Bioenergy sector in Mid Sweden

14 February 2006

Project: Biosouth

Benny Nilsson
Magnus Näslund

Preface

The proportion of bioenergy used in the Swedish energy system has steadily increased, from a little over 10% in the 1980s to about 17% in 2003. With the exception of a certain import contribution, the biofuels used in the Swedish energy system are indigenous, consisting mainly of:

- Wood fuels
- Black and green liquors
- Peat
- Refuse
- Ethanol

Wood fuel is wood raw material that has not been submitted to any chemical process: bark, needles, leaves, wood logs and fuel raw material from the forestry and wood industry, e g shavings, cutter shavings, saw dust and dry wood chips. Svebio estimates that a total of 135 TWh energy from wood fuels can be extracted from Swedish forests, as compared to today's 50 TWh.

When handling forest residues in Sweden 3 different methods are used. The collecting of forest residues are mainly applied at final felling sites.

Main factors in the profitability of collecting forest residues are;

- Quantity of forest residues, ratio ≥ 40 tonnes per hectare.
- Distance to buyer (heat distributor, industry, refining factories etc.)
- Forest terrain and availability
- Landowners will in selling the forest residues although relatively poor payment.

Bioenergy sector in Mid Sweden

Biofuels in general

The proportion of bioenergy used in the Swedish energy system has steadily increased, from a little over 10% in the 1980s to about 17% in 2003. Most of the increase has been by industry and district heating plants.

With the exception of a certain import contribution, the biofuels used in the Swedish energy system are indigenous, consisting mainly of:

- Wood fuels
- Black and green liquors
- Peat
- Refuse
- Ethanol

They are used mainly in the forest products industry, in district heating plants, the detached house sector and for electricity production.

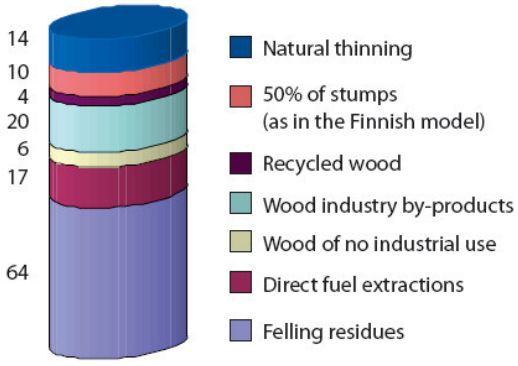
Wood fuels

Wood fuel is wood raw material that has not been submitted to any chemical process: bark, needles, leaves, wood logs and fuel raw material from the forestry and wood industry, e g shavings, cutter shavings, saw dust and dry wood chips. There is also recycled wood fuel, such as demolition wood. Wood fuel can be processed and refined into chips, briquettes, pellets or wood powder. Pellets and briquettes are dry compressed fuels with good qualities for transports, storage and combustion.

Annual forest growth in Sweden is 107-109 million m³ standing volume (stem volume over bark from stump to tip excluding branches and tops). During the 1990s, the felling rate was around 70 percent of the country's annual forest growth (65-70 million m³ standing volumes). The more activities like cleaning and thinning that take place, and the more timber that is being extracted for pulp industry and sawmills the more wood fuel is made available in the form of by-products and felling residues.

Thus there is a large wood fuel potential that is not being exploited and that could even become larger in the future in step with technical developments. But a physical asset of wood fuel is not the same as a truly accessible wood fuel supply. Estimates of available wood fuel involve judgements of what is economically, ecologically and technically possible and whether you expect the ash to be returned to the forest lands or not. The swedish bioenergy association, Svebio, estimates that a total of 135 TWh energy from wood fuels can be extracted from Swedish forests, as compared to today's 50 TWh. The judgement is based on studies performed by the Swedish University of Agricultural Sciences (SLU).

Composition of the wood fuel potential (TWh)

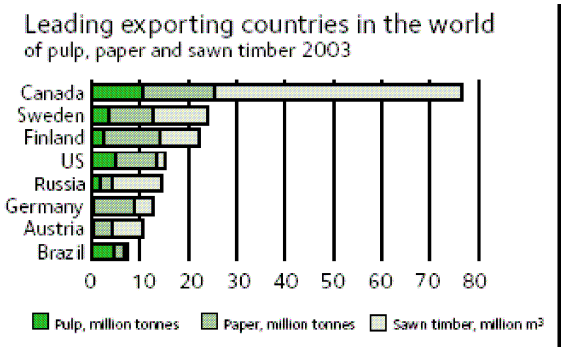


Source: Swedish University of Agricultural Sciences (2003) and National Board of Forestry (1999).

Swedish forest industry

The forest industry is one of Sweden's most important industrial sectors. The forest industry plays a more important role in the Swedish economy than it does in other EU countries, with the exception of Finland. The forest industry and forestry account for almost four percent of Sweden's GDP.

The Swedish forest industry rests on the



country's forest raw materials, with recovered fibre becoming an increasingly important material in paper production. Globally, Sweden is a great power in the world of forestry.
We are the world's fourth largest exporter of pulp, the third largest of paper and the second largest exporter of sawn timber. Sweden's pulp and paper industry is Europe's third largest after Germany and Finland.

Producers of biofuels

Every year the Swedish Bioenergy magazine carries out a survey on Sweden´s producers of biofuels on the open market. The results of 2004s survey shows on an increased turnover of about 10 percent to about 5500 million SEK among the participating 40 companies on bioenergy's list. All the companies on the top-ten-list have increased their turnover; most prominent are Råsjö, SBE Brikettenergi and Talloil.

© Bioenergy COMPANY *(Top 10)*		Total turnover (MSEK)
1	Råsjö Torv (7)	594
2	SCA Skog, Norrbränsle (1)	486
3	Arizona Chemical (4)	450
4	Naturbränsle (3)	423
5	SBE Brikettenergi (6)	419
6	Sydved Energileveranser (2)	413
7	Södra Skogsenergi (8)	291
8	Tall Oil (9)	250
9	Sveaskog (10)	180
10	SÅTAB (15)	140
	Others	1764

The companies answer for the numbers in the survey them self and should for that reason be seen with certain wariness. There are also several minor companies who aren't on the Bioenergy magazines list. A complete list can be seen in the appendix.

Systems and handling of forest residues

Forest residues and energy is a rather new product for the swedish forest sector, which has a long history of producing wood for pulp and saw mills. Therefore the organisation for bioenergy commonly are placed outside the "main" forest administration. One of the domination forest companies in northern Sweden, has an organisation where the bioenergy is administrated in a separate daughter company. Another example in mid Sweden, is a pure bioenergy company owned by the association of private forest owners and a number of sawmills. These two companies will be described later.

It can be any of the forest owner, the felling entrepreneur or the bioenergy company who takes the initial initiative to gather residues at a certain felling site. When a forest owner is about to do a final felling larger than 0,5 ha, it has to be reported to the local board of forestry. The information will therefore be public. This has to be done two months in advance, and the board decides if the felling will be allowed. It is very seldom the decision is any other than approval, but a forest owner may not clear cut more than a certain percentage of the total owned area.

Forest owners have not always a positive attitude towards selling the residues. Their arguments are that selling the residues will normally increase the income for a final felling with in the best case 2-3%, imply a risk of loosing nutrients and give more damage to the soil surface and private roads. On the other hand, There are advantages for the forest owner with getting rid of the residues. According to research, the cultivation will be less costly and of better quality, the survival of the plants seems to improve and it is possible to do the planting one year after felling instead of two.

When the bioenergy company looks at a site where felling is going to be made, either by its own initiative or after being contacted by the landowner or the entrepreneur, the decide if they are interested in buying the residues. The decision is based upon the following factors:

- Estimated quantity of forest residues, ratio ≥ 40 tonnes per hectare is preferable.
- Distance to buyer (heat distributor, industry, refining factories etc.)
- Forest terrain and other availability factors as terrain transport distance.

The first two ones are the most important. The importance of the quantity implies that almost all objects for gathering forest residues are final felling sites. Thinning sites gives commonly to low quantities, and the exceptions for that is in the southernmost of Sweden. It also implies that forest residues commonly are taken from pure spruce forests or forests with at least 50 % content of spruce.

There is an interaction between these factors, so a short distance can for example compensate a lower quantity.

After deciding that an object is suitable for gathering of residues, the biofuel company make a deal with the entrepreneur who makes the forest felling, that a " fuel adapted harvesting" shall be made. This means that the residues shall be places in heaps and that all tops in a heap shall have the same direction. The heaps have several advantages, the biomass will dry better, it is easier to collect the residues without getting any soil with it and finally that the gathering will be faster. A part of the fuel adapted harvest is also that the small bushes shall be cut down in advance, so these, including roots and soil, not is following when the residues are loaded on the forwarder. For the felling entrepreneur, a fuel adapted harvest will imply a little lower productivity, which the bioenergy company has to compensate for.

Then it is up to the bioenergy company to gather and forward the residues to the roadside. This is either done by themselves or by an entrepreneur. When the forwarder picks up the residues by a crane, it is of big importance that the content of stones and gravel are kept low. Such contamination will cause wear and/ or damage of the crushing equipment later.

Forwarding can be made immediately after harvesting the timber, or after a year or even later. A reason to wait is that the material dries fairly well in the small heaps and another that

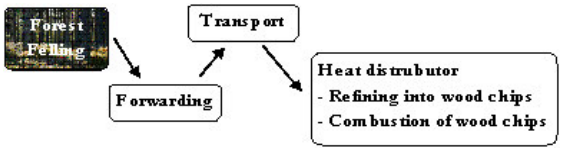
the needles partly will fall off. The latter is desirable both for the nutrient situation in the forest and the combustion properties for the fuel. It is not always possible to wait until the needles have fallen off. In northern Sweden for example, long distances of forestry roads are ploughed only for the forest felling, and it would be expensive to plough once again just for fetching the residues. It is off course also desirable for the bioenergy company to gain an income from the residues as soon as possible, instead of "storing" it in the forest.

The roadside is next possibility to store the material. Here it is commonly placed in bigger heaps of 5 m height, 5 m width and as long as necessary, and covered with strong waterproof paper. Drying also takes place in this stage of the chain, though not so efficient as in the small heaps. The needles are also falling off, improving the fuel quality, but in this case not the nutrient situation in the forest. The issue of storing or get the income as soon as possible is the same in this stage, though here are two costs already taken instead of one.

In practise, these two are the actual storages of biofuel in the chain.

After the residues have been forwarded to roadside, 3 different methods are used for the further transport to the customer.

Method 1

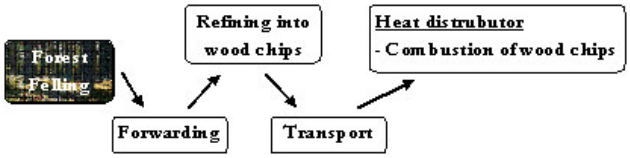


Method one is a commonly used method in collecting forest residues in Sweden. The chain has four so called main steps and starts with felling or thinning forest. Then you forward it to the main road and transport it to the nearest customer for refining and combustion.

This method has profitability when the distances to the heat distributor are between 0-60km and the quantity of forest residues is acceptable. It is not possible for a truck to reach full weight with not crushed forest residues, as they are too voluminous.

It is depending on that the customer has equipment for crushing the fuel. If the customer have sufficient space and not have noise restrictions, it is possible to gain a very efficient crushing with high capacity driven on electricity.

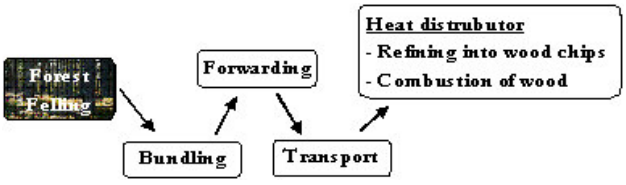
Method 2



Method number 2 is also a commonly used method in Sweden. This method has its difference from the first method when refining the forest residues. In this method the refining takes place before the transport to the heat distributor at a terminal. When refining the forest residues before the transport, the profitability of transporting the fuel goes up to 100km instead of 60km.

This method is more expensive than the first method at short distances, due to that the refining costs are higher. The crushing machines must be smaller in order to be mobile, and are using diesel as fuel. The transport on the other hand will be less costly, as a truck can reach the maximal allowed weight with chips. A disadvantage with this solution is that the storability of chipped material is lower than unchipped, meaning that the system is less flexible than the others.

Method 3



Method number three is a relatively new method in Sweden and is only used in a few places at present. This method uses the principle of bundling the forest residues into large logs which afterwards forwards to the main road for transport to a distributor for refining and combustion.

Bundling implies an extra rather costly moment in the supply chain, but reduces the costs for other moments. Forwarding is for example more

rational if the residues are bundled. The same machine and same gripper can be used as for forwarding timber, the loading and unloading is faster and as the bundles are compact the loads can be heavier. The efficiency of the road transports will be better compared to method 1 and equal to method 2. Nevertheless an advantage is that the same trucks can be used as for timber transports, and it is possible to store the bundles anywhere in the chain.

A key factor for bundles is that the customers are able to crush them. They demand a big crusher that will be noisy, and district heating plants are especially in southern Sweden oftenly located into or too close to the cities.

This method is still at the testing stadium but has shown a positive effect in questions like the drying process and transport. But at present the profitability of this method seems to be doubtable compared to method 1 and 2.

Transport

The transport cost is of course depending on the distance to the consumer, but commonly it is in the same size as forwarding and crushing. A Swedish study from 1998 [Lönner et al] presents following transport costs:

	Initial cost (SEK/ ton)	Cost per km (SEK/ ton)
Chips	25,2	0,58
Uncrushed residues	24,2	0,803

Table 1, Transport costs.

For a distance of 50 km it implies 54,2 SEK/ ton for chips and 64,35 SEK/ ton for uncrushed residues.

There are continuous trials to reduce the transport costs. Trucks can be equipped with facilities for compressing the residues, but in practise this has not yet been successful. The reason it that the residues do require strong forces to be compressed, which will make the equipment so heavy that the truck cannot load so much more than without compressing.

A more common way to reduce the transport costs is to use a system with return freights. There are of course not any return freight all the way out to the forest site, but to places rather close, so the driving distance without load can be minimised. Instead of using specialised trucks with compressors, such a system will require flexible trucks.

At the customer

At the customer, commonly a district heating plant, measurement of the delivered fuel takes place. Normally the truck passes a scale while arriving and leaving the place, giving the weight of the load. Then randomly samples of moisture content is taken. If uncrushed forest residues is delivered, the moisture measurement is more difficult. One way to decide the moisture content is that experienced staff watch the material and make judgements. As backup, samples can be taken after the material is crushed.

Then the energy content is calculated, which will be the base for final payment to all participants in the previous chain.

If the material is not crushed yet, crushing will take place here. After crushing the storability of the material decreases. Degradation starts, and it is advantageous to combust the fuel as soon as possible. Mixing of different fuels according to a "recipe" is common to do in the inlet bin to the boiler.

Many district heating plants are located close to the citys and settlements (they were built when the fuel was oil or peat), and in such places crushing will be too noisy. A common solution for this is to have a terminal outside the city, or buy fuel that already are crushed.

Commonly there are no bigger fuel storages at the heating plants. They rather have control of the arrival of the trucks, so they make their deliveries in a regular way. As the fuel demand is depending of the temperature, the trucks have to do more frequent deliveries in cold weather. For the economy of the transporter, it is harmful if queues occurs while delivering.

Bioenergy trade

Below is a brief description of two bioenergy companies working in the mid Sweden area. They have different owner structures which have influence of their acting.

The customers of biofuel are the district heating suppliers in the region, and for refined material as pellet and briquettes all from private households to distant powder fuelled heating plants.

The heating plants using unrefined fuel (bark, saw dust, forest residues, peat, wood chips) have commonly rather detailed specifications of the fuel quality, such as size distribution, moisture content, ash content. It is important for the fuel supplier to follow these specifications and it is commonly done by mixing different materials. Mixes of bark and saw dust are for example a very common fuel in district heating boilers. Forest residues are also oftenly mixed with for example various parts of bark in order to control the moisture content. The larger district heating plants commonly buy the fuels separated and do the mixing by themselves. Forest residues are very seldom used without any addition.

As transport costs are an important part of the economy in bioenergy trade, the biofuel companies are very urgent to reduce this as far as possible. This is done by taking as heavy loads as possible on the trucks, reduce the distance for deliveries, find return freights etc.

Bioenergy company 1

In the mid Sweden area, there is one dominating forest company with an ownership of 2.6 million hectares of forest. They deliver wood to their own pulp mills and sawmills. Except from their own forest, they also buy rights to do final cuttings from other forest owners. The industry is not self-supplied by their own forestry, so certain amounts of round wood is bought. Pulp and paper products are their most profitable segment.

The bioenergy business is organised in a daughter company, which is dealing with the waste products from both own saw mills and pulp mills and other suppliers. The waste products is bark, saw dust, wood chips, but also the forest residues from own forestry as well as from others.

The total delivered fuels in 2004 was about 3.7 TWh, of which 60% is sawdust and bark, 20% is fuel pellets, 8% wood chips, 8% forest residues and 4 % is peat.

The saw dust that are going to be pelletised, is transported to any of their 4 pellet factories. Together, their annual capacity is 300.000 tons. The pellet is delivered in different ways, by sea transport to distant customers, in the shape of bulk directly by truck to private customers, and in bags to retailers. The pellet is used in all kind of furnaces, from stoves to powder fuelled district heating boilers.

Their customers for unrefined fuels are mainly district heating plants in the region in various sizes from less than 1 MW up to several 100 MW. Some of them, oftenly the smaller plants, buy mixed fuel, while the bigger customers commonly does their own mixes.

There is also an internal transfer of biomass, as some of the pulp mills are not satisfied with its own bark amount, or if they find it advantageous to use of the bark anywhere else.

The forest residues are gathered by their own entrepreneurs, at sites from the mother company forestry as well as from others. They are using all of the three methods mentioned earlier, though bundling only on experimental level. Which one is depending on the customer and the transport distance, customers who have own crushing equipment buys uncrushed material, while others want already crushed.

As the pulp products are the most beneficial segment for this company, and they are not self-supplied, they have an interest in keeping the price for pulpwood low. There is a relation between the pulp wood price and the fuel price, and by keeping the supply of fuel high, this might act as a pressure also on the pulp wood price.

Bioenergy company 2

Bioenrgy company 2 is owned by a private forest owners association and 6 private sawmills.

The business concept is to make use of the rest-products from the sawmills and in recent years also forest residues. In total, the annual traded amount is about 800 GWh, shared on bark, forest residues and wood chips as biofuel to heating plants, and sawdust as raw material to the chipboard industry.

They have a terminal that is able to treat material, which earlier has been an environmental problem, for example cleaning material from the sawmills. Earlier it was taken to the refuse tip, but today it can be revised into biofuel

Material comes to the terminal by lorry, is weighed, quality checked and registered. The material consists mainly of rest-products from the sawmills, that is bark, spill and cleaning material, but also rotten pulpwood of spruce are part of the assortment, which is handled. The raw material is revised in the lines of the establishment and the finished fuel is mixed and stored depending on the buyer's demands

In order to reduce the transport costs, a very minute deliverance plan is made between delivering sawmills, stocks and the customer.

Forest residues do not pass the terminal, but is delivered directly to customers according to method 1 or 2. According to the ownership, forest residues are mostly taken from fellings on private owned forests. This implies smaller felling sites in average. They are also depending on several small forest owners different ways of administrating their forest, which is complicating the planning for the bioenergy company. On the other hand, this company is acting purely commercial, and only trying to satisfy the demand with as good profit as possible.

Key factors for implementation of "Stock office"

Demand and supply is the two major conditions for the design of a stock office.

Demand

When doing the initial market survey, the important issues are the annually requested amounts in the area where the stock office is supposed to operate, and the quality each potential customer is requesting.
It shall also be included in the survey approximately which price each customer are ready to pay for the quality they are requesting, if they are prepared to pay a higher price for a better quality and if they are prepared to buy a lower quality to a lower price.

But there are also other conditions that are of interest, such as:

- the distribution over the year (how big is the demand winter- respectively summertime?)
- The maximum demand (maximal day, week and month)

A question is whether the stock office shall have the responsibility to have the capacity to deliver the max demand or if the customer shall have a storage. If the stock office take that responsibility they must have access to a transport system that are able to fulfil the maximal demand deliveries, which can be expensive because it means that the capacity is unnecessarily big most of the time.

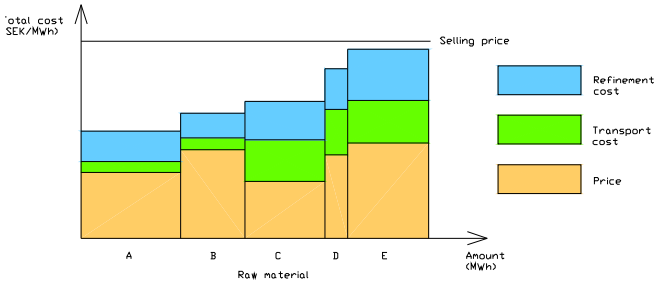
The distance to the customers must be investigated, as well as the possibilities to return freights.

Supply

Parallel to the demand, the supply must be investigated. Important properties for each raw material are:

- Amount (how much is available at which time)
- quality (is it good enough for the customer or is there need for refinement)
- Price
- Location (distance to customer or refining site)
- Refinement cost (estimation of the cost for refining up to requested quality)

The raw materials can be ranked in the order they shall be taken into account., as in the figure below.



By this way, it is possible to see how big amounts that can be traded by the stock office, until the cost reaches the level the customers pay for the fuel. By multiplying the amount of each fuel with the difference between the cost and the selling price, the profitability for each fuel is gained. The total income for the stock office is calculated by adding the different fuels to each other.

Design

By comparing the supply and the demand, it is possible to see the demand for refinement of the fuel. The result can be anything between no refinement at all and refinement into pellets (if not taking ethanol or gasification into account). If there is a demand for refinement, the capacity shall be calculated. Examples of refining activities are:

- Crushing or shipping
- Tearing (bark)
- Removal of pollution (ex. sand and stones)
- Mixing
- Drying
- Compacting (pelletising/ briquetting)

Depending on the capacity, but also the geographical distribution of both the raw material and the customers, the refinement equipment can be either mobile or non mobile. Non mobile machinery gives normally lower costs and can be driven by electricity instead of diesel.

A chipper gives commonly better size distribution of the fuel than crushing (i.e.less fines), but is much more sensitive for sand and stones in the material.

Organisation

The ownership of a stock office can be either from the suppliers side, a free standing company or from the buyers side. The most common way in Sweden is that it is forest owners, saw mills etc. (like the two companies describes earlier) who take the initiative to create a value of their residues. If there is a demand for more fuel than these can supply, free standing companies commonly fill up. They do not have access to any own raw material, but are therefore more active in finding other sources for raw material. Finally, if the consumers of fuel still don´t get the volumes they are demanding, they have to take the responsibility themselves for producing fuel. It can also be a way to have impact of the price level. An example of a district heating company which produces fuel for themself is "ENA Energi" in the town of Enköping. They are renting agricultural land for growing short rotation coppice in large scale.

References

Lönner et al, 1998, *"Kostnader och tillgänglighet för trädbränslen på medellång sikt"*.The Swedish University of Agricultural Sciences, Department of Forest-Industry-Market Studies, Report No 51.

ENA Energi, http:/ / www.enae.se

Appendix

© Bioenergy		Type of fuel/energycarrier			Turnover fuel (million SEK)				
	COMPANY	Wood	Peat	Refined	Small-scale DH (MSEK)	External delivery	Own consumption	Total turnover	REGION
1	Råsjö Torv (7)	FR,WC,B,RW	P	FB,FP	1,8	592	–	593,8	G,S,N
2	SCA Skog, Norrbränsle (1)	FR,WC,B,RW	P	FB,FP	–	486	–	486	S,N
3	Arizona Chemical (4)	–		Pine-oil	–	450	–	450	I
4	Naturbränsle (3)	FR,WC,B			–	423	–	423	S,N
5	SBE Brikettenergi (6)			FB,FP,WP	62	341	16	419	G,S
6	Sydved Energileveranser (2)	FR,WC,B,RW			–	413	–	413	G,S,N
7	Södra Skogsenergi (8)	FR,WC,B	P	FP.FB	1	290	–	291	G
8	Tall Oil (9)	FR		FP,Pine-oil	–	250	–	250	G,S,N
9	Sveaskog (10)	FR,WC,B,RW			–	180	–	180	S,N
10	SÅTAB (15)	FR,WC,B			–	140	–	140	S,N
11	Skellefteå kraft (12)	–	P	FP	30	105	–	135	S,N
12	Härjedalens miljöbränsle (13)				B	130	2,5	132,5	
13	Stora Enso (14)	WC,FR,B			–	100	25	125	S
14	Vänerbränsle (17)	WC,FR,B		FB	–	113	–	113	S,I
15	Vida Energi (5)	WC,FR,B, FW		FB,FP	–	107	–	107	G
16	Econova Energy	WC,B,RW			–	104	–	104	G,S
17	Sävsjö Trädbränsle	–		FB,FP,WP	–	79	–	79	G
18	BooForssjö	FR,WC,B		FP	–	60	17	77	G,S
19	Norra Skogsägarna	FR,B			–	75	–	75	N
20	Statoil Pellets	–		FP	–	73	–	73	G,S
20	Bioenergi i Luleå	–		FP	–	73	–	73	N
21	Derome Bioenrgi AB	FR,WC,B,RW		FB	–	60	13	73	G
22	Graninge Kraft & Värme	WC		WP	–	35	33	68	G
23	Agro Oil	–		FP	–	65	–	65	G,S,N
24	REBIO	FR,B,RW	P	FB	–	62	–	62	I
25	Palmtrans	WCB,FW			–	62	–	62	G,S,I
26	Mellanskog Bränsle	FR,B,WC			–	55	–	55	G,S,N
27	Linköpings skogstjänst	FR,WC,RW,FW		FB,FP	–	46	–	46	G
28	Wisswood	–			–	45	–	45	G
29	Agrobränsle	WC,FR			–	33	–	33	G,S,I
30	MBAB Energi	–		FB,FP	–	29	–	29	N
31	Fulghum Fibre Fuels	–		FP	–	25	–	25	I
32	Martinssons Trä	FR,WC,B			–	12	7	19	N
33	Gotlands Flis	B,FR			9	8	1	18	G
34	Gällivare Värmeverk	–	P		–		13	13	N
35	C F Berg & Co	WC,B,FR		FB		12		12	G
36	Moelven Notnäs	B			–	10	–	10	S
37	Cogab	RW,B			–	10	–	10	G
38	Laxå Pellets	–		FP	–	9	–	9	
39	Balungstrands Sågverk	B			–	5	3	8	S
40	Lida Timber	B		FB	–	4	1	5	G
41	Dalsjö Energi	–		FB	–	3	–	3	G
							Total:	**5409,3**	**MSEK**

Defenitions

Wood: WC=wood chips, B= bark & sawdust, FR= forrest residues, RW= recycled HW=hog fuel & FW= fire wood

Peat = P

Refined fuel: FP=fuel pellets, FB=fuel briquettes & WP= wood powder

Region;
N=Norrland
S=Svealand
G=Götaland