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The Swedish biofuel market - studies of Swedish foreign biofuel trade and of the consequences of hurricane Gudrun

Olle Olsson

UPPSALA
UNIVERSITET

Teknisk- naturvetenskaplig fakultet
UTH-enheten

Besöksadress:
Ångströmlaboratoriet
Lägerhyddsvägen 1
Hus 4, Plan 0

Postadress:
Box 536
751 21 Uppsala

Telefon:
018 – 471 30 03

Telefax:
018 – 471 30 00

Hemsida:
http://www.teknat.uu.se/student

Abstract

The Swedish biofuel market - studies of Swedish foreign biofuel trade and of the consequences of hurricane Gudrun

Olle Olsson

Growing awareness of the limited supply of fossil fuels, combined with the realisation that combustion of fuels such as oil and coal is a cause for global warming, has led to increased interest in renewable energy sources. One such is bioenergy, energy extracted from biological material. Bioenergy is Sweden's largest renewable energy source and accounts for 17% of Swedish energy supply. Biological material used for energy purposes is generally referred to as biofuels. This thesis has studied two aspects of the Swedish biofuel market, with focus on the biofuels used in the district heating sector. The first objective has been to investigate the extent and characteristics of Swedish foreign biofuel trade. This investigation has resulted in an estimation that roughly 7 TWh (25 PJ) of biofuels were imported in 2003, mainly from the Baltic States, North America and Mainland Europe. In the same year about 0.1-1 TWh (0.36-3.6 PJ) of biofuels were exported.
The second objective has been to investigate how the Swedish biofuel market has been affected by hurricane Gudrun, which struck the south of Sweden early January, 2005. This investigation shows that the effects of the hurricane on the biofuel market have been rather mild so far. The largest effect has been a dramatic decrease of the extraction of logging residues in the storm area, which may result in a scarcity of biofuels in Southern Sweden in 2006. This will in turn probably lead to an increased Swedish biofuel import and higher biofuel prices.

Handledare: Bengt Hillring
Ämnesgranskare: Matti Parikka
Examinator: Elisabet Andresdottir
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Sammanfattning

Förnyelsebara energikällor väntas få en allt större betydelse för världens framtida energiförsörjning. Detta beror i hög grad på en växande medvetenhet om den begränsade tillgången på fossila bränslen och ökade farhågor för att utsläpp av växthusgaser kan bidra till globala klimatförändringar. En av de förnyelsebara energikällor som det sätts störst hopp till är bioenergi, energi utvunnen genom förbränning av biologiskt material. Den stora fördelen med bioenergi, jämfört med energi som utvinns ur fossila bränslen, är att bioenergi inte bidrar till växthuseffekten, då den mängd koldioxid som släpps ut i atmosfären vid förbränning av en växt är lika med den mängd koldioxid som tas upp av den förbrända växten under dess levnadstid. Bioenergi svarar för 17 % av Sveriges energitillförsel vilket gör bioenergi till Sveriges största förnyelsebara energikälla. Merparten av ökningen av användningen av bioenergi i Sverige har ägt rum de senaste 25 åren som ett resultat av goda råvarutillgångar i form av skog och starka politiska styrmedel med höga skatter på fossila bränslen och stöd till användning av biobränslen. I och med denna starka ökning av användningen av bioenergi har det också vuxit fram en stor biobränslemarknad där de största köparna är fjärrvärme- och kraftvärmeverk.

I det här examensarbetet har två aspekter av den svenska biobränslemarknaden studerats. För det första har en studie gjorts för att undersöka den svenska utrikeshandeln med biobränsle under 2003, och för det andra har undersökts hur biobränslemarknaden påverkades av orkanen *Gudrun*, som drabbade södra Sverige natten till den 9 januari 2005. Arbetet för att uppfylla dessa mål har bedrivits genom en blandning av användande av befintliga källor såsom offentlig statistik och ny information som inhämtats genom en enkät och ett flertal intervjuer med aktörer på biobränslemarknaden.

Undersökningen av den svenska utrikeshandeln med biobränsle har resulterat i en uppskattning att ungefär 7 TWh importerades till Sverige 2003, något som är en ökning sedan slutet på 90-talet då importen uppskattades vara runt 6 TWh. Importen dominerades av restprodukter från skogsindustrin och torv från Baltikum, tallolja och pellets från Nordamerika samt hushållsavfall och återvunnet trä från Holland och Tyskland. Exporten av biobränslen från Sverige är av olika orsaker svår att uppskatta men en bedömning är att 0.1-1 TWh biobränsle exporterades 2003. Exporten bestod i huvudsak av tallolja, torv och pellets och gick till Norge, Storbritannien, Danmark med flera.

Orkanen *Gudrun* fällde skog i södra Sverige motsvarande en hel årsavverkning för hela landet. Då den svenska biobränslemarknaden till stor del består av avverkningsrester och biprodukter från sågverksindustrin var det rimligt att tro att marknaden skulle påverkas på ett eller annat sätt av denna naturkatastrof. Undersökningen som gjorts visar emellertid att påverkan från orkanen har varit relativt mild. Den största effekten är att uttaget av avverkningsrester har minskat drastiskt i södra Sverige på grund av att bränsleanpassade avverkningar ej har kunnat utföras i de stormdrabbade skogarna. Detta kan komma att medföra en brist på oförädlade biobränslen i södra Sverige, då den ökade mängden sågverksrester som kommer ut på marknaden efter stormen knappast räcker för att kompensera bristen på avverkningsrester. En eventuell massiv nedklassning av massaved till bränsleved den kommande våren kan dock komma att ersätta denna brist. I annat fall kan en ökning av importen av biobränsle till södra Sverige förväntas, och en fortsatt stigning av priserna på biobränsle är också att vänta.

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1 Introduction

The depletion of the world's oil resources, combined with growing concerns that combustion of fossil fuels may be a cause for global warming, has led to a rapidly increased interest in finding alternative energy sources. One such is *bioenergy.* Bioenergy is energy that is extracted from (predominantly vegetable) biological material. Bioenergy is considered a renewable energy source since plants are continuously regenerated through the photosynthesis. Bioenergy is also carbon dioxide-neutral, since the amount of carbon dioxide released through the burning of the plant is equal to the amount absorbed by the plant in its lifetime. In the last twenty-five years, Sweden has managed to almost halve its dependency on oil, something that to large extent has been achieved by replacing oil with biofuels in the district heating sector and the forest industry. A major reason for the rapid growth of bioenergy in Sweden has been the large raw material resources available in the country's vast forests. Residues from loggings and the forest industry make up the bulk of the biofuels used in Sweden. Bioenergy now accounts for 17% of Swedish energy supply and is expected to continue to grow especially since bioenergy is to play a large part in the fulfilment of the government's goal that Sweden will have broken its dependency on oil by 2020.

The growth of bioenergy use has naturally led to a growth of biofuel trade and the biofuel market, which will be the main themes of this report.

1.1 Project objectives

The project laying the ground for this report has had two main objectives:

1. With the increased use of bioenergy and a high demand for biofuels in Sweden, a substantial increase of import of biofuels has taken place since the beginning of the 1990's. The first objective of this project has been to investigate the Swedish foreign biofuel trade in the year 2003. The year 2003 has been chosen because the investigation is to be part of an EU project, *EUBIONET*[1], focused on investigating European biofuel trade as a whole, using the year 2003 as its point of reference.
2. The ravaging of hurricane *Gudrun* on 8-9 January 2005 felled almost as many trees as is normally cut annually in the whole of Sweden, something that was bound to affect the forest industry in one way or another. But what about biofuels? How would the Swedish biofuel market, which consists mostly of forest residues, be affected? The second objective of the project has been to investigate how the Swedish biofuel market has been affected by hurricane *Gudrun*.

1.2 Disposition

The report begins with a chapter (2 Methodology) describing the methodology used during the project, after which the Definitions chapter (3) discusses some key terms essential for comprehension of the subject at hand. The next chapter (4 Bioenergy in Sweden-past, present and future) gives the history of bioenergy development in Sweden and a brief outlook at the coming years. After this introduction to bioenergy in general follows a section (5 Bioenergy trade) discussing different aspects of bioenergy trade, covering some key characteristics of this subject, e.g. who the actors on the market are, the logistics of biofuel trade and so on.

[1] See www.eubionet.net for more information on the EUBIONET project as a whole.

From here the report will be divided into two parts according to the two objectives. The first objective is also the first to be focused on in chapter 6 (Objective 1: The Swedish foreign biofuel trade in 2003), investigating the Swedish foreign biofuel trade in 2003. Here is given a rendition of the backgrounds of the Swedish import and export of biofuel. Then some estimations of the extent of the trade are presented and compared, resulting in a combined estimation. The second objective is in focus in chapter 7 (Objective 2: The effects of hurricane *Gudrun* on the Swedish biofuel market), with the consequences of hurricane *Gudrun* on the biofuel market being discussed in chronological order. Ending the report (8 Conclusions and final discussion) is a summary and a discussion of the results and of the report as a whole, along with propositions for what kind of research is to be done to acquire more thorough understanding of Swedish biofuel trade.

1.3 Project limitations

Although the forest-related industries are the biggest users of biofuel in Sweden, they mostly use own-produced fuels, which never enter an open market. This makes the district heating plants the biggest buyers of biofuel in Sweden. Therefore focus in this project is on the biofuel traded for use in the district heating sector.

Also, the project does not include investigation of the consumers market for biofuel used for heating of detached houses, since an investigation of this market would demand a completely different approach than the large scale trading of biofuels for use in district heating.

2 Methodology

2.1 Background research and project strategy

The first stage of the project was initiated in the beginning of summer 2005 and consisted of collecting sufficient background information. This was initially mainly collected from literature such as *Energi från skogen*[2], *Växande Energi*[3] and a number of scientific articles. However, as the development in the bioenergy area is proceeding quickly, it soon became apparent that other sources had to be used in able to get a more up to date perception of the field. Periodicals such as *Nordisk Energi*[4], *Energimagasinet*[5] and particularly *Bioenergi*[6], provided insight into the current development in the bioenergy sector. The Internet was also used extensively for this purpose.

Although the bioenergy sector is rather large in Sweden, it has not been very thoroughly studied and the mechanisms of the biofuel market still hold many question-marks. Therefore it was necessary to use many different approaches to obtain the information needed to make a well-founded analysis and reach credible conclusions about the subjects in question.

2.2 Literature studies

Work aiming to construct the theoretical framework on which to base the analysis of the empirical results began early on and continued all through the autumn. Much of the material was based on the previously mentioned *Energi från Skogen*[7] and *Växande Energi*[8], but since these in many cases were not able to provide sufficiently comprehensive information, other sources had to be used. The Internet proved to be an invaluable resource for this task. The websites of the *Swedish Energy Agency*[9], *Swedish Forest Agency*[10] and *Statistics Sweden*[11] were excellent sources for statistics on energy issues, forest matters and international trade figures, respectively. Another Internet resource used extensively was the website of the bioenergy periodical *Bioenergi*[12], where back issues of the periodical stretching back to 1995 can be found. Articles from different newspapers, forest periodicals and energy publications also proved very valuable.

2.3 Survey methodology

2.3.1 Reasons for conducting a survey

The initial reason for conducting a survey was to use it as a means to fulfil Objective 1, aiming to investigate the international biofuel trade to and from Sweden. There are no reliable official statistics available on this, which calls for the use of other methods to obtain the information. In this case it was decided that the best method was by constructing a questionnaire which

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[2] P. O. Nilsson (ed.) , *Energi från skogen* (1999)
[3] Swedish Energy Agency, *Växande energi: bioenergin i Sverige – en marknad i utveckling* (2003)
[4] *Nordisk Energi*, Scandinavian Industry Publishing AB, Stockholm
[5] *Energimagasinet*, Teknikförlaget TFAB, Halmstad
[6] *Bioenergi*, Svebio Stockholm
[7] SLU, *Energi från skogen* (1999)
[8] Swedish Energy Agency, *Växande energi…* (2003)
[9] www.stem.se
[10] www.svo.se
[11] www.scb.se
[12] http://www.novator.se/bioenergy/index3.html

would be filled in by a number of actors believed to be involved in international biofuel trade. However, since the purpose of the project was twofold, it was decided that the survey could also be used as a method of fulfilling Objective 2, investigating the effects of the hurricane *Gudrun* on the biofuel market.

2.3.2 Construction of the questionnaire

The questionnaire[13] used to conduct the survey was to have two separate sections, one section for investigating international bioenergy trade and one section for investigating the consequences of hurricane *Gudrun* on the biofuel market.

The "International trade" part of the survey is part of an EU project, *EUBIONET*, aiming to investigate the European biofuel market as a whole, and therefore this part of the questionnaire had to fit in with the guidelines given by the coordinators of the EU project. Several versions of the questionnaire were constructed and discussed with the supervisor of the thesis, Prof. Hillring. It was finally decided that a rather open questionnaire was the best approach. This strategy meant that the respondents could themselves choose which units and currencies to use when filling in the questionnaire. This approach was chosen to minimize the work and time the respective companies would have to put into filling in the questionnaire, which would hopefully increase the response rate.

As for the part of the survey concerning the effect of Hurricane *Gudrun* on the biofuel market, the difficulty was to construct a questionnaire with a structure fixed enough to be easy to fill in, while at the same time open enough not to restrict the respondents. The method chosen to achieve this was to try and narrow down the ways in which the market could have been affected by *Gudrun* into a handful of multiple-choice questions. Attached to each of these questions was an empty space where the respondents were asked to clarify or specify the answers given in the multiple-choice questions.

2.3.3 Choice of respondents

The questionnaire was sent to about 60 companies involved in biofuel trade. The companies were chosen with an aim to cover as much of the market as possible with a survey with a relatively small number of respondents. The logical approach to achieve this seemed to be to somehow identify the most important, i.e. the biggest, actors on the market. This method was also presumed to be the smoothest to get as good international trade statistics as possible, under the assumption that the biggest actors on the market also are the ones who do most of the international trading. The main tool to identify the respondents was statistics from the trade organizations *Svenska Fjärrvärmeföreningen* (The Swedish District Heating Association) and *Svenska Bioenergiföreningen* (The Swedish Bioenergy Association). From the former, a list[14] of the biggest DH plants in Sweden was used, and from the latter, information was used from a list[15] of the biggest Swedish biofuel suppliers. Furthermore, one respondent is a company that strictly *trades* biofuels and was not included on any list. For classification reasons however, this "extra" respondent has been categorized as a "supplier" in the analysis. Otherwise, it would have been possible to identify the company, betraying the promise made to the respondents that all survey answers would be anonymous.

[13] The questionnaire can be found as appendix B.
[14] Svensk Fjärrvärme, *Statistik 2003*. Available at http://www.svenskfjarrvarme.se/download_biblo/1245/stat-2003.xls
[15] Svebio, "Biobränsleleverantörer 2004" in *Bioenergi* no.1 2005

2.3.4 Getting the answers

The questionnaires were sent out September 30th, 2005. Around October 25th, when 25 questionnaires had been responded and received, a reminder in form of a letter was sent to the companies who had not yet responded.[16] By the beginning of December, an additional ten answers had come in, and it was by this time decided that the survey should be considered completed.

2.3.5 Response statistics

Out of the approximately 60 companies who were sent questionnaires, 35 answered and returned the questionnaire, which amounts to a total frequency of answers of 58%. Since just slightly more than half of the companies who were sent questionnaires responded, it was decided that a non-response analysis[17] was necessary in order to give the results some statistical credibility. By comparing the companies who have not responded to the entire initial selection, it is possible to identify and hopefully eliminate biasing factors. The methodology when doing this is based on using available knowledge about the population, and investigating these characteristics. In this study, two basic facts were known about the companies: the region where the companies are based, and the size of the companies. Since the respondents were chosen from two different populations, it seemed logical to study the response statistics not only for the total population, but for each of the two subpopulations as well. Looking at the two categories of companies included in the investigation, it can be noted that the two separate frequencies of answers for DH plants and biofuel suppliers are roughly the same as for the total population. Out of the 40 DH plants that were sent questionnaires, 23 answered which amounts to a frequency of answers of 58%. For the suppliers, 12 out of 20, or 60%, answered. For the continuing analysis, the two categories will be treated separately.

2.3.5.1 Suppliers

Questionnaires were sent to 20 biofuel supplying companies, and as previously mentioned, the frequency of answers was 60%. Apart from the absolute number of answers, it is also interesting to look at the total fuel turnover of those who answered the survey and compare this to the total fuel turnover of those who were sent questionnaires. According to the 2004 figures in *Bioenergi* no. 1 2005[18], the total fuel turnover of the 20 biggest biofuel suppliers in Sweden was SEK 4 529 million. The combined fuel turnover of the companies who have answered the survey amounted to SEK 2 665 million, or 59% of the total fuel turnover of the top 20 companies, which is about the same as the percentage counting in absolute numbers. Looking again at the top 20 list, it is also worth noting that the companies who have answered the survey are spread seemingly randomly through the list, i.e. it is not just big or small companies who have responded. This implies that a company's size has not been the decisive reason for answering the survey or not.

The other factor that has been examined is region, i.e. the region in which the companies are based. Sweden was for this purpose divided[19] into three regions: "North", "Middle" and "South", according to the map found in *Figure 1* on page 18. The regional distribution for all the companies who were sent questionnaires is such that ten out of the companies were located in the "Middle" region, five were located in the "North" region and five in the "South". Looking at the regional distribution of those who actually answered the survey, a

[16] The letter can be found in appendix C.
[17] The methodology follows the instructions found on pages 118-121 in Jan Trost, *Enkätboken* (2001)
[18] Svebio, "Biobränsleleverantörer 2004" in *Bioenergi* no.1 2005
[19] The regional division is the same as in STEM, *Prisblad för biobränslen, torv, m.m.* (2005)

distinct bias can be noted. In the "North" region, five out of six[20] companies (83%) responded, and in the "South" four out of five (80%). However, in the "Middle" region only three out of eleven companies (27%) responded. This drop-out percentage was so remarkable that it had to be examined more thoroughly. This was done by contacting the supply companies in the "Middle" sector who had not answered the survey via telephone, asking them why the survey had not been responded. All companies who had not answered the survey were contacted via telephone, but only four could be reached. Two out of these stated that they did not know about the survey at all, but said that even if they had seen the questionnaire they probably would not have had the time to answer it. One of these also said that his company was very reluctant to giving out this kind of company information. Out of the other two that were reached, one stated that "I would have answered 'No' to all questions so I didn't see the point in filling it in at all" and one said that he found the questions to be "odd" and that he did not have time for filling in the questionnaire. A common denominator for at least three of these seems to be lack of time and this could prove to be decisive factor for the low response percentage in the "Middle" region. It is not clear however why the companies located in the "Middle" sector would have less time on their hands than those in the "North" and "South". One theory is that there is more competition in the "Middle", seeing as there were almost as many companies in this region as in the two others combined, and that this fiercer competition causes the companies to be not only under more stress, but also less willing to hand out company information. More research is needed to clarify this, but for this project, the matter has to be closed at this point.

2.3.5.2 District heating plants

Questionnaires were sent to 40 district heating (DH) plants, and 23, or 57.5% of the questionnaires sent out, were answered. This number is however somewhat misleading, since this is only the absolute number of questionnaires that have actually been sent in, not the actual number of DH plants that have been covered in the survey. The major source for this confusion is the fact that the "Big Three" companies, E.ON, Vattenfall and Fortum, each run several big DH plants, and it was not clear to the author whether each DH plants should answer their own questionnaire or if one questionnaire was enough for each of the "Big Three". In some cases answers have come in both from specific plants owned by one of the "Big Three" and from head offices who state that they have answered on behalf of all the company's plants. This does cause some confusion as to whether the specific plants who have answered should be considered as included in the "Head Office" answers or if they should be allowed to "speak for themselves". Adding difficulty to the matter is the fact that all figures have been treated anonymously, i.e. it has not been possible to distinguish which figures are connected to a specific company. In the end, it was decided that the different plants should be included separately, but the reader should be aware of this as this is a source of uncertainty in calculating the "International Trade" figures, since this means that some import figures could be overlapping. Also, another source for potential overlapping is the fact that one of the companies included in the survey is a biofuel trading company, acting as purchaser of biofuel on behalf of some municipality-owned DH plants in the middle and south of Sweden. This means that some figures could have been included twice.

For the DH plants as for the suppliers, it is interesting to complement the response statistics in absolute numbers by studying the response percentage in other factors. With the DH plants, an interesting choice of complementing factor is the amount of delivered heat in

[20] The observant reader may have noticed that only *five* surveys were sent to supply companies in the "North" region, which leads to the inevitable question how five out of *six* companies could have answered. The reason for this discrepancy is that one questionnaire that was sent to a DH plant in the "North" region was actually passed on to and answered by a biofuel supplier part of the same energy concern as the DH plant.

TWh. The total amount of delivered heat from DH plants in Sweden is about 47.5 TWh (171 PJ)[21], and the companies which were sent questionnaires represent approximately 38 TWh (136.8 PJ). In turn, the DH plants who have answered the survey represent about 27 TWh

	Total heat amount delivered in 2003	Percentage of heat delivered from Swedish district heating in total in 2003
Swedish district heating in total	47.5 TWh (171 PJ)	100%
Companies that were sent surveys	38 TWh (136.8 PJ)	81%
Companies that answered the survey	27 TWh (97.2 PJ)	57%

Figure 1. Answer percentages, measured in delivered heat in TWh

(97.2 PJ), which is about 71% of the 38 TWh (136.8 PJ) that are delivered by all the companies who received questionnaires, and about 57% of all heat from Swedish DH plants. Looking at the "size" factor it is worth noting that, as with the "supplier" category no real size bias can be observed, other than that all of the "Big Three" on the Swedish energy market, E.ON., Fortum and Vattenfall, have answered the survey. As for the regional distribution, four of the 40 companies are categorized as "North", 20 as "Middle" and 16 as "South". As for response statistics, two out of four companies (50%) in the "North" region have answered the survey, in the "Middle" region 14 out of 20 (70%) and in the "South" 7 out of 16 companies (44%) answered the survey. It is interesting that whereas the response statistics of the supply companies in the "Middle" region were quite poor, the DH statistics for the same region are the best of the three. This could be seen as implying that the regional factor is not the decisive one. On the other hand, the DH market cannot really be compared to that of the biofuel suppliers, as the DH plants have local monopolies in their respective areas of operation, whereas the supply market is much more of a *market* with actual competition.

To sum up, no clear factor explaining why a DH plant has answered the survey or not can be perceived, and therefore, the companies who had not answered the survey were contacted via telephone and asked why they had not answered the survey. Representatives from just three companies could be reached, but all of these stated "lack of time" as being the reason for not answering the survey.

2.3.6 About the international trade figures

Apart from the 35 companies that responded the survey, international trade figures from one actor was also given orally and thus, all in all, the figures presented in this section represent information from 36 actors on the Swedish biofuel market. Out of these, 16 (44%) have stated that they trade biofuel internationally, and all 16 report *import* figures. Assuming that out of the companies included in the survey, it is primarily DH plants that import biofuels, this number is interesting. If 16 of the 23 DH companies that answered the survey state that they import biofuels this could be interpreted as that perhaps as many as 60-70% of the DH plants included in the survey import biofuels. This could however be jumping to conclusions. As was mentioned in the previous section (2.3.5), some of the companies who had not answered the survey were contacted via telephone, and one of the company representatives stated that he did not see the point in filling out the questionnaire since he would have answered "No" to

[21] Svensk Fjärrvärme, *Statistik 2003*. Can be found at http://www.svenskfjarrvarme.se/download_biblo/1245/stat-2003.xls

all questions. It is possible that other companies have had similar thoughts, and that many of the companies who have not answered the survey do not import biofuels at all.

As previously mentioned, the respondents were given some degree of freedom regarding how to fill in the figures. The natural consequence of this was an inconsistency in how amounts of traded biofuel and prices were presented, in terms of units and currencies. For example, some biofuel shipments were presented in tonnes, others in MWh and in the same manner, some prices were given in euros and others in dollars. In order to compile the results, it was necessary to convert some figures, making it possible to add up the traded amounts and compare prices. The amount of biofuel traded will be presented in TWh, whereas many companies have presented the data in weight measurements. The conversion factors used to obtain a homogenous data set and comparable price figures can be found in appendix A.

2.4 Interview methodology

As a complement to the survey and to obtain new perspectives on hurricane *Gudrun*'s effect on the bioenergy market, interviews were conducted with six persons active on the biofuel market. The aim with the interviews was to give the respondents an opportunity to present their point of view on the matter, contrasting with the broad picture given by the survey. The respondents of the interviews were selected from the companies who had answered the survey, and were chosen to get a view as broad as possible, covering both buyers and sellers of biofuels. It also seemed wise to try and chose interviewees from different parts of Sweden. Thus, the country was divided into three parts, north, middle and south, according to the division used in *Prisblad för bioenergi, torv m.m.*[22], a quarterly publication with current biofuel price statistics on biofuels. Representatives for one producer of biofuels and one district heating plant were interviewed in each one of these parts of the country to get a selection as heterogeneous as possible.

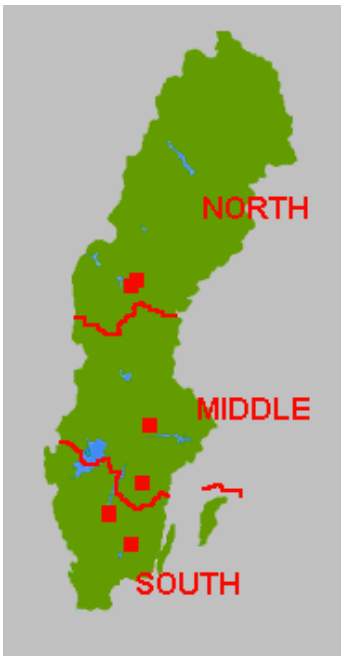

Figure 2. Map of Sweden displaying the locations of the six interviewed companies.

The structure of the interviews was a rather open one, focusing on covering a number of themes in a conversation-like manner. An interview guide was constructed[23], focusing on a

[22] Swedish Energy Agency, *Prisblad för bioenergi, torv m.m*

[23] The interview guide was based on the instructions given in Jan-Axel Kylén, *Att få svar* (2004). The guide can be found as appendix D.

handful of key topics regarding different aspects of hurricane *Gudrun* and the effect it might have had on the company at hand. It is however important to mention that the interview guide was continuously developed as the interviews went along. Previous interviews gave rise to new questions that could be included in following interviews and so on. However, since these new questions did not go outside the topics covered in the original interview guide, only one version of the interview guide is included.

Four out of the six interviews were conducted on location at the offices of the different companies, and two were conducted by telephone. All interviews but one were recorded with an mp3 player and then summarised in writing. The interview not recorded was so short that it could be compiled without recording.

2.5 Compilation and analysis

The final part of the project was to put the pieces together and clarify which conclusions could be drawn. As for the consequences and aftermath of hurricane *Gudrun*, information from the survey and the interviews were complemented with recently released data of a more quantitative nature from different other sources, like the Swedish Forest Agency[24]. Together with the theoretical framework previously established, this provided material sufficient to draw conclusions about the repercussions of the hurricane so far and in coming years. A similar approach was used for the process of making reliable estimations of the Swedish international biofuel trade, comparing the figures obtained through the survey to previously performed studies on the subject and the available statistics that could be found.

[24] www.svo.se

3 Definitions

3.1 What is bioenergy?

Since bioenergy is the subject of this thesis, it is important to begin by defining some key conceptions and terms of the subject. To begin with, the word *bioenergy* is a combination of the greek word *bi'os*, meaning life and "energy".[25] Therefore "bioenergy" can be interpreted as "living energy" or energy that stems from living things, which is actually exactly what bioenergy is. Bioenergy is an umbrella term for all forms of energy that are extracted from biological material, *biomass*. Biomass that is used for energy purposes is commonly referred to as *biofuels*.

3.2 Why is bioenergy considered a sustainable source of energy?

A major reason for the growth of and increased interest in bioenergy in recent years is the search for alternatives to fossil fuels in the wake of the Kyoto protocol. The Kyoto protocol puts focus on reducing emissions of green house gases, mainly carbon dioxide (CO_2). The origin of bioenergy is the reason why it is considered a renewable and carbon dioxide neutral energy source. Combustion of vegetable biofuels does cause carbon dioxide emissions into the atmosphere, but since the amount released during combustion is equal to the amount that the plant absorbs during its lifetime, the net release of carbon dioxide is zero.

3.3 Some biofuels common on the Swedish market

A dilemma when discussing biofuels and bioenergy is the lack of thorough international standardisation in the area. It is not always obvious how to describe and categorize different biofuels, but below will be given a somewhat rough guide just to give the reader an understanding of what is later referred to. The following is a presentation of the fuels traded on the Swedish market. The terms used in this report are based on the recommendations provided by the Swedish Standards Institute[26].

Primary forest-fuels[27] are fuels made out of residues and by-products from fellings. The only processing that is done before combustion is drying and chopping the raw material into fitting sizes.

- *Fuelwood* are logs from which twigs and branches have been removed, and that have been cut into lengths suitable for fuel purposes. Fuelwood is used primarily for private small-house heating but chips from fuelwood (usually logs that do not live up to saw timber or pulpwood standards) are also used to some extent in the district heating sector. Fuelwood accounts for about 9 TWh (32.4 PJ) of energy in Sweden every year.
- *Forest chips* are pieces of about 1-5 cm cut up from residues from fellings such as *tops and branches*, which are a major part of the Swedish biofuel market. Tops and branches are harvested mostly from spruce, simultaneously with final fellings. The tops and branches are left in piles in the forest to dry for a few months. Also, during

[25] SLU, *Energi från skogen* (1999)
[26] Swedish Standards Institute, *TS 14588:2003: Solid biofuels-Terminology, definitions and descriptions* (2003)
[27] The material in this section is compiled from SLU, *Energi från skogen* (1999) and Svebio, *Fokus Bioenergi* 2/2004.

this time the needles fall off which lessens the nutritional loss when removing the felling residues. After this, the tops and branches are transported out to a roadside landing where they are put in stacks. From here the tops and branches are either transported for chipping at the location where they are to be used, or, they are chipped in the forest and then transported to the plant.[28] There are several logistical advantages in letting the felling residues dry as much as possible before chipping them up, something that will be more thoroughly discussed in section 5.1.

Figure 3. Forest chips being loaded onto a truck[29]

Refined solid wood-fuels are processed from raw material in order to change its properties to optimize the material's usability for energy purposes. Refined wood-fuels are usually comprised of by-products from the wood processing industry, and are refined to obtain fuel with a lower moisture percentage and higher thermal value. This gives refined wood-fuels significant logistical and combustion-related advantages compared to unrefined wood-fuels[30].

- *Fuel powder* is produced through the grinding of raw wood material into a powder consisting of particles smaller than 1 mm. Fuel powder is dried to obtain a dry matter content above 90%.[31] It is almost exclusively used in plants larger than 5 MW.[32]
- *Pellets* are small cylinders with a diameter less than 25 mm and a maximal length of four times the diameter. The process of making pellets is such that sawmill residues are dried until it has a dry matter content of around 90%, after which it is grinded into chips and pressed into cylinders. Pellets are commonly used in district heating and combined heat and power plants as well as in private small-house heating. [33] It is estimated that 1.2 million tons, or about 6 TWh (21.6 PJ), of pellets was delivered to the Swedish market in 2004.[34]
- *Briquettes* are produced in a process similar to that of pellets, but briquettes are larger with a diameter more than 25 mm. Briquettes are mostly used in district heating and combined heat and power plants.[35]

[28] http://www.norrbranslen.sca.com/default.asp?/se/produkter/grot.asp (060108)
[29] Image from http://www.novator.se/bioenergy/bildarkiv/Flisning/sidor/d70chipsloadingtruck.htm
[30] SLU, *Energi från skogen* s. 36 (1999)
[31] ib.
[32] Swedish Energy Agency *Växande Energi* (2003)
[33] See for example Svebio, *Fokus Bioenergi* 2/2004
[34] http://www.pelletsindustrin.org/pdf/Statistik041231.pdf?id=3&instance=1&lang=se (060116)
[35] See for example Svebio, *Fokus Bioenergi* 2/2004

Figure 4. Briquettes[36]

Figure 5. Pellets[37]

Recovered wood is increasingly used as fuel in Swedish district heating and combined heat and power plants. The term is used for wood that has previously been used in e.g. buildings or furniture. When used as fuel, the recovered wood is often grinded into chips, commonly referred to as "RW chips" [38] to distinguish them from chips made from felling residues. 1.6 TWh (5.8 PJ) of RW chips were used[39] in Swedish district heating in 2003, a lot of which was imported[40].

Peat consists of "dead plants that decay under wet conditions with low or no oxygen supply"[41]. It is harvested from bogs and accounted for roughly 4 TWh (14.4 PJ) of energy in 2004[42]. Peat is often co-combusted with other biofuels in district heating and combined heat and power plants to reduce different problems that can occur when burning biofuels. It should be mentioned that the inclusion of peat as a biofuel is not uncontroversial. Peat is considered a fossil fuel by the EU, UN and the International Energy Agency, but is classified as "a slowly renewable biomass"[43] fuel in Sweden and Finland, and is therefore included as a biofuel for this project. Peat entitles to green electricity certificates according to the Swedish certificate system but on the other hand counts as a fossil fuel in the emissions trading context. This has caused an ongoing controversy in Sweden. Many district heating plants have stopped using peat as fuel because of the high costs of buying emission rights, which has in turn led to somewhat of a crisis for the peat production industry[44].

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[36] Image from http://www.novator.se/bioenergy/bildarkiv/Branslen/bilder/34.13.Briketter.JPG
[37] Image from http://www.novator.se/press/pellets/bilder/PelletsiHandLag151.13.jpg
[38] Chips made out of recovered wood are in Sweden referred to as "RT-flis"
[39] Svensk Fjärrvärme, *Statistik 2003*. Can be found at http://www.svenskfjarrvarme.se/download_biblo/1245/stat-2003.xls
[40] The mechanisms of the RW import will be discussed thoroughly in later chapters.
[41] http://www.torvproducenterna.se/english/basic-facts.shtml (051017)
[42] Statistics Sweden online: http://www.scb.se/templates/Publikation____139316.asp (051207)
[43] http://www.regeringen.se/sb/d/831/a/7208 (060131)
[44] See e.g. www.torvproducenterna.se for more information on the peat controversy.

Figure 6. Peat harvest[45]

Tall oil is a residue from the pulp production process. Tall oil can, at least according to the company *Tall Oil*, replace fossil oils in many applications without any major adjustments.[46] A few years ago, a tax on tall oil was introduced to promote the use of tall oil in industry instead of burning it.[47] As a result, tall oil for energy purposes is quite heavily taxed compared to other biofuels. Nonetheless, about 1.6 TWh (5.8 PJ) of tall oil was used in Swedish district heating in 2003.[48]

Fuels based on **municipal solid waste** are becoming increasingly common as environmental legislations have become tougher. From January 1st 2005 depositing of garbage in landfills is prohibited in many European countries, including Sweden. Refuse that is not being recycled is instead incinerated, in Sweden often in district heating and combined heat and power plants, and about 85% of the refuse consists of biomass such as paper, food scraps etc.[49] Normally the refuse is burned without refining, but refined versions also exist, for example **refuse derived fuel pellets**, or simply **RDF pellets** for short**.** RDF pellets are industrial- and office refuse compressed into cylinders with a diameter of about 10 mm and a length of about 50 mm, i.e. similar to the size of wood pellets.[50]

3.4 District heating

Almost half of all Swedish biofuel use takes place in the *District Heating* (DH) sector. District heating will be mentioned and discussed extensively throughout the report, and therefore some key concepts concerning district heating will be presented here.

District heating is a means to provide heating for buildings through the distribution of hot water from a large plant where fuel is burned to heat water to appropriate temperature.[51] The first district heating system in Sweden came into use as early as 1948[52], but the major part of the development has taken part the last 30 years, and district heating now provides heating for almost half of all Swedish commercial and residential premises.[53]

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[45] Image from http://www.novator.se/bioenergy/bildarkiv/Torv/miniatyrbilder/39.4.Stycketorvupptagning.JPG
[46] http://www.talloil.se/english/broschyr.pdf (060108)
[47] http://www.novator.se/environment/mor/mor9821.html (060108)
[48] Svensk Fjärrvärme, *Statistik 2003*. Can be found at http://www.svenskfjarrvarme.se/download_biblo/1245/stat-2003.xls
[49] http://www.rvf.se/m4n?oid=849&_locale=1 (060111)
[50] Johanna Ulenius, *Möjligheter att kontrollera damning från fasta bränslen genom kemisk behandling* (2005). Available at http://www3.ima.kth.se/ImaExt/Upload/Dokument/JUexjobb.pdf.
[51] Swedish Energy Agency, *Energy in Sweden 2004*. (2004)
[52] http://www.svenskfjarrvarme.se/index.php3?use=publisher&id=1179&lang=1 (051019)
[53] Swedish Energy Agency, *Energy in Sweden 2004*. (2004)

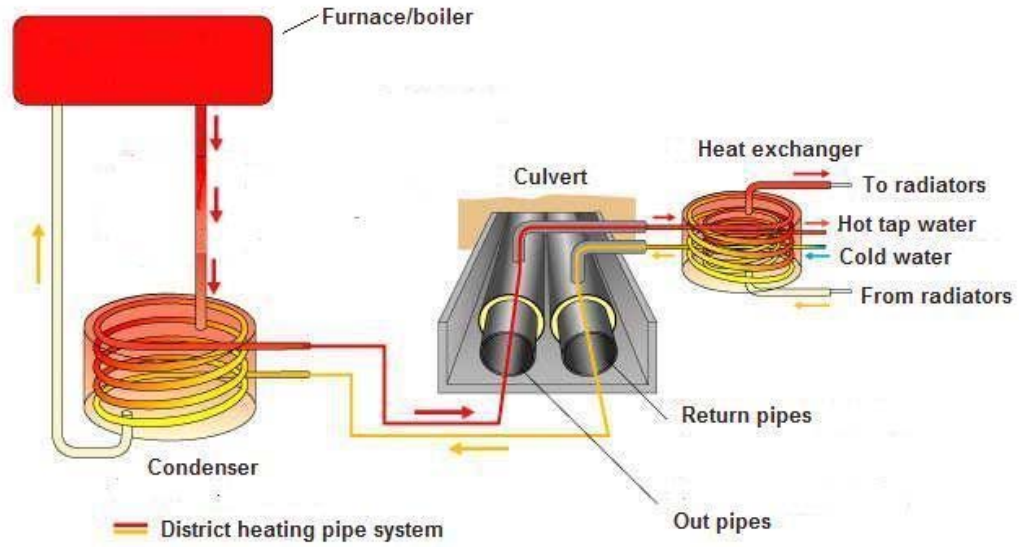

Figure 7. Outline of a district heating system[54]

In recent years, it has become increasingly common in Sweden to build district heating plants that also produce electricity, so called *Combined Heat and Power* (CHP) plants. In these plants, the steam from the boiler is used to drive a turbine which in turn drives a generator generating electricity.

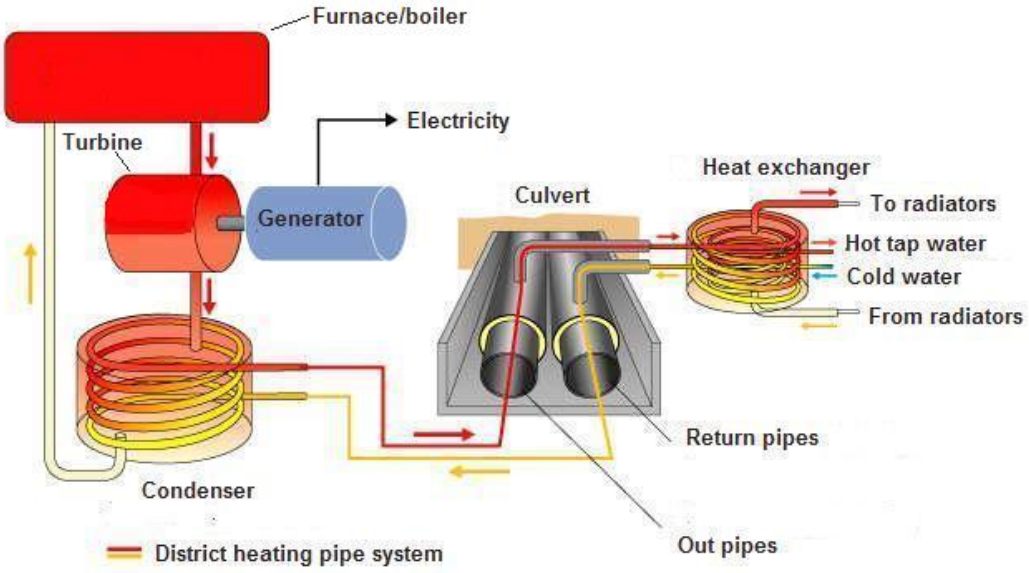

Figure 8. Outline of a combined heat and power (CHP) plant.[55]

3.5 Forestry measurements

When trading forest products, several different measurements are used to describe the wood. It should be noted that these are only a few of existing measurements:
The abbreviations are of Swedish origin, but will nevertheless be used herein:

[54] Modified from http://www.ne.se/jsp/search/article.jsp?i_art_id=170795 (060213)
[55] Modified from http://www.ne.se/jsp/search/article.jsp?i_art_id=170795 (060213)

- **m^3sk** is cubic metres standing volume (stem volume over bark from stump to tip).
- **m^3pb** is cubic metres solid volume incl. bark.
- **m^3fub** is cubic metres solid volume excl. bark.

4 Bioenergy in Sweden – past, present and future

4.1 Bioenergy development in Sweden since the late 70's

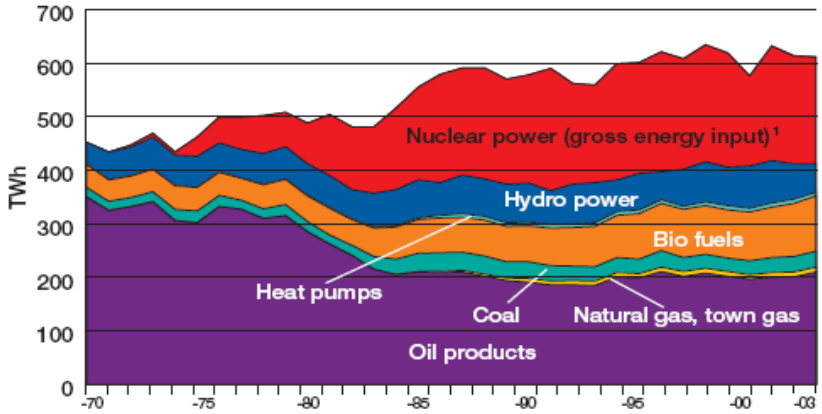

Figure 9. Swedish energy supply 1970-2003[56]

Bioenergy accounted for about 16% of total Swedish energy supply during 2003. This large share is quite unusual compared to the rest of Europe and other mature industrialized parts of the world.[57] However it is interesting to note, as can be seen in *Figure 9*, that a large part of Swedish bioenergy growth has taken place the last 25 years. This growth is partly a result of rising prices on fossil fuels but also to a large extent due to a conscious choice of energy politics. The two major oil crises of the seventies, and the devastating effect this had on world economy, proved to the world the vulnerability of being too dependant on oil. In order to obtain a higher level of self sufficiency in the energy area, Swedish energy policies were increasingly focused on raised energy and environmental taxes on fossil fuels. It also became possible to receive governmental fundings for peat and biofuel heating.[58] This was a contributing reason for an extensive conversion process from oil to biofuels in the Swedish district heating sector, illustrated in *Figure 10*.

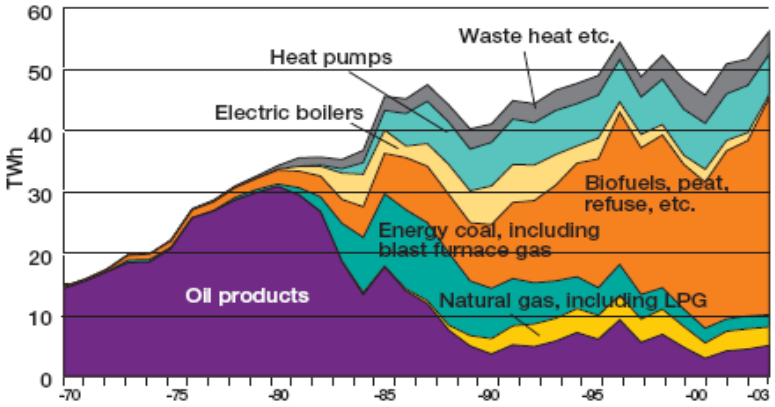

Figure 10. Energy input sources for Swedish district heating 1970-2003. [59]

[56] Swedish Energy Agency, *Energy in Sweden 2004* (2004)
[57] Sweden's neighbour on the other side of the Baltic Sea, Finland, is one of the few "developed" countries with a similar amount of biofuel use.
[58] Swedish Energy Agency, *Växande energi: Bioenergi i Sverige, en marknad i utveckling* (2003)
[59] Swedish Energy Agency, *Energy in Sweden 2004* (2004)

Starting at the beginning of the eighties, DH plants began to shift from oil to peat and biofuels. With rising environmental concerns and in the nineties, the fight against global warming and the Kyoto protocol, this development continued steadily. By the turn of the millennium, bioenergy had replaced oil as the dominant fuel used in DH plants. The rapid growth is attributed to the combination of large demand for biofuels from the DH plants, and also to the great forest resources in Sweden which have provided relatively inexpensive and easily available fuel. There also large growth potential in the use of forest fuels. A study from 1998 estimates that the potential supply of wood-fuels is about 135 TWh (486 PJ)/year, out of which only 50 TWh (180 PJ) are extracted presently.[60]

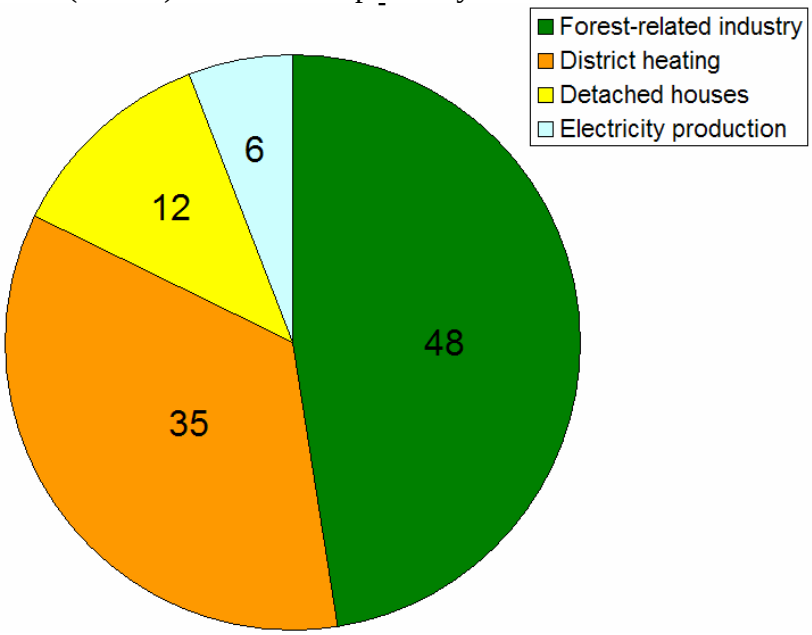

Figure 11. Bioenergy use in different sectors, in TWh. [61]

Today, the largest use of biofuel in Swedish is within the forest-related industries. The changed direction in energy politics in the beginning of the 1980's had an effect on Sweden's many energy-intensive industries as well as on the district heating sector. Many of the energy-intensive industries are found in the forest industry sector which naturally have good access to wood-fuels of different kinds. The use of biofuels in the forest-related industries increased from 29 TWh (105 PJ) in 1980 to 47 TWh (169 PJ) in 2000, while at the same time the use of oil decreased by about 75%. This development is illustrated in *Figure 12* and *Figure 13* below.

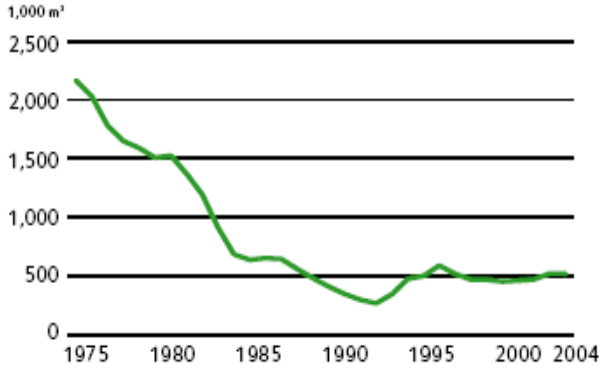

Figure 12. Oil consumption in Swedish paper and pulp industry 1975-2004. [62]

[60] G. Lönner and others, *Kostnader och tillgänglighet för trädbränslen på kort sikt.* (1998)
[61] Swedish Energy Agency, Energy in Sweden 2004 (2004)

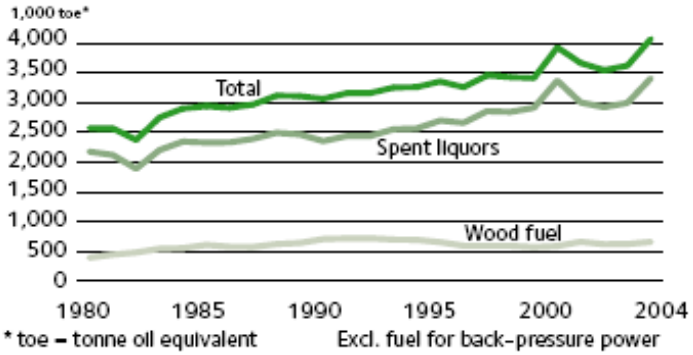

Figure 13. Biofuel consumption in Swedish paper and pulp industry 1980-2004. [63]

4.2 Current and future bioenergy development in Sweden

4.2.1 Large potential in electricity production from biofuels

The 2003 introduction of the electricity certificate system have made electricity production in Combined Heat and Power plants, of which a majority use biomass as fuel, increasingly profitable. The system is an attempt to making renewable electricity in general, more competitive. Energy producers are given one certificate for each MWh of renewable electricity that is produced, and they can sell this certificate to electricity users (except some energy-intensive industries), who in turn are obliged to buy a certain share of their electricity from renewable sources. The idea is that this will create a demand for renewable energy, thereby increasing its competitiveness. [64] According to the Swedish District Heating Association (*Svensk Fjärrvärme*), there is a great growing potential in CHP electricity production; it is estimated that as much as 28 TWh (100.8 PJ) of electricity could be produced annually compared to today's 5 TWh (18 PJ)/year[65]. In a shorter perspective, it is estimated that the use of biofuels in CHP plants will more than double by 2010 compared to 2002.[66] Also, a recent survey[67] estimates that the electricity production from biofuels in the pulp industry will increase by 55% from 2004 to 2010, something that also can be largely attributed to the electricity certificate system.

4.2.2 Increased extraction of tops and branches

Up until now, the majority of the forest residues used as biofuel in Sweden has been harvested in the southern parts of the country, whereas residues from sawmills have dominated in the north and middle parts of the country. A survey from 1998 shows that logging residues, such as tops and branches, were extracted from almost 60% of the final fellings in the south, whereas in the north and central parts of Sweden, tops and branches were extracted from only 5% of all cutovers[68]. The latter small percentage is in large a consequence of the fact that it has not been economically viable to extract residues from loggings in northern Sweden, due to an immense surplus of wood refinement by-products. The aforementioned introduction of the

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[62]The Swedish Forest Industries Federation, *Facts and figures 2004* (2004)
[63] ib.
[64] For more information on the certificate system, see e.g. Swedish Energy Agency *Energy in Sweden 2004* (2004).
[65] Svensk Fjärrvärme, *Fjärrvärme och kraftvärme i framtiden* (2004)
[66] ib.
[67] Jakob Hirsmark., Elcertifikatsystemets effekter på biokraft inom massaindustrin (2005)
[68] Jörgen Filipsson, "Primärt skogsbränsle i Sverige-produktion, metoder och förbrukning", *Resultat 17/1998* from *Skogforsk* (The Forest Industry Research Institute of Sweden).(2004)

electricity certificate system seems however to increase the demand for biofuels to the point where extraction of logging residues will become profitable in the north.[69] Herein lies a large growing potential, since the northern and central parts of Sweden contain about 80% of the forests in Sweden[70].

Figure 14. Tops and branches about to be chipped. [71]

4.2.3 Energy crops

Straw, weed, hemp, and short-rotation coppice such as *Salix* are examples of some crops that are grown for energy purposes in Sweden. Energy crops today account for 0.5-1 TWh (1.8-3.6 PJ) of Sweden's energy supply[72], but as the demand for biofuels is increasing, so is the interest in energy crops. In a time of energy demand and massive agriculture over-production, energy crops could prove to be a remedy to both problems. Some sources estimate[73] that energy crops have the potential to contribute with as much as 22 TWh (79.2 PJ) in the future. In spite of this, energy crops development seems to have come to somewhat of a halt in recent years. The total area used for energy crops in Sweden has in fact decreased from more than 15 000 hectares in 2000[74] to less than 14 000 hectares in 2005[75].

Figure 15. Salix.[76]

[69] "Toppskottet", supplement in *Vi skogsägare* no.1/2005.
[70] Statistics Sweden, *Marktäckedata 2000* (2000)
[71] Image from http://www.novator.se/bioenergy/bildarkiv/Flisning/bilder/49.2BruksFlisare.JPG
[72] *Fokus Bioenergi* 4/2004
[73] Svebio, *Fokus Bioenergi* 4/2004
[74] Statistics Sweden, *Use of arable land in the year 2001* (2001), can be found at http://www.sjv.se/webdav/files/SJV/Amnesomraden/Statistik%252C%2520fakta/Arealer/JO10/JO%252010SM0201/JO10SM0201.pdf
[75] Statictics Sweden, *Use of agricultural land in 2005* (2005), can be found at http://www.scb.se/statistik/JO/JO0104/2005A01/JO0104_2005A01_SM_JO10SM0502.pdf
[76] Picture taken by the author.

5 Biofuel trade

5.1 Characteristics of biofuel trade

5.1.1 Transportation

A major issue when discussing biofuel trade is transportation. This is especially true for the bulky unrefined biofuels (e.g. tops and branches), that make up a major part of the solid biofuels traded in Sweden. Of the total cost for biofuel from tops and branches, transportation accounts for almost 40%.[77] Due to this, it can be hard to make biofuel transportation economically viable, and 150 km seems to be the upper limit for highway transportation of biofuels. [78] This is the main explanation for the fact that biofuels traditionally have been produced in the same area where they are consumed, e.g. a sawmill in a certain area delivers its residues to the local district heating plant for combustion. Transportation by ship or train is economically viable at longer distances, which is the reason for the increasing import of biofuels to Sweden from the other side of the Baltic Sea. On the other hand, transportation via ship and train is a lot less flexible than highway transportation and only applicable when large amounts are transported to one destination.

5.1.2 Storage[79]

While most of the biofuel consumption takes part during winter when demand for heating is at its highest, the majority of the biofuels become available during summer, when a lot of felling residues are produced during harvesting. This inevitably makes storage an important factor in the biofuel supply chain.

To begin with, the major problems with biofuel storage are afflicted with unrefined biofuels such as forest chips, in which the moisture percentage is a lot higher than in e.g. pellets or briquettes. Refined biofuels such as the latter two rarely cause any problems during storage. However, the high moisture percentage causes unrefined biofuels to be exposed to microbial activity such as bacteria and fungi. These microbes are the source of many problems when handling unrefined biofuels. The degradation of the biomass generates heat, a phenomenon which is boosted when large amounts of biofuel are packed together in a stack. If the generation of heat is allowed to evolve there is a risk of a decrease in fuel quality, as well as the risk that the stack could spontaneously combust. The microorganisms also pose a threat to the working environment of the people handling the fuel due to large amounts of fungi spores that have been observed around stacks of forest chips. If inhaled, these spores can cause different forms of allergic reactions such as fever, dry cough and muscle pains. The reactions are commonly known as woodmould-disease[80], and have for example led to several cases where handling personnel have been forced to quit their jobs due to such health problems.

There are however measures that can be taken to reduce the storage problems caused by the microbial activity. The best way to minimize the problems mentioned above is to dry the fuel *before* it is chipped. It is now also becoming increasingly common to leave the harvest residues in the forest to dry and for the needles to fall off. This is a way not only to decrease the moisture content in the fuel, but also helps the forest environment as the degrading needles work as a fertilizer in the harvested area.

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[77] Swedish Energy Agency *Växande Energi* (2003)
[78] ib.
[79] This is based on Swedish Energy Agency (2003) and SLU, *Energi från skogen* (1999)
[80] "Trämögelsjuka" in Swedish.

5.1.3 Prices[81]

Price formation on biofuels varies with the different types of fuels and with the origin of the fuel in question. Prices on fuels that are made from sawmill by-products is generally dependant on supply and demand. On the other hand, the prices on tops and branches, which are extracted during fellings, are generally set by the cost of extracting the fuel.

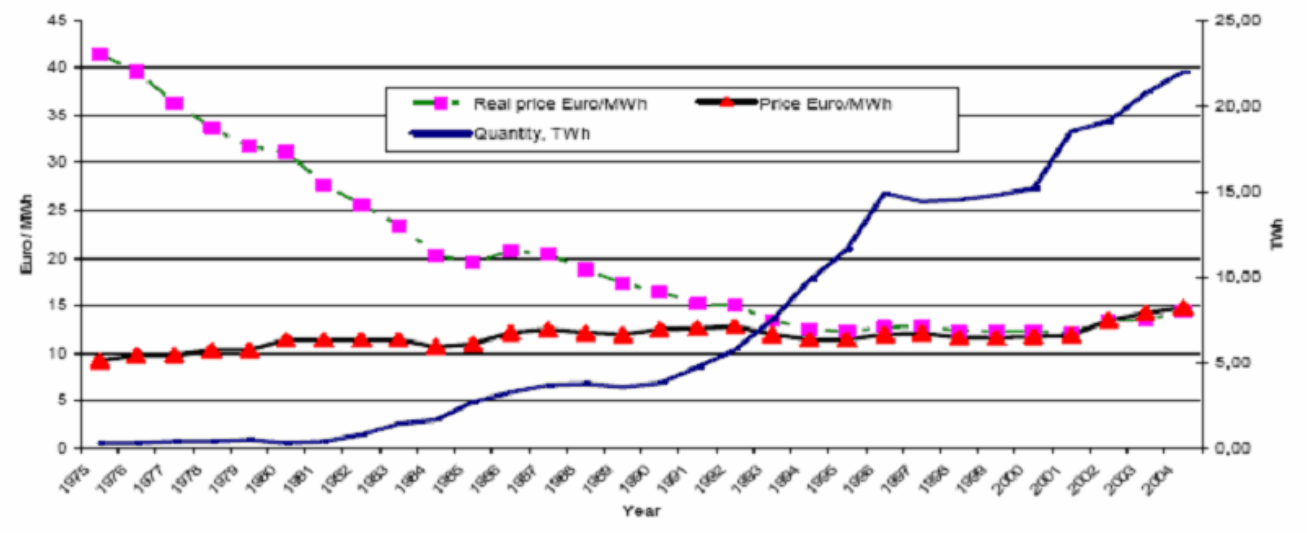

Figure 16. Biofuel prices 1975-2004[82]

Biofuel prices have, in real prices, decreased continuously since 1970, something that is quite remarkable considering the rapid growth in the bioenergy sector, and particularly the district heating sector, during the last 20 years. This has been explained as an effect of the vast supply of biofuels in Sweden in the form of residues from the forest industry, and also from the appearance of low-cost imported biofuels that have helped keeping biofuel prices in general at a lower level than would otherwise have been the case.[83] In the last five years, however, this development seems to have changed, as can be seen when comparing *Figure 16* and *Figure 17*. Biofuel prices have gone up some 25% between 2000 and 2004.

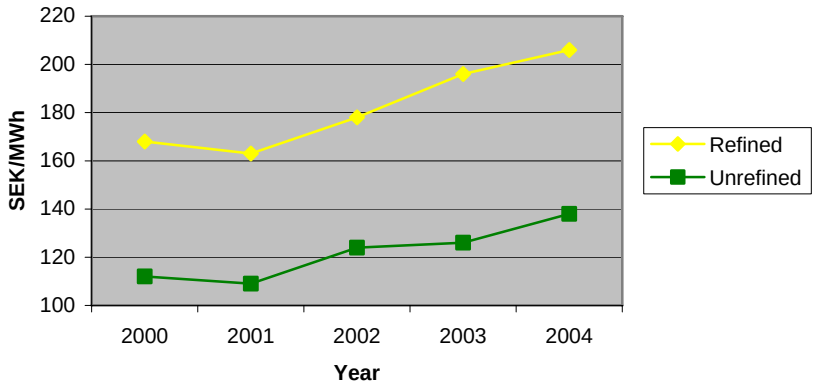

Figure 17. Biofuel prices 2000-2004[84]

[81] The price statistics herein are based on figures quarterly presented by the Swedish Energy Agency. The Swedish Energy Agency admits that the figures are not part of official Swedish statistics and should be interpreted carefully. Regardless, it is the belief of the author that the statistics are reliable as a tool for noticing price trends, which is how they will be used in this section.
[82] Matti Parikka & Reinhard Madlener, "Economics of Sustainable Energy Wood Production" (2005)
[83] Bengt Hillring, "The Swedish Wood Fuel Market" in *Renewable Energy* 16 (1999)
[84] Swedish Energy Agency *Prisblad för biobränslen, torv, m.m.*

It is also important to see the development of biofuel prices in the context of other forest products. Simplified, during and after a felling, felled stemwood is sorted into one of three categories: timber, pulpwood or fuel. The wood of the highest quality goes as timber, which also pays the most. Wood that does not qualify as timber becomes less valuable pulpwood, and finally, wood that does not match the standards of pulpwood goes as biofuel. This has traditionally been the order of precedency, but in recent years there have been indications that this might be changing. Due to a combination of falling prices on pulpwood and rising biofuel prices, caused by the continuously increasing demand, prices on biofuel have approached pulpwood prices. Should this development continue, a situation might appear where the forest owner is paid more for selling the wood as fuel than as pulpwood. This is naturally a scenario that the pulp industry is desperate to avoid. The pulp industry is therefore working hard to increase the quantity of other assortments of biofuels such as tops and branches on the market, to keep biofuel prices at a "safe" level.[85]

5.2 The supply side

Since a large majority of the domestic biofuel on the Swedish market consists of forest residues, it seems natural that Swedish biofuel production is closely connected to the forest industry as a whole. However, when bioenergy began to grow in Sweden in the early 1980's, the forest industry feared that the growing bioenergy market would lead to growing competition for forest products.[86] This has since changed, and nowadays the bioenergy industry is largely integrated in, and organized by, the forest industry. Several of the leading Swedish forest companies are represented directly or indirectly[87] on the top 10 list of Sweden's largest biofuel suppliers, who together control about 70 percent of domestic biofuel sales. [88] However, the situation is still evolving quite rapidly, with mergers and take-overs leading to an increasingly concentrated market.

5.3 The demand side - district heating

After the forest-related industry, DH and CHP plants are the biggest users of biofuel in Sweden. However, as discussed previously however, the forest-related industry mostly uses own-produced biofuels, which makes the DH and CHP plants the biggest *buyers* of biofuel in Sweden.

5.3.1 District heating in Sweden

The DH plants in Sweden have until recently usually been run by municipally-owned energy companies, but this has changed in recent years. As the economic situation of many municipalities[89] has worsened, more and more district heating plants have been sold to large energy companies such as Vattenfall, Fortum or E.ON[90].

[85] Skogsindustrierna, "Papper, trä eller energi" in *Tidningen Skogsindustrierna* 2/2003
[86] Graham R, Hektor B., Rakos C., Roos J. *Factors for bioenergy Market Development* (1998)
[87] i.e. some of the companies are owned by forest and pulp companies, e.g. *Sydved Energileveranser* is a subsidiary companyof *Sydved*, which in turn is jointly owned by the forest concern *Stora Enso* and the paper company *Munksjö*.
[88] "Biobränsleleverantörer 2004" in *Bioenergi* no. 1/2005
[89] The word *municipality* is used as a translation for the Swedish term "kommun".
[90] Formerly known as *Sydkraft*/*Graninge.*

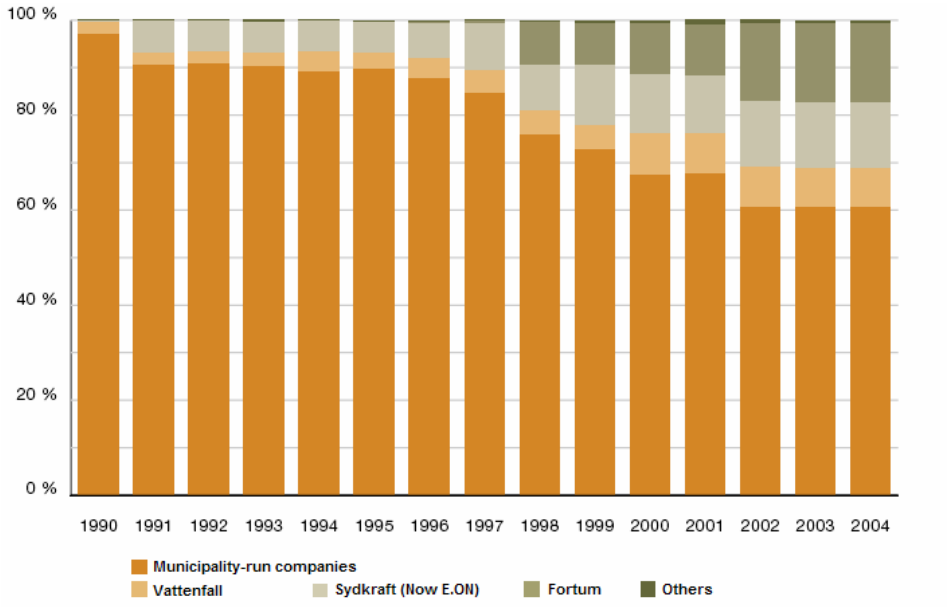

Figure 18. Ownership of Swedish district heating 1990-2004[91]

Since whoever runs the DH plant in a certain municipality usually has a monopoly on district heating in the municipality, there have been some discussions as to how this will affect district heating prices. Many argue that a municipality-run monopoly composes no problem since there is no real profit interest in such an enterprise. However, when the monopoly is run by a trans-national energy corporation working under the pressure of target profits, the situation is another. As an answer to the criticism that private monopolies will lead to district heating customers being overcharged, the Swedish District Heating Association has introduced a system called *Reko Fjärrvärme* (free translation "Fair District Heating"). To be certified according to the system a company that supplies district heating has to live up to certain terms that stipulate reasonable pricing, customer relations and transparency.[92]

[91] Modified from: Swedish Energy Agency, *Energimarknad 2005* (2005)
[92] http://www.svenskfjarrvarme.se/index.php3?use=publisher&id=1364&lang=1 (051019)

6 Objective 1: The Swedish foreign biofuel trade in 2003

6.1 Swedish foreign biofuel trade

The Swedish bioenergy market has traditionally been a predominantly *Swedish* market in the sense that the great majority of the biofuel used in Sweden has also had Swedish origin. The large supply of residues from fellings and forest-related industries was the major biofuel source during the 80's and early 90's, and a vital factor for the rapid growth of Swedish bioenergy use during these years. However, with the increasingly growing demand for biofuels, especially in the DH sector, importing biofuels became an interesting alternative to large users such as DH plants.

6.1.1 Incentives for biofuel import

- A dominating incentive for large Swedish biofuel consumers to import biofuels is, perhaps not surprisingly, prices. Looking at the Baltic States for example, production costs for biofuels in the forest-rich Baltic States Estonia, Latvia and Lithuania are much lower than in Sweden. Especially DH and CHP plants located in regions with low local wood-fuel supply such as around lake Mälaren can benefit from this. This is due to the fact that transporting the fuel by ship across the Baltic Sea is a quite inexpensive means of transportation compared to transporting domestic biofuel by truck. [93]
- Another reason for the increased import could be connected with the trend that municipal DH plants are purchased by multinational energy companies[94]. A study[95] made in 2003 suggests that since these new owners have long experience of international trade, and already are active in several countries, it is only natural for them to utilize an international approach to buying biofuel as well.
- In several European countries a scarcity of land for landfills has led to tougher waste legislation. For example, this has brought about that landfilling of garbage is prohibited in the European Union from January 1st, 2005. Hence, the waste has to be taken care of in other ways, e.g. by incineration. However (using Germany as an example), whereas the Swedish district heating system has been developed extensively to the point where 90% of the energy is made use of when burning refuse, German plants reach an efficiency of only 39% at average. All in all, this makes the exporting of refuse from Germany to Sweden profitable for both parts and a contributing factor for the increasing Swedish biofuel import.[96]

6.1.2 How much biofuel is imported?

As for the extent of the Swedish import, this is difficult to estimate. In Sweden, there are reliable official statistics for most things, but not, unfortunately, for biofuel imports. Due to this, several individual studies using different approaches have been conducted in the last decade or so to come up with reliable estimations of the amount of biofuel annually imported to Sweden. Results from two of these studies are presented below.

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[93] Karin Ericsson & Lars J. Nilsson, "International biofuel trade – a study of the Swedish import" in *Biomass and Bioenergy* 26 (2004) 205-220

[94] As discussed previously in chapter 5.3.

[95] Ericsson & Nilsson (2004)

[96] SEPA, *Import av avfall* (2001) and B. Hillring & J. Vinterbäck, "Development of European wood-fuel trade" in *Holzforschung & Holzverwertung* (2000)

- Hillring and Vinterbäck[97] conducted a telephone survey in 1999 estimating the Swedish biofuel import to have been somewhere between 4.2 and 6.7 TWh (15.1-24.1 PJ) for the year 1997. The uncertainty in the estimation was due to the possibility that some figures could have been counted twice, as some of the companies included in the survey merely trade biofuels, importing biofuels for delivery to e.g. DH plants. As for the future development of the import, the authors say that the Swedish import is "…expected to level out over the coming years"[98], due to increased domestic biofuel use in the exporting countries.
- Ericsson and Nilsson[99] used a somewhat different strategy, using already available figures trying to estimate not only the direct imports of biofuels, but also the indirect import. The indirect import was estimated by treating biofuel produced from residues of imported timber and pulp-wood as "imported biofuel". The data was collected from sources such Statistics Sweden, the Swedish Wood Fuel Association, the Swedish Forest Agency and the Swedish Environmental Protection Agency. This study resulted in an estimate of the direct Swedish biofuel import in 2000 of about 5 TWh (18 PJ), and the indirect import of 2.5 TWh (9 PJ).

6.1.3 What is imported, and from where?

The trade routes for foreign biofuel heading for Sweden and the types of biofuel imported are in many ways connected with the reasons for Swedish biofuel import presented previously. A common denominator here is that the countries exporting biofuels to Sweden are predominantly those who can use sea transports.

- Canada is a major exporter of biofuels to Sweden, providing pellets for Swedish plants.
- Wood chips and pellets are in large numbers imported from the Baltic States, particularly Latvia, where e.g. the Swedish biofuel company *Svensk Brikettenergi* has established a branch.[100]
- Germany and Holland are, for reasons discussed previously, exporting different forms of refuse and waste products to Sweden.
- Peat is imported from several countries, the biggest exporters being Estonia, Latvia and Finland.[101]

6.1.4 Swedish biofuel export - small but potentially growing

Biofuel is also exported from Sweden to some degree. Very little has been done to investigate this trade, but it is known that pellets have to some degree been exported from Sweden.[102] With the increasing interest in bioenergy in the rest of Europe largely due to the countries' efforts to live up to their commitments to the Kyoto protocol, the biofuel export from Sweden could be expected to increase in coming years. This could in turn lead to higher competition of biofuels, as the growth of domestic biofuel use in Sweden does not seem to be halting.

[97] Hillring & Vinterbäck (2000)
[98] Hillring & Vinterbäck, p. 11 (2000)
[99] Ericsson & Nilsson (2003)
[100] See e.g. http://www.brikettenergi.se/foretag_3.htm (060131)
[101] Statistics Sweden, *Peat 2003. Production, use, environmental impact*, can be found at http://www.scb.se/templates/Publikation____129543.asp
[102] SLU, *Växande energi* (2003)

6.2 Estimations of the Swedish foreign biofuel trade in 2003

As discussed in chapter 2 Methodology, several different approaches were used to determine the extent and characteristics of the Swedish foreign biofuel trade in 2003. Essentially, two different methods were used.

- Statistics from both official sources such as *The Swedish Environmental Protection Agency*[103] and *Statistics Sweden*[104] and trade associations such as *The Swedish Association of Pellet Producers*[105].
- A survey including 60 companies active on the biofuel market, constructed and compiled by the author.

Also, several Swedish harbours known to handle biofuels were contacted via telephone and asked to give figures on how much biofuel was unloaded in 2003. This approach did not give very much information however, since it in many cases was unclear if e.g. unloaded wood chips were to be used in the pulp industry or as biofuel. The data that was given was very rarely more specified than "biofuels" or "wood chips", making it very difficult estimate the trade in energy measurements.

6.2.1 Import

6.2.1.1 Import figures from available import statistics

To obtain biofuel import statistics using solely already available material, it was a necessity to use many different sources since no compiled comprehensive statistics on the matter is available. The import is composed of several different fuels, and the statistics for these have to be sought for in different sources.

- The Swedish Association of Pellet Producers states that the total import of pellets to Sweden was 265 512 tons, which is about 1.27 TWh (4.6 PJ). [106] No data is available regarding the origin of the pellets.
- Data from The Swedish Environmental Protection Agency[107] indicate that approximately 1.5 TWh (6.9 PJ) of different kinds of refuse were imported to Sweden for energy purposes in 2003. The refuse was imported mainly from Germany, Norway, Denmark and the Netherlands.
- According to Statistics Sweden:
    - 384 000 tons of peat, or about 1 TWh (3.6 PJ), was imported to Sweden in 2003 with Estonia, Latvia, Finland, Russia and Belarus as the the main countries of origin.[108]
    - 37 000 tons of tall oil, or about 390 TWh (1.4 PJ) was imported to Sweden in 2003. The largest exporters of tall oil to Sweden were Finland, Canada, USA, Norway and the UK.[109]

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[103] www.naturvardsverket.se
[104] www.scb.se
[105] www.pelletsindustrin.se
[106] http://www.pelletsindustrin.org/pdf/Statistik041231.pdf?id=3&instance=1&lang=se
[107] Swedish Environmental Protection Agency, *Införsel av avfall till Sverige år 2003* (2004)
[108] http://www.ssd.scb.se/databaser/makro/crossroad.asp?hid=ImpTotalKNAr4&lang=1&langdb=&xu=C9233001&yp=tansss&inl= , KN number 270 300
[109] Statistics Sweden, http://www.ssd.scb.se/databaser/makro/crossroad.asp?hid=ImpTotalKNAr4&lang=1&langdb=&xu=C9233001&yp=tansss&inl= , KN numbers 3803 0010 and 3803 0090. (060131),

- 491 537 tons of fuelwood[110] was imported in 2003, which amounts to about 1.9 TWh (6.8 PJ).[111] Estonia, Latvia, Lithuania and Russia were the dominating countries of origin.

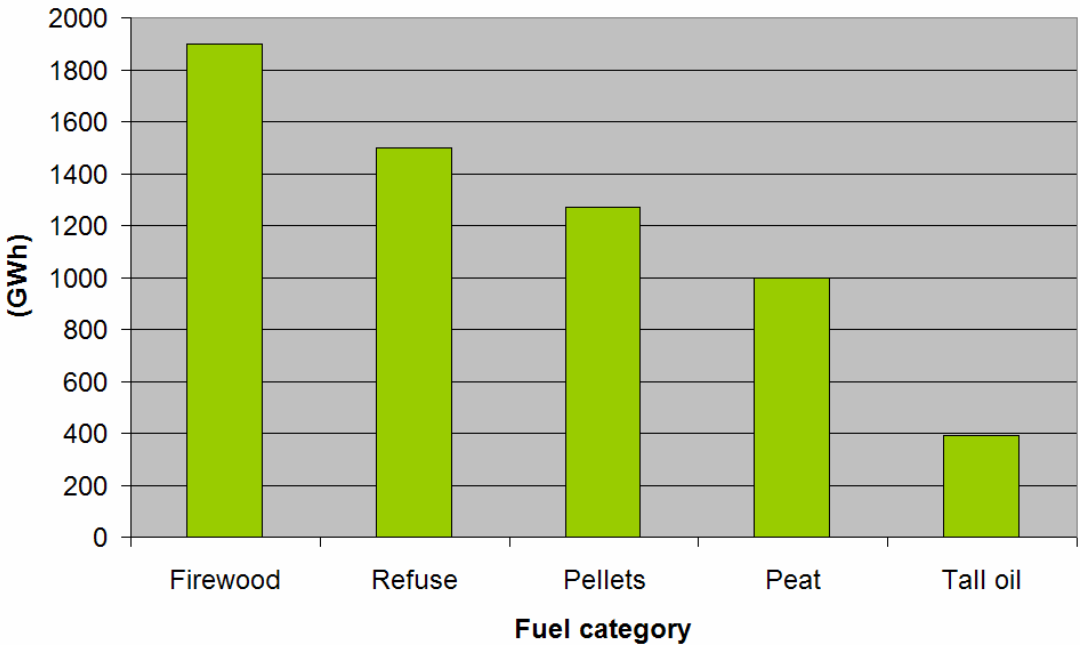

Figure 19. Biofuels imported to Sweden in 2003, obtained from already available statistics.

These figures combined add up to about 6 TWh (21.6 PJ).

6.2.1.2 Import figures from the survey

Compiling the received data, the combined biofuel import for the year 2003 adds up to slightly more than 7 TWh (25.2 PJ). Taking a closer look at the data collected provides some interesting insight into what is imported, from where it is imported, and how much of what is imported from where.

6.2.1.2.1 What is imported?

The survey results present pellets as the biggest biofuel category imported to Sweden with more than 2 TWh (7.2 PJ) in 2003. More than 1.2 TWh (4.3 PJ) each of peat and tall oil were imported, making them the second and third biggest imports. The fourth place goes to wood chips, with just over 1 TWh (3.6 PJ), and then there are several fuel categories which accounted for 100-500 GWh (0.36-1.8 PJ) each. The "other" category is composed of fuels that were too vaguely labelled by the respondents for them to be categorized.

[110] The KN number 4401 1000 includes "Fuelwood in logs, blocks, twigs and brushwood". For the calculation of the import in energy measurements, the heating value of fuelwood has been used. This is worth noting, as it may have resulted in the estimates for "Fuelwood" may be somewhat exaggerated.

[111] http://www.ssd.scb.se/databaser/makro/crossroad.asp?hid=ImpTotalKNAr4&lang=1&langdb=&xu=C9233001&yp=tansss&inl= ,KN number 4401 1000. (060131)

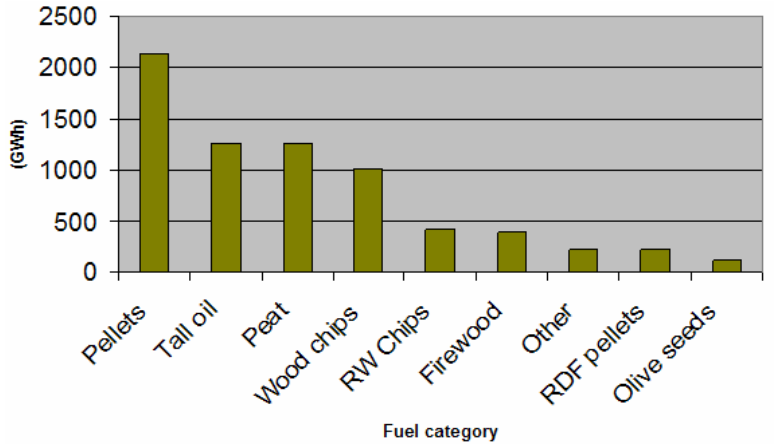

Figure 20. Swedish biofuel imports in 2003 according to the survey, sorted by fuel category

6.2.1.2.2 Which countries are involved in the trade?

As for where the fuel is imported from, three major regions of origin can be perceived: Mainland Europe, North America, and countries on the other side of the Baltic Sea, e.g. Latvia, Estonia and Belorussia. Fuel from Mainland Europe is exclusively waste products such as recovered wood and fuel made from municipal waste whereas North America is a big provider of tall oil and pellets. Pellets are also transported in large quantities to Sweden across the Baltic Sea, as are large amounts of peat and wood chips. Vague geographical specifications from the respondents regarding the origin of the fuel makes the list of the top countries of origin somewhat incomplete, but it can still be interesting.

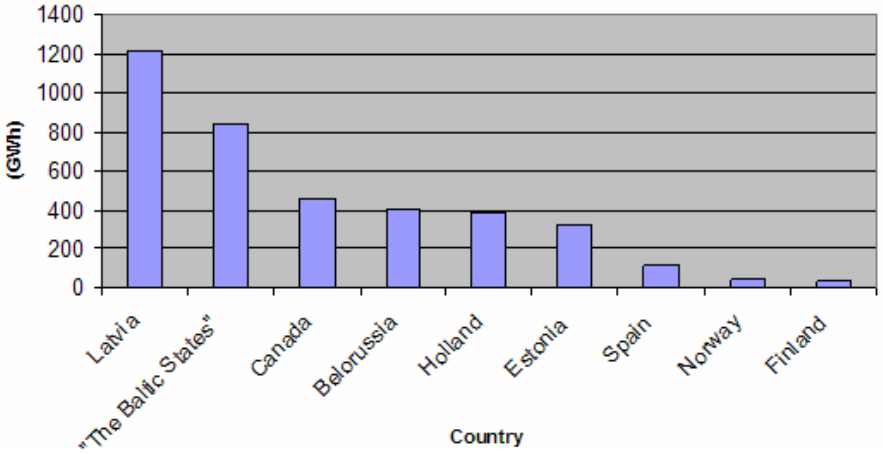

Figure 21. Swedish biofuel imports in 2003 according to the survey, sorted by country of origin.[112]

Using the data obtained through the survey, a schematic map of the Swedish biofuel import has been created, displaying the trade patterns of some different biofuels.

[112] It should be pointed out that the author is very well aware that "The Baltic States" is not a country. Many respondents do not however specify *which* of the Baltic States is in question. Due to this and for the sake of having to leave out as little of the data as possible, the "The Baltic States" category is included.

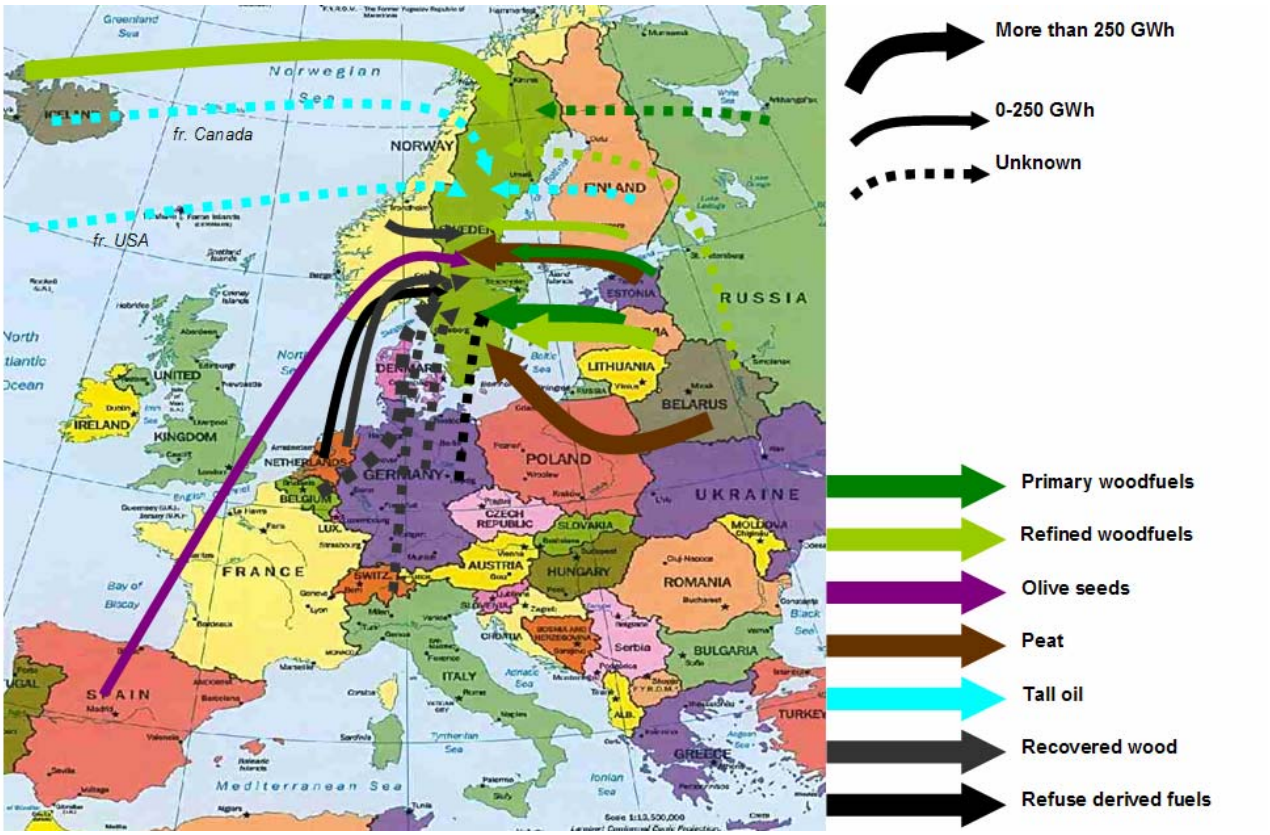

Figure 22. Swedish biofuel import patterns according to the survey results

6.2.1.2.3 Prices

The participants in the survey were also asked to give information on the prices of the biofuel traded. Probably because this is considered delicate company information, not many companies have given out price information. However, from the ones who have given out price information, the following can be noted:

- The mean price of imported refined biofuels, i.e. pellets and briquettes, was according to the survey 155 SEK /MWh in 2003. This can be compared to 196 SEK /MWh, which was the mean domestic price for Sweden as a whole in 2003 according to the Swedish Energy Agency[113].
- The mean price of imported unrefined biofuels, i.e. forest chips, was according to the survey 132 SEK /MWh in 2003. According to the Swedish Energy Agency[114], the mean domestic price for unrefined biofuels used in DH plants for Sweden as a whole in 2003 was 126 SEK /MWh.

An interesting aspect to note here is the fact that the mean import price for unrefined biofuels is almost the same as the domestic mean price. This could imply that other factors than price is the dominating incentive for the import of forest chips. However, due to the small number of respondents who have given out price information, one should be careful drawing conclusions from these figures.

[113] Swedish Energy Agency, *Prisblad för biobränslen, torv, m.m. 4/2005* (2005)
[114] ib.

6.2.1.3 Comparing the results of the two methods

The results from the two methods of estimating the Swedish biofuel import in 2003 do differ to some degree as to the extent of the import for some of the fuels. For example, the estimation of the import of pellets from the figures obtained through the survey is almost twice as large as the figures from the Swedish Association of Pellets Producers. For fuelwood on the other hand, the figures from the survey are only about 25% of the figures from Statistics Sweden. By conjoining the results of the two methods it is possible to estimate an upper and a lower limit for the import figures. Using the lower number for each of the fuels that are represented in both the methods adds up to about 5 TWh (18 PJ) while using the upper numbers adds up to approximately 9.5 TWh (34.2 PJ). This can be seen as an interval in which the true amount of biofuels imported to Sweden probably is found.

6.2.2 Export

Since no companies included in the survey reported any export figures, the only available sources for estimating the export in 2003 are official statistics and figures provided by trade organizations.

- The Swedish Association of Pellet Producers state that 5800 tons of pellets, or about 28 GWh (0.1 PJ) was exported in 2003.[115] No data was available on what countries were the destinations of the export.
- According to Statistics Sweden:
    - 104446 tons of peat, or about 260 GWh (0.94 PJ), was exported in 2003. Denmark, Norway and the Netherlands were the major receivers of the export.[116]
    - 69502 tons of tall oil, or about 753 GWh (2.7 PJ) was exported in 2003. Norway, Austria and Finland were the largest receivers.[117]
    - 18788 tons of fuelwood, or about 71 GWh (0.26 PJ) was exported in 2003. Almost all this was exported to Norway.[118]

These figures add up to about 1 TWh (3.6 PJ). However, it is of outmost importance that these figures are treated carefully. Both tall oil and peat can be used for a wide range of purposes other than as fuel, and it is therefore far from certain that all of the peat and tall oil exported from Sweden is to be used for energy purposes. If tall oil and peat is excluded, the total export amount adds up to about 0.1 TWh (0.36 PJ).

[115] http://www.pelletsindustrin.org/pdf/Statistik041231.pdf?id=3&instance=1&lang=se

[116] http://www.ssd.scb.se/databaser/makro/crossroad.asp?hid=ExpTotalKNAr4&lang=1&langdb=&xu=C9233001&yp=tansss&inl= KN number 270 300

[117] http://www.ssd.scb.se/databaser/makro/crossroad.asp?hid=ExpTotalKNAr4&lang=1&langdb=&xu=C9233001&yp=tansss&inl= KN numbers 3803 0010 and 3803 0090

[118] http://www.ssd.scb.se/databaser/makro/crossroad.asp?hid=ExpTotalKNAr4&lang=1&langdb=&xu=C9233001&yp=tansss&inl= KN number 4401 1000

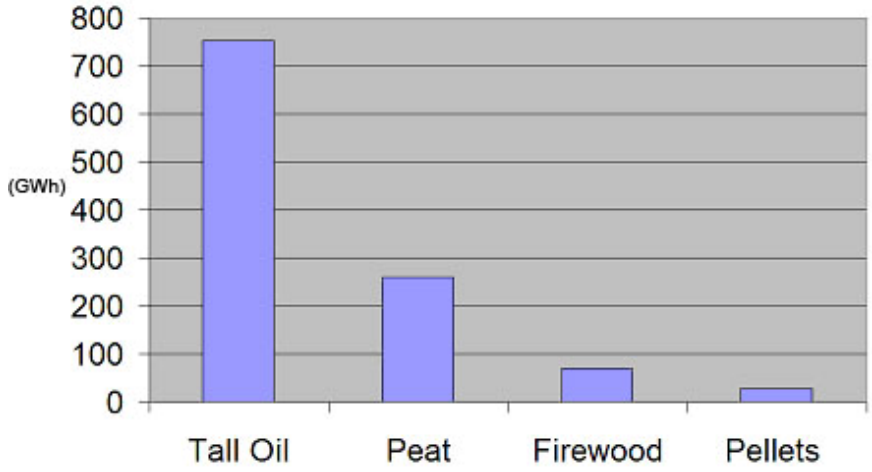

Figure 23. Statistics of biofuels exported from Sweden in 2003, obtained through compilation of available statistics.

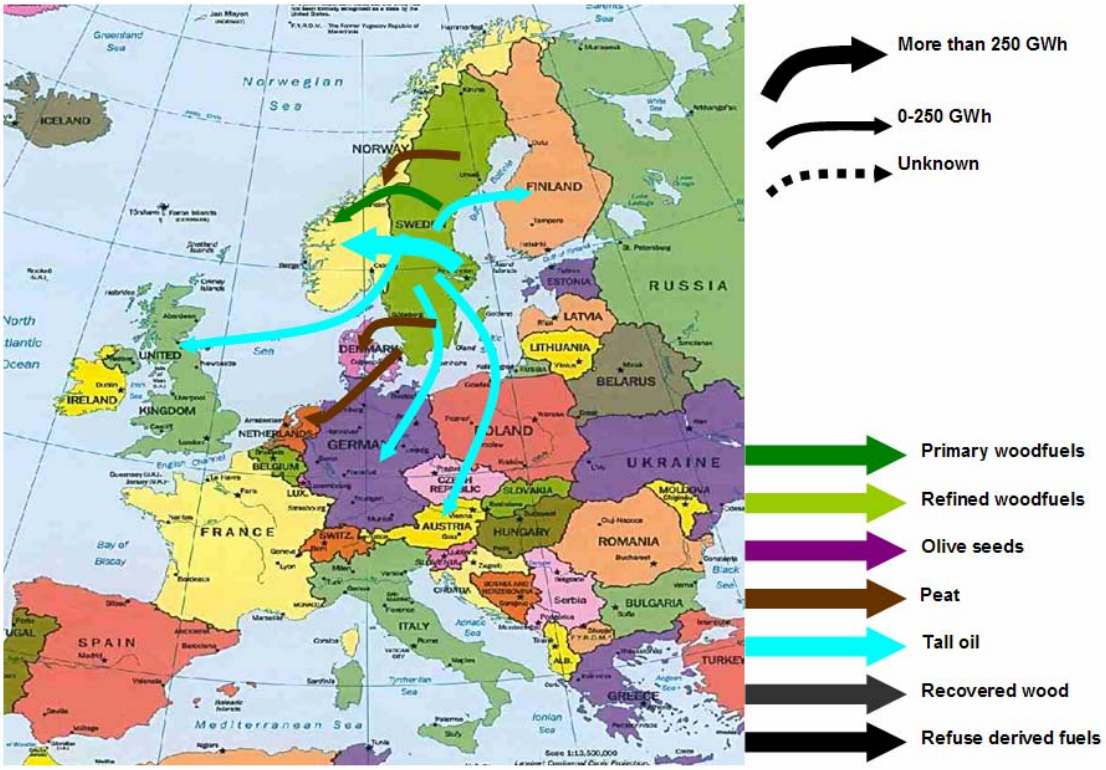

Figure 24. Swedish biofuel export patterns in 2003. Observe that tall oil and peat could be use for other purposes than as fuel, i.e. these figures could be exaggerated.

6.3 Conclusions: Swedish foreign biofuel trade now and in the future

6.3.1 Imports

To get an idea of how the biofuel import has evolved in recent years, comparing the previous estimates of the import with the estimates of the import in 2003 may provide some insight.

1997 (Hillring/Vinterbäck)	2000 (Ericsson/Nilsson)	2003 (This study)
4.2-6.7 TWh	5 TWh	7 TWh (5-9.5 TWh)

Figure 25. Comparison of different estimates of the Swedish biofuel import 1997-2003

Even though the figures are approximate and the upper estimation of the 2003 import may be exaggerated, the trend seems to be that the import has increased in the first years of the new millennium. This is not surprising, seeing the continuously increasing demand for biofuels in Sweden. The increased import in recent years may also be seen in the light of biofuel price development since the year 2000. The increased prices and the increased import could be related, perhaps due to a combination of a lack of domestic biofuel supply and increased European biofuel demand as a whole. Though this is little more than mere speculation, the two developments may be connected, and investigating this more closely could provide valuable insight on the development of the European biofuel market in the years to come. Another factor expected to affect the Swedish biofuel import is the previously discussed peat controversy. As has been presented above, large amounts of peat were imported to Sweden in 2003, but this may be changing in coming years. If the current trend where Swedish DH plants are moving away from the use of peat as fuel due to large costs for emission rights, a natural consequence will probably be a decrease of the peat *import* as well. The forest damages caused by hurricane *Gudrun* in early January 2005 could also indirectly affect the Swedish biofuel import, something that will be discussed in greater detail in the second part of this report.

6.3.2 Exports

Since very little research has been done on the extent and characteristics of the Swedish biofuel export, it is difficult to draw any profound conclusions from the compilation of readily available statistics presented above. The Swedish biofuel export amounts to 0.1-1 TWh (0.36-3.6 PJ), but due to lack of available statistics, the fact that some of the export might not actually be for energy purposes, and that no companies included in the survey stated any export figures, these figures are very approximate. The future development of the Swedish biofuel export is also difficult to predict, but high European biofuel demand, due to the rapid growth of bioenergy in Germany, Spain and the UK, could lead to a change in European biofuel trade patterns, which in turn could change the amount of biofuels exported from Sweden.[119] Regardless, more research is definitely needed to obtain a more complete view of the Swedish biofuel export.

[119] See e.g. http://www.pelletsindustrin.org/graphics/pdf/Information_fran_pelletsind.pdf?id=2&instance=1&lang=se (060321)

7 Objective 2: The effects of hurricane *Gudrun* on the Swedish biofuel market

On the night between January 8th and 9th 2005, the south of Sweden was struck by one of the most devastating storms in decades. Large regions in Skåne and southern Småland were faced with winds well above the Beaufort definition of a hurricane[120] and in some areas winds were gusting to over 50 m/s. The consequences were catastrophic. Telephone lines were cut, roads were blocked by falling trees and several hundred thousand people had their power knocked out. Even a month after the storm, ten thousand people were still without electricity. It is estimated that the storm caused damages in excess of SEK 4 billion, *excluding* forest damages. Altogether, this makes hurricane *Gudrun* (which the storm has since been called) one of the worst natural disasters that have hit Sweden.[121] But hurricane *Gudrun* has also turned out to be an economic disaster. A large proportion of the areas most badly struck by the storm were densely forested. That is, they were densely forested *before* the storm. The Swedish Forest Agency estimates that the fierce winds fell 75 million m^3sk of timber.[122] This amount of felled trees "…corresponds to nearly an entire year's cutting for the whole of Sweden."[123].

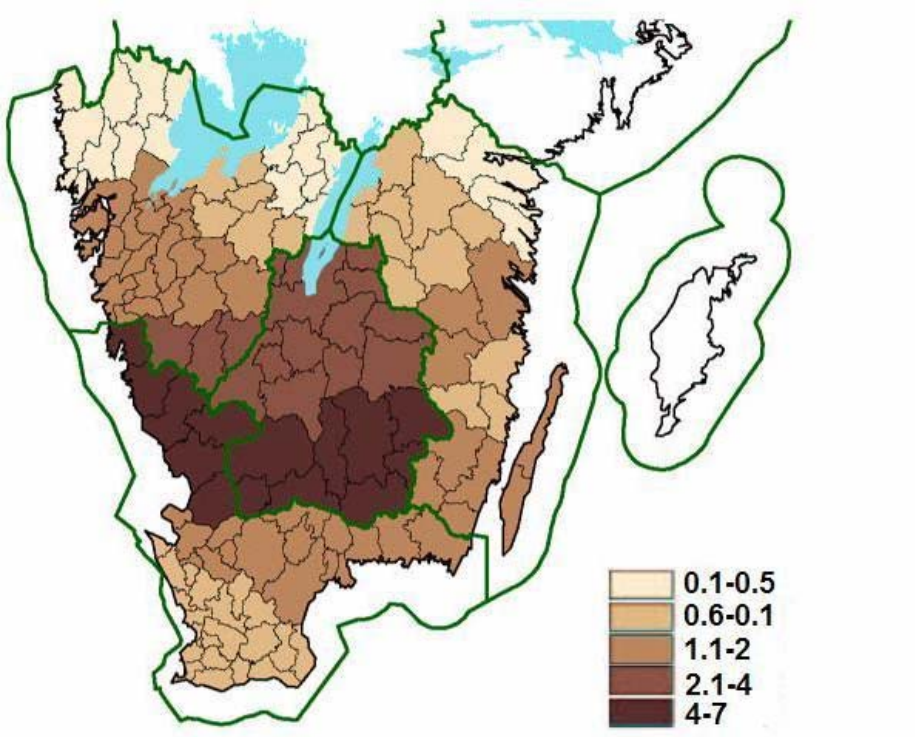

Figure 26. Forest damage by hurricane Gudrun in different regions, measured in number of normal annual fellings[124]

[120] 33m/s
[121] Website of the Swedish Energy Agency(STEM): http://www.stem.se/WEB/STEMEx01Swe.nsf/F_PreGen01?ReadForm&MenuSelect=C209FB3D6E4D944DC12570050043575D&WT=Energiberedskap.Elf%F6rs%F6rjning.Stormen%20*Gudrun* (060116)
[122] ib.
[123] Website of the Swedish Forest Agency, http://www.svo.se/minskog/templates/Page.asp?id=15014 (060111)
[124] http://www.svo.se/episerver4/dokument/sks/stormfakta/bilder/stormfalln_arsavverkn.jpg (060116)

In some regions, the number of trees cut down corresponds to up to *seven* annual fellings, as the map above shows. Apart from Sweden, the Baltic States also suffered badly from the storm, which can be exemplified by the fact that an annual felling in Latvia was cut by the storm.[125]

Not surprisingly, the forest community was in quite an uproar when the consequences of the hurricane became clear. For many private forest owners the hurricane was a great personal tragedy as they saw the work of generations laid waste in just a matter of hours. This section will describe the effects of hurricane *Gudrun* on the biofuel market. It will be divided chronologically in three parts.

- The first part will describe what was initially believed to happen to the biofuel market, based on what was known in the early months of 2005.
- The second part gives a description of the situation in the autumn and winter of 2005.
- The third part will be a look into the future and what the consequences of the storm will be for 2006 and beyond.

7.1 Hurricane *Gudrun*: Spring 2005

7.1.1 Initial reactions and theories about the effects on the bioenergy market

In the months following hurricane *Gudrun*, actors within the bioenergy community presented different theories on how they thought the market would be affected by the hurricane. In this section, some of these theories will be presented.

In *Energimagasinet* #3/05[126] representatives from several biofuel supply companies were asked to give their view on the situation.

- **Anders Törnqvist**, head of the *Sydved Energileveranser*'s Borås office said that "No-one in the forest industry is thinking about biofuels [after the storm (author's note)]. Everyone is occupied with saw wood and pulpwood"[127] and that his company were running low on wood chips due to no tops and branches being taken care of when clearing up after the storm.[128]
- **Mats Håkansson**, president of *Södra Skogsenergi*, also points to the shortage of wood chips due to an 80% decline of tops and branches coming out of final fellings in southern Sweden. He does not think that this will affect the overall production of biofuel although he does believe that large volumes of biofuel could start coming out of the storm-affected area in 2006 and 2007. [129] Håkansson is also quoted in an edition of *Bioenergi* published shortly after the storm. According to this, Håkansson believes that the short-term[130] consequences of the storm will be an increase of fuel from stem-wood, a decrease of tops and branches and an increase of bark and sawdust, the latter due to the increase in sawmill activity. In the long run there will be a shortage of wood chips and fuel from round wood, something that can be replaced with either increased harvest of tops and branches from thinnings, increased use of peat or increased import.[131]

[125] Swedish Forest Agency, *Stormeko* (Special edition of *Skogseko*, focused on the consequences of Hurricane Gudrun) (2005)
[126]
[127] "Oklara konsekvenser av *Gudrun*" in *Energimagasinet* no. 3 2005.
[128] ib.
[129] ib.
[130] i.e. three years or so.
[131] "Stormen" in *Bioenergi* no. 1 2005

- **Gustav Melin**, of *Agrobränsle*, based in Örebro in the middle of Sweden, is under the impression that the storm has caused a decline in fellings in Svealand since all available logging resources have been redirected to the south to help with clearing up after the storm. He also adds that a large part of the wood felled by the storm will become fuel when it after a few years of storage has become useless as pulpwood.[132]

On the 25th of May, on the 25th anniversary of *Svenska Bioenergiföreningen* (The Swedish Biofuel Association) in Stockholm, a panel debate took place on the topic "After hurricane *Gudrun* – how will the biofuel market be affected?". The panel consisted of actors with different roles within the biofuel community.[133]

- **Göran Hedman** of *Naturbränsle i Mellansverige AB* said that his company had been planning for a raise in production this year, but that this had to be postponed due to the lack of logging resources in the middle of Sweden. Hedman also said that the price development will depend highly on the weather the coming summer (2005). If it would rain a lot, less timber would be damaged by insects and therefore less timber would become biofuel, and the other way around[134].
- **Eddie Johansson**, of the municipally-owned energy company *EnaKraft AB* in Enköping, said that prices could start to increase in 2006 and 2007, but that most energy companies had contracts that were running for a long time which provides some protection against short-term price fluctations.[135]
- **Mats Håkansson** of *Södra Skogsenergi* said that there was a spirit of cooperation between suppliers and buyers of biofuel and that it would therefore be highly improbable that either part would risk these good relations for a short-term gain[136].

7.1.2 Summary of initial reactions and theories

While the actors quoted above seem to agree on the early repercussions of the storm, i.e. that there was a decrease in tops and branches extraction and a lack of logging resources in the regions outside the storm area, their theories about the long-term consequences differ. Håkansson of *Södra Skogsenergi* believes that large amounts of biofuels could come out of the storm area in coming years while *Enakraft*s Johanssson on the other hand believes that the years 2006 and 2007 could bring about an increase in prices. The latter speculation somewhat contradicts the former since an increase in prices would be a probable effect of a lack of biofuels.

7.1.3 Hurricane effects that were believed to affect the biofuel market

As the above section shows, there were initially lots of speculations as to the effects of the hurricane on the biofuel market. Below some of these phenomena are discussed and explained.

7.1.3.1 Increased sawmill activity

The effects for the refined biofuels market are very much proportional to the amount of timber being sawn, since refined biofuels such as pellets, briquettes and fuel powder are made from

[132] ib.
[133] The author was present in the audience and took notes which make up the source material for this section.
[134] Hedman Göran., at panel debate in Stockholm May 25th 2005.
[135] Johansson Eddie, at panel debate in Stockholm May 25th 2005.
[136] Håkansson Mats, at panel debate in Stockholm May 25th 2005.

sawmill residues, i.e. sawdust. The more timber sawn, the more sawdust is produced and the more raw material becomes available for producers of refined biofuels. So if large amounts of the wood from the storm-struck area could be used as saw timber, this would also mean large supply of raw material for pellets. There would also be an increase in the supply of bark, another sawmill residue that to large extent is used as raw material for refined biofuels.

7.1.3.2 Downgrading of pulpwood

The consequences for unrefined biofuels are very much dependant on *downgrading*. As previously discussed[137], wood from fellings is labelled either as saw timber, pulpwood or biofuel, depending on the quality of the wood. After hurricane *Gudrun*, one of the main fears among forest owners, besides the risk of lower prices in general due to market flooding, was that the damages of the hurricane would lead to massive downgrading of the quality of the trees damaged by the storm. With literally millions of trees being felled it would take a long time to take care of it all, during which time the logs would lay vulnerable to attacks from fungi like the *blue-stain fungus* and the *wood-rotting fungus*, and insects such as the *spruce engraver* and the *striped ambrosia beetle*. The fear was that trees that undamaged could be sold as saw timber might be downgraded to pulpwood, and trees that could be sold as pulpwood might be downgraded to fuelwood, i.e. biofuel. A massive downgrading of pulpwood trees would i.e. lead to large amounts of unrefined biofuel coming out of the storm-struck area.

7.1.3.3 Decreased amounts of logging residues

A decrease in logging residues, particularly tops and branches, is by some of the actors quoted in the previous section seen as the major effect of the hurricane. The major reason for the expected decrease is that harvesting of tops and branches is done mainly during final fellings in which the extraction of the felling residues is carefully integrated into the felling process as a whole. This is an absolute necessity for the harvesting of tops and branches to be economically viable. The situation in the forests struck by hurricane *Gudrun* is however, as Anders Törnqvist is quoted in chapter 7.1.1, one where all focus is on rescuing as much of the felled wood for saw timber and pulpwood purposes. Extraction of tops and branches would tie up logging resources desperately needed for handling saw timber. Thus, since tops and branches in comparison with saw timber and pulpwood render very little income for the forest owner, little precautions have been made in the storm area for taking care of logging residues for energy purposes. In April 2005, Törnqvist presented some figures on the expected effects of hurricane *Gudrun* on the extraction of wood-fuels. According to this, it was estimated that there would be a 15% decrease in wood-fuel supply in southern Sweden as an effect of the storm due to large decreases in the extraction of tops and branches. [138]

7.2 Hurricane *Gudrun*: Autumn 2005

During the months following the hurricane there were quite a number of theories as to what the effects of the storm on the bioenergy market would be, as was discussed in chapter 7.1. This chapter will deal with what had actually happened six months later, in the autumn of 2005. The material herein is based on **a)** statistics and reports about e.g. the progress in clearing up the damages of the storm, **b)** six interviews with representatives from biofuel

[137] In chapter 5.1.3.
[138] Presentation at *Virkesforum 2005* in Stockholm April 14th, 2005. Powerpoints from the presentation are available at http://www.skogsindustrierna.org/LitiumDokument20/GetDocument.asp?archive=1&directory=710&document=3055 (060201)

suppliers and DH plants in different parts of Sweden and **c)** the previously mentioned survey that was sent to companies active on the bioenergy market.

7.2.1 Development in the storm area

Come autumn 2005 it became obvious that the process of taking care of the felled wood had gone much faster than expected. The Swedish Forest Agency (SFA) published a memo[139] in the beginning of November with statistics on the progress in clearing up after storm. According to this, 39 million m^3fub (67%) out of an estimated total of 58 million m^3fub had been taken care of by September 30th. The SFA also said that many of the bigger actors doing work in the storm-struck forest expected to have finished with the large scale work by January 2006. Included in the memo was also a rendition of the composition of the wood taken care of so far. The following table presents a comparison between these figures and figures for the compiled fellings in Sweden in 2003.

Wood category	**Wood taken care of from the storm area by September 30th, 2005**[140]		**Total fellings in Sweden 2003**[141]	
Sawlogs	62,8%	(21,3 million m^3fub)	50,9%	(34,4 million m^3fub)
Pulpwood	35,4%	(12 million m^3fub)	39%	(26,3 million m^3fub)
Fuelwood from stemwood	1,8%	(0,6 million m^3fub)	8,7%	(5,9 million m^3fub)

Figure 27. Percentages of different wood categories a normal year, and from the storm area up until September 2005

It seems as though the share of saw timber from the clearing-up after the hurricane is actually higher than on a normal year, and that the share of fuelwood is a lot lower than normal. The reason for this is probably that fuelwood, as tops and branches, has not been prioritized during the hasty work taking place in the storm area.

Another interesting fact to note from the SFA memo is that the major part of the wood from the storm had remained in southern Sweden. About 1.1 million m^3fub had been exported.[142]

7.2.1.1 Downgrading fears may have been exaggerated

It also seems as there has not been as much downgrading as was first thought. Leif Brodén, head of the forest concern *Södra* said[143] in October that the downgrading would only be about one million m^3, compared to three million m^3 that was initially expected. Brodén says that this is due to the fact that "A lot less [than was initially feared (author's note)] was damaged in the actual storm, and [there was (author's note)] good weather during spring time, with rain and hard winds"[144]. Ulf Johansson, who does field research in the storm area, also points to the weather as being an explaining factor for the relatively small damage to the wood. In an interview in July he said that "The biggest problems are with the spruce engraver, the striped

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[139] Swedish Forest Agency "Upparbetning av stormvirke m.m. efter stormen *Gudrun* fram till 2005-09-30"Available at:
http://www.svo.se/episerver4/dokument/sks/aktuellt/press/2005/PM%20Upparbetning%200501027.pdf .

[140] This does not include wood that has been taken care of by smaller actors or individual forest-owners, and sadly no figures on the amount of tops and branches taken care of are available.

[141] Swedish Forest Agency, *Swedish Statistical Yearbook of Forestry 2005* (2005)

[142] Swedish Forest Agency "Upparbetning av stormvirke m.m. efter stormen *Gudrun* fram till 2005-09-30"

[143] Thorsten Engman, "Bra tryck på Södra trots stormfälld skog" in *Dagens Nyheter* October 24th, 2005.

[144] ib.

ambrosia beetle and the pine shoot beetle. Luckily, we had a cold spring, so there aren't that many of them."[145].

7.2.2 Development outside the storm area

7.2.2.1 Less fellings due to lack of resources

Looking at some of the initial reactions quoted in the "Hurricane *Gudrun*: Spring 2005" section, it is clear that the repercussions of the storm were not expected to be isolated to just southern Sweden. Göran Hedman of *Naturbränsle i Mellansverige* and Gustav Melin *Agrobränsle*, who both work with biofuel supply companies in the middle of Sweden, mentioned the risk of a lack of logging resources in the north and middle of Sweden as a considerable consequence of the storm. Hedman especially saw this as a serious matter, as he feared that this could lead to a setback in his company's plans of expanding the harvesting of tops and branches in middle of Sweden. In the autumn of 2005, reports from some of the forest companies started to come out, making it possible to see what the consequences of the storm had been. From some of these it is possible to estimate the decrease in logging that was discussed previously:

- *Skogsägarna Mellanskog*, a large forest company operating from Lake Vänern up to Lake Storsjön, state it has had a 16% decrease in fellings in the first eight months of 2005 compared with the same period the previous year.[146]
- *Skogsägarna Norrskog*, which operates in the provinces of Jämtland, Medelpad, Västernorrland and a part of southern Lappland, reports a 12% decrease in fellings.[147]
- And finally, *Norra Skogsägarna*, which is active in the northernmost parts of Sweden, has had a decrease of just slightly more than 1 percent.[148]

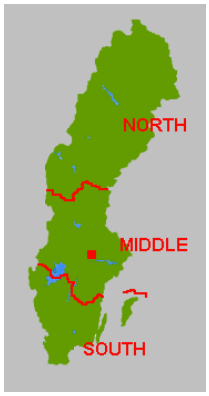
These are interesting figures, implying that the consequences of the hurricane decrease with the distance to the storm area. Also, the figures confirm that fellings has indeed decreased in the middle and northern parts of Sweden as a consequence of the redirection of logging resources to the storm area. This might very well affect the future supply of tops and branches in these areas.

[145] Lena Berglund, "Forskaren som har skogen i generna" in *Hallands Nyheter*, July 15th, 2005.
[146] http://www.skogsagarna.se/default.asp?oewCmd=3&id=9210&archiveid=168&pageid=2150&path=2129 (060117)
[147] http://www.skogsagarna.se/default.asp?oewCmd=3&id=9148&archiveid=168&pageid=2144 (060117)
[148] http://www.skogsagarna.se/default.asp?oewCmd=3&id=9418&archiveid=168&pageid=2144 (060117)

7.2.3 Interviews with bioenergy market actors[149]

Anders Ericsson[150] is head of the Heat Division at the municipally-owned energy company *Mälarenergi* in Västerås. In the company's CHP plants, Mälarenergi uses biofuel, peat and coal as fuel. Their productive apparatus is quite flexible and they can shift fuel swiftly depending on what the situation demands.

Ericsson received the first prognosis of the effects of Hurricane *Gudrun* from forest consultants who were working for Mälarenergi at the time of the storm. According to these, the likely scenario was that there would be a surplus of biofuels the first two years after the storm, and this would then be followed by ten years of shortage. This early prediction was largely based on the first prognoses of the storm damage as a whole. It was initially believed that great quantities of the wood felled by the storm would be damaged to the point were it would only be useable for energy purposes. Based on this, Mälarenergi were discussing the possibilities of transporting damaged wood by train from the storm area to the CHP plant in Västerås where the wood would be chipped into chips and used as fuel in the plant. This early picture did however prove to be incorrect. The work clearing up after the storm has gone a lot faster than expected, and a lot less wood than feared has been degraded to biofuel. Also, since the clearing up in the forest has been conducted in a quite hasty manner, there has not been any time for taking care of the residues from the fellings. All focus has been on trying to preserve pulpwood, an effort that on the whole has been successful.



Ericsson says he has seen no real price fluctuations as an effect of the storm, neither up nor down. In the spring of 2005 Mälarenergi signed new fuel contracts that stretch until spring 2006, and Ericsson is of the opinion that any price changes would hade affected these new contracts. He thinks there are two reasons for the hurricane not having much of an effect on the bioenergy market. First, he points out that the bioenergy market is actually not a very well functioning market. Regional monopolies are common, so in many cases there are no real incentives for downward pressure on prices. Second, as a consequence of a lot of felling resources being redirected to the storm-struck area, there has been less fellings in the middle and north parts of Sweden.

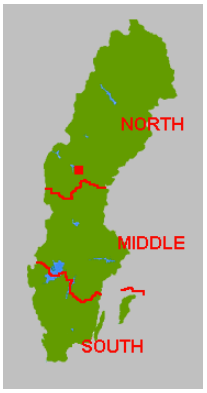
Ericsson does however believe that the development the coming spring (2006) will be interesting. Tops and branches from fellings are normally made use of about one year after a felling, so any potential tops and branches should start coming out on the market a year after the storm. In the long term, the hurricane will lead to less fellings in the area affected by the storm, which could lead to a shortage of tops and branches. On the other hand, there are possibilities to increase the harvesting of tops and branches in the north parts of Sweden. There is also now more profitable to harvest tops and branches during fellings with the recent years' rising prices on biofuel.

Anders Lindbergh[151] is head of production at Östersund-based *SÅTAB*, a company that delivers biofuel made from sawmill residues.

When Lindbergh first heard of hurricane *Gudrun*, his first thoughts were "What will happen to all this wood?". It seemed obvious to him that the industry in the vicinity of the storm would have no chance of taking care of everything, but after some estimations of costs of transports etc. it also became clear that "…we will have to get paid by the farmer in

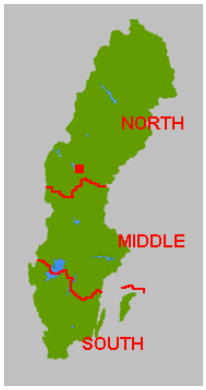
[149] A methodological discussion about the interview process can be found in chapter 2.
[150] Interview with Anders Ericsson in Västerås 051103
[151] Interview with Anders Lindbergh in Östersund, 051107

Småland if he wants to send us his wood". According to Lindbergh, no biofuel from the storm area has come up to affect SÅTAB. He does add that it might be possible that coastal northern regions could receive some marginal volumes, but this is not very probable. Lindbergh feels that the overall mood in the business has been quite calm seeing that not much wood-fuel has come out on the market as an effect of the storm up until now, and not much seems to come out in the future either. The reasons for this are that no tops and branches have been extracted from the clearings in the storm-struck region, and that a lot less wood has been damaged during the summer than was initially expected. The fact that the forest company Södra has lowered their pulpwood requirements, which means that wood that normally would be downgraded to fuel is now accepted as pulpwood. Lindbergh says that the decrease of fellings in northern Sweden has been the effect of the storm that he has become most aware of.



Tomas Jonsson[152] is responsible for fuel supply at the energy company *Jämtkraft*, based in Östersund.

Jonsson believes that many initially thought that the biofuel market would be flooded as an effect of the hurricane *Gudrun*. Regarding what actually happened, Jonsson draws a parallel to a storm that struck Härjedalen and Dalarna a few years back. When that storm came, there was an initial belief that there would be a surplus of damaged wood. However, clearing a forest area damaged by a storm takes a lot of time, and you can at most reach around 75-80% of normal capacity. This storm nearly led to timber becoming an article in short supply, but did not have any significant effect on the biofuel market. Jonsson says that a lot of the things that was learned from this previous storm were confirmed with hurricane *Gudrun*. With hurricane *Gudrun* no tops and branches were harvested from the storm area which Jonsson believes will lead to an increase in demand for e.g. peat. Jonsson says that he had some different thoughts as to whether the hurricane would bring on a surplus or a shortage on biofuel, but in the end he came to the conclusion that not much would happen on the market, at least not in the short run. Before the storm there was somewhat of a shortage on biofuels in the area surrounding Lake Mälaren and Jonsson thinks that this could act as sort of a buffer in case large amounts of biofuel would come out of the storm area. Another possible effect of the storm is that there would be less incentives to transport biofuel from the north Sweden to the south, as there might be a surplus in the south.

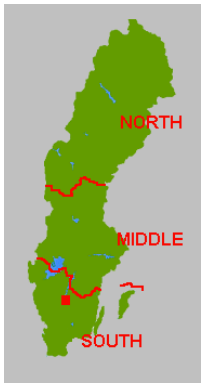


Jonsson says that there is always a risk of price dumping in situations as these, but he emphasizes that even though bioenergy is big in Sweden, the bioenergy industry is quite small. Jonsson believes that due to a long-range view of the market and a desire not to damage the market, price levels have remained at a higher level than necessary. Jonsson believes that the fact, that the trade association *Svebio* has both members that are producers of biofuels and members that are consumers of biofuel, is important. This could have contributed to people in the industry having learned to cooperate and find mutual solutions rather than acting as nothing more than partners in a business deal.

Tomas Isaksson[153] is head of production at *Svensk Brikettenergi* (SBE) in Huskvarna, a company that makes biofuel out of sawmill residues.

[152] Interview with Tomas Jonsson in Östersund (051108)
[153] Interview with Tomas Isaksson in Huskvarna (051114)

Isaksson's first thought after the storm was that there would be an increase in raw material. The sawmills are going full steam to take care of all the wood from the storm, and will keep doing so for two more years. In other words, there is good short-term supply of raw material. Isaksson says that the effect of the storm became pretty much as he had expected. Initially it was however believed that the raw material coming from the sawmill industry would become cheaper, but this has not been realised, at least not yet.

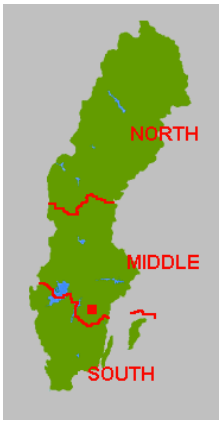


There is a lot of talk about a shortage on tops and branches for the industry as a whole, but Isaksson says that you have to consider the possibility that this is something that actors on the market are just saying for strategic reasons. On the whole, Isaksson says that many who make predictions about the consequences do so out of own interest.

Another aspect is the possible downgrading of timber to pulpwood and of pulpwood to biofuel. But Isaksson says that it is possible that the bioenergy market will not notice the storm in any other way than that there has been "chaos in the forest" for one year. As for future long-term development, Isaksson believes that prices will rise.

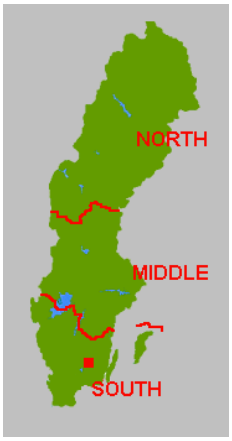
Anders Folkesson[154] is managing director of *Sydved Energileveranser* (SE), a company that buys, refines and sells wood-fuels. Two thirds of their sales is unrefined wood-fuels such as wood chips and one third is bi-products from the sawmill and pulp industry, e.g. bark.

Folkesson begins by pointing out that the raw materials that SE uses require a lot of planning. He exemplifies this by describing the extension of the tops and branches production cycle. Residues from fellings that took place in the season 2003/04 were left to dry and were put into stacks in the summer of 2004. In the following season, 2004/05, the residues are chipped into chips and delivered to the customer. As an effect of this, Folkesson says that the hurricane would not have any effect in the short run. But: what will happen the following season, 2005/06? It has become clear that no tops and branches are coming out from the storm area since no tops and branches are being harvested there. The storm struck January 9th, 2005 which means that during the season 2005/06, tops and branches from the first half of the season 2004/05, since no tops and branches were harvested after January 9th, i.e. the second half of the season. Thus, half of the expected amount of tops and branches will be available in the season 2005/06. However, a lot of fuelwood from the storm clearing is becoming available, which by and large makes up for the shortage of tops and branches, creating somewhat of a balance. Folkesson emphasises that SE will have no problems supplying their customers. Regarding the next season, 2006/07, no tops and branches at all will become available in the storm area since no fuel-adjusted fellings were done in the season 2005/06 due to the storm. The question is if this can also be compensated with fuelwood, something that is highly dependant on the quality on the pulpwood that is still left in the forest. Folkesson does not want to speculate about this. What the situation will be like if large quantities of fuelwood come out on the market is also uncertain. One scenario is that actors on the market will pay less to the forest owners which would lead to DH plants being the "winners" since they will be able to buy inexpensive fuel. Folkesson also points out that it will not be possible to take care of the tops and branches from the season 05/06 later, as the forest machines will have run them over. Also, the only way to get good economics in handling tops and branches is to integrate the harvesting of the tops and branches into the felling process as a whole.



[154] Interview with Anders Folkesson, conducted via telephone (051123)

As for price development, Folkesson does not think that much has happened, except for a price decrease of perhaps 5% in the storm area. On the other hand, Folkesson says that prices have gone up in the area surrounding Lake Mälaren due to the fact that no tops and branches are coming out of that area either since all logging resources have been diverted to the storm area. Also, this area is not being compensated in form of fuelwood as in the storm area, and it is not economically viable to transport fuelwood from the storm area. On the whole, Folkesson does not feel that the biofuel business has been that affected by the storm. One consequence is however that Sydved had plans to increase their harvesting of tops and branches from the area surrounding Lake Mälaren and north, but that these plans have been cancelled due to the storm. However, Folkesson does not think that this will slow down the fast growth in the bioenergy sector since there is a continuously high demand from both from industry and from DH plants.



Ulf Johnsson[155] is head of production at a CHP plant owned by the municipally-owned energy company *Växjö Energi*, which was actually the first company to use wood-fuels in district heating.

Johnsson believes that the bioenergy market has not been affected at all by hurricane *Gudrun*. There have not been any mentionable price fluctuations and the shortage on tops and branches that has been an effect of the storm has been made up for with fuelwood. Johnsson says that there continues to be a surplus of biofuels.

[155] Interview with Ulf Johnsson, conducted via telephone (051123).

7.2.4 Results from the survey

The survey was sent to 60 companies involved in bioenergy trade in one way or another, e.g. DH plants, producers of biofuels etc. 35 answered and returned the survey which amounts to a total frequency of answers of 58%.[156] The respondents were in the survey asked to give some basic facts about their company, thus providing some interesting characteristics without the actual company being revealed. Before the results of the questions revolving around the consequences of the hurricane, these background statistics regarding the survey respondents will be presented.

7.2.4.1 General information regarding the respondents

7.2.4.1.1 Regional distribution

To begin with, the regional distribution of those who answered the survey was such that half were categorized as "Middle", roughly a third as "South" and roughly a fifth as "North".

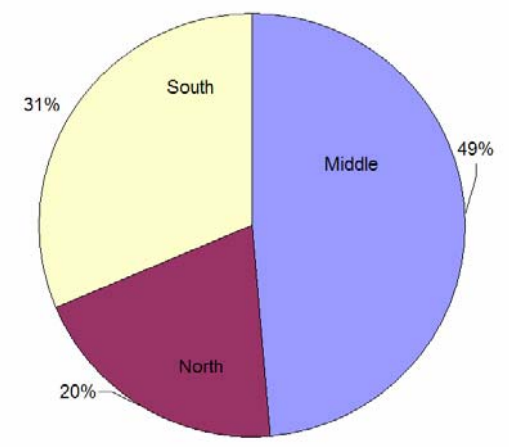


Figure 28. Regional distribution of the respondents

7.2.4.1.2 How do the companies trade biofuels?

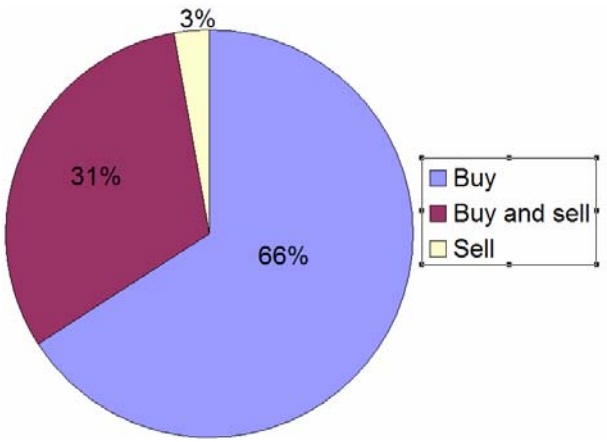


Figure 29. How the companies trade biofuels

[156] A thorough methodological discussion regarding the process of constructing and compiling the survey can be found in chapter 2.

The respondents were asked *how* they trade biofuels. Two thirds state that they only buy biofuels, roughly one third that they both buy and sell, and one respondent solely sells biofuels. These numbers are quite similar to the amount of suppliers and DH plants, respectively, who responded the survey.[157] It is reasonable to interpret this as that the DH plants are the ones who have stated that they solely buy biofuels and that the companies who have said that they both buy and sell (and the one company that just sells biofuels) are the supply companies.

7.2.4.1.3 Yearly fuel turnover

To get an idea of the size of the companies involved in the survey, they were asked to give an estimate of their yearly fuel turnover. The companies could choose from three different alternatives, up to SEK 75 million/year, 75-300 million or more than SEK 300 million/year. The answers were fairly evenly divided:

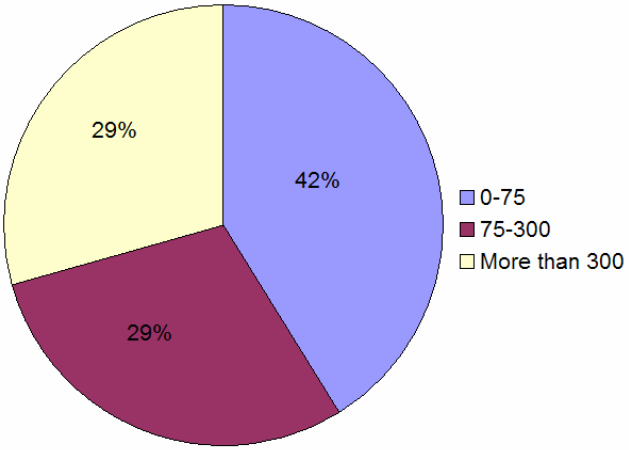


Figure 30. Yearly fuel turnover in million SEK as reported by the respondents.

7.2.4.1.4 Ownership

The respondents were asked to specify ownership characteristics of their respective company; private, government/municipality or mixed ownership.

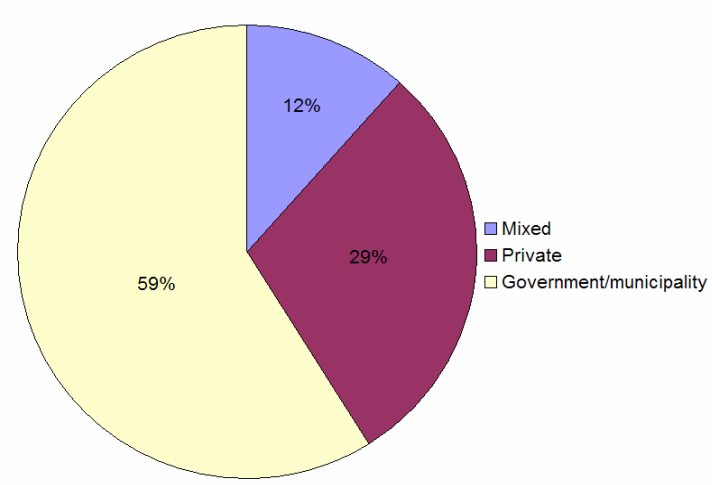


Figure 31. Ownership data as reported by the respondents.

[157] Roughly two thirds of the survey responses are from DH plants/energy companies and roughly one third are from biofuel suppliers.

7.2.4.2 General Hurricane *Gudrun* response statistics

As for the part of the survey regarding the consequences of hurricane *Gudrun*, the respondents were asked to answer five questions. The first question was simply “Have you noticed any effect from Hurricane *Gudrun* on biofuel trade?”

Out of the 35 who answered the survey, 11 (31%) stated that hurricane *Gudrun* has had an effect on the biofuel market.

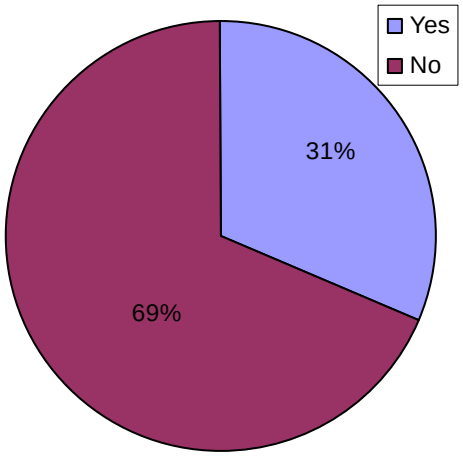


Figure 32. Answers to the question "Have you noticed any effect from hurricane Gudrun *on biofuel trade?"*

Out of the 11 who answered “Yes” to the question, six are regionally categorized as “South”, four as “Middle” and one as “North”.

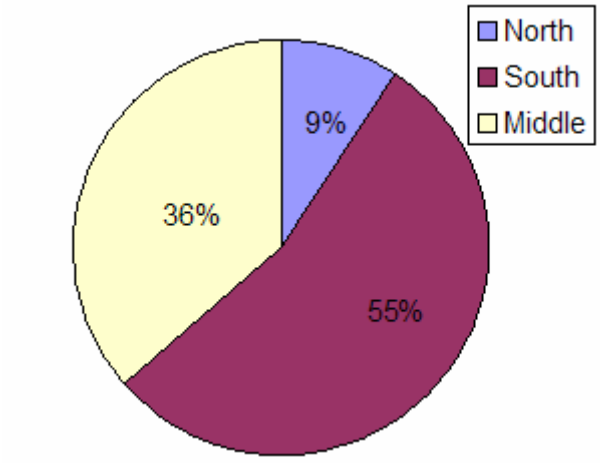


Figure 33. “Yes” answers to the question "Have you noticed any effect from hurricane Gudrun *on biofuel trade?", sorted regionally.*

7.2.4.2.1 Regional differences

As can be seen in the figures below, there are noticeable differences between the three regions regarding the perceived effects of the hurricane on the biofuel market.

- In the “North” region, one out of seven stated that the hurricane had affected biofuel trade.
- In the “Middle” region 4 out 13 answered “Yes” to the question.
- In the “South” region, i.e. the region physically most damaged by the storm, 6 out of 11 companies stated that the hurricane has indeed affected the biofuel market.

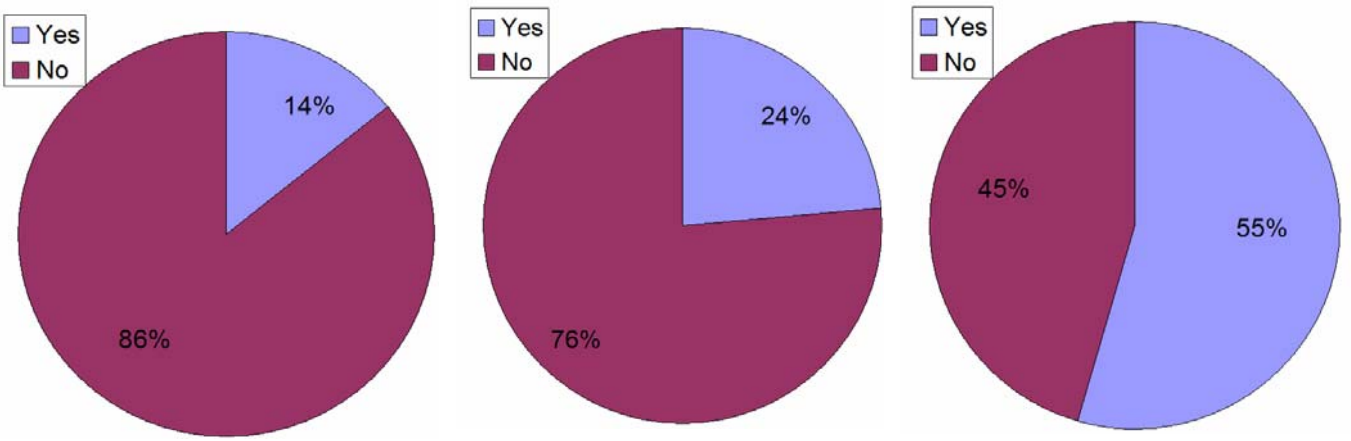


Figure 34. Answer statistics for the question "Have you noticed any effect from hurricane Gudrun *on biofuel trade?"*

7.2.4.2.2 Comments

The respondents were also asked to comment on their answers.

- Out of the “South” answers, several point to the lack of tops of branches as a major effect of the storm, and that this shortage has been replaced by sawmill residues and fire wood. One actor does however also comment on a lack of fire wood.
- In the “Middle” group, a comment worth noting is that one actor answers that they haven’t noticed any effects of the storm yet, since they have long-term contracts. Another one points to a lack of tops and branches.
- In the “North” region, one actor answers that “the effects will not be seen until next year”. Another one answers that there is a lack of logging resources.

It is also interesting to study the comments from those who have answered “No” to the question. Out of these, several have commented that they have not seen any effect from the hurricane *yet*.

7.2.4.3 Domestic trade

The following questions focused on trying to clarify *how* the storm had affected the biofuel market. Different aspects of biofuel trade were covered in order to shed some light on the possible consequences.

The first follow-up question was “Have you noticed any effect from hurricane *Gudrun* on domestic biofuel trade?” Out of the eleven who had answered “Yes” to the first question, whether the storm had affected the biofuel trade at all, 10 agreed that the storm had affected domestic trade, and one disagreed.

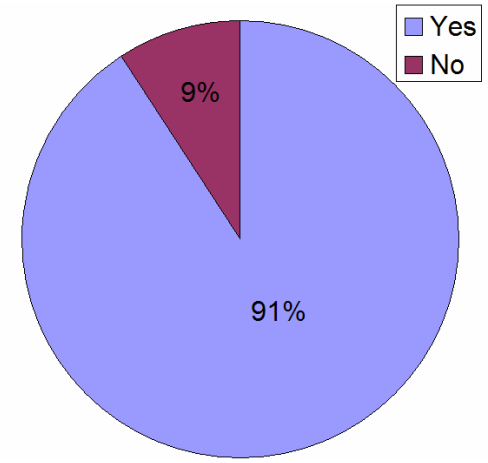


Figure 35. Percentage of those who thought that the storm had affected biofuel trade who thought that domestic *biofuel trade had been affected.*

The respondents were then asked in what way the hurricane had affected the domestic market. Had it changed with regards to

- The types of fuel that are traded?
- Which trade routes are used?
- The extent of the trade?
- The prices?

or

- Some other factor?

Eight respondents chose to answer the question regarding whether the storm had changed the types of fuels traded. Out of these eight, six answered "Yes" and two answered "No". Four of those who answered "Yes" also attached comments to their answer, all of them pointing to the lack of tops and branches and the increased amount of fuelwood.

Eight respondents also chose to answer the question regarding whether the trade routes had changed as an effect of the storm. Out of these, three answered "Yes" and five answered "No". There were two comments, both attached to "Yes"-answers, saying "This could mean decreased import in the southern and middle parts of Sweden"[158] and "Longer transports", respectively.

Eight answered the question whether the extent of the trade had changed, and all of them answered "No, there is no difference". There were no comments to this question.

Nine respondents answered the question regarding possible price fluctuations in the wake of the hurricane. Three of the said "Yes, the prices have gone up.", three said "Yes, the prices have gone down.", and three answered that "No, the prices haven't changed.". The regional distribution of these answers can be seen in the below table.

Region	Higher prices	Lower prices	No price changes
North	0	0	0
Middle	2	0	1
South	1	3	2

Figure 36. Answers to the question " Have you noticed any effect from hurricane Gudrun *on biofuel trade?", sorted regionally.*

[158] It could be worth noting that this comment comes from an actor based in the north of Sweden.

There was one comment attached to this question. This is a respondent from the "Middle" region who has answered "Yes, the prices have gone up" who explains that the price raise is an effect of decreased logging in the vicinity.

7.2.4.4 Foreign trade

The last part of the survey investigates whether the respondents fare of the opinion that hurricane *Gudrun* has had an effect on foreign Swedish biofuel trade. The first question was, naturally, "Have you noticed any effect from hurricane *Gudrun* on foreign biofuel trade?" Eight respondents answered this question, six answered "No" and two answered "Yes".

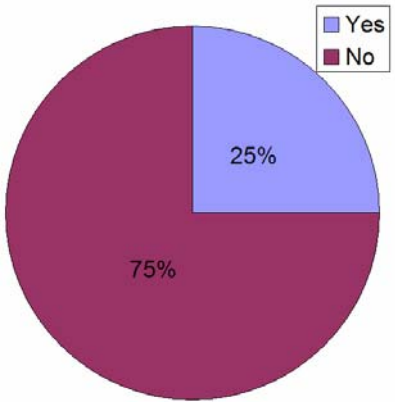


Figure 37. Answers to the question "Have you noticed any effect from hurricane Gudrun *on foreign biofuel trade?"*

There were not many answers to the specifying follow-up questions so they will not be presented separately. Worth noting is however that one respondent who answered that foreign prices have gone up because a lot of Latvian machinery has been transferred to Sweden as an effect of the storm. According to the respondent, this creates a lack of resources in Latvia that have lessened Latvian biofuel capacity which in turn has led to higher prices.

7.2.5 Consequences of Hurricane *Gudrun* on the biofuel market so far

From the mass of information that is presented above it is possible to draw at least a few conclusions as to the effect of hurricane *Gudrun* on the biofuel market one year later. There seems to be a general consensus that the effects so far have been quite mild, but they are nonetheless interesting.

- The storm has had mainly local effects, primarily affecting the south of Sweden through the shift from tops and branches to fuelwood and sawmill residues in the south. This has been due to the change in felling methods in the storm area compared to normal fellings.
- As for the rest of the country, the largest effect is the decrease in fellings of about 15% in the middle of the country due to lack of logging resources, which could affect the future supply of tops and branches.
- There is something of a general consensus within the bioenergy community that the effects of the storm, especially on biofuel prices, will be seen more evidently in the coming year and the years to follow. This discussion is covered in chapter 7.3.
- Some mixed regional price fluctuations have taken place as a consequence of the storm, but so far, the storm has had only marginal effects on biofuel prices.

To get a more quantitative understanding of what the consequences of the storm have been hitherto, the following counting experiment might provide some guidance. Below is an approximate comparison of the production of solid biofuels in southern Sweden a “normal” year and the hurricane year 2005, based on statistic figures and statements from biofuel actors.

Fuel Year	Tops and branches	Fuelwood	Sawmill residues	Pulp industry residues	Total
2004	2.6 TWh	3.8 TWh	1.7 TWh	0.5 TWh	**8.6 TWh**
2005	0.5 TWh	1.7 TWh	4.6 TWh	0.9 TWh	**7.7 TWh**

Figure 38. Table of approximate biofuel in southern Sweden 2004 and 2005[159]

As previously implied, the figures in the table do not necessarily reflect the actual amount of biofuel production for the south of Sweden. However, the proportions between the figures in 2004 and 2005 are probably fairly accurate, suggesting an approximate 10% decrease in biofuel production in southern Sweden due to of the hurricane. The main reason for the decrease is the previously discussed decreased extraction of tops and branches from the storm area, combined with the decreased share of stemwood used as fuelwood. Although there are larger amounts of sawmill and pulp industry residues available in 2005, this does not make up for the lack of primary wood-fuels.

[159] The calculations upon which the estimations are made can be found in appendix E.

7.3 Conclusions: Consequences for 2006 and beyond

As discussed in the previous section it seems as if the full effects of hurricane *Gudrun* on the biofuel market have not been seen yet, and that 2006 might be the year when the consequences will become clearer. The reasons for this delayed effect are essentially threefold.

- First, the production cycle for tops and branches can stretch over a year's time from felling to incineration, which means that it is in 2006 that the lack of tops and branches from 2005 will affect the market. [160]
- Second, most of the companies taking part in the survey use contracts that stretch over one or several years, so price changes because of hurricane *Gudrun* will not be revealed until the signing of new contracts is due.
- Third, a common remark found in articles and interviews regarding the work clearing up after the storm, is that the downgrading danger is not over yet as insects might still inflict large damages on felled wood. This could lead to large quantities of pulpwood being downgraded for use as fuel.

7.3.1 How to make up for the wood-fuel deficit

Even though the long-term consequences of the hurricane may still be somewhat unclear, there is every indication that there will be a wood-fuel deficit in southern Sweden as an effect of the storm. Below, some fuels that can be used to make up for the deficit are reviewed and evaluated.

7.3.1.1 Downgraded pulpwood?

As mentioned above, massive downgrading of pulpwood due to insect and/or fungi attacks in 2006 could make up for some or all of the wood-fuel deficit, but downgrading of the pulpwood will mean large economic losses for forest-owners. Therefore one must be aware that this is a scenario that the entire forest community is working desperately to avoid, and that the downgrading may be avoided. If the case should be in 2006 as in 2005, that the fear of insect attacks is proven to be exaggerated, other alternatives will have to be sought to make up for the deficit.

7.3.1.2 Peat?

In the end of January 2005, some weeks after the storm, it started to become clear that the hurricane could lead to a wood-fuel deficit and speculations began on how this would be redeemed. Some suggested[161] that an increase, perhaps a doubling, of the peat harvest could help replace the lack of logging residues. However, during the year that has passed since the storm, the probability of this has lessened substantially. As mentioned previously, the inclusion of peat in the emissions trading system has led to many DH plants beginning to move away from the use of peat as fuel. Also, in the beginning of February 2006, *The Swedish Agency for Economic and Regional Growth* (NUTEK), delivered a report to the Swedish government recommending that peat production should not be subsidized. [162] Previously, there have been discussions regarding whether peat production should receive extra fundings to make up for the problems caused by the classification of peat as a fossil fuel

[160] Discussed in chapter 5 and also (thoroughly) in the interview with Anders Folkesson of *Sydved Energileveranser*.
[161] http://www.nyteknik.se/skrivUt.asp?art_id=38506 (060203)
[162] http://www.nutek.se/sb/d/198/a/3083 (060203)

in the emissions trading context. The fact that NUTEK recommends that no extra fundings are given minimizes the probabilities that such a subsidy will become a reality. It also lessens the probability that DH plants will use peat to make up for the wood-fuel deficit caused by hurricane *Gudrun*.

7.3.1.3 Imports?

To replace the lack of forest residues in the storm area with imported biofuels has been discussed as a plausible alternative. Biofuels have been imported in rather large quantities to Sweden for some fifteen years and contributes substantially to the Swedish biofuel market. An increased import of biofuels could be one way to make up for the wood-fuel deficit caused by hurricane *Gudrun* in the south of Sweden. However, this transition from domestic fuels to imports can not be expected to take place without problems. To begin with, hurricane *Gudrun* also struck the Baltic States who are large exporters of biofuel to Sweden. This could mean that as in Sweden, supply systems, particularly for primary wood-fuels, may have been disrupted by the new measures needed to be taken in the wake of the storm. Secondly, conclusions from the investigations of the first objective of this thesis imply that the Swedish biofuel import has remained rather stable in the last five years or so, after having grown continuously through the 1990's. While the reasons for this are unclear, it could imply more competition for available biofuels in Europe and also higher prices. As there, according to the survey, were very small price differences between domestic and imported primary wood-fuels[163], any increase in imports to make up for the deficit will probably be to substantially higher prices.

7.3.2 Price development in *Gudrun*'s footsteps

As many signs imply that a lack of biofuels being the effect of hurricane *Gudrun*, it is reasonable to believe that the increase in biofuel prices that has been taking place since the turn of the millennium, will continue. Unless large amounts of pulpwood is damaged and downgraded to biofuel in 2006, the decrease in wood-fuel production in southern Sweden will not be easily replaced by alternative fuels, as was discussed above. Also, several biofuel production companies active in the middle of Sweden have had to postpone increases in the extraction of tops and branches due to a lack of logging resources. Increased extraction of logging residues in the north and middle of Sweden is a large biofuel resource that is far from being fully developed, and is seen as a very important factor for future Swedish biofuel supply. As the increase in demand for biofuels not seems to be halting, the combination of a decrease in tops and branches extraction in the south of Sweden and the postponing of increased extraction in the middle of the country will have consequences for the Swedish biofuel supply/demand balance. The continuously increasing demand will not be met by a corresponding increase in domestic production, which most likely will lead to both increased import and that the rise in biofuel prices will continue.

While biofuel prices continue to rise, development points in the opposite direction for pulp chips. At the end of December 2005, upset voices were heard from sawmill owners due to the pulp industry having lowered the price on pulp chips by 20%.[164] This large price decrease combined with the increased biofuel prices could lead to that prices on biofuel once again will approach the prices on raw material for the pulp industry.

[163] See chapter 6.2.1.2.3

[164] Gustaf Tapper, "Sänkt flispris får sågverken att rasa" in *Dagens Industri* (051229).

8 Conclusions and final discussion

The work upon which this report is based has had two main objectives: to investigate the Swedish foreign biofuel trade in 2003, and to study how the biofuel market has been affected by the hurricane *Gudrun*. Before the concluding discussion, results of the two objectives are summarized.

8.1 Summary: Swedish foreign biofuel trade in 2003

The results from the investigation of the Swedish foreign biofuel trade in 2003:

- The Swedish biofuel import in 2003 is estimated to be about 5-9.5 TWh (18-34.2 PJ).
- The most important origins of the import are:
  - The Baltic states and Belarus (pellets, logging residues, peat).
  - North America (tall oil and pellets)
  - Mainland Europe (municipal solid waste and recovered wood)
- Prices on imported refined biofuels are about 25% lower than domestic ones, whereas prices on imported primary wood-fuels are roughly the same as the domestic ones.
- The Swedish biofuel export in 2003 was 0.1-1 TWh (0.36-3.6 PJ).
- The most important fuel categories of the export were peat and tall oil.

8.2 Summary: Hurricane *Gudrun*

The effects of hurricane *Gudrun* on the biofuel market can be summed up as follows:

- The hurricane has brought about a large decrease in the extraction of tops and branches in southern Sweden. This decrease will to some degree be replaced by increased amounts of sawmill residues, but a wood-fuel deficit in the south is nonetheless likely.
- Unless a lot of pulpwood is downgraded to fuel in 2006, the deficit will have to be replaced largely by increased imports.
- Higher prices on biofuel as an effect of the deficit caused by the storm, combined with decreased prices on raw material for the pulp industry, could lead to increased competition for pulp chips.
- In the rest of Sweden, the hurricane has led to somewhat of a setback in the expansion of logging residues extraction.

8.3 Concluding discussion

As for the development on the biofuel market in the coming years it can be expected that the new trend that began around the year 2000 with increasing biofuel prices will continue. The effects of hurricane *Gudrun* is likely to lead to that the large Swedish biofuel demand will not be matched by domestic supply, as the increase in Swedish biofuel production will be somewhat halted as an effect of *Gudrun*. Downgrading of pulpwood from the hurricane area to biofuels due to insect and/or fungi attacks in the spring and summer of 2006, could make up for the deficit, but this is not to be counted on, since downgrading is very dependant on weather. Also, the forest industry as a whole is working intensely to protect the pulpwood and avoid downgrading. Thus a wood-fuel deficit in 2006 due to the hurricane is a highly probable scenario. Although it could be possible to replace the domestic deficit with increased imports, this may come with some problems. It is unknown whether e.g. biofuel supply chains in the

Baltic States also were damaged by the hurricane of January, 2005. This has not been examined during this project, but if such is the case, the hurricane could lead to a shift in Swedish biofuel import patterns, with imports from other countries potentially replacing the large amounts of biofuels normally that normally comes to Sweden from Estonia and Latvia.

8.3.1 Suggestions for further research

Throughout the work on this project, it has become clear that there is a lot of research to be done to get a comprehensive view of the mechanisms that make up the Swedish biofuel market. To begin with, one interesting observation is the fact that the biofuel market in a new way brings together two large sectors with long traditions, the forest industry and the energy producing companies, in which some of Sweden's largest companies can be found. The two sectors have for a long time had a special relationship due to the large amounts of electricity used in the forest industries. With the appearance of a large biofuel market, the relationship between the forest industry and the energy producers has in a way become the opposite, with the forest companies supplying fuel for the energy companies. This new situation deserves to be more thoroughly examined. Another subject on the same theme is the fact that more and more electricity is produced within the forest industries, which in the future could lead to a situation where the forest industries *buy* biofuel for use in electricity production which in turn could possibly lead to the forest industries becoming self-sufficient in electricity.

A limitation with the study of the Swedish foreign biofuel trade that has been conducted during this project is the fact that research has been conducted strictly from a Swedish perspective. This was a conscious choice made to limit the project, but is an obvious weakness with the study. To complement the approach used in this study with a study focusing on the exporting countries would certainly provide a more comprehensive view of the extent and characteristics of Swedish foreign biofuel trade.

References

Books

Jan-Axel Kylén, *Att få svar* (2004), Bonnier Utbildning AB

Per Olov Nilsson (ed.), *Energi från Skogen* (1999), SLU Uppsala

Swedish Energy Agency, *Växande energi: Bioenergin i Sverige – en marknad i utveckling* (2003), Swedish Energy Agency, Eskilstuna

Jan Trost, *Enkätboken* (2001), Studentlitteratur AB

Scientific articles

Karin Ericsson & Lars J. Nilsson ”International biofuel trade – A study of the swedish import” in *Biomass & Bioenergy* 26 (2004) 205-220

Jörgen Filipsson, ”Primärt skogsbränsle i Sverige-produktion, metoder och förbrukning”, *Resultat från Skogforsk 17/1998*

Graham R, Hektor B., Rakos C., Roos J. *Factors for bioenergy Market Development* (1998)

Skogforsk, *Resultat från Skogforsk* #2 2005 (2005)

Bengt Hillring, ”The Swedish Wood Fuel Market” in *Renewable Energy* 16 (1999)

Bengt Hillring & Johan Vinterbäck “Development of European wood-fuel trade” in *Holzforschung & holzverwertung*, Vienna 2000

Newspapers and periodicals

Bioenergi

Website: http://www.novator.se/bioenergy/index3.html

Svebio, ”Biobränsleleverantörer 2004” in *Bioenergi* #1 2005

Svebio, ”Stormen” in *Bioenergi* #1 2005

Kent Nyström, ”Svebio 25 år” in *Bioenergi* #3 2005

Other

Lena Berglund, ”Forskaren som har skogen i generna” in *Hallands Nyheter*, July 15th, 2005.

”Oklara konsekvenser av *Gudrun*” in Energimagasinet #3 2005, Teknikförlaget TFAB, Halmstad
Thorsten Engman, ”Bra tryck på Södra trots stormfälld skog” in *Dagens Nyheter* October 24th, 2005.
Nordisk Energi, Scandinavian Industry Publishing AB, Stockholm
Skogsindustrierna, “Papper, trä eller energi” in *Tidningen Skogsindustrierna* 2/2003
”Toppskottet”, appendix in *Vi skogsägare* #1/2005.
Gustaf Tapper, ”Sänkt flispris får sågverken att rasa” in *Dagens Industri* 20051229
Stormeko (special edition of *Skogseko*, 2005) Swedish Forest Agency, Jönköping

Other publications

Jakob Hirsmark, *Elcertifikatsystemets effekter på biokraft inom massaindustrin* (2005)
G. Lönner and others, *Kostnader och tillgänglighet för trädbränslen på kort sikt.* (1998)
Matti Parikka & Reinhard Madlener, “Economics of Sustainable Energy Wood Production“ (2005)
Svebio & Swedish Energy Agency, *Fokus Bioenergi* #2 2004, #4 2004 (2004)
Swedish Energy Agency, Energy in Sweden 2004 (2004)
Swedish Energy Agency, *Energimarknad 2005* (2005)
Swedish Environmental Protection Agency, *Införsel av avfall till Sverige år 2003* (2004)
Swedish Forest Agency ”Upparbetning av stormvirke m.m. efter stormen *Gudrun* fram till 2005-09-30” Can be found at: http://www.svo.se/episerver4/dokument/sks/aktuellt/press/2005/PM%20Upparbetning%2005 01027.pdf .
Swedish Forest Agency, *Swedish Statistical Yearbook of Forestry 2005* (2005)
Swedish Forest Industries Federation, *Facts and figures 2004* (2004)
Swedish Standards Institute, *TS 14588:2003: Solid biofuels-Terminology, definitions and descriptions* (2003)
Anders Törnqvist, Presentation at *Virkesforum 2005* in Stockholm April 14th, 2005. Powerpoint slides from the presentation are available at http://www.skogsindustrierna.org/LitiumDokument20/GetDocument.asp?archive=1&director y=710&document=3055 (060201)

Johanna Ulenius, *Möjligheter att kontrollera damning från fasta bränslen genom kemisk behandling* (2005). Available at http://www3.ima.kth.se/ImaExt/Upload/Dokument/JUexjobb.pdf.

Websites

Statistics Sweden

Main webpage: www.scb.se
http://www.scb.se/templates/Publikation____139316.asp (051207)
http://www.ssd.scb.se/databaser/makro/crossroad.asp?hid=ExpTotalKNAr4&lang=1&langdb=&xu=C9233001&yp=tansss&inl=_KN number 270300, 38030010, 38030090 and 44011000 (20060208)
http://www.ssd.scb.se/databaser/makro/crossroad.asp?hid=ImpTotalKNAr4&lang=1&langdb=&xu=C9233001&yp=tansss&inl= , KN number 270300 (20060208)
http://www.scb.se/templates/Publikation____129561.asp (20060205)
Statistics Sweden, *Use of arable land in the year 2001*, can be found at http://www.sjv.se/webdav/files/SJV/Amnesomraden/Statistik%252C%2520fakta/Arealer/JO10/JO%252010SM0201/JO10SM0201.pdf (20060213)
Statictics Sweden, *Use of agricultural land in 2005*, can be found at http://www.scb.se/statistik/JO/JO0104/2005A01/JO0104_2005A01_SM_JO10SM0502.pdf (20060213)

Swedish Energy Agency

Main webpage: www.stem.se
http://www.stem.se/WEB/STEMEx01Swe.nsf/F_PreGen01?ReadForm&MenuSelect=C209FB3D6E4D944DC12570050043575D&WT=Energiberedskap.Elf%F6rs%F6rjning.Stormen%20*Gudrun* (20060116)

Swedish Forest Agency

Main webpage: www.svo.se
http://www.svo.se/minskog/templates/Page.asp?id=15014 (20060111)
http://www.svo.se/episerver4/dokument/sks/stormfakta/allman/STORMeko.pdf (20051012)

The Swedish District Heating Association

Svensk Fjärrvärme, *Statistik 2003*. Can be found at
http://www.svenskfjarrvarme.se/download_biblo/1245/stat-2003.xls
http://www.svenskfjarrvarme.se/index.php3?use=publisher&id=1179&lang=1 (20051019)
http://www.svenskfjarrvarme.se/index.php3?use=publisher&id=1364&lang=1 (20051019)
Svensk Fjärrvärme, *Fjärrvärme och kraftvärme i framtiden* (2004), can be found at
http://www.svenskfjarrvarme.se/index.php3?use=biblo&cmd=detailed&id=869 (20051019)

Swedish Peat Producers Association

Main webpage: www.torvproducenterna.se
http://www.torvproducenterna.se/english/basic-facts.shtml (20051017)

Others

http://www.nyteknik.se/skrivUt.asp?art_id=38506 (20060203)
http://www.nutek.se/sb/d/198/a/3083 (20060203)
http://www.brikettenergi.se/foretag_3.htm (20060131)
http://www.norrbranslen.sca.com/default.asp?/se/produkter/grot.asp (20060108)
http://www.regeringen.se/sb/d/831/a/7208 (20060131)
http://www.rvf.se/m4n?oid=849&_locale=1 (20060111)
http://www.talloil.se/english/broschyr.pdf (20060108)
http://www.novator.se/environment/mor/mor9821.html (20060108)
http://www.entom.slu.se/misc/virkesskador.htm (20060116)
http://www.skogsagarna.se/default.asp?oewCmd=3&id=9210&archiveid=168&pageid=2150&path=2129 (20060117)
http://www.skogsagarna.se/default.asp?oewCmd=3&id=9148&archiveid=168&pageid=2144 (20060117)
http://www.ne.se/jsp/search/article.jsp?i_art_id=170795 (20060213)

Pictures

http://www.novator.se/bioenergy/bildarkiv/Flisning/bilder/d70chipsloadingtruck.JPG
http://www.novator.se/bioenergy/bildarkiv/Branslen/bilder/34.13.Briketter.JPG
http://www.novator.se/press/pellets/bilder/PelletsiHandLag151.13.jpg

http://www.novator.se/bioenergy/bildarkiv/Torv/miniatyrbilder/39.4.Stycketorvupptagning.JPG

http://www.novator.se/bioenergy/bildarkiv/Flisning/bilder/49.2BruksFlisare.JPG

http://www.svo.se/episerver4/dokument/sks/stormfakta/bilder/stormfalln_arsavverkn.jpg (060116)

Oral sources

Anders Ericsson of *Mälarenergi*, interview in Västerås 20051103

Anders Folkesson of *Sydved Energileveranser*, interview conducted via telephone 20051123

Göran Hedman of *Naturbränsle*, panel debate in Stockholm 20050525

Mats Håkansson of *Södra Skogsenergi*, panel debate in Stockholm 20050525

Tomas Isaksson of *Svensk Brikettenergi*, interview in Huskvarna 20051114

Eddie Johansson of *Enakraft*, panel debate in Stockholm 20050525

Ulf Johnsson of *Växjö Energi*, interview conducted via telephone 20051123

Tomas Jonsson of *Jämtkraft*, interview in Östersund, 20051108

Anders Lindbergh of *SÅTAB*, interview in Östersund, 20051107

Appendix A: Conversion data

Energy content in different biofuels

- Wood chips: 1.9 MWh/ton[1]
- Wood pellets: 4.8 MWh/ton[2]
- Wood chips made from recovered wood: 3.8 MWh/ton[3]
- Municipal Waste: 3.1 MWh/ton[4]
- Tall oil: 10.83 MWh/ton[5]
- Peat: 2.5 MWh/ton[6]
- Olive seeds: 4.494 MWh/ton[7]
- Briquettes: 4.7 MWh/ton[8]
- Firewood: 3.8 MWh/ton[9]
- RDF pellets: 4.536 MWh/ton[10]

Currency

1 Euro = SEK 9.17=1.11 US$[11]

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[1] This is assuming that that chips are "green chips" i.e. that they have not been dried, SLU, *Fakta skog* #5/1995
[2] SLU, Energi från skogen (1999)
[3] SLU, *Fakta skog* #5 1995
[4] ib.
[5] According to www.talloil.com, (051202) tall oil has a heat value that is 95% of that of Heating oil(EO5), which in turn, according to Novator, *Vedpärmen* (1996) has a heat value of 11.4 MWh/ton. 0.95*11.4=10.83 MWh/ton
[6] SLU, *Fakta skog* #5 1995
[7] According to one of the respondents of the survey.
[8] SLU, Energi från skogen (1999)
[9] ib.
[10] According to www.reslab.com.au/resfiles/waste/text.html (051202) RDF pellets have the 60% of the heat value of coal, which according to http://www.torvforsk.se/torvfakt.htm (051202) is 7.56 MWh/ton. 0.60*7.56=4.536.
[11] This value is an average of the exchange rates at the beginning of January, April, July and October 2003. The exchange rates are courtesy of rl.se/valutakurser (060103)

Appendix B: Questionnaire used for the survey

Institutionen för Bioenergi

Enkät om bioenergihandel

OBS! Denna sida är endast för att hålla reda på vilka som besvarat enkäten. Sidan kommer att rivas bort innan uppgifterna behandlas för att anonymisera alla uppgifter.

☐ Vi vill ta del av det sammanställda resultatet av undersökningen.

Kontaktuppgifter

---	---
Företagsnamn	Kontaktperson
---	---
Kontaktpersonens telefonnummer	Kontaktpersonens e-postadress

1. Allmänna uppgifter

Hur handlar ni med biobränsle?

Köper	Säljer	Köper och säljer
☐	☐	☐

Hur stor är er bränsleomsättning per år?

0-75 milj. kronor	75-300 milj. kr	Mer än 300 milj. kr
☐	☐	☐

Hur ser era ägareförhållanden ut?

Privat	Statligt/kommunalt	Blandat ägande
☐	☐	☐

Vilken typ av handelsöverenskommelse brukar ni använda?

Direkta köp/sälj (spot)	Kortare kontrakt (upp till 6 mån)	Fleråriga kontrakt
☐	☐	☐

2. Import av biobränslen (2003)

Bränsletyp	Ursprungsland	Kvantitet (ange enhet)	Pris/enhet (ange enhet)

2. Export av biobränslen (2003)

Bränsletyp	Destination(land)	Kvantitet (ange enhet)	Pris/enhet

3. Handelsrutter (2003)

3.1 Importrutter

Fordon	Bränsle	Kvantitet (ange enhet)	Från	Till	Via
Tåg					
Lastbil					
Fartyg					
Annat					

3.2 Exportrutter

Fordon	Bränsle	Kvantitet (ange enhet)	Från	Till	Via
Tåg					
Lastbil					
Fartyg					
Annat					

4. Konsekvenser av Stormen Gudrun?

I januari i år drabbades södra Sverige av en av de värsta stormarna i mannaminne, med vindbyar som uppmättes till 50 m/s. Stormen *Gudrun* fällde 75 miljoner kubikmeter skog, vilket ungefär motsvarar en normal årsavverkning för hela Sverige. Den svenska biobränslemarknaden består i huvudsak av restprodukter från den inhemska skogsindustrin. Syftet med den här delen av enkätundersökningen är att försöka utröna hur den inhemska och den internationella handeln med biobränsle påverkats av stormen.

Inledning

1. Har ni märkt av att stormen haft någon effekt på handeln med biobränslen?

☐ Ja ☐ Nej (Om ni svarade nej, hoppa över fråga **2-10**.)

Kommentarer:

Inrikeshandel

2. Har ni märkt av att stormen haft någon effekt på inrikeshandeln med biobränslen?

Ja ☐ Nej ☐ (Om ni svarade nej, hoppa över fråga **a-e** nedan.)

Om ni svarat ”Ja” ovan, anser ni då att inrikeshandeln har förändrats med avseende på…

a) …typen av biobränsle som ni handlar med?

Ja ☐ Nej ☐

Kommentarer:

b) …handelsrutter?

Ja	Nej
☐	☐

Kommentarer:

c) …inrikeshandelns omfattning?

Ja, mycket mindre inrikeshandel	Ja, mindre inrikeshandel	Nej, ingen skillnad	Ja, mer inrikeshandel	Ja, mycket mer inrikeshandel
☐	☐	☐	☐	☐

Kommentarer:

d)…priser?

Ja, det är mycket lägre priser	Ja, det är lägre priser	Nej, det är ingen skillnad	Ja, det är högre priser	Ja, det är mycket högre priser
☐	☐	☐	☐	☐

Kommentarer:

e) …annat?

Kommentarer:

Utrikeshandel

3. Har ni märkt av att stormen haft någon effekt på utrikeshandeln med biobränslen?

Ja	Nej	
☐	☐	(Om ni svarade nej, hoppa över fråga **a**-**e** nedan.)

Om ni svarat ”Ja” ovan, anser ni då att utrikeshandeln har förändrats med avseende på…

a) …typen av biobränsle som ni handlar med?

Ja	Nej
☐	☐

Kommentarer (Ex:”*Vi köper mycket mer pellets än förut men nästan ingen grot*”):

b) …handelsrutter?

Ja	Nej
☐	☐

Kommentarer:

c) …utrikeshandelns omfattning?

Ja, mycket mindre utrikeshandel	Ja, mindre utrikeshandel	Nej, ingen skillnad	Ja, mer utrikeshandel	Ja, mycket mer utrikeshandel
☐	☐	☐	☐	☐

Kommentarer:

d)…priser?

Ja, det är mycket lägre priser	Ja, det är lägre priser	Nej, det är ingen skillnad	Ja, det är högre priser	Ja, det är mycket högre priser
☐	☐	☐	☐	☐

Kommentarer:

e) …annat?

Kommentarer:

Appendix C: Letter attached to the questionnaire

Institutionen för Bioenergi

Enkät om handel med bioenergi

Den internationella handeln med biobränslen är under stark tillväxt och Sverige är ett av de ledande länderna i Europa vad gäller både produktion och användning av biobränslen. För att få en klar bild av utvecklingen ur en svensk synvinkel utförs denna enkätundersökning. Detta är den svenska delen i ett EU-projekt som syftar till att kartlägga handeln med bioenergi över i Europa. Ett viktigt syfte med undersökningen är också att ge aktörer på biobränslemarknaden möjlighet att ge sin syn på hur marknaden påverkats av orkanen Gudrun, som drabbade södra Sverige i januari i år. Den avslutande delen av enkäten ägnas helt åt att undersöka detta. Undersökningen är utformad och kommer att bearbetas av Institutionen för Bioenergi vid Sveriges Lantbruksuniversitet i Uppsala.

Enkäten som ni har fått har skickats ut till ett femtiotal företag som handlar med bioenergi på ett eller annat sätt, dvs. pelletsproducenter, värmeverk etc. Vi ber er att svara på frågorna i så hög grad ni kan och om ni känner att kategorierna eller svarsalternativen inte är tillräckliga så skriv då i marginalen om det behövs för att specificera. Om ni har några frågor kring enkäten så är det bara att kontakta oss via e-mail (olssonolle@gmail.com) eller telefon (070-372 3733).

När ni fyllt i enkäten, vik då ihop den och stoppa den i det bifogade frankerade kuvertet och posta det i närmaste brevlåda. Vi är tacksamma om ni svarar så snart som möjligt. Någon vecka efter att enkäten skickats ut kommer vi att påminna de som ännu inte svarat. När svaren inkommit och sammanställts återkommer vi via telefon för att följa upp. Den information som ni lämnar ut kommer att anonymiseras och behandlas med högsta diskretion.

Tack på förhand för er medverkan!

Med vänliga hälsningar

Olle Olsson, examensarbetare
Institutionen för Bioenergi, SLU i Uppsala

Bengt Hillring, prefekt
Institutionen för Bioenergi, SLU i Uppsala

Appendix D: Interview guide

Stormen Gudruns påverkan på marknaden för Bioenergi

Impuls:

Stormen *Gudrun* fällde skog motsvarade en hel svensk årsavverkning. Den svenska biobränslemarknaden består i stor utsträckning av avverkningsrester och kan påverkas av stormen på ett eller annat sätt.

Problem:

Hur har marknaden för biobränsle påverkats av stormen?

Uppläggning:

Energiföretag och biobränsleleverantörer intervjuas och får berätta om hur de upplever att marknaden påverkats.

Intervjuguide

1. När du hörde om stormen i januari i år och den mängd skog som hade fällts, hur trodde du då att ni som företag skulle påverkas?
2. Vilka konsekvenser trodde du att stormen skulle få för biobränslemarknaden som helhet?
3. Vilka har de faktiska konsekvenserna blivit?
4. Vad tror du om framtida konsekvenser?

Appendix E: Calculations for the comparison of wood-fuel production in Southern Sweden in 2004 and 2005

Woodfuel production in southern Sweden the "normal" year 2004:

In 2004, tops and branches were extracted from 24975 hectares in southern Sweden.[1] Typically 175 m^3s/hectare is extracted[2]. Tops and branches have a thermal value of 0.595 MWh/m^3s[3] giving the following multiplication for the production of tops and branches in 2004:
24795*175*0.595≈**2.6 TWh** of tops and branches in 2004

In 2004, 8.6% of the stemwood felled in Sweden was used as firewood[4]. Using this percentage for southern Sweden and multiplying with the total amount of wood felled in southern Sweden in 2004, 22.89555 million m^3fub[5] and the thermal value of firewood, 1.9 MWh/m^3fub[6] gives:
(0.086*22.8955*10^6*1.9≈) **3.8 TWh** of firewood in 2004

In 2004, 51.5% of the stemwood felled in Sweden was used as saw timber. Out of the timber sawn in sawmills, roughly 5% of the end up as sawdust used as raw material for biofuel production[7]. Sawdust has a thermal value of 0.65MWh/m^3sk and 27.585 million m^3sk was felled in southern Sweden in 2004. About 15% of the saw timber end up as bark, bark having a thermal value of 0.6 MWh/m3sk. Thus we get:
(0.515*0.05*27.585*10^6*0.65≈) **460 GWh** of sawdust used for biofuel in 2004.
(0.515*0.15*27.585*10^6*0.6≈) **1279 GWh** of bark from sawmills in 2004

In 2004, 39% of the felled wood was used as pulp wood. 7% of pulp wood is bark, usable as biofuel. This gives:
0.39*0.07*27.585*10^6*0.6≈**452 GWh** of bark from pulp wood in 2004

This amounts to a total of (2.6+3.8+0.46+1.279+0.452=) **8.59 TWh** of woodfuel from southern Sweden in 2004.

Woodfuel production the hurricane year 2005:

Estimating the tops and branches production in the storm area is a difficult task since there are no readily available statistics on this. It is however certain that it has decreased severely. As mentioned in the first Hurricane Gudrun chapter, Mats Håkansson of *Södra Skogsenergi* made a statement early in the year estimating that there would be an 80% decrease in tops and branches production because of the storm. Using this number for arguments sake, the

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[1] Swedish Forest Agency, *Skogsstatistisk årsbok 2004* (2005)
[2] Näslund et.al. *Teknik och råvaror för ökad produktion av pellets* (2003)
[3] Malin Ringman, *Fakta skog* 5/95 (1995)
[4] SFA, *Skogsstatistisk Årsbok 2004*
[5] ib.
[6] *Bioenergi* 4/98
[7] This does not include bark.

following estimate is made. An 80% decrease in tops and branches production compared to 2004:
2.6 TWh – (0.8*2.6) = **0.52 TWh** of tops and branches in southern Sweden in 2005.

As for firewood, 1.8% of the wood taken care of from the storm area was firewood. Assuming that this share stays the same for the all the storm-felled wood estimated total amount of wood to be taken care of is 50 million m^3fub and the thermal value 1.9 MWh/m^3fub:
$0.018*50*10^6*1.9$ = **1.7 TWh** of firewood in southern Sweden in 2005.

62.8% of the wood taken care of from the storm was saw timber. Assuming again that this share remains constant and the thermal value 0.65 MWh/m^3sk for sawdust and 0.6 MWh/m^3s for bark we get, with 50 million m^3fub≈60 million m^3sk:
$0.05*0.628*60*10^6*0.65$=**1.225 TWh** of biofuel from sawdust in 2005.
$0.15*0.628*60*10^6*0.6$=**3.391 TWh** of bark from sawmills in 2005.

35.4% of the wood taken care of from the storm was pulp wood. About 7% of the pulp wood is bark, giving:
$0.07*0.354*60*10^6*0.6$=**892 GWh** of bark from pulp wood in 2005.

This amounts to a total of (0.52+1.7+1.225+3.391+0.892=) **7.728 TWh** of wood-fuel in from southern Sweden in 2005.

The differences between these two calculations is (8.59-7.728)=**0.862 TWh**, i.e. a decrease of about 10% in wood-fuel production from 2004.