Swedish University of Agricultural Sciences
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The German, Swedish and UK wood based bio energy markets from an investment perspective

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Glossary

Abbreviations
CHP = Combined heat and power
CO_2 = Carbon dioxide
DE = Germany
DH = District heat
EU = The European Union
EU10+2 = New Member States except Malta and Cyprus, and two candidate countries Bulgaria and Romania
EU15 = Member States of the European Union before 1.5.2004: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, the United Kingdom
EU25 = Member States of the European Union 1.5.2004: EU15 and Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia
EU 27 = Austria, Belgium, Bulgaria, Cyprus, The Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and The United Kingdom
EU30 = EU25 and Bulgaria, Romania, Turkey, Norway and Switzerland
Eurostat = Statistical Office of the European Communities
GJ = Gigajoule
Green Energy = Refers to energy produced from RES
IEA = International Energy Agency
IGCC = Integrated Gasification Combined Cycle
kW = Kilowatt
MWe = Megawatt, electric
MWth = Megawatt, thermal
OECD = Organisation for Economic Co-operation and Development
PC boiler = Pulverized coal-based boiler
PJ = Petajoule, 10^15 J
RES = Renewable energy sources
RES-E = Renewable Energy Sources used for electricity production.
RES-H = Renewable Energy Sources used for heat production.
RES-T = Renewable Energy Sources used for transportation.
SE = Sweden
TGC = Tradable green certificate
UK = The United Kingdom
UN = The United Nations
UNCED = The United Nations Conference on Environment and Development
UNFCCC = The United Nations Framework Convention on Climate Change
VTT = Technical Research Centre of Finland

Conversions
One Swedish Krona = 0,1029 Euro
One Swedish Krona = 0,1220079 American Dollars
One Swedish Krona = 0,0887408617 British Pounds
One British Pound = 1,06945499 Euros
One Dollar = 0,774653343 Euros

1 kilowatthour (kWh) = 3.6 megajoules(MJ)
1 PJ (petajoule) = 10 ^15 J
1 kWh (kilowatt hour) = 3,600,000 Joule
1 toe (tonne oil equivalent) = 0.000041868 PJ
MWh to MW: MWh refers to energy, MW refers to power.. Energy = amount of work, power = rate of work. One MWh = one million watts of power applied over the period of an hour. One MW = one million watts per second. To convert MWh to MW: MWh = MW / Hours. (Hours = time applied in hours)

Summary

The bio energy industry provides interesting investment opportunities due to several factors including; a strong political will to increase renewable energy production, favourable financial returns and opportunity to benefit from available governmental grant schemes and subsidies. Biomass is also to a large extent an untapped resource that offers opportunities for greater exploitation. However, there are obstacles for an expansion of the bio energy industry such as logistical and technical issues as well as relatively long investment horizons (as a result of high capital costs).

This thesis examines and compares the investment situation facing the Swedish, German and UK bio energy sectors through; literature studies, qualitative interviews and country specific calculations of maximum feedstock (i.e. wood) paying capabilities (WPC's) for relevant technologies. The three thesis included countries are interesting to compare from an investment perspective as they differ regarding biomass resources, established technologies, implemented governmental incentive schemes for renewable energy sources etc.

Thirteen interviews consisting of one phone conference with more than one person interviewed, one personal meeting and eleven phone interviews form the base for the empirical material. The persons interviewed are either generally knowledgeable of the bio energy sector as a whole or associated to a specific bio energy producing installations. The interviews highlight high associated capital costs, economic optimisation of feedstock supply, existing demand, access to electric and/or heat grids and governmental incentive systems as determining factors for investors in the three countries.

The thesis included countries have different ways of supporting renewable energy generation. In Sweden and the UK, government imposed quota regulations on suppliers to source parts of their electricity from renewable energy sources are imposed. These quota systems rely on certificates being handed out to producers of green electricity for each MWh of electricity produced. These certificates must then be sourced by suppliers in order for them to prove that they have fulfilled their renewable energy quota. The certificate price is set by market conditions, i.e. the relation between the number of producer awarded certificates in relation to the set quota for suppliers. In Germany a feed-in system is applied which rewards producers with a guaranteed grid access and a minimum fixed electricity price for each MWh of green electricity fed in to the grid. The German system is limited to smaller scale installations with a capacity of no more than 20 MWe and an output not exceeding 175,2 GWh annually.

The Swedish and UK quota systems are well liked by some of the as they support any installation scale and as they are market oriented systems which allows renewable energy sources to compete with traditional energy sources such as coal. Respondents however see a problem in making long term investment decisions based on fluctuating certificate prices. The German feed-in system is viewed as a stable and reliable remuneration scheme where investors know exactly what revenues they can expect from their electricity production. However, as the feed-in level is fixed producers cannot pass on increasing costs to the end consumers as is the case with variable electricity prices.

The Wood Paying Capability (WPC) calculations point towards a relatively high paying capability (SE=30,1 €/MWh, DE=45,6 €/MWh, UK=37,9 €/MWh) which is generally well above biomass prices. The relatively high WPC values indicate that there are positive profit margins on all three markets. Furthermore, the WPC results display large variations in paying capability between the three countries. These variations in turn may be explained by governmental remuneration levels being adjusted to differing structural conditions such as biomass availability and existing infrastructure e.g. in the form of district heating systems. Furthermore the WPC variations are also affected by large differences in country specific electricity spot prices and variations regarding installation associated costs utilised in the calculations. Regarding the high German WPC value, it should be noted that large scale facilities in the Swedish and UK systems may render better financial figures if the total remuneration is calculated as the German system has a capacity and output limit.

The main factors limiting the entry of new actors on the examined bio energy markets are high capital costs and logistic issues. The associated high capital costs has traditionally incurred long pay off times ranging from 15 to 25 years which has often deterred bio energy investments or steered investors towards other renewable energy sources such as wind power. Biomass is also often a scattered resource which in combination with the biomass fuels bulk and relatively low energy content makes the fuel ill-suited for long transports. However, both logistical and capital issues may be overcome by future investments in truly large scale installations through economics of scale. Regardless of scale, an optimised feedstock solutions stand out as particularly important aspect both as uncovered by the interviews and by previous research. The feedstock logistical solution determines how much fuel a facility has available and thus it limits the financially viable plant scale as well as it directly affects fuel sourcing costs. The relative importance of an optimised sourcing solution is illustrated by the fact that forest residues delivered at plant generally costs twice as much as coal delivered at plant.

Furthermore, the relative importance of the different investment deciding factors is influenced by the prevailing structural conditions on the examined markets. For example, feedstock or logistical issues are less likely to hamper investments on the Swedish market than on the UK market.

Keywords: Bio energy, Investment, Paying Capability, Renewable Obligation Certificates, Levy Exemption Certificates, Green certificates, Feed-in tariffs

Table of Contents

GLOSSARY 1

SUMMARY 3

TABLE OF CONTENTS 5

1. INTRODUCTION 7

1.2 Purpose, research question and Scope 9

2. THEORETICAL FRAMEWORK 11

2.2 Economic Theory used in the Model Calculations 14
2.3 Theory Critique 15

3. METHODOLOGY 17

3.1.1 General Description and assumptions ***17***
3.1.2Qualitative Method ***17***
3.1.3 Interviews ***18***
3.1.4 Qualitative semi-structured interviews ***19***
3.2 Literature review 20
3.3 Definitions and assumptions 21

4. THE BIO ENERGY SECTORS IN SWEDEN, UK AND GERMANY 23

4.1 Technologies and Costs 23
4.2 Biomass Availability and Trade 26
4.3 Production and consumption 30
4.4 Prices for electricity, heat and feedstock 32
4.5 Incentives 33
4.5.1 Governmental Incentives – An introduction ***33***
4.5.2 Tradable Emission Rights ***34***
4.5.3 Sweden ***35***
4.5.4Germany ***37***
4.5.5 The United Kingdom ***38***
4.5.6 Summary of the main Incentive Systems ***40***
4.6 Future outlook 41

5. RESULTS 43

5.1.2 Interviewed Actors ***43***
5.1.3 The Investment Decision ***43***
5.1.3 Market Structure and Characteristics ***44***
5.1.4 Future outlook ***45***
5.1.5 Costs ***45***
5.1.6 Favored Investments ***46***

6. MODEL CALCULATIONS 47

6.1.2 Costs ***47***
6.1.2 Revenues ***49***
6.2.3 WPC Calculations ***50***

7. APPLYING THE THEORY 54

7.1.2 Structure of the bio energy market - Germany ***56***
7.1.3 Structure of the bio energy market – UK ***56***
7.1.4 Forecasting the Future ***57***

8. DISCUSSION 59

8.2 Literature Findings 59
8.3 The Interviews 60
8.4 WPC Calculations 62
8.5 The Structure of the Examined Markets 64

8.6 WHERE TO INVEST 65
8.7 FUTURE RESEARCH 67

ACKNOWLEDGEMENTS 68

REFERENCES I

FIGURES I
TABLES I

LITERATURE III

APPENDICES IX

A: GLOSSARY SEE BEGINNING IX
B: DEFINITIONS AND SPECIFICATIONS IX
B 1General definitions in accordance with the 2007 "Biomass fuel trade in Europe Summary Report" ix
B 2 Text Derived and Directly Translated from the Biomasse V Document ix
B 3CEN/TS 14588 Biomass Definition Standard xi
B 4 Approved fuels in the Swedish Green Certificate System – translated by the authorxi
B 5 Fuels Eglibel for ROCs - Office of Gas and Energy Markets definition xi
C: ANNEX XII
C 1 Feed-in tariffs in Germany – Guideline Documents xii
C 3 Construction costs, operating costs and efficiencies of new biomass power plants – Shared EIA Estimations xv
C 4 Swedish Biofuel Costs – Numbers produced by the Swedish Statistical Authority..xvi
C 5 Assumptions used for the Thesis Calculations xvi
C 6 Interview Respondent Description and codes xvii
C 7 Extended Interview Results xviii
C 8 Regarding the performed Eurostat Database Query xxviii
C 9 Excel Calculations xxix

1. Introduction

1.1 Problem definition and background

Problem definition

In order to reduce the European Union's negative environmental impacts and dependency on energy imports a number of EU wide targets and policies have been established for the member countries. Among the more ambitious is the collective target for 20% renewable energy in final energy consumption by 2020. (VTT, 2006 (1))

Of the different renewable energy sources bio energy is an interesting alternative as the biomass resource currently is utilized to a relatively low extent. In 2004 the EU 20 area produced an equivalent of 2742 PJ from biomass representing about 50% of the estimated biomass potential (EUBIONET II, 2007 (1)). Also, the utilisation of biomass is expected to increase in order to fulfil environmental targets such as the mentioned EU 20% RES by 2020. This means that the biomass utilisation is expected to increase significantly and thus the bio energy industry is likely to expand. Growing environmental concern and rising energy prices in general may further increase the interest for bio energy.

Figure 1 shows the difference between the 2005 share of renewables in final energy consumption and the country specific target for 2020 and thus gives an indication of the potential for an expansion of the bio energy industry in the included countries. Note the relatively large differences between share and target in two of the scope countries Germany and the United Kingdom and the large share of RES used and targeted in Sweden.

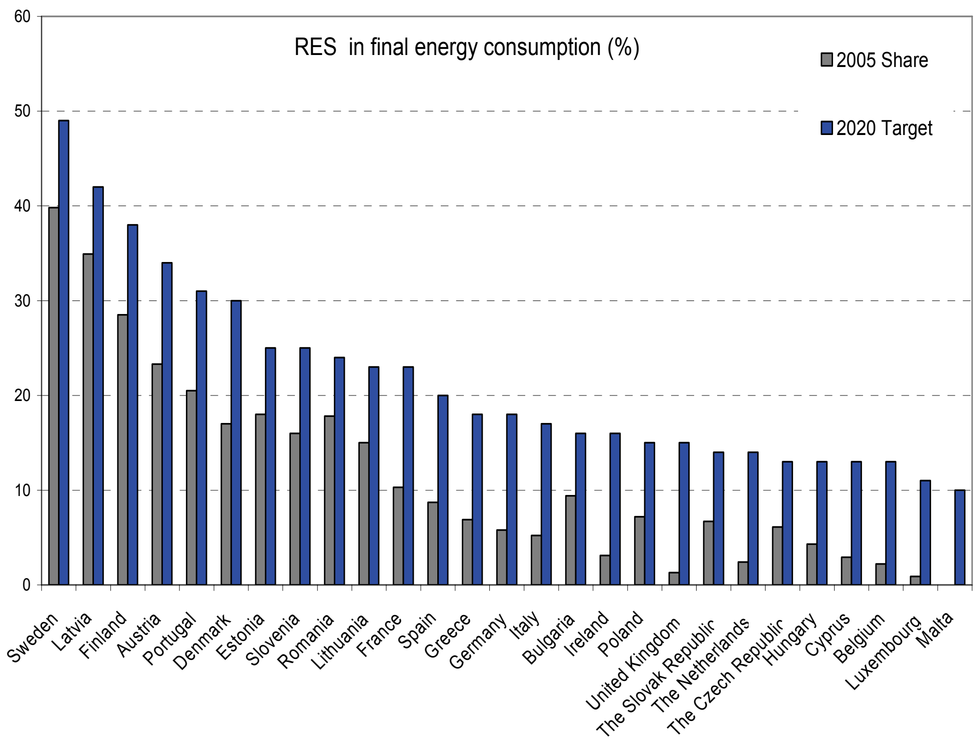


Figure 1. Actual RES in final energy consumption 2005 and targets for 2020. Adapted From (Department of Business Enterprise & Regulatory Reform, 2008)

The bio energy industry is part of the growing renewable energy sector which represented investments exceeding 148 billion dollars globally in 2007 (UNEP, 2008) is in itself a sufficient reason for the thesis purpose of examining the bio energy investment climate.

Background - Sweden
Bio fuels (bio fuels here meaning fuels derived from biomass and biomass being material of biological origin that has not been, or only insignificantly has been, transformed chemically/biologically) stand for about 28% of the Swedish final energy consumption. (www, Svebio, 2009 (1)) The Swedish bio energy market is characterized by a good availability of raw materials, a for the bio energy industry favourable taxation system, a large forest industry that functions as both a user of bio energy and a supplier of biomass to other users and finally Sweden has a large established network of district heating systems. (EUBIONET, 2006 (2)) One of the reasons for the well established district heating system is that in many cases the systems have been subsidized through investment grants, in some of these cases the grant was conditional that the sites would use bio fuels (fuels derived from chemically/biologically unaltered biological origin) for at least five years. (EUBIONET, 2006 (2))

The forest industry is the biggest bio energy user in Sweden, in 2004, 52% of the total bio energy usage can be derived to the industry's heat and electricity production. The second largest bio energy consuming sector is the large district heating sector which stands for 36% of the total bio energy usage in Sweden. (Energimyndigheten, 2004) CHP production contributes to 6% of the total usage of electricity in Sweden which is less than the EU average. (www, svenskfjarrvame, 2008 (1)) The dominating fuels utilized to provide energy for the Swedish district heating system are bio fuels, i.e. fuels derived from chemically/biologically unaltered biological origin, which have replaced oil during the past decade. (Kungliga Ingengörsvetenskapsakademien, 2002) In 2003 Swedish CHP plants consumption of solid wood fuels where divided according to 62% forest and logging residues, 22% densified wood fuels and 16% recovered wood. (EUBIONET II, 2006 (2)) In 2005 46,5 TWh of heat energy was delivered to the Swedish district heating system. (www, svenskfjarrvarme, 2008 (2))

Background - Germany
In 2006 RES represented 5.8 % of the primary energy consumption in Germany and RES in the total gross electricity consumption accounted for 12 %. (www, german-renewable-energy, 2009 (1)). In 2007 there were more than one thousand heat generating biomass plants in Germany and also in 2007 bio energy accounted for roughly 6% of the required heat in Germany. In the same year CHP plants accounted for 1.5% of Germany's electricity consumption. (www, renewables-made-in-germany, 2009 (1)). 130-140 CHP plants utilizing solid bio fuels (fuels as defined by Biomasse V, see Anex B 2) with a capacity ranging up to 20MW where in operation in Germany in 2005. The group of CHP plants in the size of 5-20MW where dominated by municipal utility operators. The average CHP plant in Germany has a capacity of around 6MWel. (EUBIONET II, 2006 (1))

In Germany, as in many other European countries, there is a more recent (compared to Sweden) trend towards a greater biomass utilisation mainly due to governmentally controlled incentives such as the Renewable Energy Sources Act and the following Biomass Ordinance (described further on). (EUBIONET II, 2006 (1))

In Germany the most common wood based fuel used for CHP production is waste wood, industrial wood and different types of wood residues. Forest based residues are mostly used for electricity production. (Thornley & Cooper, 2008)

Generally the bio energy technology in Germany is continously evolving, especially concerning CHP plants Germany can be considered one of the world technology leaders. (www, renewables-made-in-germany, 2009 (1)).

Background - The United Kingdom
In 2008 about 1, 5% of the UK's energy was sourced from renewable sources, which is low in relation to most European countries and also in relation to the 15% RES in 2020 UK target. (Pöyry energy Consulting, 2008) The UK domestic supply of biomass is small to that of e.g. Sweden or Germany yet it is estimated that the domestic supply could be increased substantially through the expansion of wood energy crops and dry agricultural residue. (EUBIONET II (3), 2006)

The gross consumption referring to biomass was around 31 PJ and the biomass input to power generation production was roughly 3 PJ in 2004.

Biomass has historically not been of interest and thus has not been established on a large scale in Great Britain. This is partly due to the fact that incentive schemes have focused on the promotion of high technology electricity-only production, i.e. the production of heat has not been valued or prioritized to date. (EUBIONET, 2006 (1))

The UK is heavily dependent on the combustion of gas and coal for its electrical production. (Thornley & Cooper, 2008) Despite the relatively low availability wood is the largest feedstock for renewable heat in the UK accounting for about 70 % of the produced heat. (Miles & Rosillo- Calle, 2008)

Figure 2 shows the relations between the three scope countries concerning biomass in gross heat production and gross electricity generation in 2006.

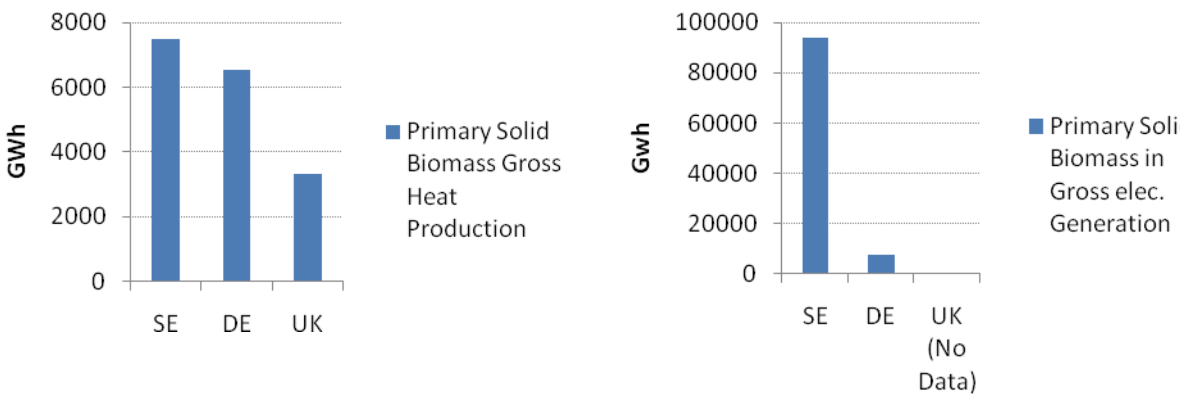


Figure 2. Primary production/generation from biomass in 2006. Source www, IEA, 2009 (1)

1.2 Purpose, research question and Scope

Purpose
The purpose of the thesis is to analyze and compare the investment situation facing the bio energy sectors in Sweden, Germany and the United Kingdom.

Research question

What are the country specific characteristics facing the bio energy industry in Sweden, Germany and the United Kingdom? And which economic factors, structural conditions and governmentally imposed regulations or systems can be viewed as the most important for the bio energy industry?

Scope

The bio energy sector is defined as the large scale utilisation of biomass for production of energy in the form of electricity and/or heat. The term large scale is a relative expression that is defined differently on different markets. For the purpose of the thesis the downward limit to what is considered as large scale is drawn at decentralized district heating systems ranging in sizes from 5-10MW. The phrase "energy producer" covers producers of heat and electricity or producers of electricity or heat. The thesis scope is restricted to solid wood based fuels.

2. Theoretical framework

2.1 Porters Five Forces

General
When making the crucial decision whether or not to make an investment in a specific industry the predicted profitability of the selected industry can be seen as a determinant factor influencing the decision. (Grant, 2008) Industry structure and industry profitability are the key factors in the widely adapted theoretical framework known as Porter´s Five Forces model (Porter, 1980).

Porter defines industry profitability as the rate of capital return in relation to capital costs and views industry profitability as being dependent on five competitive variables or sources. Three of the sources can be found within the existing industry; competition from substitutes, competition from new entrants and competition from already established competitors. The two remaining sources can be found outside the industry and are defined as power from suppliers and power from buyers. How important each of the five forces is will be determined by industry specific structural variables. For example, the threat of new entry will to a degree be determined by the costs for entering the industry. (Grant, 2008) Figure 3 gives an overview of Porter´s Five Forces model.

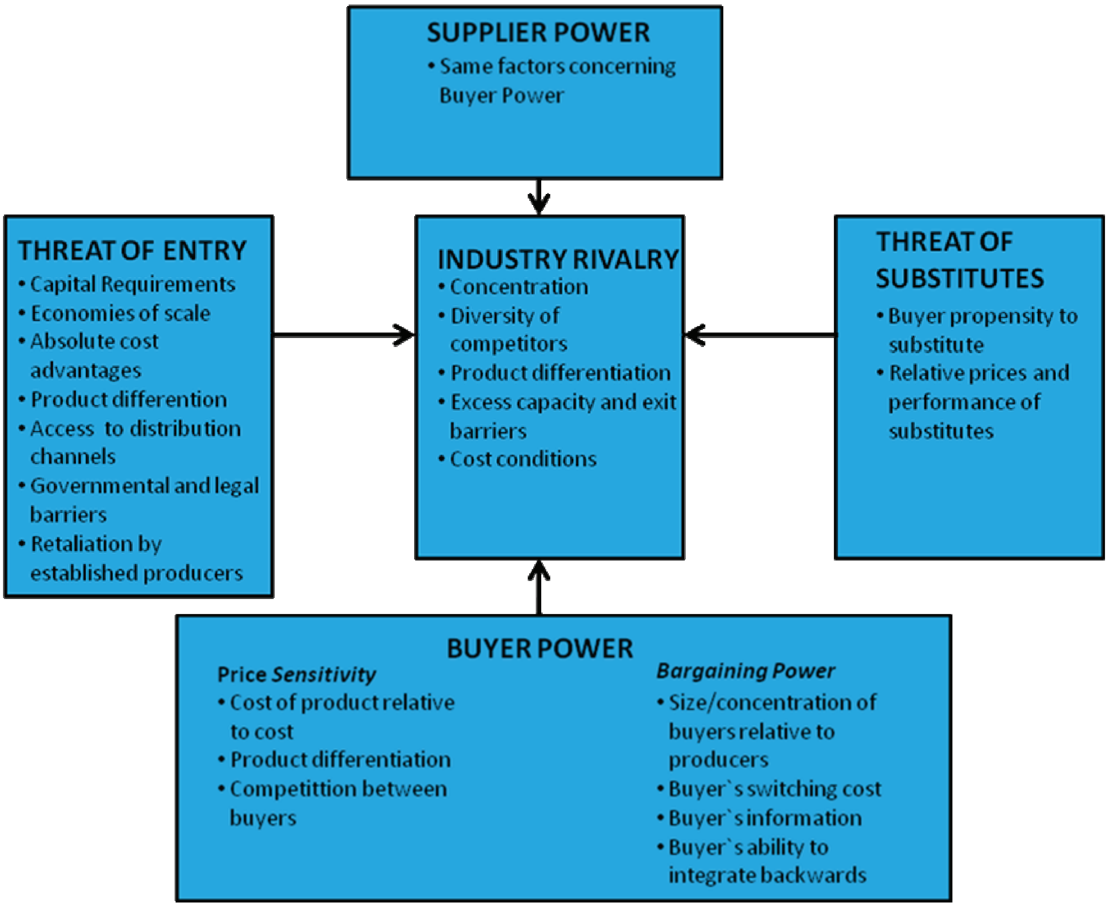


Figure 3. Porter's Five Forces Model. Adapted From Grant, 2008.

Porter's Five Forces
Porter - Threat of Substitutes
The "threat of substitutes" box describes customer's will and possibility to leave one product

for another and related to this is what price a costumer is prepared to pay. In this context substitution implies that one product type is switched for another. For example a travel agency may be substituted by online booking. Other products like gasoline have fewer substitutes. Thus from solely a “threat of substitutes” perspective the gasoline industry offers attractive competitive circumstances for new entrants. The relative threat of substitution is mainly dependent on the availability and price of alternatives and also the perceived quality of the available alternatives. Generally a complex product that is difficult to evaluate on a performance basis is less likely to be substituted on a price basis. (Grant, 2008)

Porter - Threat of Entry
The second intra-industry factor is the threat of new entries. Regarding the threat of new entries the fundamental factor to be considered is if the industry producing returns on its capital that exceeds its cost of capital. If this is the case there is a theoretical interest for new actors to enter. The deciding factor regarding whether new entrants will be able to establish themselves is then what types of entry barriers that characterize the examined industry. These may consist of high capital requirements associated with entering the industry. Furthermore, the industry may be characterized by economies of scale which may put new entrants in the position of choosing between entering on a large scale and possibly underutilizing its resources or entering on a smaller scale and thus carrying a higher unit cost on its production while the established actors may have an advantage in large scale production and already established market shares. Besides economies of scale there may be absolute cost advantages associated with entering a new industry. These absolute cost advantages are not dependent on scale but other factors giving certain actors an advantage. Usually absolute cost advantages are related with the low cost access to a certain resource. Also, established actors may have an advantage in brand recognition and customer loyalty. Another form of entry barrier is the possible problem for new entrants of gaining access to a distribution channel. It has been argued that the most effective barriers are those created by governments e.g. through monopolization. Finally, the threat of different types of retaliation from established actors, e.g. price wars, may form a barrier as a deterrent for new entrants. The presence of strong entry barriers has been empirically proven to generate higher profits. (Grant, 2008)

Porter- Industry Rivalry
The third intra-industry factor is concerned with rivalry between established actors. The intra industry competition can be seen as influenced by a number of factors. Firstly, the concentration or numbers of actors on a specific market will be an important factor regarding the level of competition. For example, a market dominated by two large players will generally have a lower level of competition (e.g. as a result of price coordination) than a market that is characterized by a large number of actors. The price competition that is often associated with a large number of producers may be counteracted by differencing objectives, cost and strategies between established actors. Depending on the characteristics of the sold product differentiation may also be possible on a product level. If the product is a commodity, price is often the sole mean of competition between firms. Another important factor affecting the rivalry of an industry is the presence of excess capacity among producers which tend to put a downward pressure on the price of the industries products. The presence of excess capacity may be associated with cyclical demand or a result of previous overinvestment in the industry. One of the main factors that play an important role in industry pricing and thus often industry rivalry is the cost conditions of the industry. Specifically the ratio of fixed to variable costs is important. If the fixed costs are high and the variable costs relatively low there is a risk of price dumping and overproduction as companies may tend to produce for marginal profits. (Grant, 2008)

Porter - Buyer and Supplier Power
Besides the intra industry aspects the model also considers buyer- and supplier/seller power. The relative power of the buyer is affected by two main factors, the buyer's price sensitivity and the buyer's relative bargaining power. Price sensitivity in turn is affected by a number of factors such as the importance of the supply for the buyer, the level of product differentiation (available substitutes), competition among buyers and how important the supplied product is for the quality of the buyer's product. Generally the less important, less differentiated and less competitive the buyer market is the more price sensitive, i.e. more powerful, the buyer will be. The relative bargaining power can be summarized as one actor's ability to choose whether or not to deal with the other actor. A couple of factors can be mentioned that influence buyers bargaining power: the size and concentration of buyers in relation to the size and concentration of suppliers will play an important role as a large actor can exercise great power against a smaller one as the relative cost of a cancelled deal is much smaller to the larger actor. Also a buyer that is well informed regarding different supplier's price and product quality will have a stronger negotiating position as more favourable alternatives will put an overly expensive or low quality supplier out of business. Finally, the buyer ability to integrate vertically e.g. produces certain components, may put pressure on suppliers to lower prices or raise quality. (Grant, 2008)

The same arguments and logics applied to the buyer's price sensitivity and relative bargaining power can be applied to the seller or supplier, the only difference lies in from which focal company the analysis is made. (Grant, 2008)

Applying the Model
As the model's central idea is that industry structure determines industry competitive forces and thus the profit offered by the industry the first step in applying the model should be to determine the structure of the examined industry. This may be a very complex process and it is usually not as straightforward as a first glance at the model may imply. Integrated companies that perform a number of supply chain activities and industries that are hard to define (e.g. what the substitutes for a specific product are and what the boundary of the industry is) pose problems for the analysis. In order to overcome these problems a thorough definition of the industry to examine should be made by setting precise product and geographical definitions etc. (Grant, 2008)

If the model framework is successfully applied two of the most important outcomes from using the model is a tool for predicting the future industry profitability and after having done this form a competitive strategy which may include changing the industry structure. A forecast using industry structure may be divided into three steps:

1. Analysis of the industry's current level of competition, profitability and current structure.
2. Analysis of the different factors/trends that are changing industry structure.
3. Applying the structural changes to the five forces and thus the profitability of the industry.

After this analysis a strategy that may involve changing industry structure can be devised. This process involves two steps: Firstly the structures hampering industry profitability are to be identified and secondly a decision whether to attempt to change these structures needs to be made. For example the construction of entry barriers or consolidation of an industry may be outcomes of this strategic analysis. (Grant, 2008)

2.2 Economic Theory used in the Model Calculations

Capital Costs

Capital costs consist of the investments made which in turn can be divided into amortization, time, interest and the residual value of the investment. In other words, the capital costs consist of the depreciation of capital and the interest cost of using capital. Assuming linear amortizing the value to be amortized every year is dependent on the expected residual value of the investment. For example an investment of 1.000.000 € that has an expected residual value of 100.000 and a linear amortization time of ten years is amortized with (1.000. 000-100.000) / 10 = 90.000 € annually. The interest cost of the investment is a fixed percentage of the booked value of the investment. Assuming an interest of 10% the interest cost annually the first five years is calculated as follows (In €). (Johansson & Samuelsson, 1986)

Amortization	Interest
Year1: 90.000	0.10*1.000.000 = 100.000
Year2: 90.000	0.10*(1.000.000-90.000) = 91.000
Year3: 90.000	0.10*(1.000.000-180.000) = 82.000
Year4: 90.000	0.10*(1.000.000-270.000) = 73.000
Year5: 90.000	0.10*(1.000.000-360.000) = 64.000

Thus, the total capital cost amounts to 90.000 + 100.000 = 190.000 € in Year 1 and 90.000 + 91.000 = 181.000 in Year 2 and so on (Johansson & Samuelsson, 1986).

Instead of a linear depreciation a digressive or progressive method may be used depending on whether the assets loses the most value during the beginning or end of its calculated lifetime, the expected technological development affecting the expected lifetime of the investment etc. (Johansson & Samuelsson, 1986)

Operating Costs

Operating costs consist of the unit cost of producing one marginal unit. The alternative costs can be specified as the costs of occupying the resources used to produce. (Johansson & Samuelsson, 1986)

Paying Capability

As part of achieving the thesis purpose a comparison between specified installations' paying capability for their wood based fuel is performed further on in the thesis. The thesis defines an installation's paying capability as revenue streams minus costs and thus represents a measure of what the installation is *capable* of paying for its wood based fuel. This in turn can be used as a part of the investment decision analysis as the calculations uncover the upper limit for the tolerated fuel prices. That is, if fuel prices are projected to e.g. rise above the maximum paying capability the investment should probably not be undertaken. Furthermore, the installations profit margins can be roughly projected by changing model in values for costs and revenues and the model can thus be used for straight forward sensitivity analyses.

The calculations are based on general costs and country specific revenue streams. The general types of costs that have been chosen are seen to represent a feasible type of installation investment.

In order to obtain numbers on paying capabilities excel based calculations of the paying capability are performed. The calculation of the paying capability is to a degree inspired by existing models (www, swd, 2008 (1)), (Svensk Fjärrvärme, 2005), (ElForsk, 2007) but also to a large degree by the information uncovered during the thesis learning process. The calculations are based on the market price for electricity and heat, generating costs and the country specific incentive schemes. The model provides a simplified picture of the investment situation but the aim is that it should cover as many crucial variables as possible in order for it to remain relevant.

The unit that the paying capability is calculated in is €/MWh and the general formula has the following basic parameters;

Revenue Streams	
Revenues from Electricity production	xx € / MWh
Revenues from Heat production (If any)	xx € / MWh
Value of governmental support system	xx € / MWh
Costs	
Total Generating Costs (capital, operating etc.)	xx € / MWh

Paying Capability: (€ / MWh) = (Revenues from electricity production + Revenues from Heat production (If any) + Value of governmental support incentives) – (Generating costs)

The main governmental support systems are represented by the Green Certificate System in Sweden, Feed-in Tariffs in Germany and The renewable Obligation Certificate System in the UK. Indirect measures such as taxes or the Tradable Emissions Scheme are assumed to be reflected in a higher energy price in general (as the use of fossil fuels is made more expensive).

2.3 Theory Critique

The Five forces model has received varying criticism during its soon more than thirty year's lifespan. Some have argued that the theory lacks theoretical rigor and that the assumed relation between structure and conduct is not thoroughly sub stained. Also, it is an empirical fact that the industry structure and firm profitability are correlated to a relatively low extent (20%). (Grant, 2008)

Furthermore the theory assumes that alternative goods are substitutes, i.e. competitors, and that these substitutes lower the profits available in the industry. This assumption fails to consider other types of products and thus it fails to recognize the value of complement products. For example, the value of the car industry is positively correlated with the availability of gasoline (i.e. a complementary product). Thus other products should not only be viewed as value destroying but also as value adding. (Grant, 2008)

Also, the theory can be criticized for having a too stable view of industries. Competition only predicted by considering stable structural factors will fail to take in to account the fact that innovation and entrepreneurship can change industry characteristics rapidly. (Grant, 2008) The critique that the model fails to take into to account the positive effects from complementary products also means that collaborative behaviour between firms is not taken into account. (Ghemawat, 2001)

As said before the Five Forces Model was formulated almost thirty years ago and there are therefore obvious flaws due to changes in the general business environment such as globalisation and its related effects. However the model has been evolved through its life span and variables such as import competition and multimarket contact has been added to the model. (Ghemawat, 2001) Also, the model fails to take into account what can be referred to as the “sixth force” complements, i.e. collaboration. However, despite all its flaws the model can be useful as a tool for using available information of industry structure to predict profitability and support the strategy making process. The relatively low correlation between industry structure and industry profitability of less than 20% still provides proof that structure plays an important role. (Grant, 2008

3. Methodology

3.1 Method

3.1.1 General Description and assumptions

The investment situation in the researched countries is assessed on the basis of knowledge gained from literature, interviews and country specific calculations estimating wood paying capability for wood based fuels. It is assumed, all other things equal, that a higher paying capability implies a more favorable investment situation. This as the paying capability, as defined in the thesis, basically measures the difference between costs and revenue streams. The overall purpose of the interviews is to gain industry specific knowledge and insights.

3.1.2Qualitative Method

Quantitative method can be said to investigate predetermined variables and circumstances in different populations, events and situations while qualitative method can be described as having the purpose of identifying and determining unknown or to an unsatisfactory degree known variables and properties (Starrin & Svensson, 1998). More precisely quantitative method involves counting and / or measuring while qualitative method is descriptive in nature. (Gilham, 2000) Qualitative method suits research that aims to start the analysis "with a blank page" or without preconditions as opposed to the quantitative method that, as mentioned, is primarily used to quantify more or less known variables. The idea behind the qualitative approach is to ask simple open questions and to receive interesting and fulfilling answers. (Trost, 1997)

Gilham (2000, 11) defines "What qualitative methods enable you to do" as follows:

1. "To carry out an investigation where other methods – such as experiments – are either not practicable or not ethically justifiable."
2. "To investigate situations where little is known about what is there or what is going on. More formal research *may* come later."
3. "To explore complexities that is beyond the "scope" of more \`controlled\` approaches."
4. "To \`get under the skin\` of a group or organization to find out what really happens – the informal reality which can only be perceived from the inside."
5. "To view the case from the inside out: see it from the perspective of those involved."
6. "To carry out research in to the *processes* leading to results (for example how reading standards were improved in a school) rather than into the \`significance\` of the results themselves."

I have chosen a qualitative method approach as the purpose of the thesis (i.e. "…analyze and compare the investment situation facing the bio energy sectors in Sweden, Germany and the United Kingdom…") since the examined field contains many, for me, unknown variables which are best explored by a qualitative method for the following reasons;

Firstly, as part of the wider purpose is to collate real world evidence in the form of knowledge and views from people associated with the bio energy industry and as the content of this "evidence" (i.e. the results of the interviews) is not known, or known to a lesser extent, the purpose fits the explorative nature of the qualitative method as described above. Secondly, the ambition to collect industry specific knowledge coincides well with what Gilham (2000, 11) describes as "getting under the skin of a group" in order to uncover an informal truth and the wish to view the case from the "inside out" (taking the perspective of the examined industry). Finally, much of the thesis interest lies within the processes that lead up to more or less favorable investment situations. These processes in turn are not easily described by close end or questioner questions.

3.1.3 Interviews

Interviewing is a time consuming and complicated process. As interviews tend to be time consuming the number of interviews should be adjusted to the purpose and resources of the project. Factors that generally imply that interviewing is not a suitable method include: a large geographical dispersion of the people of interest for the interviews which makes the process more complicated, anonymity for the interviewed cannot be preserved (i.e. the interviewer knows who he or she is interviewing) or if the questions asked are closed or straight forward. Conversely interviewing is more suitable if there are a limited number of respondents involved, the persons of interest for the interviews are easily accessible, the questions are open (require a extended response to make sense) or if the material is sensitive in any way which in turn requires the respondent to trust the interviewer. (Gillham, 2000)

For the thesis purpose qualitative semi structured interviews are seen as the best available approach as country specific and experienced based knowledge cannot be easily accessed otherwise. Also, there may be a risk that important factors may be overlooked should the analysis be based solely on a literature research as the area of investigation is substantial and difficult to completely cover within the timeframe of the thesis. The type of insights that the interviews aim to collect is not suitable as close end questions as argued under *4,1,2 Qualitative Method* and interviewing has been chosen in order to promote an open and creative discussions despite the obvious drawbacks such as a widely dispersed group of interest for the interviews.

Although some of the above stated arguments may suggest that the rather complex issues that the thesis examines are best performed via face to face meetings, phone interviews with persons and companies associated with the bio energy industry has been chosen as the main interviewing method. The decision to predominately utilise phone interviews instead of face to face meetings was mainly based on the fact that the thesis is written under economic restrictions which e.g. has prevented the author from visiting the widely dispersed respondents. The main drawback of utilising phone interviews is the fact that different forms of indirect communications such as body language are lost. Also, it is hard for the interviewer to know what situation the interview subject is in, e.g. the phone call may come at an inappropriate time. (Jacobsen, 1993)

The process of selecting respondents for the interviews has been performed in a manner inspired with what Trost describes as strategic selection. This approach include stating variables and characteristics that are of interest for the interviewer and creating categories of variables that should characterise the approached respondents. (Trost, 2001)

The sought after characteristics of the thesis respondents have been defined as follows;

- They are bio energy producers
- They mainly utilise wood based fuels
- They are active in Sweden, Germany or the United Kingdom
- They are assumed to have a good understanding of their respective bio energy market

These characteristics have formed the category from which respondents have been contacted. Persons that have been assumed to have a good overall understanding include fuel managers, managing directors of heat and/or power plants, plant managers and various technical professionals within the bio energy industry. Although the thesis interest categories have been defined by a method resembling strategic selection the final selection and of the respondents have been performed in line with what Trost describes as a convenience sample. A convenience sample basically means that an approach to contact respondents fitting the stated characteristics is made and that the researcher then interviews respondents that he or she comes across. This approach means that a convenience sample is not representative in a statistical sense. (Trost, 2001) However, representativity and validity in a statistical sense are not are not interesting when conducting qualitative interviews. This as it is not possible to conceive and experience objectively. Rather the interviewer's subjective interpretation is a natural part of the chosen qualitative method. Because of this, validity in a statistical sense is not possible (nor interesting) to obtain via qualitative interviews. Instead validity, for the purpose of the thesis, can be defined as how well the method reflects its source and how well it facilitates a general understanding of the problem. (Lanz, 1993) This definition of validity also means that the selection of the interview subjects need not be random or extensively large in order to be represent the examined population, rather the process needs to facilitate relevant information. The thesis respondents have been chosen to represent the overall population of bio energy investors in Sweden, Germany and the UK.

The respondents have mainly been contacted by e-mail and often found through company web pages and other forms of internet research. Also, the personal networks of the two thesis supervisors Dr. Folke Bohlin at SLU Uppsala and Hannes Lechner at Pöyry Forest Industry Consulting London have been utilised and proved valuable as a basis for establishing first contacts.

The interviews have been conducted and recorded by the author. Most of the interviews have been conducted by phone but direct meetings have been booked when possible. Eight Swedish, three UK and two German respondents have participated in the interviewing process. The interviewed persons are not named nor are their respective company names revealed. This obviously means that readers of the thesis cannot back-track information gained or double check respondent inputs. This fact might be argued as giving the thesis less relevance or validity. However, the interviewed persons are described (title, type of business, country represented etc.) and validity as described above can still be achieved regardless of whether the names of the interviewed actor are published. One crucial factor for opting for the confidential approach is that this has been requested by several of the respondents

3.1.4 Qualitative semi-structured interviews

Interviews differ regarding their level of standardization and structure. Also, the definition of these two variables may differ. For this thesis, a standardized interview is defined as an interview technique leaving no room for variation between different interviews conducted. In this method the interviews are performed in the same manner and specific questions are read in the exact same way in each interview. Opposite, a semi-structured interview leaves room for variation and the interviewer adapts the interviewing process to the respondents. For example the respondent may control in which order the questions are asked and unplanned follow up questions may be asked. Generally, a low level of standardization leaves greater room for variation in the interviews conducted. Structure can be defined as a measure of whether the questions asked have set alternatives for the respondent's answers. Another definition of structure is that a structured interview, as opposed to an open interview, keeps the subject of the interview contained to a specific area. (Trost, 2005)

The above mentioned regarding standardization and structure can be connected to what Grindstedt (2005) described as a semi-structured interviewing technique. This technique may take the form of an interviewing schedule with both open ended and close ended questions. Although the schedule serve as a base for the interview the order in which the questions are asked is free, other topics may be raised during the interviews and the interviewer may give direct feedback on the interview subjects answers. This procedure is designed to leave room for sharing and exchanging of world views. The semi-structured interviewing technique can be said to promote a natural discussion and spontaneous information sharing. However, there should be no illusion that semi-structured interviews are objective or that the interviewed persons are totally unaffected and to no degree steered by the interviewer. This as it can be argued that even the smallest gesture or indications by the interviewer may steer the discussion or the result in a certain direction. This in turn is connected to the classical dilemma of the interviewer wanting to secure information but at the same time he or she wants to secure the validity (here meaning the trustworthiness) of the interviews. One way of securing a higher validity is through active collaboration between the interview parties. This collaboration can for example be achieved through open discussion of the interview questions in order to assure that the interviewed person understands the meaning of the questions. In this manor misunderstandings may be minimized. Besides discussing the meaning of the interview questions an overall flexibility by the interviewer has been argued to further increase the validity of the interviews as, this flexibility may take the form of thorough discussions of the both the questions and answers. (Grindstedt, 2005)

All in all, the semi-structured interview suits the purpose of the thesis interviews, i.e. to gain industry specific knowledge, as the flexibility and openness of the method promotes an open discussion and information sharing. It is also in the interest of the thesis to have a level of comparability between the interviews as the aim is to actually compare the investment climate between the researched countries.

A questionnaire (Annex C2) template has been established in order to give the interviews a similar direction but the aim has been to be very open to what the respondents want do discuss and what they feel is important. The questionnaire was made available to the respondents before the interviews took place, this in order give the respondents time to contemplate and reflect on the interview subjects. The questioner (Annex C2) is based around open ended questions examining the investment climate of the examined markets from a structural perspective in line with the thesis main theoretical frame work (i.e. Porters Five Forces Model). The questioner has been tested through pilot interviews with persons associated to SLU Uppsala. The pilot interviews revealed no major flaws in the questioner and the original design was not altered before the thesis interviews were conducted. During the interviews follow up questions and alterations to the template structure have been allowed to promote the intended explorative nature of the interviews.

3.2 Literature review

The number of reports and research projects relevant to the thesis scope that have proven useful during its completion are vast and a selection of the most critical material has been done for this section.

The EUBIONET II WP1 "Current Situation and future trends in biomass fuel trade in Europe" country reports for Sweden, Germany and the United Kingdom (EUBIONET, 2006 (1)), (EUBIONET, 2006 (2)), (EUBIONET, 2006 (3)) and the EUBIONET II "Biomass Fuel trade in Europe Summary Report" provide information on country and aggregate level regarding biomass resources, energy use of biomass, biomass users, fuel prices and biomass import and exports. (EUBIONET, 2007 (1))

The 2007 EREF "Prices for Renewable Energies in Europe: Feed in tariffs versus Quota

Systems – a comparison" provides basic information on governmentally controlled incentives that are utilized in different countries as well as a comparison of the systems. The report presents country based diagrams on market and certificate/feed-in prices concerning different types of energy. (EREF, 2007)

The 2006 VTT report "Bioenergy in Europe Opportunities and barriers" provides information on RES support schemes and policy issues, implementation of these policies and the general state of bio energy in different EU countries, biomass availability and bio energy technologies. (VTT, 2006)

A number of IEA reports and fact sheets have been used during the thesis completion. The 2007 report "IEA Energy Technology Essentials. Biomass for power and CHP" factsheet provides valuable information on various bio energy techniques and their associated costs. (IEA, 2007) Also from 2007 the "Good Practice Guidelines- Bioenergy Project Development & Biomass Supply" report provides good insights in biomass resources, production and promotion. (IEA, 2007 (1)) The IEA report "Energy Technologies Perspectives - In support of the G8 Plan of Action" provides a comprehensive general insight in energy technologies. (IEA, 2006) Regarding costs and some of the mathematical background for the model calculations the 2005 IEA report "Projected Costs of Generating Electricity – 2005 update" has proven useful. (IEA, 2005) Finally the 2004 IEA task 32 report "Techno-economic evaluation of selected decentralised CHP applications based on biomass combustion in IEA partner countries – final report" has proven a useful source for estimating the proportion of different costs and revenues and what type of costs and revenues that is important for biomass CHP production in general. (IEA, 2004 (1))

The 2007 Elforsk report "El från nya anläggningar" (Electricity from new installations) have proven very useful as it presents relatively new and well defined cost estimations for various types of CHP and electricity installations. (Elforsk, 2007)

The main theoretical framework is built around the Five Forces Model Presented by Porter. (Porter, 1980) However, as there have been substantial changes to the business environment (e.g. globalization) since the 1980's when Porters model was created more recent literature connected to the model has been utilised. The 2008 "Contemporary Strategy Analysis" contemporises Porters Five forces framework as well as examines the models possible applications and weaknesses. (Grant, 2008) Much of the same can be said about the 2001 book "Strategy and the Business Landscape – core concepts" which has been used for the same purpose but to a lesser extent. (Ghemawat, 2001)

Web pages of the European Union, Swedish, German and UK energy and statistical authorities, numerous interest organisations etc. have proven very useful as they are often the source of the most recent information and the reader is advised to follow the links presented in the reference list for further reading on various bio energy related topics

3.3 Definitions and assumptions

The information and data presented in the thesis are based on official figures such as country specific trade numbers or official Eurostat statistics (Eurostat New Cronos Database) derived from reports, websites and other trusted information sources. The quality of the statistics varies from country to country and between the type of fuel or other commodity that is examined. For example, firewood is traded and used unofficially to a large extent which implies that numbers stating traded amounts of firewood in general are flawed (VTT, 2006

(1)). Also, up to date statistics regarding e.g. price information is usually available but not always for free. As the thesis is executed under restricted economic circumstances less recent statistics have been utilised in some instances. Furthermore up to date statistics are not always available.

Biomass in particular has many definitions (country specific, sector specific, EU definitions etc.) and the term biomass may have different meanings depending on “which” type biomass that is discussed. This implies that any discussion on bio energy needs to be started with a clear definition on which type of biomass that is involved. To achieve this numbers on biomass availability, trade, production etc. are presented in combination with a clear definition of what type of biomass that is considered.

Another important aspect concerning different types of biomass definitions from a producer point of view are which fuels that are included in the various RES support schemes presented in the thesis. This is a crucial aspect as it will affect the type of installations supported by the various incentive schemes and thus the financial attractiveness of different installations and investment options.

With this background readers are encouraged to study the glossary, definitions and appendix sections for a complete list of thesis referred documents, standards and precise definitions on accepted forms of biomass in the various country specific support schemes etc.

4. The Bio Energy sectors in Sweden, UK and Germany

4.1 Technologies and Costs

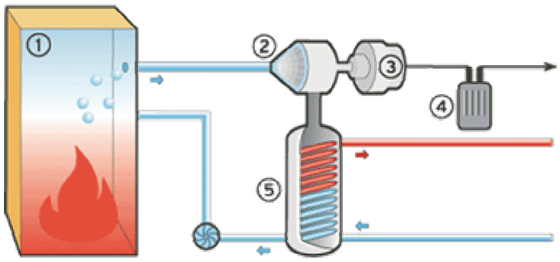
Transformation

The most widely used technologies to produce heat and/or power from biomass are combustion, gasification, combined heat and power (CHP) production, co-firing and the utilisation of refined biomass fuels (e.g. pellets or pyrolysis oil). (VTT, 2006 (1)) Liquid fuels are not within the scope of the thesis.

Of the different types of biomass wood is especially suitable for combustion due to its relatively low ash and nitrogen content. (VTT, 2006 (1)) There are three main types of combustion technologies consisting of grate firing, suspension firing and fluidised bed firing. (Nordic Energy Research, 2007) Grate firing, as the name implies, consists of a grate base on which biomass is burned and through which air flows to the incineration process. Grate firing is a robust technique that allows most types of biomass to be utilized (Nordic Energy Research, 2007). Suspension firing is a technique in which the biomass is dried and pulverized to a moisture content of four to seven percent and a particle sizes below 0, 8 millimetres. The powder is then blown into an incinerator. The suspension firing technique can be used in conventional coal-fired plants which provide a great advantage in cost saving as it is not necessary to build an entirely new power plant. Fluidised bed incinerators have an incineration bed consisting of a hot sand layer. Biomass is added to the sand layer and the material is kept in constant motion by incineration air that is fed in to the incinerator. The sand layer resembles a boiling fluid – it fluidises. The technique allows a large degree of contact between the different materials and a good mixture of biomass and air resulting in an intensive incineration. (Bohlin et al, 1999)

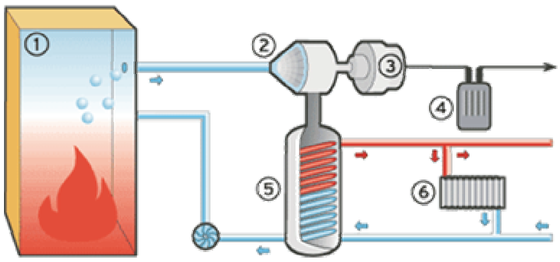
Thermal gasification is a process in which biomass (solid) is transformed in to gas that can be used in gas engines, boilers, gas turbines and fuel cells for power and heat production. (Nordic Energy Research, 2007) Gasification is a two staged process; firstly the biomass undergoes a partial combustion in which gas and charcoal are produced. Secondly the charcoal reduces the product gases, mostly consisting of carbon dioxide and water vapour, to carbon monoxide and hydrogen. Depending on the type of gasifier methane and other higher hydrocarbons may be produced. (Johansson et al, 1993)

The two main types of power plants used to produce electricity from coal, gas, oil and biomass are condensation- and CHP plants. A condensation power plant only generates electricity while a CHP plant generates both heat and electricity. The CHP plant utilizes the total energy content of the used fuel to a further extent, as it creates more energy in relation to the energy content of the inserted fuel than the condensation plant. However, the condensation plant creates more electricity in relation to the added fuel. (IVA, 2002) Figures 4 and 5 show the principles of the two types of power plants.



1: Steamer
2: Steam turbine
3: Generator
4: Transformator
5: Condensator

Figure 4. A Condensation Plant. With Permission, www, vattenfall, 2008 (1).



1: Steamer
2: Steam turbine
3: Generator
4: Transformator
5: Condensator
6: District heating

Figure 5. A CHP Plant. With permission, www, vattenfall, 2008 (2).

As mentioned CHP systems are interesting as they utilize the fuel input to a large degree. However, from a pure electricity producing point of view CHP plants are not very efficient and it could therefore be argued CHP production should be viewed as heat production with electricity as a bonus product. From a practical perspective CHP plants should be placed close to the heat consuming source as electricity generally is cheaper to transport than heat. Many types of fuels are suitable for powering CHP plants and more attention is being paid to biomass as result of rising prices on alternative energy sources and a growing environmental concern. (IEA, 2008)

Co-firing means that biomass is used in combination with another fuel such as coal. Also, energy producers may choose to gasify the biomass separately before co-firing the gas with pulverised coal or fluidised bed boilers. (VTT, 2006 (1))

Among the newer technologies integrated gasification and combined cycle (IGCC) systems are among the cleanest and most efficient technologies. IGCC systems can utilize any type of carbon based feedstock. The system gasifies its feedstock which is used to power a gas turbine and the generated heat from the gas turbine exhaust then produces steam which runs a steam turbine. (IEA, 2006) Although the technology is relatively new IGCC plants running on black liquor are already competitive from an economic perspective. (IEA, 2007)

For micro generation (up to 5MWe) Stirling engines (piston engines that run on gas expansions following temperature changes) are generally suitable. Feedstock may consist of biogas and natural / residual heat sources. Development on Stirling engines for CHP applications is under way. (IEA, 2007)

Installations and typical costs
There are many types of feed stocks and transformations that are utilised in the bio energy sector and thus the associated costs vary considerably. (IEA, 2007) Table 1 presents typical

costs associated with different types of technologies. Note that local conditions concerning feedstock prices and transport distances in particular will have a strong impact on costs. Also, the capital costs are presented as €/MW i.e. a cost of installed power while the electricity generating costs are presented in €/MW h i.e. a cost measure of applied power relative to the estimated output of the different installation types. (IEA, 2007)

Table 1. Typical cost associated with bio energy. (Biomass cost 0, 65 €/MWh; Discount rate 10%; 2) Heat value 1, 08 €/MWh) Adapted from EIA, 2007.

Technology	Efficiency (%)	Typical Size (MWe)	Capital Costs €/MW	Total Electricity Generating Costs €/MWh
Co-firing (coal fired installation)	35-40	10-50	850.000-1.000.000	38,7
Dedicated steam cycles	30-35	5-25	2.300.000-3.880.000	85,2
Integrated gasification combined cycle	30-40	10-30	2.300.000-3.100.000	93,0
Gasification + Engine CHP	25-30	0,2-1	3.800.000-5.400.000	85,2
Sterling engine CHP	11-20	0,1	850.000-1.000.000	100,7

As shown by Table 1 coal fired plants combined with co-firing require the smallest capital investment and co-firing biomass produces an efficiency that is on a relatively high level. Thus constructing coal fired plants and co-firing is an efficient and economical alternative. A co-combustion of up to 10 % biomass requires relatively small investments while a co-combustion over 10 % in general will require more investments (e.g. changes in mills, burners and dryers) Biomass in general has a combustion efficiency that is about 10 % lower than that of coal. (IEA, 2007)

Dedicated biomass plants are generally much smaller than conventional coal fired plants and the main reason for this is the problem with securing large enough local feed stocks (i.e. because of transport costs). The smaller size roughly doubles the investment cost in €/MWh. (IEA, 2007)

The Swedish Report "Electricity from new Installations 2007" (title translated by the author), produced by Elforsk, a Swedish research organisation, presents electricity generating costs for a variety of electricity (and heat in some cases) generating installations. For example the electricity generating costs for a 80 MW biomass CHP installation and a 30 MW biomass CHP installation are stated to be 85,2 respectively 108,4 €/MWh (Not including taxes, fees or subsidies and interest 12 %). (Elforsk, 2007)

The approach that the above stated estimations have used for calculating the electricity generating costs for CHP type installations is to assume that the produced heat has a production value that CHP producers benefit from. For example, Elforsk 2007 assumes that the produced heat has a value of roughly 18 €/MWh which is equal to the assumed cost of heat production. (Pers.Com, Wrangensten, 2009) This approach allows for comparison between CHP type installations and other RES alternatives such as wind as the produced heat can be valued and included in the calculations. The 2007 Elforsk report also utilises a fixed annual heat value depending on the effect of the CHP installations. The fixed heat value is equal to the alternative cost of building a heat producing boiler i.e. the value of having an existing heat production (Elforsk, 2007)

Regarding capital costs specifically a number of estimations have been identified;

The 2004 IEA report "World Energy Outlook" states a general capital cost for renewable energy technologies in 2002 of roughly 1.550.000 € per MW (IEA, 2004).

Published in 2005, the IEA report "Projected costs of generating electricity – 2005 update" specifies overnight costs for CHP plants. For example, an 8 MWe and 20 MWth biomass fired CHP plant in Austria has a predicted overnight cost of 2.880.000 € per MW. (IEA, 2005)

Recently shared IEA information (Annex C3) states a construction cost of 2.440.000 € per MW for small to medium CHP plants in 2015. (Pers.com., Olejarnik, 2009)

The lifespan of a CHP installation varies depending on type location etc. but a rough estimated lifespan is around 15-25 years with at least 5000 operating hours annually. (www, Decentralised Energy Knowledge base, 2009 (1))

The variation in numbers stated above shows the complexity of stating an average capital cost, note that all but one of the above stated numbers are derived from the same principal source (IEA). Another difficulty with capital cost figures is that they are usually given in dollars / kW i.e. a measure of installed effect while the thesis model calculates the paying capability in terms of €/MWh i.e. a measure of power generation.

As in the case with capital costs an average price for operational cost is likely to be relatively unique to the installed unit. This as many costs and revenues are locally dependent. For example CHP producers are dependent on access to an existing district heating system and to which extent the existing system is expanded. (IEA, 2005) Also, as mentioned local feedstock prices will affect costs considerably. (IEA, 2007

4.2 Biomass Availability and Trade

Availability

Besides the political will and measures to promote RES the actual available biomass will affect the supply and demand situation regarding wood based biomass. In the 2006 "*Bioenergy in Europe-Opportunities and Barriers"* The Technical Research Centre of Finland (VTT) states that the European use of biomass and waste generated 2888 PJ of energy in 2006 and estimates that by 2050 this number can grow to between 9000-13400 PJ annually. According to the same report the European biomass resources could cover demand until 2010 with a predicted consumption of 6280 PJ annually. Also according to "*Bioenergy in Europe-Opportunities and Barriers",* a biomass consumption rising above the 6280 PJ level means that biomass sourcing outside of Europe will be necessary. In the report biomass is classified into the main areas agricultural (i.e. agricultural residues, livestock wastes and energy crops), forest (i.e. wood fuel and forest residues produced during logging, thinning and cleaning activities), industrial (i.e. residues from forest- or food industries) and waste (i.e. demolition wood, municipal solid waste, landfill gas and sewage sludge gas). (VTT, 2006 (1)) Although, the thesis examines the paying capacity for wood based biomass the availability and price of the other forms of biomass is interesting as these have an indirect effect on the price of the analysed biomass resources as they may be considered as alternatives to the examined bio fuels. The historic- and predicted increase in potentials for energy production from biomass for the EU 15 countries is presented Table 2.

Table 2. Historic and future potentials for biomass utilisation EU 15 area, reference year 2000. Adapted From VTT, 2006 (1)

	2006 Potential (PJ)	2010 Increase in energy potential	2020 Increase in energy potential
Agricultural	1633	25%	50%
Forest	1298	20%	40%
Industrial	879	40%	80%
Waste	754	40%	80%

Table 2 gives a good indication of the historical and predicted biomass availability in the analysed area. As Figure 6 shows, waste and industrial has the largest growth potentials followed by the agricultural sector. Consequently, it can be assumed that in order to fully utilize the European biomass availability, the traditional biomass forms used for energy such as pellets, wood chips etc. will have to be complemented by other wood based sources and also, to a large degree, by non wood based sources such as municipal waste and animal manure.

Concerning the forest based wood resource specifically, the annual round wood balance (i.e. the difference between the annual fellings and the annual increment) in Europe amounts to 186 million m3 (1.339PJ) annually. Although this represents a sizeable resource it is very hard to estimate how much of the remaining increment that could be used for energy purposes. A more obvious forest resource for energy production are harvesting residues, the estimated annual harvestable amount of harvesting residues in Europe amounts to 63 million m3 (453, 6PJ) annually. Also, about 9 million m3 (64, 8 PJ) of stumps could potentially be used for energy production. Based on the assumption that the sources for energy production are felling residues, stumps and 25% from the round wood balance the available forest fuel in Europe amounts to about 140 million m3 annually which translates into 1008 PJ of energy. This represents about 24% of the current use of RES in the EU25 area. (VTT, 2006 (1))

Figure 6 shows the techno-economical (i.e. practically available) biomass resources for the EU 20 countries. Note that these practical numbers may vary substantially from the reported theoretical numbers. The figures do not take into account all available wood based resources, such as virgin wood, but a good estimation of the country specific wood based resources can be made nonetheless. For example, a large share of forest residues indicate a large availability of virgin wood as the harvesting of virgin wood results in a diverging flow of by-products including forest residues. UK is listed as one of the lowest ranking countries regarding domestic biomass resources while Sweden and Germany are among the top ranking countries. “Other biomass” mainly consists of short rotations crops and different types of agricultural fuels and wood residues refer to industrial wastes and residues. (VTT, 2007)

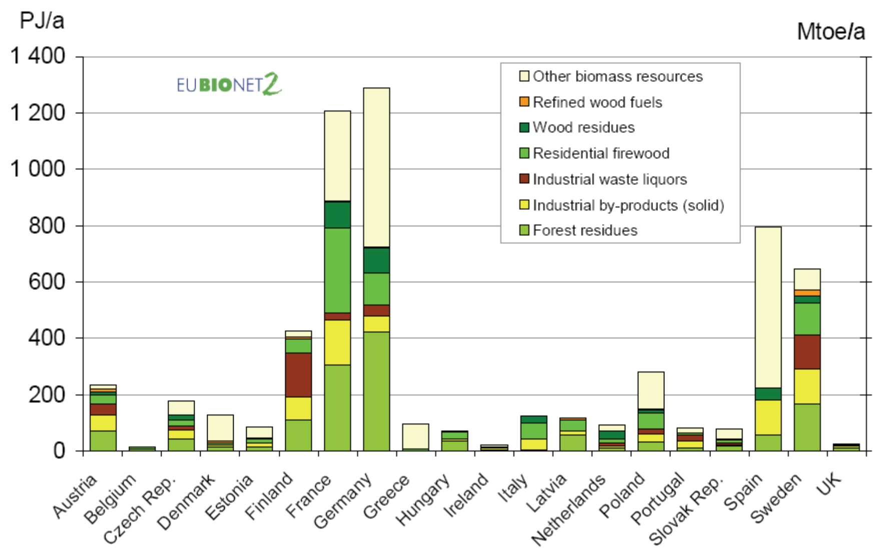


Figure 6. Available biomass resources EU 20 countries. With permission from VTT 2007.

Germany has the largest resource of estimated biomass resources amounting to a number around 1200-1300 PJ annually. Sweden's corresponding number is 600-650 PJ while the UK number is estimated at around 60 PJ. Sweden theoretically has the largest possibility to further utilize its domestic biomass resources as the current utilisation rate is estimated at 22% of the available biomass. Germany is estimated to utilize 31% of its biomass resource while the United Kingdom (despite its relatively low current energy from biomass production) is already at a ratio of 193% bio energy use in relation to available biomass resources (2004 numbers). (VTT, 2007)

Trade

Currently the world trade of biomass (not including waste) is about 1005 PJ, there is however a huge future potential to expand the trade in the long term according to the IEA Task 40 estimation. In this category of biomass, i.e. not including waste, the greatest growth potential for biomass in energy production seems to lie within the utilisation of harvesting residues, agro biomass and fruit based biomass. The most traded biomass fuel is pellets, this is mainly due to the compact volume and density properties of pellets incurring in relatively low transportation costs per weight unit. It is estimated that the annual world production of pellets is around 4 million tons and 70% of this production takes place in the Baltic Sea area. The Baltic Sea area also plays an important role in international biomass trade. The trade mainly consists of flows from new EU members such as Estonia, Latvia, Poland and Lithuania to old member states such as Sweden, Denmark, Germany and the Netherlands. Central Europe trades mainly with Austria. Also, biomass imports from overseas, mainly Canada, occur. In 2006 over 400 000 tonnes were exported from Canada to Europe. (VTT, 2007)

Table 3 summarizes the official bio fuel (solids as defined by CEN/TS 14961) trade flows for the three scope countries. For each country import and export quantities are stated. In cases where the origin (source) of the imported quantities or target countries for the exported quantities (destination) are known these are stated. (VTT, 2007) Note that the stated numbers refer to bio fuels and not biomass in general, i.e. products such as pulp wood or timber are not included.

Sweden stands out as the biggest trader of bio fuels. The trade is mostly concerned with the Baltic States and Belarus. The UK is the biggest importer which of course is related to the domestic availability and supply of bio fuels. All three countries are net importers.

Table 3. The import and export of biomass fuels in 20 EU countries 2004, numbers also include raw material use. Adapted From VTT, 2007

Germany	Imports (PJ)	Source Country (if available)	Exports (PJ)	Destination Country (if available)
Sawdust	0,17		0,4	
Wood waste				
Chips	1		1	
Pellets				
Matured wood**	8,55	Netherlands (NL)	5,25	Italy
Total	9,72		6,65	
Balance	– 3,07			
Sweden	**Imports,**	**Source**	**Exports**	**Destination**
Sawdust	1,99		3,12	
Chips	3,6		2,1	
Firewood	1,2	Estonia, Latvia, Lithuania, Russia	0,26	Norway
Pellets	4,6	Finland, Estonia,Russia	3,5	
Tall Oil	1,3–4,3	Finland, Canada, USA, Norway, UK	2,7	Norway, Austria, Finland
Different kinds of refuse	3,9			
Olive seeds	0,1	Spain		
Peat	3,6-4-3	Estonia, Latvia, Finland, Russia, Belarus	0,94	Denmark, Norway, NL
Total*	15,39		12,62	
Balance	– 2,77			
UK	**Imports**	**Source**	**Exports**	**Destination**
Palm Waste	7,47			
Olive Waste	4,57	Spain		
Tall Oil	4,81	Sweden		
Wood Pellets	2,82			
Sunflower Pellets	0,33			
Palm Oil	0,11			
Bioethanol	1,82			
Fuel Wood	4,41		4,5	Ireland
Charcoal	1,76		0,31	
Biodiesel			0,76	EU Market
Wheat			0,4	Albengoa
Total	28,1		5,97	
Balance	– 22,13			

*Tall Oil and Peat not included **Matured wood referrers to various waste wood

4.3 Production and consumption

In Europe firewood is the most used solid bio fuel (solid as defined by CEN/TS 14961). Industrial by products and residues are also widely utilised. (VTT, 2007) Figure 7 gives an overview of the origin of the energy derived from biomass in 2004.

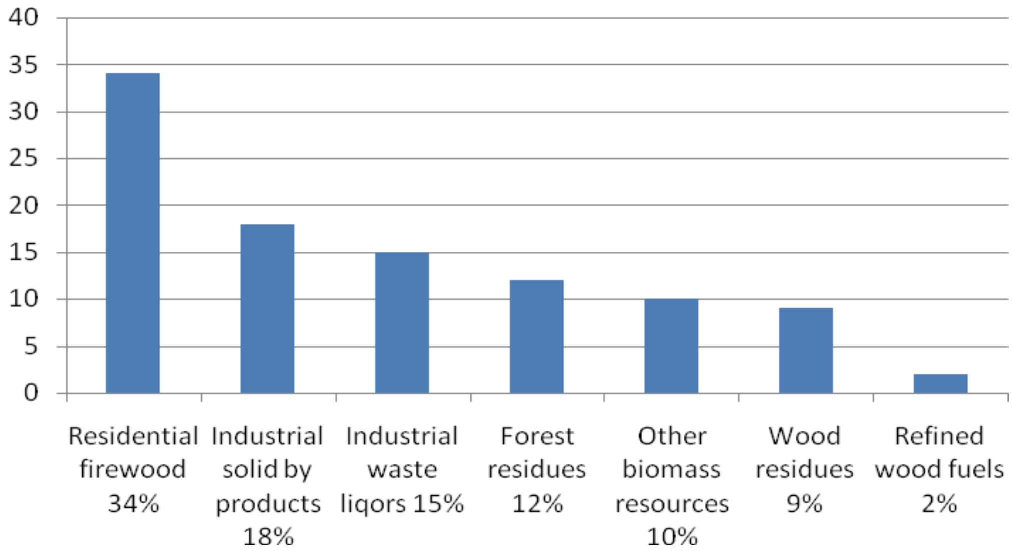


Figure 7. Energy from biomass in EU 20 area 2004. Adapted from VTT, 2007.

Among the top ranking bio energy producing countries the pulp and paper industry often plays an important role. This is due to the benefits from combining bio energy production with these industries (e.g. integration of fuel/ energy supply and process/power steam demand). The biggest users of bio energy in combination with the pulp and paper industries are Sweden and Finland which is natural as these countries are the biggest pulp producers in Europe. (VTT, 2006 (1)) The following numbers on total primary energy production from bio energy and wastes and the paper industries share of this production gives an indication of the relative importance of the paper industry for the target countries bio energy sectors as well as an indication of the bio energy production and use in general. (Numbers in PJ)

Table 4. Primary energy from biomass and pulp & paper industries share. Adapted from VTT, 2007.

	Primary energy production from biomass and waste 2004 (PJ)	Bio energy in pulp & paper industries 2004 (PJ)	Pulp & Paper share of biomass in primary energy production (%)
DE	391,5	26,5	7,2
SE	312,6	187,8	60,1
UK	29,5	1,7	5,8

Note the large share represented by the Swedish pulp and paper industry and the large difference in primary energy production between the two countries Sweden and Germany versus the United Kingdom. Also, it should be noted that the primary energy from biomass numbers presented here also includes waste. (VTT, 2007)

In order to obtain as recent and relevant numbers as possible on the three scope countries biomass consumption a simultaneous and specifically designed web based search of the

Eurostat New Cronos database has been performed. The product groups chosen for the database query are "Wood and Wood Wastes" (Code 5541) and "Biomass and Wastes" (Code 5540). The parameter chosen to describe the total consumption of these product groups is "Final Energy Consumption – Adjustment" (Code 10700). Please refer to Annex C8 for a complete description of the chosen parameters.

The following results regarding final energy consumption of the two product groups were generated from the Eurostat database presented in Table 5 as well as a diagram (unit is PJ);

Table 5. Final energy consumption in Sweden, Germany, UK and the EU 27 area, the unit is displayed in 1000toe. Source www, Eurostat, 2009 (5)

Product Groups	Final Energy Cons. EU27 (PJ)	Final Energy Cons. Germany (PJ)	Final Energy Cons. Sweden (PJ)	Final Energy Cons. UK (PJ)
Biomass & Wastes	2439,3	409,9	212,0	30,3
Wood & Wood Waste	2164,7	264,8	203,9	12,6

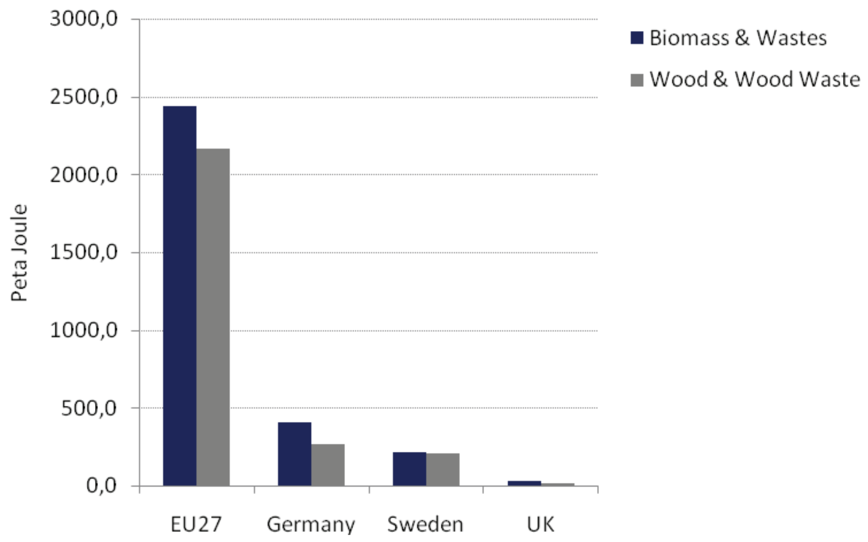


Figure 8. Final energy consumption in Sweden, Germany, UK and the EU 27 area, the unit is displayed in 1000toe. Source www, Eurostat, 2009 (5)

Even with non traditional bio energy sources such as waste, sewage gas and chicken litter included the United Kingdom with a population exceeding 60 million (www, national statistics, 2009 (1)) has a very low consumption from bio energy especially compared to Sweden (with a population of about 9 million.) (www, Statistiska Centralbyrån, 2009 (1)) Germany's relatively high numbers on both production and consumption reflect both the large biomass resources available, as described earlier on, and the population about 82 million (www,Statisches Bundesamt Deutschland, 2009 (1)) and size of the country. Population figures are not completely relevant e.g. as much of the Swedish consumption is correlated to industrial use and as much of the Swedish production is exported. However, the population size indicates the potential size of consumer demand as well as the relative size of the scope countries

Finally it should be noted that woody biomass is likely to play an important role in both the production and consumption in the expansion of bio energy industry. This as estimates on biomass availability generally point out wood biomass as the biggest or one of the biggest untapped biomass resources. (EUBIONET II (1), 2007), (VTT, 2006 (1))

4.4 Prices for electricity, heat and feedstock

The value of incentives such as green certificates, ROCs or feed-in tariffs and the market prices for electricity and heat are naturally a crucial component of every investment decision regarding bio energy in the three scope countries. These variables are also central to the calculated paying capability presented further on. The values of the main incentive schemes have already been presented under *2.6.2 Sweden, 2.6.3 Germany* and *2.6.4 UK.* Table 6 presents electricity spot prices in the three scope countries. (Electricity rates in €/Mwh.)

Table 6. Electricity spot prices. Source (in order presented); (www, apxgroup, 2009 (1), (www, nordpool, 2009 (1), (www, eex, 2009 (1))

Country	Electricity Spot price (€/MWh)	Period
UK	62,3	Average of Dec-08/Jan-09*
SWE	40, 1	090119-090218
DE	56,5	090101-090216

Regarding the price producers receive/charge for their produced heat; this is largely dependent on local conditions such as existence and access to local networks and local availability and price for biomass. Due to this locally dependant nature of heat prices it is difficult to present an accurate average heat price. (IEA, 2005)

However, the following average prices may serve as relevant sources of information for comparative purposes; For 2008 an average of 251 district Swedish district heating companies stated prices results in an average heat price of 71,7 €/MWh. (www, Avgiftsundersökningen, 2008 (1)). In November 2008 the average German district heating price amounted to 69, 4 €/MWh. (Pers.Com, Pushkarev, 2009) The UK has a far less developed district heating system than Sweden and Germany. Only 6% of the limited CHP capacity is connected to a district heating system. (IEA, 2007 (2)) As the system is small there is no systematic data collection regarding district heating prices (Pers.Com, Wiltshire, 2009) As a result of this there is not any real analytical value in obtaining an average for a virtually nonexistent market.

German prices for woodchips average around 80 €/ton (35% water) (www, CARMEN, 2009 (1)) and pellets average around 216 €/ton (www, CARMEN, 2009 (2)) (delivered costs for five tons within 50 km). The UK biomass market is still relatively "new" and comprehensive statistics on biomass in the UK is currently not available. Roughly wood fuel quality wood chips (35 % water content) average around 64 to 96 € per tonne). Pellets also vary considerably in price and may range from 160 to 213 € per bulk tonne and 213 to 267 € per bagged tonne. (Significant variations from these numbers occur (Pers.Com, Hogan, 2009) For Swedish biomass prices please refer to Annex C 4.

Finally, IEA has used the following assumed average fuel costs for biomass in various calculations:

OECD countries: 24,79 €/MWh
Non-OECD countries: 17,04 €/MWh
(Pers.Com, Centurelli, 2009)

4.5 Incentives

4.5.1 Governmental Incentives – An introduction

Table 7 summarizes the different types of incentive systems aimed at promoting the production of RES electricity represented in the EU 27 area.

Table 7. The main European incentive schemes and promotion measures for RES. Adapted from European Wind Energy Association, 2002

RES promotion		Direct		Indirect
		Price/Grant Driven	Quantity Driven	
Governmental	Investment focussed	Investment subsidies	Tendering System	Environmental Taxes
	Generation Based	E.g. Feed-in tariffs	E.g. Tradable Green Certificates	
Voluntary	Investment focussed	Shareholder- and contributor programs		Voluntary agreements
	Generation Based	Green Tariffs		

Voluntary systems are dependent on the consumers' willingness to pay for RES energy and may e.g. take the form of voluntary procurement of green electricity at a price above the usual market price (direct) or other agreements between parties on the open market e.g. in the form of investment contributions (indirect). (European Wind Energy Association, 2002)

The governmental systems can, as the voluntary systems, be divided in to investment focussed (subsidies and the tendering system) and generation based systems (feed-in tariffs and tradable green certificates). Generally an investment focus is aimed at subsidised capital investments while a generation based approach concentrates on subsidising output or variable costs. Furthermore, the approaches can be divided in to price- and quantity driven approaches;

The price driven approaches usually consist of investment subsides based on the RES generating capacity of an installation (Investment focused) or they can be based around fixed feed-in tariffs or fixed premium systems (Generation based). The price driven systems all support producers of green electricity financially with a subsidy per installed kW capacity or per kWh produced and sold. (European Wind Energy Association, 2002)

The quantity driven systems are built around government decisions regarding the desired level of RES energy on the market and a connected RES support system which is designed to aid in the achievement of the set quota. The price for RES energy is then in principle set by competition on the market as quota obliged actor's source certificates. The tradable green certificate system (The system applied in Sweden) is a good example of this system.

(European Wind Energy Association, 2002)

The tendering system basically means that the government announces a specific amount of energy that is to be created through a specific technology and that interested producers submit bids to obtain a contract for the specified production. The producer offering the lowest cost of providing the specified energy wins. The winning producer is then contracted for a limited time period, usually around 15-25 years. (European Wind Energy Association, 2002)

Indirect strategies can consist of taxes or other indirect measures which for example may increase the cost of utilizing fossil fuels and therefore promote the production of RES energy. (European Wind Energy Association, 2002)

4.5.2 Tradable Emission Rights

According to the European trade directive each member country is obliged to establish and maintain a system with tradable emission allowances. Each year each individual member state sets a targeted number of emission credits and which companies it intends to give emission credits, this is then audited by the EU-commission that approves the schemes if it is in accordance with the countries obligations according to the Kyoto Protocol. The companies concerned can apply for credits from their respective governments or trade allowances on the open market. One pollution allowance gives the owner the right to release one ton of carbon dioxide. The system is based around the idea that there is a price for pollution (CO_2) and that companies that pollute less than the level represented by their issued emission rights can sell their surplus emission rights on the open market. The overall purpose of the tradable emissions scheme is to lower CO_2 emissions at an effective cost. (www, energimyndigheten, 2008 (1))

As mentioned, emission rights are traded and there is a Europe wide market for the certificates. The trade concerns mostly carbon dioxide emissions but as of 2008 nitrous oxide is also included in some member states. For the period 2008-2012 90% of the allowances are to be handed out for free. The member countries have a choice of auctioning out the remaining 10%. (www, energimyndigheten, 2008 (2)) The types of facilities included in the emission trading scheme 2008 to 2012 are incineration facilities with a installed capacity of over 20MW and smaller incineration facilities connected to a district heating system with a total capacity of over 20MW, oil refineries, coke plants, the iron- and steel industry, the mineral industry and the paper- and pulp industry. (www, energimyndigheten, 2008 (3)) The emission rights sets the limit for how much a company can pollute; pollution above the limit requires the company to purchase more emission rights from the open market. Alternatively, an actor that pollutes less than the emission limit can sell his/her abundant emission rights. Anyone can purchase emission rights of one of the many brokers or directly from companies. (www, energimyndigheten, 2009 (1))

All three scope countries have adapted to the above described EU directive and national schemes and controlling organisations have been established in order to manage the system. (www, utsläppshandel, 2009 (1)), (www, bmu, 2009 (1)), (www, defra.gov, 2009 (1))

Prices on emission rights ranged from 8,50 to 12,32 €/emission right on the European Energy Exchange during the time span 090116 to 090217 (www, eex, 2009 (2))

4.5.3 Sweden

The System

The Swedish bio energy market is governmentally managed through taxes, grants and subsidies, tradable emission rights and tradable green certificates. (Energimyndigheten, 2007)

The two main taxes used for environmental purposes are the carbon dioxide- and sulphur taxes. The carbon dioxide tax, that was introduced in 1991, obliges a fee of 0,0957 EUR (2007 prices) per kilo of carbon dioxide emission for all fuels except bio fuels (bio fuels here meaning fuels derived from biomass and biomass being material of biological origin that has not been, or only insignificantly has been transformed chemically/biologically) and peat. (Energimyndigheten, 2007) Heavy industry and CHP production is obliged for 21 % C0 tax and heat only production is obliged for 100% $C0_2$ tax. (Elforsk, 2007)The sulphur tax gives a 3,0895 EUR tax per released kilo of sulphur from coal and peat and 2,7806 EUR per cubic meter for oil per every tenth weight percent of sulphur content in the oil. Also, established in 1992, a environmental fee for emissions of nitric oxide amounting to 4,1191 EUR per kilo of released nitric oxide applies for boilers, gas turbines and stationary incineration facilities of at least 25Gwh annually. In relation to the environmental taxes there is also a general fiscal tax on energy paid for most types of fuels which is based on the energy content of the fuel. Heavy industry and CHP production is obliged for 0% energy taxation while heat only is obliged for 100%.

The production of electricity is exempted from energy- and carbon dioxide taxes but not from nitric oxide or sulphur taxes. As of 2006 the incineration of certain municipal wastes are included in the energy taxation system.

Bio fuels and peat are basically untaxed for all users with the exemption of a sulphur tax on peat. (Energimyndigheten, 2007)

There are suggested changes to the Swedish taxation system. For instance, the government in its coming climate bill proposes that heavy industry, CHP and other exempt actors will be obliged for a 30 % CO_2 tax in 2011 and a 60 % CO_2 tax in 2015. (Olofsson et al, 2009)

There are different grants and subsidies available for the development of more environmentally friendly techniques and practices. For example the climate investment programme allows municipalities and other actors to seek grants for measures that reduce the emissions of green house gases in Sweden. (Energimyndigheten, 2007)

In Sweden the system with tradable green certificates is utilized as the main RES electricity incentive scheme. The system means that producers of RES energy receive a certificate for every MWh of electricity produced. (Peat is included since 2004) (See Annex B 4 for approved fuels) which gives a revenue on top of the market electricity price for producers. This is combined with a fixed RES energy quota that applies to;

- Electricity suppliers delivering electricity to end consumers.
- Electricity users consuming electricity they produced themselves or users consuming electricity they bought on the open market.
- Electricity intensive industry (Defined as producers using at least 190 MWh for every million SEK of value added to their production).

There is an exception from the certificate system for the electricity intensive industry. These actors are exempted from the costs of the system but they are required to declare their electricity use to the Swedish authorities. The certificates are issued by Svenska Kraftnät a Swedish state utility. (www, Energimyndigheten, 2009 (7))

The set quota amounted to 12,6% of the total electricity consumption in 2006 and the obliged quota varies from year to year. In order to fulfil their quota the obliged actors must purchase certificates at a market set price either from producers or from specialised traders that deal with certificates. Thus the system puts the obligation on the consumers and distributors as well as giving a premium to environmentally friendly energy producers. As mentioned there is no set price for the certificates, instead the price is set by the involved buyers and sellers. (www, Energimyndigheten, 2009 (5)) The average certificate price for the period 2008-01-28 - 2009-01-28 was 25, 68 €. (www, elcertifikat.svk, 2009 (1)) To ensure that the costs of the system are not unnecessarily high older installations are to be phased out. This is done by the rule that installations taken in to operation after the first of May 2003 are given a certificate right for at least fifteen years but no longer than until 2030. Installations that are older are given a certificate right till 2012 (2014 for some exceptions). Other than this only new installations are to be issued certificates. (Energimyndigheten, 2008) Some confusion regarding what is to be regarded as a "new" installation has been present among producers and the Swedish Energy Agency is currently producing a draft for a law that will specify the requirements for new installations and the eligibility for improved older installations. The draft will be presented in April/May 2009. (Pers.Com, Johansson, 2009)

Figure 9 shows the planned quota development 2003 till 2030.

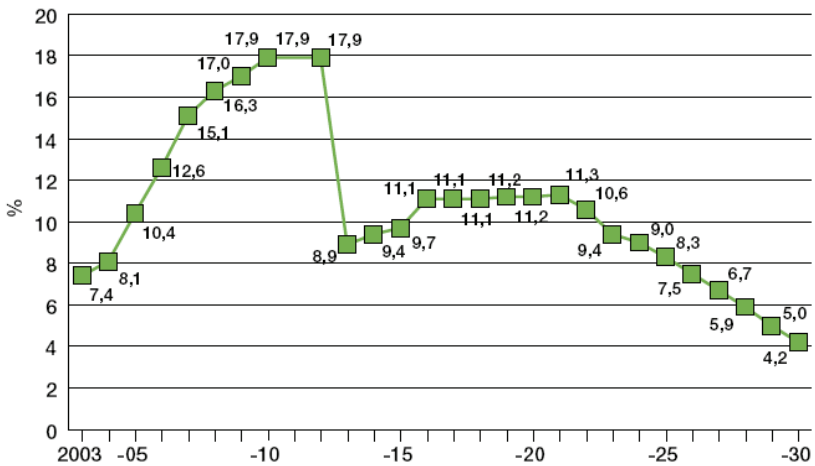


Figure 9. Quota development in the green certificate system. With permission, Energimyndigheten, 2007.

Figure 10 visualises the above described system;

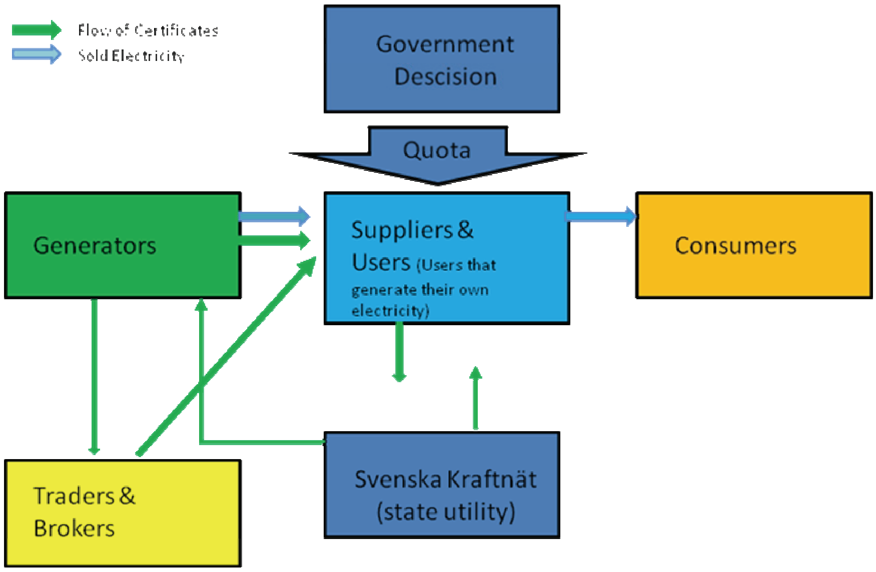


Figure 10. The Swedish Certificate system

Outcome of the schemes so far

Historically environmental taxes have played an important role in the Swedish bio energy market. However, the effect of the taxes on fossil fuels and CO_2 generally resulted in a maximised output in existing installations rather than encouraging building of new ones. For a limited period of time available investment grants which significantly increased the expansion of new installations were introduced. The investment grants replaced by the certificates system in 2003 which generally, like the taxations system, has increased output of RES energy but not to new investments. The Swedish certificates system is unique in allowing exceptions from the system for its industry. (Thornley & Cooper, 2008)

To conclude, although Sweden has very favourable conditions for the production of RES energy in general and bio energy specifically incentives have proven useful/needed in order to boost production. (Thornley & Cooper, 2008)

4.5.4Germany

The System

In Germany the main economic incentive is the *Renewable Energy Sources Act* (EEG) which promotes feed-in tariffs, the exemption of bio fuels (From biomass as defined by Biomasse V, see Annex B 2*)* from the mineral oil excise tax, investment support and loans for smaller installations (70-100kW), the market introduction programme which offers support for innovative renewable products and the market introduction funding programmes that offers grants and loans at favourable rates for renewable energies installations. The latter was at a level of 230million € in 2006. (ET Bioenergy, 2006 (1))

There is no specific CO_2 tax in Germany. However, electricity produced from renewable sources for own use is exempt from electricity tax. (In 1999 taxes on fossil fuels increased and a tax on non RES electricity was introduced at the same time. ET Bioenergy, 2006 (1))

The feed-in system guarantees producers grid access to public networks combined with an obligation for the public networks to buy electricity produced from RES, e.g. biomass, at a minimum compensation for a period of 20 years. The annual depreciation of the guaranteed compensation was 1,5% in 2006 for new installations. (ET Bioenergy, 2006 (1)) For feed in tariff levels and depreciation rates please refer to Annex C1. As a result of the promised fixed electricity price, or feed-in, the German system is not linked to market electricity prices.

Also, there are bonuses available e.g. for innovative technology that are paid on top of the feed-in, Annex C1 states the available bonuses and eligible installations (pers. com., Rothacher, 2009). The feed-in and any bonuses are paid instead of the market electricity price, not as in the case of the Swedish (and UK) system which ensures certificate revenues on top of the market electricity price. (ET Bioenergy, 2006 (1))

One very important aspect of the German feed-in system is the fact that the system only supports biomass capacities up to 20MW and a annual output of 1754 GWhe (8760 operating hours). That is a 20 MWe installation with an output lower than 175,4 GWhe is eligible for feed-in remuneration. After this limitation the electricity must be sold on the open market. Installations larger than 20MW are not eligible for fed-in remuneration. Also, for installations over 5 MWe feed-in tariffs are only eligible for CHP. (Pers.Com, Rotacher, 2009)
Figure 11 visualises the German Feed-in system;

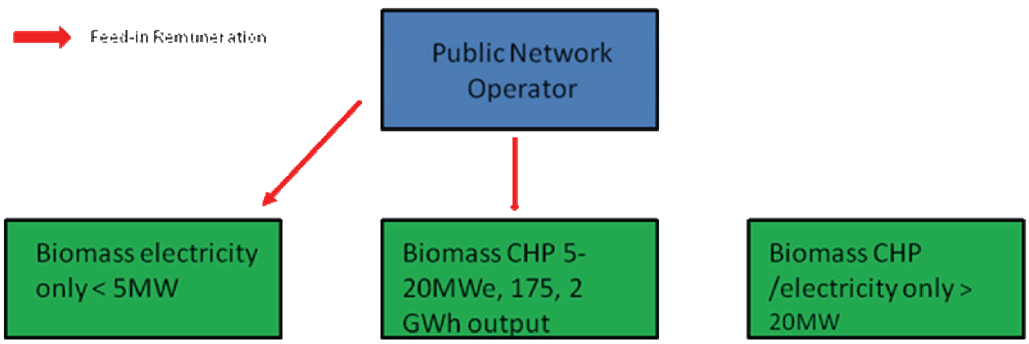


Figure 11. The German Feed-in system.

The cost of the feed-in system (i.e. the difference between the tariff value and the market price for electricity) is carried by the taxpayers or / and the end consumers who buy the green electricity sourced and sold by utilities. (ET Bioenergy, 2006 (1))

Outcome of the schemes so far
The German market has had a history of a low prioritization of biomass as a renewable source but more specific support for biomass in general has been undertaken such as biomass targeted subsidies (especially concerning CHP from 1999 and onwards). Also, German taxation and fixed tariff systems (i.e. tax exemptions for renewables) in combination with other efforts have proven relatively successful in promoting biomass utilisation. However, biomass has a large variety of origins and qualities and support mechanisms therefore are often lacking in some aspect. Looking onwards, a fixed price system may fail if it does not match the development of the market prices. (Thornley & Cooper, 2008)

4.5.5 The United Kingdom

The System
The main UK RES market economic incentives are the *Renewables Obligation* (RO) scheme which allows RES producers to claim Renewable Obligation Certificates for each MWh of green energy produced in combination with a governmentally imposed quota for suppliers, the fact that renewable fuels (e.g. biomass) are exempt from the *Climate Change Levy* (CCL) and

carbon trading schemes. (www, Department of Enterprise and Regulator Reform, 2009 (1))

The RO sets targets of green electricity to be sourced for energy suppliers. The target is incremental and started at 3% in 2002-2003 and will be at a level of 10,4% in 2010-2011. (EUBIONET II, 2006 (3)) Renewable obligation certificates (ROCs) are issued by the office of gas and electricity markets to eligible producers, e.g. designated biomass power plants, for each MWh of green energy they produce. These certificates can then be sold to suppliers aiming to fulfill their obligated targets or to brokers which in turn may sell the ROCs on the open market. (www, bwea, 2008 (1)) The RO system requires each supplier to provide evidence that the set quota for sourced renewable energy has been met. This can be done either by presenting ROCs or by buyout payments to cover a shortage in ROCs by the supplier. (Of gem, 2007) Figure 12 provides an overview of the described system.

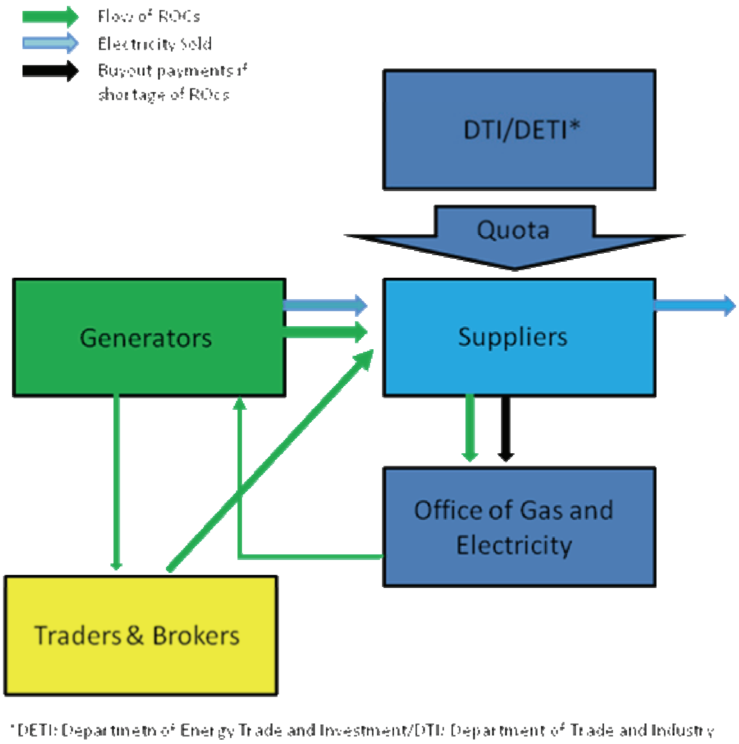


Figure 12. The UK ROC system.

Producers of green energy can also claim levy Exemption Certificates (LECs) and Renewable Energy Guarantee of Origin (REGO) for each MWh (for each KW in the case of REGOs) renewable energy generated. The latter has no monetary value, instead the REGOs are just a way of showing that the energy produced is from a renewable source. The REGOs can be useful for energy sources that are renewable but not included in the RO system. LECs need to be claimed by utilities for them to exempt business consumers from the Climate Change Levy (CCL) (4,71 €/MWhe) this in turn means that generators can sell LECs to utilities or specialised brokers at a market price. Essentially the LECs are proof that sourced energy is exempted from the CCL that can be traded at market set prices. (www, Department of Enterprise and Regulator Reform, 2009 (1))

Since 2001 the CCL is applied for the industry, commerce and public sectors on the use of energy (0,159pence/kWh for gas, 1,242pence/kg for coal, 1,018pence/kg for liquefied petroleum gas (LPG), 0,456pence/kWh for electricity) and the purpose of the levy is to encourage these sectors to invest in more environmental friendly production processes. (EUBIONET II, 2006 (3)) As mentioned, energy production from renewable energy sources is exempt from the levy. (www, businesslink, 2008(1)) For the definition of biomass that is in accordance with the ROC systems please refer to Annex B 5. The ROC price is set by the market and as of the 13th of January 2009 the average price was 51,81 pounds. (www, e-roc, 2009 (1)).

The RO system is currently technology neutral (as is the Swedish green certificate system) but changes in the scheme have been suggested. These would contain rewarding certain high risk investments/technologies with more than one ROC/MWh. For example a dedicated biomass plant is proposed to receive 1,5 ROCs/MWh and a dedicated biomass CHP plant is proposed to receive 2 ROCs/MWh. The proposed changes are currently being processed and may be implemented from 1st of April 2009 at the earliest. (BERR, 2009)

The four main UK biomass sources; forestry materials, agricultural residues, energy crops and imported biomass are, with the exemption of imported biomass, subject for different support programs. The Biomass Infrastructure Scheme, The Woodland Grant Scheme and the Energy Crops Scheme are example of fuel provision support schemes together worth around 120 million pounds invested over a four year period. Also, there are specific programs supporting RES generation equipment and energy flows. (www, Royal Commission on Environmental Pollution, 2009)

For biomass specifically there is a grant called the bio energy capital grant which for the period of 2009 to 2011 will hand out 12m pounds. The maximum single payment is 500.000 pounds. (www, bioenergycapitalgrants, 2009 (1))

Outcome of the schemes so far

In the UK taxation (i.e. CCL) has so far not been at a sufficient level to alter behaviour and promoting RES. (Thornley & Cooper, 2008) This is evident as only about 1,5 % of the final energy consumption in the UK was sourced from RES in 2008. (Pöyry energy Consulting, 2008)

Also, as the renewable obligations scheme currently and historically has not considered which type of technology that is used to generate green energy biomass has been considered a relatively expensive alternative in a country with limited domestic biomass resources. This means that in order to promote bio energy to a higher extent more technology specific incentives needs to be utilised in the UK (which is also under way as described above). (Thornley & Cooper, 2008)

4.5.6 Summary of the main Incentive Systems

Sections 2.6.2, 2.6.3 and 2.6.4 describe the structure of the incentive systems in the three scope countries on a relatively detailed level. Table 8 provides a simplified overview of the three main incentive schemes (which are utilised in the thesis WPC calculations).

Table 8. Summary of Main Incentive Schemes

Country	Incentive	Awarded	Function
SE	Green Certificate System	One Certificate/MWh of RES electricity	Certificate quota for suppliers/consumers and certificates awarded for RES producers. Price is set by market as suppliers/users aiming to fulfill their quota and/or traders/brokers interact.
DE	Feed-in Tariffs	Fixed price per kWh/RES electricity	Fixed prices in combination with net access are promised for a certain period of years and a certain depreciation rate for RES producers. Feed-in level is decided by type of technology and capacity of the applying installation. The system is basically aimed at small to mid scale installations (up to 20MWe capacity and 175, 2 GWh output).
UK 1	Renewable Obligation Certificates	One ROC/MWh RES electricity	RES quota for electricity suppliers in combination with ROCs awarded for RES producers. Suppliers aiming to fulfill their obligation buy ROCs from producers or brokers which prove that the supplier has sourced RES electricity according to the set quota.
UK 2	Levy Exemption Certificates	One LEC/MWh RES Electricity	Utilities are obliged to source LECs to exempt business consumers from the CCL which means that generators can sell LECs to utilities or other third parties (market prices for the latter).

The Swedish and UK systems provide revenue on top of the market price for electricity. The German system promises fixed electricity prices instead of the offered market price up till a certain scale and output.

4.6 Future outlook

As earlier mentioned there is a growing will demonstrated for the increase of RES utilisation and therefore biomass utilisation in Europe. The fundamental drivers behind this growing interest can be seen in a growing environmental concern where greenhouse gas emissions and climate change play a central role as countries try to reduce their usage of fossil fuels. Furthermore, the European Union is currently heavily dependent on energy imports and the levels of imports are expected to rise significantly during the coming years. (VTT, 2006 (1)) These factors favour the use of RES (i.e. biomass-, wind-, solar-, hydro- and geothermal energy). And out of RES energies biomass is a unique energy source as it is the only fuel that can be easily converted to satisfy all energy sectors (heat, power and liquid transport fuels). (VTT, 2006 (1)) Also, biomass has a great potential as it, as mentioned earlier, is currently an underutilized resource as it has been estimated that only 50% of the available solid biomass fuel potential in the EU 20 area is utilized. It is also interesting that two of the thesis scope countries have the largest (Germany 1300PJ) and the fourth largest (Sweden 648 PJ) biomass resources among the European countries. (VTT, 2007)

Regarding the type of energy to be produced from biomass the EU-commission has predicted that the electricity usage is to increase and the heat utilisation to decrease. In relation to this one important issue is to increase the electricity production of CHP plants if these types of installations are to be invested in. (Energimyndigheten, 1999) Of all the RES investments wind power currently attracts the largest flow of invested capital. Funds invested in wind during 2007 exceeded 50 billion dollars globally. (UNEP, 2008)

The expansion of the bio energy sector in the short term, on a wide perspective, is likely to be dominated by co-firing. However there are many other interesting alternatives in use and under development. The main factors that are hampering a faster bio energy expansion for the moment are feedstock availability, transport costs and conversion efficiency. (IEA, 2007) Also, investors will generally not invest in a bio energy project without having a market for their product (i.e. green energy) secured. This is not always the case and even if markets are assured the applied conditions may not always be viewed as favourable enough. This combined with the fact that the production of bio energy generally cannot compete with fossil fuels from a purely economic perspective means that political will and incentives play a large part in expanding the bio energy industry. One simple fact that may help to explain this is that forest residues delivered to a plant in general costs twice as much as coal delivered to a plant (costs of CO_2 emissions not included). (IEA, 2007 (1))

Large scale bio energy projects are associated with larger capital costs than coal or gas plants which deter investors looking for a shorter payback period of 2-4 years as opposed to 15-25 years. Bio energy also faces competition from other RES installations such as hydro -, geothermal or wind installations that often provide investors with competitive prices and costs in relation to bio energy. (IEA, 2007 (1))

Although bio energy in some situations may be a less interesting investment option than conventional fuels existing financial and economic incentives seem to be encouraging bio energy investments. For example a survey including 70 CHP installations in Sweden showed that 63 % of the respondents found the Swedish Green Certificate system as a determining factor for their investment decisions. Also, 23 % stated that the system had some relevance in their investment decision. (Svebio, 2005)

Besides the need for governmentally controlled support systems the issue of local available feedstock supply for large bio energy installations or an otherwise optimised fuel supply situation needs to be solved in order to make bio energy investments more attractive. This in order to reduce transport and other associated costs and thus making bio energy more competitive from an economical point of view. One option may be growing biomass fuels within an acceptable distance from planned / existing bio energy installations. Also, further development on more efficient technologies, e.g. integrated gas/ steam turbine systems (IGCC), will aid the bio energy expansion. (IEA, 2006)

The much debated “credit crunch”, i.e. the global economic downturn, has had relatively little effect on the overall (global) investment trend regarding RES. Investments were somewhat hampered during the first half of 2008 but reached the previous year’s levels during the second half. Generally the financial community regards the RES market as a growing one and there are many actors willing to take part in its future growth. (UNEP, 2007)

5. Results

5.1 Interview Results

5.1.2 Interviewed Actors

In total thirteen respondents have participated in the performed qualitative interviews. One phone conference (with two respondents interviewed simultaneously), one personal meeting and ten phone interviews form the base for the thesis results. Eight of the respondents were Swedish, three were UK based and two of the respondents were German actors.

The actors interviewed and the obtained results are presented on an anonymous basis as anonymity has been requested specifically by some of the respondents. Please refer to Annex C6 for a general description of each interviewed actor.

For an extensive result presentation please refer to Annex C7 where I have written down all results that I feel relevant to the thesis. The extended result presentation is divided under headlines referring to the interest topics that were used as guidelines during the interviews. Not all topics or headlines from the questionnaire are used and the headlines have been slightly altered in order to mirror the obtained results. Each interview subjects input to the interest topics are presented in accordance with their issued codes according to Annex C6.

The following section presents the results on a general and country specific level under headlines inspired by the utilised questioner interest topics (which in turn is based around Porters industry structure theories). After this, chapter 6.1 applies Porters Five Forces Model to the uncovered results on a country specific level. The model is used as a tool for describing the current trends and structures on the examined markets. Also, an attempt to look ahead and predict probable future trends and developments on the three scope markets is made.

5.1.3 The Investment Decision

- **General;** Governmentally controlled incentives are regularly mentioned as crucial for biomass investments. Taxes on fossil fuels turn the attention towards bio fuels and certificates/ROCs/feed-in tariffs raise an interest for electricity generation. Basically because "coal is cheaper". For the UK market specifically, some of the results point towards that the ROC system alone does not represent a sufficient economical incentive for smaller scale installations as periodically occurring investment grants are important especially for installations in the scale of 30-60MWe.

- **General;** Locally available feedstock or securing long term feedstock supply through contracts is also mentioned as important. As opposed to this view growing energy crops abroad or importing wood chips from North America is also seen as a feasible solution by some of the involved actors. A favourable localisation is also important and connected to the aspect of locally available feedstock.

- **General;** Local demand for heat is crucial for heat or CHP production. The demand for green electricity is also implicitly mentioned as important as the certificate systems are considered as important.

- **General;** Environmental concerns and a will to be environmentally friendly are also mentioned as important.

- **General;** Regarding the type of technology fuel flexibility is seen as an important way of reducing dependency and risks.

- **UK/SE;** Specifically regarding the UK and Swedish systems new legislations that clarify which producers that will be eligible for certificates (Sweden) and technology specific support for e.g. biomass is under way. Both these issues have been mentioned as making biomass investments more favourable.

- **UK;** For the UK market investment grants that the government utilises are mentioned as important. However, these grants are not constantly available as they are used as a "tap" for the government to financially aid the RES industry when needed (according to U3).

- **SE/UK/DE;** For the UK and German markets present and historical regulations that have promoted RES technology in a "technology blind" (i.e. the same remuneration has been present for all types of RES) manor has been disadvantageous to the bio energy industry as other RES options, e.g. wind, has been seen as more profitable. However, biomass specific support has been undertaken and more is under way. This has proven useful, for instance UK investors mentioned the proposed changes in the ROC system that will offer 1, 5 ROCs for designated biomass installations etc. as having a positive effect on the will to invest in bio energy. The Swedish access to local feedstock through large forest resources and a large forest industry has probably put bio energy investments in a more positive position despite the Swedish systems technology blind aspects.

5.1.3 Market Structure and Characteristics

- **Sweden;** The Swedish market is said to be characterised by many large district heating systems, a large biomass resource and a well established and large forest industry. The market for biomass and bio energy is said to be mature with relatively few sellers and a competition that is locally decided. The forest industry is a major player on the market that both consumes and sells biomass. As a result of the economic downturn many actors that previously have been dependent on biomass residues from the forest industry have been forced to find alternative sources as the sawmills slow down their production. Prices for wood based feedstock is said to be rising and are thought to remain on a relatively high level. The Swedish taxation system is and has been effective in reducing the use of fossil fuels and the certificates system seems to encourage investments in biomass to electricity.

- **UK;** The UK market is characterised by a relatively immature market for biomass and bio energy. Thus transparency in to market prices etc. is relatively low. The market for bio energy seems to be a "hot spot" with large players announcing big projects. The UK domestic biomass resource, especially the wood based one, is relatively small and many of the planned expansions are thought to be fuelled by imports. There is no established market for heat/district heating in the UK and even with very favourable conditions for CHP in the ROC system being promised a large CHP expansion is not likely. Planning and obtaining permissions has been mentioned by several actors as an issue on the UK market. The UK investors do not show the same conformity as the respondents on the Swedish and German markets. There are basically two main trends in wood based bio energy; small or midscale investments or huge port based installations. The latter has not been built or tested previously on a large scale and thus much of the technological and economical aspects are unknown or known to a lesser extent.

- **DE;** The German market is mentioned as having a large and mature market for waste wood. Also, there are established markets for other types of traditional fuels such as pellets or wood chips. The situation for new entrants on the German market is seen as troublesome as biomass prices will go up and as demand is met at a relatively high level (mature market). The German feed-in system is seen as a "sure bet" where you know what you get. However, the issue of fluctuating fuel prices and set electricity prices is seen as somewhat of a problem as the producers extra costs cannot be distributed to an electricity customer as in the case with flexible prices. One UK actor sees the German system as troublesome as it does not support what he calls large scale installations (hundreds of MWe).

5.1.4 Future outlook

- **General;** Waste is seen as a profitable investment, especially by the Swedish actors. However, waste incineration facilities are more expensive (operational and capital costs) and waste is not an abundant resource. Basically nobody wants to build the last waste incineration facility and be left with an expensive specialised installation without access to locally available feedstock.

- **SE;** The bio energy market in Sweden is not thought to go through any drastic changes in the coming 10 to 15 years other than a small but steady increase in capacity.

- **DE;** The German market is thought to develop more towards decentralised micro generation CHP (for new investments). The market is seen as relatively mature and no drastic changes are expected. Geothermal installations are seen as a favourable RES investment in the future.

- **UK;** The UK market is as mentioned not mature like the Swedish and German ones and an expansion is expected, mostly in designated biomass power plants.

- **General;** There is also a belief that the European markets will merge and that a common electricity stock market will form. One respondent even mentions a common biomass market/stock exchange.

5.1.5 Costs

- **UK/SE;** Large scale investments are mentioned as necessary for profitable investments by Swedish and UK actors. What large scale is defined as differs somewhat but the limit for what can be considered as large scale is in the area of 100MWe in this case. (as opposed to some opinions regarding smaller or medium sized installations)

- **General;** Boat transport is seen as a relatively cheap way of transporting biomass long distances. However, the profitability of these transports is set by the rates charged by the boat operators which in turn have fluctuated a lot in the past months.

- **General;** The biomass price is seen as an important factor but the energy producers paying capability seems to be relatively high. One of the Swedish respondents explicitly states that the energy producers have a higher paying capability than a competing pulp mill.

- **General;** Labour costs are seen as small or unimportant costs relative to the other involved costs.

- **General;** The general cost situation facing the bio energy producers is seen as relatively similar in the three scope countries. However, while the UK investors mention their costs rising significantly as the sterling falls to the euro, Swedish actors regards construction costs as falling as builders are under pressure by a reduced demand as an effect of the economical downturn.

- **General;** Electricity prices are said to be at a high level and also expected to rise.

- **General;** Biomass prices are also expected to rise.

5.1.6 Favored Investments

- **General;** A move towards low quality type fuels (e.g. waste wood, industry residues, municipal waste etc.) as opposed to using virgin wood seems to be a general wish/belief.

- **SE/DE;** CHP is seen as a favourable investment if a local market for heat can be found. (i.e. Sweden and Germany)

- **SE;** Combining CHP with another type industrial production, e.g. pellets, is seen as a profitable and effective investment.

- **UK;** In the UK new legislation promising 1, 5 ROCs for designated biomass plants and 2 ROCs for biomass CHP plants put these investments in a favourable condition.

- **General;** Also in the UK, very large scale installations seem to be an investment mentioned by many actors. Off course, there are large scale (depending on what is defined as large scale) installations in Sweden and Germany as well but the trend towards truly large scale installations in the size of 300MWe is most evident in the UK.

6. Model Calculations

6.1 The Model

The utilised model has the following general appearance (country specific calculations are presented further on);

Revenue Streams	
Revenues from Electricity production (a)	xx € / MWh
Revenues from Heat production (If any) (b)	xx € / MWh
Value of governmental support system (c)	xx € / MWh
Costs	
Total Generating Costs (capital, operating etc.) (d)	xx € / MWh

Wood Paying Capability (WPC) =

(a+b+c) - d:

(a) Revenues from electricity production €/MWh
+
(b) Revenues from Heat production (If any) €/MWh
+
(c) Value of governmental support incentives €/MWh)
-
(d) Generating costs €/MWh

Indirect measures such as emission rights and various taxes are assumed to be included in a generally higher price for energy in general and will not be included in the model calculations.

6.1.2 Costs

Cost estimation sources and content

The costs associated with CHP production are taken from the 2007 Elforsk report: "Electricity from new installations" (report name translated by the author). The report presents total electricity generation costs for 10 MWe, 30 MWe and 80MWe size CHP installations. The total electricity generation costs can be utilised as cost estimations for the calculations as they take in to account the variable and fixed value of producing heat for CHP installations. The result is essentially a total cost estimation that is specified below. (Elforsk, 2007)

The utilised Elforsk calculations (without taxes, subsidies and fees and 12 % interest) contain the following variables (Elforsk, 2007):

- Capital Costs
- Fixed operations and management costs
- Variable operations and management costs
- Fuel Costs (Forest Residues 15,4 €/MWh, Pellets 25,4 €/MWh)
- Reinvestment Costs
- Localization Costs
- Heat value (variable)
- Heat value (fixed)

Cost estimations for electricity only production are derived from the IEA publication "Biomass for Power Generation and CHP" which produces similar cost estimations as the Elforsk report. (IEA, 2007)

The utilised IEA calculations are based on the following assumptions (Pers.Com, Taylor, 2009):

- Fixed overhead costs (10% interest)
- Other fixed overhead costs (land, buildings, maintenance etc)
- Variable fuel costs (Biomass cost utilized 3dollars/GJ = 0,65 €/MWh (IEA, 2007)
- Variable operating costs

The included costs are very similar with the main difference being that the Elforsk costs include a heat value as CHP is considered and that the Elforsk calculations are specified to a further extent than the IEA calculations/definitions which are presented in a more aggregated form.

Adjustments to the total electricity generation costs
As the model calculations aim to estimate a maximum paying capability for the utilised feedstock, variable fuel costs should not be included in the cost estimations and these costs will therefore be subtracted from the total electricity generation costs. That is, as the calculations aim to present values on the maximum producer paying capability for wood, i.e. a maximum tolerable variable fuel cost, the variable fuel costs should not be included in the total cost estimation. For Sweden and Germany the total is subtracted with the included 15,4 €/MWh variable fuel cost. (See the above stated Elforsk 2007 variable content). For the UK calculations the included biomass cost of 0,65 €/MWh is subtracted from the total.

Installation types and properties
For Sweden and Germany a designated biomass CHP plant has been chosen as a likely investment. For Germany a smaller 10MWe installation has been chosen as cost estimates was available for 10, 30 and 80 MWe installations and the 30 or 80MWe installations would not be eligible for feed-in tariffs. For Sweden the 30MWe associated costs were chosen as they represented a feasible cost level. For the UK a designated biomass power plant (designated steam cycle) has been chosen as a likely investment.

Installation specific efficiencies, i.e. power and/or heat output in relation to fuel input, is an important aspect as it directly affects the total electricity generating costs. This as the total generating costs are obtained by dividing the total cost estimations as stated above with the installation specific efficiency times the assumed number of operating hours;

$$\text{Total Electricity Generating Costs} = \frac{\text{Total Costs(Capital costs, management etc.)}}{\text{(Efficiency*number of operating hours)}}$$

Thus, a high efficiency will generally result in a lower total electricity generating cost. (Pers.Com, Wrangensten, 2009) Installation specific efficiencies are also very important from a variable fuel cost perspective. The better the efficiency the lower the variable fuel cost will be as less fuel will be needed to produce electricity and / or heat.

In this context it is also important to consider the total efficiency of an installation. For example a CHP installation may have a total efficiency above 100 % as both heat and electricity is produced from the utilised fuel energy. (Elforsk, 2007) Conversely a condensating plant generally has a much lower total efficiency of 30 – 40 % (IEA, 2007) This implies that producers of both heat and electricity generally benefit to a higher degree from each MWh of utilised fuel wood. However, condensating plants have an advantage in terms of electricity producing efficiency. In this aspect CHP production is much less effective and is usually mainly considered as heat production with an electricity production bonus. (IEA, 2008)

Efficiencies will not be considered in the model calculations as variable fuel costs or fuel usages are not directly included. However, it is of great importance to bear in mind that the resulting WPC calculations only present a gross value of the maximum *tolerable* variable fuel costs. An installations true variable fuel costs will, as discussed above, be greatly affected by its efficiency, i.e. how much fuel it utilises in relation to the produced revenues from electricity and / or heat. Thus WPC values will have different meanings depending on the type installation and technology that is analysed.

Assumptions

The Elforsk calculations assume a general economic lifespan of 20 years and an annual utilisation rate of 4500 hours. (Elforsk, 2007) IEA generally utilises payoff times in the area of 25 years for these types of calculations (Pers.Com, Taylor, 2009). Regarding the annual utilised hours for non CHP and the calculations in the "Biomass for Power Generation and CHP" these assumptions have not been available due to IEA personnel changes since the report was written (Pers.Com, Taylor, 2009). However a general utilisation rate of 6000 hours for condensation plants is mentioned in the 2007 Elforsk report. (Elforsk, 2007)

All cost estimations are from 2007 which have implications on the results of the calculations. The IEA numbers are general and not specified for a specific country. However, the Elforsk numbers are based on Swedish conditions and there are some Swedish market and monetary facts that might be of interest:

- 1 Swedish Krona in 2007 (year average) would be worth 1, 03 Kronors in January 2009 which represents a change of 2,54 %. (www, SCB, 2009 (1))

- Many of the input material costs and other variable costs have increased since 2007, see for example Annex C4 and the steadily rising wood chip costs in Sweden.

- Besides capital and operating costs construction costs are likely to be at a lower level in 2009 than in 2007 as the economic downturn puts pressure on builders to lower prices, this assumption is backed up by some of the Swedish interview results. This in turn may result in somewhat lower maintenance costs if construction or repair is involved.

6.1.2 Revenues

Electricity revenues

Current electricity spot prices have been collated from up to date electricity trading sites on the internet and averages of one to two months are used as in-data. These spot prices are seen as representative as producer faced electricity revenues as opposed to the much higher consumer faced market prices. This as grid management, grid access and other variable costs lower the "true" electricity revenue for producers which are not depicted in the relatively high consumer faced market prices. (Pers.Com, Rotacher, 2009)

Heat revenues

Regarding the utilised heat revenues, adjusted average consumer faced market prices for Germany and Sweden are utilised as best estimations. The obtained market prices are subtracted with an 18,5€/MWh variable heat production cost presented in the Elforsk cost calculations. This is done in order to assure that the heat revenues are kept on a, from a producer perspective, relevant level by adjusting for variable costs associated to heat production. This as the consumer faced average market price for heat is not seen as representative for the heat revenue as received by the producers.

Governmentally controlled revenues
Producer faced revenues generated from the Swedish Green Certificate System, the UK RO system and the German feed-in system are included in the calculations.

Specifically regarding the UK calcualtions (LECs and heat)
For the UK the value of tax avoidance (LECs) is included in addition to the ROC value. This as the LECs are a part of the RO system and as the LECs can be sold and traded in the same manner as ROCs. The LEC value is assumed to be equal to that of the avoided tax cost (4,7 €/MWh (www, Department of Enterprise and Regulator Reform, 2009 (1)). Also, for the UK calculations heat is not included as the district heating system is only developed to a small extent. It can therefore be assumed that new installations generally will not have access to an existing district heating system. Although new regulations that will favour CHP will make investment in this technology more interesting the lack of a market for heat is seen as a major obstacle. The only real option for large scale CHP production today would be to combine biomass CHP production with other types of industry, e.g. chemical production (Pers.Com. U1, 2009). This would however be an investment outside the scope of the thesis as for example chemical production is certainly not included within the scope.

6.2.3 WPC Calculations

Country Specific Calculations – Sweden

Revenues

- **a)** Electricity; Market spot price = 40 €/MWh (www, nordpool, 2009 (1)
- **b)** Heat; Market average corrected with variable heat production cost; 71,7 – 18,5 = 53,2 €/MWh (www, Avgiftsundersökningen, 2008 (1))
- **c)** Certificate value; = 25,68 €/MWh (www, elcertifikat.svk, 2009 (1))

Costs

- **d)** 30MWe CHP (SE); Total electricity generating cost corrected with included fuel costs; 104,2 – 15,4 = 88,82€/MWh (Elforsk, 2007)

Calculation

(a+b+c)-d = (40+53, 2+25,7) – 88,8

Result

Maximum wood paying capability for Sweden: **30,1** €/MWh

Country Specific Calculations – Germany

Revenues

- **a)** Heat; Market average corrected with variable heat production cost; 69,39 – 18,5 = 50,9 €/MWh (Pers.Com, Pushkarev, 2009)
- **b)** Feed-in value; Basic feed-in 7,79 c€/kWh + CHP bonus 3c€/kWh, see Annex C1 for a complete description of the feed-in remuneration = 107,9 €/MWh

Costs

- **c)** 10MWe CHP (DE); Total electricity generating cost corrected with included fuel costs; 128,6-15,4 = 113,2 €/MWh (Elforsk, 2007)

Calculation

(a+b)-c = (107,9 + 50,9) – 113,2

Result

Maximum wood paying capability for Germany: **45,6** €/MWh

<u>Country Specific Calculations – UK</u>

Revenues

- **a)** Electricity; Market spot price = 62,3 €/MWh (www, apxgroup, 2009 (1)
- **b)** ROCs; 55,4 €/MWh (www, e-roc, 2009 (1))
- **c)** LECs; 4,7 €/MWh (Tax value) (www, Department of Enterprise and Regulator Reform, 2009 (1))

Costs

- **d)** Designated Steam Cycle (UK); Total electricity generating cost corrected with included fuel costs; 85,21-0,65 = 84,56 €/MWh (IEA, 2007)

Calculations

(a+b+c)-d = (62,3+55,4+4,7) - 84,6

Result

Maximum wood paying capability for the UK: **37,8** €/MWh

Please refer to Annex C 9 for printouts of the excel based calculations.

Figure 13 visualizes the results; Germany has the highest theoretical wood paying capability according to the calculations;

Figure 13. Maximum Wood Paying Capability for each of the scope countries.

Figure 14 displays changes in WPC values as heat, electricity and Green Certificates revenues are varied ceteris paribus. The Figure demonstrates the WPC values linear dependency on heat, electricity and certificate values that characterize the calculations. Figure 14 depicts the Swedish example but the same linear dependency and direct correlation is present for the German and UK calculations. All values are in €/MWh.

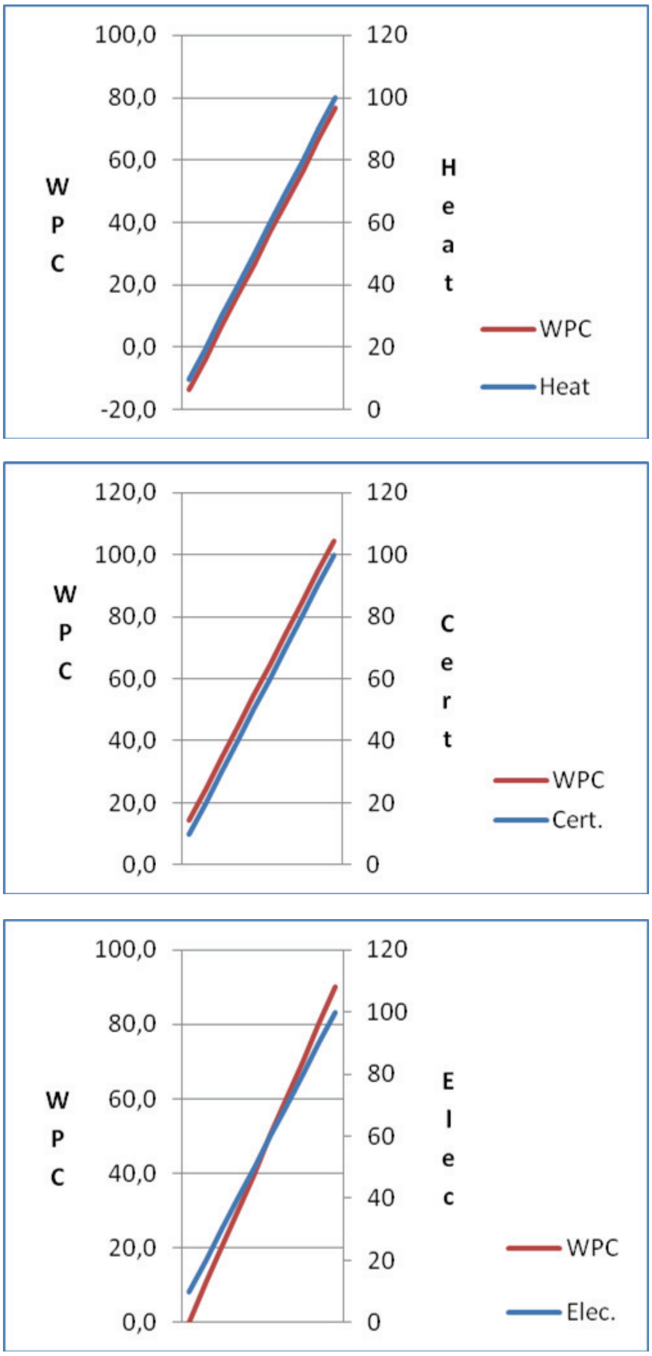


Figure 14. The linear dependency between WPC and heat, electricity and incentive value. (Note that installations exceeding 20MWe capacity and 175,2 output will not be supported by the German feed-in system).

The resulting paying capability is at a level well above some of the stated biomass prices as described by Figure 15 which shows the calculated WPC and woodchip prices;

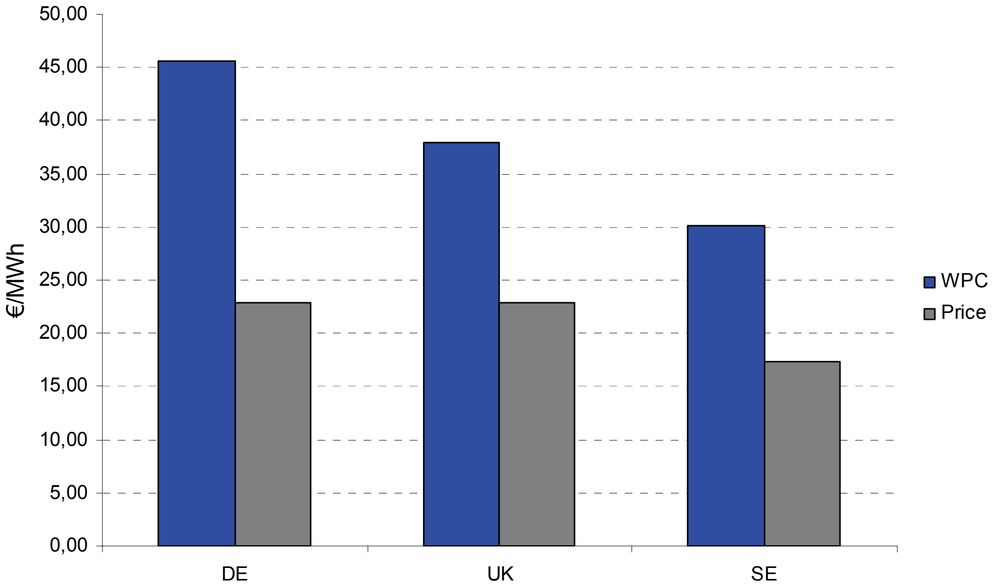


Figure 15. Wood Chip prices compared to estimated WPC.

Note that the UK calculations are performed under a lower interest rate (10 % as opposed to 12% for Sweden and Germany) and that a shorter pay off time is utilized for the German and Swedish calculations (20 as opposed to 25 years). Although varying interest rates and payoff times are not a preferable base for the calculations more conformed costs have not been available.

7. Applying the theory

7.1 The Five Forces and the Bio Energy Industry

As the main theoretical framework of the thesis is Porters Five Forces Model the structure (as revealed by the thesis interviews and literature studies) of the three scope countries is analysed with the aid of Porters model in the following section. The analysis has two main parts; Firstly, a general description of the bio energy industry’s structure is undertaken. Secondly, a forecast for the future of the bio energy industry using the methodology described under 3.1.2 is performed.

In order to make a relevant analysis the industry needs to be defined and structured. For the purpose of this specific analysis the bio energy industry and the involved actors are simplified and defined as depicted by Figure 16.

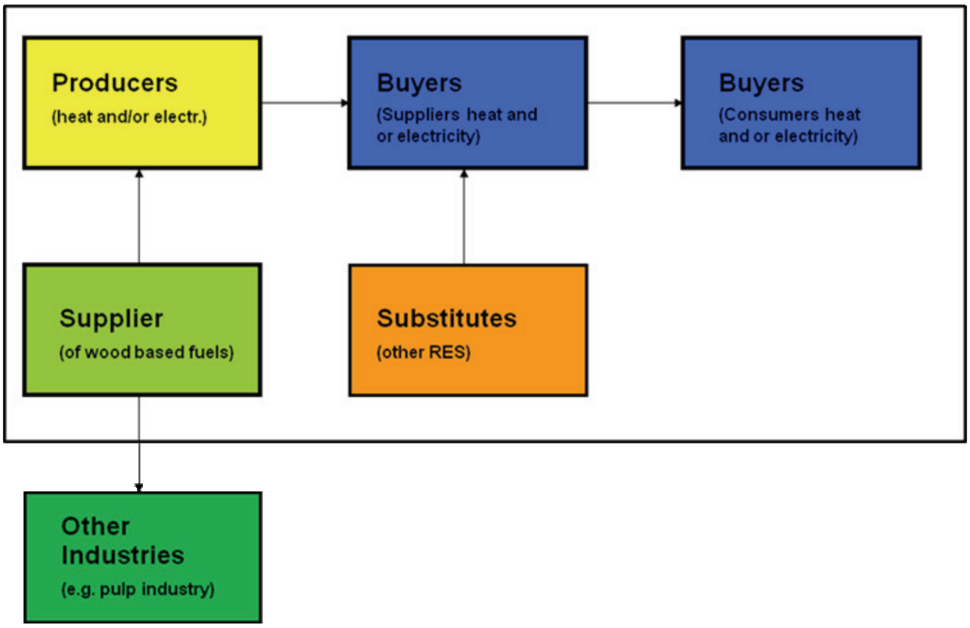


Figure 16. Bounding of the industry.

Producers source feedstock from the suppliers which in turn can choose to sell their feedstock to other industries. As related industries, e.g. the pulp and paper industry or the sawmilling industries, share a common interest in the bio energy industries feedstock these actors have been included in the analysis. Buyers can source certificates and ROCs from producers or other RES sources. Other industries are only considered as competitors for feedstock not as competitors on the heat or electricity markets.

Threat of Substitutes, Industry Rivalry and Threat of entries are analysed under a common heading as all aspects are primarily seen to be concerned with other RES sources or entries of new bio energy actors.

7.1.1 Structure of the bio energy market - Sweden

Supplier Power

The Swedish market for wood based fuels is dependent on the Swedish forest industry, especially the sawmills. Also, there are relatively few sellers on the wood based biomass market. All this implies that the market could be characterised by a relatively high level of seller power (i.e. high price sensitivity and a high bargaining power) However, as Sweden is a country with a large domestic biomass resource, the level of supplier power can be reduced by the availability of alternative feedstock supply. This effect can in turn be counteracted by the financially viable transport distance for biomass which narrows down the available alternatives for producers. The issue of relatively high feedstock prices mentioned by some of the respondents may however be connected to the fact that there are relatively few sellers on the market. Finally, the fact that Sweden has the lowest feedstock price of the three scope countries seems to indicate that the determinant factor is a locally available feedstock that is keeping prices down.

Suppliers can choose to sell their feedstock to other actors. Here the energy producers, under current market conditions, are regarded as a relatively powerful actor as competing industries such as the pulp industry is currently battling the economic downturn and facing small, if any, revenues. As the sawmills are also struggling the sought after residues from these installations are decreasing and competition for that specific feedstock is also increasing. One of the Swedish respondents explicitly mentioned that he, as a CHP producer, had a higher paying capability than a competing pulp mill.

Buyer Power

The bargaining and price sensitivity of electricity suppliers and end consumers is low. Suppliers are forced to source certificates by law and electricity prices are set by the stock exchanges and macroeconomic forces. The weakest part is off course the consumers as the suppliers generally can pass on increased costs to the end consumer.

Regarding the heat market these suppliers are not affected by the certificate system. The buyer - supplier situation is complicated by the fact that in many cases Swedish municipal actors act as both producers and grid operators (this is also true for electricity in some cases) and thus also as buyers as defined by Figure 23. As heat is less viable for long distance supply, as opposed to electricity, a lower degree of buyer power is likely to characterise the buyers of heat (there are less alternatives). Conversely, heat producers also have fewer alternatives as they are restricted by the existing district heating system.

Threat of entry, Industry rivalry and Threat of Substitutes

The Swedish market is generally considered as a mature market where there are no drastic changes expected to take place over the coming years. Entry barriers exist primarily in the form of high capital costs and in the fact that any new CHP installation need to be connected to an existing district heating system.

It has been mentioned that other RES alternatives are often favourable from an investment point of view. E.g. wind power has received a large interest and associated investments on a global level. Also, bio energy is often considered a relatively expensive investment and technology specific support has proven useful as bio energy investment drivers in Germany and the UK. However, the country specific benefits from using biomass in Sweden as e.g. local feedstock are often available. Also, in Sweden where bio energy is often associated with CHP, bio energy is favourable from e.g. wind power as it can satisfy both a heat and electricity demand.

New entries need to be matched by an existing or increased demand which is not met by existing or modified existing installations. This is correlated to what Porter describes as the tendency of excess capacity to put a downward pressure on prices. That is, new entries are not likely if the added capacity means that certificate prices float downwards which would lower the profit margins for industry as a whole.

7.1.2 Structure of the bio energy market - Germany

Supplier Power

Much what has been said about the Swedish market can be said about the German one. Germany also has a mature market and especially for waste wood. One of the respondents mentions a shift in power as suppliers of waste wood have gone from a situation where they would pay producers to take care of their waste wood (i.e. gate fees) to a new situation in which they actually get paid for their waste wood by the energy producers. This shift in power (both bargaining and price sensitivity) is a result of the market maturing and growing and as a result of this feedstock getting scarcer. Also, more traditional wood based fuels (such as woodchips) are seen as a limited resource which would imply a strong supplier position due to lack of viable alternatives.

Buyer Power

The conditions for the buyers in Germany are somewhat different from e.g. Sweden concerning electricity. This as the fixed price system is utilised and thus the power (bargaining and price sensitivity) conditions between the buyer and seller is neutralised. However, for capacity over 20MWe and an output over 175, 2 GWh the situation is opposite as market prices and market economic forces set the price. From this perspective the buyer power is relatively strong as the bio energy producers that exceed the established quota have to sell their electricity in competition with all other available electricity sources.

Also, the suppliers operating in the feed-in system cannot pass on increased electricity costs to the end consumers as the system provides a fixed feed-in price. Regarding the power factors concerning the heat market not much new input can be said that has not been mentioned under the Swedish analysis. Specifically for the German market raised heat prices can be used as an answer to increased feedstock prices (instead of raising electricity prices)

Threat of entry, Industry rivalry and Threat of Substitutes

Regarding other RES sources these are likely to have an advantage towards bio energy as other RES forms, e.g. wind power, historically have been endorsed by the government to a higher extent than bio energy. Also, investments in geothermal installations are seen as an interesting alternative by one of the respondents. However, new taxation laws and specific CHP support are likely to make bio energy a more interesting. As with Sweden, Germany has a developed district heating system which in combination with the feed-in system makes bio energy interesting from an investment point of view.

In Germany the total existing RES capacity does not affect feed-in levels as in the Swedish case where a larger production of RES energy will cause certificate prices to float downwards.

A limited available feedstock has been mentioned as an entry barrier. This limitation is however most likely not connected to a physical lack of wood based feedstock but rather local forestry policy on the use of virgin wood as feedstock for energy production. This in turn means that the conditions may change rapidly depending on government policy.

7.1.3 Structure of the bio energy market – UK

Supplier Power

The UK is, as opposed to the Swedish and German markets, a relatively immature market for bio energy and biomass. There is very little transparency in to the biomass market and there is no systematic collection of e.g. biomass price statistics. This lack of transparency is likely to increase the suppliers of wood based biomass relative power as buyers may not be aware of alternatives and reasonable prices. This however will only be the case in a short term perspective as a growing bio energy industry is very likely to give rise to a structured biomass supply industry.

As discussed earlier there are plans to source much of the increased wood based biomass demand through imports from e.g. North America. These imports will be formed around large contracted qualities (millions of tonnes annually) and thus one can assume that bargaining power and price sensitivity will be relatively equal between parties. This as such a large supply could be hard to secure but at the same time a contract of millions of tonnes of woodchips would be very valuable to the supplier.

Buyer Power
As in the Swedish case the buyer power is limited. While the suppliers can chose from where to source their ROCs the producers need not be concerned of who buys their certificates as these are priced and traded on an open market. In both the Swedish and UK system the buyer situation is ultimately determined by the governmentally set quotas in relation to the existing RES capacity. That is, it is the overall market conditions rather than individual bargaining power that will determine the ROC price.

Threat of entry, Industry rivalry and Threat of Substitutes
As in the case of Sweden and Germany there are many financially interesting alternatives to biomass designated power plants for example onshore wind power has been mentioned as a strong competitor. Biomass is despite this an interesting alternative mainly due to the ROC system and this effect will be more powerful after April 1st if the suggested changes to the systems are implemented. Technology specific support seems to be required in order for biomass to prevail over other types of RES sources on a large scale.

As mentioned the UK has a relatively immature bio energy market. This can imply that there is more room for new biomass designated power plants (heat is generally of less interest in accordance with what has previously been discussed) compared to Sweden and Germany. Empirically the interviews point out that the UK is the most dynamic market with very large energy projects planned and under way.

7.1.4 Forecasting the Future

As described earlier Porters Five Forces Model can be used as a tool for predicting future profitability for the examined industry. The process has three main steps;

1. Analysis of the industry's current level of competition, profitability and current structure.
2. Analysis of the different factors/trends that are changing industry structure.
3. Applying the structural changes to the five forces and thus the profitability of the industry

1. Current level of competition, profitability and current structure
Competition within the bio energy industry is more a matter of securing demand (which is likely to be created and affected by government policy), grid access and feedstock. If this is not possible e.g. because of an already existing actor that is using the feedstock or supplying demand this is more a form of barrier to entry. Entry barriers can also be in the form of capital

requirements or a non existing heat market facing a would be CHP producer. These important structural conditions are more open in the less matured UK market, with the exception of a non existing heat market, than the more matured Swedish and German bio energy markets.

Regarding the profitability faced by the producers in the tree scope countries the calculations point towards a WPC that is well above the prices for biomass, especially wood chips. This in turn suggests that there are profits to be made on all the examined markets as long as feedstock, market access and demand are secured.

Regarding the UK and Swedish incentive systems the stated quotas and number of issued certificates and ROCs will affect the value of the incentive systems and thus the profits received by the producers.

2. Analysis of the different factors/trends that are changing the industry

For the UK market the most important factor that is likely to change the industry structure/profitability in the short term are the technology specific changes that are due to take place from 1St of April 2009. As implied by the interviews many of the planned expansions that are taking place now are impacted by these changes. Besides the governmental incentives the profitability of the large planned installations is important for the future development of the UK market. If these large projects fail is likely that fewer investors will be drawn to the UK market in the short term. For Sweden and Germany no radical structural changes are expected. The clarifying directives that the Swedish Energy Agency will present in April/May (regarding which installations are to be considered as new and older/modified installations eligibility for certificates) may have a positive influence but will most likely not result in a boom of bio energy investments. Rather as there are many existing CHP and heat installations it is more likely that these installations will be modified gradually to qualify for certificates (Regarding Sweden). A couple of Swedish respondents see a future in bio energy combines as these installations can utilise positive synergy effects from maximising the energy input/output. In Germany a shift towards smaller scale systems is predicted. The German market is also likely to evolve at a relatively slow pace.

3. Applying the structural changes to the five forces and thus the profitability of the industry

The UK industry is the one that is likely to have the most significant change in industry profitability mostly due to the changes in the incentive system. The market is also likely to undergo a relatively large expansion mostly limited by the level of ROCs that need to be sourced on a national level and other possible incentives such as government grants. The Swedish and German markets are likely to remain on the same profitability level for a relatively long period of time. The profits will mostly be affected by heat, electricity and feedstock prices. Rising feedstock prices will increase costs but at the same time electricity prices are thought to go up which will counteract the effect of the increased feedstock costs.

8. Discussion

8.1 Method

Validity

The respondents' reasons for participating differ and in most cases they are not fully known. One respondent was very open with that he expected that he would be shared the thesis results and thus he saw the interview from a mutually beneficial perspective. Other respondents stated that they wished to help and contribute to the thesis and my efforts as a student. The attitude that most respondents showed was that of a limited interest in obtaining something in return. Rather, they saw their 30-40 minute participation as a relatively small inconvenience and participated as a goodwill gesture.

I have not experienced that any of the interviewed actors have had hidden agendas or tried to steer my results in their favour. However, personal interests affecting the shared information may have occurred. This is, according to me, not likely to be an important bias in my results as I have a relatively large selection of respondents that are dispersed both geographically and regarding their field of business which should allow for a broad spectrum of views. Also, I have performed a broad simultaneous literature research parallel to the interviews which have allowed me to value the trustworthiness of the information shared.

There have been more interviews conducted with Swedish (8 respondents) than UK (3 respondents) and German (2 respondents) actors and more UK interviews performed than German ones. This has a couple of reasons; Regarding the Swedish market the personal networks of people connected to SLU Uppsala has proven very useful in establishing first contacts and also for creating an interest for the interviews. Secondly, many of the Swedish actors involved are municipal businesses; confidentiality is usually less of a problem with these actors than many of the contacted UK and German companies (that were predominately private equity investors). Thirdly, in the case of the German contacts the language barrier, I do not speak German, may have been an issue as would be respondents may have been hesitant in conducting interviews in a language other than their mother tongue.

Having said this, I still believe that the interviewing results are valid in the meaning that they provide valuable information on the researched subject. As the interviews are qualitative their validity is not decided by the number of interviews in each specific country but rather the quality of the performed interviews which I consider as high. Also, many of the interviewed persons had knowledge and views regarding other markets than the one which they were operating in and thus e.g. German country specific information have been obtained through "Swedish" interviews.

8.2 Literature Findings

High costs

The literature points out high costs, feedstock limitations and logistical issues as the main factors hampering bio energy investments. This as bio energy investments, i.e. capital costs, are relatively high due to the fact that biomass installations generally are much smaller in scale compared to similar fossil fired installations. Also, many other RES investments, such as wind power, often offer lower capital costs and shorter payoff times. The small scale is in turn an effect of the biomass feedstock's water content and bulk which makes the fuel ill-suited for long transports which limits the financially available feedstock and consequently the feasible installation size. One IEA report estimates that the capital costs of biomass fired installations is roughly double that of a coal fired installations. Also, biomass is a relatively expensive feedstock compared to other alternatives such as coal. The high costs and logistical issues associated with biomass investments have often steered RES investments towards other forms of renewable energy such as wind power.

However, there are benefits from using biomass, e.g. the reliability and flexibility in energy output, that are being recognized more and more. Also, as RES utilization is to increase in line with governmental commitments such as the collective 20 % RES in 2020 EU target biomass represents an important untapped RES resource. Governments are also realizing that biomass generally needs technology specific support in order to compete financially with other RES alternatives accepted within the various governmental RES support schemes. Consequently biomass specific support schemes are being and have been implemented in the UK and Germany e.g. in the form of higher remuneration being offered to biomass in the RO system or biomass CHP bonuses in the feed-in system.

8.3 The Interviews

Feed-stock issues, capital costs and securing demand

Two important factors that the respondents mention as affecting their investment decisions are locally available feedstock and the high capital costs associated to bio energy investments. Locally available feedstock is however only regarded as important for small to midscale installations. This as the financially feasible transport distance for biomass, or the catchment area of an installation, is connected to its scale and localisation (i.e. the amounts of biomass needed as feedstock and the installations accessibility). For example a 300MWe port based installation seems to have a global catchment area, as some UK respondents mention sourcing woodchips from North America. Conversely a smaller inland installation in Sweden is said to have a catchment area of around 150 km. (Note: In Germany the feed-in system only supports installations up to 20MWe and thus large scale installations in Germany are not seen as financially viable by the respondents).

High capital costs are discussed and mentioned as an issue by many of the respondents. The relatively high capital costs are dealt with in various ways and valued differently by different actors. For example; Swedish municipal producers seem to be more inclined to accept long pay off periods as a result of high capital costs. Some Swedish actors view payoff times in the area of 20 to 25 years as acceptable. Conversely UK private investors seem less willing to invest under such long term conditions. For these actors governmental investment support is mentioned as important (if available). Another way that some UK actors are trying to cut payoff times is to lower the relative capital costs through economics of scale. This as the capital costs are connected to the installation scale which can render higher profits through efficiency and lower production costs per MWh and thus cut payoff times considerably. Also, the UK government has recognised the issue with high capital costs associated to bio energy production and has proposed amendments to the RO system that will offer higher incentives to high risk investments such as bio energy (i.e the earlier mentioned 1,5 ROCs for designated biomass and 2 ROCs for biomass CHP) The UK respondents see this amendment as positive and claim that it is an important aspect for lowering their payoff times. Regarding payoff times it is interesting that the interviewed Swedish respondent representing a bio energy combine states that his installation has a predicted payoff time of 10 years which is very low compared to what was stated by other Swedish respondents.

For Sweden and Germany CHP is often considered the best alternative for bio energy production and thus a local heat demand and access to a district heating system or other heat market is crucial. This as heat, as opposed to electricity, needs to be sold on a local level since heat is not viable for long distance transports. For electricity production grid access and the government RES quota in relation to existing RES capacity (or feed-in level) determines the market conditions as the RES electricity market is the main market for bio energy producers. This as bio energy producers selling their electricity on the open market is in a disadvantage vs. for example producers using coal which generally have lower associated costs according to what was said under 7.1.

Logistics and governmental Support

Regardless of the scale and catchment area of an installation logistical optimisation is seen as a very important aspect that will often determine whether or not to invest. All respondents mention logistic aspects as crucial in some way and much of the discussions regarding investments are centred on sourcing or sourcing optimisation issues. Generally the respondents represent two views; Either installations need to be of such a large scale that economics of scale allow for large quantities to be transported for long distances or installations need to be placed in a favourable area where biomass is locally available at a favourable price.

Besides logistical issues country specific governmental support schemes are mentioned by all respondents. Generally respondents see the financial support offered by the various systems as important or even necessary for the profitability of the bio energy industry. However, several respondents add that the incentive systems alone do not ensure a favourable investment situation. Rather, the support systems enable bio energy to compete with other alternatives, such as coal, but it is only one of many important factors.

The views on the UK RO system and the Swedish Green Certificate System are very similar (which is not surprising as the systems are very similar). Depending on the type of producer, e.g. a designated electricity only biomass plant vs. a CHP producer with a limited electricity production, the incentive systems are valued differently as the certificates or ROCs consequently represent different shares of the installations total revenues. The importance of the certificates or ROCs therefore range from being viewed as crucial for the investment decision to being regarded as “icing on the cake” i.e. a welcome but not crucial extra revenue. The main issue of the RO and Green Certificate systems from a producer point of view is the fact that ROC and certificate prices fluctuate and therefore makes investment calculations less reliable. This in turn is not the case with the German feed-in system that promises a fixed income over a 20 year period. However, respondents interested in large scale production mention the scale limitation of 20MWe as deterring investments. German producers themselves see the fact that there revenues are fixed while their costs fluctuate as a problem as they cannot pass on increased costs on to the electricity consumers through raised consumer faced electricity prices. From this aspect CHP production is mentioned as interesting as it is possible for these producers to pass on increased costs to heat consumers.

To conclude the main factors that seem to affect the investment decision as uncovered by the interviews seem to be;

- High capital costs
- Logistics/feedstock aspects
- Existence and access to a profitable market
- Existence and level of remuneration offered by incentives

8.4 WPC Calculations

Large variations but also differing conditions
The WPC calculations rendered the following results;

Sweden; 30,1 €/MWh
Germany; 45,6 €/MWh
The UK; 37,8 €/MWh

The results point towards a wood paying capability in the area of 30 to 45 € per MWh which is well above the current feedstock prices. There is quite a large difference between the three scope countries WPC results as Germany has a 15 € higher WPC value than Sweden and the UK has 8 € higher value compared to Sweden. These differences are considerable, especially between the Swedish and German WPC values. It is however important to emphasize that the thesis WPC calculations are performed as €/MWh estimations. This implies that the German system, which has limitations regarding the size and output of the installations that are eligible for feed-in tariffs, may render a smaller total remuneration for producers depending on whether they exceed the scale and output stated in the German feed-in system. Thus it can be assumed that the remuneration in €/MWh can generally be at a higher level when the rewarded output is limited as is the case in the German system.

Differing system regulations does not however fully explain the varying results. Other reasons may include governmental remuneration levels being adjusted to differing structural conditions, variations in electricity spot market prices and differing total cost estimations.

The higher remuneration offered to the UK producers could for example be related to the absence of a heat market characterizing the UK bio energy sector compared to Sweden or Germany. The revenues from heat production are mentioned by many Swedish, and some German bio energy producers, as a very important revenue source. Other more favorable structural conditions on the Swedish and German markets as opposed to the UK market are a more developed bio fuel sector and a larger supply of domestically available feedstock. Taking these structural differences in to account it can be assumed that the governmental remuneration is likely to be adjusted to a level on which bio energy producers can compete with other RES and non RES energy sources given the prevailing market conditions. As the UK producers generally cannot benefit from CHP production or domestically available biomass resources a higher level of remuneration is thus likely to be required by the UK producers compared to e.g. Swedish actors. (E.g ROC + LEC value = 60 €/MWh vs. Swedish Green Certificates = 25€/MWh). Another important factor is the utilized electricity spot prices. For example the UK 62 €/MWh electricity price as opposed to the Swedish 40 €/Mwh electricity price directly affects the WPC results in favor for a higher UK WPC value.

The utilized total cost estimations also directly affect the WPC values. For Sweden and Germany somewhat higher CHP capital costs have been utilized as opposed to the UK electricity only biomass plant.

All in all, a higher governmental remuneration level, that may be a result of differing structural conditions, electricity prices and higher CHP capital costs may explain the difference between the WPC values. As, mentioned the high German WPC value is likely to be connected to the systems limitations from a total remuneration perspective.

Do WPC results reflect a more favorable investment climate?
As the thesis examines the investment climate in the three scope countries it is of vital interest to examine whether higher WPC values reflect a more favorable investment climate. The WPC calculations view the maximum WPC as the difference between costs and revenues and thus a higher WPC value should imply higher profit margins and consequently a more favorable investment climate. It is however very important to consider the conditions affecting the remuneration systems. For example a 300MWe biomass installation will not receive any remuneration whatsoever by the German feed-in system which in turn will considerably lower the WPC value as defined by the thesis. Also, as mentioned the investment decision is not based on any single factor. Thus, even if there seems to be positive profit margins on a specific market as defined by the thesis calculations, investments may be hampered by e.g. logistical issues or a situation where the RES capacity is relatively high or increasing in a fast pace in relation to the government set quota.

Regarding producer faced heat values and total cost estimations
Firstly, the utilized heat values are to be considered as best estimations of a variable (i.e. heat) that is locally sold and priced. This as heat is not viable for long transports which in turn means that produced heat needs to be sold within a limited area. This means that local conditions, essentially local supply and demand, will determine the consumer faced heat price and thus also the producer faced heat revenue. Due to these factors each CHP or heat only installation can be said to face a unique market and heat prices therefore vary considerably. However, as installation specific values on heat have proven hard to obtain adjusted consumer faced heat average prices have been used.

Secondly, something should be said about the relation between the utilized producer faced heat and electricity revenues; For the WPC calculations electricity spot market prices and average consumer faced heat prices adjusted with variable heat production costs has been considered as suitable in-values. This as the consumer faced market prices for heat and electricity do not reflect the incurred grid management costs, distribution costs and other variable cost faced by producers. The adjusted consumer market average price for heat in Sweden is at a higher level than the utilized spot prices for electricity (SE; Heat 53,2€/MWh vs. Elec: 40 €/MWh). Also, for Germany, the heat and electricity levels are very similar (DE Heat; 50,9 €/MWh vs. Elec. 56,5 €/MWh). This relation is challenged by views expressed by some of the respondents during follow-up discussions concerning the interviews which indicate that the producer faced electricity revenues should be at a higher level than the corresponding heat revenues. Some of these discussions indicate that the consumer faced heat price should be corrected downwards to a further extent than has been done in the thesis calculations in order to better depict the producer faced heat revenue. One respondent estimates that the consumer faced market heat price should be corrected downwards with as much as 40-50 %. (Pers.com, S 5) Conversely, other respondents state that the utilized producers faced heat revenues are “roughly” correct (Pers.com, S 6). Yet another respondent states that heat and electricity generate relatively similar revenues (not considering the governmental support available for electricity i.e. green certificates) (Pers.com, S 8).

The differing views expressed concerning the utilized producer faced heat revenues reflect the mentioned local dependency and variation in heat pricing and thus the difficulty in setting an average consumer faced heat revenue. It should also be noted that variable costs such as the distribution costs will vary depending on the size of the examined district heating network. For example a smaller network will have smaller distribution costs. (FVB, 2005)

Taking the above stated into account it is possible that the utilized producer faced heat revenues are set at a too high level. However, the author does not regard arbitrary lowering the producer faced heat revenues on this basis as a thoroughly sustained approach. Rather, the performed adjustments of the Swedish and German consumer faced heat prices with the 18, 5 €/MWh variable heat production cost, which roughly equals 25-26 % of the consumer faced heat price, is considered as reliable in relation to the available information.

Regarding the utilized total cost estimations these are all based around relatively small scale installations. This approach is likely to coincide well with probable investments in Germany as the feed-in system is designed for small to midscale installations. However, for Sweden and the UK larger scale installations are likely to be more interesting from an investment point of view. Had cost estimations for larger scale installations been available and utilized it is likely that the included capital costs had been at a lower level.

8.5 The Structure of the Examined Markets

Market Structure and future development

- *Porter's Model and The UK;* The UK market seems to be growing with room for more RES producing capacity in relation to ROC quotas and prices. Since only a limited heat market is present electricity only production is often the best alternative. The room for extra capacity in combination with limited domestic biomass resources seem to inspire large scale installations which can be supported through imported biomass. However, as mentioned the economics of these large projects are not fully known as there is not much former experience in this kind of installations. There are also existing and planned smaller to midscale projects under way in the UK which rely on locally available and favourably priced biomass. The UK RO system offers a high level of remuneration compared to Sweden and Germany. The higher level remuneration is likely to be a result of the less favourable structure facing the UK producers; i.e. no existing heat market and a scarce domestic biomass resource.

- *Porter's Model and Germany;* The German market is more mature than the UK market and has a relatively high level of capacity installed. CHP is a viable option on the German market as there is a developed district heating system. Since the market is more mature (i.e. there is more installed bio energy capacity) than the UK market the same level of bio energy expansion anticipated in the UK market is not likely to occur. Also, as the feed-in system has a limit for the scale of installations supported, large scale installations in the size of hundreds of MWe is less likely to be financially interesting. Smaller scale installations mean that some of the economics of scale are lost which could imply that locally obtained feed-stock is an important factor to a higher degree than in the other two scope countries. Future bio energy investments in Germany are predicted to take place in the area of decentralised micro generating CHP.

- *Porter's Model and Sweden;* The Swedish market is the most mature market with a relatively high existence of installed capacity. The market for bio energy is not expected to grow at a fast pace but rather at a slow and steady pace as a few new installations are built and older ones are modified. Regarding the scale of future projects large scale installations will be supported by the Swedish Green Certificate system. However, as heat is considered an important factor for bio energy investments in Sweden heat demand is likely to limit the scale of the investments in combination with the certificate price fall that new large biomass to electricity investments could result in. There seems to be a belief in the economics of bio energy combines (CHP and industrial production e.g. pellets) which is also backed up by the fact that current installations seem to be gaining higher profits than the traditional CHP producers or at least these installation have a, for Sweden, relatively short pay off time. Sweden has a large domestic biomass resource and a high utilisation level mostly due to its large forest industry that is both a user and seller of wood based biomass.

- *Incentive systems and market structure;* It has been stated that bio energy is often not competitive to fossil fuel and other RES alternatives from a purely economic perspective. As a result of this governments aiming to increase their respective country production of bio energy needs to support its bio energy sector through various incentive schemes. However, the three scope country markets seem to respond differently to the offered remuneration. In Sweden, the general Green Certificate system that offers the same remuneration to all RES producers is in place while the UK and German governments offer specific support to bio energy. Still, the Swedish bio energy sector is the most evolved to date. This fact may be explained by a more favourable market structure for bio energy producers in Sweden. As Sweden has a large biomass resource, that is also made available by its forest industry through fellings and diverging flows from e.g. sawmills, and a large existing district heating system it seems that bio energy is and has been economically viable without the support of targeted support. Conversely investments on the other examined markets, especially the UK market, have not been undertaken on a large scale without targeted bio energy support. This in turn may be explained by the fact that e.g. the UK market has limited biomass resource, a small forest industry and virtually no district heating system. These structural conditions may be considered as entry barriers hampering investments which in turn require a higher remuneration level for would be bio energy producers. Also, as uncovered by the interviews the long Swedish tradition taxation on fossil fuels is likely to have contributed to the evolvement of the Swedish bio energy sector

8.6 Where to Invest

The thesis results suggest that there are positive profit margins on all three markets and that these margins are largely created by governmental support to the RES sector in general and bio energy specifically. However the results also state that governmentally created profit margins alone do not bode for a favourable investment decision. This as bio energy investors do not see one single factor as determinant for their investment decision, rather a mix of circumstances determine the favourability of a market. The different factors (high capital costs feedstock/logistics issues, grid access, demand (locally for heat or in the RES system as a whole for electricity) and governmental support) also have a different importance depending on the current market structure. For example the government offered remuneration will have different affects depending on the prevailing market structure as discussed in 7.4.

What should then be considered as the most favourable structure or system for bio energy investments? Off course this depends on the favoured installation type and specific market conditions as described above. However, for investors considering any of the three scope countries the following can be said;

Sweden

The Swedish Green Certificate system is favourable as it supports any scale and output. However, as certificate prices are set by the market investors must base their decisions on projections on future certificate prices.

The structure of the Swedish market is characterised by a large and relatively easily available domestic biomass resource and a forest industry that both consumes and produces biomass. Due to these conditions there is a long tradition of utilising biomass in various forms in general and for bio energy specifically. Thus, there is a well established district heating system, logistical solutions for transporting biomass etc.

To conclude; The Swedish market is mature and any further investments need to be considered from this perspective. I.e. local demand for heat, existing capacity on the RES electricity market and feedstock availability are factors that need to be analysed. As there is a large available biomass resources it is likely that installations may be fuelled fully or partially by domestic biomass resources.

Germany

For smaller scale installations (maximum 20MWe) the German feed-in system seems to be efficient. However, producers see a problem in the fact that their costs fluctuate while the feed-in remains fixed. Generally, the stability of the system is seen as its main advantage as you know what you get and thus break even calculations etc. are more straightforward

The structure of the German market is characterised by a well established district heating system and large domestic biomass resources. However, government policies on fellings and the use of forest based fuel for bio energy production seems to limit the available biomass. Wood waste is currently used to a relatively large extent but the market is seen as mature with an increasing competition for the waste wood feed-stock.

To conclude; Government regulations in Germany favour relatively small scale installations. As smaller scale installations have smaller catchments areas local feed-stock is likely to be an important factor. CHP is a feasible option for bio energy investments as there is a established district heating system and specific CHP support (e.g. CHP bonuses in the feed-in system) Taking all this in to account investors aiming at the German market should aim at securing locally available biomass feedstock and also secure local demand for heat. Installations larger than 20MWe are not likely to be financially interesting as these will not be supported by the feed-in system. German investors need not be concerned by the development of the total RES capacity as in the Swedish or UK case.

UK

As with the Swedish system the UK RO system with set quotas and market priced certificates can support any type of RES installation and installation scale. The fluctuating certificate prices pose a drawback as investment decisions are based on less certain information but the system is also more flexible from a market point of view as an increased capacity regulates the profits and theoretically the level of new entries.

The UK has a small domestic biomass resource and thus a small related forest industry. There is not an established district heating system present. However, these drawbacks may be outweighed by the high level of targeted biomass support present and under way in the UK.

To conclude; UK investors should focus on investing in biomass designated power plants. Of the three scope countries the UK producers face the most challenging feedstock supply situation and investors considering the UK market need to carefully weigh their logistical decisions. The two alternative approaches seem to lie either within smaller scale installations fuelled by the limited domestic biomass resource or larger scale installations relying on imported biomass. For investors aiming at large scale installations the associated risks are considerably higher as the investment represents substantially higher capital investments.

8.7 Future Research

Interesting areas for future research within the bio energy industry include feedstock supply issues and efficient supply chain management within the bio energy industry. This as the thesis point out supply issues as a major factor from an investment and profitability perspective. Also, as truly large scale bio energy installations are under way traditional thoughts on feasible biomass transport distances needs to be challenged as the industry examines sourcing from a global rather than a local perspective. Furthermore, in order to increase the attractiveness of the bio energy industry from an investment point of view more research concerning new and more efficient technologies such as IGCC systems is of interest.

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Finally, all the interview respondents have been very helpful and their input and knowledge have been of crucial importance to the thesis. I truly appreciate them taking their time to participate.

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Figures

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Figure 2:
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Figure 3:
General model designed by the author no direct reference available

Figure 4:
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Figure 6:
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Appendices

A: Glossary see beginning

B: Definitions and Specifications

The following definitions and specifications are included in the appendices section as they contain important information regarding e.g. eligible fuels for various support schemes etc. and thus may prove useful for readers interested in specific fuels or other aspects not explicitly mentioned in the thesis text.

B 1General definitions in accordance with the 2007 "Biomass fuel trade in Europe Summary Report"

Forest residues: forest residue chips or hog fuel from final fellings (tops, branches, bark), thinning (whole tree chips), delimbed small sized trees (stem chips) or stumps.
Domestic (residential) firewood: log wood and splitted and chopped firewood
Industrial byproducts and residues, solid: chemically untreated wood fractions from pulp and paper industry and mechanical wood processing industry, i.e. sawdust, bark and chips.
Refined wood fuels: pellets and briquettes
Industrial byproducts and residues, waste liquors: mainly black liquor, but also pine and birch oil, soft soap, methanol, biosuspencions, and other liquid industrial byproducts used for energy production.
Wood residues or used wood: chemically treated industrial wood residues (no heavy metals or Halogenated organic compounds), construction and demolition wood, packaging and paper Waste
Other biomass resources: short rotation coppice (willow, poplar, etc.), energy grasses (reed canary grass, miscanthus, etc.), straw, straw pellets, olive residues (exhausted olive cakes, olive pruning) and/or other specified biomass resources. Following resources have also been included in this category: corn cobs and stalks, vineyard and other pruning, rice husks, residues from peach canneries and cotton ginning, nut shells, wine factory residues, landscape management residues, as well as meat and bone meal.
Peat include milled and sod peat and peat briquettes and pellets. Peat is considered as a slowly renewable biomass in Nordic countries (Crill et al 2000) and therefore included in the study. The resolution of the EU Parliament on 14 December 2006 calls the Commission to include peat, with regard to the lifecycle aspect, as a long-term renewable energy source for biomass and bioenergy production. The IPCC (International Panel for Climate Change) classifies peat as an own category. (VTT, 2007)

Solid biofuels spefication and classes (CEN/TS 14961) standard classifies biomass resources in the following main categories:
1 Woody biomass
1.1. Forest and plantation wood
1.2. Wood processing industry, byproducts
and residues
1.3. Used wood
2 Herbaceous biomass
2.1 Agriculture and Horticulture herb
2.2 Herb processing industry, byproducts
and residues
3 Fruit biomass
3.1 Orchard and horticulture fruit
3.2 Fruit processing industry, byproducts and residues

All categories include also blends and mixtures.

(VTT, 2007)

B 2 Text Derived and Directly Translated from the Biomasse V Document

(1) Biomass within the meaning of this Ordinance shall be taken to mean fuels made of phytomass and zoomass. This shall also include products, by-products, residues and waste from phytomass and zoomass whose energy content comes from phytomass and zoomass.

(2) Biomass within the meaning of paragraph 1 shall include in particular:
1. Plants and parts of plants
2. Fuels made from plants or parts of plants whose components and intermediate products have all been produced from biomass within the meaning of paragraph 1
3. Waste and by-products of plant and animal origin from agriculture, forestry and commercial fish production
4. Biological waste within the meaning of Art. 2 No. 1 of the Biological Waste Ordinance (Bioabfallverordnung)
5. Gas produced from biomass within the meaning of paragraph 1, by gasification or pyrolysis, and all resulting products and by-products
6. Alcohols produced from biomass within the meaning of paragraph 1, whose components, intermediate products, products and by-products have been produced from biomass.
(3) Without prejudice to paragraph 1, the following shall be considered biomass within themeaning of this Ordinance:

1. Waste wood, comprising used wood (used products made from wood, wood materials and composites with a proportionally high wood content) or industrial waste wood (waste wood from woodworking and wood processing operations and waste wood from operations in the wood materials industry) which is considered waste, except where this conflicts with sentence 2 or where the waste wood, pursuant to Art. 3 No. 4 is not recognised as biomass.
2. Gas produced from waste wood within the meaning of No. 1, except where this conflicts with sentence 3 or the waste wood is not recognised as biomass under Art. 3 No. 4.
3. Plant-oil methyl ester, except where this conflicts with sentence 3.
4. Flotsam from waterbody management and from shoreline management and cleaning.
5. Biogas produced by anaerobic fermentation, where fermentation does not involve the use of materials included in Art. 3 Nos. 3, 7 and 9 or where more than 10% by weight of sewage sludge is used. Sentence 1 No. 1 shall apply to waste wood which contains residue from wood-preserving agents or contains halogenorganic compounds in its coating only in cases where it is used in installations whose certification for establishment and operation is granted under Art. 4 in conjunction with Art. 6 or Art. 16 of the Federal Emission Control Act (Bundes-Immissionsschutzgesetz) no later than three years from the date this Ordinance enters into force. Wood-preserving agents shall include substances used in processing and finishing wood that have biocidal effects on wooddamaging insect pests or fungi, and also substances that reduce the flammability of wood. Sentence 2 shall apply as appropriate to the use of gas produced from waste wood as defined in sentence 1, no. 1. Sentence 1 No. 3 shall apply only to use in installations that go into operation three years from the date this Ordinance enters into force or, where installations are involved that are subject to certification under the Federal Immission Control Act, whose certification for establishment and operation has been issued in accordance with Art. 4 in conjunction with Art. 6 or Art. 16 of the Federal Immission Control Act.

(4) Substances from which electricity is produced in old installations within the meaning of Art. 2 (3) sentence 4 of the Renewable Energy Sources Act, and for which compensation has been received for electricity produced from biomass prior to 1 April 2000, shall continue to be recognised as biomass in these installations. This shall not apply to substances as defined in Art. 3 (4) and Art. 5 (2).

Art. 3
Excluded Biomass
The following shall not be considered biomass within the meaning of this Ordinance:
1. Fossil fuels and products and by-products made from them.

2. Peat.
3. Mixed municipal solid waste from private households and similar waste from other source areas.
4. Waste wood:
a) that contains more than 0.005% by weight of polychlorinated biphenyls (PCB) oder polychlorinated terphenyls (PCT) within the meaning of the provisions of the PCB/PCT Waste Ordinance (Abfallverordnung) of 26 June 2000 (Federal Law Gazette I p. 923)
b) that contains more than 0.0001% by weight of mercury
c) of other types, if its thermal exploitation as waste for recovery is prohibited under the Closed Substance Cycle and Waste Management Act.
5. Paper, cardboard, pasteboard.
6. Sewage sludges within the meaning of the Sewage Sludge Ordinance (Klärschlammverordnung).
7. Harbour sludge and other waterbody sludges and sediments.
8. Textiles.
9. Animal carcasses or parts thereof and products within the meaning of Art. 1 (1) of the Animal Carcass Disposal Act (Tierkörperbeseitigungsgesetzes), which are to be disposed of in slaughter houses pursuant to ordinances enacted thereunder, and substances which occur through their disposal or through other means.
10. Landfill gas.
11. Gas from sewage treatment installations." (Pers.com., Rothacher 2009)

B 3CEN/TS 14588 Biomass Definition Standard

"CEN/TS 14588 Defines biomass as; ("material of biological origin excluding material embedded in geological formations and transformed to fossil" (herbaecus biomass, fruit biomass and wood biomass.) Bio fuel is defined as "fuel produced directly or indirectly from biomass." (EUBIONET, 2006 (1))

B 4 Approved fuels in the Swedish Green Certificate System – translated by the author

Paragraph 4: a holder of a production plant is entitled to be awarded certificates according to Chapter 2. 1 § 5 Act (2003:113) on electricity if the plant uses bio fuels, which may consist of:

1. trees, tree parts, logging residues and other residues and by-products of forestry,
2. bark, returned inclines, mud, pine oil, wood chips, sawdust and other residual materials and by-products from the forest industry processes,
3.energy crops, cereals, olive stones, nutshell, straw and reeds,
4. sorted waste wood and wood waste which is sorted from mixed waste, or
5. biogas, formed when organic matter such as manure, sludge from municipal and industrial sewage, household waste and waste from food production, restaurants and trade breakdown of methane-producing bacteria in oxygen-free conditions.

The same applies to pellets, briquettes, powders and liquids, or other processed forms of the biological material referred to in 1-4. Regulation (2004:99)"
(www, Energimyndigheten, 2009 (6))

B 5 Fuels Eglibel for ROCs - Office of Gas and Energy Markets definition

The definitions of biomass, waste, and co-firing
2.1. The definitions of biomass, waste and co-firing are fundamental to the classification of fuelled stations and the issuance of ROCs to fuelled stations under the RO.

Biomass
2.2. To claim ROCs for electricity generated from biomass, the fuel used will ordinarily need to meet the definition of biomass in the Orders. To meet the biomass definition an individual fuel must have an energy content of at least 90 per cent that is derived directly or indirectly from plant or animal matter.

Fuel that can treated as biomass
2.3. If less than 90 per cent of the energy content within an individual fuel is derived directly or indirectly from plant or animal matter, it will not itself meet the biomass definition. However, if the fuel is one of two or more non-fossil fuels used at the generating station in any month, and the combined energy content of these fuels is more than 90 per cent plant or animal matter derived, then the combination of these fuels can be treated as biomass.
2.4. Where a fuel is a fraction of a mixture of wastes that, taken as a whole, is itself biomass (i.e. at least 90% of its energy content is derived directly or indirectly from plant or animal matter) then that fuel is classed as biomass.
100% biomass

2.5. The term "100% biomass" in this document refers to biomass material that is 100% biomass by energy content (and does not therefore derive any of its energy from fossil fuel or fossil fuel derived sources)." (www, OfGem, 2009, p 14 (1))

C: Annex

C 1 Feed-in tariffs in Germany – Guideline Documents

Biomass

Basic fees

Share of capacity	**2009 EEG** Decision by the German Bundestag 06.06.2008[3]	Government's draft amendments to the EEG dated 05.12.2007	EEG Progress Report of 07.11.2007	2004 EEG
Up to 150 kW$_{el}$	**11.67[1]**	11.67[1)]	11.67[1)]	10.67
from 150 kW$_{el}$ to 500 kW$_{el}$	**9.18**	9.18	9.18	9.18
from 500 kW$_{el}$ to 5 MW$_{el}$	**8.25**	8.25	8.25	8.25
5 MW$_{el}$ to 20 MW$_{el}$	**7.79[2]**	7.79[2)]	7.79[2)]	7.79

1) Including existing facilities
2) Only if the electricity is produced using combined heat and power generation
3) Basic Fees raised 1.0 c/kWh for emissions abatement by licensed facilities, existing and new facilities up to 500kW, when formaldehyde release-limits according to the administrative regulation Technical Instructions on Air Quality Control (TA Luft) are maintained.

Bonuses for Biomass I

Bonus for the use of cultivated biomass ("NawaRo Bonus")				
	2009 EEG Decision by the German Bundestag 06.06.2008	Government's draft amendments to the EEG dated 05.12.2007	EEG Progress Report of 07.11.2007	2004 EEG
Share of capacity up to 150 kW$_{el}$ *Biomass excluding biogas* *Biogas* *-With at least 30% use of farmyard manure or slurry* *-Plant material predominantly from landscape conservation*	**6.00** **7.00** **+4.0** **+2.0**	6.00 8.00 +2 ct	7.00 8.00	6.00 6.00
Share of capacity up to 500 kW$_{el}$ *solid biomass* *liquid biomass* *gas biomass* *Biogas* *-Minimum 30% manure* *-Plant material predominantly from landscape conservation*	**6.00** **0[1)]** **6.00** **7.00** **+1.0** **+2.0**	6.00 0[1)] 8.00 8.00	7.00 7.00 7.00 7.00	6.00 6.00 6.00 6.00
Capacity up to 5 MW$_{el}$ *solid biomass* *liquid biomass* *gas biomass* *where wood burnt /* *where wood from short rotation coppice and landscape management material burnt*	**4.00** **0[1)]** **4.00** **2.50** **4.00**	4.00 0[1)] 4.00 2.50 4.00	4.00 4.00 4.00 2.50 4.00	4.00 4.00 4.00 2.50 2.50

1) Only for facilities commissioned after 01.01.2009

Bonuses for Biomass II

Technology bonus for facilities up to 5 MW_{el}			
2009 EEG Decision by the German Bundestag 06.06.2008	Government's draft amendments to the EEG 05.12.2007	EEG Progress Report 07.11.2007	2004 EEG
Innovative Plant Technology 2.00	2.00	2.00	2.00
Gas Reprocessing: **a) up to a maximum of 350 Nm^3/Hour 2.00** **b) up to a maximum of 700 Nm^3/Hour 1.00**			

CHP bonus (only for the share of feed-in deemed to be CHP electricity)			
2009 EEG Decision by the German Bundestag 06.06.2008	Government's draft amendments to the EEG dated 05.12.2007	EEG Progress Report 07.11.2007	2004 EEG
Up to 20 MW_{el}	Up to 20 MW_{el}		Up to 20 MW_{el}
3.00[1)]	3.00[2)]	3.00	2.00

1) Also for existing facilities operated as CHP iSv Facility 3 for the first time after 31.12.2008. Existing facilities with a capacity up to 500kW, when the Facility 3 requirements are met.
2) Also for existing facilities operated as CHP for the first time after 31.12.2008.

Degression for Biomass

2009 EEG Decision by the German Bundestag 06.06.2008	Government's draft amendments to the EEG 05.12.2007	EEG Progress Report 07.11.2007	2004 EEG
Basic Fees and Bonuses: 1.0%	Basic Fees and Bonuses: 1.0%	Basic Fees and Bonuses: 1.0%	Basic Fees: 1.5%

Sample calculations for fees payable for electricity from biomass facilities:

Capacity of 2.5 MW_{el}[1)] with CHP and technology bonuses

Share of capacity up to 150 kW_{el} = 6%
Share of capacity from 150 kW_{el} to 500 kW_{el} = 14%
Share of capacity from 500 kW_{el} to 2.5 MW_{el} = 80%

Heat extraction and use (CHP) at 100% electricity production

	2009 EEG Decision by the German Bundestag 06.06.2008	2004 EEG
Basic fee Share of capacity to 150 kW_{el} Share of capacity to 500 kW_{el} Share of capacity to 2.5 MW_{el}	**0.06 x 11.67** **+ 0.14 x 9.18** **+ 0.80 x 8.25**	0.06 x 10.67 + 0.14 x 9.18 + 0.80 x 8.25
CHP bonus	**+ 3.00**	+ 2.00
Technology bonus	**+ 2.00**	+ 2.00
Total payments	***= 13.59***	***= 12.53***

1) For example, this might be a facility with 3 MW_{el} of installed capacity, running for 7,300 hours a year at full capacity (see note on p. 1)

(Pers.com., Rothacher 2009)

C 2 Interview Topics – Copy of the Letter Sent to the Respondents
Dear Sir/Madam

My name is Per-Martin Fors and I am a student at the Swedish University of Agricultural Sciences (SLU) in Uppsala. I am currently compiling data for my Master of Forestry thesis comprising of 30 European Credit Transfer System (ECTS) points which is the equivalent of 20 weeks of full time studies.

The thesis examines and compares the investment situation facing the bio energy industry in Sweden, Germany as well as the United Kingdom. The main approach to collate information for the thesis is literature studies and qualitative interviews. The purpose of the interviews is to gain experience based industry knowledge.

The interviews will mainly be based around the following topics but may take other directions and involve other topics depending on your views on what should be included in the discussions.

- Could you please describe the factors initiating your investment decision? What was the background leading up to the decision and what main experiences were gained?

- Please describe the structure and characteristics of your bio energy market according to you. What is the supplier/buyer situation for wood based fuels like? What level of competition characterizes the bio energy industry? What is the situation for new entrants on your market? Who are the main outside-industry competitors? (Available substitutes for bio energy)?

- In your view, what characterizes the profitability of the examined market – which fiscal, financial and governmentally controlled instruments or incentives do you think are the most important for the bio energy industry? Which are the key success factors? How important are the incentives? Could you exemplify?

- Future outlook and trends for the bio energy industry on your market.

- Cost structures on the examined bio energy market. Compared to other countries or regions are costs such as labour and energy prices relatively high or low?

- What, in your view, is the typical or most attractive investment or trend on your market?

I hope you find this interesting and that you have a possibility to take part. A copy of the finished thesis or a detailed summary will be made available to you and you may remain anonymous if requested.

Sincerely,

Per-Martin Fors SLU Uppsala, Sweden 081215

C 3 Construction costs, operating costs and efficiencies of new biomass power plants – Shared EIA Estimations

Table 5 ▻ Construction costs, operating costs and efficiencies of new biomass power plants

	2015				2030			
	Construction cost ($ per kW)	O&M costs ($ per kW)	Efficiency (net, LHV)*	Capacity factor (%)	Construction cost ($ per kW)	O&M costs ($ per kW)	Efficiency (net, LHV)*	Capacity factor (%)
Small to medium-scale CHP								
United States	3400	101	28%	47%	3150	95	29%	47%
Canada	3050	91	28%	43%	2850	86	29%	43%
Mexico	3050	91	28%	43%	2850	86	29%	43%
Europe	3150	95	28%	44%	3000	89	29%	44%
Japan	3250	98	28%	43%	3100	92	29%	43%
Korea	3200	96	28%	43%	3000	90	29%	43%
Australia	3300	99	28%	43%	3050	91	29%	43%
Russia	3100	93	28%	43%	3950	89	29%	43%
China	2950	89	28%	43%	2800	84	29%	43%
India	2900	87	28%	43%	2750	82	29%	43%
Indonesia	2900	88	28%	43%	2750	82	29%	43%
Other Asia	2900	88	28%	43%	2750	82	29%	43%
Brazil	3000	90	28%	43%	2800	84	29%	43%
Other Latin America	3000	89	28%	43%	2800	83	29%	43%
Africa	2950	88	28%	43%	2750	82	29%	43%
Middle East	3000	90	28%	43%	2800	84	29%	43%
Biogas digestion								
United States	2900	87	31%	63%	2700	87	32%	63%
Canada	2600	78	31%	63%	2450	74	32%	63%
Mexico	2600	78	31%	63%	2450	74	32%	63%
Europe	2700	81	31%	63%	2550	81	32%	63%
Japan	2800	84	31%	63%	2650	84	32%	63%
Korea	2750	82	31%	63%	2600	82	32%	63%
Australia	2850	85	31%	63%	2600	85	32%	63%
Russia	2650	80	31%	63%	2550	76	32%	63%
China	2550	77	31%	63%	2400	77	32%	63%
India	2500	75	31%	63%	2350	75	32%	63%
Indonesia	2500	75	31%	63%	2350	70	32%	63%
Other Asia	2500	75	31%	63%	2350	70	32%	63%
Brazil	2550	77	31%	63%	2400	72	32%	63%
Other Latin America	2550	77	31%	63%	2400	72	32%	63%
Africa	2550	76	31%	63%	2350	71	32%	63%
Middle East	2600	77	31%	63%	2400	73	32%	63%
Waste incineration								

(Pers.com., Olejarnik, 2009)

C 4 Swedish Biofuel Costs – Numbers produced by the Swedish Statistical Authority

Tabell 1 Trädbränsle, kronor/MWh fritt förbrukare, löpande priser exklusive skatt.

Period	**2004**	**2005**	**2006**	**2007**				**2007:3**	**2007:4**	**2008:1**	**2008:2**	**2008:3**[P]
				Hela Sverige	Norra[2]	Mellersta[3]	Södra[4]					
Förädlade trädbränslen: (briketter & pellets)												
Värmeverk	206	204	211	244	277	256	230	252	248	265	262[R]	290
Skogsflis:												
Industri	125	121	119	128	-[1]	-[1]	-[1]	126	127	140	144	155
Värmeverk	138	137	146	158	169	163	142	160	166	159	165	173
Biprodukter:												
Industri	112	95	112	153	-[1]	-[1]	-[1]	150	168	162	158	153
Värmeverk	114	121	128	134	127	140	127	137	142	157	145[R]	160
Returträ:												
Värmeverk	74	80	78	64	-[5]	69	51	61	58	68	70[R]	66

1) Den regionala redovisningen omfattar endast värmeverken. Observera att medelpriserna i regionerna är mera osäkra än medelpriset för riket. 2) Y, Z, AC och BD län. 3) AB, C, D, E, S, T, U, W och X län. 4) Övriga landet, 5) Alltför få uppgifter i underlaget för att redovisa. **R)** Uppgiften har reviderats sedan Prisblad 2/2008. **P)** Preliminär uppgift.

(Energimyndigheten (1), 2008)

C 5 Assumptions used for the Thesis Calculations

Production Costs Include (Elforsk, 2007)
Capital Costs
Other fixed overheads (land, buildings, maintenance)
Variable Fuel Costs
Variable Operating Costs
Reinvestment Costs
Localisation Costs
Variable Heat Value
Fixed Heat Value
Assumptions Prod Costs (Elforsk, 2007)
Biomass Costs = Forest Residues 15, 4 €/MWh, Pellets 25,4 €/MWh)
Average Variable Heat Production Cost (Biomass fired boiler) = 18, 5€/MWh
Discount Rate 12 %
Production Costs Include (IEA, 2007)
Fixed Overheads
Other fixed overheads (land, buildings, maintainance etc.)
Variable
Variable fuel costs
Variable operating costs
Assumptions Prod Costs (IEA, 2007)
Biomass cost utilized 3dollars/GJ or 0,65 €/MWh
Discount Rate 10 %

Conversions		
Price in kwh to price MWh	Kwh*1000	
MWh to kWh	Mwh*1000	
kWh to MWh	kwh/1000	
One Swedish krona equals	0,1029	Euros
One Swedish krona equals	0,12	U.S Dollars
One British Pound Equals	1,07	Euros
One Gigajoule Equals	0,28	MWh
One U.S. dollar	0,77	Euros
One tonne of wood chips	3500,00	kWh
Typical Biomass Installations and Electricity Generation Costs (IEA, 2007)	**€/MWh**	
Co-firing	38,73	
Dedicated steam cycles	85,21	
IGCC	100,70	
Gasific.+engine CHP	85,21	
Stirling engine CHP	100,70	
Typical Biomass Installations and Electricity Generation Costs (Elforsk, 2007)	**€/MWh**	
80 MWe CHP	81,36	
30 MWe CHP	104,22	
10 MWe CHP	128,616	

C 6 Interview Respondent Description and codes

The interviewed actors will here be briefly described and assigned code names where; S 1 equals interviewed actor number one on the Swedish market, G 1 equals interviewed actor number one on the German market, U 1 equals interviewed actor number one on the UK market and so on.

S 1: A person (male) employed within the traditional Swedish forest industry and specialised in bio fuel development issues.

S 2: A person (male) employed by a large international energy company specialised in fuel management issues.

S 3: A person (male) working for a Swedish energy operator providing energy services, district heating and cooling, natural gas. The company also operates an electricity supply network. The person is specialised towards energy systems and energy trade.

S 4: A person (male) managing a Swedish bio energy and bio refinery combines (heat, electricity and refined wood fuel).

S 5: A person employed by a Swedish district heating company. S 4 has a long experience in the Swedish bio energy industry and is specialised in technical issues of bio energy.

S 6: A person (male) employed (Executive Director) by a Swedish municipal heat (mostly heat only production bio, waste and other) and power (hydro) company.

S 7: A person (male) employed (project leader) by a Swedish municipal district heating and power producer

S 8: Two persons (male/female) that participated in a phone conference. Both persons are employed by a Swedish municipal power, heat, water, sewage and broadband provider. The male is employed as a production manager and the female is employed as a development engineer. Both persons had a good insight into the Swedish market in general as well as a CHP investment the company undertook during the period when investment grants where issued for CHP installations in Sweden. (The system was later replaced by the green certificate system)

G 1: A person (male) working at a plant operation department at a German energy supply and facilities company. (Electricity, heating, cooling and contracting)

G 2: A person (male) responsible for sales and strategic development at a German company that build and operate biomass (waste wood) power stations (CHP). G 2 also has a good insight into the UK bio energy market.

U 1: A person (male) employed as a biomass manager at an electricity only condensating biomass plant in the UK.

U 2: A person (male) employed by a newly formed RES producing company with good insights in to the UK bio energy market.

U 3: A person (male) employed (Director) by a large UK based bio energy and biomass logistics company.

The results from the respondents are presented under 5.2.

C 7 Extended Interview Results

Factors initiating the investment decision

S 4: The respondent viewed a locally available feedstock and existing technology as well as knowhow as important factors influencing the investment decision. S 4 stresses the importance of economical logistical solutions and the importance of keeping the transport distances for bio fuels at a minimum. The respondent mentions that the existence of green certificates where crucial for the decision to produce electricity.

S 7: The taxes that were introduced on fossil fuels directly affected the respondents company to convert its boilers from coal fired to biomass fired in the 1990's. Later green certificates for electricity production and higher levels on electricity prices lead to the decision to invest in CHP. The respondent claims that the occurrence of green certificates where crucial for the decision to invest in electricity production. Also, fuel flexibility was an important issue during the investment calculations. This as the respondent states that his company did not want to be completely dependent on one type of fuel and that the price for that particular fuel. In order to achieve this desired fuel flexibility the respondents company has opted for a fuel mix not completely made up out of certificate eligible fuels, about 25 % of the planned fuel use is made up of non renewable fuels. This means that not all of the electricity production generates certificates which results in an obvious decrease in revenues. This drawback is however outweighed by the fact that fuel costs will be lower and dependency and thus risks for the company is decreased. When discussing whether the investment calculations from a municipal actors point of view puts a larger weight to socio-economic benefits and thus has lower economic demands than a private actor the respondent agrees to an extent. However, he states that even if the municipal investor needs to maximise the total welfare of the community a specific investment, e.g. CHP, needs to be as profitable as possible in order to maximise the total welfare.

S 8: The respondents describe their investment in a 30MWe and 70 MWth CHP plant as dependent on three factors; 1) There was a need for a larger heat production 2) There was a will to replace fossil fuels due to taxes, rising prices on fossil fuels and also because there was a drive towards a more environmentally friendly production. 3) As the situation was then the outlook for energy consumption in their local area pointed upwards. The installation was built with the aid of investment grants (this system was later replaced by the green certificate system in 2003, authors note).

U 1: The respondent states that the ROC system was a determinant factor for their investment decision. "Coal is so much cheaper than biomass so you just would not make the investment without the ROCs"

U 1: regarding pay off times the respondent states that the UK payoff times for dedicated biomass stations (electricity or CHP) generally are in the area of 8-10 years. On a question on why the payoff times are relatively low (compared to earlier mentioned 15-25 years in Sweden the respondent sees the proposed 2 ROCs for CHP and high electricity prices compared to continental Europe as factors influencing the pay off time calculations positively.

U 2: Sees the proposed changes to the ROC system that are to be made from 1st of April as important for making biomass a more interesting alternative for investors. The system as it is designed before 1st of April 2009 is technology blind and biomass was often not as interesting as other investments such as on shore wind power from an economical point of view.

U 3: The respondent sees the ROC system as very important from an investment point of view both as an economical factor but also as a signal from the government that it is committed to supporting bio energy. However, the respondent does not see ROCs as a guarantee for a profitable investment. For smaller and midscale installations he states, investment grants will be necessary to ensure profitability. In order to ensure profitability without investment grants a large scale (200-300MWe is required).

Regarding biomass specifically the respondent sees it as a very important energy source as biomass (as opposed to e.g. wind power) can provide a stable, reliable and easily altered power source. That is, you know what you get and you can easily change output.

Structure and characteristics of the examined market
S1: The respondent mentions that the Swedish bio energy market is characterized by an existing and highly developed district heating system and a good availability of domestic biomass resources. Also, the Green Certificate System is mentioned as an important factor. The respondent does not feel that the bio energy market is characterized by a high level of competition, from a biomass sourcing perspective. However, he mentions that the competition may be high locally as biomass sourcing and logistics rely on relatively low transport distances (50 to 100 kilometres) in order to remain profitable. The main outside-industry competition according to the respondent comes from domestic wastes. S 1 mentions a 12 % tax on waste incineration and the issue of depositing the ash residues from waste as drawbacks.

S 2: District heating is described as the central aspect for bio energy production in the Nordic countries. The respondent says that no investment will be made without securing access and demand for heat production. Specifically the respondent says: "Heat delivery is the determinant factor, sold electricity is a bonus". The respondent says that the competition facing bio energy producers varies depending on local conditions (i.e. local availability and demand). The logistical aspects are mentioned as the reason for these locally determinant factors in accordance with S 1's view on local competition for biomass. Waste is mentioned as an alternative for biomass but the interviewed underlines that waste availability is not always guaranteed and that waste incineration facilities are relatively expensive. However, ash depositing is not seen as a problem in Sweden as the ash can be used as filling material and neither is the 12 % tax seen as a problem as it is passed on to the end consumer. S 2 also sees coal as an alternative for biomass as prices on both coal and emission rights are relatively low.

S 2: The Swedish Green Certificate system is seen as a functioning and relatively effective incentive. However, the respondent also expresses some critique against the Swedish certificate system: The system promises green certificates for RES producing installations built before 2003 for 15 years (exceptions can be made but for no longer than 2030) and new installations. The problem consists of some uncertainties regarding what can be viewed as a new installation as this is not clearly specified according to the respondent which in turn causes uncertainties for bio energy investors. For example if only certain parts are replaced, e.g. the boiler, is the installation to be viewed as new or old? S 2 also state that there is a relatively large difference regarding what the energy companies regard as profitable and what the Swedish forest industry regard as profitable investments. For example the forest industry has invested in electricity production to a larger extent than the dedicated energy producers. These as the energy producers, according to S 2, have stricter investment demands and longer pay off times. This in turn is partly due to the fact that energy producers have fewer months during which they can collect profits, “We make money during six months on a typical year – the forest industry makes money during twelve or eleven months”. This as the warmer months of the year means that relatively little heat is sold. Finally, S 2 mentions heat pumps as a source of competition for district heating and that the price for heat pumps is an important factor for the heat producing actors.

S 3: The respondent describes the Swedish bio energy market as mature on which bio fuels (forest based) are viewed as an important product rather than just a bi-product as in the past. Also, the market for bio fuels is under more and more market competition as more actors enter the market. S 3 also mentions the complexity of the biomass sector as the price of a certain feedstock is not the only important factor to consider. For example waste has no cost, operators are often financially rewarded for taking care of waste, but waste incineration facilities are generally expensive and waste incineration has a high level of wear on the facilities which incur high operation and management costs. In relation to the discussion on waste incineration S 3 mentions that in Sweden the available waste is relatively limited as there has already been a significant expansion of waste incinerating facilities in Sweden. Regarding the ash produced from waste incineration the respondent doesn’t see a major obstacle in the waste produced ash. He also points out that burning bio fuels also produces ash that needs to be handled in one way or another.

S 4: The respondent does not see his installation as competing with other actors for its wood based feed stock, instead S 3 means that his installation utilises low quality energy wood which is not sought after by other locally active actors. At the same time the respondent mentions that the price for energy wood in the area affected by the installations sourcing has gone up as a result of the installations sourcing.

S 5: Regarding the Swedish market for wood based biomass the respondent mentions that the market is characterized by relatively few sellers. Also, the respondent states that the logistical issues with biomass (i.e. that they are not viable for long transports, authors note) means that you “are stuck” with certain sellers and thus the market is not defined by a high level of competition among sellers.

S 5: Also, in relation to the discussion on raw materials (wood based biomass) the respondent sees the Swedish bio energy market as controlled by the traditional forest industries and other parties connected to the harvesting of forest materials. This in turn means that much of the wood based resources are kept within the forest industry (used as fuel/input material) where for example round wood and wood chips are traded between pulp producers and sawmills. It can be hard for new entrants on the bio energy market from a raw material perspective to gain access to the flows of wood based biomass.

S 5: Regarding the governmental incentive systems in Sweden the respondent sees the different type of taxes imposed on fossil fuels (CO_2-, energy- and Sulphur taxes) from which bio energy is exempt from as the most efficient governmental incentives. The respondent states that these taxes, which ultimately rest on the polluter pays principle, are efficient in sanctioning unwanted behaviour (i.e. the use of fossil fuels). Regarding the Swedish certificate system the respondent does not regard the system as an efficient system from a wider socio-economic perspective. This as the certificate system is not based on the polluter pays principle (i.e. you pay for your negative environmental impact) but rather is a system that promotes certain behaviour, for example incinerating certain types of fuels. The respondent means that the main difference is that the certificate system implies that the more e.g. bio energy that is utilized the higher the certificate cost is for the society as a whole while the taxation system that sanctions a negative behaviour leads to the tax costs decreasing as the negative behaviour is phased out.

S 5 Also talks about emission rights and he does not regard the system with tradable emission rights as effective. First of all the respondent concludes that the price for electricity has been raised as a result of the emission rights system. This as the emission rights are handed out for free while the general electricity price on power stocks are set by referring to the costs for coal generated electricity and the market price for emission rights. This means that producers are handed free emission rights but at the same time they can benefit from the generally raised electricity price, i.e. the system works as a free revenue increase for the bio energy producers. The respondent sees an initial auctioning of the emission rights instead of handing them out for free. This system, the respondent means, would be more effective than the practice of giving the emission rights for free which have had little or no effect on the production of fossil fuels.

S 6: The respondent sees a problem for his company (regarding heat from biomass production) connected to the economic downturn as much of the traded biomass in Sweden usually stem from the Swedish forest industry (e.g. sawmill residues) and as the sawmills are heavily affected by the general economic downturn their production is lowered resulting in less forest industry residues available for bio energy production. This in turn means that other fuel sources, such as pulp wood grinded to wood chips, are utilised which usually results in higher fuel costs. The reason that relatively high value biomass sources such as pulp wood is utilised is, according to the respondent, that the Swedish biomass system is dependent on residues from the forest industry and that there is no available alternative in the short term. This as entrepreneurs aiming to harvest energy wood from cannot compete with the forest industry under normal conditions. This in turn creates a kind of vacuum during economic downturn as there is nowhere to turn for energy biomass.

S 8: The respondent describes their general market conditions as characterized by rising feed stock prices and both respondents predicts that these prices will continue to rise. As the situation is currently the CHP plant, that utilises 80 % biomass, states that they are competing with the pulp mills for their feedstock and one of the respondents state; “Yes, we are competing with the pulp mills and we can pay more” This as the respondent states that they, as energy producers, have larger margins than the pulp industry. Regarding the Swedish incentives the respondents see a need for greater clarity regarding certain issues, specifically they would like to know what is considered a “new” installation (See S2 above) and which installations that will be eligible for certificates in the future.

G 1: The respondent states that the main characteristic of the German bio energy market is the feed-in tariffs and their implications for electricity production. Specifically G 1 states that problems may arise as raw material prices fluctuate while the feed-in remains constant. This is a problem especially as demand for bio energy rises. Because of this fact CHP production has a benefit as producers can pass on raised raw material costs in a higher heat price. Regarding the companies fuel situation G 1 states that the company is fully dependent on wood chips as its primary wood based biomass fuel.

G 1: Sees the situation for new entrants as something that will become more difficult in the near future as raw material prices (biomass as included in the EEG 2009, authors note) will go up and availability will go down. G 4 mentions that this effect will vary between different regions in Germany depending on local availability and local Government policies on wood usage.

G 2: On a discussion regarding new entrants the respondent claims that the German bio energy market in general and the waste incineration market specifically are mature. (This implicitly means that new entries are kept at a low level or are rare, authors note.) Explicitly regarding obstacles on the UK market the respondent sees planning issues and obtaining permits and consent for the building of installations as troublesome and time consuming, a time span of one to on and a half years of planning is mentioned.

G 2: When discussing the ROC system in comparison with the fixed price feed-in and the respondent is asked to choose which market he regards as the most favourable of the two the respondent prefers the "continental one where you know what you get at all times". As opposed to this the respondent says that "The ROCs can be traded and are subject to (price, authors note) swings as all markets". In relation to what G 1 said regarding the eventual problem with fixed feed-in tariffs and flexible raw material prices G 2 agrees to a degree but he also states that incineration techniques and other technological progress may counteract the rising cost of raw materials in the long run.

U 1: On the question: Why electricity only production? The respondent replies "… at the moment if we sell that steam we lose our ROCs which means that we are not allowed to utilise the steam and we have to condensate it which obviously makes us very inefficient"

U 1: Continues: "The bitter side of that is that as of the 1st of April this year there is an amendment to ROC bill in the UK and we would be able to sell our steam and claim the ROCs as well." (This quote is connected to a previous discussion on the decision to invest in an electricity only plant) The respondent continues the discussion and mentions different types of remunerations for biomass dedicated installations and specifically the respondent states that if the regulation is changed as proposed after April 1st a dedicated biomass CHP plant will be able to claim 2 ROCs per MWh. The respondent believes that the planned regulation changes will make CHP an interesting alternative. However, as the heat market in the UK is not developed in the same way as e.g. Sweden or Germany heat production would generally be aimed at industry costumers that need heat/steam in their production. The respondent mentions that the location of a CHP plant, with a local market for heat, is relatively hard to find as a result of the way the UK infrastructure looks (no real district heating system, authors note) and as finding new industrial customers are relatively few and often strive to produce their own heat. "The ideal situation for us would be a dedicated biomass CHP installation where we sell the heat to an industry costumer and at the same time collect 2 ROCs for our heat and electricity production."

U 1: The respondent sees complications and time consumption during the securing of planning permissions, financing, securing entrance to foreign export markets (biomass, authors note) and establishing a connection to the national grid as the main obstacles for new entrants. However, the respondent mentions that many projects are planned and that many more are in the pipeline waiting for the credit market to recuperate – which implies that obstacles are not stopping new entrants.

U 1: During a discussion on other companies and their planned investments (plans in the UK in the size of hundreds of MWe dedicated biomass has been mentioned by other respondents) the respondent mentions that plans for long term supply of wood chips from North America as a base for bio mass supply plans. The logistical solution there being shipments of 20.000 to 40.000 tons of wood chips arriving at UK borders and biomass plants being located near these ports.

U2: As mentioned by many other actors the respondent does not see a potential for district heating in the UK primarily due to the lack of an established system. Furthermore the respondent does not think that there is much room for investments in a district heating system as the climate in the UK is not cold enough and as gas is and has been the traditional choice for heating. This in turn means that a CHP production in the UK will be more difficult than had a district heating system been available. The respondent states that it generally would be hard for a heat producer to find a market for his produced heat and that a CHP producer often would have to supply heat at basically no profit.

U 2: On a discussion concerning some of the large dedicated biomass power stations being planned in the UK the respondent does not see these installations feed stock supply plans as sustainable. This as the mentioned installations are thought to be supplied by wood chips from North America which in turn means that fossil fuel transports will be used for transporting the large amounts of feed stocks required. Instead, the respondent believes that the utilised feedstock should be indigenous and relatively local. This in turn would imply that the scale of the installations would be limited. Also, connected to the discussion on transporting feedstock the respondent mentions that an internationally synchronised certificate system that would allow e.g. UK electricity suppliers to buy certificates from Swedish bio energy producers (that utilize local Swedish forest resources) could be a more effective solution.

U 3: The respondent sees the UK ROC based system as a competitive and effective system as the best solutions are endorsed as lowest cost alternatives are needed in order to survive the entrance of more and more RES viable alternatives.

Profitability of the examined market/Success factors
S 1: Governmental incentives are mentioned as an important factor influencing the profitability. Also, the development in other EU countries are seen as important from a fuel price perspective as this may influence the competition for wood based fuels in Sweden.

S 3: During a discussion on the incentive systems in the three scope countries feed in tariffs are said to be preferable in the sense that they clearly specify a guaranteed tariff while the certificate prices may fluctuate and thus provide less certainty for investors. S 3 confirms what S 2 said regarding the uncertainty aspect of what is to be considered as a “new” installation. In a general discussion regarding investments the respondent estimates the general lifetime for new bio energy installations to somewhere between 15 and 25 years. On the topic of what the main factors affecting the profitability of the Swedish bio energy industry the respondent replies:

S 3: “Taxes, without the Swedish taxation system it (the bio energy industry, authors note) would not survive”

Interviewer: “You mean taxes on fossil fuels”

S 3: “Taxes on everything but bio fuels”

Interviewer: “Ok, so you mean the fact that bio fuels are tax exempted”

S 3: “Yes”

The respondent also points out that the certificate system is vital for the bio energy based electricity production, the heat production would however still be profitable without the certificates according to the respondent.

S 4: Once again the respondent stresses the importance of efficient logistical solutions in order to secure profitability. Also, S 4 mentions that the cost for its feedstock has a strong effect on the profitability of the installation. S 4 sees his installation type, i.e. a bio refinery in combination with electricity and heat production, as a solution that allows for both effective logistical solutions and positive synergy effects between the different installations.

G 1: When asked about key success factors the respondent sees the location of a plant as crucial as the plant needs to secure long term contracts with heat/electricity customers.

G 2: “Security of fuel” is mentioned as crucial. As other respondents have stated G 2 states that biomass is not very suitable for transport from an economical point of view which implies that it is important to secure a local supply.

U 2: The respondent concludes that the profitability for RES production in general and biomass specifically is very dependent on the incentive systems that are in place. The respondent says that; “If there is a political will to expand the bio energy industry it is up to the government to make the business profitable, otherwise there will be no investments”

U 3: The respondent sees availability of favourably priced feed stock, ROCs and availability of government grants as the main factors influencing profitability. Furthermore the respondent mentions that the UK government during certain periods has offered capital grants for biomass investments that can amount to as much as 30 % of the capital costs. The respondent continues that these capital grants are a prerequisite for medium or small scale installations. Without the capital grants the respondent states large scale is needed for profitability (large scale was discussed as being in the area of 300MWe, authors note) Regarding what many other respondents have said regarding the need for locally available feedstock the respondent does not agree. He, like other investors in the UK looking at building installations in the size of approximately 300MWe, sees importing biomass as feasible solution. The respondent mentions growing feedstock abroad and importing it by boat as an alternative.

Future outlook and trends

S 1: The respondent views waste incineration as a future trend and expects future investments in that area and that waste incineration in some cases will replace wood based fuels.

S 2: The interviewed fuel manager does not predict any dramatic changes on the Swedish bio energy market for the coming 10 to 15 years. He predicts an annual bio energy growth of 3-5 TWh (10-18PJ).

S 3: The respondent believes that the bio energy industry in Sweden has a bright future with a growing international trade especially concerning wood based fuels. Regarding waste incineration S 3 (as mentioned) sees the benefits of waste to energy but points out that there is a relatively limited supply of waste in Sweden, import of waste could be an option.

S 4: The respondent expects the price for electricity to rise considerably within two years. He also mentions the possibility that Sweden may export green electricity to the UK as coal power and other fossil energy sources are to be phased out.

S 5: Believes that bio energy in the future will be too expensive for the practice of just using pure bio fuels for on purpose incineration (e.g. for heat only production). The respondent believes that CHP, heat recovery, steam recovery etc. will be a must in the future.

S 5: The respondent believes that there will be a development towards a common European electricity market. Furthermore, the respondent sees a future for a European stock for biomass where prices are stated in accordance with transport distances and other factors. This would create a higher level of transparency in the bio energy market.

S 7: Believes in a limited expansion in the district heating system in rural areas.

G 1: The respondent sees a general shift from large biomass CHP plants consuming wood based fuels in the area of 20.000 to 100.000 tonnes annually towards smaller decentralised installations in the size of 1MWth to 5MWth. One aspect of this is that the larger plants are relatively sensitive to feedstock price fluctuations.

G 2: The respondent sees a probable expansion in geothermal power in Germany in the future. Regarding biomass availability the respondent does not believe in growing biomass simply for the purpose of using it as energy as; "The opinion of the people will not tolerate if you use huge tracts of arable land to grow something that you later want to burn".

G 2: Regarding UK and CHP G 2 believes that there will be a market for heat and that district heating will grow. However, he sees obstacles in large costs for district heating systems and gas/electricity as being preferred by the consumers. The respondent concludes that heat/heat recovery is a very important economical aspect from his point of view.

U 1: Does not see a certain technology / investment as dominating the future bio energy market. CHP- and condensation plants are mentioned as two interesting alternatives. CHP may be an interesting alternative from an economic perspective but the problem is finding a market for the produced heat.

U 3; The respondent sees a future for large scale (for example 200-300MWe) biomass installations. This as a large scale is needed for profitability. The respondent states that smaller type installation (40-60MW) are only interesting from an investment point of view if backed up by government capital grants.

Cost structures

S 1: The respondent has no specific input on cost structures but mentions that future biomass investments need to be large in size in order to be profitable and that the biomass sourcing for these large installations need to be relatively local (depending on the scale).

S 2: Sees CHP production in Sweden as profitable but says that the CHP business does not offer large profit margins. Also, the pay-off time for a biomass installation is estimated to 20-25 years.

S 3: Views the operational and capital costs as relatively equal between Sweden and the rest of Europe. From an outside industry perspective the respondent mentions that coal is a cheaper fuel alternative than bio fuels (wood based). The respondent points out the previously utilised El Forsk (Elforsk, 2007) report as a reliable source for cost estimations.

S 4: The respondent had no input regarding cost structures besides the already mentioned logistical issues and efficiency and economical benefits of a bi energy bio fuel combine. Regarding specific costs and incomes S 4 did not want to estimate numbers but rather he expressed a wish to come back at a later time with exact numbers.

S 5 does not agree that CHP production is completely dependent ion heat production and that revenues arising from electricity are just "icing on the cake" as expressed by a Swedish CHP producer. The respondent states that these type of claims are politically correct (e.g. publically owned / publically supported installations need to motivate their investment costs by claiming that they are primarily concerned with providing heat to the public, authors note) and that they might have been true historically but that the electricity prices of today mean that electricity is an important contributor to overall profitability as well as heat.

S 5:Also states that it is only in countries like for example Sweden and Finland where the market for biomass is mature where there is a accepted market price (with local variations, authors note). In less mature markets the respondent claims that the prices vary considerably.

S 6: The respondent has an interesting input regarding waste incineration. During a discussion on biomass costs and a comparison with wastes is made the respondent implies that the end result whether one gets paid to take care of wastes or pays a market price for biomass. This as; 1) Capital costs for a waste incineration facility is higher than the corresponding costs for a biomass incineration facility 2) The wear on waste facilities are much higher and 3) operations and management costs are also higher in waste incineration facilities. All this means that the price paid for the wastes used are to be regarded as remuneration for the extra costs included in waste incineration rather than a revenue source according to the respondent. The respondent also points out that waste, or rather the amount of waste available, is also depending on the general economic conditions as waste levels tend to decrease in economic downturns.

S 6: The respondent points out the fact that incineration of peat is eligible for green certificates but that peat incinerated for heat production is not exempt from taxes (which other biomass sources are).

S 8: During a discussion on the costs of transporting biomass one of the respondents state that even if there is an obvious issue with transporting biomass (bulk and water content, author note) the feedstock can be transported long distances by boat as this is a relatively low cost alternative. This is however affected by the transport costs that can vary considerably and off course the paying capability of the involved actors.

S 8: The respondents, as mentioned earlier, state that the feedstock prices are rising and predict that they will remain at a high level in the future. Because of this one important aspect is fuel flexibility which means that the producers do not become dependent on one type of fuel but rather can spread their risks on different fuel types. The respondents also claim that Sweden has relatively high biomass prices compared to the rest of Europe.

G 1: when discussing costs in general the respondent states that labour costs are small from a holistic perspective.

G 2: The respondent states that the market for energy production from waste wood in Germany is very mature and that the fuel supply situation has shifted from a practice where the producers of energy from waste wood would get paid to take care of waste wood to a situation where they are not paid or even have to pay for their feedstock. G 2 also mentions that there is a large untapped potential for waste wood in the UK amounting to about 11 million tonnes annually.

U 2: Does not see especially large margins in the waste wood to energy market in the UK especially since the British pound have been weakened towards the euro and as the company has many of its material and other investment costs in euro. However, the respondent states that there are profits to be made, otherwise they would not be in the bio energy business.

U 3: The respondent states that the economics of the large types of biomass installations are not completely known as these types of projects (regarding the large scale) have not been undertaken previously). As mentioned, the respondent claims that his company has calculated the option of building plantations for biomass feedstock and importing this feedstock to the UK and found the solution favourable.

Typical investment/Favoured Investment
S 1: See 5.2.5.

S 2: In accordance with what S 1 said regarding the future outlook S 2 also sees a growing interest in what he calls "low quality fuels" which he specified as less virgin type wood and more wood wastes and municipal waste incineration. Also, regarding primarily Sweden and Finland the utilisation of forestry wastes (i.e. tree tops, branches and stumps) is expected to increase.

S 3: The respondent mentions biomass CHP as a currently attractive investment as the economic downturn helps lower the otherwise to high capital costs as construction prices are on a lower level.

S 4: The respondent sees his type of bio energy and bio refinery combine as an attractive and profitable solution.

S 5 Sees a great potential for pellets both in Sweden and Europe as a whole and therefore views CHP bio energy in combination with a bio refinery e.g. in the form of pellet production as a profitable investment.

S 6: On a question on what kind of bio energy investment the respondent would make under current conditions the respondent answers that he would invest in biomass to electricity generation as the prices for electricity are favourable. S 6 also points out that there is a benefit in electricity production as it is a commodity that can be easily traded over long distances compared to heat which is dependent on local market conditions.

S 7: The respondent sees CHP as the only real option when considering a new heat producing installation, there is no economic reason to build a heat only unit. The respondent feels that the main question is regarding which fuels the installation should run on. Different alternatives include municipal wastes and forest biomass.

S 7: The respondent sees a future for multipurpose installations where CHP is combined with different types of industrial productions and applications as this means that the value of the utilised input fuel is maximised.

S 8: The respondents regard biomass CHP as the typical and most favourable investment today. Waste fired installations are also mentioned as interesting but as there has been a recent installation built close to the respondent's installation the waste feedstock is relatively scarce from the respondent's local point of view.

G 2: On the UK market the respondent regards waste wood incineration facilities as a favourable investment as the market is relatively unexploited. On the German market the respondent, in line with what he stated earlier, sees geothermal installations as a favourable investment.

U 2: As mentioned earlier the respondent believes in indigenous supply for biomass installations as the best option from a sustainability point of view. Thus medium scale installations fired with locally available feed stocks are preferred by the respondent. The respondent does not believe in CHP production as there is a very small market for heat in the UK.

G 2: Does not see a large potential in co-firing biomass as co-firing can only be done to a certain degree without losing too much efficiency.

C 8 Regarding the performed Eurostat Database Query

Note that the fuels included in the thesis scope, referred to as bio fuels, differ from the Eurostat definition which only constitute liquid bio fuels (Code 5545) (www, Eurostat, 2009 (1)) where as the thesis scope only considers solid wood based fuels. As the thesis investigates bio fuels broadly defined as wood based, a number of Eurostat statistical groups can be of interest. However, the following two groups have been chosen; Biomass and Wastes (Code 5540) and Wood and Wood Waste (Code 5541). The two groups are defined by Eurostat as follows;

Biomass and Wastes (Code 5540)
"Biomass and wastes cover organic, non-fossil material of biological origin, which may be used for heat production or electricity generation. They comprise wood and wood waste, biogas, and municipal solid waste and bio fuels. Renewable industrial waste should be reported under the various categories mentioned. The non-renewable part of industrial waste is not covered here, but under industrial wastes (Code 7100)." (www, Eurostat, 2009 (2))

Wood and Wood Waste (Code 5541)
"Wood & wood waste covers purpose-grown energy crops (poplar, willow, etc.), a multitude of woody materials generated by industrial processes or provided directly by forestry and agriculture (firewood, wood chips, bark, sawdust, shavings, chips, black liquor, etc.) as well as wastes such as straw, rice husks, nut shells, poultry litter, crushed grape dregs, etc.)." (www, Eurostat, 2009 (3))

It is evident that none of the two groups perfectly fit the thesis scope, for example chicken litter under code 5541 or the (liquid) bio fuels under code 5540 are certainly not within the scope. However, the data also contains interesting and relevant variables.

The variable chosen to describe the utilisation of the two fuel groups (5540/5541) is Final Energy Consumption – Adjustment. Note that transports, i.e. liquid fuels, are included which is not part of the thesis scope.

Final Energy Consumption – Adjustment (10700)
"Final energy consumption covers energy supplied to the final consumer's door for all energy uses. It is the sum of final energy consumption - industry (Code 101800), final energy consumption - transport (Code 101900) and final energy consumption - household, commerce etc. (Code 102000)." (www, Eurostat, 2009 (4))

C 9 Excel Calculations

SWEDEN

(For complete references please refer to thesis reference list if not below)

Prices €/Mwh and €		Source
Market Electricity price	40	(www, nordpool, 2009 (1)
Market Heat price	71,72	www, Avgiftsundersökningen, 2008 (1))
Market Certificate price	25,68	(www, elcertifikat.svk, 2009 (1))

Type of producer	
Heat	YES
Electricity	YES

Revenue Streams €/MWh		Source
Electricity	40	(www, nordpool, 2009 (1)
Heat *	53,22	www, Avgiftsundersökningen, 2008 (1))
Green Certificates	25,68	(www, elcertifikat.svk, 2009 (1))

Costs €/MWh		Source
30 MWe CHP**	88,82	(Elforsk, 2007)

Maximum Wood Paying Capability €/MWh
30,1

* Heat value is adjusted with heat generating costs of 18,5 € (Same principle is applied for Germany).

** Variable fuel costs of 15,4 € subtracted from total costs (Same principle is applied for Germany).

GERMANY

(For complete references please refer to thesis reference list if not below)

Prices €/Mwh and €		Source
Market Electricity price	56,5	(www, eex, 2009 (1)
Market Heat price	69,39	(Pers.Com, Pushkarev, 2009)

Type of producer	
Heat	YES
Electricity	YES

Revenue Streams €/MWh		Source
Heat	50,9	(Pers.Com, Kilburg, 2009)
Feed in Value *	107,9	(Pers.Com, Rotacher, 2009)

Costs €/MWh		Source
10 MWe CHP	113,2	(IEA, 2007)

Maximum Wood Paying Capability €/MWh
45,6

* Basic remuneration = 7,79 euro cents + 3 euro cent CHP bonus

UK

(For complete references please refer to thesis reference list if not below)

Prices €/Mwh and €		Source
Market Electricity price	62,3	(www, apxgroup, 2009 (1)
ROCs Market Price	55,41	(www, e-roc, 2009 (1))
LECs Value *	4,71	(www, Department of Enterprise and Regulator Reform, 2009 (1))

Type of producer	
Heat	NO
Electricity	YES

Revenue Streams €/MWh		Source
Electricity	62,3	(www, energy.eu ,2009 (1)) For consumption of 3500 kwh / year
ROCs	55,41	(www, e-roc, 2009 (1))
LECs *	4,71	(www, Department of Enterprise and Regulator Reform, 2009 (1))

Costs €/MWh		Source
Dedicated steam cycle	84,56	(IEA, 2007)

Maximum Wood Paying Capability €/MWh
37,9

* LEC value assumed equal to value of avoided tax cost

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Examensarbeten/Master Thesis

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