

Local Investment Programmes in Sweden

*Pulling the pulp and paper industry to profitable  
investments*

A study of four bioenergy projects in the  
Swedish pulp and paper industry

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## **Abstract**

Switching from oil to biofuels appears to be good business for the Swedish pulp and paper industry today. Mixing traditional wood fuels with sludge residues makes the transition even more profitable. Public financial support of 159 MSEK has pulled the four pulp and paper industries studied in this thesis to invest another 538 MSEK, creating annual cost savings of 150 MSEK per year. This thesis shows that bioenergy investments in the pulp and paper industry are considerably profitable today even without subsidies due to the increased prices on oil and electricity and a strengthened waste policy.

*The Swedish Local Investment Programme* has supported the introduction of new technology and achieved significant reductions of carbon dioxide emissions at a low socio-economic cost. In addition 160 000 annual tonnes of sludge previously being disposed is now used for energy production substituting about 23 000 m<sup>3</sup> of oil per year.



## **Executive Summary**

*Local Investment Programmes* (LIP) have pulled the Swedish pulp and paper industry to undertake profitable bioenergy investments, investments which would have been delayed or not carried out at all if no subsidy was received. Subsidies may be one way to pull for renewable energy investments. However, if renewable investments can be considered beneficial by themselves, subsidies are not only unnecessary but inefficient from a socioeconomic point of view. The findings of this thesis has implications for the current Swedish Climate investment programmes (KLIMP) as investments that the industry were not willing to undertake by themselves five years ago can today be considered as clearly profitable due to increased prices on oil and electricity as well as a strengthened waste policy. The bioenergy investments studied in this thesis can be considered as a success not only for the individual companies, but also for the government: (i) Local Investment Programmes have supported the introduction of *new technology* which may facilitate and speed up the initiation of similar investment today, (ii) environmental benefits have been achieved at a *low socioeconomic cost* and, (iii) requirements from new policy instruments have been encouraged to be fulfilled before they entered into force. However, if environmental benefits shall be attained in a socio-economic efficient way it shall be questioned if public resources should be used for similar investments today. But, in a business environment characterised by short sighted benefits, investments profitable in the long run may be hindered. *This thesis investigates the need for subsidies for undertaking bioenergy investments in the Swedish pulp and paper industry* with the focus on aspects of *profitability*. The work is part of a socioeconomic evaluation of the Swedish Local Investment Programme, carried out by researchers at The International Institute of Industrial Environmental Economics (IIIEE).

Considering the reinforced Swedish waste policy the pulp and paper industry is especially interesting when looking at profitability and *resource efficiency improvements*. There is a significant amount of sludge produced in the production process of pulp and paper which until today often have been treated as waste. This thesis looks at four bioenergy investments aiming at mixing sludge residues with traditional wood fuels. All investments have received financial support within LIP. The method of analysis is based on general premises of investment appraisal methods, identifying and quantifying cash flow payments and capital costs for the investments undertaken.

The results show that subsidies of 159 MSEK have helped these industries to undertake bioenergy investments creating annual net operating cost savings of 150 MSEK per year. A total investment of 697 MSEK gives an aggregated pay back time of 3,6 years corresponding to the even shortest payback times (3 to 4 years) required by the industry to undertake similar investments. In addition, the introduction of *electricity certificates* (aiming at stimulating production of renewable electricity) gives significant incentives to the pulp and paper industry to initiate electricity production based on biofuels: A 100% price increase on electricity, the last four years, together with the possibility to receive extra revenues from electricity certificates (at a price almost equivalent to the general price of electricity!) opens up for new business opportunities.

The investments studied contributes to a reduction of 160 000 tonnes of CO<sub>2</sub> per year (about 30% of the total reductions achieved within the LIP until present). 160 000 annual tonnes of sludge, previously being disposed, is now used for energy production and substitutes 23 000 m<sup>3</sup> of fuel oil per year. The annual *capital cost* per reduced kilo of CO<sub>2</sub> is about 50 % lower compared to other projects within LIP. Moreover, if the Swedish CO<sub>2</sub> tax is a correct value of the environmental cost -knowing that the industry is only burdened with 25% of the general CO<sub>2</sub> tax – the investments in the pulp and paper industry are considerably *cost efficient* as the subsidy level is significantly lower than the assumed environmental cost for the CO<sub>2</sub> emissions.





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# 1 Introduction

## Bioenergy investments – Are subsidies necessary?

One objective of the Swedish energy policy is to support renewable energy sources in different ways and investment subsidies can be one way to push the development in this direction. However if incentives already exist for taking action in that direction, public financial support would not only be unnecessary but also inefficient from a socioeconomic point of view. This thesis investigates if subsidies are needed for undertaking bioenergy investments in the pulp and paper sector or if actually bioenergy investments can be considered as attractive business opportunities in itself.

This thesis is part of a socioeconomic evaluation of the Swedish Local Investment Programme (LIP), commissioned by the Swedish Environmental Protection Agency (EPA) and carried out by researchers at The International Institute of Industrial Environmental Economics (IIIEE). The main purpose of LIP is to facilitate and speed up the transition of Sweden to a more ecological sustainable society by supporting investments for energy efficiency improvements

This thesis looks at four bioenergy investments in the pulp and paper industry carried out within LIP. Apart from being one of Sweden's major industries the pulp and paper industry is interesting due to the large amount of sludge created in the production process. This sludge contains organic material as fibre sludge, biological and chemical sludge. The Swedish waste tax introduced in 2000 together with the upcoming regulation not allowing organic waste to be disposed from 2005, give clear incentives to minimise the amount of sludge disposed.

According to the concept of industrial ecology, waste can be considered as a resource that the economy has not yet learned to use efficiently (Graedel, 1995). In such a context the pulp and paper industry is especially interesting to study when investigating incentives for undertaking actions to reduce the amount of waste disposed. Increased credibility regarding environmental concerns, reduced cost and improved competitiveness are as some of the benefits expressed due to the bioenergy investments undertaken and investigated in this thesis. However taking on the risk for investing in new technology and at the same time demanding pay back times of 3 to 4 years, pulp & paper businesses do not always seem willing to undertake investments by themselves.

## Local Investment Programme

The Local Investment Programme (LIP) is the Swedish government's largest contribution ever to support sustainable development in Sweden. Between 1998 and 2002 more than 6 billion SEK was granted for Local Investment Programmes in Swedish municipalities (Institutet för ekologisk hållbarhet, 2003)<sup>1</sup>. Preliminary results (see the forthcoming socioeconomic evaluation of LIP by Kåberger and Jürgensen) indicate that investment projects for about 4-5 billion SEK have been realised. On average the granted subsidies makes up about

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<sup>1</sup> From the start, in total 7.2 billion SEK were set aside by the government for the programme until 2003 (Miljödepartementet, 2001). However, due to lack of financial resources applications were possible only until the end of 2001.

25% of the total investment sums and the total investment figure is therefore expected to amount to 15 to 20 billion SEK.

LIP involves physical investments with the aim to reduce environmental impacts, for instance investments related to energy efficiency, use of renewable resources and reuse and recycling. Other objectives are the introduction of new technology as well as increased employment opportunities.

The Swedish municipalities are the coordinating actors of the programmes and also the largest recipients of the investment subsidies. However, profit making actors may receive subsidies under the same conditions as other actors<sup>2</sup>. However *subsidies can not be given for investments that would have taken place due to existing law or regulation or for continuous expenses or investments which would in any case been carried out* (SFS 1998:23, §17). If efficiency is defined as reaching preset goals at the least possible cost (Sterner,T, 2003, p. 136) it is not *efficient*<sup>3</sup> from a society point of view to give additional financial support for activities that would have been carried out already at a lower marginal cost for society. However aspects of profitability are not interesting just because it is expressed in law or economic theory. Common sense tells that supporting *profitable*<sup>4</sup> investments assumed to be realised anyhow should be questioned and this is the starting point for this thesis.

## Purpose and research question

The *purpose* of this thesis, as mentioned, is to investigate the need for subsidies for undertaking renewable energy investments in the pulp and paper sector or if actually renewable energy investments in this sector can be considered as attractive business opportunities by themselves. Further the thesis aims at assessing if investment subsidies have been used efficiently or if they could have been used for other alternative investments and thus in total give higher benefits for society as a whole. The main focus will however be on the issue of *profitability* as it is assumed to be the most determining factor for businesses when deciding upon investments and the need for investment subsidies.

This thesis looks at four energy investments related to the pulp and paper industry. Apart from being among the largest investments in monetary terms within LIP, the selected projects have some especially interesting features when studying aspects of profitability as well as incentives created by different policy instruments. First, the projects have the intrinsic values of industrial ecology and the measures taken involve resource efficiency improvements as; (i) waste heat recovery and (ii) sludge from the production process previously disposed, now used as fuel for energy production. In addition the investments touch upon a changing energy policy towards increasing support for renewable energy resources and strengthened emission and waste regulations.

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<sup>2</sup> For profit making actors the subsidy can only represent a maximum of 30% of the total environmental investment.

<sup>3</sup> In Economic theory efficiency is achieved when marginal costs equal marginal benefits. However according to Sterner (2003) a more pragmatic approach is needed when coordinating different policy instruments and objectives in practice.

<sup>4</sup> In this context *profitability* is defined as an action taken that is more beneficial due to reduced cost and/or higher revenues either compared to an alternative action or a status quo situation where no action is taken. The cost and revenues are assumed to be directly related to the specific action taken.

In order to complete the purpose it is needed to identify if investments would have been carried out even if no subsidy was received. To do this it is assumed that an investment is carried out if it is regarded profitable for the business and/or if any law or regulation obliges the investment to be carried out.

The *research question* of the thesis is:

**Can the investments be regarded as profitable even if no investment subsidy was received under (i) conditions prevailing *ex ante* and (ii) conditions prevailing *ex post*?**

Conditions prevailing *ex ante* are defined as *conditions prevailing at the time the investment decisions were made* by the companies and conditions prevailing *ex post*, defined as *conditions prevailing at present*. Conditions considered in the assessment are assumed to be critical factors for the outcome of the investment as regards to profitability. Thus there can be aspects that affect profitability that are not included in the assessment since they are not considered as having any significant impacts on the results. The critical factors identified for this assessment are energy prices (cost for fuel oil, biofuels and electricity) waste regulation, waste taxes, the carbon dioxide tax and electricity certificates. These will be the main factors for the profitability assessment. *Profitability* can be defined in many different ways depending on what initial assumptions are made. This is further explained in chapter 2.

The following questions are leading the analysis of the findings of the research question:

1. Which are the most significant factors determining the results?
2. What are the implications of the results for the pulp and paper industry?
3. What are the environmental benefits and socioeconomic implications?
4. What are the implications of the results for similar investments in the future?

## Methodology

To be able to contribute to an evaluation of LIP there is a need to put emphasis on making some general conclusions about the case studies.<sup>5</sup> According to Yin (2003) a good use of theory can help to set the limits of the case study research but will also be important to be able to make generalizations about the results. The theoretical framework for the assessment of the cases selected is based on general premises of investment appraisal methods, with focus on quantitative economic analysis, identifying changing cash flow payments and estimating capital costs due to the investments carried out. The analysis may vary depending on the aim and characteristics of each project. Nevertheless there are some common issues that are considered in more or less all investment analysis which will be the focal point of this thesis.

The most essential material for the assessment is the application forms for subsidy, for each investment project handed in to the Swedish Environmental Protection Agency, including quantitative cost analysis and final reports handed in when the projects were finalized.

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<sup>5</sup> Case study research is not considered to be a good method to produce optimal generalizations. According to Stake (1995) comparative and correlation studies will do this better, but Stake also put forward that some modified generalizations may still be valid in case study research.

However to receive relevant information not covered in application forms or reports, the *project owners* – the actors responsible for each investment project- have been contacted. On site visits have been made for two of the projects at; *Rottneros Rockhammar AB* (Rottneros bruk pulp plant) and *SCA Graphic Sundsvall AB* (SCA Östrand pulp plant). Interviews have been made by telephone with the other projects at; *SCA Hygiene Products AB* (SCA Lilla Edet paper plant) and *Katrinefors Kraftvärmeverk AB* (A combined Heat and Power plant owned together by Metsä Tissue AB paper plant and the local district heating company Mariestads Energi AB). The overall purpose of the contacts has been to get a better understanding of each project and to know why the project owners initially considered the investments and how important the subsidy has been for making the investments come into place. In addition more specific questions have been posed about initial assumptions made in the cost analysis regarding energy consumption, energy prices, taxes and charges etc.

## Scope and limitations

The main focus of the thesis is to assess the profitability of the energy investments from a business perspective. The socioeconomic benefits will also be considered and identified to some extent. However not neglecting the importance of socio economic benefits, these are not the main basis for the analysis.

This thesis consists of an *economic analysis* of the selected cases, though it shall be noted that the investment process in general includes many other issues to consider in addition to the economic analysis.<sup>6</sup> However, such issues will not be covered in this thesis. Moreover the research questions imply that the aim is not to give any precise estimation on *how* profitable the investments can be considered to be *ex ante* or *ex post* meaning that the research method will be qualitative even if the assessment will include quantitative estimations to be able to answer the research questions. Further quantitative estimations regarding profitability depend, as pointed out above, strongly on how profitability is defined and what assumptions the economic analysis is based on.

As mentioned the assessment will to a large extent be based on the information in application forms including cost analysis and final report, though the aim of this thesis is not to perform an audit of the economic investment estimations. However, it shall be stressed that different written information has not always been consistent in between and sometimes it has been difficult to get straight information.

## Outline of thesis

Chapter 2 describes the method used for the assessment of profitability and definitions and assumptions are explained. In Chapter 3 each investment project is assessed individually. The assessment is made in two steps; (i) *ex ante*, following assumptions based on initial conditions prevailing at the time the investment decision was made, and (ii) *ex post* following assumptions based on conditions prevailing at present. Finally a brief aggregated assessment is made by summarising all the individual projects. Chapter 4 aims at analysing factors, which has

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<sup>6</sup> In reality investment decisions appear more complicated and there is a need to look beyond the general assumption of maximising profits as investment decisions are made within an organizational context. Large capital investments also have an important role in the strategic planning of a company's business and the investment process is often related to predefined objectives of the company (Löfsten, 2002).

promoted or hindered the investigated investments to be undertaken. Central aspects emerging when conducting profitability assessments will also be examined in this chapter. Chapter 5 brings up the environmental benefits due to the investments. Further socioeconomic efficiency and policy incentives is analysed and discussed.

## 2 Assessment framework

This chapter describes the method used for the assessment of profitability. Moreover definitions and assumptions are explained.

### The economic assessment

Profitability is one core issue when considering investment projects; still profitability can be perceived very differently which affects assumptions made in investment analysis. Profitability may be defined as “*the excess of returns received over expenditures in a transaction or series of transactions*” (Webster’s International Dictionary, 1993). There exist several definitions of investments. According to Ljung & Högberg (1998, p. 9) investment is defined as “*a capital investment that creates cash flow payments during a longer period of time*”. When considering new investments the procedure prior to deciding upon what actions shall be taken may include the following steps;

1. Defining the problem to be solved;
2. Screening of solutions and investment alternatives;
3. Analysis;
4. Drawing conclusions and give recommendations;

Number three and four are the main focus for the analysis of this thesis. However all the steps will be important for the analysis as whole. The “Analysis” focuses on economic analysis, thus assessing the investments in monetary terms. “Drawing conclusions” is considered as regards conclusions of profitability. The analysis may vary depending on the aim and characteristics of investments. Nevertheless there are some common issues that are to be considered in more or less all investment analysis, which is included in the assessment and described below.

*The initial investment* is all the non-recurring payments that the investment initially entails e.g. machines, buildings, start up costs and education costs. All expected *cash flow payments* due to an investment shall be estimated for its whole length of life. There is an uncertainty when estimating cash flow payments that will occur in the future. The value of the cash flow payments (in and out) is dependent on when in time the payments take place and the assumed discount rate used to value future payments as if they were taking place today.

The *length of life* of an investment is determined by either the economic lifetime or technical lifetime. The economic lifetime can be described as the time until when the investment is not considered to give maximal profitability anymore. Due to technological development the *economic* length of time is often shorter than the *technical* length of time, the time the investment can be in use as regards the physical wearing out (Ljung. Et.al. 1998, p. 11). The economic length of time is usually preset by standard rules defined by previous experiences as regards operating costs, market and technical developments and preset depreciation times. (Ljung et.al., 1998, p.11)

### General assumptions

In this analysis *profitability* is defined as *an action considered creating higher benefits either compared to an alternative action or status quo*. The analysis is based on the following assumptions.



The cost estimation for the initial investment payment will be based on *annuities*, assuming that all initial investment payments occur at the same time; year 0. Thus, the capital cost related to each investment will be estimated on annual bases dependent on the assumed discount rates and depreciation times. The assumed discount rates and depreciation times varies between each investment. They are individually set depending on how the project owners perceive their investments. The discount rates shall in an ideal situation express the preference of time, i.e. discounting the future estimated cash flow payments. The depreciation time is generally related to the economic length of life. As the investments assessed have different features, assumed discount rates and depreciation time follows initially assumptions made for each investment project.

Estimated pay back times are included in the assessment. A pay back time simply illustrates the time it takes for an investment to be paid back<sup>7</sup>. In the applications the pay back time is generally referred to when evaluating the profitability of the investments. According to the applications the calculated pay pack times are referred to as straight pay back times, meaning that no interest rate is considered. Straight pay back times is also applied in this assessment.

The changing cash flow payments due to the investment will be estimated. The energy cost and revenues are overall the most significant items in all the individual investment analysis, i.e. the changes in both energy use and energy production stands for the most significant cash flow payments. Accordingly the analysis will focus changing payments as regards energy cost and revenues; cost for fuels and electricity and revenues from district heating and electricity.

Costs due to waste taxes and revenues from *electricity certificates*<sup>8</sup> are also estimated. Together with the CO<sub>2</sub> tax these are the policy instruments assumed to have the most significant impacts on the economic analysis.

*Ex ante* the assessment is based on assumptions made by the project owners in the initial investment analysis. For the majority of investments the initial assessments enclosed to the applications shows estimated cash flow payments and capital costs for each investment. However when assumptions are not explained, the assumptions have been based on oral information from the projects owners.

When there are payments which are not considered in the initial estimations but can be assumed to have significant impacts on the economic analysis these have been added in the assessment. Assumptions made regarding energy prices and tax levels are presented in table 2-2-1.

*Table 2-2-1 Assumed energy prices and tax levels.<sup>9</sup>*

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<sup>7</sup> The initial investment payment divided by the estimated net cash flow payments/year gives the pay back time.

<sup>8</sup> *Electricity certificates* is a policy instrument, introduced 2003, which brings extra revenues to electricity producers using renewable energy resources for energy production. The certificates are distributed by the government in accordance with the amount of electricity produced by a company. The producer will sell the electricity as usual, but if the electricity is produced by renewable resources the producer will get additional income by sold certificates. The demand for certificates is determined by a quota duty related to the energy user, who has to buy quotas according to the preset quota. The quota duty is preset by law and is continuously increased until 2010 (SFS 2003:113). However, the pulp and paper industry among other industries, is exempted from the quota duty for their own consumption of electricity (SFS 2003:113, ch. 4, §2). Electricity certificates is further discussed in chapter 4.

Prices SEK/MWh	Ex ante	Ex post
Electricity	Individual assumption s	260
Oil	Individual assumption s	190
Biofuel	Individual assumption s	+ 20%
CO <sub>2</sub> tax	56	56
Electricity certificates	-	220
Waste tax (SEK/ton)	250	370

The *individual assumptions* mean that the figures are individual for each case and according to the investment estimations made by the project owners. These assumptions are specified in the each assessment separately. The assumed price on electricity (ex ante) varies between 120 - 150 SEK per MWh (one exception is the Katrinefors combined heat and power plant which ex ante was burdened with an electricity tax and thus facing a higher electricity price; 238 SEK per MWh). The assumed price on oil (ex ante) is 140 SEK per MWh for all the investments but with the same exception as for the price on electricity; the CHP plant faces a higher price; 271 SEK per MWh, due to the energy tax on fuel oil for CHP plants. However, today the CHP plants are burdened with the same energy taxes as the industrial sector, i.e. no energy taxes and no taxes on electricity use. Therefore the same assumption about energy prices can be made for all projects ex post. The individually assumed prices on biofuel vary between 75-120 SEK per MWh. The variation can probably be explained by the possibility to individually negotiate the price on biofuel to greater extent than the prices on fuel oil and electricity. The assumed prices on biofuel ex post are increased by 20%, based on the individually assumed prices ex ante.

The CO<sub>2</sub> tax level for the manufacturing industry (including the pulp and paper industry) is only 25 % of the general tax level. The tax can be further reduced if the total tax payment exceeds a preset maximum amount. The CO<sub>2</sub> tax system for the industrial sector is rather complex and varies between companies. The tax level referred to is the tax level assumed ex ante when paying 25% of the general CO<sub>2</sub> tax. No changes of the tax level are assumed, i.e. the CO<sub>2</sub> tax level is assumed to be constant; 56 SEK per MWh.

The waste tax is based on the tax level in year 2000; 250 SEK per ton disposed and the raised waste tax level introduced in 2003; 370 SEK per ton (Skatteverket, 2004).

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<sup>9</sup> The assumed price for electricity is based on the average elspot price 2004 (Nordpool, 2004). The assumed price for fuel oil is based on approximations of the average annual prices during 2003 (SPI, 2004) and current oil prices. The price for electricity certificates is based on the average current market price (Nordpool, 2004).

### 3 Assessment of profitability

In this chapter each investment project will be assessed individually following the assumptions made in the previous chapter. The assessment is made in two steps; (i) *ex ante*, following assumptions based on initial conditions prevailing at the time for the investment decision, and (ii) *ex post* following assumptions based on conditions prevailing at present. Finally a brief aggregated assessment is made by summarising all the individual projects.

#### SCA Lilla Edet – Using nearly 100% sludge for energy production

SCA Lilla Edet AB<sup>10</sup> is producing soft paper, toilet paper and tissues for the consumer market but also business to business, under the brand names Edet and Tork. The products are mainly produced by using recycled fibers and the production capacity is about 100 000 ton of paper per year. SCA Lilla Edet has about 480 employees. The SCA Lilla Edet production plant have invested in a combustion system which makes it possible to use fibersludge from the own production process as their main fuel. In 2000 Edet bruk applied for investment subsidy within LIP for the installation and the project was finalised at the end of 2003.

The recycled fibres used for production of soft paper needs to be cleaned before going into the production process. In this process the main residues are short fibers, thickening in the form of kaolin and printing ink. Until the new installation was in place these residues have been considered as waste and disposed within the own facility. To find a long-term solution for the fibersludge the investment in a Fluidised bed boiler (BFB boiler) made it possible to use different sorts of fuels including fuels with high water content such as the fibersludge. The boiler is connected to a turbine generating electricity, aiming to supply 25 % of facility's electricity consumption.

The main fuel is mechanically dewatered fibersludge. According to the application wood residues were to be used as an additional fuel to stabilise the combustion process and increase the energy value in the fuel mix. However, since the boiler was installed in November 2003 the amount of fibersludge used as fuel has continuously increased, currently making up 75-80% of the total fuel used. In the future fibersludge is predicted to account for 100 % of the fuel used for energy production. Thus additional biofuels will not be required and transport of biofuels to the facility will not take place. However the fibersludge may only contain 30% water and has to be dried before combustion.

Biofuel, i.e. mainly fibersludge is substituting the use of oil and electricity for the production of steam. In addition the boiler has been designed to meet future EU regulation regarding emissions of NO<sub>x</sub>, SO<sub>x</sub>, particulate matters and dioxins. Considering the high ash content of the fibersludge the project also include a study of the possibilities to use the ash in forests or in other industrial processes<sup>11</sup>. According to the initial application steam was also planned to be supplied to a nearby company producing gypsum carton and in turn they would provide fibersludge residues for combustion at SCA. But the company left the project before any

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<sup>10</sup> SCA Lilla Edet is a production facility and part of SCA Hygiene Products AB within the SCA corporate, a multinational company manufacturing hygiene products, packaging material and paper for printing, with a net turnover of 88 billion SEK.

<sup>11</sup> Yet no outlet for the ash has been identified and the ash is currently transported to a closed landfill site in the municipality of Trollhättan.

contract was signed. However steam and condensate pipes have been installed to supply heat to the district heating plant in the municipality of Lilla Edet and SCA is now delivering 100% of the district heating, in total 13.5 GWh/year.

The initial investment cost was estimated to 253 MSEK out of which 76 MSEK was applied for as subsidy. The final in initial investment cost landed on 270 MSEK, mainly due to an increased value of the Euro. The BFB boiler stands for the main investment cost, 114 MSEK.

The main environmental effects include annual reductions of fuel oil consumption estimated to about 80 GWh and reduced external electricity consumption estimated to 100 GWh per year. According to the final report, the amount of fibersludge disposed will be decreased by 80 000 ton per year, which is 100% of the total annual amount of sludge produced. The combustion capacity of the boiler is 100 000 ton of sludge per year. Further it is believed that the project can contribute to the ecological system by improving the circulation of nutrients developing possibilities to use the ash residues from the combustion.

### Profitability assessment ex ante<sup>12</sup>

The investment estimation according to the application (Table 3-1) predicts that Lilla Edet will save about 30 MSEK/year due to the initiation of steam and electricity production based mainly on their own fibersludge which will reduce purchased external electricity and fuel oil consumption. Lilla Edet does not have to pay any disposal tax as they dispose the sludge on their own facility and in the estimation it is assumed that there will be no alternative cost for not using the sludge for combustion. A pay back time of 3-4 for years is in general demanded within the SCA group for similar investments. According to SCA Lilla Edet the subsidy was necessary to carry out the investment. The final received subsidy of 76 MSEK (30%) reduced the pay back time from 8.4 to 5.9 years.

*Table 3-1 SCA Lilla Edet pulp plant; Ex ante - Abbreviated investment estimation, according to the application of LIP (Figures per year)*

<b>SCA Lilla Edet Ex ante MSEK/year</b>	Fossil fuel based energy system	BFB boiler using fibersludge as main fuel No subsidy	BFB boiler using fibersludge as main fuel Received subsidy 76 MSEK (30%)
Total operating costs	50.4	20.1	20.1
Savings	-	30.3	30.3
Initial investment cost (MSEK)	-	253.3	177.3
Pay-back time (years)	-	8.4	5.9

<sup>12</sup> Prices assumed ex ante; Electricity 150 SEK/MWh; Fuel oil 140 SEK/MWh; CO2 tax 56 SEK/MWh; Biofuel 93 SEK/MWh.

Even though the major reason for carrying out the investment was to find a solution to the increased amount of fibersludge disposed, the project was carried out at a time when Lilla Edet considered reinvesting in a new boiler and combustion system. However if SCA had chosen to invest in a conventional boiler, continuing using oil and electricity as before, the initial investment cost would have been significant lower compared to the current BFB boiler. The alternative initial investment cost for a conventional boiler system can be estimated to 150 – 180 MSEK, about 100 MSEK less than the BFB system.<sup>13</sup> The results when comparing an estimation of the capital cost for the BFB boiler with the estimated capital cost for the alternative investment along with the amended reduction of purchased electricity, is presented in Table 3-2<sup>14</sup>.

Table 3-2 SCA Lilla Edet pulp plant; Ex ante - Abbreviated investment estimation including capital cost, alternative investment cost and amendment of overestimated reduction of electricity purchase (Figures per year)

SCA Lilla Edet Ex ante MSEK per year	Fossil fuel based energy system	BFB boiler using fibersludge as main fuel No subsidy	BFB boiler using fibersludge as main fuel Received subsidy 76 MSEK (30%)
Total operating costs	50.4	27.2	27.2
Gross savings	-	23.2	23.2
Annuity ( int. rate 5%, depreciation 10years)	0.13	0.13	0.13
Annual capital cost	19.5	32.9	23.0
Total investment cost	69.9	60.1	50.2
Net Savings	-	9.8	19.6
Initial investment cost (MSEK)	150	253.3	177.3
Pay-back time (years)	-	10.9	7.6

Even though taking into account the overestimated reduction of purchased electricity the estimation in Table 3-2 indicates that Lilla Edet will make net savings of 9,8 MSEK per year *ex ante* without the subsidy, by investing in a BFB boiler and electricity production instead of investing in a boiler based on fuel oil and not producing electricity. Thus, if comparing the cost for an alternative investment the bioenergy investment can be considered as profitable even if no subsidy is received.

Considering the received subsidy of 76 MSEK the net savings increase to 19.6 MSEK per year *ex ante*. The savings is mainly due to the reduction of purchased electricity but also due to the transition from fuel oil to biofuels including fibersludge. Even though the assumed capital cost is significant higher for the BFB boiler compared to a conventional boiler, the estimated

<sup>13</sup> The most significant cost is the boiler, where the price for a conventional boiler can be estimated to about 25% of the price of a fluidised bed boiler (Malmberg, 2003 May 13). Other main costs which would be affected (see table 2-1) are costs for the control system, the fuel handling system and maintenance cost.

<sup>14</sup> The information is according to investment estimation by Lilla Edet.

cost savings from, 50 to 27 MSEK per year, for fuel and electricity is more than enough to cover the capital cost. The subsidy reduces the payback time from 10.9 to 7.6 years.

### **Profitability assessment ex post**

Assuming increased prices on electricity and fuel the fossil fuel based energy system would entail more than 50 % higher operating costs compared to estimations ex ante (table 3-3). However due to limited access to excess steam the production of electricity has turned out to be lower than estimated, currently the amount is 10 GWh per year compared to 33 GWh estimated initially. Therefore the amount of purchased electricity increased and the estimated energy cost for the BFB system is higher than if the estimated electricity productions would have been attained.

Assuming that fibersludge is used more or less as the only fuel, as indicated in the final report, there is no need for external biofuel and the reduced cost for purchased biofuels can be estimated to 6 MSEK<sup>15</sup>.

The planned cooperation and supply of steam to the neighbouring company was not accomplished. The revenue from the supply of steam was estimated to 5.4 MSEK, but will not take place. However supply of heat of 13.5 GWh to the district heating plant in Lilla Edet has been carried out. The income from supplying district heat is estimated to 2.7 MSEK (13.5 GWh\* 0.2 SEK/ kWh).

According to estimations total annual net savings would be 20 MSEK if no subsidy was received. The total net savings *ex post* is estimated to 30 MSEK per year including capital cost and subsidy, thus 50% higher than the estimations ex ante. The increased savings decrease the pay back time ex post which can now be estimated to 5 to 6 years comparing 8 years according to estimations ex ante (including subsidy).

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<sup>15</sup> Increased use of fibersludge will increase the energy cost for drying the fibersludge, though it is assumed to be less than the cost for external biofuels.

Table 3-3 SCA Lilla Edet pulp plant; Ex post - Abbreviated investment estimation (Figures per year)

SCA Lilla Edet Ex post (MSEK per year)	Fossil fuel based energy system	BFB boiler using fibersludge as main fuel No subsidy	BFB boiler using fibersludge as main fuel Received subsidy 76 MSEK (30%)
Total operating costs	78.6	42.6	42.6
Gross savings	-	36.0	36.0
Annuity ( int. rate 5%, depreciation 10y)	0.13	0.13	0.13
Annual capital cost	19.5	35.1	25.2
Total investment cost	98.1	77.7	67.8
Net Savings	-	20.4	30.3
Initial investment cost MSEK	150	270	194
Pay-back time (years)	-	7.5	5.4

### Katrinefors CHP plant – Mixing wood fuels with sludge

1999 Katrinefors Kraftvärmeverk AB (KKAB) applied for financial support for the construction of a new Combined Heat and Power plant (CHP plant). The new CHP plant was taken into commercial operation in the end of 2001 and has substituted former heat and power production based on oil. The project was initiated by the local district heating company Mariestads Energi AB and the softpaper industry Metsä Tissue AB. Katrinefors Kraftvärmeverk AB is owned by Mariestads Energi (50%) and Metsä Tissue (50%) and supply Metsä Tissue with steam (90 GWh), district heat (90 GWh) to Mariestad Energi and electricity (30 GWh) to the grid per year .

The district heating network was previously only extended to 50% of its potential. However the previous system for district heating could only be expanded continuing using fuel oil. With the new BFB boiler the capacity has been increased making it possible to expand the district heating network by using biofuels to nearly 100%. The supply of electricity is dependent on the amount of steam and heat produced. The development of the price on electricity will also determine the amount of that will be produced. However it is technically feasible to produce between 40-45 GWh of electricity per year.

The main fuel used is wood (70%) and fibersludge (30%), residues from the production process at Metsä Tissue AB. The fibersludge is pressed and dried to a level of 50% dry substance before used as fuel. The fibersludge used is estimated to substitute 4000 to 5000 m<sup>3</sup> of oil per year (equivalent to 40-50 GWh/year). Until the new installation was in place 60 000 tonnes of fibersludge (30% dry substance) has been disposed on the municipality's landfill every year.

According to the final report the environmental effects have turned out to be better than predicted. The total consumption of oil has decreased by 27 000 m<sup>3</sup> per year compared to 20 000 m<sup>3</sup> as predicted; CO<sup>2</sup> emissions have decreased by 73 000 tonnes per year compared to 45 000 tonnes and the amount of fibersludge disposed is 60 000 ton less per year than previous to the new investment.

## Profitability assessment ex ante<sup>16</sup>

According to estimations ex ante (table 3-4) the construction of the CHP creates increasing revenues of 40 MSEK per year for KKAB. But the total cost exceeds the net revenues creating a net deficit of 0.5 MSEK per year if no subsidy is received. When keeping the previous district heating plant in place the net surplus is estimated to 1 MSEK. When a subsidy of 30 MSEK is received the net deficit turns into a net surplus of 2 MSEK per year.

Table 3-4 Katrinefors CHP plant; Ex ante - Abbreviated investment estimation according to the application of LIP (Figures per year)

<b>Katrinefors Kraftvärme</b> <b>Ex ante</b> <b>MSEK per year</b>	Fossil fuel based district heating system	BFB boiler mainly woodfuel No subsidy	BFB boiler mainly woodfuel Received subsidy 30 MSEK (15%)
Initial investment cost MSEK	11.8	210	180
Annuity (discount rate 7%, depreciation 25 years)	0.14 <sup>17</sup>	0.086	0.086
Annual capital cost	1.7	19.7 <sup>18</sup>	17.2 <sup>19</sup>
Total operating costs	12.6	35.7	35.7
Total cost	14.2	55.4	52.8
Revenues <sup>20</sup>	15.3	54.9	54.9
Gross surplus <sup>21</sup>		16.5	16.5
Net surplus/loss	1.0	-0.5	2.1
Pay-back time years	-	13 <sup>22</sup>	11 <sup>23</sup>

However the initial investment estimation does only consider aspects directly related to the CHP Company. If including Metsä Tissue and Mariestad Energy in the system boundary the estimation changes<sup>24</sup>. According to the application the reduction of fuel oil is estimated to

<sup>16</sup> Price assumed ex ante; Electricity 238 SEK/MWh; Fuel oil 271 SEK/MWh; Biofuel 120 SEK/MWh. The higher price on Electricity and Fuel oil is due to different energy taxes for CHP plants prevailing ex ante.

<sup>17</sup> Assumed depreciation 10 years.

<sup>18</sup> Includes capital cost for the previous installations (1.7 MSEK/year).

<sup>19</sup> Includes capital cost for the previous installations (1.7 MSEK/year).

<sup>20</sup> Prices assumed ex ante; District heat 302 SEK/MWh; Steam 200 SEK/MWh; Electricity 200 SEK/MWh.

<sup>21</sup> Gross surplus=(Increased revenue) – (Increased operating cost); 39.6-23.1= 16.5

<sup>22</sup> 210/((54.9-15.3)-(35.7-12.6))

<sup>23</sup> 180/((54.9-15.3)-(35.7-12.6))

<sup>24</sup> The system boundary does not include district heating customers as the assessment focus on profitability related to the companies. However, new district heating customers stand for a significant amount of reduced oil consumption due to the



20 000 m<sup>3</sup> (200 GWh). Katrinefors Kraftvärmeverk does only count for 15 GWh reduction of fuel oil. If Metsä Tissue stands for 60 GWh<sup>25</sup>, then this is equivalent to 11 MSEK cost savings per year for Metsä Tissue. Adding the tax cost for disposed sludge, 15 MSEK, which can be avoided by turning the sludge into fuel used at the CHP plant, the estimations turn out to look different (table 3-5). Total cost savings for Metsä Tissue according to the estimations below are 26 MSEK per year ex ante.

Table 3-5 Katrinefors CHP plant; Ex ante - Extended system boundary including estimated cost reductions of fuel oil and waste tax for Metsä Tissue (Figures per year)

<b>Extended system boundary Ex ante (MSEK per year)</b>	BFB boiler mainly woodfuel No subsidy	BFB boiler mainly woodfuel Received subsidy 30 MSEK (15%)
Cost saving for fuel oil (including CO <sub>2</sub> tax)	11.4	11.4
Saving Disposal tax cost	15.0	15.0
Total cost savings	26.4	26.4
Cost for steam from KKAB	-18.6	-18.6
Additional annual savings	7.8	7.8
New Pay-back time	8.6 <sup>26</sup>	7.4 <sup>27</sup>

When extending the system boundary to include Mariestad Energi and Metsä Tissue the estimated revenue from supplying steam to Metsä cannot be included as it can only be considered as an internal reallocation. However the revenue from supplying district heat is still included as it is transferred to outside external customers. In table 3-5 the estimations are shown for the new system boundary and additional savings are estimated to about 8 MSEK per year. By extending the system boundary and include the savings for reduced oil consumption and reduced tax cost for disposed sludge, the initial estimated net loss of 0.5 MSEK per year turns into a net surplus of about 7 MSEK per year for the whole system.

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change from individual oil boilers to district heating. The extended system boundary will neither include revenues from supplying steam to Metsä Tissue which is included in the initial estimation amounting to 18.6 MSEK per year.

<sup>25</sup> According to KKAB the estimated reduced oil consumption (GWh/year) can be divided by 1/3 (60/185) related to Metsä Tissue and 2/3 (125/185) to Mariestad Energi.

<sup>26</sup>  $210 / ((54.9 + -15.3) - (35.7 - 12.6) + 7.8) = 210 / 24.3$

<sup>27</sup>  $180 / ((54.9 + -15.3) - (35.7 - 12.6) + 7.8) = 180 / 24.3$

## Profitability assessment ex post<sup>28</sup>

As illustrated in table 3-6 the net loss according to estimations ex ante is now changed to a surplus of 27 MSEK per year. If no subsidy was received the estimated surplus would still be 23.5 MSEK per year. Increased prices on district heat and electricity including introduction of electricity certificates raise the estimated revenues ex post by 50%, from 55 MSEK to 80 MSEK per year. These estimations still assumes a reduction of the electricity production from 50 GWh, estimated in the initial calculation, to 29 GWh ex post according to the final report. However between 40 and 50 GWh per year of electricity production is still technically feasible. Assuming a production of 50 GWh per year will give revenues of 10 MSEK per year in addition to the 80 MSEK estimated below.

Table 3-6 *Katrinefors CHP plant; Ex post - Abbreviated investment estimation (Figures per year)*

<b>Katrinefors Kraftvärme Ex post (MSEK per year)</b>	Fossil fuel based district heating system – Status quo	BFB boiler mainly woodfuel No subsidy	BFB boiler mainly woodfuel Received subsidy 30 MSEK (15%)
Initial investment cost MSEK <sup>29</sup>	11.8	220	190
Annuity (interest rate 7%, depreciation 25 years)	0.14 <sup>30</sup>	0.086	0.086
Annual capital cost	1.7	20.6 <sup>31</sup>	18.0 <sup>32</sup>
Total operating costs <sup>33</sup>	11.7	35.6	35.6
Total annual cost	13.4	56.2	52.5
Revenue <sup>34</sup>	15.3	79.7	79.7
Gross surplus <sup>35</sup>	-	40.5	40.5
Net surplus/loss	1.9	23.5	27.2
Pay-back time years	-	5.4	4.7

<sup>28</sup> Until 2004 combined heat and power plants were charged both for energy tax and the general CO<sub>2</sub> tax level but from 2004 combined heat and power production have the same taxation rules as industry as regards fuels used for heat production, i.e. no energy tax and only 25% of the CO<sub>2</sub> tax (Statens Energimyndighet, 2003).

<sup>29</sup> For Specification of Investment costs see appendixes.

<sup>30</sup> Assumed depreciation time; 10 years.

<sup>31</sup> Includes capital cost for the previous installations (1.7 MSEK/year).

<sup>32</sup> Includes capital cost for the previous installations (1.7 MSEK/year).

<sup>33</sup> The reduced operating cost is due to the tax reform for combined heat and power production. Since 2004 CHP plants face the same level of energy taxes as the industrial sector.

<sup>34</sup> Prices assumed ex post; District heat 500 SEK/MWh; Steam 240 SEK/MWh; Electricity 260 SEK/MWh.

<sup>35</sup> Gross surplus=(Increased revenue) – (Increased operating cost)

Cost savings for Metsä ex post, due to reduced oil consumption and evading cost for disposal tax, is estimated to 24 MSEK; 16 MSEK higher than estimations ex ante, due to increased price on fuel oil and raised disposal tax from 250 SEK/ton ( in 2000) to 370 SEK/ton (in 2003). (Table 3-7)

Table 3-7 Katrinefors CHP plant; Ex post – Extended system boundary including estimated cost reductions of fuel oil and waste tax for Metsä Tissue (Figures per year)

<b>Extended system boundary Ex Post MSEK per year</b>	BFB boiler mainly woodfuel No subsidy	BFB boiler mainly woodfuel Received subsidy 30 MSEK (15%)
Cost saving for fuel oil (including CO <sub>2</sub> tax)	20.4	20.4
Saving Disposal tax cost	22.2	22.2
Total cost savings	42.6	42.6
Cost for steam from KKAB	-18.6	-18.6
Additional annual savings	24.0	24.0
New Pay-back time	3.5	3.0

### Rottneros Bruk – Recovering heat and improving the product quality

Rottneros Bruk is a pulp plant which belongs to the Rottneros AB company group<sup>36</sup>. The plant produces 140 000 tonnes of pulp is per year mainly for the export market. Rottneros Bruk has 170 employees and the annual turnover is about 400 MSEK.

1999 Rottneros Bruk applied for financial support to invest in a new refinery used for the production of CTMP pulp. The new refinery was installed in the end of 2001 and is the largest investment ever at Rottneros bruk amounting to 73 MSEK. The main reason for the investment is to improve the production process and the final quality of the pulp, but also to increase the energy efficiency and recover heat that was previously wasted. By shifting the previous refinery (atmospheric pressure) to a new pressurised refinery it is possible to improve the energy efficiency by recovering pressurised steam which is used for drying the pulp later in the production process. The initial estimation predicted a reduction of fuel oil from 90 GWh to 30 GWh per year. Rottneros have achieved a reduction of 51 GWh during 2003.

Initially the project included collaboration with the local district heating company. Excess heat and fibersludge from the production process, intended to be used as fuel were to be supplied to the district heating company but the project failed due to disagreements on how the project was to be carried out.

In general the final project is considered successful, both with regards to energy savings and the final pulp quality. The machines are old and the investment in a new refinery has improved the production process and the product quality. However the demand for fine pulp has increased in the last years which demand more energy in the drying process. At the start it was planned that the project was to include the initiation of electricity production. However Rottneros Bruk did not start producing electricity and has currently no plans to do so.

### Profitability assessment ex ante<sup>37</sup>

According to estimations ex ante (table 3-8) the subsidy is needed to make the investment profitable, considering increased total annual costs. However the required pay back time is generally between 7 to 8 years for similar investments at Rottneros. Accordingly the pay back time of 6.2 years, if no subsidy was received, falls within this requirement.

Table 3-8 Rottneros bruk pulp plant; Ex ante – Abbreviated investment estimation (Figures per year)

<b>Rottneros Ex Ante (MSEK per year)</b>	Pressurised Refinery No subsidy	Pressurised Refinery Received subsidy 21.9 MSEK (30%)
Initial investment MSEK	73	51.1
Annuity (discount rate 18%, depreciation)	0.196	0.196
Annual capital cost	14.3	10.0
Operating costs	-11.7	-11.7
Total cost difference MSEK/year	2.6	-1.7
Pay-back time	6.2	4.4

### Profitability assessment ex post

The oil consumption has been reduced by 50 GWh (comparing 60 GWh predicted ex ante). However, due to the increased price on oil the cost reduction in total is raised from 11.7 MSEK per year to 12.5 MSEK per year ex post.

According to estimations ex post (table 3-9) the subsidy is needed to make the investment profitable, though the pay back time is acceptable according to requirements by Rottneros. Nevertheless the profitability assessment ex post does not consider the improved product quality achieved due to the new refinery.

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<sup>37</sup> Prices assumed ex ante; Fuel oil 140 SEK/MWh; CO2 tax 56 SEK/MWh.

Table 3-9 Rottneros bruk pulp plant; Ex post – Abbreviated investment estimation (Figures per year)

<b>Rottneros Ex Post (MSEK per year)</b>	Pressurised Refinery No subsidy	Pressurised Refinery Received subsidy 21.9 MSEK (30%)
Initial investment MSEK	73	51.1
Annuity (discount rate 18%, depreciation 15 years)	0.196	0.196
Annual capital cost	14.3	10.0
Operating cost	-12.5	-12.5
Total cost difference	1.8	-2.5
Pay-back time	5.8	4.1

### SCA Östrand Pulp plant – Switching from oil to biofuels

SCA Östrand pulp plant produces chlorine free sulphate pulp (400 000 ton/year) and CTMP pulp (Chemical Thermo Mechanical pulp, 70 000 ton/year). The plant is part of the company group SCA Forest products AB within the SCA Corporate. SCA Östrand has 430 employees. Östrand produces steam and electricity for their production processes and steam for the neighbouring paper plant Wifsta bruk. Östrand also supply 100% of the district heating to the local district heating network in the municipality of Timrå.

In 2000 Östrand applied for the subsidy for the reconstruction of the bark and oil boiler including an installation of a BFB boiler to increase the capacity for combustion of biofuels. The project also consists of installation of a new economiser, a low NO<sub>x</sub> burner and electrofilter to reduce emissions of particulate matters<sup>38</sup>. Östrand have had difficulties to find a reliable solution to reduce emissions of NO<sub>x</sub> and particulate matters and the only way lower the emission level according to the application was to install a new boiler.

The environmental effects appear to be rather consistent with the predictions according to application. The reduction of oil corresponds to approximately 180 GWh per year – a reduction of 82% and the reduction of CO<sub>2</sub> emissions are about 55 500 ton per year. Moreover the energy efficiency is improved now using 11% less fuels (expressed in GWh/year) than previous. The amount of ashes which was estimated to decrease by 30 % turned out to decrease by 75%; 618 ton per year instead of 2451 ton ashes per year before the new installation was in place. It is assumed that the low amount of ashes is due to the combustion technology of the BFB boiler. The ashes are used for construction works within the production plant and are not considered to be a problem for the company.

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<sup>38</sup> SCA Östrand has had difficulties to find a reliable solution to reduce emissions of NO<sub>x</sub> and particulate matters and the only way lower the emission level was to install the new boiler (according to information from the application).

## Profitability assessment ex ante<sup>39</sup>

The estimations show annual gross savings of 31 MSEK per year. As a result of reduced oil consumption and improved energy efficiency due to the BFB boiler system annual operating costs are decreased by more than 50%. Estimated cost for capital raises the annual cost for the BFB boiler system but still annual savings can be estimated to about 11 MSEK per year even if no subsidy was received. When considering received subsidy of 31 MSEK, the estimations show that the investment create annual net savings of about 17 MSEK<sup>40</sup>.

The received subsidy of 31 MSEK is estimated to reduce the payback time from 4 years to about 3 years and according to the application a payback time of 3-4 years is normally required in the sector for these kinds of investments.

SCA Östrand has delivered steam and heat to both Wifsta bruk and the local district heating plant for several years before the new energy investment and has not affected the supply of external energy. The supply is rather stable and has not changed after the new installation.

*Table 3-10 SCA Östrand pulp plant; Ex ante - Abbreviated investment estimation according to the application of LIP (Figures per year)*

<b>SCA Östrand Ex ante (MSEK per year)</b>	Fossil fuel based energy system	BFB boiler mainly woodfuel No subsidy	BFB boiler mainly woodfuel Received Subsidy 31 MSEK (24%)
Initial investment cost MSEK	10	127	96
Annuity (interest rate 11%, depreciation 10 years)	0.17	0.17	0.17
Annual capital cost	1.7	21.6	16.3
Total operating costs	56.6	25.0	25.0
Total cost	58.3	46.6	41.4
Gross savings	-	31.6	31.6
Net savings	-	11.7	17.0
Pay-back time years	-	4.0	3.0

<sup>39</sup> Prices assumed ex ante; Electricity 120 SEK/MWh; Fuel oil 140 SEK/MWh; CO2 tax 56 SEK/MWh; Biofuel 75/MWh.

<sup>40</sup> It can be discussed if it is realistic to assume the same lifetime (20 years) and depreciation period (10 years) for both investments. Assuming that the alternative investment has to include a new reinvestment after a certain number years it would increase the cost for keeping the previous boiler in place.

## Profitability assessment ex post

Estimations ex post indicate increased savings compared to estimations ex ante, showing gross savings of 37 MSEK due to the BFB boiler investment and reduced cost for fuel oil. The pay back time is reduced from 4 years ex ante to 3.6 years ex post (no subsidy received).

Table 3-11 SCA Östrand pulp plant; Ex post - Abbreviated investment estimation (Figures per year)

<b>SCA Östrand Ex post (MSEK per year)</b>	Fossil fuel based energy system	BFB boiler - mainly woodfuel No subsidy	BFB boiler - mainly woodfuel Received Subsidy 31 MSEK (24%)
Initial investment cost MSEK	10	134	103
Annuity (discount rate 11%, depreciation 10 years)	0.17	0.17	0.17
Annual capital cost	1.7	22.8	17.5
Total operating costs	67.6	30.6	30.6
Gross savings		37.0	37.0
Total cost	69.3	53.4	48.1
Net savings	-	15.9	21.2
Pay-back time years	-	3.6	2.8

## Aggregated assessment of profitability and summary

The investments all together create positive cash flow payments of 91 MSEK per year ex ante (table 3-12), i.e. under conditions prevailing at the time the investment decision was taken. Including received subsidies the pay back time is 5.5 years compared to 7.3 years if no subsidies were received. Looking at the situation ex post the positive cash flow payments have according to estimations increased by about 60%, from 91 to 150 MSEK per year reducing the pay back time to 3.6 years including received subsidies. If no subsidy were received the pay back time ex post (under conditions prevailing at present) is estimated to 4.6 years.

Table 3-12 Aggregated investment estimation – Annual net operating cost savings due to the investments undertaken (Figures per year)

<b>Aggregated savings (excl. capital costs) MSEK</b>	Ex ante	Ex post
Aggregated savings	91	150
<b>Total Initial Investment</b>		
Aggregated Initial investment in total	663	697
Subsidy	159	159
Aggregated Initial investment (net amount)	504	538
Pay back time years no subsidy	7.3	4.6
Pay back time years including subsidy	5.5	3.6

The main cost savings for the pulp and paper industry are due to reduced oil consumption approximated to an energy value of 400 GWh per year. Part of the reduction is due to energy efficiency improvements though the major part of the oil consumption has been substituted with wood fuels to about 50% and internal sludge to about another 50 %. For one of the projects, SCA Lilla Edet, a significant reduction of electricity consumed has contributed to the most significant cost reduction.



## 4 Analysis of profitability

Predicting to what extent cost and revenues will change if a certain investment is undertaken or not undertaken is a complicated task. This chapter aims at analysing factors which has promoted or hindered the investigated investments to be undertaken. Central aspects emerging when conducting profitability assessments will be examined in this chapter. According to the premises of general investment theory these aspects are often referred to as how to deal with uncertainty; price changes and tax effects.

### Perceptions of profitability

By some of the project owners a pay back time of 3-4 years is generally demanded to undertake similar investments. However some of the investments were undertaken when the subsidy was received, even though the pay back time exceeded the general requirement of pay back time. Thus 3-4 years of pay back time does not appear to be a stringent condition for undertaking similar investments, but rather an indication of the high priority of short term benefits. As Northcott (1998, p 26) put it; short term success puts more emphasis on liquidity whereas long term success is expressed by means of profitability. Accordingly the requirement of short pay back time may hinder investments that are profitable in the long term to be undertaken.<sup>41</sup>

Three out of four investments undertaken are considered profitable *ex post* according to the project owners themselves. One exception is the bioenergy investment at Lilla Edet, facing problems when using nearly 100% fibersludge as fuel and the success of the investment undertaken depends on how well these problems can be solved in the near future. Initially several project owners considered the use of sludge to be more of a manner to get rid of sludge previously disposed and did not consider the sludge as an attractive alternative fuel. However, judging from the opinion of the projects owners *ex post* the conditions appears to be changed. Using sludge as an alternative fuel for energy production is considered as a more realistic option today.

In some of the projects investigated restoration of equipment in place or less costly alternative investments have been considered. However it may not always be rational to restore old equipment as there is a risk that a “fanatic” focus on cost minimisation leads to keep existing constructions in place to long. To divide up investment capital on continuous improvements of an existing construction may hinder a more profound modernisation at the time when it will be inevitable. (Ljung, B et.al., 1998, p.20). Again, this indicates that short sighted benefits may hinder investments profitable in long term to come into place. Consequently in a business environment characterised by short sighted benefits there is a risk for investment subsidies to become institutionalised. In such a situation businesses may improve there ability to provide clever arguments to attain public financial support.

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<sup>41</sup> However some of the investment projects are, according to applications, described as long-term environmental energy investments.

## Uncertainty – Aspects of risk

Investments are often associated with long term changes and there is no guarantee that assumptions made at the time for the investment decision will be the same in the future. According to Löfsten (2002) the discount rate is aiming at expressing not only compensation for waiting and lost purchasing power but also compensation for risk. The discount rate can be defined as “The rate of return at which future cashflows are discounted in order to express those cashflows in equivalent present value monetary terms” (Northcott, 1998, p.xiii). Thus the discount rate is supposed to express the uncertainty of future cash flow payment.

The assessment of risk appears to vary according to the initial applications. Some of the project owners consider the investments to be characterized by well-known technology while others consider the initiation of using fibersludge as fuel to be related with significant risks, which the companies were not willing to undertake, by themselves at the time the investments were decided upon. Using fibersludge for energy production is considered as a new experience for some of the companies and earlier experience would have been of value according to some of the project owners. According to SCA Edet bruk, they were the first and is still the only paper plant in the world that nearly use 100 % fibersludge as fuel for energy production.

For two of the projects (Edet bruk and KKAB) the combustion of fibersludge is related with significant problems. For instance at Edet bruk the residues from the production process of paper, based on recycled paper, are mainly short fibres, thickening in the form of kaolin and printing ink. The fibres are difficult to dry and may create problems in the combustion process. However the discount rate used for the investment estimation is relatively low and does not appear to represent the assessed risk for the project. SCA Lilla Edet declaring the risk to be significant has assumed a discount rate of 5% and Rottneros declaring the risk related to the investment to be negligible has assumed a discount rate of 18%. If investments in technology for combustion of fibersludge can be considered to imply a relatively high risk due to new technology and the lack of experience of similar projects this could have been expressed by the discount rate arguing for the need of support due to the risk and uncertainty implied by the investment rather than due to requirements of short pay back time.

Compared to the initial investment payment, the estimation of cash flow payments is generally a more difficult task and predicting future energy prices may be even more difficult. However if assuming that price on oil has the tendency to fluctuate more than the price on wood fuels the bioenergy investments undertaken are not only of advantage due to reduced fuel costs but also due to less uncertainty about future fuel prices. Policy change is another factor creating uncertainty around investments and may neither be easy to foresee. A regulatory environment which is often changed will due to uncertainty reduce incentives for long term investments (Field, 1997, p.186). Some of the project owners have also expressed the uncertainty regarding policy changes as part of the reason for not being convinced to undertake the investments by themselves.

## Analysis of policy instruments

### Energy Taxes

Aggregated avoided cost due to reduced CO<sub>2</sub> tax payment can be estimated to 22 MSEK per year due the investments undertaken<sup>42</sup>. Currently the manufacturing industry does not pay any energy taxes and the CO<sub>2</sub> tax level is 25 % of the general tax level. The tax can be further reduced if the total tax payment exceeds a preset maximum amount. Adding that the industry is neither facing any tax on electricity consumption this indicates that the this energy policy so far have not given enough incentives for the pulp and paper industry to change from fossil fuels as oil to renewable energy sources as wood fuels and fibersludge.

The CO<sub>2</sub> tax was implemented in 1991 and is paid per kilo of CO<sub>2</sub> emissions for all fuels except biofuels and peat. (Statens Energimyndighet, 2003). The CO<sub>2</sub> tax has continuously been increased since it was introduced, from 720 SEK per m<sup>3</sup> fuel oil (1991) to 2598 SEK per m<sup>3</sup> fuel oil(2004) (Riksskatteverket, 2004). However the reduced CO<sub>2</sub> tax for the industrial sector has been adapted keeping the tax level unchanged (Statens Energimyndighet, 2003).

If industry were to pay full CO<sub>2</sub> tax savings due to reduced CO<sub>2</sub> payments would be five times higher or just around 100 MSEK per year due to the investments, increasing the annual savings by 50% from 150 MSEK to about 230 MSEK per year.<sup>43</sup> As a result the incentives for carrying out bioenergy investments would appear much stronger if the general tax level also covered the industrial sector.

### Strengthened waste regulation

The law of disposal tax was introduced 2000 and the tax level has since then continuously been increased from 250 per ton in 2000, to 370 SEK per ton in 2004 (Skatteverket, 2004), giving increased incentives to find alternative solutions for waste treatment. A 50% increase of the tax level changes the aggregated avoided cost, due to reduced waste tax payment, from 16 MSEK to 23 MSEK per year<sup>44</sup>.

According to the new Swedish waste regulation (SFS 2001:512) issued in 2001 and entering into force in 2005, prohibiting the disposal of organic waste, gives clear incentives for concerned actors to find an outlet for their waste. Most companies concerned, point out that finding a long-term solution for the waste problem is one of the main issues behind the investment. Accordingly there existed an awareness of the problem and the necessity to find an alternative solution for the fibersludge *before* the regulation was issued in 2001.

Rottneros bruk may represent a good example of the increased incentives to find an alternative outlet for the sludge produced. Until the end of 2003 the fibersludge was put on landfill but due to an increased disposal tax the sludge is currently transported to Norrköping (about 200 km from Rottneros bruk) where it is used as raw material for fuel production. To

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<sup>42</sup> Aggregated reduction of oil consumption; 407 GWh\* 56 SEK/MWh (CO<sub>2</sub> tax) = 22.79 MSEK.

<sup>43</sup> 260 SEK/MWh\*407 000 MWh= 106 MSEK

<sup>44</sup> Lilla Edet does not pay any waste tax due to the possibility to “store” waste within the facility. If they were to pay waste tax the aggregated avoided cost would be 40.5 MSEK per year ex ante and 60 MSEK per year ex post.

be able to use the fibersludge themselves Rottneros is at present installing a BFB boiler on its own, not applying for investment subsidy<sup>45</sup>.

### **Electricity certificates - a strong incentive for renewable electricity**

Electricity certificates were introduced 2003 and the purpose is to encourage the use of electricity produced from renewable resources. Electricity certificates is a straight forward policy instrument in that sense that it brings direct revenues to the electricity producer when using renewable energy resources for energy production. The certificates are distributed by the government in accordance with the amount of electricity produced by a company. The producer will sell the electricity as usual, but if the electricity is produced by renewable resources the producer will get additional income by sold certificates. A certificate is issued for every MWh of renewable electricity sold. The development of the market for electricity certificates depends on the balance between demand and supply of certificated electricity production, whereas the demand is determined by a quote duty related to the energy user. The quota duty is preset by law and is continuously increased until 2010 (SFS 2003:113). However electricity used by certain manufacturing industries including the pulp and paper industry is exempted from the quote duty (SFS, 2003:113, ch. 4, §2). Therefore the pulp and paper industry is not only avoiding the alternative cost for purchasing external electricity if producing electricity from renewable resources but also getting additional revenue from selling electricity certificates to energy users obligated to fulfil their quote duty.

The economic incentives for the pulp and paper industry to produce electricity from renewable resources have dramatically increased since the time investments were initiated. The alternative cost for the pulp and paper industry for not producing renewable electricity production has increased by nearly 400 % if including possible revenues from electricity certificates<sup>46</sup>. The aggregated revenues from electricity certificates can be estimated to 10 MSEK per year, thus revenues from certificates are not significantly important as regards aspects of profitability for the specific investments investigated in this thesis. However the introduction of electricity certificates can in general be considered to give significant incentives to the pulp and paper industry to initiate electricity production.

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<sup>45</sup> Even though they are aware of the possibility to receive public financial support by the current investment support program, KLIMP (Climate investment programmes, SFS 2003:262) Rottneros is not considering applying for subsidy.

<sup>46</sup> Assuming a current price of electricity of 260 SEK/ MWh and 220/MWh per sold electricity certificate compared to the price for electricity in the initial estimations of 120-200 SEK/MWh an not revenues from electricity certificates..

## 5 Socioeconomic benefits and cost efficiency

This chapter brings up the environmental benefits and, briefly, some of the social benefits. Socioeconomic efficiency is discussed regarding the CO<sub>2</sub> emissions. The amount of subsidy allocated in relation to the CO<sub>2</sub> reductions and also the total investment figures in relation to the CO<sub>2</sub> reductions will be considered. A comparison is made between the subsidy level and the Swedish CO<sub>2</sub> tax.

### Socioeconomic benefits

*Table 5-1 Environmental benefits – Reductions of CO<sub>2</sub> emissions and reductions of fibersludge disposed (Figures per year)*

<b>Approximate reductions of CO<sub>2</sub> emissions &amp; fibersludge disposed</b>	<b>CO<sub>2</sub> ton/year</b>	<b>Fibersludge (ton/year) 30 % dry substance</b>
Katrinefors Kraftvärmeverk AB	-73 000	- 60 000
SCA Östrand	-55 400	- 2 500
SCA Lilla Edet	-20 000	-100 000
Rottneros bruk	-14 100	0
<b>Total</b>	<b>-162 500</b>	<b>-162 500</b>

With regard to the projects studied, the total reductions of CO<sub>2</sub> is estimated to 162 500 tonnes per year (table 5-1), which is about 30 % of the total annual CO<sub>2</sub> reductions achieved within LIP until present (570 000 tonnes have been estimated as total CO<sub>2</sub> reductions for the programmes finalised and reported by June 2004, see forthcoming Socioeconomic evaluation of LIP). About 160 000 tonnes of fibersludge per year, that were previously been disposed is now used for energy production substituting 23 000 m<sup>3</sup> of fuel oil. In total the four projects studied contribute to an annual reduction of 40 000 m<sup>3</sup> of oil. Reduced emissions of NO<sub>x</sub>, SO<sub>x</sub>, particulate matters and dioxins represent other environmental benefits. However, figures on these emissions are not reported consistently, why any aggregated figures is not presented here.

The transition to local renewable energy resources, reduced consumption of fossil fuels and increased collaboration between local companies are mentioned as some of the main benefits according to the assertions by the Swedish Energy Agency. Further, it is worth mentioning the significant amount of sludge in Sweden that is currently not used. The introduction of new technology (where SCA Lilla Edet may represent a very good example) can create positive spin off effects. Lilla Edet is using nearly 100% fibersludge as fuel in their energy production. In the application of Lilla Edet it is pointed out that there has been a big interest for the project, both from customers and other interesting actors. As far as SCA Lilla Edet knows there is currently no similar project in place in the whole pulp and paper industry. Supporting this kind of “risk investments” can be a way to prepare the industry for upcoming policy instruments and new regulations and in that way attain practical experience being useful for similar investments carried out in the future.

Reduced costs due to investments are not only beneficial for the individual businesses but also create indirect socioeconomic benefits as an improved position of the industry reduces the

risk for lost jobs and future job opportunities. As expressed in the application of SCA Östrand, the pulp plant and the neighbouring paper plant are the largest employers in Timrå, totally accounting for 800 employees. It is believed that it is of great importance for the future development and survival of the plants to have the possibility to invest in sustainable energy production both as regards environmental concerns but also for competitive reasons.

## Cost efficiency and Policy Incentives

The investment projects studied indicate that investments related to the pulp and paper industry appears to be more cost efficient compared to projects supported by LIP in general (table 5-2).<sup>47</sup> As the investments entail CO<sub>2</sub> reductions during several years the lifetime of the investments has to be considered to give correct values. A simplified calculation, assuming an average lifetime of 10 years, (see figures in table 5-2) indicates that the investments studied in the pulp and paper industry are about 40 to 60% to less costly than other LIP projects (expressed as the annual *capital cost* per reduced kilo of CO<sub>2</sub>). The same link can be recognised when comparing the allocated subsidy and the CO<sub>2</sub> reductions achieved, where estimations indicate that projects supported by LIP in general have been allocated a higher amount of subsidy per kilo of CO<sub>2</sub> reduced (0.14 SEK per kilo of CO<sub>2</sub> reduced comparing 0.10 SEK for the investments studied in the pulp and paper industry, and 0.6 SEK if three out of four investments are considered).

Table 5-2 Socio-economic efficiency– Total capital cost, allocated subsidies and CO<sub>2</sub> tax (Figures per kg of CO<sub>2</sub> reduced)

SEK per year (Annuity 10 years)	LIP in general (Excluding the 4 assessed projects)	Pulp and paper industry (The 4 assessed projects)	Pulp and paper industry (3 out of 4 assessed projects)
Capital cost (including subsidy)/kg of CO <sub>2</sub> reduced	0.72	0.43	0.30
Allocated <b>subsidy</b> /kg of CO <sub>2</sub> reduced	0.14	0.10	0.06

In the figures for “three out of four projects” in table 5-2, the investment at SCA Lilla Edet is excluded. At Lilla Edet, the total investment per kg of reduced CO<sub>2</sub> is significantly higher than in the other projects studied (1.35 SEK per kg CO<sub>2</sub> compared to 0.30 SEK; the average for the other three projects). Further the *subsidy level* is also considerably higher per kg of CO<sub>2</sub> reduced (0.38 SEK/kg of CO<sub>2</sub> compared to 0.06 SEK). A major part of the energy efficiency improvement at Lilla Edet is due to decreased consumption of electricity and the initiation of renewable electricity, internally produced. Efficiency improvements or environmental benefits, regarding electricity, are not reported in the final reports of LIP.

If an alternative energy investment has been considered by the companies, the additional capital needed for the investments undertaken may be a more appropriate figure when

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<sup>47</sup> In total, *subsidies* of approximately 4 billion SEK have been allocated within LIP. However the estimation in table 5-2 is based on the projects finalized and reported by June 2004, out of which projects contributing to reduced CO<sub>2</sub> emissions stands for 0.7 billion SEK (the total investment amount for these projects is about 3,6 billion SEK).

estimating the cost for CO<sub>2</sub> reductions. For instance at Lilla Edet it was considered to change the old energy system and reinvest in a new fossil fuel based system, which would have implied a capital investment of 150 MSEK. The current biofuel energy system (including the BFB boiler and the equipment for electricity production) implied a capital investment of 270 MSEK, thus an additional capital of 120 MSEK compared to the fossil fuel based system. Considering the additional capital of 120 MSEK the cost for CO<sub>2</sub> reductions would be even lower (see figures in table 5-2) for the pulp and paper industry. However the subsidy level allocated has been based on the total investment capital (*not* on the additional investment capital) even in the case when alternative investments have been considered by the companies.

As mentioned in previous chapters the manufacturing industry is only burdened by 25% of the general CO<sub>2</sub> tax, i.e. 0.19 compared to 0.76 SEK per kg of CO<sub>2</sub>. If assuming the general CO<sub>2</sub> tax, 0.76 SEK per kg, to be a correct value of the environmental cost for CO<sub>2</sub> emissions, public subsidies below 0.57 SEK per kilo CO<sub>2</sub> (0.76-0.19) can be considered as socio-economic efficient. Assuming an average lifetime of 10 years for the investments, the allocated subsidy of 0.10 SEK per annual reduced kilo of CO<sub>2</sub> clearly indicates that the investments in the pulp and paper industry can be considered cost efficient from a socio-economic perspective, as benefits can be presumed to be higher than the cost for the CO<sub>2</sub> reductions.

If the pulp and paper industry were burdened with the general CO<sub>2</sub> tax level the subsidies received would not be considered cost efficient as the costs would exceed the benefits for reduced emissions. On the other hand, if the industry were facing a higher tax level the incentives would be much stronger for undertaking similar investments without subsidy support (The CO<sub>2</sub> tax is also discussed under *energy taxes*, chapter 4).

Apart from the project owners themselves, the Swedish Energy Agency mention in their assertions that the upcoming prohibition to dispose organic waste enhances the interest for using sludge as an energy source. Considering §16 of the LIP regulation stating that “*investments must be assumed to have significant environmental improvements, which would not have taken place due to requirements by existing law and regulations*”, the assertion seems to be in line with the regulation. However, approaching the legitimacy of financial support from an efficiency point of view, the approval of a subsidy can be questioned if assuming that the investments would have come into place anyhow<sup>48</sup>. Moreover, as investments investigated can be considered as relatively cost efficient compared to projects within LIP in general this may create a dilemma for authorities deciding upon which projects that shall receive an investment subsidy. On one hand it is evident that investments considered profitable by themselves; i.e. without subsidy, shall not be receive financial support. On the other hand, if investments can be considered to be cost efficient as regards the environmental benefits the allocation of subsidies may become a tricky issue, not only for the authorities allocating subsidies, but also for companies recognising their favourable position for negotiation. If certain businesses recognise the possibility to undertake investments, not only profitable for the business itself, but also considered “attractive” from a socio-economic view, it may be tempting to present investments in such a way that subsidy appears necessary for undertaking investments.

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<sup>48</sup> According to the project owners, two of the projects would probably have been undertaken even if no subsidy had been received, just being a matter of time.

## Socioeconomic benefits – Who shall pay?

According to the Swedish environmental policy resource efficiency, reuse and recycling shall be encouraged and renewable energy resources shall be prioritised (SFS 1998:808). Local Investment Programmes may be one way to support this policy. However there are always alternative uses for tax payers' money<sup>49</sup>. Therefore the willingness to pay for environmental investments by the business itself shall be considered. Improved credibility regarding environmental concerns and as consequence increased competitiveness and a better image of products is expressed as some of the advantages following these types of investments undertaken in the pulp and paper industry. Another investment undertaken is referring to improved product quality and an enhanced production process as the main reasons behind the investments. Still these kinds of benefits may be difficult to estimate in monetary terms. However, it highlights the recognition from the businesses themselves to take action towards environmental improvements and as consequence take on the cost for doing so. In the end, is it the final consumer who shall pay for higher production cost or shall tax payers pay the bill for environmental improvements that the consumer may already demand?

One voice recognising the influence of investment support tells that

*“The board hate becoming aware of loosing the opportunity to receive subsidies”* and further states;

*“The deadline for application of subsidy made the board undertake the investment which would otherwise have been delayed or not carried out at all”.*

Accordingly, in a business environment characterised by short sighted benefits investment subsidies may still be an effective way to make companies act upon investments that would, as expressed above, have been delayed or not carried out at all.

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<sup>49</sup> One way to value the “alternative use” of tax payers' money is to apply a tax factor. A tax factor > 1 can be applied to show that the use of tax payers' money hinders the highest possible consumption and production value to be realized. For instance, a tax factor of about 1.3 is commonly used when performing socio-economic evaluations of investments in the Swedish transport sector. (SIKA, rapport 2002:4)



## **6 Conclusions and Implications**

### **Conclusions and implications for the pulp and paper industry**

Switching from oil to biofuels appears to be good business for the Swedish pulp and paper industry today. Mixing traditional wood fuels with sludge residues makes the transition even more profitable. The investments studied in this thesis show that subsidies of 159 MSEK have pulled the pulp and paper industries to undertake bioenergy investments creating annual net operating cost savings of 150 MSEK per year. With a total investment of 697 MSEK giving a pay back time of 3.6 years corresponds to the payback time of 3 to 4 years in general required by the industry to undertake similar investments.

Investments which the pulp and paper industry was not willing to undertake by themselves, at the time the projects were decided upon, are today considerably profitable even if no subsidy would be received, due to increased price on oil and electricity and continuously raised waste taxes. In addition, the new waste regulation entering into force 2005, not allowing disposal of organic waste, gives further incentives to find an alternative outlet for the sludge produced in the pulp and paper industry.

The introduction of electricity certificates, aiming to stimulate the production of renewable electricity, gives significant incentives to the pulp and paper industry to initiate electricity production based on biofuels. In addition to a 100% increase of the electricity price, the pulp and paper industry may receive revenues from sold electricity certificates at a price almost equivalent to the general price of electricity.

The significant risk related to the initiation of using fibresludge for energy production and the lack of previous experience was the major reasons for the pulp and paper industry to argue for financial support at the time the investments were decided upon. However, in a business environment requiring short pay back times, short sighted benefits are prioritised which may hinder investments being profitable in the long term to be undertaken.

### **Conclusions about environmental benefits and socioeconomic implications**

The pulp and paper industry have undertaken investments enhancing the transition to local renewable energy resources and reduced consumption of fossil fuels. 160 000 ton of annual CO<sub>2</sub> emissions are reduced, making up about 30% of the total reductions within the Local Investment Programme finalised until today. 160 000 tonnes of sludge previously disposed, are now used for energy production substituting 23 000 m<sup>3</sup> of fuel oil per year, which represents about half of the amount reduced concerning the investments studied. With a significant amount of sludge produced in the production processes the introduction of new combustion technology may facilitate and speed up the initiation of similar investments in other pulp and paper industries.

<b>SEK per year</b> (Annuity 10 years)	<b>LIP in general</b> (Excluding the 4 assessed projects)	<b>Pulp and paper industry</b> (The 4 assessed projects)	<b>Pulp and paper industry</b> (3 out of 4 assessed projects)
<b>Capital</b> cost (including subsidy)/kg of CO <sub>2</sub> reduced	0.72	0.43	0.28
Allocated <b>subsidy</b> /kg of CO <sub>2</sub> reduced	0.14	0.10	0.06

Estimations indicates that *investments in the pulp and paper industry are cost efficient* compared to investments within LIP in general as regards CO<sub>2</sub> reductions. Expressed as the annual *capital cost* per reduced kilo of CO<sub>2</sub>, the investments studied in the pulp and paper industry are about 40 to 60% to less costly than other projects in LIP. The socio-economic benefits due to the investment in the pulp and paper industry significantly exceeds the cost if assuming the general CO<sub>2</sub> tax level of 0.76 SEK/kg CO<sub>2</sub> to be a correct value of the environmental cost. Since the industry is only burdened with 25% of the general tax and the subsidy level does not exceed the remaining 75% of the assumed external cost, the studied projects can be considered cost efficient from a socio-economic point of view.

The *competitive position* of the businesses has been improved compared to other businesses, which did not undertake similar investments at the same time. Apart from benefits for the individual companies, an improved competitive position also generates indirect socio-economic benefits as there is an increased probability of not losing local employment opportunities.

Similar investments to the ones studied in this thesis, are today carried out without subsidies. This has implications for the current Swedish Climate investment programmes (KLIMP). Accordingly tax payers' money can be better used for other pilot projects generating environmental benefits which would not be realised without financial support. However, the significant cost efficiency identified for the investments studied may create a dilemma for the authorities deciding upon projects receiving subsidy. It is evident that investments considered profitable shall not receive additional financial support. But if investments can be considered to cost efficient regarding the environmental benefits achieved, the allocation of subsidies may become a tricky issue not only for the authorities allocating subsidies, but also for companies recognising a favourable position for negotiations.

## Concluding remarks

The current Swedish energy policy affects the investments studied in this thesis *ex post*, explicitly, and the investments *ex ante*, implicitly, as some policy instruments which were not in place before the investment decisions were taken, could plausible have been foreseen by concerned actors. In such a context the energy investments can be considered as a success for the individual companies, but also for the government as the policy instruments implemented *ex post* were encouraged to be fulfilled before they came into place.

## **Suggestions for further research**

The investment subsidies allocated to the pulp and paper industry can be a way to overcome the transaction costs sometimes considered to be a barrier for the introduction of Cleaner Technology. If assuming that the allocated subsidies represent the transaction cost for taking on Cleaner Technology investments, this needs to be put in a more holistic context taking into account other factors, in addition to pure profitability analysis, influencing investments decisions in the industrial sector. This topic was brought up by a member of the reference group for the socioeconomic evaluation of LIP, and represents an interesting area for further research.

As brought up in this thesis the incentives would be much stronger for the industry to undertake similar investments without subsidy support if the industry were burdened with the full CO<sub>2</sub> tax. This highlights the interest of making further research into the area of socioeconomic efficiency and the future design of policy instruments.



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### Interviewees

Company	Name & Title	Date
<i>Katrinefors Kraftvärmeverk AB</i> , The municipality of Mariestad (Interview by telephone)	Rolf Åkesson – <i>Manager Director</i>	2004/08/23
<i>Rottneros Rockhammar AB</i> (Rottneros bruk), The municipality of Sunne (On site visit)	Uno Bengtsson - <i>Manager CTMP</i>	2004/08/06
<i>SCA Graphic Sundsvall AB</i> , SCA Östrand, The municipality of Timrå (On site visit)	Jan-Åke Ohlsson - <i>Project Manager</i> Marika Kroppegård – <i>Controller</i> Mats Jakobsson - <i>Department Manager</i>	2004/06/29
<i>SCA Hygiene Products AB</i> , SCA Lilla Edet, The municipality of Lilla Edet (Interview by telephone and e-mail)	Anders Helgesson – <i>Energy Technology Manager, SCA Lilla Edet</i> Jyrki Veikko Mattila – <i>Energy Technology Manager, SCA Hygiene Products AB</i>	2004/05/10 2004/08/06

## **Abbreviations**

LIP	Local Investment Programmes
CHP	Combined Heat and Power plant
EPA	Environmental Protection Agency
BFB	Fluidised Bed Boiler





