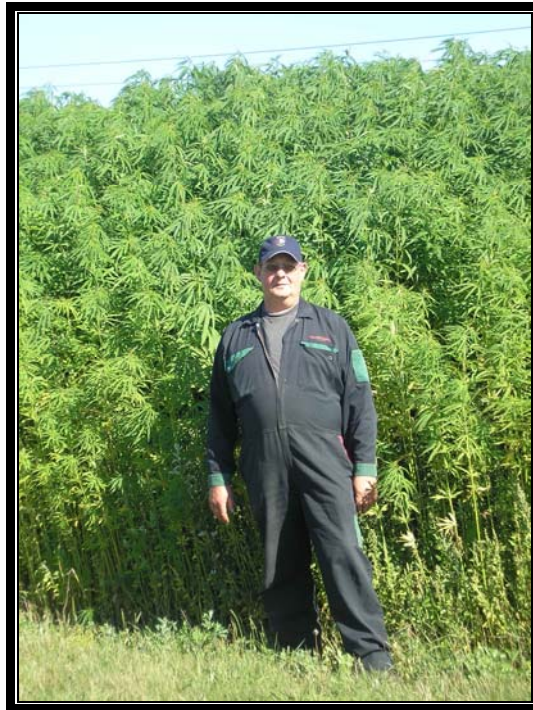


Investigating potential contract models to stimulate commercial production of energy crops

Risk perceptions and risk reduction options for agro-biofuel production in
Sweden, France and Finland

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Thesis for the fulfilment of the
Master of Science in Environmental Management and Policy
Lund, Sweden, September 2008

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Published in 2006 by IIIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiiee@iiiiee.lu.se.

ISSN 1401-9191

Acknowledgements

I want to thank Philip Peck for letting me conduct this study for him and for the Bioenergy NoE and for organizing to send me on research exchanges with the Bioenergy NoE partners INRA and VTT. I also want to thank Håkan Rosenqvist for providing valuable insights into the world of agriculture and for helping me find the first interviewees.

I am grateful to Geraldine Bocqueho at INRA in Grignon, France, for the organization of the research exchange visit to France and for being of great assistance in translation matters and data collection. Thank you also for being a great traveling companion.

I am also grateful to Teuvo Paappanen at VTT for the organization of the research exchange to VTT in Jyväskylä, Finland. Thank you for sharing extensive knowledge with me, for the extensive translation work and for driving so many kilometers with me to reach the interviewees.

Last but not least I want to thank everyone that I have had the opportunity to interview during this work - thank you for your time, knowledge and insights and for being so forthcoming and making this study so fun and interesting to conduct.

Abstract

Perception of risks and related costs associated with energy crop cultivation pose a barrier to expansion of production, and therefore economies-of-scale are not achieved and investments in new infrastructure harder to justify. In this study, the risk perceptions for agro-biofuel production in Sweden, France and Finland are delineated and a new contractual arrangement to reduce such risk perceptions proposed based on 55 in-depth interviews conducted with agro-biofuel producers and users.

The proposed contract model is based on three factors; degree of duration (number of years), degree of flexibility (number of price negotiations per year or per contract duration, and possibility to cancel the contract if circumstances change) and degree of cost control (the producers' level of integration into the production chain). It was found that the degree of duration preferably is medium-long, about 5 years, and the flexibility high, whereas the degree of cost control might vary between farmers depending on their activity level and possession of machinery and negotiation skills. Entrepreneurial farmers with machinery and high negotiation skills want a high degree of cost control, in particular if the energy crop is a large share of their income. Active farmers prefer a medium high degree of cost control, assisting during harvest with own machinery (such as driving a side-wagon next to the harvester) and inactive farmers a low degree of cost control because they value the low labour-input.

The price of the agro-biofuel product is linked to the price of conventional biofuels (such as wood chips from forestry), but with shared risk of increased prices for transport fuel via a partial indexation of the price to the diesel price. "Windfall profits" from for example subsidies or the CO₂ emission trading scheme are suggested to be allocated to the producer as an incentive for production.

The active farmers were found to be the least satisfied with the decision to grow an energy crop, in part because they to a larger extent have substituted cereal production with energy crop production, and the grain prices rose dramatically in the beginning of 2008, and in part because they have difficulties to be as profitable as the entrepreneurial farmers (who can harvest themselves and negotiate contracts directly with the fuel-users, thus avoiding costly middlehands) and have higher demand on profitability than the inactive farmers (who have retired or work outside the farm).

Executive Summary

Background

Cultivation of energy crops on arable land (in this study referred to as agro-biofuel) is an alternative business activity for farmers who want to diversify their production portfolio and venture into new markets. Renewable sources of primary energy are expected to play an important role in securing energy supply and sustainable development in the European Union in the future, and by 2020, the share of renewable energy of the total energy consumption shall be 20 % and the share of biofuels in the vehicle fuel mix 10 % according to the European energy policy (2007). Today, bioenergy constitute 64 % of the renewable energy supply in the Union, and 4 % of total domestic energy supply. The share of domestic energy supply is expected to double by 2010 (Swedish Energy Agency, 2008).

The interest from farmers to grow energy crops on cropland is however hardly overwhelming today. Surveys show that there are significant barriers to the uptake of these energy crops, including real and perceived production- and market risks. These risk perceptions could potentially be reduced by new contractual arrangements.

However, as of now the risk perceptions for commercial agro-biofuel production are not sufficiently investigated and delineated, which is necessary to understand the potential of new contractual forms for commercial production of agro-biofuel.

Research questions

The overarching research question is:

How is a contractual arrangement with potential to reduce risk perceptions for commercial agro-biofuel production designed?

The two sub-questions are:

- 1 What are the real and perceived risks associated with agro-biofuel production and use?***

- 2 What are the preferences of producers and fuel-users regarding contractual arrangements?***

Methodology

55 in-depth, semi-structured interviews have been carried out in this study. Stakeholders in Sweden, France and Finland, mainly agro-biofuel producers and users, but also intermediate buyers and experts in the field of agro-biofuel have been interviewed.

Three categories of producers were developed by the author, based on the level of importance of the agro-biofuel-production in the overall farm business and in fact as a consequence of a noted difference in how the farmers respond to the pre-specified questions within the three categories. These were entrepreneurial farmers (high importance of energy crop production on overall income), active farmers (medium high to low importance of energy crop production on overall income) and inactive farmers (low importance of energy crop production on overall income, often retirees or landowners who work outside the farm).

Risk perceptions

The study indicates that energy crops should be planted by entrepreneurial farmers or inactive farmers. The first category can integrate far into the production chain and contain both farmers and “businessmen” to some extent, i.e. can negotiate with power plants themselves, and the inactive farmers will accept a low economic return from the land in return for small labor inputs. For active farmers to be producing energy crops, the price should be higher and the organization stronger among the farmers themselves, in order for them to have a higher control over costs and more alternatives on the market.

For the grass crops like hemp, miscanthus, switchgrass and RCG, the production risk is in fact perceived as lower than for cereals. Harvesting techniques, other logistical issues and combustion technologies for dry crops with relatively high ash content and low ash melting points (compared to wood chips) need to be further improved in order to increase competitiveness and reduce costs. These production issues thus have significant implications for the economic results from the production activity.

A medium high degree of duration of a contract reduces the market risk perception. This is illustrated by the fact that the market risk was found to constitute a tangible risk in all cases due to the insufficiently evolved markets, except for the Finnish case, where the 5-year contracts with fuel-users appear to suit both parties, and in a few cases in France where the 7-year contracts with the buyer were perceived as satisfying.

Both the market situation and the policy situation are almost exclusively expected to work in favor of the agro-biofuel producers (i.e., higher price) in the future. Policies are however perceived as volatile both for agricultural production and for bioenergy, and a business activity strongly dependent on policy is not perceived as reliable. A more reliable policy environment could therefore increase the uptake of energy crops as well as the use of energy crops by heat- and power producers.

The need for information is hardly overwhelming, since most farmers today have internet-connection and access to advisors. However, experience exchange and study visits among farmers were requested, in particular in Sweden. More contacts with markets and potential buyers was also requested, and a potential means of strengthening the energy crop producers' market position would be to provide consultations with marketing experts – marketing is hardly what the typical farmer is used to or trained for, but perhaps what the farmer who wants to succeed on the energy market (in the case of agro-biofuel, the energy market is local or regional due to a feasible transportation distance maximum of about 100 km) needs.

Contract preferences and proposal for a new contractual model

Based on the results from interviews with growers and users of energy crops, it appears that a preferable duration is some 5 years, i.e. medium high degree of duration. However, if it is to achieve some outcome, the degree of duration should be compensated by a high degree of flexibility to attract the farmers, who particularly in Sweden are reluctant to long-term contractual commitments, meaning that price negotiations should take place every year and both parties (in particular, this is important for the growers because the production is typically more important in their business portfolio than the agro-biofuel is to the power plant) can cancel the contract if circumstances fundamentally change.

The degree of cost control is preferably worked out on an individual basis with the farmer (unless this conveys unacceptable costs), and could very well vary depending on the farmer category he/she belongs; farmers who are agricultural entrepreneur tend to favor selling at the gate, active farmers tend to favor selling at the edge of the field and inactive farmers tend to favor selling on the root.

A solution could be to develop three different contractual models differing according to the degree of cost control desired by the grower.

Figure 1-1 shows the conceptual contract model, where the red line indicates the proposed contract model for commercial production of energy crops.

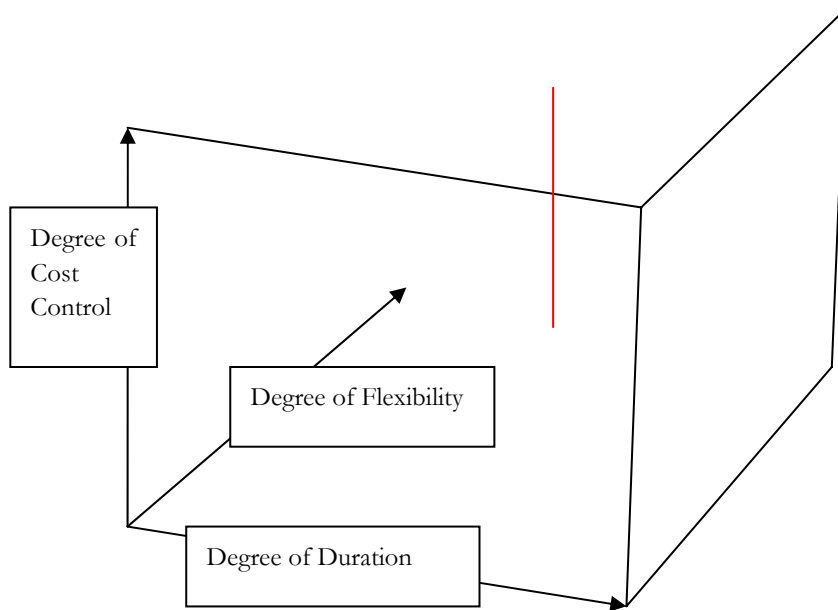


Figure 10-1 Conceptual contract model applied to European commercial production of energy crops

The price of agro-biofuel is preferably following biofuel prices. This is often a natural development since they are comparable products. As little manipulation of the markets as possible is an advantage in order to build up confidence for the agro-biofuel as a sustainable primary energy source.

However, having a part of the price indexed to the price to the oil- and diesel price index split the risk of suddenly increasing transportation costs between the producers and fuel-users and seem to be a feasible contract element, based to what has been stated in interviews. Another option is to have recurring price negotiations, either on a regular basis or following drastic price changes for transportation.

As a quality assurance measure for the fuel-user, it is reasonable that the price varies with the moisture content (i.e., quality) of the delivered product and that the “windfall revenues” from financial policy instruments applied over Europe or nationally, for example the European Trading Scheme, tax refunds on electricity or feed-in tariffs, be paid to the farmer as an incentive or “carrot”.

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1 Introduction

1.1 Background and problem statement

Cultivation of energy crops on arable land (in this study referred to as agro-biofuel) is an alternative business activity for farmers who want to diversify their production portfolio and venture into new markets. In the 1990s, following a generous establishment subsidy and high expectations on the development of the market price of biofuel, about a thousand Salix-plantations (fast-growing willows) were established by Swedish farmers (SOU 2007:36). However, bad production experiences, volatile policies and low profitability had a few years later put an end to 27 % of the plantations (Helby et. al, 2006).

“Farmers are not married to cereals. If there a buyers, there will be growers.”

– former hemp-grower in Skåne, Sweden

The fact remains however that renewable sources of primary energy are expected to play an important role in securing energy supply and sustainable development in the European Union in the future. By 2020, the share of renewable energy of the total energy consumption is to be 20 % according to a proposal from the European Energy Committee, and the share of biofuels in the vehicle fuel mix 10 %, according to the European energy policy agreed upon in 2007. Today, bioenergy constitute 64 % of the renewable energy supply in the Union, and 4 % of total domestic energy supply. The supply of biofuel in the Union is expected to double by 2010 (Swedish Energy Agency, 2008; European Commission, 2008).

Primary bioenergy sources of agricultural origin (in this study referred to as agro-biofuel) constitute about 35 % of the existing bioenergy resources in Europe and can thereby contribute largely to secure the expected doubling of supply of biofuel (Swedish Energy Agency, 2008). Examples are short rotation woody crops like Salix (harvested every 3-4 years), grass crops like hemp, miscanthus and reed canary grass or straw, a byproduct from cereal production.

Currently however, the interest from farmers to grow energy crops on cropland is hardly overwhelming. A survey by Paulrud et al (2007) show that there are significant barriers to the uptake of these energy crops, including real and perceived production- and market risks. Other barriers are personal preferences and values, for example that arable land should be used for production of food (Paulrud et al, 2007; Helby et al, 2006). In order to stimulate increased production of energy crops, the real and perceived risks must be reduced, via the design and implementation of risk reduction measures. Such risk-reduction measures are described by Rosenqvist and Peck (2008) for the case of Salix, and include modeling of new contractual arrangements between producer and fuel-user. This type of risk reduction tool is intended to reduce the perceived market risk by providing security to the farmer that the product will get sold, perhaps even for a fixed price or for a price indexed to another product for which the farmer feels certain that the price development will be to his advantage. According to the Paulrud et al (2007), 39 % of farmers are today reluctant to grow energy crops due to expected low profitability, suggesting that the market risk is perceived as significant. A new contractual arrangement can be a valuable tool to reduce this risk perception and is therefore the focus of this thesis.

However, the perception of risks associated with biofuel production have not been sufficiently delineated and evaluated. This is necessary to understand the potential of various new contractual forms for commercial production of agro-biofuel and this is therefore the first task of this work.

1.2 Purpose and objectives

This study will look closer on the potential for different contractual forms between commercial producers and users of agro-biofuel, with the purpose of reducing the risk perceptions associated with agro-biofuel. The objectives are the following:

- Delineate the real and perceived risks associated with commercial production of agro-biofuel in Sweden, France and Finland
- Investigate the preferences and expectations of producers and users of agro-biofuel in Sweden, France and Finland with regards to contractual arrangements
- Propose a contract model with potential to reduce risk perceptions associated with agro-biofuel production and use in Sweden

1.3 Research questions

The overarching research question is:

How is a contractual arrangement with potential to reduce risk perceptions for commercial agro-biofuel production designed?

The two sub-questions are:

- 1 What are the real and perceived risks associated with agro-biofuel production and use?***
- 2 What are the preferences of producers and fuel-users regarding contractual arrangements?***

1.4 Scope and boundaries

This study is looking closely at the commercial systems of agro-biofuel production in Sweden, which is the focus country, and on a more shallow level in France and Finland. These additional country studies are mainly intended to enrich the work and provide additional inputs for achievement of the objectives. The interviews have been conducted in the counties

of Skåne, Uppland, Södermanland and Västra Götaland in Sweden, in the regions of Centre and Normandy in France and the central part and Ostbotnia in Finland.

Producers (farmers) and fuel-users (heat- and power plants) are the principal interview objects, but other stakeholders such as intermediate buyers (Agroenergi), agricultural advisors, researchers and experts have also been interviewed. In France, no fuel-users were interviewed due to time constraints and the low availability. Bical (intermediate buyer) did not agree to be interviewed.

Within this work, energy crops refer exclusively to non-edible crops whose main function is for energy production, and thus cereals or oilseed used for biofuel production are not included. The energy crops studied are Salix and hemp in Sweden, miscanthus and switchgrass in France and reed canary grass (RCG) in Finland (these crops are classified by the European Union as *energy crops* which makes the farmer eligible for the energy crop aid of 45 Euro/ha).

Risks include the production risks, i.e. technical or biological risks associated with growing the energy crop, and the market risk, i.e. lack of markets or insufficient revenues due to a low market price of the product or a high market price for production inputs. The political risk is also assessed as a sub-component to the market risk. The risk categories are investigated in the light of their implications on the economic result for the farm business from the energy crop production/the heat- and power plant from the use of the energy crop as a fuel.

Real risks are for example risks that can be verified by an objective source, for example an external advisor or expert. Perceived risks are such risks that the producer of fuel-user might believe exist because he/she is misinformed or lack knowledge and experience of energy crop production and use, and are thus mainly existing “in the person’s mind”.

1.5 Project context and limitations

This work is a part of the project “Agro-bioenergy in Europe: Reduction of Risk Costs for Energy Crops” carried out by the following Bioenergy NoE partners: the International Institute for Industrial Environmental Economics (IIIEE) in Sweden, INRA (Institut National de la Recherche Agronomique) in France, VTT Technical Research Centre in Finland, EC Renewable Energy Centre in Poland and Aston University in the UK. The objectives of the project are the following:

1. review the theoretical underpinning for a range of interventions to reduce real and perceived risk associated with energy crops
2. delineate risk perceptions for bioenergy crop production that are emerging among stakeholders in the field of practice
3. assess the relative potential for new or novel “crop-production contractual forms” to achieve risk cost reduction

For this particular piece of work INRA and VTT have played important roles. Research exchanges with these institutes were organized in order to compare the situations in Sweden, France and Finland. Twelve in-depth interviews with energy crop producers in France were

conducted between the 23rd of June and 3rd of July with the help of Geraldine Bocqueho, at INRA in Grignon. Teuvo Paappanen at VTT in Jyväskylä, Finland, organized eight in-depth interviews with energy crop producers and three interviews with fuel-users between August 18th and 22nd. Both researchers assisted with translation during interviews.

Thus this thesis is building on an already defined problem, for which the theoretical basis (objective 1) has been outlined within the study by Rosenqvist & Peck (2008). However, the scoping, planning and execution of this work has been the responsibility of the author. The first supervisor of this thesis, Philip Peck, has borne the responsibility for institutional arrangements required to facilitate this study, and for the financial support for the work.

The geographical areas in which the research has been conducted in the respective countries were chosen based on different criterias; in Sweden, the regions with largest production (in hectares) of Salix and hemp were investigated, whereas in France the availability of contact details and data on producers determined the region and in Finland the geographical distance from the starting point in Jyväskylä. Interviewees have been found via Agroenergi, Bical, Chambre d'Agriculture, VTT, researchers at IIIIEE and the Swedish University of Agricultural Sciences. This study is thus not presenting any statistical results, and is based on in-depth interviews with a small sample.

2 Situation description

This chapter gives a background to the commercial energy crop production in Sweden and provides an overview of the situation for energy crop production in France and Finland. The European policy environment for energy crop production is also described.

2.1 Energy crop production in Sweden

2.1.1 Potential and actual production

Biofuel contributes to 19 % of total energy supply in Sweden, or 116 TWh. The dominating biofuel source is forestry products, but about 1 %, or 1,5 TWh, have agricultural origin. Crops for energy production are planted on about 70 000 ha of the approximately 2.7 million ha of arable land in Sweden (SOU 2007:36), including grain and oil plants.

Table 1-1 shows the areal distribution of the different energy crops. Apart from the production of vehicle fuel like ethanol and biodiesel (mainly RME), the energy crops are primarily used in district heating plants, for combined heat- and power production and for small-scale use in domestic boilers (normally requires the raw material to be transformed into briquettes or pellets).

Table 2-1 Areal distribution of energy crops in Sweden

Crop	Produced energy carrier	Area of plantations (ha)
Wheat	Ethanol	25 000
Oat	Heat	5000
Straw	Heat	By-product from cereal production
Oil plants	Biodiesel	25 000
Salix	Heat	14 000
Reed canary grass	Heat	600
Grass	Biogas	300
Sum		70 000

Source: SOU 2007:36

The Swedish Bioenergy Association (Svebio) estimated in 2004 the potential for agro-biofuel in Sweden to 23 TWh/year. Similar calculations were made by the Swedish E.P.A in 1997 (28

TWh/year), Lantmännen in 2006 (29.65-36.5 TWh/year) and the Association of Swedish Farmers in 2007 (22 TWh/year). These calculations are however based on potentially available land area (500 000 – 600 000 ha, and in Lantmännen's estimation up to 1 million ha). In the Swedish decision on agricultural policy in 1990 it was assumed that around 800 000 ha would be available for other production than food production, and of this the Biofuel Committee in 1992 determined that 250 000 – 330 000 could be used for biofuel production (SOU 2007:36).

The realistic potential of energy crop production is probably much lower than these estimations, when taking into account economic viability and preferences of farmers etc. (Swedish Energy Agency, 2008). According to Paulrud et al, (2007), almost 40 % of the farmers are today *not* interested in growing energy crop due to low expectations on profitability, a dislike of crops that are more than 4 meters high and the long-time commitment associated with investment in a plantation with long lifetime (in the case of Salix, with a plantation lifetime of 20-25 years).

2.1.2 Development of energy crop production

Apart from cereals dedicated to ethanol or heat production, Salix is the most widespread energy crop on Swedish arable land and has been cultivated since the 1980's, mainly in Skåne and Mälardalen. Most new plantations were established in the first half of the 1990's when a substantial establishment subsidy was given to the growers as an action by the Swedish government to promote renewable energy sources. The deregulation of the agricultural market in 1991 had also caused the cereal prices to drop and the Swedish agricultural policy was going through a reform encouraging alternative business activities such as agro-bioenergy production (SOU 2007:36). Another attractive feature of the Salix-plantations was the low labor-intensity, which frees up time at the farm.

About 1200 farmers established Salix-plantations at this time, and the expectations were high on the new crop. Unfortunately however, they were to a large extent unfulfilled. Harvest yield turned out low due to lack of production know-how and vulnerable crops, the policies were volatile and unreliable and most importantly, the expectations on the price development for bioenergy had been overly optimistic (Helby et al, 2006). Moreover, a floor price for cereals accompanied the EU entrance and the Common Agricultural Policy (CAP), and grain prices eventually started to recover. The interest in Salix leveled out, and a few years later it was shown that 27% had terminated the plantations, long before the plantation lifetime was over, and 25% regretted planting Salix at all (Helby et al, 2006).

Figure 1-1 shows expectations on the uptake of Salix by the Swedish Environmental Protection Agency, the Biofuel Commission and the Federation of Swedish Farmers for 2010 and 2020, juxtaposed against the actual plantations established until 2005.

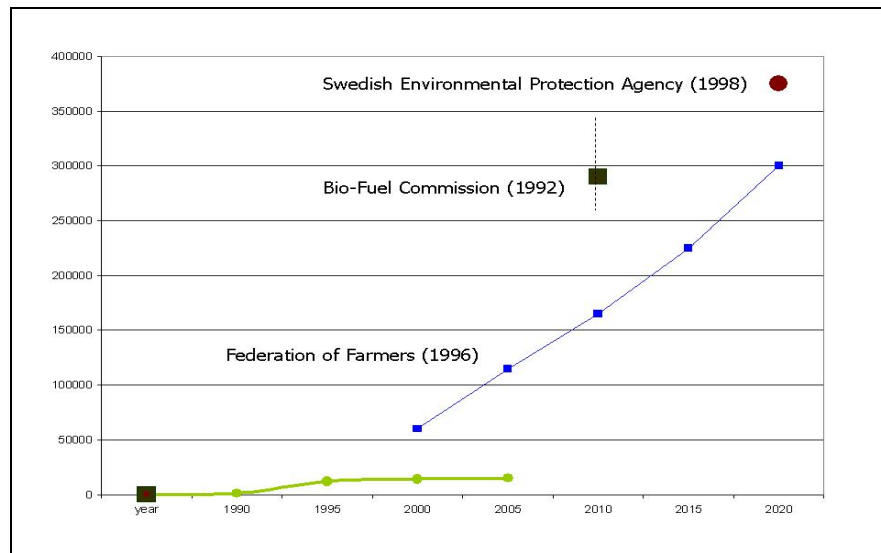


Figure 2-1 Expectations on Salix plantations in Sweden 1989-2020

Graph by Peck, 2006. Source: Helby et al., 2006

Reed canary grass and hemp are marginal crops that in 2006 had been planted on approximately 500 and 600 ha respectively, as seen in Table 1-1. As these crops are planted and harvested annually, these figures can however fluctuate greatly from one year to another and for example be influenced by weather conditions and price of alternative crops, such as the cereal price.

2.1.3 Policy environment

EU policies and regulations are in addition to national policy schemes affecting the production of agro-biofuel in Europe. In particular, the regulations and subsidies under the Common Agricultural Policy (CAP) play a central role.

In 2007, the European Council agreed on an energy policy including targets of 20 % renewable energy of the EU domestic consumption as well as 10 % biofuels of the gas- and diesel consumption in 2020. This had been preceded by the European Common Climate Programme (ECCP) including Directive 2003/03/EC on the promotion of the use of biofuels (5.75 % blend of biofuels in the European consumption of transport fuel by 2010) and Directive 2007/77/EC on Electricity Production from Renewable Energy Sources.

The Swedish Riksdag agreed on proposition 2005/06:172 in 2006, which included targets of 25 % reduction of emission of greenhouse gases in 2020 compared to 1990 and Swedish independence of fossil fuels for transport and heating in 2020. Other important policy instruments assumed to have favored renewable energy over fossil fuels are high energy- and carbon taxes (The Swedish Government, 2008).

Farmers producing agro-biofuel is entitled to 45 Euro/ha in energy crop aid, however for a maximum of 2 million ha in total within the Union. In 2008, the actual amount was 30

Euro/ha (VTT). In order to receive this subsidy, the grower must have a contract with a buyer.

Farmers are also entitled to the Single Farm Payments or the Single Area Payments regardless of whether they produce food crops or energy crops. These subsidies are one order of magnitude larger than the energy crop aid, but since they are crop-neutral, they are sometimes disregarded in economic calculations for production costs and profitability of agro-biofuel. Production costs calculations by Rosenqvist for energy crop production in Sweden (Appendix A) do not consider the crop-neutral subsidies, and neither do Agroenergi when calculating the profitability potential of Salix (Appendix B). However, calculations by VTT for production and delivery cost of RCG in Finland take all subsidies received by the farmer into account (Appendix [later]). Subsidies received by the Finnish farmers (with implications on the risk perceptions, as will be shown) are seen in detail in appendix D and can serve as an example of the subsidization of agricultural businesses producing energy crops.

Salix-plantations have been subsidized with 10 000 SEK/ha in Sweden since the beginning of the 1990s, and an additional 4000 SEK/ha for fencing if needed. It was reduced to 5000 SEK/ha in 1997, in connection with Sweden entering the EU. At its peak, about 16 000 - 19 000 hectares of Salix had been planted (this figure varies between sources) a figure that was later reduced and currently is at 14 300 ha (Swedish Energy Agency, 2008).

The fluctuating subsidy level for Salix illustrates the volatility of energy- and agricultural policies in the past. Such volatility will lower the stakeholders' confidence in the policies and could therefore have implications on the decisions on production activity, in particular for plantations with long lifetime. Other policies that have changed are the requirement for set-aside land, abolished in 2007, which potentially have implications for energy crop production as energy crops were in fact allowed on the set-aside land. Moreover, the 45 Euro/ha energy aid subsidy is currently being revised by the European Commission (2008).

Hemp as such was forbidden to grow by Swedish law until 2003, when industrial hemp became legal. In 2007, about 30 species became legal energy crops, and also entitled to the European energy crop aid (Agroväst and Swedish Board of Agriculture, 2006).

The European Trading Scheme (ETS), which puts a price on CO² emissions by obligating emitting industries to purchase emission rights to a price determined on the market for such emission rights, can also affect the development of agro-biofuel systems. This is in the context of this study best illustrated by the production of RCG in Finland, which in many plants is replacing peat. Peat is not considered a renewable energy source by the EU, and when replaced by a renewable source the amount of emission rights the plant is forced to purchase is reduced, increasing the competitiveness of RCG over conventional fuels (in fact, as will be shown the profitability of growing RCG in Finland is for the grower closely related to the price of ETS emission rights in Europe).

2.1.4 Markets

Agroenergi AB (a company within the farmer cooperative Lantmännen Group) is buying the majority of the volumes of Salix chips produced in Sweden and delivers to about 20 district heating plants. Agroenergi is thus a middlehand between the producer and fuel-user. Annual

delivery contracts are applied but the possibility of long-term contracts up to 10 years is being evaluated (Larsson, S., interview May 2008).

Agroenergi is also conducting R&D for Salix clones, and has so far developed 24 types of which about 10 are in commercial production. The company is also administrating the harvesters in Sweden (which has led to accusations of preserving a monopoly situation). According to the company (May 2008), there are seven fully equipped machines in total in Sweden. The few machines make the harvesting system vulnerable and inefficient, and the situation creates a bottleneck in the production chain. However, the investment cost for the special machinery required for the harvest is too high for an individual farm, although there are agricultural entrepreneurs who have developed their own harvest machines (Rosenqvist H., interview March 2008).

The market for Salix-chips is of regional character as cost- and energy efficiency reasons put constraints on the reasonable transportation distance. The district heating plants are preferably located within 50 km from the producer and maximum at 100 km distance (Slagbrandt R., interview August 2008).

Hemp is a relatively new crop and the markets are emerging. Growers today are often producing briquettes of the raw material and sell small scale and locally for home heating purposes (a consequence of this is that they not always make use of the energy crop aid of 45 Euro/ha. The money received for 1-2 ha does not justify the work hours put down for the rather complicated application process and there are often no contracts in place which is a requirement for the subsidy). However, the hemp fibers can in fact be used in various industries such as pulp&paper, construction, furniture and textile which opens up many potential markets as long as the fibers can be separated to a reasonable cost, which means that there must be significant volumes produced in order to justify investment in the required machinery. The byproduct from hemp fiber production could then be used as agro-biofuel, and in fact separation of the fibers improves the combustion properties of the plant (Jacobsson T., interview June 2008)

2.1.5 Cost structure and profitability

Production costs vary significantly between crops (see appendix A). For example, the cost of production of Salix was in 2006 calculated to be 134 SEK/MWh and for hemp 269 SEK/MWh, by Rosenqvist (2006). In the case of hemp, the solution to the high production cost is to make a value-added product such as briquettes and sell in small quantities to local buyers, which means that the price received can be 3-4 times higher than if sold in bales to heat- and power plants.

As such, the risk-averse nature of businesses implies that the growers and users of the new crop will require something tangible in return for the risk (potential of experiencing lower economic returns and also the uncertainty and discomfort involved) they take when growing an energy crop, for example higher profits than for a conventional business activity (Peck & Rosenqvist, 2008). According to Rosenqvist (2008) the cost of growing the energy crop includes not only the actual production cost and alternative cost of land (rising significantly with the increase in cereal price in 2008) but also the cost of risk. The detailed calculation in 2006 indicates that the production cost (composed of the three cost elements discussed above)

was, expressed in 2006 Euro, about 14.4-18 Euro/MWh¹ (1 GJ = 3,6 MWh) and as the price is at best in the same range, we are at break even and no risk premium is given to the grower.

Figure 1-1 shows a cost structure for cultivation of willows in Sweden 2006, developed by Rosenqvist and Nilsson (2006) as an example of a cost distribution for an energy crop.

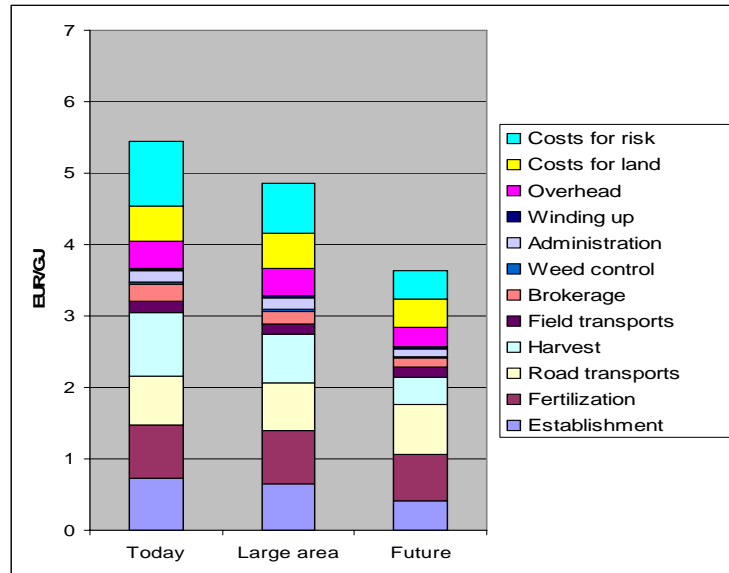


Figure 2-2 Cost structure for a Salix-plantation in Sweden

Source: Rosenqvist & Nilsson, 2006

However, according to Rosenqvist and Nilsson (2006), the cost of producing energy crops can be reduced by 20-25 % before 2020 which would make the energy crops more competitive on the bioenergy market as well as compared to cereal crops as business activity. Salix, hemp, miscanthus and reed canary grass has respectively a 32 %, 12 %, 18% and 15 % production cost reduction potential compared to cereals according to Rosenqvist (2006). An important factor for reducing production costs is to increase volumes produced, as a larger production system make investments seem safer and economies of scale can be obtained.

2.2 Overview of energy crop production in France

In France there are 18 million hectares of cropland (FAO, 2008). Energy crops are very marginal - according to Bical, the leading bioenergy-producing company operating in France there are 1 300 ha of miscanthus planted in the country (focus product for the company). Other energy crops grown in France include switchgrass, approximately 60 ha in 2008, poplar on 170 ha, eucalyptus on 140 ha and Salix on about 90 ha (INRA, 2008).

¹ The uncertainty of the last two years with rapidly rising cost for all agricultural feedstocks make this out of date and almost impossible to revise just now

Bical is a UK company that is, according to the company website, Europe's largest developer and commercial producer of miscanthus, with production in Ireland and France and business across Europe and USA. They provide planting material (rhizomes), and sign non-binding purchase contracts with the farmers. The contracts stretch over 7 years, which means 5 harvests because during the first two years the crop cannot be harvested. The miscanthus is sold as agro-biofuel or as animal bedding.

The demand from the energy-producing companies is still quite low, not least because of the oversupply of cheap nuclear power in France and the general absence of district heating systems. To some extent the demand is created by the farmers themselves by initiation of projects for renewable energy production, as for example an on-going project in Indre-et-Loire in a local heating plant, and use of agro-biofuel for fodder dehydration.

The Chamber of Agriculture (Chambre d'Agriculture), public centres for agricultural research, advice, product development, projects etc. that exist in each region and each department with a main office in Paris, is also a potential driver of projects involving agro-biofuel. One example of where the Chamber is getting involved is in the Indre-et-Loire project mentioned above.

2.3 Overview of energy crop production in Finland

There are some 2.3 million hectares of arable land in Finland. Half of this area is used for cereal production today, and one percent is used for reed canary grass (RCG), thus about 20 000 ha (in 2007). The Ministry of Agriculture is aiming at increasing this share to 10-20 %, or about 170 000 – 230 000 ha, as a means of increasing the share of renewable energy in the national production. According to VTT (2008), 500 000 – 700 000 ha is in theory possible to dedicate to RCG.

Salix is planted on approximately 10 ha for experimental reasons by the University of Joensuu. In those Northern conditions the yield is about 3-4 dry ton/ha (lower than in Central Sweden where yields are about 6-7 dry ton/ha and much lower than in Southern Sweden where yields can be up to 10-12 dry ton/ha) and could be used for local boilers run by the farmers themselves, a system under development in Finland (Villa, A., interview August 21).

Vapo Oy (private company and largest supplier of biofuel in Finland) and Pohjolan Voima Oy (PVO), which is a group of power plants, are the largest buyers of RCG. Both buyers have a standardized contract for RCG producers, included as Appendices E and F respectively. The price is among other factors based on the distance to the fuel-user, the moisture content and the price of CO² in the European Trading Scheme. Production and harvesting costs as calculated by VTT are included in Appendix C.

In 2006, more than 20 Finnish power plants were using RCG in the fuel mix (in total 21 GWh), but more than 100 power plants are in fact able to use grass and straw for heat production (with maximum 15 % RCG of the total energy value of the fuel to avoid technical problems like sintering). The optimal situation is that the producer is located not more than 60 km from the fuel-user, for energy- and cost efficiency reasons.

3 Analytical framework

This chapter gives an explanation of the theories and concepts related to risks and contracts applied in this work.

3.1 Risk theory

The analytical framework of this thesis builds upon the summary paper on risk theory by Rosenqvist & Peck (2008). The paper was produced as a basis for the Bioenergy NoE project within which framework this thesis has been produced. At the time of publishing of this work, this paper is available as an IIIIEE “working paper” on www.iiiee.lu.se. Additional sources are also used.

3.1.1 Introduction to risk theory

According to Rosenqvist & Peck (2008), most (if not all) business owners display aversion to risk, implying that reduction of risk has an economic value. Reducing risks associated with energy crop production will thus reduce the projected income from the production required by the farmer to take a decision to invest in it. This basic assumption is the starting point for this entire work.

3.1.2 Approaches to risk

Milton Friedman and Leonard Savage formulated the theory of risk aversion, risk neutrality and risk proclivity in 1948. Being risk-averse means choosing an alternative with less risk but also less expected return over a higher risk with higher return. Risk proclivity implies that the decision-maker is prone to take the higher risk with higher potential profits, but at the same time will accept a yield that is lower than could be expected if the yield was certain (otherwise, he would not take the risk). Risk-neutral individuals base their decisions on the expected yield (Fleisher, 1990; Robinson & Barry, 1987).

Risk-averse investors or business managers require a compensation for taking a risk, i.e., a risk premium in the form of additional economic return from the activity associated with risk. The premiums increase with risk or with the perception of risk (Sharpe, 1964), and also with the degree of risk-aversion (Fleisher, 1990, Robinson & Barry, 1987).

The rational business approach to risk is to accept a collective risk that is in reasonable proportion to the expected income from the venture, meaning that the portfolio of business activities in theory should be optimized with respect to risk and return. Applied to agriculture, this means that the farmer should keep a business portfolio that yields the optimal relationship between return and risk. However, decision-makers often base their decision on experience instead of conscious risk assessments (Wälstedt, 1987).

As regards approaches to risk, it is however important to distinguish between situations in which individuals seek risk as an experience in itself and situations where choices made affect the activity from which the person is making a living – a person can both be purchasing insurance and enjoy playing lotto, and the displayed risk approach in the respective situations should not be confused (Andersson, 1978).

3.1.3 Risk and uncertainty

In contrast to situations involving risk, defined as a situation in which the probability of different outcomes of an activity are known, uncertainty implies that no such values of probabilities can be calculated. However, the border between risk and uncertainty is blurred, especially since it is a subjective matter to establish whether or not a probability value is in fact valid or not (Andersson, 1978). According to Rosenqvist (1997), it is largely impossible to determine objective empirical probabilities for new areas of agricultural production, but at the same time, according to Andersson (1978) it is largely impossible that sudden and large changes in the techniques of agricultural production will change due to the fact that production is based on biological processes.

3.1.4 Distinction between real risks and perceived risks

The difference between real and perceived risks is quite obvious, but needs to be clearly defined for this work. Real risks are risks whose existence can be verified by objective and independent sources with sufficiently underpinned data to do so, and can be verified by other objective, sufficiently informed sources. Perceived risks are results of insufficient or skewed information, excessive risk-aversion or subjective preferences of values associated with the risk-conveying activity. Thus, they are in a sense “present in the minds of the actors” and objective data underpinning their magnitude or even verifying their validity are more difficult or impossible to gather.

3.1.5 “Safety first” or “Expected utility maximization”

In tactical analyses, the decision-making rule of “safety fist” is to make sure that the result of a decision does not end up below a critical level. The rule of expected utility maximization implies that the decision-maker knows the amount of utility or satisfaction for each possible outcome of an active choice, and chooses the alternative for which the expected utility is largest. Implications of applying the expected utility maximization is that risk premiums become difficult to establish, because the utility functions are individual and vary over time (Rosenqvist & Peck, 2008).

However, both alternatives have been criticized for being too limited, for example because factors that influence a decision not always can be expressed in monetary terms. These limitations mean that risk premiums become difficult to establish, since utility functions are individual, subjective and change over time (Fleisher, 1990).

Another important aspect is that individuals tend to say one thing in a test environment but act differently in a real situation (Tversky & Kahneman, 1974).

3.2 Risks for agricultural businesses

This section explains briefly the business risks relevant to this work, namely production-market- and political risks, applied to agricultural businesses specifically.

3.2.1 Relative weight of agricultural risks

According to a study by Wälstedt et al. (1992), 95 % of Swedish farmers with more than 50 ha cropping land consider the price risk to have major importance to their business, 85 % considered the political risk to be of major importance and 67 % considered the production risk of major importance when given a choice between major or minor (the gap to 100 % represents the respondees considering the respective risks of minor importance).

3.2.2 Market risk

Market risks includes price risk of product produced by the agricultural business and the price risk for products required for production, as well as the risk of having or not having a market on which to sell the products. If there is a risk that such market would not be available at the time of harvest, for example because of high import tariffs or sudden lack of demand for a controversial/outdated/outperformed product, this must affect the decision taken by the risk-averse farmer.

Price risk is the second most important risk for farmers with crop cultivation as main activity - the weather is the main risk - according to Patrick et al. (1985), (but the main risk for farmers relying on animal production). The price risk includes that the price received for the agricultural product is too low on the market, but also that the price of inputs required for cultivation (fertilizers, herbicides, soil preparation means, equipment and agricultural services from entrepreneurs) could be too high or volatile, and as such put the revenues from the cultivation at risk.

Market risks can be reduced via for example collection of market intelligence, diversification into several markets, futures and hedging (Patrik et al, 1985).

3.2.3 Production risk

As mentioned in the previous section, according to Patrick et al (1985) the weather is the most significant uncertainty factor for farmers with cropping as main activity. Production risks, however, include all uncertainty surrounding the performance of a crop, as the biological risks

of fungi or diseases, frost, or wild animals eating the crop (Hardaker et al, 1997). Moreover, in this work the production risk will include technical risks, such as low equipment performance or physical difficulties associated with planting, management and harvesting of an energy crop.

3.2.4 Political risk

Policies implemented by national governments or international institutions like the European Union can be highly volatile and thus convey an uncertainty to the farmer, who will not know if the production means he/she is using will be outlawed the coming year or if there will be a reduction in subsidies given for a certain activity. One example is the requirement for set-aside land that was abolished in 2008. The agricultural sector is regulated in the Common Agricultural Policy (CAP).

3.3 Risk management

There are several recognized risk reduction methods for business risks, of which some are explained briefly below.

3.3.1 Diversification

Production risks are primarily reduced via diversification into several production activities (Patrik et al, 1985).

Diversification into more than one activity, i.e. creating an activity portfolio, is a method to reduce the production- and market risk. A risk effective portfolio is a combination of activities involving risk that minimizes the spread of the expected result (Sharpe 1964, Wålstedt, 1987). Diversification is justified when the relationship between input and output of production units is linear, because it implies that economies of scale cannot be obtained (which would be in favor of specialization). However, diversification also incurs costs related to the learning process for a new activity (Robinson & Barry, 1987).

Diversification can also mean diversifying into several markets, and is then focusing on reducing the market risk only.

The level of risk for a portfolio is measured via co-variance, i.e., how the production activities covary, which is normalized by dividing the covariance with the standard deviations. The normalized variable is called the correlation coefficient and varies between 1 and -1, for which 1 is complete covariance and -1 is no risk at all. Normally, the correlation coefficients vary between 0 and 1 (Wålstedt, 1987). This is explained at length in Rosenqvist and Peck (2008).

3.3.2 Futures and options

As a means to reducing the price risk the farmer can buy futures and options on the commodity exchange market. This is common practice in for example North America for food- and agricultural products. It is currently not as common in Europe, although this alternative is being explored to cope with an increasingly deregulated food- and agricultural market in the EU.

Futures and options are not the same thing as trading the physical harvest, but a transaction of papers through which the farmer at a time when the market price is high (although he is not yet about to harvest) can secure that he will get the same price and not a potentially lower price later on when he has a physical harvest to sell. The difference between a normal contract (a “forward” contract) which stipulates that the harvest will be sold to a certain price in the future, the “future” contract means that the farmer sells contracts that he later *buys back* instead of delivering the harvest. “Option” is a contract that enables the buyer to buy a “future” at a certain price at a certain time, i.e. the commodity is in fact the “future”.

The way it works is that the farmer sells contracts on a commodity he later will harvest on the market for futures and options. If the price has fallen later on when he is about to sell the physical harvest, he will buy the contracts back to the lower price, i.e. he has made a profit. But at the same time the revenues from the physical harvest are lower than they would have been at the time when he bought the contracts, thus canceling out the profit. The net result is that the farmer is guaranteed the market price that was current at the time when he sold the contracts. If the opposite occurs and the price increases, the same net result follows upon the trade; farmer can sell the physical harvest to the higher price, but also have to buy the contracts back to a higher price than he sold them for and the two options thus brings the same result to the farmer.

This benefit of the trade on the market of futures and options is the high predictability (Swedish Agency of Agriculture, 2008).

3.3.3 Price indexation

To increase the predictability of the price development for a certain good, the price can in a contract be indexed to the price of another good or index. For example, the price of agro-biofuel could be linked to the price of wood chips, the price of the substituted crop, the oil price index or the consumer price index. Below, these indexes are explained further.

Consumer Price Index (CPI) measures the average price of consumer goods for a specific year in relation to a base year, and is a common type of national account. In Sweden, it is calculated by Statistics Sweden. It is based on price data (price of the goods/services) and weighting data (shares of expenditures as fractions of total expenditure covered by the index). Figure 2-1 presents the CPI between 1994 and 2007, with 1980 as a base year.

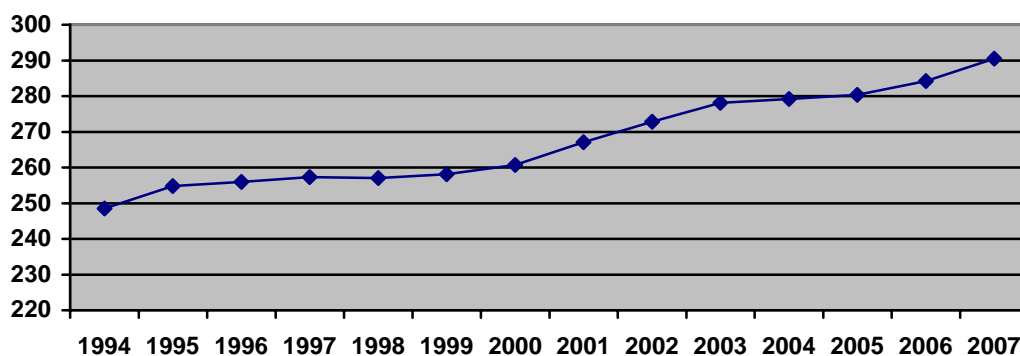


Figure 3-1 Consumer Price Index in Sweden, 1994-2007

Source: Statistics Sweden

The oil price is, simply put, determined by the global supply and demand. Figure 2-2 shows the global oil price index between 1996 and 2008. As can be seen from the figure, it has rising sharply since 2007 and was rising or fluctuating strongly during the course of this work.

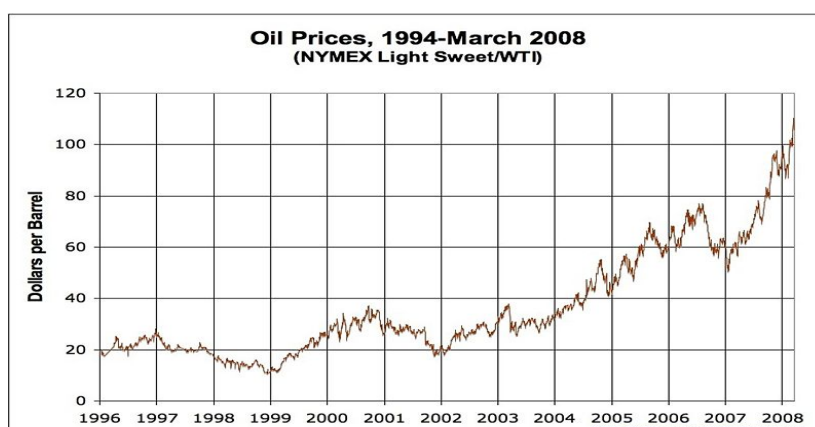


Figure 3-2 Global oil price, 1994-2007

Source: WTI

Unlike the oil price, the price of biofuel has a quite regional character due to the limited possibilities to transport biofuel long distances to a reasonable cost. This is in particular true for biofuel in non-compacted forms, like chaff or bales. For long transportation the form of pellets is better, and there is extensive international trade for pellets. Still however, the price varies notably between countries and regions (Junginger et. al.). There is today no standardized biofuel index has been developed, determining the quality requirements etc. of the product.

Figure 3-3 shows the Swedish biofuel price development between 1994 and 2007.

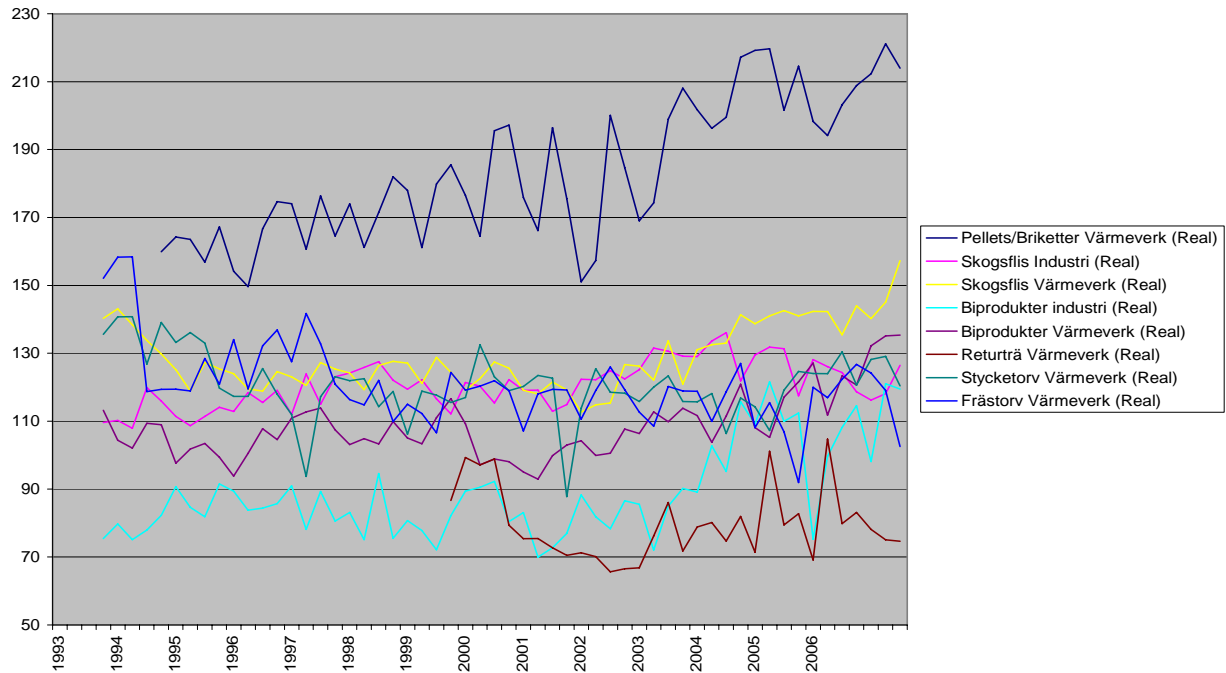


Figure 3-3 Price development of biofuel in Sweden, 1994-2008

Graph by Olsson, 2008. Source: Swedish Energy Agency

The price fluctuations between summer (with low heating demand) and winter (with high heating demand) are noticeable in the figure. The price of pellets and briquettes for heating purposes (dark blue) has been increasing substantially, while the price of wood chips for heating purposes (yellow) has had a slower price development.

3.3.4 Contract growing

Contract growing is a form of vertical integration. Vertical integration can be defined as “the process in which several steps in the production and/or distribution of a product or service are controlled by a single company or entity, in order to increase that company’s or entity’s power in the marketplace” (Investorwords.com), but for agricultural applications. In contract growing, a contract between the buyer (often a food producing company) and the producer is erected that regulates the conditions for the production on a rather detailed level, for example date of sowing, fertilizing, weed control and harvest. An example is Svenska Nestlé AB (Findus Integrated Growing), AB Felix and Foodia AB in Skåne, Sweden. Sugar is also produced in this manner, with the producing company Sockerbolaget and the growers jointly determining the amount to be produced for the Swedish market. (Nationalencycledin, 2008). The farmers’ influence on the production is thus limited, but on the other hand he is guaranteed a certain price for the product (unless the contracts stipulate an open price). Moreover, contract growing can – as in the case of sugar – regulated the volumes produced by a certain product and thus avoid overproduction. In the ideal case a partnership between the grower and the buyer (Fingrain, 2008).

3.4 Agricultural contracts

In this section, a simple conceptual contract model applicable to this work is developed based on a previously developed model by Drescher (2000) for contract farming. Although the contract in this work is not targeting contract farming but the agreement between a producer and buyer of an agricultural product, the model is considered applicable to illustrate elements of a contract.

3.4.1 Classification of agricultural contracts

According to Drescher, 2000, contract farming is an agreement between a legally independent firm and a farmer for production of a commodity for a future market. One approach to classification of contracts was developed by Mighell and Jones in 1963 (Drescher, 2000), and distinguished between 1) market specification contracts, 2) production-management contracts and 3) resource-providing contracts. The basis for the classification is the portion of the supply chain it regulates; in the first contract type, parts of the risk and management functions are transferred to the contractor, and in the second type more of the management functions lie with the contractor. Resource-providing contracts are close to vertical integration, with the contractor providing important inputs and taking over the risks and management.

3.4.2 Four-dimensional contracts

According to Grossekkettler (1978), Macneil (1981) and Williamson (1989), the four dimensions of a awareness (whether participants realize they coordinate their behavior), authority (to which extent coordination is caused by one party's power to dictate contract conditions), duration (coordination of economic plans with a temporal relationship) and investment (whether or not specific investments are carried out by at least one of the participants with regard to the contract).

Drescher (2000) uses degree of duration, degree of investment and degree of authority to build a three-dimensional conceptual model for agricultural contracts.

3.4.3 Conceptual contract model

The conceptual contract model for this work is based on the classifications of Mighell and Jones in 1963 and the conceptual model developed by Drescher in 2000, with adaptations to fit the context of this study. It is based on degree of duration, degree of cost control and degree of flexibility of the contract:

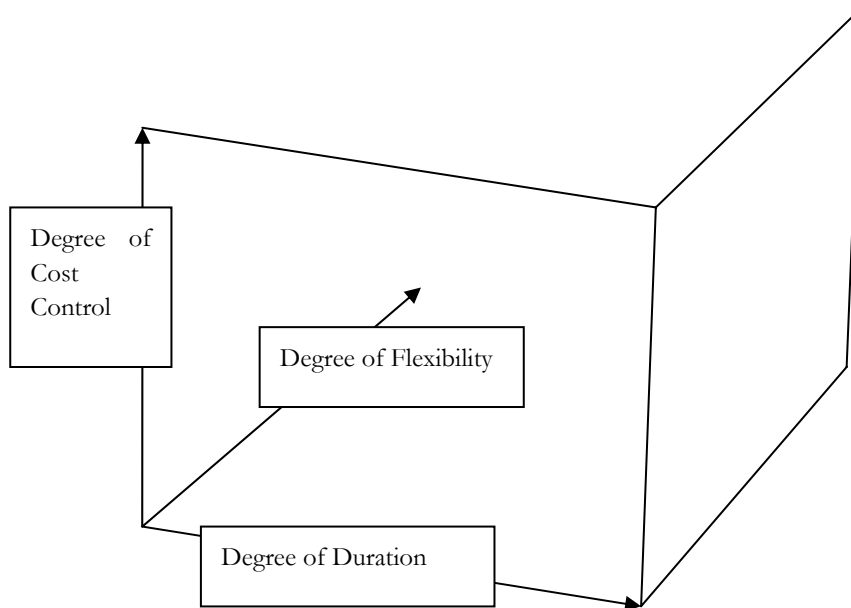


Figure 3-4 Conceptual contract model

Degree of cost control is to what extent the producer is involved in the supply chain, i.e. a reverse vertical integration. This can range from contract growing (no cost control), selling on the root (low degree of cost control), selling from the edge of the field (medium high degree of cost control) to delivery to the gate (high degree of cost control). Contracts range from short-term (annual) to midterm (3-5 years) or long-term (>5 years) contracts, and the degree of flexibility is determined by the no of price renegotiations/year and how easily the contract can be denounced by either party, for example if circumstances fundamentally change.

4 Methodology

4.1 Data collection: Literature Review

The literature review that has been conducted on previous research in the field of commercial production and use of energy crops is relatively short, mainly because not much literature on the topic is available today. Statistical surveys over attitudes and characteristics of energy crop producers from Sweden and Finland have been studied as they give insights to the barriers to the uptake of agro-biofuel and a starting point for risk perceptions. Previous proposals for contractual arrangements and organization of the commercial system for energy crop were also studied because it is related to the expected outcome of this work.

4.2 Data collection: Interviews

In-depth interviewing has been the main method of data collection in this study. 55 interviews have been carried out with stakeholders in Sweden, France and Finland. The interviews are described in this section with regards to content, structure and sample selection.

4.2.1 Interviewing as a research method

Personal interviews instead of distribution of questionnaires allow for interaction between the researcher and the interviewee which is an advantage for the semi-structured interview when discussion around a topic is desired – such discussion often needs facilitation from the researcher. Personal interviews can be conducted face-to-face or over a telecommunication medium, for example over the phone (Crano et al., 2002). In this work, it was determined early that face-to-face interviews on the site of cultivation or use of the agro-biofuel product would be the method applied, in order to create a setting in which the interviewee felt comfortable and the discussion could go in-depth into the topic without distractions. Moreover, this would facilitate additional knowledge building, for example demonstration of harvesting equipment or combustion techniques, and quantitative data such as harvest yields or energy content that the interviewee might have available on-site of production/fuel-use.

4.2.2 Selecting the interviewees

The interviews are not intended to give any statistical result and are mostly qualitative with the aim of delineating risk perceptions and feasibility of risk reduction options. Quantitative results in the form of cost data etc are sometimes provided based on the work of other researchers or data provided by interviewees. The sample of interviewees was selected based on the criteria of having planted energy crops or having considered planting energy crops at some point, but to the extent possible, the sample was steered to include farmers with different

experiences and level of satisfaction with the decision to plant energy crops. The Salix-growers were moreover distributed evenly over Skåne and Mälardalen (Counties of Södermanland and Uppsala) based on statistical data that these are the main Salix-growing regions (Rosenqvist, interview August 2008).

A few of the Salix-growers were found via Håkan Rosenqvist and Agroenergi, key informants during the first stage of the work. The interviewed farmers could then suggest other potential interviewees (utilizing the snowball effect). Hemp-growers were found via the Swedish University of Agriculture and the same snowball effect as described above for Salix-growers. In France, contact information for miscanthus-growers was provided by Bical and Chambre d'Agriculture and in Finland by Vapo and Pohjolan Voima (PVO).

4.2.3 Interview structure and questions

The interviews were semi-structured with 15-25 pre-specified, both closed and open questions. On several, elaboration on the pre-specified questions or related topics brought up by the interviewee was consistently prompted in order to gain better understanding of the situation. The topics in the farmer interviews were structured according to the following (full question sheet is included in Appendix G):

1. Role and importance of energy crop in the overall farm business
2. Cost control, price indexes and preferences for contractual forms
3. Attitude and perception of attitudes towards energy crops
4. Risk perceptions associated with energy crop
5. Information needs
6. General farm data

Interviews with fuel-users were structured according to the following (full question sheet is included in Appendix H):

1. Role and importance of biofuel/agro-biofuel for plant production
2. Price-setting options and preferences for contractual forms
3. Risk perceptions for energy crop use
4. Expectations on future demand for biofuel/agro-biofuel
5. General company data

4.2.4 Carrying out the interviews

All except for two of the interviews with the growers have been face-to-face interviews, most often carried out on the location of the production. Duration ranged between 40 and 80 minutes but in the general case around 60 minutes. Two interviews were carried out over the telephone. Apart from the pre-specified questions, the discussion was comprehensive on the farmers' approach and experience of biofuel production, providing many inputs to a discussion on the topic and further insight into the farmers' perception of the situation.

The interviews with fuel-users were mostly face-to-face, with the exception of two interviews. Discussions were encouraged on relevant topics and thus information beyond the prepared questions was also obtained.

The first two of the respective interviews made were considered pilot-interviews after which the question guidance sheets, enclosed as Appendix G and H respectively, were modified. However, the results from these interviews still apply and will be included in the analysis.

4.3 Data analysis and interpretation

This section explains how the results from the interviews and literature review are analyzed in order to draw conclusions from the work.

4.3.1 Categorization of producers

Categorization of farmers has the dual purpose of making each included farmer anonymous and at the same time distinguishing between the main farm/farmer types that might respond in a similar manner to new development in field of agro-biofuel (such as changed conditions or new policies).

Three categories were developed by the author of this study, based on the level of importance of the agro-biofuel-production in the overall farm business and in fact as a consequence of a noted difference in how the farmers respond to the pre-specified questions within the three categories. The categorization is merely a finer breakdown of the results that can be applied if found convenient, and is not expected to make this study difficult to compare to other studies.

The categorization into active or inactive farmers is supported by several actors in the field as for example Proagria in Finland (agricultural advisor) and X. The category of "entrepreneurs" was added because it was noted during interviews that farmers with entrepreneurial businesses, in particular associated with ownership of special machinery, changed the perceptions of risks and profitability associated with energy crop cultivation.

Category 1: Entrepreneurial farmers

Active farmers that in addition to farm production run an entrepreneurial business related to agro-biofuel production, for example harvesting or seed production. The share of total incomes originating from energy crop production/associated production activities is high.

Category 2: Active farmers

Active farmers who live on conventional farm production, with energy crop cultivation in their production portfolio (but not as main production activity). The share of total incomes originating from energy crop production is a low to medium high.

Category 3: Inactive farmers

Part-time farmers with jobs outside the farm, or previously active farmers (for example retirees) whose only farm production is the energy crop. The share of total incomes that originating from the farm production and consequently from the energy crop production is low.

4.3.2 Risk perceptions

The identified risks will be classified as production- or market risks and described qualitatively. Identified risks that do not fall into the production- or market risk category (as they are explained in section 2.2) are not included in the analysis but will be perhaps be mentioned briefly, however in such cases it is stated that it is not within the scope of the paper but included because of relevance for other risks. No further risk analysis or evaluation will be done, since insufficient quantitative data is available at this point.

4.3.3 Preferences and expectations

The interview data contains indications of preferences and expectations on price-setting schemes and contractual arrangements with fuel-users/producers respectively. Those preferences will be analyzed qualitatively to discern patterns or general preferences.

5 Results: Literature Review

This section contains brief summaries of some relevant studies conducted in fields related to commercial agro-biofuel systems. Statistical studies of attitudes towards energy crops among farmers in Sweden and Finland are presented to help delineate some of the barriers associated with energy crop production, and some research on contractual agreements for commercial energy systems is presented to give a more solid background to the shaping of contractual agreements between producers and buyers of agro-biofuel.

5.1 The business perspective

A report produced by the Swedish University of Agricultural Sciences in 2006 explores the business opportunities for straw fuel in the vicinity of Lund in Southern Sweden. Straw is a byproduct of cereal production and in fact not within the scope of this work, but this study is nonetheless considered relevant as it presents contractual models for commercialization of an agriculturally produced fuel for heat- and power plants (straw is in this case in competition with the energy crops investigated in this work as raw material for energy production).

Lunds Energi AB is in focus due to the company's planned investments in two new boilers, of which one is adapted to straw and grass fuels and the other for wood fuels, peat and recycled wood.

Two models are investigated; one where the farmers individually negotiates contracts with the power plant and one where they form associations that deal with the negotiations and jointly with the logistics, such as storage, handling and transportation, via contractors. A combination is suggested by Lunds Energi, who is willing to negotiate with organizations of farmers, but prefer that there exist more than one such organization to negotiate with. They are not interested in buying the fuel at an earlier point than at the gate. These associations are similar to the farmers' associations that are established institutions that negotiate price of conventional crops such as cereals and oilseeds for the agricultural businesses, and has a dual purpose of strengthening the negotiation power of the farmers and facilitating the negotiation process for both parties as fewer negotiations must take place, thus lowering transaction costs of contracts.

Contracts are suggested to run over 2-3 years based on energy content and an index. The farmer organizations have contracts with contractors (for harvest, transport etc) for 2-3 years based on tonnage.

In Denmark power plants have long experience of using straw for heat production. Previously there were so called Delivery organizations that organized deliveries and contracts with the power plants, but they were considered a barrier to free competition and were thus prohibited. The organizations were replaced by a system where the power plants search for fuel by ads in magazines, and producers can leave their offers. Annual contracts are written individually for each farmer. Point of sales is at the edge of the field, and moisture content (which should be as low as possible and not exceed 23 % more than patch wise) and bale dimensions are regulated in the contracts along with some quality requirements of the bales. The price is and

established base price calculated for time of delivery (with an interest rate of 12 %) and moisture content. The price is varying on a monthly basis.

5.2 Attitudes towards energy crop production

Statistical studies of the farmers' attitudes towards energy crops were included as they indicate potential risk perceptions associated with such crops.

5.2.1 Sweden

39% of the farmers in a survey by Paulrud et al (2007) stated "too low profitability" as the main reason for not growing bioenergy crops. According to Rosenqvist (interview, March 2008), grains might be preferred over Salix even when the expected return is actually higher for Salix, for two reasons; firstly, the farmer is already accustomed to growing grains, and has the necessary skills, tools, machinery and work force. Secondly, the Salix-plantations require a long-term commitment, and farmers are generally looking at business from a short-term perspective. Therefore, a high profitability is not a guarantee for a switch to Salix plantations.

Farmers with contractual agreements are according to Paulrud et al (2007) more likely to turn to energy crops than others, since such agreements provide an additional security that can fill the uncertainty gap many farmers face when turning to a new farm activity (or any business when trying a new business area). Having contracts in place for the crops are also the most common situation among farmers, especially for Salix (Håkan Rosenqvist, interview March 2008).

It is also shown by Paulrud et al that even though the expected return on the grown crop is influencing the willingness to grow energy crops, it does not matter whether the income is from the market price or from subsidies, as long as subsidies are considered reliable and long-term. This suggests that as long as the farmers have confidence in the economic instruments used by policymaker, they will suffice to make up for a low or volatile market price. Another result from the survey is that the farmer is more likely to switch to an energy crop if existing machinery on the farm can be used for the new crop. Furthermore, the length of the rotation period of the crop has a linear negative relationship to the willingness to grow such crop, given the uncertainty following the consequential inflexibility (Paulrud et al, 2007).

Moreover, the survey by Paulrud et al (2007) showed that 32% agreed with the statement "arable land should be used for food production" when asked for a reason not to grow energy crops. SOU 2007:36, shows that the negative attitudes towards energy crops as a replacement or competition to food production are disappearing. Important to note however, is that this study was conducted before the food prices rose to the highest level in 30 years in the first three months of 2008 (World Food Organization, July 2008). To what extent the high food prices can be attributed to biofuel production substituting cereal farming is debated, but both the Food and Agriculture Organization of the United Nations and the European Commission are putting it down as a contributing factor, although EC

***"I grow the worst
forestry product on
the best arable
land"***

–Salix-grower in
Södermanland,
Sweden

highlights that the impact is of regional character – within the EU, biofuel affect 1 % of cereal production (European Commission, July 2008).

The reluctance to grow other crops than crops for food production was most prominent among older farmers, but as shown above, the older farmers were also for other reasons not the most likely to grow willows or other energy crops and therefore, this will have a smaller impact on the total than if this preference was found among the middle-age farmers. (Paulrud et al., 2007).

Many farmers are also reluctant to crops with a height of over 4 meters (high crops limit the view and changes the esthetical impression of the landscape), which does not speak in favor of Salix-crops. A Salix plantation should preferably be at some distance from the houses, which means that the smaller the farm, the lower is the probability that the farmer for the sake of the landscape will take up such a crop. (Paulrud et al, 2007).

5.2.2 Finland

VTT has performed a study of the willingness of Finnish farmers to grow energy crops. Results show a positive attitude, in particular towards RCG, and expectations of profitability and political support for energy crop production. Change of landscape is not a problem, although the majority still thinks that arable land primarily is for food production most also prefer energy crop to forestation of fields. 10 % are sure or pretty sure they will grow energy crops at some point, but 89 % would only do so if the profitability was the same or higher than with conventional crops. Active farmers with large farms are more interested than the average, just like young farmers with high education, more often men than women and often agricultural entrepreneurs.

RCG is interesting as a crop because it can be grown on former peat land and harvested in spring when the work load is small on the farm. Oil crops are the second most favored alternative, but woody crops are not as popular and 75 % of farmers leasing out land would have restrictions for establishment of a woody crop, compared to 25 % for other energy crops.

If not producing cereals, the most favored options for alternative land use is cultivation of grass-like energy crops, forestation and having set-aside land.

5.3 Characteristics of Salix-growing farms in Sweden

A statistical study of willow (*Salix*) growers and non-willow growers in Sweden by Rosenqvist et al. (2000) shows that there are a few things willow-growers have in common, that can help delineate a picture of the prerequisites for a farmer to choose such farm activity over other activities. The results are similar for Roos et al (2000), basing their study on a theoretical model for profit-maximization, but not fully consistent with the extensive survey based on the choice experiment-method performed by Paulrud et al (2007). However, while Rosenqvist and

Roos focus solely on farmers that in fact currently grow willows, Paulrud has examined the willingness to grow energy crops in general among farmers, regardless of current farm activity, including Salix, reed canary grass (RCG) and grains for energy production. The following analysis can therefore also provide insights as to how the willingness to grow Salix differs from the willingness to grow energy crops in general.

In Sweden, a willow-growing farm has about 3 times the arable area of an average farm (Rosenqvist et al, 2000), a result that is contradicted by Paulrud et al (2007), saying that there is a negative correlation between willingness to cultivate energy crops and farm size. In other words, cultivation of Salix is favored by large farm area (which could be related to the height of Salix and subsequent wish to plant it far from the house) whereas energy crops in general are more interesting to small farms than large farms (small farms are perhaps more flexible because they possess a smaller machine park, thus have to appoint contractors for harvest etc. anyway).

While the picture is somewhat mixed, Paulrud finds that farmers cultivating energy crops are normally found among the younger farmers. Rosenqvist and Roos put the willow-growers in the middle-age section (50-65), with the explanation that the middle-age farmers to a larger extent than younger have a stable financial situation, the security of many years of experience but at the same time are less prone to stick to old habits and preferences than older farmers.

Forest growers are according to Roos more often willow-growers than others, which do not seem surprising at all as willows provide wood fuel, which the forest grower is already used to managing. However, Rosenqvists' results suggest that the relative land use of willow growers and non-willow growers is practically identical (Fig 2., Rosenqvist 2000), except for the pastureland which constitutes a smaller share at willow-growing farms. This suggest, consistent with Roos' findings, that farms with milk production and cattle are less likely to grow willows, probably a consequence of the need for such a farm to have pasture land and produce fodder.

The quality of land is also of significance – Salix is more often grown on average-yield land than on the worst or best land. From a technical point of view, Salix and grains give the highest yield on the same type of land, but calculations show that it is more cost-effective to grow grains on the best land and Salix on average land (Roos).

Leasing out of land is positively correlated with willow-growing (Roos, Rosenqvist), probably due to the fact that leasing is a consequence of a surplus of land (a large farm,) while the impact of tenancy is not as clear-cut.

Institutional owners are more often willow-growers than other farmers (Roos, Rosenqvist), which could be due to the low labor-intensity of willow crops – it is likely that a large employer is more interested in cutting labor-cost than a family farmer (Roos).

Willow-growers are most common in Örebro County, followed by the provinces of Uppland and Södermanland (especially around Lake Mälaren, a region referred to as Mälardalen), and least common in Småland, Öland, Gotland, southern part of Västergötland and Bohuslän. Skåne is somewhat average (Rosenqvist et al, 2000) but have a high percentage of other energy crops (Paulrud et al, 2007).

The many willow-growers in the Örebro area is in part due to the high demand of wood fuel in this area, which has a quite extensive district heating infrastructure, and the average-level

grain yield, which has been shown to present the best conditions for willow growing (Rosenqvist et al, 2000).

The study by Börjesson et al (2003) shows that 40% of the current Salix-growing farmers would consider keeping their Salix-crops because of the good hunting opportunities it presents.

5.4 Previous proposals for contractual arrangements for Salix

Helby et al (2004) proposes in the report “Market development problems for bio-energy systems in Sweden” that an incentive be paid to the district heating plants to encourage them to agree to long-term contract with growers. The idea behind is that the green certificate scheme that was about to be introduced in Sweden would not favour biomass over wind power and thus that the production development and markets for Salix would not have a chance to develop unless “protected” by a subsidy. Moreover, the assumptions is made that the growers benefit from long-term contracts because it relieves them from the price risk, whereas the buyers are more resistant to agree to such commitment and therefore require external support to enter such an agreement. This would bridge the gap between production cost and market price.

6 Results: Sweden

This chapter contains the results from interviews with eleven Salix-growers and six hemp-growers in the counties of Skåne, Uppland, Södermanland and Västra Götaland in Sweden.

6.1 Growing Salix

This section delineates the growers' motivations for planting Salix and the level of satisfaction with this decision among growers.

6.1.1 Why plant?



With one exception, the Salix-growers interviewed for this study had established their plantations between 1989 and 1996 (the exception was establishment in 2003).

Two of the farmers had decided to plant Salix as a means of using the set-aside land, three had planted on land that for various reasons were tricky to plant cereals on (inconvenient location or proximity to forest that brought wild animals to the crop), one overtook a lease with Salix on (thus it was accidental), one planted Salix as

the only feasible option to leasing the land to someone else due to retirement, for three the main reason was due to the low cereal prices, and one because he was optimistic about the price of wood chips.

With the exception of one of the entrepreneurial farmers, the ones that had planted because the cereal prices were low somewhat regretted their decision today, with cereal prices booming in the first months of 2008. However, although the other farmers had more or less the same type and amount of complaints around the system for Salix-production in Sweden, if they had planted as an alternative to have fallow land, land with nothing on it or instead of leasing the land to someone else, all stated that they were satisfied with their decision regardless of if they had been profitable.

6.1.2 Future of established plantations

Satisfied with their plantation or not, the only ones that in fact planned to keep their plantation were the entrepreneurial farmers (who were also the most profitable) and the inactive farmers for whom no other alternative existed.

The active farmers (with one exception, a grower who had planted in 2003 and not yet harvested), were either uncertain as to whether they would keep the plantation or not planning to keep their plantation. For some this was due to the recent removal of the requirement for set-aside land, for some because they considered the price and profitability too low, in particular as the cereal price rose significantly in 2007 while the development of biofuel price has not met the expectations. This result is somewhat in line with the result from Helby et al (2006) who showed that in 2005, 25 % of farmers that had planted Salix in the 1990s regretted this decision.

6.2 Risk perceptions

This section delineates the risk perceptions of Salix-growing.

6.2.1 Production

The harvest has proven to be a bottleneck in the system, partly because the heavy harvest machines in practice require frozen ground to operate (or the field might get damaged), partly because there are only seven of the Claas Jaguar harvesters required available in Sweden (Slagbrandt R., interview August 2008) and it was also suggested by a grower that the machines are standing still on the fields due to maintenance and refueling about 50% of the time, compared to for example a harvest machine for forestall wood chips that stand still 15 % of the time. The problem with harvest machines requiring frozen ground seemed in fact to be most severe in Uppland and Södermanland, due to the fact that although they are further north and have a colder climate than Skåne, they have barely seen frozen ground in the last ten years, whereas the farmers in Skåne are used to the fact that frozen ground only occur perhaps once every ten years and thus cannot rely on such conditions.

Frost and fungi has also been problematic for some, reducing yields significantly at times. In particular the old clones are sensitive to the colder climate in Uppland/Södermanland. Wild pigs rooting around in the fields (wild pigs are frequent in Skåne) or elks that do not even let electric fences shut them out also ruins parts of the harvest at times, up to as much as an estimated 30 % for one farmer in Skåne. Yield is also dependent on the quality of soil planted on.

6.2.2 Markets

It was suggested by several producers that the market for Salix chips and most of all, for the production factors of Salix chips such as planting and harvesting, is distorted due to the “monopoly” situation of Agroenergi for the contracting of entrepreneurs. As a consequence, profits might be lost somewhere in the production chain where the producer lacks control or

lack the possibility of taking control, and normal market mechanisms like competition are out of play.

According to farmers, their situation would have been different if they freely could choose and negotiate with the contractors to perform the harvest. It was also suggested during the interviews that Agroenergi is being too passive, do not communicate sufficiently with the growers, sometimes do not show up when supposed to and that they perhaps are not that interested in the product at all, since agro-bioenergy is a niche product in their portfolio.

Another finding is that the producers do not have sufficient power towards the market to create a favorable situation for themselves, or the capacity to create knowledge that would make markets more transparent. For cereals or oilseeds, there are farmers' associations that negotiate the product prices for the farmers – thereby the farmers have a far better negotiation position than if each one would negotiate individually. There is no such association for Salix (or energy crops), and therefore, each farmer is on his own to negotiate with the energy companies (unless they sell to Agroenergi), something that could prove difficult since they would be supplying very marginal quantities of fuel to the plant. A better organization around biofuel production could also create a platform for exchange of knowledge, experience and technical information, field trips etc, which was requested by some of the farmers. According to most of the interviewees, such a forum does not exist today.

The risk of low economic returns is the most important risk for Salix-growers. As it seems, a common situation is that the farmer is close to the break-even limit for the investment, sometimes a bit below, sometimes a bit above. Sometimes the low profitability is in part due to low yield per hectare, which relates back to the production risks, or that the Salix was planted on soil of insufficient quality or badly managed. However, even farmers that planted on good soil, using the new, better clones (for example Tora) and were very careful in their management of the plantation were close to quitting their plantation if they would not get a better price for the Salix chips.

6.2.3 Information needs

Experience exchange and exchanging of production-related advice, for example via farmers' associations or growers' meetings, is desired by growers today. Also required is information regarding the market potential and financial information. Some also considered this information readily available via Agroenergi. Agroenergi and Rural Society of Economics (Hushållningssällskapet) were also most often mentioned as responsible for providing any kind of information regarding growing of Salix, and also the farmers associations, governmental agencies and even heating plants – today the heating plants are in competition with each other for fuel, but via cooperation between the plants they could possibly increase the uptake of Salix by marketing it more to potential growers.

6.2.4 Barriers to the uptake of Salix

According to current growers of Salix, the reason that more farmers do not establish Salix-plantations relates to the lack of profitability.

”Burning food crops to produce energy is just lack of imagination”

– Salix-grower in Södermanland, Sweden

Moreover, there are farmers that prefer to grow the conventional crops that they know well and also, to have more activity on the farm than the Salix-plantation requires. Unless the farmer is interested in hunting, there are no real benefits of Salix.

Studies have shown that some farmers have a dislike of growing other crops than food crops on arable land. The general opinion on this issue among the Swedish Salix-growers is however that both energy- and food is needed and that a balance between the two needs to be established, and also to await the future development on this matter. The soil must simply be used smartly, for example by not combusting the edible crops but the waste products. Also, according to one of the entrepreneurial farmers, 5-10% of the Swedish soil should be possible to use for energy crops without using the best soils (according to one of the successful growers soil of level 7 on a scale from 1-10 is optimal for Salix. Above that, the yield from cereals is too high to exchange for a woody crop, and below that, the soil quality is too low for cultivation of Salix).

6.3 Contract preferences

This section is based on the result of the interviews with Salix-growers and presents the preferences stated by the growers with respect to contractual forms and price-setting.

6.3.1 Duration of contract

Preferences on the duration of contract are quite individual, but only a couple of the growers stated that they would prefer a contract lasting over several harvests over annual delivery contracts. Notably, growers currently selling via Agroenergi with annual contracts preferred keeping their options open and await new actors on the market, to signing long-term contracts. On the other hand, entrepreneurial farmers selling directly to heating plants were interested in long-term contracts because it would facilitate planning. Given the low profitability experienced by many growers currently selling via Agroenergi, it is hardly surprising that those farmers would be the least interested in a long-term commitment. Also, it was stated by one grower that the long-term contract is not important as long as there is profitability.

In fact, the stated preferences regarding long-term contracts suggest that the entrepreneurial farmers and the inactive farmers are the most risk-averse farmers and prone to the “safety first” approach to risk, i.e. committing to long-term contracts although the price might turn out lower. The active farmers on the other hand seem more ready to take risks in return for higher potential revenues, thus displaying the “expected utility maximization” approach. This could be explained by the fact that entrepreneurial farmers to a larger extent than the active farmers are dependent on the Salix-plantations for their living and therefore needs a certain level of security, whereas the inactive farmers simply want to take advantage of the low labour-intensity of the crop and have lower requirements on profitability.

Regarding the possibility of receiving a deduction price each year for the plantation instead of the entire income every 3-5 years at the actual harvest, the interest was quite weak. For the small growers, this option is not relevant because the revenues are so small to begin with – in

fact, for some the revenues from one harvest is basically equal to the cost of fertilizer and weed control for the next generation of trees. For farmers with large Salix-plantations it was not deemed relevant because a large Salix-plantation will have rotating harvests and thus the problem of lack of cash flow will not appear in the first place. Large farms are also liquid from other production activities. The intermediate-sized plantations/farms did not reject the option, but the risk of not being able to deliver the expected amount at the year of harvest and the possible consequences of that was mentioned as an issue for such contracts.

The general impression is that the farmers are not concerned about even cash flows as long as the activity is profitable, and moreover that they are used to volatile conditions that do not favor long-term planning, or even make the long-term contracts more of a gambling than not having a contract at all.

6.3.2 Price indexations

Most farmers considered the energy crop a product to be competing with other sources of energy on the energy market, rather than a product to be compared to cereals. Probably, the energy market was the market they had in mind when planting Salix, particularly as many took the decision in order to diversify in a time when cereal prices were low. In particular, the entrepreneurial farmers wanted to venture into the energy market, whereas a couple of the active farmers in fact stated an interest in a price indexed to cereals (in particular those who had planted Salix instead of cereals). An index based on both cereal prices and energy prices was also suggested by several farmers.

Some farmers were concerned that linking the price of biofuel to conventional energy sources like oil, coal or gas would eliminate the competitive advantage of biofuel, in particular when the price of oil is high. Although taking this into account when balancing the price and with the carbon taxes differentiating the end price of biofuel and conventional fuel to the advantage of the former, a biofuel price linked to the profitability index for cereals avoids this potential problem altogether because the price would follow a different curve – most interviewed growers believed that the fuel prices in general (both fossil fuels and biofuels) would continue rising whereas the cereal price would not (at least not to the same extent), and thus agro-biofuel could become an attractive alternative at the same time as the comparisons between the two production activities would be easier for the farmer. However, this reasoning assumes that the biofuel prices in general increase significantly, or the profitability of the grower would be compromised. A detailed analysis of potential profitability at various cereal- and biofuel price levels is out of the scope of this paper.

6.3.3 Futures and options

The market of futures and options is emerging in Sweden, but many farmers still consider it a bit risky and dangerous to get into such business, largely due to the risk of not having enough harvest to deliver in the end, which means that they will lose money if there is a price increase after they have sold the contracts on the harvest. Moreover, not everyone is interested in “gambling” because it is too difficult to predict the price fluctuations. Those who secure the price of their conventional crops might also do it for the energy crop but generally there is insufficient experience with this market.

6.3.4 Contract growing

Contract growing seems to be an option for those who planted because they did not want to have much activity on the farm, for example the inactive farmers. For the rest, the idea was not completely rejected as a potential option, and one of the entrepreneurial farmers even suggested it without being prompted as a potential for increasing the uptake of Salix among farmers. However, one farmer mentioned that it was hardly any point to have such a system, because of the small amount of work required.

6.3.5 Preferred point of sales

As has been indicated, the entrepreneurial farmers sell Salix chips at the gate to the power plants, and the inactive farmers on the root. Among the active farmers there was a noticeable preference towards selling from the edge of the field – assisting during harvest, for example by driving a second side-wagon to the harvesting machine to prevent it from standing still while the first was being emptied, reduces the cost. One active farmer, who was particularly unsatisfied with his crop and thus perhaps the least dedicated one, sold on the root. (One active farmer sold at the gate, but an important difference is that he was not selling to Agroenergi or a heating plant, but to a neighbor.) The farmer who had yet not harvested had not made up his mind, but would possibly harvest himself (5 ha) and in any case sell to the local community in small batches (i.e. which the customers picked up themselves), and there was thus no issue of transportation.

Generally, the result indicates that entrepreneurial farmers prefer to integrate far into the production chain, the active farmers preferred to integrate as far as to the harvest but leave the transportation up to the buyer, and the ones that were more engaged in work outside the farm than on the farm preferred to let the buyer integrate as far as possible into the production chain.

6.4 Growing hemp

This section is explaining the reasons among interviewees for growing hemp.

6.4.1 Why plant?



The most important motivation for growing hemp is diversification; cereal growing had for many years delivered low profits and at the same time, energy prices had started to rise. However, apart from the business perspective there are also farmers that are looking for change for the sake of change

itself. Also, the possibility of making something of the set-aside land was a reason for one grower, and the hunting opportunities tempted some.

In essence, the impression from the six interviews with hemp-growers is that there is a fundamental difference from the Salix-growers; the hemp-growers have taken the decision to grow hemp very consciously with full awareness of that they are “on their own” without advisors (the experience of growing hemp is not plentiful in Sweden), guaranteed buyers or even established harvesting- storing- and transportation techniques. They are on the very front edge of the development, maybe even too much in the front for their own good.

As a result, they now face a high market risk because the markets are still developing. At the same time, if the market development is good they will reap the benefits of already being established producers. This makes the hemp-growers more of entrepreneurs and “businessmen” than the Salix-growers; and as will be discussed at length further on marketing and exposure to potential buyers seem to be the most important risk reduction measure.

6.5 Risk perceptions

This section delineates the risk perceptions of hemp-growing.

6.5.1 Production

The hemp can in theory be harvested in November–December, but this requires a few days of temperatures below zero (to freeze-dry the plant, after which the nutrients have returned to the soil and there will be less problems with sintering in the combustion chamber). Frosts are not that common to occur in Skåne. If the hemp stands over winter, heavy snow could weigh it down to the extent that it is no longer possible to get a decent harvest with the techniques available today. Common practice is to harvest in spring, in March-April.

The required dryness of the material at harvest is a factor that in fact makes the hemp production according to growers more weather-dependent than cereals (normally dried *after* the harvest), and a lot of rain is more detrimental to the crop than drought due to its deep roots. Also, attracting wild animals is not always a good thing – for one grower, two thirds of last year’s harvest was lost due to wild pigs rooting around in the field.

There are, however, advantages of hemp compared to cereals; it is more resistant to fungi and other biological attacks and there is no weed control required, as the hemp outcompetes other seeds (which makes the crop suitable for organic farms). In fact, the many production advantages of hemp are strong contributing factors to why some of the growers decided on this production activity.

Hemp-growers are just like growers of other grass-like fuels (as opposed to woody crops like Salix) subject to a harvesting dilemma; they could either use a chopper for harvest to produce small fuel pieces at the field (chaff), which means that the transportation will be low-density and thus not very cost- or energy efficient, or harvest by mowing followed by baling, which means that more of the raw material can be fitted on the truck. On the other hand, the baling

is quite expensive and there must be a solution for crushing of the bales at the power plant. Research on harvest efficiency is on-going at the Swedish University of Agricultural Sciences, as for example the option of a one-pass harvest that chops and bales in one step, thus avoiding losses of material that sinks back to the soil after the mowing step. Bales are made by pressing and are either round or square.

6.5.2 Markets

The market risk is currently the most significant risk associated with hemp growing. There are no guarantees and no contracts, buyers are few and sometimes hard to attract and previously, supplies of biofuel imported from the East was also worrying – although the rising cost of transportation seems to have had a dampening effect on this. Moreover – even though it strictly speaking should fall under the category of financial risk – Agria, the dominating agricultural insurance company in Sweden, has yet not agreed to insure the hemp.

According to one grower, hemp cannot compete with wood chips or other energy sources if sold as raw material but must be sold as a value-added product as briquettes or pellets. This is supported by calculations by Rosenqvist (2006) showing that the production cost of hemp is 269 SEK/MWh, and with a price of 120-150 SEK/MWh at the gate Skåne county (where the hemp-growers were located) this is clearly not feasible - thus the high interest in briquetting among hemp growers (pelleting is generally considered to costly and energy-intensive). In the form of a briquette, a price of 490-590 SEK/MWh can be obtained (the higher price is explained by the fact that the end-users buy in small scale, for example a bag of 12 briquettes). However, if it would be economically viable, growers would also be open to the possibility of selling directly from the field, with no value added.



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In a broader perspective, hemp also has the potential of becoming construction material, if the fibers are separated from the straw, and also as input material for the pulp&paper industry instead of wood from forestry. Thus, the biofuel product could simply become a waste product from such production, similar to straw from cereal crops. One of the growers had in particular looked into this possibility, and regarding the current markets he could establish that if the separation of fibers and straw were to become economically viable, much larger volumes would have to be produced within a limited area than is the case today. Industries are currently not displaying much interest for the hemp either, but if the price of wood would rise as an input factor for the pulp&paper industry (which the majority of the growers are anticipating) hemp could potentially become competitive.

A much larger market would also open up if the hemp was pelleted, and thereby could be transported longer distances. This option was however not particularly favored by anyone, because of the high cost and energy requirement of a pelleting machine.

6.5.3 Information needs

The information need seems to be more on the buyers' side than on the growers' side – i.e. spreading the information of the benefits of hemp to various industries and more aggressive marketing would be more useful than additional information to growers, although some advice from experienced growers (not easy to find as the crop is relatively new) could be useful as well as more information about where to find buyers – but the core issue is currently to bridge the existing “gap” between producers and buyers.

6.5.4 Barriers to the uptake of hemp

Lack of buyers and lack of profitability is the generally stated reasons for why not more growers are interested in growing hemp, although some comments on farmers being traditional and afraid to try a new crop, or prefer to stick with cereals when the price is high – perhaps energy crops in general are also confused with Salix, which has gained a bad reputation of being detrimental to field drains (among other things).

However, for a guaranteed extra revenue of 100 Euro/ha compared to cereals, it is generally believed that many growers would switch to energy crops – according to most interviewed farmers, the profitability overshadows other preferences (they also believe this to be true for other farmers) and although some might not like “shrubs on the fields”, farmers in general are increasingly looking to diversify and spread the risks.

It was mentioned that large farms would not grow energy crops because they have invested in machines and equipment for conventional production, and are therefore slower to move to a new production activity. Also, the older farmers may be too traditional and the younger need some time to get comfortable with traditional farming before looking into something new and more risky.

Regarding the issue of producing food or energy, the general view of the farmers interviewed for this study is that energy production is *also* important.

6.6 Contract preferences

This section is based on the result of the interviews with hemp-growers and presents the preferences stated by the growers with respect to contractual forms and price-setting.

6.6.1 Duration of contracts

The results of the study show that farmers are generally *not* interested in long-term contracts with buyers. They are aware that market conditions can change that turn a seemingly advantageous contract into a disadvantage, and new actors could appear that pay better than the current buyers. The situation is however somewhat different for value-added products like briquettes or separated hemp fibers for pulp&paper industry. Value-added products might

appear less risky to sell with long-term contracts as the production cost not only depends on the conditions for raw material production, which the farmer has little influence on (for example volatile prices of fertilizers), but also on the farmers' own work (i.e. briquetting) which is less sensitive to external conditions. This reduces the vulnerability of the production. Also, industries for value-added products, for example the pulp&paper industry, are expected to pay more - and in the end it all comes down to profits.

Also, it was mentioned that the organization around growing must be more efficient to make long-term contracts feasible – and this emerging production sector does not seem to be ready for it yet.

”No one is interested in long-term contracts today”

- former grower of hemp in Skåne, Sweden

6.6.2 Price indexation

Generally, this study shows that the preference is to index the price of the hemp to energy sources, because it is competing on the same market – although for input material, the hemp-growers compete with cereal-growers. However, if the pulp&paper industry start to replace pulp fibers from forestry with hemp fibers (separated from the plant) the remaining hemp plant – in fact with better combustion properties than the fiber-containing plant – becomes a waste product – which would be in favor of the buyers, i.e. make this a cheap form of agrobiofuel, and reduce the profitability requirements of the producers.

6.6.3 Futures and options

Some growers would consider buying and selling on the market of futures and options, however some are not interested at all in this option because it is considered risky to sell anything before the physical harvest is secured. For value-added products, this is not relevant as the market of futures and options are for trade of raw material. The interviewed growers had not previously considered this option.

6.6.4 Contract growing

Contract growing is a potential option for some of the growers. This option is suitable in the sense that special machines are required for the energy crop production, and individual farms cannot bear this investment cost. It seems however that the bigger the market and perceived profitability from the production activity, the more inclined is the farmer to grow independently. Presumably, the opposite is thus also true – a small market with low expectations on profitability makes contract growing more attractive (as it normally guarantees an income). For a new, not tried-and-tested product like hemp, contract farming could be an attractive option.

6.6.5 Preferred point of sales

This study shows that entrepreneurial farmers want to sell as a value-added product (i.e. briquettes) because they believe in higher revenues than for the raw material, as raw material from the edge of the field or delivered to the buyer in order to control the costs as far in the production chain as possible and avoid middle hands. Some farmers are more flexible and prefer the most profitable option.

According to information from the actors in the field (mainly the growers themselves), hemp-growers in Sweden are mostly of the entrepreneurial kind (and often know each other even if not operating in the same regions) as it is a new crop that requires a value-adding process – exception is the farmers growing on contract for the experimental project of Lunds Energi and the Swedish University of Agriculture.

7 Results: France

7.1 Growing miscanthus and switchgrass

This section delineates the growers' motivations for planting miscanthus and/or switchgrass, and the level of satisfaction with this decision among growers.

7.1.1 Why plant?

Six out of the twelve interviewed growers of miscanthus and switchgrass in France stated diversification as the main reason of choosing to grow energy crops. The wish to diversify, in its turn, is a consequence of the low cereal prices (before 2007), and moreover, the general desire to become more independent of the CAP by venturing into new and presumably more stable markets.

Apart from diversification, differentiation was also given as a reason, as well as environmental commitment, hunting opportunities and retirement – several farmers considered energy crops to be an optimal crop for a farmer that was on the verge of retirement and wanted little work on his farm and also, a plantation to leave to his successor (often someone in the family, traditionally a son). Some planted because they had pieces of land not suitable for cereals, or because they wanted to do something with the set-aside land. One had planted in order to use on his own farm as he owned a boiler for straw.

“In 2005, faced with slumping cereal prices, I was very pessimistic about the agricultural business. It was then a question about finding a solution for the future from which I could run a profitable business on the farm” - Franck Fournier, La Blanchetière, Dpt Indre-et-Loire

7.1.2 Future of the plantations

All growers visited in France had planted in 2006, 2007 or 2008, all planned to keep their plantations and almost all would consider expand it. For those who desired little work on the farm, the entire area could potentially be planted with energy crops. Important to note is that not all had harvested yet and no one could yet say whether or not the plantation had been a profitable investments or not.

7.2 Risk perceptions

This section is delineates the risk perceptions for growing of miscanthus and switchgrass.

7.2.1 Production

Some had experienced problems with weed in the miscanthus-fields, in particular during rainy seasons when the weed grew stronger than the miscanthus. In a few cases, herbicides had not been properly applied to avoid this which implies in fact a lack of crop management skills/information.

Generally, the energy crops were considered more resistant to biological attacks than cereals.

Few of the farmers planting miscanthus today had yet harvested. Harvest is either performed with a maize chopper and transported as loose chaff of 2-3 cm, or chopped with a modified maize chopper and baled.

7.2.2 Markets

The farmers of Calvados in Normandy considered the market risk very small. All had already sold the current harvest, either to Bical (on the typical contract stretching over 7 years or 5 harvests), a local conversion unit or as animal bedding. Also, they were sure there would be buyers and that the price would follow the price of wood chips. The areas planted were in the French context large: between 5.3 and 25 ha, constituting between 5 and 13 % of the total farm area.

For the farmers in Indre-et-Loire in Centre, the perception of the market risk was quite different: according to them the market was still underdeveloped with few buyers. A few had sold the crops as fuel for fodder dehydration, some had sold as chicken bedding and one was trying to sell to municipal boilers, yet with no result. However, they were growing between 1 and 4 ha, in all but one case constituting less than 1 % of the total farm area (the exception amounted to 8 %) and thus the importance of the production in overall farm production was rather insignificant. Also, they had the support of the local Chambre d'Agriculture, were a project to stimulate growth of energy crops is currently running.



In Eure et Loir, also in Centre, one of the growers had obtained a 15-year contract with the municipal boiler with a price indexed to conventional fuel (20 %), labor cost (60 %) and the wood chips price (20 %). Another one used his crop for heating at his own farm and thus not interested in the market, and yet another one had a 15-year contract with a cooperative for dehydration of luzerne and pellet production, also with a price linked to fuel, labor and the price for wood chips X. As opposed to the two first ones, he was more worried about the availability of buyers because he was in fact growing 200 ha – the total farm area - in comparison to 2 ha each for the other two.

In all, the market risk is definitely the main risk associated with miscanthus/switchgrass cropping in France, because the market is still in development and those without the safety net of Bical to buy the crop are forced to venture into new areas to find potential buyers, acting more as “businessmen and marketers” than when selling conventional food crops.

7.2.3 Information needs

Lack of information is not considered a problem today since most farmers have access to Internet where there is plenty of information on the issue. Also, magazines and journals frequently publish articles about energy crop production.

What would be requested by new growers, according to some of the interviewees was however information on where to find buyers and on potential profitability, i.e. market information.

In Indre-et-Loire, Chambre d'Agriculture was held responsible to provide information on request, whereas the farmers in Eure et Loir and Calvados put this on Bical. However, for external advice in general the farmers also use the so called technical cooperatives, for example Agrial and Union Set. They were however *not* mentioned as responsible for providing information regarding energy crops – possibly because they have a clearly defined task in assisting and advising in conventional crop activities.

7.2.4 Barriers to the uptake of energy crops

The investment cost for the miscanthus field is very high at approximately 3 400 Euros per ha, which could therefore present a barrier to the uptake - in particular if it is difficult to obtain a credit which some growers had experienced. The cost of switchgrass is about a 10th of that, but on the other hand switchgrass has deeper roots which gave some farmers concern over the field drains.

The special machines required for harvesting is another barrier, because most farmers do not possess the machines and must thus employ contractors. The cost of chopping is about 20 Euro/ha and the cost of baling 40 Euros/h, and the cost of pelleting is about 60-70 Euro/ha (Leboeuf D., interview June 2008). The high cereal price is most definitely a barrier today, but also that the market for energy crops is new and underdeveloped, and there is a lack of buyers.

Moreover, all of the French growers brought up the issue of food shortage in underdeveloped countries this year, some without being prompted. In fact, one farmer was not going to plant additional energy crops before the debate had blown over.

7.3 Contract preferences

This section is based on the result of the interviews with growers of miscanthus and switchgrass and presents the preferences stated by the growers with respect to contractual forms and price-setting.

7.3.1 Duration of contract

Preferences for long- short- or midterm contracts appear to be quite individual. In Calvados, where the farmers felt reasonably secure regarding the availability of markets, a couple of farmers preferred a long-term contract such as the one already in place (7 years, 5 harvests) whereas two felt no need for a contract for more than one harvest. In general, there is no real pattern as to who want the long-term contract and who does not; some growers simply prefer the annual negotiations and to keep the options open whereas others prefer to have a few years ahead secured.

7.3.2 Price indexation

Linking the price of the energy crop to other sources of energy is by far more preferred than letting the price follow the profitability index for cereals. There were two reasons put forward for this; most growers seem to prefer as little manipulation of the market as possible, and most seem to believe that the price of energy will rise more than the price of cereals. Only one grower stated that he would prefer linking the price of the miscanthus to cereals.

However, a combination of indexes was an option mentioned by a couple of farmers in Indret-et-Loire and Eure et Loir – for example a combination index based on the cereal price, the energy price and labor costs, or based on consumer price index, price of cereals and price of energy with a certain portion fixed.

7.3.3 Futures and options

It was indicated in the study that using the market for futures and options for guaranteeing a certain price for their harvest is something that some farmers like and some do not, and in general there is a concern about making trades in advance regarding a crop that is not yet harvested because in case of unexpectedly low yield the deficiency must be bought from elsewhere.

7.3.4 Contract growing

The option of contract growing where a buyer dictates the production process was rejected by all farmers.

7.3.5 Preferred point of sales

In Indre-et-Loire, delivering the harvest to the buyer and thus selling at the gate was by far the most interesting option to the interviewed farmers. They considered this the option that would allow for keeping the most added-value. An exception was a retired farmer who wanted as little work as possible.

In Eure et Loir one grower preferred selling from the edge of the field because it gave him the possibility to influence the quality of the harvest. Other growers in the department were simply looking at profitability and would calculate the most beneficial option. In Calvados, the growers had no preference but most were currently selling from the edge of the field. An exception was a retired farmer who wanted to sell on the root to avoid extra work. That means that all the retirees prefer selling on the root.

8 Results: Finland

8.1 Growing Reed Canary Grass (RCG)

This section delineates the growers' motivations for planting RCG, and the level of satisfaction with this decision among growers.

8.1.1 Why plant?



Growers often plant on cut-over peat lands that are not suitable for cereal production, or simply on the worst soils or fallow land. The plantation is cheap and the work input is minimal; 10 ha take a couple of days to harvest at the most (performed by contractors) and fertilization is not always necessary. Also, RCG evens out the work load because it is harvested in spring at a time when there is little other work on a typical farm.

According to Proagria, an agricultural consultant company advising thousands of farmers, there are three types of RCG-growers; former cattle farms that are changing to a new business activity, elderly people that no longer want conventional farming activity and farmers that work outside of the farm. Diversification is not a motivation for planting a dedicated energy crops, according to Proagria, because it is not profitable enough to rely on as income. Most of the interviewed farmers did in fact have jobs outside the farm, and the estimated importance of the revenues from RCG was small, from insignificant to a few percent of total incomes (although up to 25 % of income from farming activities).

8.2 Risk perceptions

This section is delineates the risk perceptions for growing of miscanthus and switchgrass.

8.2.1 Production

For RCG the harvesting period is relatively short, because the heavy harvest machines requires a frozen ground and the short window of time for harvesting increases the sensitivity to the weather conditions. Storage is another problem, in particular if the bales are not fetched by Vapo or the power plant when expected – covering the bales with plastic is not economical but when stored on the field the moisture content and thereby the quality of the fuel decreases.

Further technical issues concerns the form in which the RCG is delivered, which in its turn depends on the machinery and equipment available at the farm and at the power plant. Bales are produced with densities of approximately 136 and 148 kg ds/m³ for round and square bales respectively (VTI, 2008), and thus be transported with a higher density than loose chaff, chopped at the farm (for example by harvesting and chopping simultaneously). A truck load of 38 500 kg is according to calculations from VTI carrying 34 MWh of loose chaff, 50-57 MWh of round bales and up to 79 MWh of square bales. In other words, more than twice as many truck loads are required to deliver the same amount of primary energy if the RCG is delivered as loose chaff instead of bales, with increased cost, fuel use and emissions as a result.

The bales must however be crushed at the power plant, which is a potential issue since most power plants have crushers adapted to the heavier wood fuel. If the grass is not properly crushed in the crushing step, it can block the conveyors and the feeding into silos and combustion chambers. A solution preferred by some power plants is to have RCG delivered as a mixture with peat or logging residues. In practice this means that the harvested RCG is transported to a peat production site or logging site for crushing and mixing.

Apart from the technical issues, no diseases are yet discovered on RCG and the biological risk is lower than for cereals (the growers indicate that it is in principle non-existent). Moreover, RCG can be planted on former peat lands or soils with lower quality – in particular due to the low requirements on yields (explained in section 7.3.2).

8.2.2 Markets

Harvesting, i.e. mowing and baling, is expensive – according to growers more or less the same as the price of the product itself; estimations range from about 90 - 170 Euro/ha for mowing and baling (5-8 Euro/MWh based on yields from 3.25 – 5.5 dry ton/ha) with baling constituting at least 70 % of the cost.

A breakdown of the production cost as calculated by VTI is found in Appendix C.

As noted by several growers and confirmed by calculations from VTI, the high cost of baling makes the curve of revenue vs. crop yield distorted, with a higher yield not meaning higher profits. It can therefore be strategic to have an average yield, perhaps not even to fertilize the crop (although a minimum yield of 3 dry ton/ha is required to receive the energy crop aid). Another aspect of this is that approximately 2/3 of the income from RCG production is from subsidies, lowering the importance of high productivity (Proagria).

The high dependence on subsidies also implies that the market is artificial, and the confidence in the product could potentially be lower (as will be seen in the next chapter).

However, none of the interviewed farmers considered the market risk to be a threat, although few had more than one option – either to sell to Vapo or directly to a power plant, depending

on geographical location. Local greenhouses or boilers could be an option, but demand is limited. The sense of security the farmers seem to experience in Finland is explained by the 5-year contract with Vapo and PVO plants. The contracts are also relatively easily cancelled, and the price is regularly renegotiated – thus, being “trapped” in a highly unfavorable contract if conditions change is not a risk.

Regarding profitability, many consider the price as too low, barely covering production costs, whereas others in fact stated to get a reasonable profit from the production or even that RCG can be the second most profitable land use options – the first being having uncultivated land. According to Teuvo Paappanen (interview, August 18), it is in fact a “moral issue” of the Finnish farmers to produce cereals at all, due to high entitlements for fallow land – a further discussion on this is however out of the scope of this study.

Prices paid for RCG are indexed to quality (moisture content), the price of CO₂, transport distance and sometimes yield. Appendix E and F contains contract agreements by Vapo and PVO. The fluctuating price of CO₂ can be the difference between low and high profitability for the farmer – several estimate that a price of CO₂ at about 20 Euro/ton makes the RCG production profitable (i.e. reach a level of accepted profitability). The fluctuations in price of CO₂ also explain the varying perceptions of profitability of RCG. However, technical problems at the plants have sometimes caused delays in fetching the bales at the field, and since covering bales with plastic is generally considered too expensive to be viable, there is a risk that the moisture content increases during storage, lowering the price paid.

Farmers stated that the profitability of RCG must be at least as high as for cereals to be of interest.

8.2.3 Barriers to the uptake of energy crops

Besides a low price received in relation to the production costs (in particular baling costs) there are according to interviewees still elderly farmers with strong traditions that are not in favor of cropland being used for other end-uses than food production.

Another barrier is that the power plants in principle have all the negotiation power and thereby can dictate the price paid to the farmer (Proagria).

Regarding the issue of producing energy on arable land, the general perceptions is that the current overproduction of food in Finland, with the country being a net exporter of cereals, allows for energy crops being cultivated on land that represents this overproduction, or on fallow lands/former peat lands (not suitable for cereal production).

The esthetical barrier seems non-existent – RCG is generally under the height of 2 meters and does not have the look of a “dense” crop as hemp or miscanthus (not to mention Salix). Also, from the landscaping perspective it is favored by farmers over having fallow land.

8.3 Contractual preferences

This section is based on the result of the interviews with RCG-growers and presents the preferences stated by the growers with respect to contractual forms and price-setting.

8.3.1 Duration of contract

Farmers in Finland are very satisfied with the 5-year contracts, allowing for price renegotiations 1-2 times a year. There are two aspects of the five-year period that makes it particularly suited for the activity; the perennial nature of reed canary grass favors a long-term contract over a short-term and the period of five years is a reasonable time for commitment and planning ahead.

8.3.2 Price indexation

Generally, the farmers indicate that they wish to be paid as much for the RCG as the suppliers of wood chips get paid for their product. Linking the price of RCG to the cereal price is however perceived as a means of reducing the risk of low economic returns, because the policies related to bioenergy production are perceived as volatile. As approximately two thirds of the income from reed canary grass comes from subsidies (according to Proagria) the concern about the durability of the subsidies is justified. It was mentioned that a link to cereal price would make comparisons with cereal production easier for the farmer who has to make the choice, although this alternative was not really preferred by anyone.

8.3.3 Futures and options

The market for futures and options seems to be a more or less unfamiliar concept among Finnish farmers.

8.3.4 Preferred point of sales

In principle the current model where the buyer fetches the bales at the edge of the field has the most advantages for the farmers. Many plant RCG in order to have less work on the farm and do not want to deal with the transportation issue, and have no machinery for crushing of the bales – required to feed it to the boiler and currently done either by the power plant on-site or by Vapo while mixed with peat at a peat production site. However, farmers that possess the machinery would consider – if it proves to be profitable – carrying out as many steps of the chain as possible before the sale. Selling on the root is also a possibility but this option reduces the possibility of selling a part of the harvest to someone else than Vapo or RCG, as for example local greenhouses (that are expected to pay more).

9 Results: Fuel-users' perspective

9.1 Sweden

The results of the interviews with representatives of heating plants and energy companies in Sweden are presented here.

9.1.1 Future of biofuel and agro-biofuel

According to Rolf Slagbrandt at Agroenergi AB, the attitudes towards biofuel at the heating plants are changing as the plants are increasingly concerned about securing supply of bioenergy, including agro-bioenergy. They are ready to pay more for the product and to buy larger volumes (an example is Eskilstuna district heating plant. In the past the interest from Eskilstuna has been quite luke-warm, but it is now the largest buyer of Salix from Agroenergi).

This is consistent with the results from interviews of six energy companies producing district heating in Skåne and Södermanland. All had projected the biofuel prices to rise as the supply no longer can meet demand – both due to potential political decisions such as an increased share of ethanol in the total vehicle fuel mix in Sweden (with the requirement of this ethanol being produced in Sweden), due to international demand and to the fact that an increasing amount of heat- and power plants adapted to biofuels rather than oil and gas are built, driven by the high oil- and gas prices. This means that primary energy must be found elsewhere, and in particular in Södermanland which is a region with an undersupply of biofuel, the demand is increasingly met through agro-biofuel and waste products.

In Skåne, the attitude towards agro-bioenergy is still quite luke-warm, biofuel is about 25 % cheaper and yet no shortage of supply seems to be worrying the energy producing companies. Lunds Energi, owned by four municipalities in the county of Skåne, estimated that their entire need for biomass could be met by Skåne's forests only, and moreover E.ON is in fact within the near future closing down its biofuelled plant in Malmö, which means that the major buyer of Salix in the region disappears. Instead, a new plant fuelled with natural gas is currently under construction in Malmö's East Harbor.

9.1.2 Conditions supporting/preventing agro-biofuel use

Whether or not the heating plant will purchase agro-biofuel is to a large extent dependent on the type of boilers they use. For example, Sjöbo heating plant (owned by Rindi AB) has boilers adapted to biofuel with high moisture content, with flue gas condensers to extract highest possible amount of energy from biomass with about 40 % moisture content. Thus, this is well suited for combustion of Salix but they are not interested in combusting straw, hemp, miscanthus and RCG. Kristianstads' heating plant experienced technical problems of sintering when in the middle of the 1990's, they started feeding Salix to their boilers – ash from Salix has a lower ash melting point than wood chips from forestry. The situation today with a

higher price for Salix than for wood chips in the region (if they pay 120-125 SEK/MWh for wood chips today, but are expecting to pay 150-160 SEK/MWh in 2-3 years) has not given them any incentive to start using Salix as fuel again.

Lunds Energi is currently burning 90 % natural gas and bio oil and only 10 % biomass, of which nothing so far is agro-biofuel (most is wood chips, recycled wood and wood briquettes) – however, two new boilers are planned, one for wood chips with ~10% mix of straw or hemp, and one mainly for straw but dedicated energy crops are also possible. The boilers are expected to stand ready in 2010 and 2014 respectively (the project has been delayed due to a high price of steel, required for building materials and equipment). They are currently involved in a hemp-production project with the Swedish University of Agricultural Sciences where they have contracted three farmers to grow hemp in order to evaluate the technical and commercial viability of the crop – according to Peter Ottosson the result so far is hardly optimistic, in particular not on the economic side. The company is not prepared to pay more than about 150 SEK/MWh for Salix chips (slightly above the 140 SEK/MWh the company is paying for wood chips), which according to calculations from the company equals 0.6-0.65 SEK/kg. This can be compared to a reasonable price for the farmer taking into account the production cost, as estimated by Lars Bengtsson (previously growing hemp at Valterslund, Skåne) at 1 SEK/kg for the raw material (i.e. not refined to briquettes or pellets) delivered in bales.



E.ON in Malmö has been using 10 % Salix in the fuel mix (which is the maximum blend for avoiding sintering in the boilers) but states that this is only because they can buy the Salix chips about 10 % cheaper than the forest residues - and because they want to have a large fuel portfolio as a long-term strategy for staying in a favorable position when the supply and demand change.

fact that at Lunds Energi with only 10 % biofuel, the fuel cost is 70 % (according to the company's calculations, this would have been 50 % if the natural gas was replaced with biofuel – thus justifying the investment in new boilers) of the company's total expenses whereas at Rindi AB in Skåne (four heating plants) with 97 % biofuel of which 5 % is Salix, the share of fuel of total expenses is 40 % and ENA Energi 60 % - which could be explained by the fact that they are operating in Södermanland where the biofuel prices are higher.

Biofuel has become the cheaper alternative to combust compared to oil and natural gas, illustrated by the

9.1.3 Contracts and price-setting

The energy companies are in general interested in long-term contracts, in particular the two companies interviewed in Södermanland County where the need for securing additional bioenergy sources seemed more acute than in Skåne (although at Mälarenergi it is stated that a

the perspective in which a supply must be secured is not longer than three years – markets, actors and options change over time).

Although the general impression is that it is a buyers' market both in Södermanland and Skåne and the growers basically have to accept the price they are given for their product, it is the growers that are reluctant to committing to a long-term contract whereas the energy companies are interested in 5-10 year contracts, preferably with recurring price negotiations each year. Most companies interviewed have long-term contracts with suppliers, except for Lunds Energi and E.ON Malmö who negotiate on a yearly basis and with a review of the agreement twice each fuel season (August 1 – July 30). With forest residue suppliers they have agreed to share the risk of increase in the diesel price – the theory behind is that otherwise the forestry suppliers will add a risk premium to the price, risk referring to the price risk for diesel.

Lunds Energi is expecting to have a mix of long-term and short-term contract for agro-biofuel producers with a share of 10-15 % open to buy on the spot-market and to adjust for variability of heat demand in the society in which they operate. Another option is to use a Danish model where the growers leave their offers at the heating plant which simply purchases in the order of lowest price offer first and so on. Rindi AB has a similar approach to contractual arrangements, wanting to secure about 70 % in contracts for several years in advance and leave 30 % open to local growers to fill.

In a way consistent with the farmers' reluctance to such price indexation (since they are on the opposite sides of the negotiation table), Lunds Energi would prefer to link the price to CPI. Rindi AB is linking the price of wood chips to "machine index", based on fuel and wages for machine operators (i.e. harvesters) and to CPI. Adjustment of prices to the price of oil is also a feasible option for E.ON Malmö. Rindi AB considers CPI to be a viable option to use as price index – or simply the costs experienced by the grower. They would not like to compete with the food market by linking price to cereals – rather, the price of energy crops could be indexed to price of straw and other organic waste products. In Kristianstad, the price of wood chips has been indexed to the diesel price, as suggested by Swedish Transport Workers Union, which has proven successful.

At ENA Energi in Enköping, the approach is that the price should reflect the production cost for the grower, including machine costs (machine index) and Mälarenergi in Västerås would consider an index to CPI or to a transport index.

9.1.4 Drivers of price change for fuel, heat and electricity

Prices of fuel are not following any other prices or indexed, but governed by supply and demand. Demand has two components; demand for heat (governed by the weather) and demand for fuel (both from other heating plants, international demand and unexpected events like storms that can increase the stored amount of damaged wood tremendously).

It is also clear that the price of biofuel depends on *regional* supply and demand, since the maximal transportation distance viable – even for forestry residues – is 100 km. The large price difference between central and Southern Sweden is natural due to low supply of biofuel in central Sweden in combination with a large population and consequential high demand for district heating. Skåne has experienced oversupply of biofuel as of lately.

9.2 Finland

9.2.1 Perspective on agro-biofuel

In the Fortum power plant in Joensuu (Fortum Voima Joensuu) about 1/6 of the RCG produced in the country is consumed (VTT). Still, this constitutes only about 0.5 % of the total fuel use in the plant, and about the same share of RCG is used in Vaskiluodon Voima (a PVO plant) in Seinäjoki and the Fortum power plant in Jyväskylä. The marginal share is to a certain extent due to technical restraints in the boiler which can be negatively affected by the chlorine content, but even more due to logistical issues; the crushing of the bales can take place either at peat production sites and arrive to the power plant as a mixture of peat and RCG, or be crushed on site and on the conveyors mixed with peat or wood chips. Mixture at peat production sites by the supplier requires transportation of the RCG to these sites, and the nature of the light RCG straws can cause problems with on-site crushing in the chain from crusher to silos to boiler; at PVO's plant in Seinäjoki, there is at least one event per week where RCG chaff interferes with the feeding to the boilers.

The volume produced within a reasonable area of the power plant (about 60 km) is also a determining factor, but is not always the limiting factor. Within a reasonable area of the Joensuu power plant 50 GWh of RCG is produced, which if used at the plant would be 5-10 % of total fuel use, but the plant is still not interested in purchasing such a volume unless it is properly mixed with peat to a maximum of 10 % on the conveyors (by the suppliers). Power plants in Finland are in general adapted to peat and wood chips, and although it would be a small investment for the plants to build an additional conveyor line for RCG, they are not eager to make such investments - partly because RCG is used in such small volumes and partly due to the fact that the profitability of producing RCG is heavily dependent on subsidies which makes an investment risky because policies can change. Rather, the plants state that they are using RCG because they want to be part of something new, and seem to be supporting new research and development more than they are securing their own need for fuel.

In general however, the desire is to increase the amount of biofuel used in the plant (forestry products like logging residues), much due to the policy situation including a tax refund on electricity for wood fuel (as of today, not comprising RCG) and the European Trading Scheme (ETS) for carbon emission rights, that puts a price on CO₂ and thus favors renewable energy sources. Peat is not classified as renewable, but is on the other hand cheaper to purchase for the plant than biofuel. Also, there is an awareness that the competition on these biofuels are increasing, for several reasons; new power plants, competition from the pulp&paper industry and the unpredictability of Russian import/export policies for wood. The availability of by-products like sawdust and bark is also decreasing because it is pelleted and sold on different markets.

9.2.2 Price-setting

The contracts that PVO plants have with producers (Appendix F) are based on moisture content, transportation distance and price of CO₂. In Vapos' contracts, the price is calculated based on amount of harvest, moisture content, transportation distance and the price paid by the power plant. According to one of the power plants, the price of RCG is in between the relatively cheap peat (8-9 Euro/MWh) and the wood fuel (13 Euro/MWh), and could be the same as for wood fuel if the technical issues were resolved, and another power plant assumes the price of peat for RCG and adjusts this to the price of CO₂ (which means that the producer can get a higher price if the price of CO₂ is high). Proagria, the agronomic advisor, is however certain that power plants could buy 15-16 Euro/MWh and still make profits – it is all a matter of negotiation power and the lack of organization among the farmers.

9.2.3 Drivers of price change for fuel, heat and electricity

The price of electricity and heat are determined by the price of CO₂, the fuel price and the tax refund for electricity granted by the government. Fuel prices are mainly determined by demand from other industries in the region.

Policies regarding the use of biofuel are recognized as a factor that would increase the share of biofuel in the Finnish energy mix in the future and thus also increase the competition for supplies. The general “fear” is that biofuel prices will increase, perhaps to 15-16 Euro/MWh within a year. Such a price increase would drive the power plants to look for additional sources of primary energy and could make energy crops an economical option, to the extent that they are technically feasible to use (that is, maximum 10-15 % of fuels in the combustion chamber). Perhaps new investments would also be considered to reduce the logistical problems associated with energy crop use at the power plants.

10 Discussion and Conclusions

In this chapter, the three commercial energy crop production systems studied and the role of farmers as energy producers will be discussed. Then the conclusions of this study, based on these results presented in the previous chapters, are presented and the research questions from section 1.2 will be answered to the extent possible.

10.1 Comparing energy crop production systems

Sweden, France and Finland are in different stages of developing a market for energy crops. Salix and RCG has a relatively long history in Sweden and Finland respectively, which means that initial problems have or should have been overcome. In the case of RCG, possible initial problems seem to have been overcome since both production risks and market risks are perceived as insignificant, whereas the Salix-production is still having problems and more and more stakeholders are having doubts regarding the future of the crop.

The success of RCG in Finland is however partly an illusion, because it is heavily based on subsidies and the “goodwill” of the power plants. The quantities of RCG supplied to the plants is often negligible compared to the total fuel quantities required for the energy production, and in some cases the RCG is in fact causing the plants technical problems every week. However, it seems like the power plants continue buying the crop in order to support the production and perhaps also as a way of improving the company image.

Another reason that the system seem to be so “harmonic” compared to the Swedish system is that many growers are not relying on the income from the RCG for the survival of their businesses (or for feeding the family for that matter), but cultivate it on the side of other activities (farm activities or external jobs). This obviously dampens the need for reducing risks and increasing profitability.

In the future, it could go either way; perhaps the RCG becomes increasingly profitable as a business activity due to increased prices of other primary energy sources such as woody biomass, oil or peat, or perhaps the plants tire of the technical issues and finds other means of appearing “green”, i.e. with renewable energy sources in the fuel mix.

The 5-year contract provided by Vapo and the PVO group in Finland seem to work very well for growers and fuel-users. A similar security is found in parts of France where Bical is providing contracts with similar degree of duration, stretching over 5 harvests (7 years as there is no harvest the first two years). The growers in these areas are certain of a future market of energy crops, especially with rising oil- and gas prices and expected increase in demand for biofuel. The perceived market risk is thus lowered with such a contract.

The situation described above would imply that the Swedish production of Salix or hemp could take a leap forward if there were buyers providing similar type of long-term contracts, for example Agroenergi or energy companies/heating plants. But what might seem odd is that few of the interviewed growers are at all interested in long-term contract as a theoretical option – rather it is the power plants that are looking for such commitment from the farmers.

Generally, there is still a gap between the markets and the producers, or perhaps a time lag – producers are expecting to be commercially viable in a time when biofuel is clearly favored over conventional fuels like oil- and gas by policymakers and an increase in competition is to be expected, but the buyers are not yet admitting to being in want for additional primary energy sources or willing to pay more than they currently do – or perhaps this impression is part of a business strategy. However, in the Central part of Sweden where biofuel prices are up to 33% higher than in the Southern part, it is definitely starting to show that there is a demand for agro-biofuel for district heating boilers, and if the international competition for biofuel increases due to political decisions or rising oil price, it is likely that the energy companies in Southern Sweden follow suit.

10.2 Should farmers be producing energy and do they want to?

Most studies so far on the topic of attitudes towards energy crops show that farmers have an aversion to such crops because they might change the landscape to the worse, they are new and risky both from the production- and market perspective and moreover, it is counterintuitive for the farmer to plant shrubs on cropland. However, although the main conclusion of this work can be summarized in the introductory quote *“If there are buyers, there will be growers”*, which has been a recurring remark from interviewees during this work, other perspectives on the matter have been that a farmer can be tired of cereals and want to try something new, want to diversify or become less dependent on subsidies and therefore want to expose themselves to the promising energy market, on which prices have been rising continuously in the first half of 2008.

In fact, some growers interviewed for this study were not as impressed by the price increase for cereals as by the oil price boom that made biofuels determinedly favorable over fossil fuels for heat- and power plants. Moreover, aging farmers in all three countries studied discover the benefits of planting something with less work requirement on the farm, just like farm-owners who have jobs outside of the farm or want farming more as a hobby because they happen to be landowners.

Regarding the different views on whether energy production should replace food production on arable land, there might be historical and geographical reasons as to why the French farmers consistently expressed concern about agro-biofuel production pushing out food production, whereas the Swedish farmers concluded that energy production is equally important and the Finnish farmers did not seem to reflect over this issue at all. This could be due to the fact that Sweden and Finland are Northern countries with cold climates, where availability of stored energy for heating purposes has been as crucial for survival as food. Also, the position of France in the middle of Europe compared to the somewhat more periphery location of Sweden and Finland, and the huge importance of France as producer of agricultural products (i.e., food) could be a reason for the much greater concern of the French farmers than the Swedish and Finnish over energy production substituting food production.

10.3 Conclusions

10.3.1 Risk perceptions for commercial production of energy crops

The study indicates that energy crops should be planted by entrepreneurial farmers who can integrate far into the production chain (possess machines and possibly negotiation skills) and thus reduce the amount of middle hands and have high cost control. Inactive farmers who will accept a low economic return from the land in return for a small labor input can sell the crop on the spot. Active farmers are generally the least satisfied with the energy crop production - a better organization in place among the farmers themselves in order to strengthen negotiation power and increase the cost control could perhaps alter the perception that the economic results of the production of energy crops is unacceptably low.

For the grass crops like hemp, miscanthus, switchgrass and RCG, the production risk is in fact perceived as lower than for cereals. Harvesting techniques, other logistical issues and combustion technologies for dry crops with relatively high ash content and low ash melting points (compared to wood chips) however need to be improved in order to reduce costs and increase competitiveness. These production issues have significant implications for the economic results from the production activity, in particular for attracting buyers.

A medium high degree of duration of a contract reduces the market risk perception. This is illustrated by the fact that the market risk was found to constitute a tangible risk in all cases due to the insufficiently evolved markets, except for the Finnish case, where the 5-year contracts appear to suit both parties, and in a few cases in France where 7-year contracts were perceived as having ideal length by producers.

Both the market situation and the policy situation are almost exclusively expected to work in favor of the energy crop producers (i.e., higher price) in the future. Policies are however perceived as volatile both for agricultural production and for bioenergy, and a business activity strongly dependent on policies is not perceived as reliable. A more reliable policy environment could therefore increase the uptake of energy crops as well as the use of energy crops by heat- and power producers.

The information need is hardly overwhelming, since most farmers today have internet-connection and access to advisors and agricultural journals and magazines. However, experience exchange and study visits among farmers were requested, in particular in Sweden. More contact with markets and potential buyers is also requested, and a potential means of strengthening the energy crop producers' market position would be to provide consultations with marketing experts – marketing is hardly what the typical farmer is used to, but perhaps what the farmer who wants to succeed on the energy market (in the case of agro-biofuel, the local or regional energy market) needs.

10.3.2 Proposed contract model for commercial production of energy crops

Based on the results from interviews with growers and users of energy crops, it appears that a preferable duration is some 5 years, i.e. medium high degree of duration. However, if it is to achieve some outcome, the degree of duration should be compensated by a high degree of flexibility to attract the farmers, who particularly in Sweden are reluctant to long-term contractual commitments, meaning that price negotiations should take place every year and both parties (in particular, this is important for the growers because the energy crop

production is typically more important in their business portfolio than the agro-biofuel is to the power plant) can cancel the contract if circumstances fundamentally change.

The degree of cost control is preferably worked out on an individual basis with the farmer (unless this conveys unacceptable costs), and could very well vary depending on the farmer category he/she belongs; farmers who are agricultural entrepreneur tend to favor selling at the gate, active farmers tend to favor selling at the edge of the field and inactive farmers tend to favor selling on the root. A solution could be to develop three different contractual models according to the desired degree of cost control.

Figure 10-1 shows the conceptual contract model, where the red line indicates the proposed contract model for commercial production of energy crops.

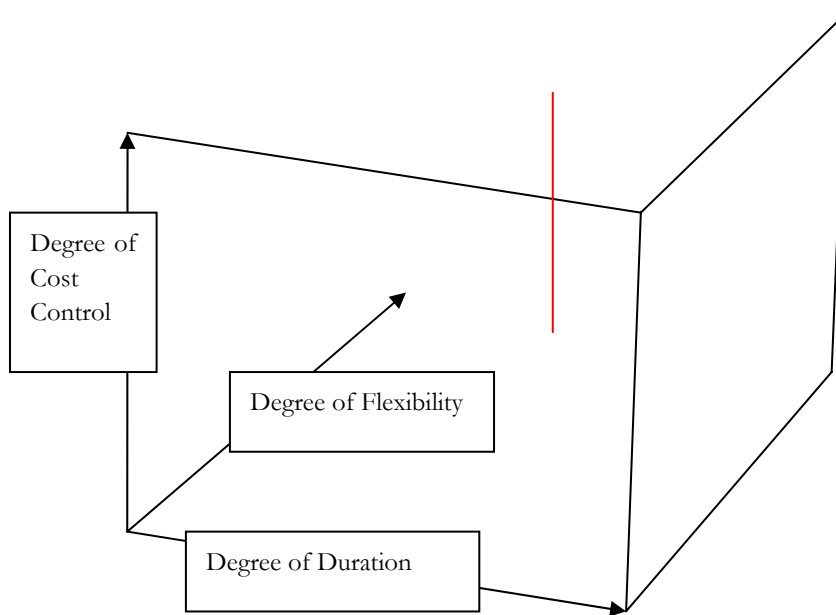


Figure 10-1 Conceptual contract model applied to European commercial production of energy crops

The price for the agro-biofuel is preferably following the price conventional biofuel. This is often a natural development since they are comparable products. As little manipulation of the markets as possible is an advantage in order to build up confidence for the agro-biofuel as a reliable primary energy source, and justify investments to adapt to this type of fuel.

However, having a part of the price indexed to the oil- and diesel price index or price renegotiations regularly or in case of drastic price increases will divide the risk of suddenly increasing transportation costs between the producers and fuel-users and seem to be a feasible and fair option, based on what has been stated in interviews.

As a quality assurance measure for the fuel-user, it is reasonable that the price varies with the moisture content (i.e., quality) of the delivered product and that the “windfall revenues” from

financial policy instruments applied over Europe or nationally, for example the European Trading Scheme, tax refunds on electricity or feed-in tariffs, be paid to the farmer as an incentive or “carrot”.

10.4 Future research needs

This has been a mostly qualitative study, delineating the risk perceptions, barriers and contractual preferences among producers and users of agro-biofuel. A statistical study to follow up on the findings and conclusions would provide a better understanding of the (relative) magnitudes of the risk perceptions. In particular, a survey over contractual preferences to show whether the preferences delineated in this study for the contractual model proposed can be statistically verified.

Several findings in this study could be investigated on a more detailed level. This includes the potential economic results of energy crop production for the three categories of farmers given different circumstances or “scenarios”, and a thorough analysis underpinning the categorization, and detailing the conditions under which each category is operating. For example, the level of debt (high for entrepreneurial farmers who bought their land to market price and low for inactive farmers who perhaps have inherited their land?), implying different perception of the alternative cost of land, and how this affects the choice of production activity.

Another area of research to explore is how the state or municipality could be involved in a contract model for a case like this when subsidies might be an absolute requirement for the business activity to be viable. Should this in fact be a three-part contract, involving the producer, the buyer and the State?

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Interviews

Name	Role / Company	Time and place of interview	Comment
Larsson, S.	Agroenergi	May 25, Småland, Sweden	Not following question sheet
Mattson, G.	Salix-grower	June 3, Skåne, Sweden	Pilot interview
Segerslätt, S.	Salix-grower	June 3, Skåne, Sweden	
Eriksson, H.	Farmarenergi Hallstahammar	June 5, Södermanland, Sweden	Telephone interview
Nyrén, J.	Mälarenergi	June 5, Södermanland, Sweden	Telephone interview
Holmén, E.	ENA Energi	June 5, Uppland, Sweden	Telephone interview
Henriksson, G	Salix-grower	June 9, Skåne, Sweden	
Klapp, R.	Salix-grower	June 9, Skåne, Sweden	
Jonsson, G.	Salix-grower	June 10, Västra Götaland, Sweden	Telephone interview
Nordström, L.	Salix-grower	June 16, Uppland, Sweden	
Thärnström, C.	Salix-grower	June 16, Uppland, Sweden	
Löfgren, A.	Salix-grower	June 17, Uppland, Sweden	
v. Stockenström, H.	Salix-grower	June 17, Uppland, Sweden	
Sällberg, M.	Salix-grower	June 17, Södermanland, Sweden	
Persson, S.	Rindi AB	June 18, Skåne, Sweden	Pilot interview
Jour, B.	Miscanthus-grower	June 23, Eure et Loir, France	
Maria, D.	Miscanthus-grower	June 23, Eure et Loir, France	
De Varine, B.	Miscanthus-grower	June 24, Eure et Loir, France	
Lecomte, A.	Miscanthus-grower	June 26, Calvados, France	
Leboeuf, D.	Miscanthus-grower	June 26, Calvados, France	

Guillot, N.	Miscanthus-grower	June 27, Calvados, France	
Dumont, T.	Miscanthus-grower	July 1, Calvados, France	
Crosnier, R.	Switchgrass-grower	July 2, Indre-et-Loire, France	
Arrault, X.	Miscanthus-grower Switchgrass-grower	July 2, Indre-et-Loire, France	
Guillier, M.	Miscanthus-grower Switchgrass-grower	July 2, Indre-et-Loire, France	
Bizieux, F.	Miscanthus-grower Switchgrass-grower	July 3, Indre-et-Loire, France	
Fournier, F.	Miscanthus-grower Switchgrass-grower	July 3, Indre-et-Loire, France	
Bersonnet, C.	Chambre d'Agriculture	July 3, Indre-et-Loire, France	
Jonsson, S.	Hemp-grower	July 22, Västra Götaland, Sweden	
Wendel, H.	Hemp-grower	July 23, Skåne, Sweden	
Jacobsson, T.	Hemp-grower	July 23, Skåne, Sweden	
Andersson, J.	Hemp-grower	July 24, Skåne, Sweden	
Mårtensson, B.	Hemp-grower	July 30, Skåne, Sweden	
Bengtsson, L.	Former hemp-grower	July 30, Skåne, Sweden	
Slagbrandt, R.	Agroenergi	August 4, Skåne, Sweden	Telephone interview
Ottosson, P.	Lunds Energi	August 13, Skåne, Sweden	
Rosenqvist, H.	Researcher, SLU	August 14, Skåne, Sweden	Not following question sheet
Svensson, S-E.	Researcher, SLU	August 14, Skåne, Sweden	Not following question sheet
Paappanen, T.	Researcher, VTT	August 18, Jyväskylä, Finland	Not following question sheet
Laitinen, V.	Proagria	August 18, Jyväskylä, Finland	Translation by T. Paappanen
Luas, P.	RCG-grower	August 19, Ostbotnia, Finland	Translation by T. Paappanen
Volanto, P.	RCG-grower	August 19, Jyväskylä, Finland	Translation by T. Paappanen

Haapamäki, H.	RCG-grower	August 19, Jyväskylä, Finland	Translation by T. Paappanen
Nyysti, J.	RCG-grower	August 20	Translation by T. Paappanen
Hantamäki, M	RCG-grower	August 20	Translation by T. Paappanen
Ala-Mäyry, H.	RCG-grower	August 20, Ostbotnia, Finland	Translation by T. Paappanen
Takala, J.	RCG-grower	August 20, Ostbotnia, Finland	Translation by T. Paappanen
Kälviäinen, H.	RCG-grower	August 20, Ostbotnia, Finland	Translation by T. Paappanen
Hipakka, J.	Vaskiluodon Voima	August 20, Ostbotnia, Finland	Translation by T. Paappanen
Kuasmanen, A.	Fortum Voima Joensuu	August 21, Joensuu, Finland	Translation by T. Paappanen
Villa, A.	Researcher, Joensuu University	August 21, Joensuu, Finland	Not following question sheet
Rannila, K.	Fortum Voima, Jyväskylä	August 22, Jyväskylä, Finland	
Hammar, T.	E.ON Malmö	August 28, Skåne, Sweden	
Resmark, M.	E.ON Malmö	August 28, Skåne, Sweden	

Abbreviations

Svebio – Swedish Bioenergy Association

RCG – Reed canary grass

VTT - Technical Research Centre of Finland

MTT – Agrifood Research Finland

INRA – Institute National de la Recherche Agronomique

ETS – European Trading Scheme

CO² - Carbon dioxide

SLU – Swedish University of Agriculture

MWh – Megawatthour (unit of energy)

SEK – Swedish Krona (the Swedish currency)

PVO – Pohjolan Voima

Appendices

- A - Compiled Energy Crop Data
- B - Profitability calculation for Salix in Sweden
- C - Production and harvesting costs for RCG in Finland
- D - Subsidies for RCG in Finland
- E - Contractual agreements made by Vapo, Finland
- F - Contractual agreements made by Vaskiluodon Voima, Finland
- G - Pre-specified questions for interviews with farmers
- H - Pre-specified questions for interviews with fuel-users
- I - Map of regions and departments, France
- J - Map of Finland

Appendix A

Compilation Energy Crop Data

	Salix	Hemp	Miscanthus	Switchgrass	Reed Canary Grass
Energy content²	4.5 MWh/dry ton (SOU 2007:36)	5.1 MWh/dry ton (SOU 2007:36)	4-4.4 MWh /dry ton (Bical)	5.1 MWh/dry ton (Cardiff School of Biosciences)	5 MWh/dry ton (MIT)
Moisture content at harvest	45-55 % (SOU 2007:36)	10-20 % (SOU 2007:36)	12-20 % (Bical)	15-30% (Cardiff School of Biosciences)	10-20 % (MIT)
Lifetime of plantation	~25 years (harvest every 3-5 years)	1	15-20 years (annual harvest)	10-20 years	~10 years (annual harvest)
Cost of growing³	134 SEK/MWh	269 SEK/MWh	233 SEK/MWh	Establishment cost: ~3000 SEK/ha	197 SEK/MWh
Harvest cost⁴	~42 SEK/MWh at 22 dry ton/ha	71 SEK/MWh at 7.5 dry ton/ha	71 SEK/MWh at 7.5 dry ton/ha	71 SEK/MWh at 7.5 dry ton/ha	71 SEK/MWh at 7.5 dry ton/ha
Average yield⁵	9 dry ton/ha and year	10 dry ton/ha	10 dry ton/ha	-	7.5 dry ton/ha
Price of raw material⁶	120-150 SEK /MWh (at the gate)	120-150 SEK/MWh (at the gate) 500 - 600 SEK/MWh (briquettes)	140 SEK/MWh (at the gate)	140 SEK/MWh (at the gate)	100-130 SEK/MWh (at the gate)
Cost reduction potential compared to cereals⁷	32 %	12%	18%	-	15%

² These are indicative figures and can vary with production conditions

³ Rosenqvist (2006). Cost of cultivation in Sweden incl. machinery and OH-costs

⁴ To edge of field. Estimation for Salix from Agroenergi (2006), estimation for grass plants from Sven-Erik Svensson (2008) and assumed equal

⁵ Rosenqvist (2006)

⁶ According to data from producers and fuel-users (2008)

⁷ Rosenqvist (2006)

Appendix B

Profitability calculation for Salix in Sweden

Source: Agroenergi

Plantation year – first harvest (5 years)

Subsidies and revenues	Period/size	Amount (SEK)
Investment subsidy	For 2008	5000
Energy crop subsidy	45□/ha * 5 yrs	2000
Harvest 16 ton ts/ha	465 SEK/ton ts	7440
<i>Sum S+R</i>		<i>14 440</i>
Costs	Period/type	Amount (SEK)
Planting	For 2008	8600
Soil preparation	Spraying, ploughing and harvest	1700
Weed control	Spraying etc	700
Fertilizers	500 kg NPK	1500
Chopping	First winter after planting	300
<i>Sum C</i>		<i>17 000</i>
<i>Sum C – (S+R)</i>		<i>- 2560 (-512 SEK/ha and year)</i>

First harvest - Second harvest (4 years)

Subsidies and revenues	Period/size	Amount (SEK)
Energy crop subsidy	45□/ha * 4 yrs	1600
Harvest 23 ton ts/ha	465 SEK/ton ts	10 695
<i>Sum (SIR)</i>		<i>12 295</i>

Costs	Period/type	Amount (SEK)
Weed control		350
Fertilizers	500 kg NPK	1500
Harvest	23 ton ts	4800
<i>Sum C</i>		<i>6650</i>
<i>Sum C- (S+R)</i>		<i>5645 (1411 SEK/ha and year)</i>

Appendix C

Production and harvesting costs for RCG in Finland

Source: VTT

	Loose harvesting		Round bales		Square bales	
	€/ha	€/MWh	€/ha	€/MWh	€/ha	€/MWh
Cultivation						
Control of quick-grass			1,36	0,05		
Ploughing			5,47	0,19		
Harrowing			2,34	0,08		
Sowing			4,27	0,15		
Handling of fertilizer			0,36	0,01		
Roll compaction			1,87	0,07		
Weed control spraying			1,36	0,05		
Seeds	12 kg/ha	5,5 €/kg	6,60	0,23		
Fertilizer	300 kg/ha	378 €/t	11,33	0,40		
Glyphosate	4 l/ha	4,51 €/l	1,80	0,06		
Herbicide	1,5 l/ha	6 €/l	0,90	0,03		
Total	37,66	1,33	37,66	1,33	37,66	1,33
Ending of RCG plantat.						
Spraying			1,36	0,05		
Glyphosate			1,80	0,06		
Total	3,16	0,11	3,16	0,11	3,16	0,11

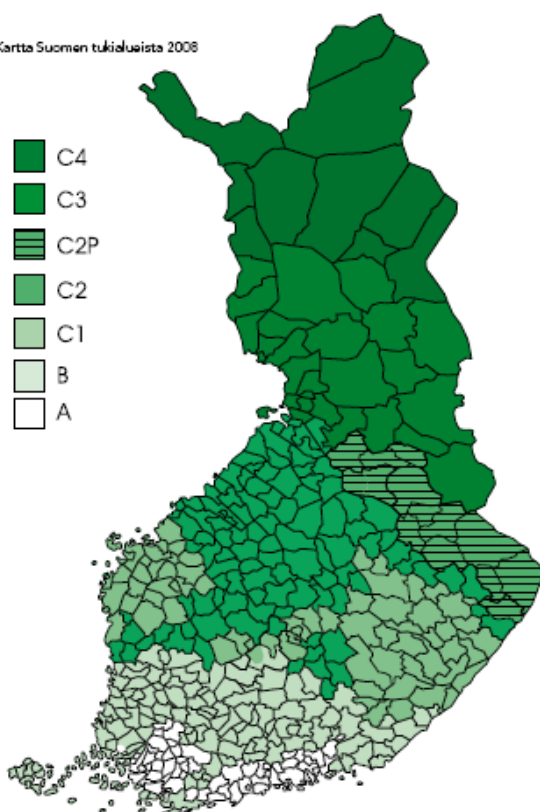
Annual fertilizing						
Fertilization			13,60	0,48		
Fertilizer	325 kg/ha	378 €/t	122,69	4,33		
Total	136,29	4,81	136,29	4,81	136,29	4,81
Harvesting						
Mowing	32,40	1,14	32,40	1,14	32,40	1,14
Windrowing					17,30	0,61
Chpping/baling	120	4,24	126,37	4,46	141,00	4,98
Transp. to field storage	31,46	1,11	27,92	0,99	24,47	0,86
Storage, labour	14,59	0,52	12,28	0,43	12,34	0,44
Storage, materials	45,38	1,60	29,32	1,04	25,11	0,89
Total	243,82	8,61	228,29	8,06	252,62	8,92
Field costs						
Capital cost of field			138,54	4,89		
Capital cost of drainage			124,44	4,39		
Total	262,98	9,29	262,98	9,29	262,98	9,29
TOTAL	683,92	24,15	668,38	23,60	692,72	24,46

Appendix D

Subsidies for Reed Canary Grass in Finland

€/ha	Support zone					
	A	B	C1	C2	C3	C4
CAP	246,60	195,84	195,84	152,67	152,67	152,67
LFA	150,00	200,00	200,00	210,00	210,00	210,00
LFA national supplement	20,00	20,00	20,00	25,00	25,00	25,00
Environmental subsidy						
- Crop farming farm	93,34	93,34	93,34	93,34	93,34	93,34
- Cattle farm	107,00	107,00	107,00	107,00	107,00	107,00
- National supplement						
General ha subsidy				35,00	51,00	102,00
Energy crop subsidy	30,00	30,00	30,00	30,00	30,00	30,00
Total, crop farm	539,94	539,18	539,18	546,01	562,01	613,01
Total, cattle farm	553,6	552,84	552,84	559,67	575,67	626,67

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Appendix E

Contractual agreements by Vapo, Finland

Duration of the contract is 5 years, after which the agreement continues automatically one year at the time if neither of the parties serve notice of termination. Vapo is also willing to negotiate a new 5-year contract.

The price is fixed for 5 years (of which the two first years the farmer will have no revenues, since the first year of harvest is the third year). It is not bound to any indexes, which is also the case for peat and wood chip.

An unfairness clause stipulates that the price can be renegotiated if circumstances fundamentally change. Such circumstances are for example refund or electricity tax to power plants, some new support for renewable energy or significant rise of the price paid by power plants.

The price paid to farmers is 50 – 200 Euro/ha depending on the harvest yield, moisture content, transportation distance and price paid by the power plant. The base price is increased by 10 % if the harvest is over 4,5 dry ton/ha and 20 % if over 6 dry ton/ha (the farmer with the highest yield in each of the five districts is awarded with a gift). The best price is paid if moisture content is below 14 %, it is lowered if over 20 % and over 30 % there is no price paid at all, although Vapo still must fetch the RCG.

Appendix F

Contractual agreements by Vaskiluodon Voima (PVO), Finland

Duration of the contracts is 5 years. Although the agreement is binding for both parties, the farmer can cancel the contract without specific reasons.

The contract stipulates the form and size of the RCG produced (round/square bales or chaff). The bales must be tied with natural fiber Sisal-string or plastic bale net

Minimum cultivation area is 5 ha.

The transportation cost is either paid by the producer or the buyer. If the producer delivers the bales, this should be done within 2 weeks after harvesting. If the buyer fetches the bales, this should be done in early summer according to a fuel use plan. Payment goes through when the whole harvest is delivered to the plant.

The price paid depends on the quality (i.e. moisture content), the price of CO² in the ETS and the transportation distance (3 distances). The quality is divided into two classes; moisture content below 20 % and below 35 %, the highest moisture content allowed. The cost savings from CO² reductions is awarded the producer up to a maximum of 18 Euro/ton. The transportation distance is divided into three categories; under 40 km, 41-80 km and 81-120 km.

Price examples:

At the gate: assuming quality class 1 and a price of CO² at 18/10 Euro/ton, RCG chaff is paid 55/43 Euro/ton (at the gate)

At field storage: assuming quality class 1 and a price of CO² at 18/10 Euro/ton, bales (1,5 m in diameter and minimum 260 kg) are paid 6,1/3 Euro/bale if under 40 km distance to the plant, 5,8/2,6 Euro/bale if 41-80 km distance to the plant and 5,1/1,9 Euro/bale if 81-120 km distance to the plant.

Appendix G

Pre-specified questions for producer interviews

A. Role and importance of dedicated energy crops in the overall farm business

1. *How many hectares are you currently cultivating energy crops on?*
2. *When did you first plant the energy crop?*
3. *What were your reasons for planting the energy crop?*
4. *How much/what kind of work do you put into the plantation? More/less than other crops?*
5. *What is the yield?*
6. *Can you estimate your production cost?*
7. *Who is the buyer of the energy crop and what contract(s) do you have for it?*
8. *Have you been profitable and are you satisfied with your decision to plant the energy crop?*
9. *How large is the share of income from the energy crop cultivation of the overall farm income/total income of farmer?*

B. Cost control, price-setting and contract preferences

10. *Are you currently selling on the root, from the edge of the field or at the gate of the buyer?*
11. *Would you prefer/consider any of the other options above, and why?*
12. *Would you prefer the price of the energy crop product to follow the biofuel prices in the region, the profitability index for cereals, CPI or any other indexes?*
13. *Do you prefer a short-term contract (annual), a midterm contract (3-5 years) or a long-term contract (>5 years)?*
14. *(For Salix-growers) Would you prefer a contract that gave you a deduction price for the future crop harvest each year instead only having an income at the year of harvest?*
15. *Are you or would you prefer/consider securing the price of the harvest at the market for futures and options?*
16. *Would you consider an option of total vertical integration from the buyers' side, like Findus is currently growing their peas?*
17. *Which of the above alternatives would you prefer and would any of them make you more inclined to keep your plantation?*

C. Perception of attitudes towards energy crops

18. *What is the share of cropland in the country that should be dedicated to fuel crops instead of food crops?*

19. *Why do not farmers grow more energy crops in Sweden?*

20. *If farmers were offered long-term contracts guaranteeing 100 Euro/ha more profits for the energy crop than for cereals, how much land would be planted with the energy crop?*

D. Perception of risks and barriers associated with energy crops

21. *What risks are there when cultivating an energy crop?*

22. *Which is more important, the technical, biological or market risk?*

23. *Is the technical, biological or market risk respectively larger than for cereals?*

24. *What kind of problems have you experienced?*

25. *What do you think can be done to reduce the risks associated with energy crop cultivation?*

E. Information needs

26. *What kind of information do farmers require in order to become interested in growing energy crops? Production advice, economic advice or logistical advice?*

27. *Is this kind of information readily available for farmers?*

28. *Who is responsible to provide such information?*

F. General farm information

29. *Total farm area, share owned and share leased*

30. *Employees*

31. *Other business activities at the farm (crop- or cattle production, horses, tourism etc)*

32. *Age of farmer*

Appendix H

Pre-specified questions for fuel-user interviews

A. Role and importance of dedicated energy crops in the overall farm business

1. *How large is the share of biofuel and agro-biofuel respectively in the overall fuel use at the plant?*
2. *What are your motives for using energy crops for combustion at the plant?*
3. *Have you encouraged production of energy crops at farms in the vicinity?*
4. *How are the contracts formed that you currently have with suppliers of biofuel/ agro-biofuel?*
5. *How large is the share of fuel costs of total costs for the plant?*
6. *How important is it for you to secure fuel supply each year or for a few years in the future (how many years)?*
7. *How important is it for you to have a supply of fuel from agriculture?*
8. *A farmer can choose from year to year to plant a new crop. How could you "tie" a farmer to planting energy crops?*

B. Price-setting options and preferences for contractual forms

9. *How are you setting the price of agro-biofuel?*
10. *What other prices or indexes are influential on the price?*
11. *What are the most important drivers behind price change for heat and electricity?*
12. *How would your financial results change if the price of agro-biofuel was linked to other fuels in the plant, biofuels in general, profitability index for cereals, CPI or other indexes?*

13. *Do you prefer short-term (annual), midterm (3-5 years) or long-term (>5 years) contracts?*

14. *How often shall the price be negotiated?*

C. Risk perceptions for energy crop use

15. *Have you experienced technical problems from the use of energy crops in the heat/power production?*

16. *How large is the maximum share of agro-biofuel that can be combusted simultaneously?*

17. *Do you see any changes in the risks of securing supply of biofuel? From forestry? From agriculture?*

18. *Do the suppliers today have more options to choose buyer?*

D. Expectations on future demand for biofuel/agro-biofuel

19. *Do you see any reasons why the demand of biofuel/agro-biofuel would increase? Political, technical, market reasons?*

20. *Are you interested in other energy crop types than the one you currently use?*

21. *How do you see the development of the oil price, biofuel prices, national energy mix and national/European policies affecting fuel prices (such as the CAP or energy policy)?*

a. General company information

22. *Production capacity*

23. *Company structure and size*

24. *Type of boilers at the plant*

25. *Recent/planned investments*

Appendix I

Map of Regions and Departments, France

The interviews were conducted in department 37 (Indre et Loire), department 28 (Eure et Loir) and department 14 (Calvados).



Appendix J

Map of Finland

The interviews were conducted in and around Seinäjoki (Ostbotnia), Jyväskylä and Joensuu.



