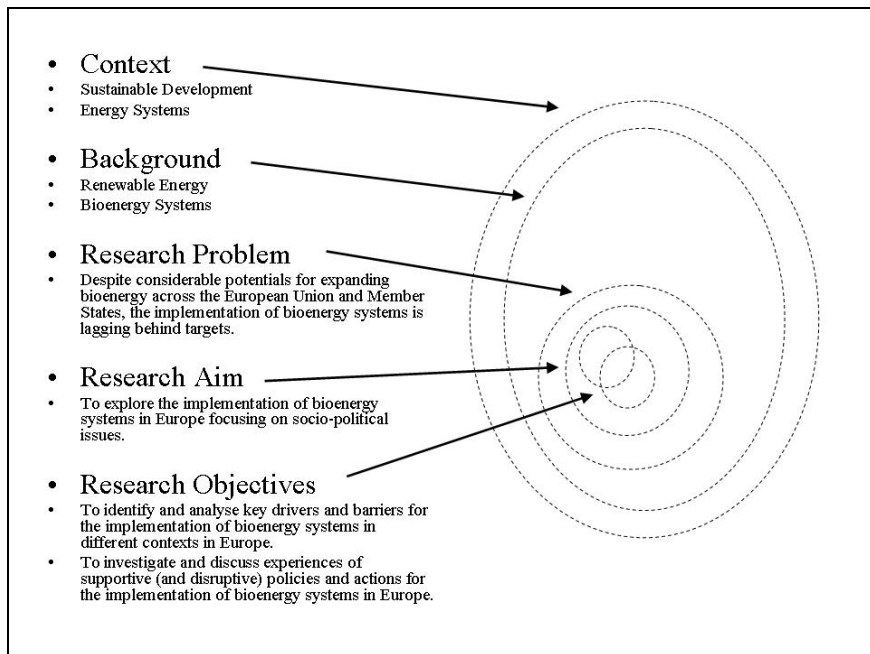


Figure 1-3. Research Overview

Source: Based on Perry (1998)

### 1.3.3 Research Objectives

The first research objective tackles: “why is there a problem?” Drivers and barriers tend to merge together into what can be called critical factors (Roos et al., 1999). A better understanding of critical factors, their interactions, and importance to the implementation of bioenergy systems is useful for any actors interested in the development of bioenergy. Going beyond identification to analysis and explanations of why such critical factors exist,

and how they affect bioenergy systems in different parts of Europe, is at the heart of this research objective.

The first research objective for this thesis is therefore as follows:

**To identify and analyse key drivers and barriers for the implementation of bioenergy systems in different contexts in Europe.**

The second research objective addresses: “how to respond to the problem?” Leverage points are places in systems where small changes result in large responses or shifts in systems (Capra, 1997; Meadows, 1999). This research objective is based on the idea that policies and/or actions that apply pressure to leverage points can often be very effective in achieving the desired goals. An improved understanding of the experiences of actors (on local, regional and national levels) with supportive (and disruptive) policies and actions is vital to the further growth of bioenergy in Europe.

The second research objective for this thesis is therefore as follows:

**To investigate and discuss experiences of supportive (and disruptive) policies and actions for the implementation of bioenergy systems in Europe.**

### **1.3.4 Research Justification**

This thesis sets out to explore the major socio-political issues affecting the implementation of bioenergy systems in Europe. Bioenergy could be considered a ‘hot’ topic in the EU, and in many other parts of the world, where renewable energy, climate mitigation, energy security and sustainable development have captured the attention of key stakeholders (particularly policy-makers and business leaders). This thesis and corresponding articles can therefore be justified on at least 4 accounts. These include:

- First, expanding bioenergy can help to address 2 of the most urgent issues facing the EU (and the world) – climate change and energy security. Bioenergy systems can decrease greenhouse gas emissions, and increase the resilience of energy systems because of the range of viable biomass inputs and the options for energy outputs (World Energy Assessment, 2000). Research on accelerating the growth of bioenergy is paramount.

- Second, there are significant calls in the literature and political circles for a greater understanding of how to overcome barriers to expanding bioenergy, especially energy crops in the agricultural sector and liquid biofuels for transport (European Commission, 2005b; Fagnäs et al., 2006). The research aim and objectives for this thesis are therefore timely.
- Third, the research work responds to requests in the literature for more research on non-technical issues affecting bioenergy (Costello & Finnell, 1998; Fagnäs et al., 2006; Rösch & Kaltschmitt, 1999). The socio-political issues explored in this thesis can be considered a rather novel approach for the bioenergy field, which can provide valuable insights into the implementation of bioenergy systems.
- Fourth, this research can be categorised as a multi-disciplinary study, which is expected to contribute not only to the bioenergy field, but also facilitate discussion with researchers working on renewable energy in various related disciplines. Much of the research, analysis and discussion in this thesis is directly relevant to the wider field of renewable energy (European Renewable Energy Council, 2004; International Energy Agency, 2003).

## ***1.4 Scope***

This research adopts a wide perspective on bioenergy that cuts across several sectors and includes a range of actors involved in bioenergy systems. The author argues that this broad viewpoint facilitates a greater understanding of the key challenges for bioenergy in Europe. The scope is narrowed to socio-political issues, which concentrates this thesis work on the major social and political factors affecting the implementation of bioenergy systems. The emphasis on socio-political issues also focuses this thesis on the main actors engaged in (and affected by) bioenergy systems.

This thesis is based on 6 peer-reviewed articles. The articles take up different topics, which are gradually more focused on specific aspects or types of bioenergy systems. Article I explores the potentials of renewable energy globally thereby setting the context for bioenergy. Articles II, Article III and Article IV shift attention to a number of bioenergy systems in Europe, exploring how they function, the key barriers to implementation, and the main benefits or drivers associated with bioenergy. Article V concentrates

on the experiences of farmers with energy crops in Sweden, Austria and Italy. Finally, Article VI looks at the socio-political context for liquid biofuels in Germany and the UK.

The geographic scope for this research work is Europe, primarily the EU and its Member States. Issues regarding international trade of solid and liquid biofuels are discussed to a limited extent. However, it is always from a European perspective. In terms of key stakeholders, local and regional actors (such as farmers, forest owners, local municipalities, local energy companies and residents) are the main focus of this thesis work. There are other relevant actors for bioenergy systems, including multi-national energy companies, which are not explored in this research.

The temporal scope for the research concentrates on the short-term (2005-2020) so that many of the conclusions and recommendations are relevant for policy-makers and business leaders today. However, a more long-term (2030-2050) perspective is in the background of the articles. This is to ensure that sustainable development remains the overarching aspiration (when exploring how to advance bioenergy systems) and to highlight the large potentials for renewable energy and bioenergy.

It is also important to indicate what is outside the scope of this thesis work. While the articles often discuss economic conditions for bioenergy, the author does not conduct any detailed economic research of bioenergy systems. The emphasis is on how economic conditions are shaped and directed through political interventions. Economic and/or financial analysis is not the focus of this research. Furthermore, the author does not quantitatively explore energy balances or greenhouse gas emissions of bioenergy systems. These issues are recognised as very important by the author but only through qualitative discussion.

## *1.5 Limitations*

This study contains some limitations and/or weaknesses that the author wants to acknowledge.<sup>12</sup> The wide scope of this research work could potentially be seen as its main weakness. The study is broad in both

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<sup>12</sup> Limitations refer to weaknesses in the research process, which are generally beyond the control of a researcher. In contrast, de-limitations refer to the scope set by a researcher, which is an attempt to 'build a fence' around the research work.

theoretical and empirical terms. The multi-disciplinary character of the research, utilising concepts and knowledge from different disciplines, makes it difficult to satisfy experts in specific disciplines. Furthermore, the aim to investigate the workings of bioenergy systems (both the parts and the whole) resulted in a challenging task for data collection, analysis and interpretation.

Another weakness of this research relates to the case studies. Firstly, the case studies are of varying depths in terms of data collection. Some case studies involved 1-2 weeks of on-site research, including interviews and site visits. Others are based on 1-2 days of on-site research. Secondly, the author of this thesis did not conduct all the empirical research. In order to work with many case studies the author needed to rely on utilising data collected by other researchers and Masters Candidates guided by the author.

The advantage of working closely with other people was that the author interacted with researchers and Masters Candidates, learning about their viewpoints, experiences and research techniques. Working in teams of researchers allowed considerably more data collection and iterative analysis of the findings. The main disadvantage was that the author had limited control over the entire research process or the full reliability of data. This was balanced by the collection of multiple information sources and interviews with a range of informants.

## ***1.6 Audience***

Perry (1998) suggests that thesis reports are often only read by supervisors and opponents. One of the strengths of a thesis based on peer-reviewed articles is that a wider audience can be attained (Teitelbaum, 2003). The target audience for this thesis work and articles is mixed and broad. Primarily, it is for the research community interested in bioenergy and renewable energy. However, it has relevance for policy-makers (and/or policy advisors), local municipalities, and industrial actors in the EU and Member States.

The articles have been published in and presented at, what could be called bioenergy forums, and also to audiences who are not knowledgeable of bioenergy issues. Bioenergy cuts across many sectors and fields, so it is important to address audiences outside the traditional bioenergy community. Finally, this thesis work is relevant for audiences engaged in bioenergy in the

new Member States, the development of energy crops and liquid biofuels, and potentially, countries and regions outside of Europe.

**Learning from Experience:** Bioenergy systems are influenced by their context in terms of natural resources and socio-political issues. Successful bioenergy systems from some parts of Europe can therefore not simply be replicated in other places. However, experiences from countries, such as Sweden and Austria, are relevant and applicable for the fast-developing new Member States (see Article II and Article IV). Many of these new Member States and other countries in Europe hold vast potentials for biomass production, such as Poland and the Ukraine.

**Expanding into Agriculture:** The major bioenergy systems in Europe have been built on forestry platforms (which will remain very important). However, bioenergy is now expanding into agriculture with the cultivation of energy crops (Gosse, 2006). It is the contention of this author that the large-scale expansion of energy crops (linked to demand for liquid biofuels) will confront complex socio-political issues (such as land use conflicts and concerns over environmental and social impacts) involving a range of actors from policy-makers to business leaders (see Article V and Article VI).

**Shifting beyond Europe:** The experiences from Europe are also relevant to actors in other parts of the world where bioenergy systems are developing and expanding (see Article III). In these places, actors engaged in bioenergy can potentially 'leapfrog' certain problems, based on the lessons learned in Europe. This is especially the case for issues of a socio-political nature at both the grassroots level through to policy formulation and implementation by governments and/or authorities (see Article I).

## *1.7 About the Author*

The background of the author has shaped this research. The author has a background in political science and environmental studies, and has published on various energy-related topics (see Appendix A). This forms the foundation of the thesis work. Political science can be described simply as the study of how groups make decisions and the power relationships within and between groups (Carter, 2001; Considine, 1994). Environmental studies is the multi-disciplinary examination of interactions between society and the environment, which includes disciplines, such as geography, ecology, economics and politics (Forsyth, 2003; Miller, 2005).

It is important to acknowledge the skills and knowledge the author does not possess, namely a strong technical or economic background. At present, engineers and economists dominate the bioenergy field (and the energy field for that matter). The author is not a ‘member’ of these disciplines, and therefore approaches bioenergy from a different perspective. The major focus of the author is on socio-political issues or in straightforward terms – people, power and policy. There is a growing interest in the bioenergy field in this kind of ‘new’ perspective (Fagernäs et al., 2006).

During the thesis period, the author has played an active role in a major European project on bioenergy involving 8 research institutes – entitled the Bioenergy Network of Excellence (NoE). The activities within the Bioenergy NoE have shaped this research and given the author many opportunities to meet experts in the bioenergy field, and gain access to data and documents. The overall goals of the Bioenergy NoE are to explore barriers to bioenergy, integrate the activities of the research institutes, and build a Virtual Bioenergy R&D Centre (see Figure 1-4).

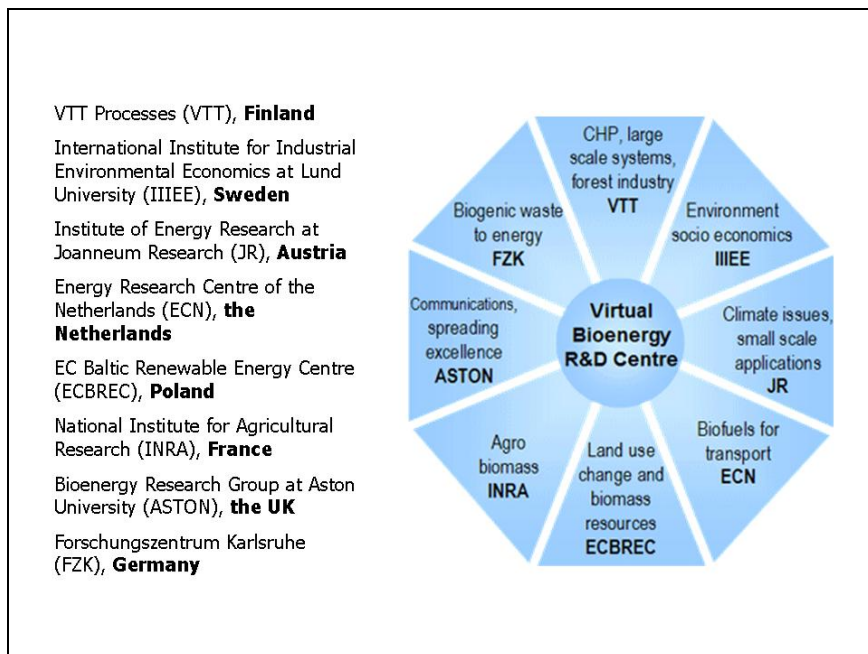


Figure 1-4. Research Institutes and Work Packages in the Bioenergy NoE

Source: Based on Fagernäs et al. (2006)

The IIIEE (the host organisation for the author) is leading the work package within the Bioenergy NoE on environmental and socio-economic issues. The work package includes the following goals: investigation of the underlying socio-economic barriers and drivers for bioenergy in Europe; identification and analysis of key barriers, conflicting interests and policy obstacles; and recommendations of strategies and actions to overcome barriers and promote bioenergy (Fagernäs et al., 2006). The IIIEE work has had an emphasis on energy crops and agriculture, as well as liquid biofuels for transport.

## ***1.8 About the Thesis***

This thesis is based on 6 peer-reviewed articles (see Table 1-4). Most of the articles have been co-authored with researchers at the IIIEE or from other organisations. However, the author has made a major contribution in all the publications in terms of data collection and analysis, and writing and editing. The articles comprise a book chapter, 3 journal papers and 2 conference papers. This thesis report begins with a summary of the overall research work, showing the linkages between the articles, as well as the general conclusions and reflections. It comprises 4 chapters.

- **Chapter 1:** This describes the context, research design, scope, limitations, and audience of the thesis work, as well as some relevant insights into the background of the author.
- **Chapter 2:** This outlines the research methodology developed and applied in the research work, including the research approach, the research methods, and the overall research process.
- **Chapter 3:** This provides a description and analysis of the research work and findings, as well as a summary of both the main case studies and articles.
- **Chapter 4:** This concludes the summary with contributions to the field, value of the research to relevant actors, and final reflections from the author.

Table 1-4. Publications and Contributions

Publications	Contributions
<p>Article I: Johansson, T.B., McCormick, K., Neij, L., &amp; Turkenburg, W.C. (2006). The Potentials of Renewable Energy. In D. Abmann, U. Laumanns &amp; D. Uh (Eds.) <i>Renewable Energy: A Global Review of Technologies, Policies, and Markets</i>. London: Earthscan.</p>	<p>The author conducted data collection, wrote parts of the article, and edited the entire article.</p>
<p>Article II: McCormick, K., &amp; Kåberger, T. (2005). Exploring a Pioneering Bioenergy System: The Case of Enköping in Sweden. <i>Journal of Cleaner Production</i>, 13(10-11), 1003-1014.</p>	<p>The author conducted data collection and analysis, and wrote the majority of the article.</p>
<p>Article III: McCormick, K. (2005). <i>Sustainable Bioenergy Systems: Experiences from Sweden</i>. Paper presented at the Asia Pacific Roundtable on Sustainable Consumption and Production, Melbourne, Australia.</p>	<p>The author conducted data collection and analysis, and wrote the entire article.</p>
<p>Article IV: McCormick, K., &amp; Kåberger, T. (2007). Key Barriers for Bioenergy in Europe: Economic Conditions, Know-how and Institutional Capacity, and Supply Chain Co-ordination. <i>Biomass and Bioenergy</i>, 31(7), 443-452.</p>	<p>The author conducted data collection and analysis, and wrote the majority of the article.</p>
<p>Article V: McCormick, K., Nilsson, H., &amp; Tomescu, M. (2006). <i>Energy Crops and the Common Agricultural Policy</i>. Paper presented at the World Bioenergy Conference, Jönköping, Sweden.</p>	<p>The author conducted data collection and analysis, wrote parts of the article, and edited the entire article.</p>
<p>Article VI: Bomb, C., McCormick, K., Deurwaarder, E., &amp; Kåberger, T. (2007). Biofuels for Transport in Europe: Lessons from Germany and the UK. <i>Energy Policy</i>, 35(4), 2256-2267.</p>	<p>The author conducted data analysis, wrote parts of the article, and edited the entire article.</p>

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# CHAPTER TWO

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## 2. Methodology

The research methodology for this thesis is described in this chapter under 4 key headings. First, there is a short discussion on how this research is positioned in terms of research paradigms. Second, the research approach based on systems thinking is presented. Third, the main research methods are outlined, which include literature reviews, case studies, site visits, stakeholder interviews, industry interactions, and research workshops. Fourth, there is an overview of the research process, and the analytical frameworks developed and applied in the articles.

### *2.1 Research Paradigm*

Research activities are shaped by research paradigms from the practical development to how findings are analysed and presented.<sup>13</sup> The author positions this research work within several research paradigms in an attempt to address real-world complexity. Research paradigms can be described in terms of ontology, epistemology and methodology. Ontology is the reality that researchers choose to study, epistemology is the relationship between that reality and the researcher, and methodology is the suite of techniques applied by the researcher to explore that reality (Alvesson & Sköldbberg, 2000; Morgan & Smircich, 1980).

**Ontology:** The author believes that a real, physical world exists beyond our knowledge and comprehension. However, a social world also exists, which is constructed and influenced by our life experiences, knowledge and values (Morgan & Smircich, 1980). Researchers create models or frameworks as a way to deal with the infinite complexity of the world. By constructing models researchers create various realities for themselves and others (Flick,

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<sup>13</sup> A research paradigm can be defined as a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them (Morrow & Brown, 1994).

2006). The author acknowledges that there are always multiple perspectives and constructed realities.

**Epistemology:** It was a primary goal of this research to explore real-world problems and focus on practical applications of knowledge. The author was part of the research process, being able to define how reality was scoped and studied (Hammersley, 2000). As stated, the author acknowledges that there are always different understandings and conclusions from the same data. The author therefore engaged in a constant reflective and iterative process on alternative interpretations of the data and findings (Alvesson & Sköldbörg, 2000; Hammersley, 2000).

**Methodology:** Utilising a combination of research methods allows a more in-depth understanding of reality from different viewpoints, which is crucial when exploring topics or issues involving a range of actors (Healy & Perry, 2000). In this research, the author focuses heavily on qualitative methods, including literature reviews, case studies, site visits, stakeholder interviews, industry interactions, and research workshops. The foundation of this research is therefore the use of diverse kinds of data sources and a mix of qualitative methods (Morrow & Brown, 1994).

## *2.2 Research Approach*

This thesis is based on a systems approach (Meadows, 2002; Olsson & Sjöstedt, 2004). Systems thinking is utilised worldwide and has become well established in some disciplines (International Institute for Applied Systems Analysis, 1980). However, the systems approach has many interpretations and could be seen as a controversial concept (Olsson & Sjöstedt, 2004). For the author, the systems approach involves studying problems in a holistic way utilising a range of research methods and concepts from different disciplines.

At the heart of a system is the interaction between a number of elements, and a defined external environment (Capra, 1997). Furthermore, systems can have inputs and outputs of energy, information and/or matter. Feedbacks are present in all complex systems where an output becomes an input (see Figure 2-1). It is not so important if the object of study is a system in the 'real' world but instead the focus should be on systemic research and practice. Systems thinking and analysis is used to gain a better understanding of reality not to identify systems (Meadows, 2002).

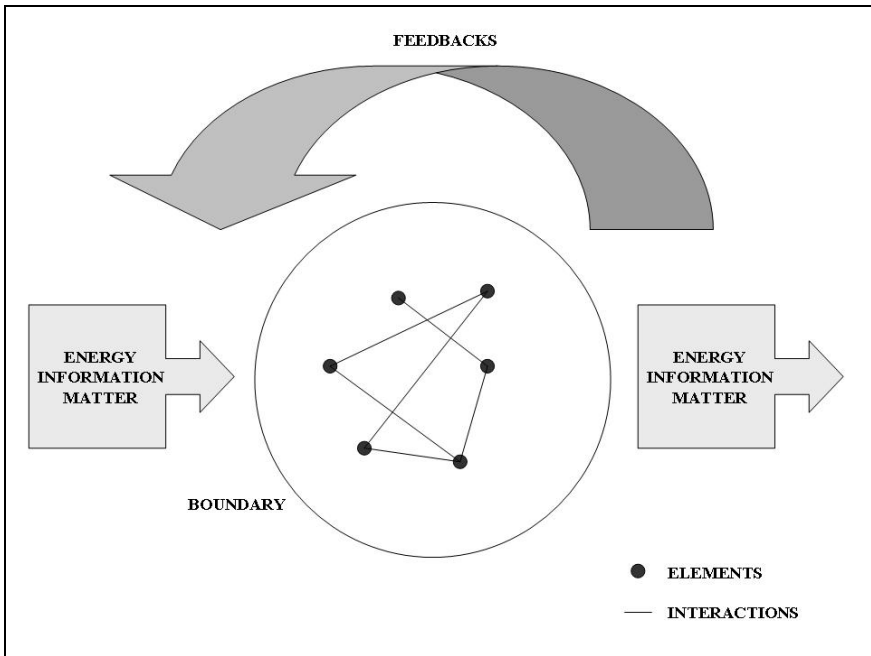


Figure 2-1. Systems Diagram

Systems models are mental constructs used by researchers to understand the world and take action (Senge, 1993). Systems thinking helps to structure complex relationships in reality and thus make them open for study (Quade & Miser, 1985). Systems models are also an effective pedagogical tool for researchers to explain findings to others (Meadows, 1999). The author utilised the systems approach primarily to better understand bioenergy systems, but also to depict findings and concepts in presentations.

Applying systems thinking to bioenergy highlights the elements that make up bioenergy systems, and the interactions between the elements (Meadows, 2002). Bioenergy systems comprise a range of inputs, outputs, interactions, elements and feedbacks. It is also important to recognise that bioenergy systems consist of both technical aspects, such as conversion technologies and biomass resources, and overarching social aspects, such as policies and actors (Geels, 2004).

Bioenergy systems comprise 4 main technical aspects, which are biomass resources, supply systems, conversion technologies and energy services. Furthermore, the systems approach highlights the range of actors engaged in (or affected by) bioenergy systems (see Figure 2-2). The actors are connected

through a complex and dynamic web of networks, partnerships and policies. The actors can include local governments, research institutes, forestry companies, farmers, waste management companies, residents, environment groups, and local energy companies.

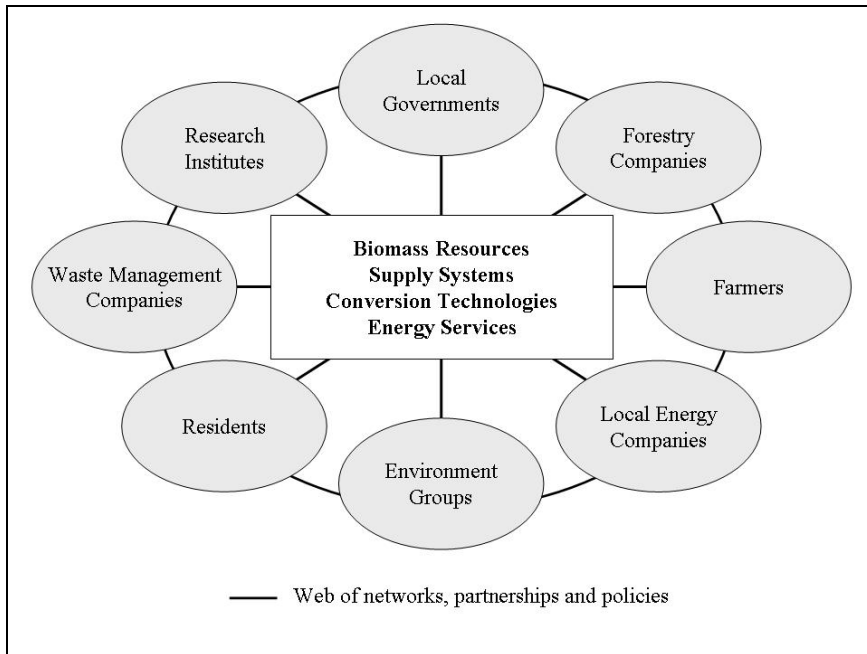


Figure 2-2. Bioenergy Systems with Actors

Researchers who utilise a systems approach have a significant interest in leverage points or places within complex systems where a small shift in one parameter can have large impacts (Meadows, 1999). The author attempted to use systems thinking to explore the influence and role of different actors in the implementation of bioenergy systems. The author also explored the networks, partnerships and policies relevant to the bioenergy field to gain a better understanding of 'hidden' structures, and ultimately, leverage points.

## 2.3 Research Methods

The author often engaged with other researchers and worked as a team. In this way, the author benefited from interacting with researchers in different fields. The data collection (and analysis) by a number of Masters Candidates at the IIIIEE directly contributed to this thesis (see Table 2-1). Furthermore,

the supervision process involved the author with other researchers at the IIIIEE. Engaging with both Masters Candidates and researchers has been a valuable learning experience, which has greatly added to the work of the author, not only in terms of raw data, but also in terms of the application of research methods and the interactive teamwork process.

*Table 2-1. Research Supervision*

<b>Year</b>	<b>Author</b>	<b>Supervisors</b>	<b>Topic</b>	<b>Scope</b>
2004	Vishal Aggarwal	Helen Nilsson Kes McCormick	Energy Crops and the Common Agricultural Policy	European perspective
2005	Angelica Bello	Lena Neij Kes McCormick	Biomass Potentials for Energy Purposes	International perspective
2005	Mihai Tomescu	Philip Peck Tomas Käberger Kes McCormick	An Innovative Bioenergy System in Action	Regional case study in Austria
2006	Robert Hlep	Philip Peck Kes McCormick	Emergence of a Bioenergy Company	Business case study in Sweden
2006	Hanna Savola	Andrius Plepys Kes McCormick	Biogas Systems in Sweden and Finland	Sweden and Finland
2007	Yuliya Voytenko	Kes McCormick Philip Peck	Bioenergy Potentials in the Ukraine	Ukraine

This thesis involved a combination of research methods and different informants. An important objective of the author was to utilise a number of research methods to meet the requirements of ‘method’ triangulation (Bloor, 1997; Morrow & Brown, 1994). These research methods primarily included literature reviews, case studies, site visits, stakeholder interviews, industry interactions, and research workshops. The author also conducted interviews with informants from a range of sectors and different backgrounds in order to carry out ‘informant’ triangulation (Bloor, 1997).

### **2.3.1 Literature Reviews**

This thesis work involved a diversity of data sources, which have formed the basis of this summary, the articles and the case studies. There were 2 types of literature reviews conducted during the research process by the author. First, finite and focused literature reviews often associated with the development of specific case studies. Second, ongoing literature reviews connected to the broader research work on renewable energy resources, technologies, policies and innovation with a specific focus on bioenergy systems.

### **2.3.2 Case Studies**

This thesis relies heavily on case studies, which incorporate aspects of participatory research and action research (see Table 2-2). These techniques engage differently with research subjects, they have contrasting purposes and assumptions, and they produce different kinds of results or outcomes (Ottosson, 2003; Pain & Francis, 2003; Stake, 1995). Developing case studies was selected as a primary research method because it supported the main goal of the author to explore the implementation of ‘real’ bioenergy systems.

*Table 2-2. Research Techniques*

<b>Types</b>	<b>Comments</b>
Case Study Research	Case study research involves multiple perspectives and data sources, engages in a mix of both qualitative and quantitative analysis, and focuses on ‘how’ and ‘why’ questions rather than ‘what’ questions (Stake, 1995; Yin, 2003a).
Action Research	Action research combines action or change with research, and involves 4 steps in a flexible research cycle, which are planning, acting, observing, and reflecting. It requires the involvement by the researcher in an organisation or project (Boog, 2003; Ottosson, 2003).
Participatory Research	Participatory research is an integrated activity that often combines social investigation and educational work. The ultimate goal is structural transformation and the improvement of the lives of those people in the research focus (Pain & Francis, 2003).

Recent refocusing on action research and participatory research arises partly from the desire among some researchers to go beyond identifying and describing problems, to engaging with actors to find solutions (Brown & Tandon, 1983; Eden & Huxam, 1996; Pain & Francis, 2003). In other words, to have real impacts on those actors involved in a study. As stated, this research work combined conventional case studies with participation by the author in some projects under investigation (see Table 2-3). This greatly improved the understanding by the author of the ‘real-life’ systems, and helped to focus the research on applicable solutions (Hayward, Simpson, & Wood, 2004).

*Table 2-3. Examples of Participation*

<b>Activity</b>	<b>Description</b>
Seminar organised by the IIIEE and Bioenergy NoE over 2 days in Berlin, Germany and Gubin, Poland.	The seminar involved participants from industry and academia from Sweden, Germany and Poland. In Berlin on the first day, the seminar was hosted at a CHP plant where the participants engaged in discussions on key barriers to bioenergy, and biomass supply. In Gubin on the second day, the participants visited plantations of energy crops, and debated biomass production in Europe. The objective was to connect actors from Germany and Poland, and share experiences from Sweden.
Engagement in projects by the IIIEE and Bioenergy NoE in Vansbro, Sweden and Umbertide, Italy.	The projects involved the expansion of the bioenergy system in Vansbro to include pellets production, and the formation of a network of actors in Umbertide to invest in a CHP plant. The objective was to engage in projects and utilise the knowledge of key barriers for bioenergy to shift projects towards success. In Vansbro, there was success with the construction of a pellets production plant to complement the existing CHP plant. In Umbertide, a network of actors is forming. However, investments are pending.

This thesis work utilises 12 case studies from 8 countries in Europe. Additionally, there are a further 3 country studies on Sweden, the UK and Germany (see Article III and Article VI). Most of the case studies have been discussed directly in the articles. However, some of the research on Poland and the Ukraine has been developed more recently. Conducting the case studies relied on local partners for organising site visits and stakeholder

interviews, and connecting researchers with relevant local and regional actors. The partners included local municipalities, research institutes and companies or consortiums (see Appendix B).

### **2.3.3 Site Visits**

The research work for this thesis involved a range of site visits. For example, these included visits to conversion technologies, forests, farms, waste management centres, plantations of energy crops, and companies with wastes, among others. The objective of such site visits was to observe companies and projects in action, meet and interview informants in their 'home' environments, and 'experience' bioenergy systems. Additionally, key informants were often at ease and eager to show and explain in detail the development of 'their' bioenergy systems (Stake, 1995).

Extensive field notes were recorded by the author, and often checked and collated with the notes of research colleagues. As the site visits usually involved a small group of researchers, the author was able to utilise the combined observations. This added an extra dimension to the site visits, and ultimately improved the case studies. Additionally, the author took photographs on site visits to capture observations, and for use in presentations to convey important messages (see Appendix C). The site visits played a crucial role in the research process and the case studies (Yin, 2003a).

### **2.3.4 Stakeholder Interviews**

This research is based on interviews with a wide range of informants, primarily during the development of the case studies.<sup>14</sup> Interviews with various informants from the community, industry, government and academia allowed the author to obtain different viewpoints on the research topics. A triangulation of informants was therefore possible to check 'facts' and identify issues of disagreement or tension (Morrow & Brown, 1994). The same questions and themes were discussed with different informants. Such an approach was vital to the reliability and validity of the data collection process (Bloor, 1997).

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<sup>14</sup> Each of the case studies involved between 5-35 interviews. The author also conducted approximately 20 interviews with informants outside the case studies to gain a general overview of bioenergy systems in Europe.

The interviews were mainly semi-structured, involving a list of core questions. However, the author applied a flexible approach to interviews allowing informants to diverge from the questions to other topics they considered important (Yin, 2003b). Before each interview, the author set out goals and devised a plan for how to interact with the informants (Bryman, 2004; Stake, 1995). In most cases the author encouraged informants to ‘tell their story’ about their role in the development of bioenergy systems, and their relationships with other relevant actors.

It is important to indicate that the author did not carry out all of the interviews. There were 3 ways in which the interviews were conducted. First, some of the interviews involved only the author, which were mostly those outside the case studies. Second, the author often worked in a team with research colleagues and Masters Candidates on the development of case studies. In this way, there were several researchers running the interviews. Third, the author closely supervised and guided Masters Candidates who handled the interview process in some cases.

### **2.3.5 Industry Interactions**

Since the start of the research work in 2004, the author has attended 12 major conferences and seminars on bioenergy and energy policy. These forums have provided opportunities for the author to interact with industry representatives. While the presentations have been input for this research, it is the conversations and discussions with industry representatives that have really been valuable to the author. Conferences bring together key stakeholders from the bioenergy sector in a single place, prompting interactions, debate, and business deals (Bryman, 2004).

The author made particular use of 2 conferences convened in Jönköping, Sweden. Namely, the World Bioenergy Conference in June 2004 and May 2006. At both these events the author made presentations. First, the author presented on innovation in bioenergy systems. Second, the author presented on energy crops, farmers and the CAP. The presentations helped the author to meet various key stakeholders, discuss preliminary findings, sketch out further research strategies, and shape the research direction of this thesis work.

### **2.3.6 Research Workshops**

The IIIEE and Bioenergy NoE organised 8 research workshops between 2004-2007 focused on environmental and socio-economic issues for bioenergy in Europe (see Appendix D). These research workshops have involved up to 15 researchers from 8 different research institutes, and invited guests from academia, government and industry. The author has presented research work and participated in discussions at the various research workshops.

The research workshops have involved participants with a range of educational backgrounds and experiences, including economics, politics, engineering, business, science, planning, and management. Complementing the multi-disciplinary interaction between the researchers was the different cultural backgrounds and perspectives from several Member States in the EU, including Sweden, Finland, France, the UK, Germany, Austria, the Netherlands, and Poland. The research workshops were therefore both multi-disciplinary and representative of Europe.

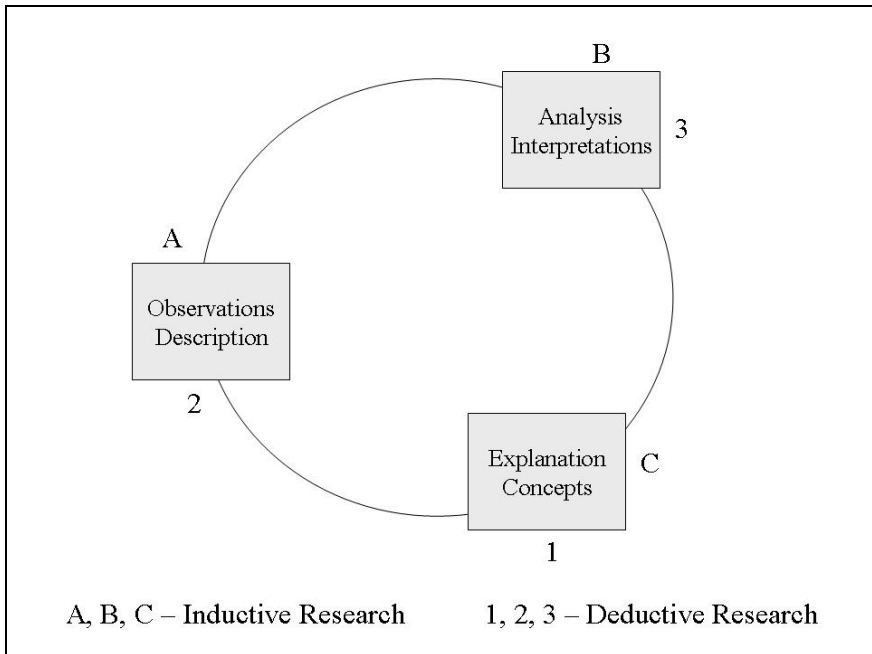
Additionally, the Bioenergy NoE has organised 2 conferences, which were attended by 70-100 researchers on both occasions. The conferences involved several research workshops over 2-3 days. The first was held in Petten in the Netherlands hosted by ECN, and the second was held in Helsinki in Finland hosted by VTT Processes. Both the research workshops and conferences have been significant opportunities for the author to meet with various experts in the bioenergy field in Europe to discuss issues, learn about new research, and test ideas.

## ***2.4 Research Process***

It is useful to think about the relationship between concepts or theory and the research process in terms of inductive and deductive strategies (see Figure 2-3). Deductive research is the process by which a researcher utilises what is known about a particular domain and the theoretical considerations, and then describes a hypothesis to test through empirical scrutiny (Bryman, 2004). In contrast, this research work is predominantly based on an inductive strategy where concepts or explanations are the outcome of research and observations in the field.

The research process for each of the articles generally started with observations, then analysis and interpretation, and concluded with concepts

or explanations. This approach is also commonly known as grounded theory, which is based on the notion that theory or concepts should not be applied to the subject under investigation but ‘discovered’ from working in the field (Flick, 2006). The aim of grounded theory is not to reduce complexity by breaking research problems down into variables that ‘fit’ with existing theory but instead to increase complexity by including context (Alvesson & Sköldbberg, 2000).

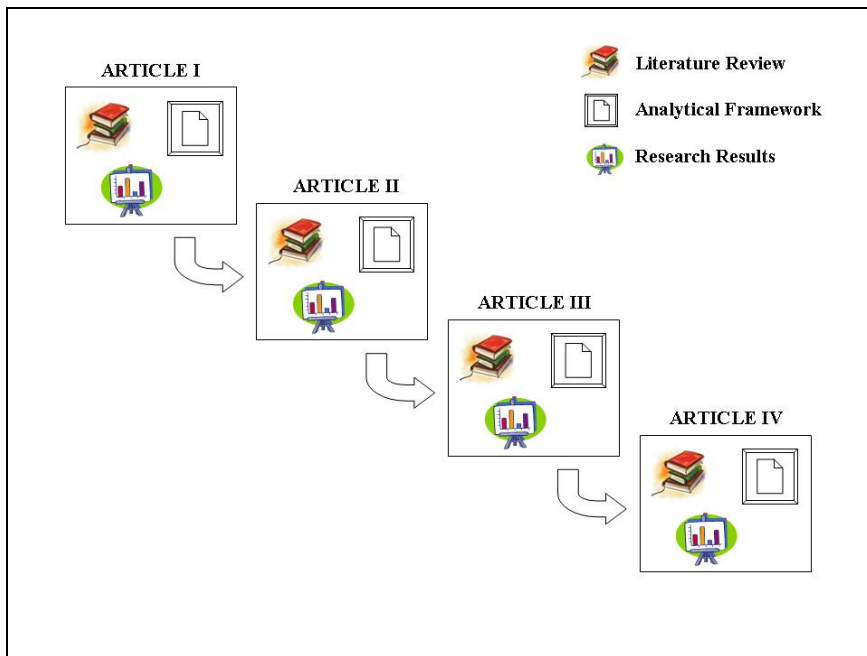


*Figure 2-3. Inductive and Deductive Strategies*

### **2.4.1 Background to the Analytical Frameworks**

Undertaking innovative research work demands an iterative process involving a back and forth between data and concepts, and between formulation and critique (Connel, 1985). The research process follows its own path. If a researcher knew its course in advance, the research would not be worth doing (Teitelbaum, 2003). At the same time there are certain tasks or elements that are present in most research projects. The development and use of analytical frameworks is such an element, which is intimately connected with the overall research methodology.

An analytical framework is a way of conceptualising and interpreting the world around us (Teitelbaum, 2003). They can be used as a source of inspiration for identifying, collecting and analysing data (Bryman, 2004). In a thesis based on articles it is suggested in the literature to build on each of the publications (Connel, 1985). In other words, the literature review and data collection, the analytical framework and data analysis, and the research results or findings should link together and form a well-defined path (see Figure 2-4).



*Figure 2-4. Research Process I*

In this thesis, the research process has followed a similar path to that suggested in the literature with some deviations (see Figure 2-5). Participating in a major European project on bioenergy, namely the Bioenergy NoE, heavily influenced the research work by the author. The articles reflect the changing focus of the Bioenergy NoE during the period 2004-2007. Furthermore, the author applied a number of interconnected analytical frameworks to explore different topics of interest rather than a single technique.

The articles in this thesis have shifted focus starting with contexts and potentials for bioenergy and renewable energy in Article I, which was

primarily based on a wide literature review. In Article II, Article III and Article IV the emphasis was on key drivers and barriers for bioenergy systems. Finally, the research work on energy crops in Article V and liquid biofuels in Article VI concentrated more on recommendations for policies and actions. This general description of the research process shows the evolution in the thesis work.

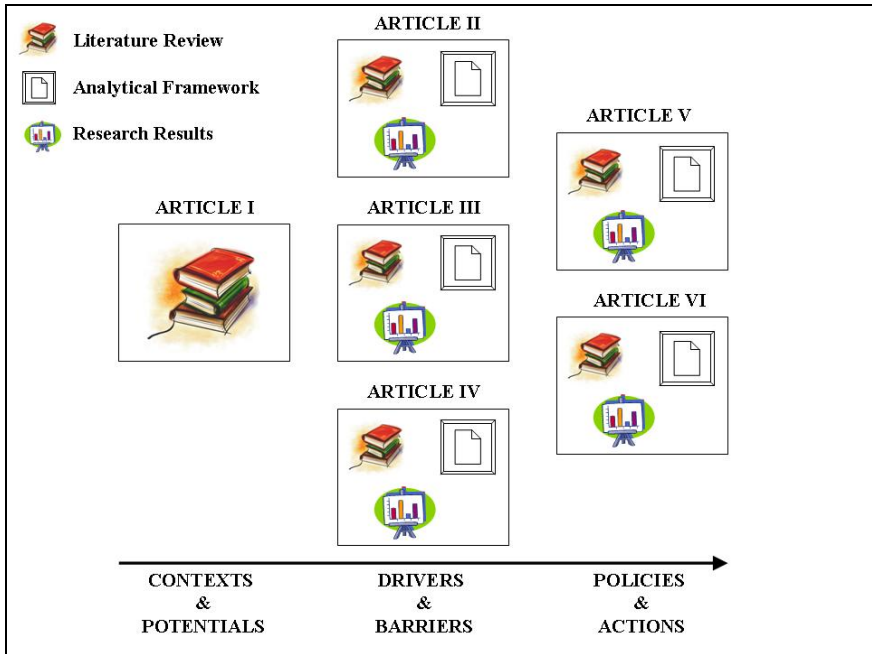


Figure 2-5. Research Process II

## 2.4.2 Development of the Analytical Frameworks

In this thesis work, the articles utilise several analytical frameworks, which are interconnected and overlap (Figure 2-6). The analytical frameworks applied to better understand bioenergy systems could be grouped into 4 main blocks. These include drivers, barriers, components and factors, and markets, institutions, actors and networks. It is important to recognise that any analytical framework is an attempt to provide some simplistic order to an infinitely complex world. So caution is needed when interpreting results or findings.

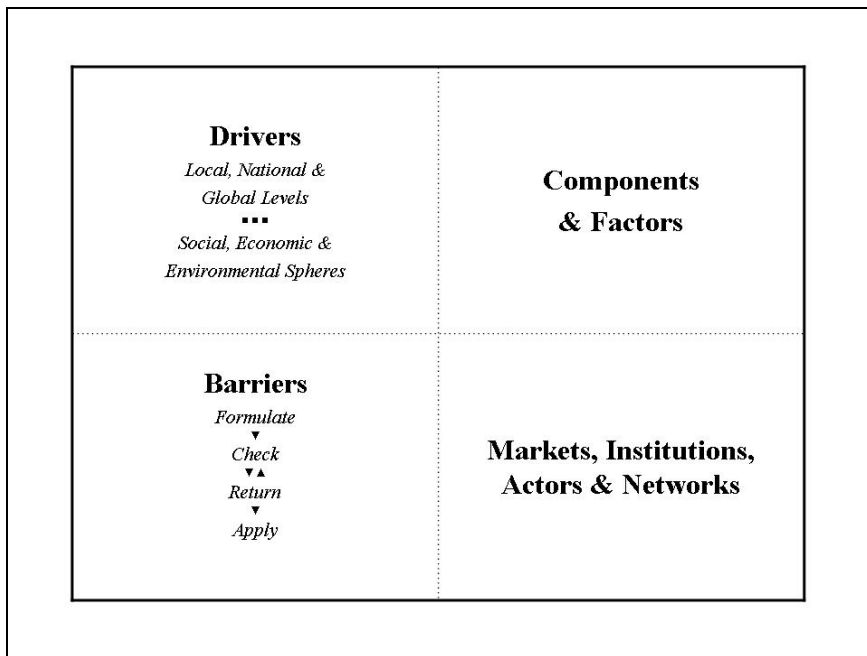


Figure 2-6. Analytical Frameworks

**Components and Factors:** The research work in Article II is based on a basic framework involving components and factors (see Figure 2-7). It is observable from the case studies and the literature that bioenergy systems comprise a number of main technical components, which include biomass resources, supply systems, conversion technologies and energy services (Fagernäs et al., 2006; Sims, 2002). These technical components are not necessarily in a linear order. For example, supply systems may be required in several parts of the chain. In most cases, if not all, bioenergy systems contain each of the components.

Adding to the complexity of bioenergy systems is the influence of non-technical factors (Costello & Finnell, 1998). While technical issues tend to be relatively straightforward to identify, Rösch & Kaltschmitt (1999) emphasise the importance of investigating non-technical issues in parallel. Article II identifies and explores sustainability issues, institutional relationships, and market conditions through an in-depth case study on a pioneering bioenergy system in Sweden. What constitutes the major non-technical factors for the success or failure of bioenergy systems in general is explored throughout the articles.

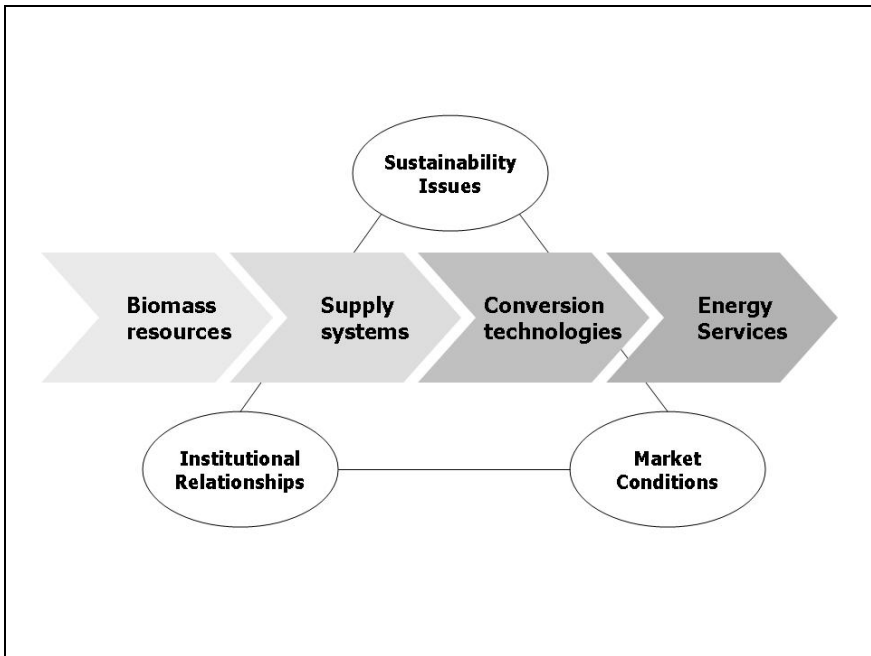


Figure 2-7. Components and Factors

**Drivers for Bioenergy:** The literature identifies a number of drivers for expanding bioenergy, particularly combating climate change and improving energy security (Boyle, 2004; European Commission, 2005b). In Article III, the author explores key drivers for bioenergy systems in Sweden by analysing the benefits associated with bioenergy across local, national and global levels, as well as social, economic and environmental spheres. This analysis highlights the potential benefits and/or drivers from well-planned bioenergy systems, particularly in terms of promoting regional development activity.

It can be confusing with the terms ‘benefits’ and ‘drivers’. Bioenergy systems result in impacts (both positive and negative). Benefits are defined here as positive impacts associated with the implementation of bioenergy systems. These benefits can act as drivers for bioenergy systems. However, it is important to recognise that benefits are not always sufficient to be effective drivers, especially for investors (Carter, 2001). It generally depends ‘who benefits?’ and ‘who pays?’ (Hahn, 2000). In many cases, benefits flow to the local community or national goals but not directly to investors.

**Barriers for Bioenergy:** In Article IV, the author engaged in a research process to identify, analyse, and test assumptions about key barriers to bioenergy by utilising a set of case studies. In collaboration with other researchers from the Bioenergy NoE, the author identified a range of constraining factors for the implementation of bioenergy systems. A group of case studies was then selected to explore these factors or barriers in greater depth. This research work built on Roos et al. (1999) who analysed barriers and drivers for bioenergy, labelled as critical factors.

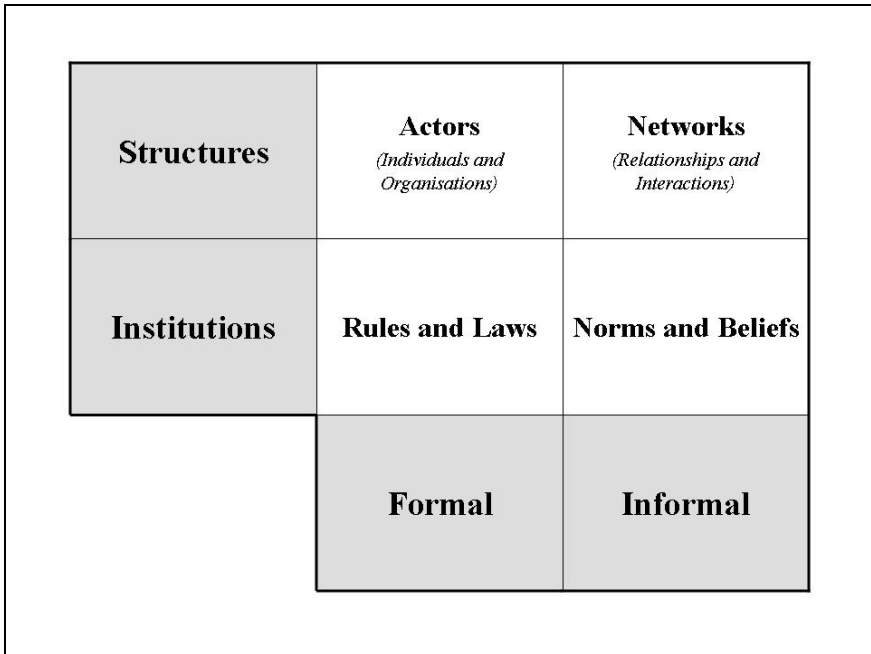
The procedure sketched for the barrier analysis involved 4 steps. First, formulate theoretical barriers appearing to obstruct the development of bioenergy. Second, check if the barriers can explain the difference between achieving success and unrealised potential in a set of case studies through interviews, observations, discussions, and documents. Third, if the barriers are not sufficient to explain the difference, return to the theoretical barriers. Fourth, otherwise, check if the understanding of key barriers is able to assist in transforming case studies from unrealised potential to success.

Testing if the understanding of key barriers for bioenergy is able to support transformations in the case studies required interactions with key stakeholders. The IIIIEE and Bioenergy NoE have initiated collaboration with actors developing bioenergy systems in Umbertide, Italy and Vansbro, Sweden (as discussed earlier in this thesis). The approach itself appears to be a beneficial exercise for stimulating learning processes both for researchers and the actors engaged in bioenergy systems.

**Markets, Actors, Networks and Institutions:** The analytical framework utilised in Article VI to explore markets for liquid biofuels in Germany and the UK is closely linked to the conceptual framework developed by Jacobsson & Johnson (2000). It distinguishes between the components and the functions of technological systems, which can be defined as networks of actors interacting, competing and collaborating to generate, diffuse and utilise technology (Organisation for Economic Co-operation and Development & International Energy Agency, 2003). The conceptual framework highlights the important role of markets, actors, networks and institutions for technological systems.

Markets are commonly understood as mechanisms for the trade of goods and services. However, it is important and useful to define the other key terms of actors, networks and institutions (see Figure 2-8). Actors are either individuals or organisations. Formal structures with specific functions that

are created by groups of individuals can be labelled as organisations (Considine, 1994; Ornetzeder & Rohracher, 2006). Networks often act as informal structures, which link actors together, both inside and between organisations (Aldrich & Fiol, 1994; Edquist & Hommen, 1999).



*Figure 2-8. Actors, Networks and Institutions*

Geels (2004) ‘opens the black box’ of institutions to discuss innovation and technological systems adopting the concept of rules. The different kinds of rules consist of regulative, normative and cognitive (Scott, 1995). Regulative rules constrain behaviour and regulate interactions. They involve rewards and punishments enforced by sanctions. Normative rules are related to values, norms and duties. Cognitive rules are linked to the frames through which meaning and understanding are achieved. They are connected to symbols (words, concepts and myths).

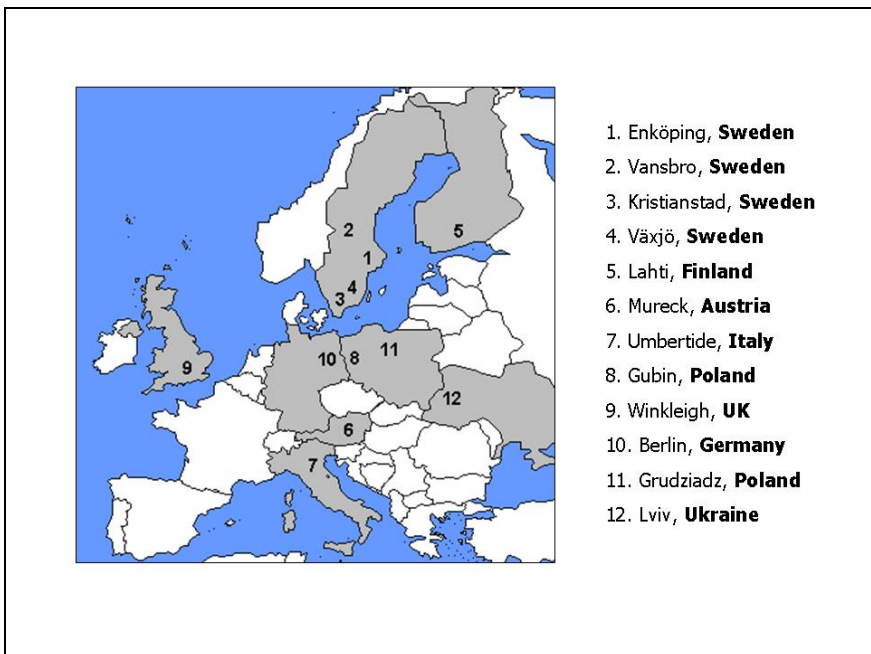
The author interprets institutions as either formal or informal. Laws and rules are formal institutions that regulate relations between individuals and organisations. But the ‘rules of the game’ that govern markets for liquid biofuels (or bioenergy more generally) are not often explicit. Informal institutions in the form of norms and beliefs play a significant role in the ‘real’ world (Considine, 1994; Edquist, 2004). The distinction between

formal and informal in terms of structures and institutions highlights the need for a deeper understanding of both the 'visible' and 'invisible' (Olsson & Sjöstedt, 2004).

# CHAPTER THREE

## 3. Description and Analysis

Developing and analysing case studies has formed a major part of this thesis. A total of 12 case studies in 8 countries in Europe have been explored (see Figure 3-1). This chapter provides a summary of the case studies, and it briefly presents each of the articles. This chapter also integrates the findings of the articles and case studies to investigate key drivers and barriers, and experiences with policies and actions for bioenergy systems generally, and more specifically for energy crops and liquid biofuels. Further detailed analysis and findings are contained within the articles.



*Figure 3-1. Case Studies in Europe*

### 3.1 Summary of Case Studies

As stated, this research work has involved 12 case studies on bioenergy systems located in 8 different countries in Europe. These include Sweden, Finland, Austria, Italy, the UK, Germany, and Poland, which are Member States of the EU, and, in addition, the Ukraine (see Figure 3-2). Most of the case studies are discussed directly in the articles. However, some of the recent research findings on Poland and the Ukraine have not been published externally. Further investigations in Poland and the Ukraine are important next steps for the progress of this research.

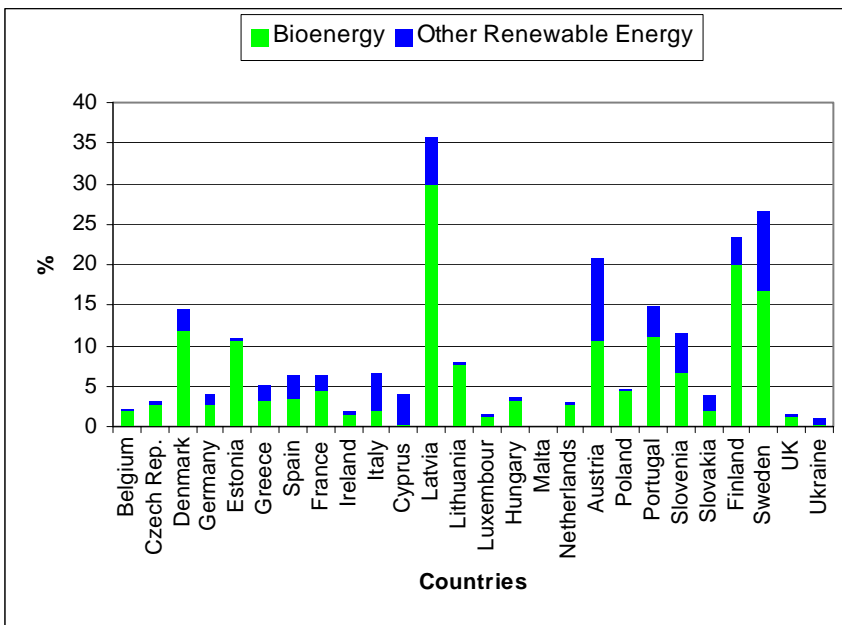


Figure 3-2. Bioenergy Utilisation in Europe in 2004 (%) in the Primary Energy Supply

Source: European Commission (2006a); International Energy Agency (2007b)

Note: The data for the Ukraine on bioenergy includes combustible renewables and wastes.

The selection of case studies from across Europe is based on an interest by the author to explore experiences with bioenergy in different contexts. Only a few Member States in the EU could be described as having significant shares of bioenergy. The utilisation of biomass for energy purposes varies greatly between Member States depending on a range of factors, including policies and strategies for renewable energy, available natural resources, and

the structure of energy systems (European Renewable Energy Council, 2004).

The countries in Europe with large shares of bioenergy include Sweden, Finland and Austria, which have large forest resources, strong forestry industries, extensive district heating systems, and a long history of policy measures for bioenergy. As a small country, Latvia also has an impressive share of bioenergy. In absolute terms, France, Germany, Sweden and Finland utilise the most biomass for energy purposes (see Figure 3-3). However, no Member States are fully utilising their capacity for bioenergy (Ericsson & Nilsson, 2006; Fagernäs et al., 2006).

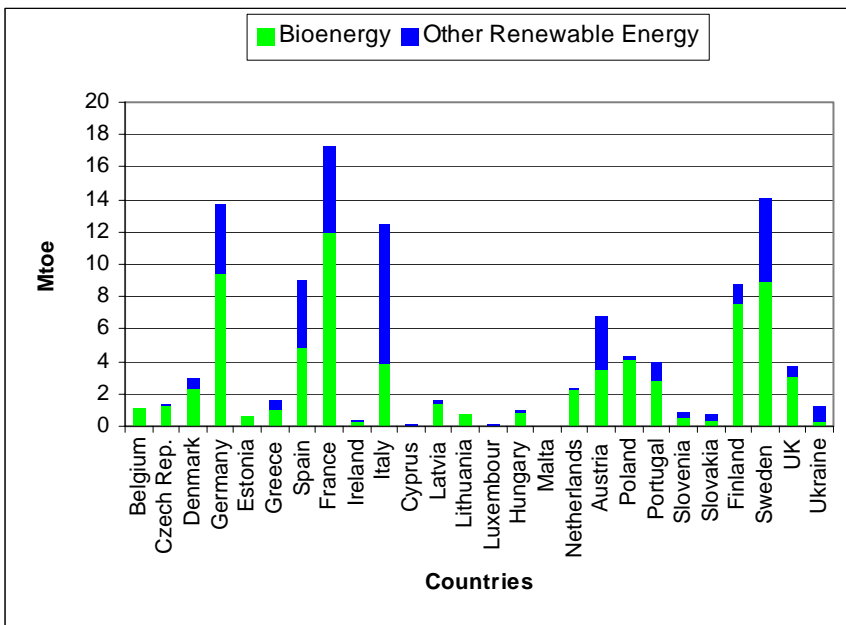


Figure 3-3. Bioenergy Utilisation in Europe in 2004 (Mtoe) in the Primary Energy Supply

Source: European Commission (2006a); International Energy Agency (2007b)

Note: The data for the Ukraine on bioenergy includes combustible renewables and wastes.

Sweden, Finland and Austria can be considered leading countries on bioenergy utilisation (Fagernäs et al., 2006). Italy and the UK in Western Europe are only starting to expand the implementation of bioenergy systems. The experiences in Eastern Europe are also relevant because of

their large biomass production potentials. Poland and the Ukraine in particular could become exporters of solid and liquid biofuels to other parts of Europe. This thesis therefore explores countries from Western Europe (including the pioneering Member States and those in the infant stages of developing bioenergy) and Eastern Europe.

The IIIIEE in collaboration with the Bioenergy NoE have explored and analysed bioenergy utilisation in a number of Member States (see Appendix E). The case studies developed in this thesis work provide insights into the situations of different countries in Europe, and when combined with the work from the IIIIEE and Bioenergy NoE, the broader European progress on advancing the implementation of bioenergy systems (see Appendix F). The investigation of 8 countries from across Europe highlights similarities and differences, and points on interest for European policy.

### ***3.2 Summary of Articles***

While the potentials for renewable energy are very large, the demand for technologies is strongly linked to the market situation, and can be dramatically affected by policy measures. Article I reviews the literature on resources, technologies and markets for renewable energy (particularly bioenergy), and outlines recommendations, including: understanding local renewable energy flows; supporting all steps in the innovation chain for technologies and systems; setting ambitious but realistic targets and timetables in combination with effective policy measures; and developing methods and procedures for calculating the value of distributed energy generation. This article provides the foundations for the thesis.

Article II investigates the evolution of a pioneering bioenergy system in Enköping in Sweden, and identifies 3 important conditions that explain the success. First, the introduction of the carbon tax in Sweden provided market conditions making bioenergy sufficiently competitive with fossil fuels. Second, the know-how developed by the local energy companies through experimentation and collaboration with research institutions encouraged investments in local opportunities. Third, the formation of partnerships in a regional network of actors (including private companies, research institutions, and local government) helped to co-ordinate the development of the bioenergy system.

Many studies on bioenergy identify combating climate change and improving energy security as key drivers for the implementation of bioenergy systems (European Renewable Energy Council, 2004; Sims, 2002). Article III explores 4 bioenergy systems in Sweden and highlights how they also stimulate regional development activity, including: distribution and diversification of energy systems based on locally available biomass resources; partnerships and synergies, particularly for industries that produce waste or by-products; business and employment opportunities generated along the whole bioenergy chain; and environment and landscape goals achieved through well-planned bioenergy systems.<sup>15</sup>

Article IV suggests that economic conditions, know-how and institutional capacity, and supply chain co-ordination are potentially key barriers obstructing the implementation of bioenergy systems in Europe. This article, based on case studies, industry interactions and research workshops, also exposes 4 points about barriers to bioenergy. First, there are no absolute barriers to realising the EU targets on bioenergy utilisation. Second, it is non-technical challenges that are hindering bioenergy rather than technical issues. Third, barriers for bioenergy are dynamic and depend on the context. Fourth, there are consistent policies and actions observed in the case studies to overcome barriers.

Article V investigates the perspective of farmers from Umbertide in Italy, Enköping in Sweden, and Mureck in Austria on the CAP reforms that aim to facilitate investments in energy crops. Farmers and agricultural associations communicate a range of barriers hindering energy crops. To accelerate the diffusion of energy crops in Europe, this article proposes that the CAP could act as the main policy framework to co-ordinate support on a number of fronts, including: introduce establishment subsidies; expand information campaigns; initiate demonstration projects; support agricultural cooperatives; subsidise (small-scale) conversion technologies; evaluate landscape changes; and promote multiple benefits.<sup>16</sup>

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<sup>15</sup> This article was presented in Australia to an audience from various parts of the Asia-Pacific. The majority of the audience were not knowledgeable of bioenergy. Some members of the audience could also be considered opponents to bioenergy. Part of the challenge was to communicate the lessons learned from Sweden and Europe to 'non-experts' and 'non-believers'. This learning experience was incorporated into later presentations and articles.

<sup>16</sup> This article was presented to an audience of 'experts' on bioenergy. The author received valuable feedback from a range of participants, which was later incorporated into the final version of the article.

Article VI describes, compares, and analyses the development and diffusion of biodiesel and bioethanol, and the socio-political context for the biofuels industry, in Germany and the UK. It aims to contribute to discussion on the formation and evolution of markets for liquid biofuels in the EU. This article derives a range of general conclusions from the assessment of the German and British experiences with biodiesel and bioethanol that are particularly relevant for the early stages of a biofuels industry. To facilitate comparison between Germany and the UK this article utilised an analytical framework involving markets, actors, networks and institutions.

### ***3.3 Drivers and Barriers***

The first research objective for this thesis is to identify and analyse key drivers and barriers for the implementation of bioenergy systems in different contexts in Europe. It essentially tackles: “why is there a problem?” In this section there are 2 parts:

- The first part looks at key drivers for bioenergy systems in Sweden focusing on how regional development activity has been stimulated in 4 case studies.
- The second part is based on 8 case studies from different countries, research workshops, and industry interactions to explore key barriers for bioenergy systems in Europe.

#### **3.3.1 Key Drivers for Bioenergy Systems**

The location, scale and management of bioenergy systems shape their impacts (both positive and negative). Many studies of bioenergy identify combating climate change and improving energy security as positive impacts from bioenergy and therefore key drivers (European Renewable Energy Council, 2004; Sims, 2002). Promoting regional development is also often identified in the literature although it is not well explored by empirical studies (see Table 3-1). This thesis investigates regional development activity associated with bioenergy systems in 4 case studies from Sweden.

The case studies in this thesis suggest there can be a number of benefits that flow from bioenergy systems to local and regional actors in Sweden. These benefits appear to be key drivers for investments in bioenergy. McKay (2005) makes similar observations from woodfuel projects in the UK. For

local and regional actors, global environmental issues are of lower relative importance. The wide range of benefits from woodfuel projects is higher on the local community agenda. Economic reasons and regional development are prevailing determinants of support for woodfuel projects in the UK (McKay, 2005).

*Table 3-1. Drivers for Bioenergy Systems*

<b>Drivers</b>	<b>Comments</b>
Combating climate change	Bioenergy systems can decrease greenhouse gas emissions if replacing fossil fuels, establishing energy crops, or integrating with carbon capture and storage.
Improving energy security	Bioenergy systems can increase the resilience of energy systems because of the range of viable biomass inputs, the different conversion technologies, and the options for energy outputs.
Promoting regional development	Bioenergy systems can promote distributed and diversified energy systems. Bioenergy systems can stimulate partnerships to exploit synergies. Bioenergy systems can generate (direct and indirect) employment and business. Bioenergy systems can support environment and landscape goals.

**Distribution and diversification:** In the 1970s there was an interest in Sweden to diminish the reliance on imported oil. In a referendum in the 1980s it was decided to shift away from nuclear power (Swedish Energy Agency, 2004). The concerns with nuclear power and imported oil have helped to promote distributed and diversified energy systems in Sweden primarily based on bioenergy. The introduction of the carbon tax in the 1990s, which only applies to heat, has stimulated a significant shift from fossil fuels to utilising a range of biomass resources in district heating systems (Swedish Energy Agency, 2004).

In the Kristianstad case study and Växjö case study the local governments have committed to become Fossil Fuel Free (FFF). The goal is to replace all fossil fuels for electricity, heat, and fuels for transport with renewable energy (and through improved energy efficiency). The aim to become FFF appears

to stimulate distributed and diversified energy systems often based on bioenergy. For example, in the town of Kristianstad the local government has invested in a CHP plant based on biomass and a biogas plant, converted boilers in public buildings from oil to biomass, and initiated the use of biogas in public buses.

Agriculture residues and organic waste are likely to be utilised predominantly in regional systems. For example, in the Enköping case study a range of biomass resources collected in the region are utilised to supply heat and electricity to the town of Enköping. In contrast, energy crops and forest residues can be transformed into internationally tradable products. For example, in the Vansbro case study there is production of wood pellets from forest residues (obtained through thinning the local forests) with expected markets both nationally and internationally.

**Partnerships and synergies:** Many bioenergy systems in Sweden are linked to industries that produce waste or by-products. These by-products can be transformed into co-products when coupled with bioenergy (Roos et al., 1999).<sup>17</sup> For example, the biogas plant in the Kristianstad case study illustrates how waste can be utilised in bioenergy systems. Waste from households, manure from agriculture, and waste from the food industry is used for both energy and fertiliser. The biogas plant therefore transforms waste (of no value) into resources based on partnerships with waste management companies.

Actors involved in bioenergy systems are often stimulated to look for synergies and possibilities for collaboration once projects have been initiated. In the Enköping case study, the local government decided to apply the nitrogen rich water from their treatment facility for wastewater on energy crops to meet an agreement on the health of the Baltic Sea. Under this agreement each local government in Sweden is required to reduce nitrogen leakage to the Baltic Sea by 50 percent. The collaboration in Enköping engaged several actors to harvest energy crops, utilise wastewater and reduce nitrogen leakage.

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<sup>17</sup> Many industries produce waste or by-products that are collected by waste management companies and transported to landfills. Bioenergy systems often open up opportunities to utilise by-products, which can therefore transform what is viewed as waste destined for landfills into co-products of value.

There are some 15,000 ha of energy crops (predominantly willow) in Sweden (Helby, Rosenqvist, & Roos, 2006). This represents only a minor contribution to bioenergy at present. However, energy crops are expected to play a fairly significant role in the future energy supply in Sweden (Commission on Oil Independence, 2006).<sup>18</sup> The Enköping case study highlights the challenges of building partnerships between energy companies and farmers. Interestingly, the energy companies have leased land from local farmers to plant and harvest energy crops because the farmers are unwilling to invest in energy crops themselves.<sup>19</sup>

**Business and employment:** Bioenergy systems involve many activities that can generate employment opportunities and business partnerships. The production and utilisation of biomass requires harvesting, transporting, and distributing. Equipment and technology is manufactured and contracts are signed to provide the biomass resources, maintain the supply systems, establish the conversion technologies, and generate the energy services. Business and employment is stimulated across several sectors and different actors.

Only about 50 percent of a tree is utilised when it is felled for the purpose of providing wood products or paper. The remaining 50 percent can be used for energy utilisation (Kåberger, 2004). Furthermore, after the wood products or paper have served the intended purposes and the opportunities for recycling are exhausted, most of the energy content is recoverable. If this viewpoint is taken, bioenergy is not competing with the forest industry. On the contrary, in Sweden, bioenergy is important to the viability of the forest industry in general and sawmills in particular (Swedish Bioenergy Association, 2003).

As suggested, bioenergy systems can generate both direct and indirect employment (Boyle, 2004). The employment generated through bioenergy systems is closely connected to stimulating regional development activity. In the Vansbro case study the local employment and regional development associated with the production of wood pellets were crucial factors in further investments in bioenergy. The utilisation of local biomass resources

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<sup>18</sup> There are estimates (or projections) of some 300,000 ha to 500,000 of energy crops to help replace fossil fuels (Commission on Oil Independence, 2006).

<sup>19</sup> For a more in-depth analysis of the challenges facing the widespread diffusion of energy crops in Europe see Article V.

implies that expenditure on energy provision is retained in the local community and re-circulated.

**Environment and landscape:** Utilising biomass resources for energy purposes requires management and planning to meet the goals of sustainable development. In Sweden, forestry practices have improved in terms of preserving habitats and biodiversity in combination with expanding demands for bioenergy (Kåberger, 2004). In fact, the health and productivity of forests relies on thinning and managing the forests (Swedish Bioenergy Association, 2003). For example, in the Vansbro case study the need for thinning forests was linked directly with the development of a wood pellets plant.

When biomass resources are harvested from forests for energy purposes the nutrients and minerals are diminished in the forest soils. Ash recycling after stabilisation is feasible with almost 100 percent of all nutrients and minerals contained in the ash, except nitrogen (Swedish Bioenergy Association, 2003). In the Växjö case study it is recognised that ash recycling is necessary in a bioenergy system (designed to promote sustainable development), which has resulted in trials with ash recycling. In the Enköping case study the ash is returned to the forests.

A number of environment and landscape goals can be achieved when establishing energy crops. They can act as visual or wind barriers on the landscape, prevent erosion and soil degradation, and create habitats for birds and mammals thereby supporting greater biodiversity on agricultural land (Kåberger, 2004). Furthermore, energy crops can be used to restore degraded land. For example, cadmium in fertilisers has resulted in undesired levels of cadmium in agricultural land. Willow has the capacity to absorb cadmium, so planting willow and storing the ash after combustion can diminish levels of cadmium in agricultural land (Swedish Bioenergy Association, 2003).

### **3.3.2 Key Barriers for Bioenergy Systems**

Studies on barriers obstructing the development and diffusion of bioenergy systems often take different analytical perspectives (see Table 3-2). These studies tend to produce lists of many types of barriers. Based on case studies, research workshops and industry interactions, this thesis work identified economic conditions, know-how and institutional capacity, and supply chain co-ordination as potentially key barriers for expanding

bioenergy in Europe.<sup>20</sup> The case studies from Sweden, Finland, Austria, Italy, Poland, the Ukraine, Germany and the UK illustrate that success is achieved in bioenergy systems by overcoming all of the key barriers.

*Table 3-2. Barriers for Bioenergy Systems*

<b>Source</b>	<b>Identification of Barriers</b>	<b>Analysis of Barriers</b>
Costello & Finnell (1998)	Regulatory Financial Infrastructural Perceptual	Analysis of institutional challenges for the implementation of bioenergy systems.
Roos et al. (1999)	Integration Scale effects Competition within biomass sectors Competition with different sectors National policy Local policy and opinion	Analysis of both drivers and barriers for bioenergy labelled as critical factors.
Rösch & Kaltschmitt (1999)	Financial Administrative Operational and organisational Perceptual	Analysis concentrates on non-technical challenges for expanding bioenergy rather than technical issues.
Turkenburg (2000)	Costs of biomass Conversion technologies Supply systems Features of biomass Socio-economic issues Organisational barriers Public acceptability Ecological aspects Competition for land	Analysis identifies a range of barriers obstructing the implementation of bioenergy systems.
Sims (2002)	Economic Technical Environmental Social Policy Perception	Analysis highlights the many commercial opportunities for bioenergy and the barriers to commercial investments.

<sup>20</sup> Since the publication of Article IV the author has made a number of improvements on the arguments presented. These changes are addressed here.

There are 3 main points that deserve attention in regards to key barriers for bioenergy systems in Europe. First, it is non-technical issues that dominate key barriers. While resolving technical issues is important there appear to be no technical issues that are key barriers to meeting EU targets on bioenergy utilisation. Second, a number of barriers in the literature merge into the key barriers identified in this research. Third, as indicated, there is a range of obstacles suggested in the literature. The purpose of analysing key barriers is to identify the challenges of primary importance that Member States and the EU need to confront to expand bioenergy.

**Economic conditions:** Initiating bioenergy systems requires overcoming many obstacles related to economic conditions, which are heavily influenced by political support and policy measures (Fagernäs et al., 2006). Economic conditions have both a broad context and specific issues for investors. Broadly speaking, bioenergy systems compete with fossil fuels and nuclear power, which have the advantage of both energy subsidies and externalised costs.<sup>21</sup> Furthermore, the positive impacts or benefits of bioenergy systems are rarely recognised in energy markets (without supportive policy measures).

More specifically, the case studies from Sweden, Finland, Austria, Italy, Poland, the Ukraine, Germany and the UK highlight that investors face a number of significant obstacles to implement (and invest in) bioenergy systems. Put simply, the obstacles relate to ‘who pays?’ and ‘who benefits?’ in relation to bioenergy systems. Investment grants, carbon and energy taxes, and green certificate schemes are all evident in the case studies as ways to recognise (and value) externalised benefits of bioenergy systems that do not flow to investors but rather to the local community or national goals (Hahn, 2000).

There is distorted competition in energy markets linked primarily to energy subsidies. A report by the European Environment Agency (2004) provides an assessment of energy subsidies in the EU.<sup>22</sup> While there is no agreed definition for energy subsidies (resulting in different estimates and confusing debates) the report concludes that fossil fuels and nuclear power continue to

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<sup>21</sup> The term externalities refers to a cost or benefit from any activity that affects actors ‘external’ to the activity. In other words, the ‘internal’ actors do not bear all of the costs or reap all of the benefits. Externalities can be either positive, when externalised benefits are generated, or negative, when externalised costs are imposed upon others (Carter, 2001).

<sup>22</sup> Visit <http://www.externe.info/> for more information on energy subsidies.

profit from energy subsidies. It also argues that sustained support is needed for renewable energy to shift towards sustainable energy systems.

In order to expand renewable energy it is also important to consider externalised costs, which are often excluded from energy markets. A report for the European Commission (2003) on externalised costs outlines the negative impacts of fossil fuels, nuclear power, and renewable energy.<sup>23</sup> Not surprisingly, fossil fuels and nuclear power produce significant negative impacts compared to renewable energy. For renewable energy to compete with fossil fuels and nuclear power, it is crucial that externalised costs are internalised in energy markets in some way through policy measures (Forsyth, 2003).

As stated, bioenergy systems often produce positive impacts that are not compensated by energy markets, including improving energy security, combating climate change, and promoting regional development (Boyle, 2004; European Commission, 2005b). These externalised benefits are often described and documented by investors. However, it is rare that the positive impacts of bioenergy are able to actually support investors (Sims, 2002). For example, in the Winkleigh case study there are a number of benefits associated with the development of a bioenergy system. However, investors cannot incorporate these benefits into evaluations.

Investment grants were critical to establishing the bioenergy systems in both the Enköping case study and the Mureck case study. In the Enköping case study the investment grants accounted for approximately 40 percent of the investment costs. In the Mureck case study there are several connected bioenergy systems, which received investment grants between approximately 30 percent and 75 percent of the total investment costs. Investment grants are used as interventions in energy markets to recognise externalised benefits and therefore promote sustainable energy systems (Carter, 2001).

The carbon tax in Sweden has altered economic conditions making bioenergy sufficiently competitive with fossil fuels for heat production, which is evident in the Enköping case study.<sup>24</sup> Recently, a green certificate

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<sup>23</sup> Visit <http://reports.eea.eu.int/> for more information on externalised costs.

<sup>24</sup> In 1991 the Swedish Government imposed a carbon tax on greenhouse gas emissions from the combustion of fossil fuels to produce heat (Swedish Energy Agency, 2004). However, since 2004 the carbon tax has been adjusted and reduced by the Swedish Government.

scheme has provided further incentives for electricity from biomass in Sweden.<sup>25</sup> In Finland, there is research and development, carbon and energy taxes, and investment grants, dedicated to expanding renewable energy. The Lahti case study highlights the positive effects of national policy measures in Finland. This support (in Sweden and Finland) is in explicit recognition of the positive impacts associated with bioenergy systems (and negative impacts of fossil fuels), and the fact they are not recognised by energy markets.

The dependence on energy imports in Italy is expanding interest in renewable energy. The implementation of a green certificate scheme has also improved the profitability of renewable energy. However, bioenergy systems in Italy, as explored in the Umbertide case study, require further support to compete with energy imports. The Gubin case study shows that there is no effective enforcement of national policy measures and no significant incentives for energy crops in Poland. If bioenergy is to expand in Poland and the EU then it is imperative to create favourable economic conditions for farmers to invest in energy crops (Gosse, 2006).

**Know-how and institutional capacity:** When it comes to establishing bioenergy systems a combination of know-how (knowledge and skills) and institutional capacity is needed to shift from unrealised potential to success. A lack of understanding of the bioenergy industry by the finance sector may be a barrier as well as a lack of experienced maintenance staff. The required know-how may be developed in existing actors through learning processes as well as by the introduction of new actors. In the Gubin case study, Agrobränsle (a company from Sweden) has assisted with cultivating energy crops in Poland.

Learning processes are evident in the Enköping case study where the local energy companies developed experience with bioenergy in the decades that followed the oil crises in the 1970s. In the Lahti case study, there was confidence in the reliability of conversion technologies and availability of biomass resources, which resulted in a swift installation and transition to exploiting bioenergy. In contrast, there is modest knowledge and skills with bioenergy in the Umbertide case study. Confidence to make investments is

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<sup>25</sup> The effects of the green certificate scheme in Sweden are debateable. While green certificates are intended to support bioenergy systems, they also create uncertainty for investors because it is extremely difficult to predict the evolution of prices for green certificates (Jacobsson, 2006).

therefore fragile. In the Gubin case study it is apparent that utilities in Poland have little experience with renewable energy and significant interests in fossil fuels.

Energy crops are expected to play an important role in expanding bioenergy in the EU and across Member States (European Commission, 2005a). However, farmers often have minimal experience with growing, processing, storing, and transporting energy crops. Uncertainty based on a lack of experience discourages many farmers from investing in energy crops. In the Enköping case study, farmers thinking about establishing dedicated energy crops have articulated serious concerns over flexibility, knowledge, and risks. Even when farmers are convinced of the long-term viability of energy crops, they are often too concerned by short-term effects on their work practices and economic flows.

There are considerable possibilities for expanding energy crops in Poland and the Ukraine (Ericsson & Nilsson, 2006). However, the Grudziadz case study and the Lviv case study indicate that farmers are in desperate need of support and demonstrations of biomass production. In the Lviv case study the common response by farmers about their views on energy crops is 'they believe what they see and not what they hear'. Since there are few examples of profitable plantations of energy crops in the Ukraine the vast majority of farmers show little interest to invest any resources (or time) into bioenergy systems.

Bioenergy is often considered a fuel of the past rather than a fuel of the present and future (Hall & Scrase, 1998). An improved understanding of bioenergy systems by the public and politicians is important to generate the support necessary for expanding bioenergy in the EU. In fact, a limited awareness of bioenergy often results in resistance to viable and profitable bioenergy systems as demonstrated in the Winkleigh case study in the UK. Altering the perceptions of both the public and politicians about utilising biomass for energy purposes is closely linked to building up the legitimacy of the bioenergy industry.

In the Umbertide case study, there is opposition to bioenergy because it is perceived as waste incineration. What causes some of the confusion is that biomass resources in Italy are legally categorised as waste. It is therefore

commercially difficult to exploit bioenergy.<sup>26</sup> In contrast, the reaction by the local community in the Lahti case study to the utilisation of Municipal Solid Waste (MSW) in the CHP plant is predominantly positive rather than the expected negative response. What appears important is that the profits from the CHP plant flow back into the local community and the management costs for disposing of MSW have declined.

**Supply chain co-ordination:** Bioenergy systems require functioning and organised supply chains that meet the needs of all relevant actors. Energy companies and biomass suppliers are significant actors in bioenergy systems. Investing in biomass resources is generally only possible if there are energy companies purchasing biomass. In addition, establishing conversion technologies is generally only possible if there are biomass suppliers supplying biomass.<sup>27</sup> Furthermore, technologies and systems are required for harvesting, refining, and transporting biomass. Supply chain co-ordination is therefore critical to the implementation of bioenergy systems across the EU.

The bioenergy system in the Mureck case study provides electricity, heat, and fuels for transport. The impressive cooperation between a regional network of actors is important to the success. The companies initiated cooperation because they recognised the advantage of working together. In the Enköping case study the formation of partnerships has helped to manage the expanding bioenergy system. In contrast, there are problems with establishing collaboration between companies and the local government in the Umbertide case study. There is a similar experience in the Gubin case study where bringing the actors together is difficult.

In some instances there is competition for biomass resources. In the Enköping case study, the local energy companies manage a bioenergy system that utilises a range of biomass resources. This bioenergy system allows flexibility in terms of inputs when competition arises for biomass.

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<sup>26</sup> Different definitions and legislation for waste across the Member States in the EU can present problems for investors in bioenergy systems (Fagernäs et al., 2006). When feedstocks are categorised as waste this often means more stringent legislation (and possibly different reactions from the public and politicians). On the other hand, when feedstocks receive a different classification it can be a more straightforward process for investors.

<sup>27</sup> This can be called the ‘chicken and egg’ problem. Essentially it highlights the challenge of investing in biomass resources at the same time as establishing conversion technologies. Neither can proceed without the other but it is difficult to draw up contracts that are acceptable to both energy companies and biomass suppliers (in many cases).

Competition for land is also a discussion when it comes to expanding energy crops (Gosse, 2006). In the Umbertide case study, the tobacco industry is hindering the introduction of energy crops. The tobacco industry is in transition. However, the already established (and heavily subsidised) tobacco plantations mean that farmers have little motivation to change to energy crops.

In contrast to issues of competition, there are often synergies between local actors when establishing bioenergy systems (Fagernäs et al., 2006; Sims, 2002). In the Mureck case study, farmers cultivate rapeseed, which is transformed into rapeseed cake and biodiesel. The rapeseed cake serves as a protein feed for livestock, and the biodiesel is used in local vehicles. Such examples are common in bioenergy systems. However, realising synergies often requires strong co-operation between a mix of local actors and supply chain co-ordination.

Energy crops are expected to play a considerable role in future bioenergy systems (Hall & Scrase, 1998). At present the contribution of energy crops in the EU is negligible (European Commission, 2005a). The Gubin case study illustrates the potentials for energy crops in Poland. However, supply chain co-ordination appears crucial to encourage farmers to invest in energy crops. Farmers need support, demonstrations, and contracts with energy companies. The Enköping case study also indicates that farmers remain unconvinced by energy companies about the viability and profitability of energy crops. Greater incentives are required to compensate the risks.

The Berlin case study highlights the possibilities for international trade of solid and liquid biofuels, at least within Europe. The energy companies operating the CHP plant in the Berlin case study were eager to utilise biomass for energy purposes but argued that there were limited biomass resources in Germany. However, over the border in Poland there are very large potentials for harvesting energy crops, which can be used locally and/or traded internationally. A challenge for farmers in the Gubin case study in Poland is to establish connections (and deals) with energy companies in Germany.

### ***3.4 Policies and Actions***

The second research objective for this thesis is to investigate and discuss experiences of supportive (and disruptive) policies and actions for the

implementation of bioenergy systems in Europe. Basically it addresses: “how to respond to the problem?” In this section there are 3 parts:

- The first part briefly outlines a number of policies and actions that are consistently identified in the case studies from across Europe as important to overcoming barriers. Furthermore, it discusses the role of supportive economic policies and partnerships between the public and private sectors in the development of bioenergy systems.
- The second part utilises case studies from Sweden, Austria and Italy to survey experiences with energy crops from the perspective of farmers and agricultural associations. It then suggests how the CAP could act as a policy framework to provide greater support for farmers to shift agricultural land to energy crops.
- The third part analyses and compares the development of liquid biofuels for transport in Germany and the UK concentrating on the role and experiences of key stakeholders. It then presents a range of general conclusions for policy-makers in the EU based on the German and British assessment.

### **3.4.1 Bioenergy Systems**

The term barrier is a metaphor for the constraining factors that affect the implementation of bioenergy systems. The danger associated with applying the term is that it suggests absolute barriers are obstructing bioenergy. Utilising a metaphor is an effective way to draw attention to the challenges for bioenergy. While there are key barriers for establishing bioenergy systems, this research identifies no absolute barriers to realising the EU targets on bioenergy utilisation. Interestingly, there are some consistent policies and actions evident in the case studies that are employed to overcome key barriers. On a general level, these include:

**Investment grants:** The initial investments in bioenergy systems are often stumbling blocks even if key stakeholders consider the financial returns of the overall project viable. Investment grants for conversion technologies were clearly vital for several bioenergy systems in the case studies.

**Policy measures:** Agreed and established national policy measures, such as green certificate schemes, feed-in tariffs, and carbon and energy taxes, were

critical to altering economic conditions and making bioenergy sufficiently competitive with fossil fuels in the successful case studies (see Table 3-3).

**Pilot projects:** Developing know-how and institutional capacity often requires pilot projects to stimulate learning processes. Such initial projects helped to also build legitimacy for bioenergy in the case studies.

**Local initiatives:** Programs and policies on climate change, environmental protection, and regional development are identified in the case studies as the foundations for local involvement from the public and politicians in bioenergy systems.

*Table 3-3. Examples of Policy Measures*

Types	Examples
Feed-in Tariffs	The recent introduction of feed-in tariffs for electricity from biogas in Germany is propelling new developments. What is significant is that the guaranteed revenue for up to 20 years allows investors to gain access to low-interest loans. Austria has also used feed-in tariffs for bioenergy.
Green Certificate Schemes	Both Sweden and Italy have green certificate schemes that aim to support electricity from biomass. However, the effectiveness of green certificates remains debatable. Primarily because it is extremely difficult to predict the evolution of prices for green certificates.
Energy and Carbon Taxes	The carbon tax in Sweden is probably the best-known example of successfully promoting bioenergy. Essentially, the carbon tax transformed conditions for utilising biomass for heat by penalising fossil fuels for producing greenhouse gas emissions. Finland also has energy and carbon taxes that promote bioenergy.

**Local champions:** The successful bioenergy systems in the case studies were all characterised by leading individuals, who were able to build networks between organisations and guide the development of projects.

**Supply contracts:** Contracts and agreements between biomass suppliers and energy companies are observed in the case studies as significant to establishing functioning bioenergy systems.

New technological systems, such as bioenergy systems, often require supportive economic policies (Carter, 2001). There are always debates about if subsidies should have sunset clauses and whether tax breaks are necessary. For the bioenergy industry there are 2 justifications for supportive economic policies. These include:

- First, bioenergy systems often have lower environmental impacts and greenhouse gas emissions compared to fossil fuels. However, these so-called externalised benefits are rarely recognised on energy markets (Boyle, 2004; Sims, 2002).
- Second, bioenergy systems may be competitive with fossil fuels in the long-term but require assistance in the short-term to establish a new technological system (Organisation for Economic Co-operation and Development & International Energy Agency, 2003; Turkenburg, 2000).

The second argument weakens as the bioenergy industry grows and strengthens. Supportive economic policies, such as subsidies, should therefore be temporary and involve sunset clauses (Kåberger, 2004). However, permanent tax breaks in relation to fossil fuels are justified because of the first argument on lower environmental impacts and greenhouse gas emissions. Permanent tax breaks therefore apply a value to these externalised benefits on energy markets (Hahn, 2000).

Public-Private Partnerships (PPPs) are evident in some of the case studies as ways to engage both public and private actors in the implementation of bioenergy systems. As explained, bioenergy systems often result in externalised benefits that flow to the local community or support national goals. PPPs combine the social responsibility, environmental awareness, and accountability of the public sector, with the finance, managerial efficiency, and entrepreneurial spirit of the private sector (Andersen, 2004; von Malmborg, 2003).

In the case studies, PPPs between local governments and investors to develop bioenergy systems can meet the objectives of both actors. For local governments, the so-called externalised benefits (such as creating local employment and meeting environmental targets) are obtained by collaborating with the investors. For the investors, the support from the local governments can provide the necessary ingredient to invest in

bioenergy systems. However, there are challenges to define the roles of different actors in PPPs (Andersen, 2004).

### **3.4.2 Energy Crops<sup>28</sup>**

**Experiences from Sweden, Italy and Austria:** The case studies from Sweden, Italy and Austria highlight drivers and barriers for energy crops from the perspective of farmers, and also show the range of new opportunities for farmers related to bioenergy systems. The case studies involved face-to-face interviews with farmers and agricultural associations. The single payment scheme in the CAP allows greater flexibility for farmers, and permits energy crops as an option on agricultural land. However, the case studies suggest that the aid of 45 €/ha for energy crops on agricultural land and the permission to harvest energy crops on set aside land are not playing a leading role in whether or not farmers cultivate energy crops.<sup>29</sup>

The aid of 45 €/ha for energy crops is dwarfed by the tobacco subsidies of 5000 €/ha in the Umbertide case study. Additionally, in the Mureck case study, a subsidy program that was tested in the 1980s initially stimulated the cultivation of rapeseed. The subsidy program provided approximately 500 €/ha. Furthermore, farmers and energy crops are embedded in a chain of activities. Supporting the construction of conversion technologies is as important as stimulating the development of biomass resources in order to overcome the ‘chicken and egg’ problem. For example, the feed-in tariffs for ‘green’ electricity in Austria stimulated farmers in the Mureck case study to harvest energy crops.

Set aside land is an opportunity for planting and expanding energy crops. However, the amount of compulsory set aside land changes and there are rotations of set aside land in some instances. Additionally, farmers generally select their least productive agricultural land as set aside land, and utilise their most productive agricultural land for food crops (Helby et al., 2006). Focusing on set aside land can therefore present energy crops as a marginal

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<sup>28</sup> For background information on energy crops and relevant agricultural policy see Article V.

<sup>29</sup> A review of the CAP reforms that aim to support energy crops states that the effectiveness of the aid for energy crops on agricultural land is limited to specific situations (when farmers are already extremely close to planting energy crops). It also highlights that the aid for energy crops is associated with administrative burden and limited flexibility. The review does argue that the permission to harvest energy crops on set aside land appears to be an incentive for farmers (European Commission, 2006b).

activity rather than a mainstream development. If energy crops are to be integrated into a large-scale chain of activities from biomass resources to energy services, then it appears that set aside land is not appropriate. Set aside land is more suited for small-scale utilisation of energy crops.

The supply structures for biomass resources are heavily influenced by the scale and type of conversion technologies and expected markets. For example, farmers growing energy crops for regional systems in the Enköping case study and the Mureck case study have quite different experiences to farmers cultivating energy crops for solid or liquid biofuels destined for international trade. Clearly, farmers have a role to play in the success or failure of bioenergy systems, particularly those involving energy crops. It therefore appears necessary that farmers participate to some extent in the design of bioenergy systems, so that conversion technologies are not established without sufficient supply of biomass resources.

There are tensions between energy policy and agricultural policy, which are evident in the case studies from Sweden, Italy and Austria. For farmers and agricultural associations, the main objective is to produce products that provide employment to farmers. In contrast, the main objective for energy companies is to decrease labour intensity and increase cost efficiency for products. It is not surprising then that many farmers and agricultural associations are more interested in annual energy crops and far less focused on perennial energy crops. Annual crops have constant labour demands while perennial crops require almost no labour.

The Mureck case study indicates that utilising conventional crops for energy purposes is not as complicated compared to switching to dedicated energy crops, as experienced in the Enköping case study where the local energy company was forced to rent land from farmers in order to expand plantations of dedicated energy crops. Farmers know how to plant and harvest conventional crops (such as rapeseed) as opposed to dedicated energy crops (such as willow). Additionally, farmers own or have access to vehicles and equipment for conventional crops. Many of the obstacles that dedicated energy crops face are therefore not problems when cultivating conventional crops for energy purposes.

Clearly, shifting from food crops to energy crops is an economic and psychological risk for farmers (as opposed to standard crop shifts). This is particularly the case for dedicated energy crops, but also for conventional crops utilised for energy purposes. Reducing and spreading risk is therefore

paramount to stimulate farmers to cultivate energy crops. In the case studies, agricultural cooperatives demonstrate that collaboration between many farmers is a way to share the risk and facilitate the diffusion of energy crops. However, further support is necessary.

**Lessons from Sweden, Italy and Austria:** The case studies from Sweden, Italy and Austria cannot provide generalisations for all of Europe. However, they do provide valuable insights or lessons about the ‘real-life’ issues confronting farmers in regards to energy crops. The agricultural associations and farmers in the case studies communicate a range of challenges connected to shifting agricultural land to energy crops. In order to accelerate the expansion of energy crops, this thesis proposes that the CAP could act as the main policy framework to co-ordinate support for farmers on a number of fronts. In brief, these include:

*Establishment subsidies:* At present, there is lobbying in the EU and some Member States to increase subsidies for energy crops. However, this research suggests that what are most needed are focused establishment subsidies for farmers to invest in plantations of energy crops. Essentially, farmers require an economic inducement to make the shift from food to energy, particularly for dedicated energy crops.

*Information campaigns:* This research also shows that farmers are in need of more information about energy crops and examples of ‘success stories’. A proficient way to communicate with farmers is through farmers that harvest energy crops, and who can illustrate ‘success stories’, and explain what to do and what not to do in the initial steps.

*Demonstration projects:* Another effective way to promote energy crops and encourage farmers to learn about energy crops is through ‘real’ demonstrations. Visiting plantations and interacting with the farmers who maintain the plantations can facilitate the diffusion of knowledge and experience among farmers.

*Agricultural cooperatives:* Bringing farmers together in agricultural cooperatives is important because such groups can share the risk associated with diversifying into energy crops, and facilitate the purchase of equipment and vehicles for use among farmers. Furthermore, agricultural cooperatives encourage farmers to combine biomass resources, and make investments in small-scale conversion technologies.

*Conversion technologies:* Clearly, large-scale conversion technologies are the domain of the energy sector. However, small-scale conversion technologies on farms, such as boilers and stoves, are embedded in the agricultural sector. This research suggests that increasing support to purchase or convert boilers and stoves for utilising biomass can help farmers to plant energy crops for use on their own farms.

*Landscape changes:* It is often ignored that many local residents (which includes farmers) can oppose altering landscapes. Many landscapes in Europe have a considerable cultural heritage and local residents can have a connection with the land and nature. It is important that the introduction of large-scale plantations of energy crops is compatible with the cultural heritage of Europe. Participation processes with local residents and farmers under the direction of the CAP are likely to be needed to avoid conflicts.

*Multiple benefits:* Cultivating energy crops and establishing bioenergy systems often results in multiple benefits for the local community (and to meet national goals). Energy crops can enhance biodiversity, prevent erosion and provide co-products along with energy provision. Fertiliser for fields and feed for animals are common examples of co-products. It is therefore important to promote the multiple benefits to farmers.

### 3.4.3 Liquid Biofuels<sup>30</sup>

**Experiences from Germany and the UK:** The widespread cultivation of energy crops is closely linked to the demand for liquid biofuels for transport. This research work therefore explored the markets for biodiesel and bioethanol, and the socio-political context for the biofuels industry, in Germany and the UK. The research process involved interviews with key stakeholders in each country, literature reviews, and analysis of recent news articles on liquid biofuels published in the German and British media. The introduction of liquid biofuels for transport in Germany and the UK provide contrasting pictures, and insights into the development of liquid biofuels in Europe.

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<sup>30</sup> For background information on liquid biofuels and relevant energy policy see Article VI. Since the publication of Article VI a number of changes have occurred to the legislation for liquid biofuels in Germany with the introduction of the Biofuels Quota Act in 2007. These changes are addressed here.

The main driver for liquid biofuels in Germany has been the excise duty exemption, at the beginning in 1993 for B100 and since 2004 also for low-level blends of biodiesel and bioethanol (although the situation has changed with the Biofuels Quota Act in 2007). Automobile manufacturers permitting B100 in their conventional vehicles and a network of service stations supplying B100 have also been critical for the diffusion of liquid biofuels. The main barriers are the higher production costs for liquid biofuels (as compared to fossil fuels) and the uncertainty created for the domestic industry by the newly introduced Biofuels Quota Act.

In 2007, the National Government in Germany introduced the Biofuels Quota Act. The excise duty exemption for low-level blends of liquid biofuels will therefore be removed. From 2007 to 2012 the tax rates for B100 (and vegetable oil) will gradually increase and be replaced by an obligation or quota to blend liquid biofuels (Union for the Promotion of Oil and Protein Plants, 2006). The lobbying and debate over the Biofuels Quota Act has been intense with a range of claims regarding the impacts on the domestic industry (Federal Association of Biogenic and Renewable Fuels, 2007).

The Biofuels Quota Act and new tax rates appear to favour the large biodiesel producers while small biodiesel producers are disadvantaged (Federal Association of Biogenic and Renewable Fuels, 2007). This is primarily because oil companies are expected to meet their obligations through low-level blends by purchasing significant volumes of liquid biofuels. Rather than deal with many small biodiesel producers, it is likely that oil companies will sign contracts with a few large biodiesel producers both from within Germany, and also possibly through international trade.

Since biodiesel was not addressed by the mineral oil tax in Germany until 2004, it was therefore exempt from the mineral oil tax, if utilised as B100. The rise in oil prices also helped biofuels producers and suppliers compete with diesel and provide biodiesel that was more or less price competitive. Additionally, a number of automobile manufacturers responded by permitting B100 in conventional diesel vehicles. Biodiesel has primarily attracted truck operators, bus fleets and farmers because they are sensitive to changes in oil prices. They can purchase conventional vehicles, and easily switch between diesel and biodiesel depending on price and availability.

The distribution systems for B100 and E85 are difficult to establish because it requires dedicated pumps across a network of service stations. However,

in 1996 petrol with lead was prohibited in Germany by the National Government and more than 1000 pumps at service stations required replacements. At that moment the market for biodiesel in Germany was able to seize the opportunity. Until 1996, biodiesel was predominantly used in niche markets. The shift away from petrol with lead resulted in over 600 pumps being converted to provide B100.<sup>31</sup> This 'quick' transition in distribution systems transformed the biofuels industry in Germany.

The National Government in Germany has played a leading role in the development of a market for liquid biofuels and a domestic industry. The National Government has sponsored research on bioethanol and biodiesel, and invested in demonstrations of flexi-fuel vehicles and B100 in agricultural vehicles. Trade associations have also been significant for building up the domestic industry. The criticism of liquid biofuels by some environmental groups in Germany appears (so far) not to have hindered the domestic industry. For most consumers the price of liquid biofuels is clearly more important than any environmental considerations. This also appears to be the case in the UK where the general public has not been prepared to purchase liquid biofuels, which are marketed at a price premium.

The main driver in the UK for liquid biofuels has been the excise duty reduction introduced since 2002. The main barriers are the higher production costs of liquid biofuels, which – except for the cheapest feedstocks – are not sufficiently compensated by the excise duty reduction to induce blending. The signals by the National Government on whether or not it supports growth in liquid biofuels could be described as ambiguous. In contrast to Germany (where biodiesel has been produced and used since the early 1990s) the experience with liquid biofuels in the UK has only started recently. Similar to Germany, the adjustments to the excise duty have triggered the development of a domestic industry.

In the UK, liquid biofuels are often considered an expensive option for climate mitigation, rather than a means of strengthening energy security or supporting British farmers. Currently, the excise duty reduction is only guaranteed until 2008. Many biofuels producers and suppliers (especially for bioethanol) are waiting for stronger signals from the National Government. The limited support for the domestic industry is also connected to relatively

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<sup>31</sup> In 2006, there were over 1900 pumps for biodiesel in Germany, which represents more than 10 percent of total pumps (Union for the Promotion of Oil and Protein Plants, 2006).

weak trade associations, which are unable to influence policy-makers as they are in Germany. In the absence of more substantial backing for liquid biofuels by the National Government and a higher excise duty reduction most of the oil companies in the UK have adopted a wait-and-see strategy.

**Lessons from Germany and the UK:** The introduction of liquid biofuels in Germany and the UK provide contrasting pictures and a number of lessons about the drivers and barriers that can shape markets for liquid biofuels in Europe. While liquid biofuels can integrate into the established technological system based on oil, it is evident in the research on Germany and the UK that they require support to ‘get started’ (Aldrich & Fiol, 1994). This research work has derived a range of general conclusions from the assessment of the German and British experiences with biodiesel and bioethanol that are particularly relevant for the early stages of a biofuels industry. These include:

*Consumers purchase cheap rather than green:* The experience in Germany and the UK suggests that most consumers only purchase bioethanol and biodiesel if they are price competitive with petrol and diesel. In Germany, the availability and price of biodiesel has allowed B100 to establish a market and biodiesel sales continue to grow (although demand has dropped since the introduction of the Biofuels Quota Act in 2007). In the UK, the experience indicates that few consumers are prepared to purchase B5 at a price premium. The environmental reasons for purchasing liquid biofuels are simply overshadowed by price and availability.

*Excise duty exemptions or reductions are instrumental for stimulating investments in liquid biofuels:* Excise duty exemptions or reductions can ensure that liquid biofuels are price competitive. In Germany, the excise duty exemption has been crucial in stimulating the domestic industry for both biodiesel and bioethanol. In the UK, the excise duty reduction has triggered the sales and production of liquid biofuels. However, it is only sufficient for biodiesel production from some feedstocks, such as Waste Vegetable Oil (WVO) and palm oil, which limits the market for liquid biofuels. Utilising WVO is an opening for developing liquid biofuels but realistically it only has small potentials.

*National Government commitment is the foundation for a biofuels industry:* To achieve the 2010 targets for liquid biofuels in the EU, it is important for National Governments to provide clear and strong signals. In Germany, the consistent support for liquid biofuels by the National Government (and

most political parties) has encouraged investments in the biofuels industry, the oil industry to implement blending, and automobile manufacturers to ensure warranties on conventional vehicles. The shift in 2007 to the Biofuels Quota Act in Germany highlights how the biofuels industry can be heavily influenced by National Governments. In the UK, the National Government has been rather ambiguous on liquid biofuels, resulting in many oil companies adopting a wait-and-see strategy.

*Low-level blending is the easiest and cheapest way for marketing liquid biofuels but not sufficient to meet targets:* The distribution of B5 and E5 requires negligible investments in distribution systems and no new pumps or labels. Most oil companies are therefore prepared to support low-level blends more than B100 or E85, which require greater investments. However, B5 and E5 are not sufficient to meet the 2010 targets for liquid biofuels in the EU. There appear to be 2 options to respond to this dilemma. First, promote the diffusion of high-level blends, which in many instances requires the production and marketing of flexi-fuel vehicles, and distribution of liquid biofuels at many service stations. Second, adjust the fuel standards for petrol and diesel to allow blending of E10 and B10, which could be an effective way to meet the targets and expand the market for liquid biofuels.

*Niche markets are an opportunity for bioethanol and biodiesel:* Rather than only produce low-level blends for conventional vehicles, a parallel strategy for bioethanol and biodiesel is to address niche markets, such as bus fleets for public transport, truck operators, and farmers. Niche markets have several advantages, including: they can utilise high-level blends or pure forms of liquid biofuels; switch to flexi-fuel vehicles; and establish dedicated refuelling stations. It is also important to place liquid biofuels in the context of shifting to sustainable modes of transport. If liquid biofuels are used in bus fleets for public transport then not only are the fuels more sustainable but so are the modes of transport.

*Oil companies are more supportive of biodiesel than bioethanol:* At present, oil companies in Europe face an oversupply of petrol and a shortage of diesel. In both the UK and Germany, oil companies are often more critical of bioethanol than biodiesel. If policy-makers aim to diffuse bioethanol on the market, they have to exert more pressure on oil companies. Furthermore, policy-makers need to engage with automobile manufacturers to ensure they provide warranties for conventional vehicles, and to produce flexi-fuel vehicles in parallel with service stations offering high-level blends, such as E85 and B100.

*Environmental impacts and carbon balances of liquid biofuels vary:* The environmental impacts and carbon balances of liquid biofuels depend on feedstocks and the way they are farmed, processed and distributed. Environmental impacts associated with energy crops require sustained investigation. Biodiesel and bioethanol in the EU have been calculated to result in 15 percent to 70 percent greenhouse gas savings when compared to fossil fuels, while bioethanol from Brazil results in over 90 percent greenhouse gas savings (Alckmin & Goldemberg, 2004; Hass, Larive, & Mahieu, 2003). The uncertainty around ‘good’ and ‘bad’ liquid biofuels has significant implications for policy-makers.

*Sustainability certification schemes for liquid biofuels are necessary:* Presently, all liquid biofuels are treated equally irrespective of carbon balances or environmental impacts. The possible introduction of obligations for liquid biofuels in the UK appears to encompass reporting on carbon balances and environmental impacts. The ambition is therefore to ‘reward’ the more sustainable or ‘good’ liquid biofuels and ‘punish’ the less sustainable or ‘bad’ liquid biofuels. A consistent and transparent sustainability certification scheme for liquid biofuels in the EU is necessary to maintain confidence in the performance of liquid biofuels from both environmental and social perspectives.

*Support for bioethanol and biodiesel is not expected to ‘lock-in’ or ‘lock-out’ any technologies:* As first generation liquid biofuels, both biodiesel and bioethanol can be blended with petrol and diesel with no major changes in distribution systems and they can be used in conventional vehicles (with minor adjustments for high-level blends of bioethanol). Second generation liquid biofuels can also be integrated with current infrastructure. It is crucial for the long-term viability of biofuels to provide sufficient support for second generation liquid biofuels so as to expand the range of feedstocks, and to promote technologies with the most flexibility and best performance.



# CHAPTER FOUR

## 4. Reflections

Expanding bioenergy is attracting significant attention and support from the EU and a number of Member States. However, efforts must be intensified if the EU targets on bioenergy utilisation are to be achieved. Exploring socio-political issues, this thesis contributes to a better understanding of key drivers and barriers for bioenergy systems, and how policies and actions can be better designed and implemented. This chapter concludes the thesis summary with the main findings and conclusions, contributions to the field and value for relevant actors, and implications for further research.

### *4.1 Conclusions*

This thesis based on articles generates a number of conclusions in response to the research objectives. The first set of findings centre around key drivers and barriers for bioenergy systems in the EU. The second set of findings shift focus to experiences of supportive (and disruptive) policies and actions predominantly for energy crops and liquid biofuels for transport.

#### **4.1.1 Drivers and Barriers**

The first research objective for this thesis was to identify and analyse key drivers and barriers for the implementation of bioenergy systems in different contexts in Europe. The main findings include:

**Key drivers for bioenergy systems:** Combating climate change and enhancing energy security are identified in the literature as key drivers for bioenergy. Promoting regional development is also often mentioned although it is not well explored by empirical studies. This thesis conducted research on 4 case studies in Sweden to add depth to understanding of regional development activity associated with bioenergy systems. The case studies suggest there can be at least 4 benefits that flow from bioenergy

systems for local and regional actors (such as farmers, forest owners, local municipalities, local energy companies and residents). These include:

*Distribution and diversification:* Bioenergy systems can promote distributed and diversified energy systems based on locally available biomass resources and investments in both small-scale and large-scale conversion technologies. Expanding bioenergy can therefore improve the resilience of energy systems and assist in breaking dependence on fossil fuels, particularly imported oil.

*Partnerships and synergies:* Bioenergy systems can stimulate partnerships to exploit synergies between industries thereby strengthening local networks (and economies). This is particularly the case for industries that produce waste or by-products, which can be transformed into co-products of value when coupled with bioenergy.

*Business and employment:* Bioenergy systems can generate (direct and indirect) employment and business opportunities all along the bioenergy chain from biomass resources to energy services. The utilisation of local biomass resources implies that expenditure on energy provision is retained in the local community and re-circulated.

*Environment and landscape:* Bioenergy systems can support environment and landscape goals. The health and productivity of forests relies on thinning and management, which can be directly linked to (and supported by) bioenergy systems. Furthermore, energy crops can help to prevent erosion and soil degradation, restore degraded land, and enhance biodiversity.

This research on bioenergy systems in Sweden suggests that benefits linked to regional development can be key drivers for local and regional actors. Greater attention to regional development by policy-makers may in fact stimulate interest in bioenergy systems. Ignoring or brushing over the benefits for local and regional actors (as identified in some case studies) is a mistake. Farmers, forest owners, local municipalities, local energy companies and residents are key stakeholders for bioenergy systems, and they can heavily affect the success or failure of projects.

It is important to recognise that benefits or positive impacts associated with the implementation of bioenergy systems are not always sufficient to be effective drivers for investors. It generally depends ‘who benefits?’ and ‘who pays?’ in relation to the bioenergy systems. In many cases, benefits flow to the local community or national goals but not directly to investors. When

benefits from bioenergy systems are recognised through supportive policy measures (by putting a value on the externalised benefits) they can become stronger drivers for change.

**Key barriers for bioenergy systems:** Studies on barriers obstructing the development of bioenergy often adopt different analytical perspectives and produce lists of many types of obstacles. Based on case studies, research workshops, and industry interactions, this thesis work attempted to identify key barriers for bioenergy in Europe. The case studies from Sweden, Finland, Austria, Italy, Poland, the Ukraine, Germany and the UK illustrate how these barriers affect ‘real-life’ bioenergy systems. The key barriers include:

*Economic conditions:* Bioenergy systems, as with all renewable energy, must compete with fossil fuels and nuclear power, which have received and continue to benefit from energy subsidies and externalised costs. Furthermore, bioenergy often produces positive impacts that are not compensated by energy markets. Overcoming unfavourable economic conditions through effective and efficient policy measures (that recognise externalised benefits and/or charge for externalised costs) is vital to the success of bioenergy systems.

*Know-how and institutional capacity:* When establishing bioenergy systems a combination of know-how (knowledge and skills) and institutional capacity is needed to shift from unrealised potential to success. For example, a lack of understanding of the bioenergy industry by the finance sector may be an obstacle as well as a lack of experienced maintenance staff. Furthermore, learning processes and altering perceptions of both the public and politicians about bioenergy is often required to build up legitimacy for the bioenergy industry.

*Supply chain co-ordination:* Bioenergy systems require functioning and organised supply chains that overcome the ‘chicken and egg’ problem. Put simply, investing in biomass resources is generally only possible if there are energy companies purchasing biomass, and establishing conversion technologies is generally only possible if biomass suppliers exist to provide biomass. In particular, agreements on biomass supply appear to be crucial for farmers to harvest energy crops. There is also emerging competition for biomass resources and potentially land use conflicts.

This thesis concludes that to promote bioenergy systems in Europe, policy-makers in the EU and Member States need to tackle the key barriers in parallel. While economic conditions appear to be the priority, few Member States will implement supportive economic policies that dramatically affect energy markets. It is more likely that supportive economic policies will moderately assist the bioenergy industry. Addressing economic conditions, know-how and institutional capacity, and supply chain co-ordination is therefore required to create the foundations necessary for significantly expanding bioenergy.

#### **4.1.2 Policies and Actions**

The second research objective for this thesis was to investigate and discuss experiences of supportive (and disruptive) policies and actions for the implementation of bioenergy systems in Europe. The main findings include:

**Bioenergy systems:** While there are key barriers hindering bioenergy systems, this research identifies no absolute barriers to realising the EU targets on bioenergy utilisation. Interestingly, there are some consistent policies and actions evident in the case studies that are employed to overcome key barriers, including: investment grants; policy measures; pilot projects; local initiatives; local champions; and supply contracts. Not surprisingly, supportive economic policies and partnerships between the public and private sectors are observed as influential in the development of bioenergy systems.

**Energy crops:** This research investigates the perspective of farmers on energy crops. The Common Agricultural Policy reforms that aim to facilitate investments in energy crops, include: the introduction of the single payment scheme; the aid of 45 €/ha for energy crops on agricultural land; and the permission to harvest energy crops on set aside land. However, farmers and agricultural associations in the case studies from Sweden, Italy and Austria communicate a range of obstacles for shifting agricultural land to energy crops. These include:

- Supporting the construction of conversion technologies (and agreements on biomass supply) is as important as stimulating the development of biomass resources in order to overcome the ‘chicken and egg’ problem.

- The amount of compulsory set aside land changes and there are rotations of set aside land in some instances. Focusing on set aside land therefore presents energy crops as a marginal activity rather than a mainstream development.
- There are tensions between energy policy and agricultural policy, which is evident in that agricultural associations prefer annual crops (more labour and higher costs) and energy companies prefer perennial crops (less labour and lower costs).
- Shifting from food crops to energy crops is a risk for farmers in terms of changes in both work practices and economic flows. Reducing and spreading risk is paramount to stimulate farmers to cultivate energy crops.

It is difficult to generalize for Europe from a selection of case studies. However, there are valuable insights from the case studies into the ‘real-life’ issues confronting farmers and agricultural associations. Clearly, shifting from food crops to energy crops is a significant economic and psychological risk for farmers (as opposed to standard crop shifts). Agricultural cooperatives appear to demonstrate that collaboration between many farmers is a way to share the risk and facilitate the diffusion of energy crops. However, further support is necessary.

Responsibilities for the promotion of energy crops are currently scattered across different policy sectors. To accelerate the diffusion of energy crops, the author proposes that the CAP could act as the main policy framework to co-ordinate support for farmers on a number of fronts, including: introduce establishment subsidies; expand information campaigns; initiate demonstration projects; support agricultural cooperatives; subsidise (small-scale) conversion technologies; evaluate landscape changes; and promote multiple benefits.

**Liquid biofuels:** The widespread cultivation of energy crops is closely linked to the demand for liquid biofuels for transport. The introduction of bioethanol and biodiesel in Germany and the UK provide contrasting pictures and many insights into markets in Europe. These include:

*Experiences from Germany:* The main driver for liquid biofuels in Germany has been the excise duty exemption, at the beginning in 1993 for biodiesel and since 2004 also for low-level blends of biodiesel and bioethanol (although

the situation has changed with the newly introduced Biofuels Quota Act in 2007). The National Government has played an active role in the market development for liquid biofuels. Trade associations have also been important for supporting the domestic industry. The main barriers that liquid biofuels face in Germany are higher production costs (as compared to fossil fuels) and the uncertainty created for the domestic industry by the Biofuels Quota Act.

*Experiences from the UK:* The main driver in the UK has been the excise duty reduction since 2002. The main barriers are the higher production costs of liquid biofuels, which – except for the cheapest feedstocks – are not sufficiently compensated by the excise duty reduction to induce blending in the UK. National Government signals on support for liquid biofuels have so far been ambiguous. Furthermore, the domestic industry for liquid biofuels is undeveloped and inexperienced. Biofuels producers and suppliers (especially for bioethanol) are waiting for strong signals from the National Government. The limited support for the domestic industry is also connected to weak trade associations.

This research work has derived general conclusions from the assessment of the German and British experiences with biodiesel and bioethanol that are particularly relevant for the early stages of a biofuels industry. These include:

- Consumers purchase cheap rather than green. Not surprisingly, most consumers only purchase liquid biofuels if they are price competitive with petrol and diesel.
- Excise duty exemptions or reductions can ensure liquid biofuels are price competitive, and thereby stimulate investments in a domestic industry.
- National Government commitment to liquid biofuels (particularly through clear and strong signals) is the foundation for building up a biofuels industry.
- Low-level blends of E5 and B5 are the easiest and cheapest way for marketing liquid biofuels but not sufficient to meet targets in the European Union. Introducing E10 and B10 along with high-level blends is most likely required.

- An opportunity for promoting and expanding bioethanol and biodiesel is through niche markets, such as bus fleets for public transport, truck operators, and farmers.
- Oil companies are generally more supportive of biodiesel than bioethanol. If policy-makers aim to diffuse bioethanol on the market, they will have to exert more pressure on oil companies.
- Environmental impacts and carbon balances of liquid biofuels vary. The uncertainty around ‘good’ and ‘bad’ liquid biofuels has significant implications for policy-makers.
- The introduction of a sustainability certification scheme for liquid biofuels is necessary to maintain confidence in the performance of liquid biofuels from both environmental and social perspectives.
- Support for first generation liquid biofuels is not expected to ‘lock-in’ or ‘lock-out’ any technologies. However, it is important to promote technologies for second generation liquid biofuels to expand opportunities and improve performance.

## ***4.2 Contributions***

This thesis work contributes to knowledge on bioenergy and it has value for the research community, policy-makers (and/or policy advisors), local municipalities, and industrial actors in the EU and Member States. While the contributions merge into each other, they can be classified under 5 themes. These include:

**Fieldwork:** This thesis work has been based on extensive fieldwork conducted by the author and research colleagues. Developing 12 case studies in 8 countries in Europe has involved face-to-face interviews and discussions with a range of actors (such as representatives from local municipalities, forest owners and farmers) and site visits to various locations relevant to bioenergy systems (such as CHP plants and waste management facilities). The combined data collection (and analysis) activities represent an empirical contribution to the body of knowledge on bioenergy systems in Europe.

**Approach:** The author adopted a systems approach to explore bioenergy, which encourages a more holistic perspective, the use of knowledge from different disciplines, and mapping out the interactions between elements in bioenergy systems. While this approach is not new for bioenergy, this thesis work does add to the movement of researchers exploring whole bioenergy systems rather than only specific parts. Stepping back and looking at both the technical aspects and overarching social aspects of bioenergy systems opens up ‘new’ insights that are particularly relevant for a better understanding of implementation challenges.

**Methodology:** This thesis is based on a combination of research methods and a range of informants. The author conducted literature reviews, case studies, site visits, stakeholder interviews, industry interactions, and research workshops to test assumptions in the field and against industry knowledge. This represents an attempt to apply a more robust research strategy to explore the implementation of bioenergy systems. The research process also involved participation in several projects under investigation thereby directly influencing actors in the field, and adding another dimension to the research work.

**Knowledge:** There is a relatively strong knowledge base on technical issues related to bioenergy. This research work responds to calls in the literature and political circles for a greater understanding and analysis of non-technical issues surrounding bioenergy systems. At present, there is only a small amount of research on bioenergy delving into social and political factors. The focus of this thesis on socio-political issues can therefore be considered a rather novel approach for the bioenergy field. The findings can be incorporated into wider research on bioenergy systems, particularly for the design of more effective policy measures.

**Diffusion:** The author has presented the findings of this research at a number of major conferences with international audiences. The participants have consisted of the research community, policy-makers (and/or policy advisors), local municipalities, and industrial actors. The author has also made various presentations at workshops and meetings within the Bioenergy NoE. While presentations are not often mentioned in thesis work, it is the contention of the author that efforts to diffuse results are contributions to the field. Research may be of little or no value to actors if the findings are not made directly available to them.

### **4.3 Implications**

While the research findings in this thesis respond to a number of questions regarding bioenergy, they also have implications for future research. As described by the author, the diffusion of bioenergy systems (and utilising renewable energy more generally) requires some major changes in current energy systems. A number of interlinking transitions are worthy of further research. These include:

**Energy crops:** From niche energy crops to integrated land management, exploring flexibility, knowledge and (tangible and psychological) risks from the perspective of farmers in different parts of Europe, particularly Poland and the Ukraine. Growing energy crops is often perceived by farmers to involve higher risks than conventional crops. Areas for research include analysing options for compensating risks and the role of ‘new’ contractual forms to reduce and spread risks between different actors.

**Liquid biofuels:** From the first steps to widespread diffusion, researching the development of markets for liquid biofuels mapping the actors, networks and (formal and informal) institutions in detail for Europe. Areas for research include investigating the rise of industrial actors and their strategies for the diffusion of bioethanol and biodiesel in different Member States and the whole EU, and the opportunities and challenges associated with the international trade of liquid biofuels.

**Bioenergy networks:** From dispersed actors to political forces, analysing the development and formalisation of professional and industry networks associated with bioenergy. Networks play an important role for infant (and established) industrial actors in terms of legitimacy and the ability to lobby policy-makers. Areas for research include how networks are formed and how their structure influences the effectiveness to facilitate the emergence of a bioenergy industry.

**Bioenergy policy:** From disjointed political efforts to effective policy implementation, focusing on the misalignment of industrial strategies and policy measures. Industrial actors often highlight that uncertainty resulting from policy measures is a serious obstacle for investments in bioenergy. Areas for research include how policy measures act as different levels and on different actors, and direct engagement with industrial actors to better align industrial strategies and policy measures.

Additionally to the transitions in energy systems that expanding bioenergy entails, policy-makers (and business leaders) are also being confronted with controversial issues and numerous options (see Figure 4-1). In order to support decision-making processes and planning (especially in terms of the design of policy measures and decision-making tools) a number of topics or issues in the bioenergy field demand further research. These include:

**Heat and electricity or liquid biofuels:** Biomass can be utilised for different energy purposes. Diverting the majority of biomass resources to heat and electricity or liquid biofuels for transport is a strategic decision facing governments and business. Additionally, there is ‘excitement’ about the opportunities to develop bio-refineries.<sup>32</sup> However, the many options related to bio-refineries also demand difficult choices by policy-makers.

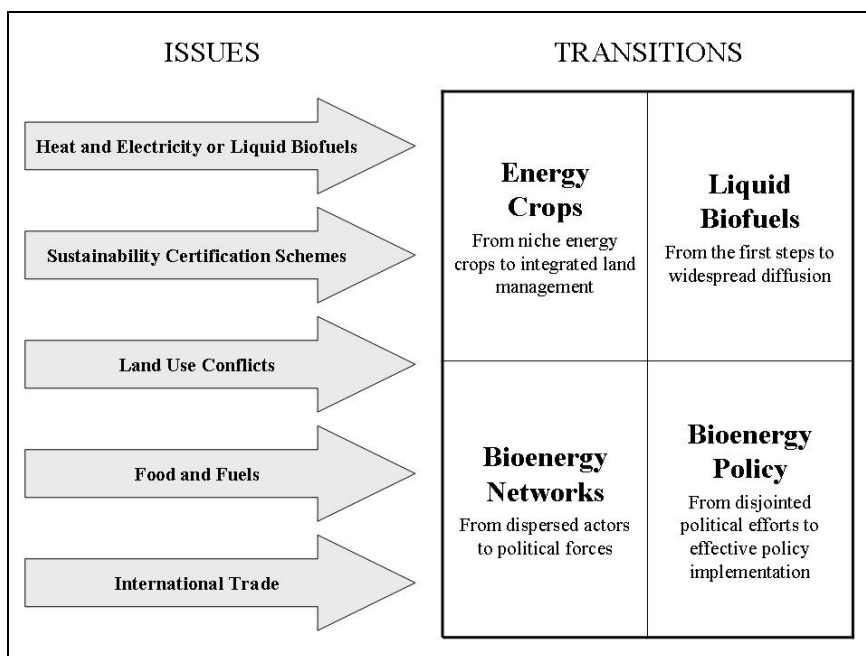


Figure 4-1. Transitions and Issues for Research on Bioenergy

<sup>32</sup> A bio-refinery is a facility that integrates conversion processes and equipment to produce fuels, electricity, materials and/or chemicals from biomass. By producing multiple products, a bio-refinery can take advantage of the differences in biomass components and maximize the value derived from biomass feedstocks (Realf & Abbas, 2003).

**Sustainability certification schemes:** There is growing concern about the environmental and social impacts of bioenergy systems, particularly for liquid biofuels. Furthermore, the introduction of sustainability certification schemes appears to be firmly on the bioenergy agenda. Designing such schemes is the first step, but how to effectively implement them is a whole another area of research.

**Land use conflicts:** Established traditions, developed markets, and embedded subsidies and support schemes heavily influence land use. With limited land available for the production of biomass resources, policy-makers need support to determine how to utilise land in the most efficient and effective ways to meet multiple goals on climate, energy, agriculture, water and biodiversity.

**Food and fuels:** There are concerns that significant increases in the utilisation of solid and liquid biofuels could negatively impact on markets for food. Both governments and business in Europe (and around the world) will need to address the potentially serious interactions between expanding bioenergy utilisation (particularly liquid biofuels for transport) and food production.

**International trade:** The international trade of solid and liquid biofuels can take advantage of countries with favourable conditions for biomass production (such as warmer climates, lower labour costs and better greenhouse gas savings). However, at present, international trade remains an elusive ambition in the face of many countries protecting their (infant) domestic industry.



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## Appendix A – Author Publications

The following is a list of all publications by the author and research colleagues, which are of relevance to this thesis work:

Nilsson, H., McCormick, K., Sinnisov, L., Ganko, E., Gumeniuk, A., Bal, R., & Tomescu, M. (2007). *Barriers to the Cultivation of Energy Crops in Poland: The Case of Willow*. Paper presented at the European Biomass Conference and Exhibition, Berlin, Germany.

Nilsson, H., McCormick, K., Ganko, E., & Sinnisov, L. (2007). Barriers for Energy Crops in Poland from the Farmers Perspective. In C.A. Brebbia & V. Popov (Eds.) *Energy and Sustainability*. Southampton: WIT Press.

McCormick, K., & Kåberger, T. (2007). Key Barriers for Bioenergy in Europe: Economic Conditions, Know-how and Institutional Capacity, and Supply Chain Co-ordination. *Biomass and Bioenergy*, 31(7), 443-452.

McCormick, K. (2007). Ecological Economics and Transport Systems. *Environmental Engineering and Management*, 6(1), 21-25.

McCormick, K., Nilsson, H., & Ganko, E. (2007). *Energy Crops: Investigation of Socio-economic Barriers for Farmers in Poland*. Research Report. Bioenergy NoE Project.

Peck, P., & McCormick, K. (2007). *Mainstreaming Bioenergy Systems: Parameters of Breaking Dependence on Fossil Fuels by 2020*. Research Report. Bioenergy NoE Project.

Bomb, C., McCormick, K., Deurwaarder, E., & Kåberger, T. (2007) Biofuels for Transport in Europe: Lessons from Germany and the UK. *Energy Policy*, 35(4), 2256-2267.

Johansson, T.B., McCormick, K., Neij, L., & Turkenburg, W.C. (2006). The Potentials of Renewable Energy. In D. Abmann, U. Laumanns & D. Uh (Eds.) *Renewable Energy: A Global Review of Technologies, Policies, and Markets*. London: Earthscan.

Orsato, R., & McCormick, K. (2006). *Eco-Activism: Greenpeace, the Oil Industry, and the Stuart Oil Shale Project in Australia*. Fountainebleau: INSEAD.

Boutin, J., Gervasoni, G., Hlep, R., Seyboth, K., Lamers, P., Ratton, M., McCormick, K., Mundaca, L., & Plepys, A. (2006). *Alternative Energy Sources in Transition Countries: The Case of Bioenergy in the Ukraine*. Paper presented at the International Conference on Environmental Engineering and Management, Iasi, Romania.

McCormick, K., Peck, P., & Kåberger, T. (2006). Breaking Dependence on Oil in Sweden: Exploring the Implications for Biofuels. *Energy for Sustainable Development*, 10(2), 127-128.

McCormick, K., Nilsson, H., & Tomescu, M. (2006). *Energy Crops and the Common Agricultural Policy*. Paper presented at the World Bioenergy Conference, Jönköping, Sweden.

McCormick, K. (2005). *Bioenergy Potentials and Dynamic Factors*. Paper presented at the Beijing International Renewable Energy Conference, Beijing, China.

McCormick, K. (2005). *Sustainable Bioenergy Systems: Experiences from Sweden*. Paper presented at the Asia Pacific Roundtable on Sustainable Consumption and Production, Melbourne, Australia.

Kåberger, T., & McCormick, K. (2005). *Market Conditions for Bioenergy in the European Union: Facing Barriers and Finding Ways to Success*. Research Report. Bioenergy NoE Project.

McCormick, K., & Kåberger, T. (2005). *An Innovative Bioenergy System in Action*. Paper presented at the International Conference on Environmental Protection is a Must, Alexandria, Egypt.

McCormick, K., & Kåberger, T. (2005). Exploring a Pioneering Bioenergy System: The Case of Enköping in Sweden. *Journal of Cleaner Production*, 13(10-11), 1003-1014.

Farinelli, U., Johansson, T.B., McCormick, K., Mundaca, L., Patel, M., Oikonomou, V., Santi, F., & Ortenvick, M. (2005). White and Green: A Comparison of Market Mechanisms to Promote Energy Efficiency. *Journal of Cleaner Production*, 13(10-11), 1015-1026.

Farinelli, U., Johansson, T.B., McCormick, K., Mundaca, L., Patel, M., Oikonomou, V., Santi, F., & Ortenvick, M. (2005). *White and Green: Conclusions and Recommendations*. Research Report. White and Green Certificates Project.

Johansson, T.B., McCormick, K., Neij, L., & Turkenburg, W.C. (2004). *The Potentials of Renewable Energy*. Paper presented at the International Conference for Renewable Energies, Bonn, Germany.

Mundaca, L., & McCormick, K. (2004). *Energy Policy Instruments and Innovation: How can tradable permit schemes influence innovation processes?* Paper presented at the International Conference on Innovation, Sustainability and Policy, Kloster, Germany.

## Appendix B – Case Studies

The following is a table with details about the case studies:

Case Studies <sup>1</sup>	Main Partners <sup>2</sup>	Main Researchers <sup>3</sup>	Main Stakeholder Interviews <sup>4</sup>	Main Site Visits <sup>5</sup>
Enköping, Sweden, Spring 2004	ENA Energy <a href="http://www.ena.se/">http://www.ena.se/</a> Enköping Municipality <a href="http://www.enkoping.se/">http://www.enkoping.se/</a>	- Luis Mundaca - Beatriz Warmburg - Bo Xie - Ian Hamilton - Matt de la Houssaye	- ENA Kraft - Naturbränsle (Forestry Association) - Agrobränsle (Energy Crops Company) - Enköping Municipality - Swedish University for Agricultural Sciences - Waste Water Treatment Company - Farmers	- Willow Plantations - Waste Water Treatment Facility - CHP Plant - Farms
Vansbro, Sweden, Spring 2004	Vansbro Municipality <a href="http://www.vansbro.se/">http://www.vansbro.se/</a>	- Philip Peck - Murat Murata - Katrin Besch - Margrethe Forssman - Oleksandr Khokhotva - Marla Maltin - Tomas Käberger	- Vansbro Municipality - Farmers - Forest Owners - Industrial Leaders (Finnveden, Procordia, Stora Enso, Mellanskog, Mellanskog Bränsle AB, Ulf Svensson AB, Rågsveden Säg)	- Forests - CHP Plant - Pellets Plant
Kristianstad, Sweden, Spring 2005	Kristianstad Municipality <a href="http://www.kristianstad.se/">http://www.kristianstad.se/</a>	- Tomas Käberger - Åke Thidell	- Kristianstad Municipality - Waste Management Company	- Biogas Plant - Biogas Stations - CHP Plant - Waste Management Facility
Växjö, Sweden, Spring 2005	Växjö Municipality <a href="http://www.vaxjo.se/">http://www.vaxjo.se/</a>	- Tomas Käberger - Åke Thidell	- Växjö Municipality - Växjö Energi AB - Växjö Värnamo Biomass Gasification Centre	- CHP Plant - Växjö Värnamo Biomass Gasification Centre

Lahti, Finland, Autumn 2004	VTT Processes <a href="http://www.vtt.fi/">http://www.vtt.fi/</a>	- Murat Murata - Allan Johansson	- Lahden Lämpövoima Oy Kymijärvi Power Plant Gasification Project	- CHP Plant
Mureck, Austria, Autumn 2005	Institute of Energy Research at Joanneum Research <a href="http://www.joanneum.ac.at/">http://www.joanneum.ac.at/</a>	- Mihai Tomescu - Philip Peck	- Project Developers (South Styria Cooperative for Energy and Protein Production, Nahwärme Mureck and Ökostrom Mureck) - Farmers - Residents - Local and Regional Politicians	- Farms - Biodiesel Plant - Bioheat Plant - CHP Plant - Biogas Plant
Umbertide, Italy, Spring 2005	Consorzio SMAI <a href="http://www.legnosmai.it/">http://www.legnosmai.it/</a>	- Åke Thidell - Luis Mundaca - Jordan Gold - Anna Roslund - Mihai Tomescu - Zhang Zhengyang - Christian Bomb - Srinivasa Gandepalli - Angélica Bello - Lars Strupeit	- Local Municipalities - Local Companies - Agricultural Co-operative - Farmers - Forest Owners - Residents - Environmental Organisation - Agricultural Equipment Company	- Farms - Forests - Tobacco Plantations - Eco-city Development - Agricultural Equipment Factory - Proposed Development Site
Gubin, Poland. Spring 2005	Agrobränsle <a href="http://www.agrobransle.se/">http://www.agrobransle.se/</a> EC Baltic Renewable Energy Centre <a href="http://www.ecbrec.pl/">http://www.ecbrec.pl/</a>	- Tomas Káberger	- Agrobränsle (Energy Crops Company) - Entrepreneurs	- Willow Plantations - CHP Plant
Winkleigh, UK, Spring 2005	Bioenergy Research Group at Aston University <a href="http://www.aston-berg.co.uk/">http://www.aston-berg.co.uk/</a>	- John Brammer	- Residents	- Proposed Development Site

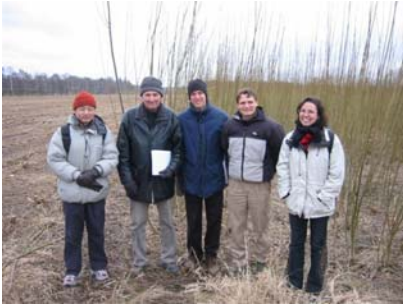
Berlin, Germany, Spring 2005	Agrobränsle <a href="http://www.agrobransle.se/">http://www.agrobransle.se/</a> Bewag <a href="http://www.vattenfall.de/">http://www.vattenfall.de/</a>	- Tomas Käberger	- Vattenfall - Bewag - Agrobränsle (Energy Crops Company)	- CHP Plant
Grudziadz, Poland, Autumn 2006	EC Baltic Renewable Energy Centre <a href="http://www.ecbrec.pl/">http://www.ecbrec.pl/</a>	- Luule Sinnisov - Helen Nilsson - Mihai Tomescu - Ewa Ganko	- Farmers - Farmers Co-operative - Farmers Union - Agricultural Advisory Board - Grudziadz Municipality - OPEC Grudziadz	- Farms - CHP Plant
Lviv, Ukraine, Spring 2006	National Forestry University of Ukraine <a href="http://forest.lviv.ua">http://forest.lviv.ua</a> National Academy of Sciences of Ukraine <a href="http://www.biomass.kiev.ua/">http://www.biomass.kiev.ua/</a>	- Andrius Plepys - Luis Mundaca - Giulia Gervasoni - Jean-Philippe Boutin - Kristin Seyboth - Marco Ratton - Patrick Lamers - Robert Hlep	- Farmers - Residents - Waste Management Company - Environmental Organisation - Researchers	- Landfill - CHP Plant - Eco-house - Farms - Rapeseed Plantations

Note: 1) Under case studies are the locations and dates of research work. 2) Main partners are the local organisations that facilitate research as well as organise meetings and interviews. They act as a gateway to research opportunities that would otherwise not be available. 3) Main researchers include the researchers involved in both data collection and analysis. In many cases teams of researchers have been involved in the research process. 4) Main stakeholder interviews comprise the organisations and types of people who were contacted and interviewed face-to-face. 5) Main site visits are the locations where researchers conducted interviews and observed bioenergy systems in action.



## Appendix C – Site Visits

The following are images and details from the site visits:



**Enköping, Sweden**

Researchers at some plantations of energy crops.



**Berlin, Germany**

Presentations at a CHP plant on biomass supply and demand.



**Lahti, Finland**

Waste from households for combustion in a CHP plant.



**Gubin, Poland**

Researchers and industry leaders meet in some fields of energy crops.



**Kristianstad, Sweden**

Biogas production, stations and vehicles.



**Vansbro, Sweden**

Forests for wood and residues for energy purposes.



**Grudziadz, Poland**

Farm land with potential for energy crops.



**Mureck, Austria**

Biodiesel production and supply for conventional vehicles.



**Winkleigh, UK**

Waste wood as an opportunity for biomass supply.



**Lviv, Ukraine**

At a waste management facility with potential for biogas production.



**Växjö, Sweden**

Wood chips for combustion in a CHP plant.



**Umbertide, Italy**

Typical landscape and farm land with possibilities for energy crops.

## Appendix D – Research Workshops

The following is a table with details about the research workshops:

<b>Workshops<sup>1</sup></b>	<b>Participants<sup>2</sup></b>	<b>Organisations<sup>3</sup></b>
Warsaw, Poland 4-5/3/2004	Magdalena Rogulska	ECBREC
	Ghislain Gosse	INRA
	Grzegorz Kunikowski	ECBREC
	Tomas Käberger	IIIIEE
Lund, Sweden 9-10/3/2004	Satu Helynen	VTT
	Eric Daugherty	JR
	Kes McCormick	IIIIEE
	Tomas Käberger	IIIIEE
	Jürgen Vehlow	FZK
	Anna Oniszk-Poplawska	ECBREC
Karlsruhe, Germany 21-22/09/2004	Helen Nilsson	IIIIEE
	Satu Helynen	VTT
	Eric Daugherty	JR
	Kes McCormick	IIIIEE
	Tomas Käberger	IIIIEE
	Jürgen Vehlow	FZK
	Kai Sipilä	VTT
	Marika Johansson	VTT
Warsaw, Poland 19-20/10/2004	Lukasz Jaworski	ECBREC
	Magdalena Rogulska	ECBREC
	Eric Daugherty	JR
	Kes McCormick	IIIIEE
	Tomas Käberger	IIIIEE
	Ewout Deurwaarder	ECN
	Lukasz Jaworski	ECBREC
Lund, Sweden 23-24/2/2005	Anna Oniszk-Poplawska	ECBREC
	Eric Daugherty	JR
	Kes McCormick	IIIIEE
	Tomas Käberger	IIIIEE
	Allan Johansson	IIIIEE
	David Longden	ASTON
	Aleh Rodzkin	Belarusan University
	Jürgen Vehlow	FZK
	Kai Sipilä	VTT
	Lars Larsson	Region Siljan
	Philip Peck	IIIIEE
	Pirrko Vesterinen	VTT
	Karin Ericsson	Lund University
	Thomas Johansson	IIIIEE
	Helen Nilsson	IIIIEE
Åke Thidell	IIIIEE	

Berlin, Germany and Gubin, Poland 9-10/5/2005	Andrzej Kucinsky	Vattenfall Poland
	Eric Daugherty	JR
	Kes McCormick	IIIIEE
	Tomas Käberger	IIIIEE
	Carsten Neumeister	Agrobränsle Germany
	Eddie Johansson	ENA Kraft
	Emiel van Sambeek	ECN
	Gustav Melin	Agrobränsle Sweden
	Jörg Asmussen	Vattenfall Europe
	Johan Tollin	Vattenfall Sweden
	John Brammer	ASTON
	Przemo Dobrzeniecki	Agrobränsle Poland
	Reihard Poetzsch	Bewag
	Marcin Pisarek	ECBREC
Helsinki, Finland 7-8/11/2006	Philip Peck	IIIIEE
	Kes McCormick	IIIIEE
	Kai Siplä	VTT
	Tuula Mäkinen	VTT
	Xander Tilburg	ECN
	Antti Arasto	VTT
Helsinki, Finland 17-18/11/2006	Philip Peck	IIIIEE
	Kes McCormick	IIIIEE
	Josef Spitzer	JR
	Vesa Hipiaine	VTT
	Eero Leppämäki	VTT
	Luwna Formela	ECBREC
	Anja Oasmae	VTT
	Gregorz Kunikowski	ECBREC
	Ewa Ganko	ECBREC
	Bernard Niclardot	INRA
	Wouter Huijgen	ECN
	Gerfried Jungmeier	JR
	Herman den Uil	ECN
Kai Siplä	VTT	

Note: 1) Shows the locations and dates of the workshops. 2) Lists the names of participants attending the workshops. 3) Identifies the organisations where participants work, including partners in the Bioenergy NoE and participants from academia, government and industry.

## **Appendix E – Project Publications**

The following is a list of all publications by staff and students at the IIIEE under the framework of the Bioenergy NoE, which are of relevance to this thesis work:

McCormick, K., Nilsson, H., & Ganko, E. (2007). *Energy Crops: Investigation of Socio-economic Barriers for Farmers in Poland*. Research Report. Bioenergy NoE Project.

Peck, P., & McCormick, K. (2007). *Mainstreaming Bioenergy Systems: Parameters of Breaking Dependence on Fossil Fuels by 2020*. Research Report. Bioenergy NoE Project.

Gervasoni, G., Boutin, J., Seyboth, K., Ratton, M., Lamers, P., & Help, R. (2006). *Bioenergy in the Ukraine: Investigating Drivers, Barriers and Scenarios*. Strategic Environmental Development Report. Master of Science in Environmental Management and Policy.

Savola, H. (2006). *Biogas Systems in Finland and Sweden: Impact of Government Policies on the Diffusion of Anaerobic Digestion Technology*. Masters Thesis Report. Master of Science in Environmental Management and Policy.

Sinnisov, L. (2006). *Barriers to Dedicated Energy Crop Cultivation in Poland: The Case of Willow in the Grudziądz Region*. Masters Thesis Report. Master of Science in Environmental Management and Policy.

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## Appendix F – Country Comparisons

The following is a table with details about country comparisons:

Countries <sup>1</sup>	Markets <sup>2</sup>	Actors <sup>3</sup>	Networks <sup>4</sup>	Institutions <sup>5</sup>
SWEDEN Enköping Vansbro Kristianstad Växjö	Leading country on solid biomass from forests, particularly for CHP and DHS. Increasing use of liquid biofuels with bioethanol and flexi-fuel vehicles. Potentials remain in both forestry and agricultural sectors.	Many actors are engaged in developing bioenergy systems, including the National Government, energy and bioenergy companies, local municipalities, forestry companies, and agricultural organisations.	Recently organised 2 <sup>nd</sup> World Bioenergy Conference with over 1000 participants. The Swedish Bioenergy Association is a strong coordinating force and a major promoter of bioenergy activities.	A range of supportive policy measures for bioenergy exists. In particular, the carbon tax transformed conditions for utilising biomass for heat. Bioenergy is a legitimate energy source, referred to as the 'green gold' of Sweden.
FINLAND Lahti	Leading country on solid biomass from forests, particularly for CHP and DHS. Forestry and agricultural sectors are promising but less so than Sweden.	Strong actors in the forestry sector and forest-related businesses, as well as actors involved in CHP and DHS. Emerging actors for liquid biofuels.	The Finish Bioenergy Association is similar to that in Sweden. There are several large bioenergy conferences organised regularly. There are strong links between the forestry sector and bioenergy business.	Finland is similar to Sweden in that bioenergy has established legitimacy. Policy measures (such as carbon and energy taxes, and investment grants) promote bioenergy systems.
AUSTRIA Mureck	Leading country on solid biomass from forests, particularly for CHP and DHS. High energy import dependency.	Primarily, forestry and wood industry, and farmers on the supply side, and actors involved in the heat market on the demand side. National Government is the principal actor shaping the favourable context for bioenergy.	The Austrian Biomass Association is relatively strong and facilitates networking between relevant actors. Formal agricultural networks and informal rural networks.	Decision on no nuclear, so renewable energy and bioenergy has become a political priority. Tradition with bioenergy. Strong economic framework for bioenergy based on investment grants and feed-in tariffs.
ITALY Umbertide	Bioenergy is only a minor energy source. Heavily dependent on energy imports, so interest in expanding indigenous supply options. Many homes heated by wood, but need modern technologies.	Actors engaged in biodiesel production. Also, some companies that make and sell modern wood stoves for heating purposes. Entrepreneurs appearing in some contexts, such as agricultural machinery.	Dispersed actors, not well coordinated. The different actors appear to be working in diverging directions, and have little political lobbying power.	Many different energy policies. Complicated laws and procedures for new energy plants. Opposition by local populations to biomass technologies, which are often perceived as waste incineration.

POLAND Gubin Grudziadz	Minor bioenergy utilisation at present, but it is the dominant renewable energy source. Very promising potentials for energy crops on agricultural land. Also forest resources. Co-firing with coal in large plants is a real option.	In the short-term the main actors are the wood and forestry industry, and energy companies obliged by law to expand renewable energy. In the long-term actors are emerging in the agricultural sector. Also, local government is often responsible for DHS.	No strong networks at present, but cooperation with other countries and immersion into EU may stimulate more organized activity on bioenergy.	No coherent or effective policy for bioenergy. No enforcement of existing policy. Renewable energy policy is scattered between various sectors.
UK Winkleigh	Bioenergy utilisation remains negligible in the overall energy system. Potential for developing energy crops, and utilising waste wood, forestry residues, and agricultural waste.	No strong leading actors for bioenergy. Electricity utilities are very powerful in shaping energy policy. Farmers are very cautious to switch from food crops to energy crops.	Collective action on renewable energy and bioenergy is only just emerging. Main actors are not united, and disorganised. Some lobbying from the farmers union for supportive policy measures on energy crops.	Focus on only electricity production rather than CHP. Unstable and unclear policy conditions. Bioenergy has little political support and it is not well understood. Trust problems between feedstock suppliers and technology investors.
GERMANY Berlin	Large utilisation of bioenergy and liquid biofuels in absolute terms. Utilisation mainly as pellets and chips for household heating and liquid biofuels in transport. Biogas is the most dynamic market currently for electricity.	There are many biodiesel producers and suppliers. Agricultural cooperatives and farmers are prominent as well. The Biofuels Quota Act demands oil companies to meet obligations on liquid biofuels.	Well-organised bioenergy trade and marketing associations lobby policy-makers. Traditionally a strong farming lobby. The host for the 15 <sup>th</sup> International European Biomass Conference.	Bioenergy is generally accepted as an alternative to fossil fuels and nuclear power. It has been receiving governmental support. There has been particularly strong policy for biodiesel. But conditions are changing with the Biofuels Quota Act.
UKRAINE Lviv	Mostly traditional use of bioenergy. Few modern technologies. Very promising potentials for developing energy crops on agricultural land. Option for exports of solid and liquid biofuels to the EU.	Few significant actors working on bioenergy. Some emerging consultancy businesses, research institutes and 'charismatic' individuals.	Recently organised 3 <sup>rd</sup> International Conference on Bioenergy in the Ukraine. But only minor cooperation between dispersed and politically weak actors.	No significant policy measures for bioenergy. On the contrary, major focus on nuclear power. Bioenergy generally perceived as niche energy option used by rural communities.

Note: 1) Countries and specific case studies. 2) Markets are mechanisms for the trade of goods and services. 3) Actors are either individuals or organisations. 4) Networks link actors together both inside and outside organisations. 5) Institutions can be formal rules or laws, or informal norms and beliefs.

## **Appendix G – Articles**

The following is the list of articles, which are the foundations of this thesis work:

- Article I Johansson, T.B., McCormick, K., Neij, L., & Turkenburg, W.C. (2006). The Potentials of Renewable Energy. In D. Abmann, U. Laumanns & D. Uh (Eds.) *Renewable Energy: A Global Review of Technologies, Policies, and Markets*. London: Earthscan.
- Article II McCormick, K., & Kåberger, T. (2005). Exploring a Pioneering Bioenergy System: The Case of Enköping in Sweden. *Journal of Cleaner Production*, 13(10-11), 1003-1014.
- Article III McCormick, K. (2005). *Sustainable Bioenergy Systems: Experiences from Sweden*. Paper presented at the Asia Pacific Roundtable on Sustainable Consumption and Production, Melbourne, Australia.
- Article IV McCormick, K., & Kåberger, T. (2007). Key Barriers for Bioenergy in Europe: Economic Conditions, Know-how and Institutional Capacity, and Supply Chain Co-ordination. *Biomass and Bioenergy*, 31(7), 443-452.
- Article V McCormick, K., Nilsson, H., & Tomescu, M. (2006). *Energy Crops and the Common Agricultural Policy*. Paper presented at the World Bioenergy Conference, Jönköping, Sweden.
- Article VI Bomb, C., McCormick, K., Deurwaarder, E., & Kåberger, T. (2007). Biofuels for Transport in Europe: Lessons from Germany and the UK. *Energy Policy*, 35(4), 2256-2267.



## Article I

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Johansson, T.B., McCormick, K., Neij, L., & Turkenburg, W.C. (2006). The Potentials of Renewable Energy. In D. Abmann, U. Laumanns & D. Uh (Eds.) *Renewable Energy: A Global Review of Technologies, Policies, and Markets*. London: Earthscan.



## Article II

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McCormick, K., & Käberger, T. (2005). Exploring a Pioneering Bioenergy System: The Case of Enköping in Sweden. *Journal of Cleaner Production*, 13(10-11), 1003-1014.



## Article III

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McCormick, K. (2005). *Sustainable Bioenergy Systems: Experiences from Sweden*. Paper presented at the Asia Pacific Roundtable on Sustainable Consumption and Production, Melbourne, Australia.



## Article IV

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McCormick, K., & Käberger, T. (2007). Key Barriers for Bioenergy in Europe: Economic Conditions, Know-how and Institutional Capacity, and Supply Chain Co-ordination. *Biomass and Bioenergy*, 31(7), 443-452.



## Article V

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McCormick, K., Nilsson, H., & Tomescu, M. (2006). *Energy Crops and the Common Agricultural Policy*. Paper presented at the World Bioenergy Conference, Jönköping, Sweden.



## Article VI

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Bomb, C., McCormick, K., Deurwaarder, E., & Käberger, T. (2007). Biofuels for Transport in Europe: Lessons from Germany and the UK. *Energy Policy*, 35(4), 2256-2267.



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Kes  
**McCormick**

# **Advancing Bioenergy in Europe**

Exploring bioenergy systems and socio-political issues

This thesis concentrates on bioenergy (or biomass utilised for heat, electricity and fuels for transport) as a renewable energy with significant potentials and options. Biomass can be considered as ‘stored’ solar energy because the process of photosynthesis ‘captures’ energy from the sun in growing plants. Bioenergy systems under the ‘right’ conditions can greatly contribute to climate mitigation, improved energy security conditions, maintenance of robust agricultural and forestry sectors, and industrial growth and greater exports.

The opportunities for exploiting bioenergy in Europe are considerable, a range of conversion technologies exists, and the European Union and some Member States have adopted supportive policy measures. However, the European Union is not expected to meet its own targets for bioenergy. This thesis explores the implementation of bioenergy systems in Europe focusing on socio-political issues. The purpose is to improve understanding of key drivers and barriers for bioenergy, and experiences of supportive (and disruptive) policies and actions.

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