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The Swedish market for wood briquettes – Production and market development

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Johan Karlhager

Linköping, February 2008

Abstract

Wood briquettes have constituted an important input to the Swedish energy system during the last two decades. However, the development of the production and markets for briquettes during the years 2000-2007 has not been studied in detail. The purpose of this study was to elucidate the state of the briquette industry. More specifically, the aims were to map the production of briquettes, describe the development of its markets, describe the production process, describe the producers and to examine the competitive situation for the producers. To collect data regarding the production and the producers, the markets, raw materials and company structures, a questionnaire was sent out to the producers during the fall in the year 2007. The results were then compiled and compared to previous studies. The description of the production process was mainly based on literature studies. The results were analyzed and related to M.E. Porter's *Five force model* to be able to describe the competitive environment for the briquette producers. The study was limited to production in Sweden and did not intend to cover a possible import of briquettes. Regarding the production process, the most common types of briquetting equipments were described. The results showed that the trend in the briquette industry was neutral, possibly negative. The turnover derived from briquette sales during the year 2006 was roughly a quarter of a billion SEK. The industry was very concentrated, with one producer accounting for 43 % of the aggregate production in the year 2006. Since the year 2000, the production of briquettes among the participating producers increased from some 210 000 tons[1] (980 GWh) (Hirsmark, 2002) to some 280 000 tons (1 300 GWh) in the year 2006. The planned expansion of the production capacity was 3,8 % within the two years to come. A typical small scale briquette producer was a small saw mill, planing mill or a joinery using their by-products as raw material. 78 % of the briquettes are produced from purchased raw material. Planer shavings and saw dust were the raw materials used by the largest number of producers. Peat was another important raw material, used only in large-scale production. Pellet producers were considered being the most important raw material competitor and an analysis showed that pellets constituted a severe threat to the briquette industry as they were important substitute products to briquettes. The analysis also showed that the briquette buyers have a strong bargaining power in their negotiations with the producers.

Key words: briquettes, bio energy, densified biomass fuels, bio fuel

[1] Metric tons, all through paper

Sammanfattning

Träbriketter har under de senaste två decennierna varit en viktig tillförsel till det Svenska energisystemet. Mellan år 2000-2007 har dock bilden av utvecklingen för produktionen och marknaderna för briketter varit osäker. Syftet med den här studien var att klargöra läget för brikettbranschen. Mer specifikt var målen att kartlägga produktionen av briketter, beskriva marknadsutvecklingen, beskriva produktionsprocessen, beskriva brikettproducenterna och att undersöka konkurrenssituationen för producenterna. För att samla in data om produktionen och producenterna, marknaderna, råvara och företagsstrukturer skickades en enkät ut till producenterna. Resultaten sammanställdes sedan och jämfördes med tidigare studier. Litteraturstudier låg dock till grund för beskrivningen av tillverkningsprocessen. Resultaten analyserades sedan med hjälp av M.E. Porters *Five Force Model* för att kunna beskriva konkurrenssituationen i brikettbranschen. Studien var begränsad till att gälla brikettproduktion i Sverige och avsåg inte att täcka en eventuell import av briketter. När det gäller tillverkningsprocessen beskrevs enbart de vanligaste typerna av briketteringsutrustning. Resultaten visade att brikettindustrin hade en neutral trend, möjligen negativ. Omsättningen från brikettförsäljningen under 2006 var ungefär en kvarts miljard SEK. Branschen var mycket koncentrerad då en tillverkare stod för 43 % av produktionen 2006. Sedan år 2000 ökade brikettillverkningen bland de deltagande producenterna från ca 210 000 ton (980 GWh) (Hirsmark, 2002) till ca 280 000 ton (1 300 GWh) år 2006. Den planerade kapacitetsökningen inom de två kommande åren var 3,8 %. Den typiska småskaliga brikettproducenten var ett mindre sågverk, hyvleri eller snickeri som använde sina biprodukter som råvara. I volym räknat dominerade köpt råvara, medan hyvelspån och sågspån var de vanligaste råvarorna sett till antalet producenter. Torv var en annan viktig råvara, enbart använd i storskalig produktion. Pellettillverkare ansågs vara de viktigaste råvarukonkurrenterna och en analys visade att pellets utgjorde ett svårt hot mot brikettindustrin eftersom de var ett viktigt substitut till briketter. Analysen visade också att köparna av briketter sitter i en stark förhandlingsposition gentemot producenterna.

Nyckelord: briketter, bioenergi, biobränsle

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1. Introduction

During the last few years, the climate change issue has received much attention in media and in the public debate. Politicians and researchers are trying to find ways to cope with the development of the greenhouse effect. There are many different suggestions of how to change the trend, but most people agree that we have to increase the share of renewable energy sources and use less fossil fuel. An increased use of bio energy is considered being a part of a whole battery of solutions. Living plants capture the solar energy and store it in carbohydrates which can be used for energy production. Plants are neutral with respect to CO_2 emissions; the amount of CO_2 released in combustion of a plant equals the amount of CO_2 captured by a plant when it grows. Although a contribution of CO_2 comes from management, harvesting, transport and densification of bio fuels, the net emissions from most bio energy systems are still much lower than from fossil fuels. Turning biological material, preferably wood material, into briquettes or pellets is one way of making bio fuels more attractive for various energy users. For most purposes, it creates a fuel that is easier to handle than unprocessed wood, and transportation becomes more efficient as the amount of water and air unnecessarily transported is reduced. Wood briquettes and wood pellets are the two types of fuels included in *densified biomass fuels* (DBF:s). Briquettes and pellets are made denser than the raw material, often by some kind of mechanical pressure.

Briquettes have been produced in Sweden since the 1980's, but since the year 2001, no public studies have been carried out regarding the production of wood briquettes in Sweden. Many factors concerning the markets for briquettes have changed and it is hard to find information about e.g. briquette production levels, market development and production technology. Depending on whom you ask about the development of briquette production, you will obtain answers varying greatly. Thus there is a need for examining the Swedish briquette market, and this thesis aims at covering a relatively wide perspective of briquette related issues; from raw material and production process to market development and production levels.

The latest survey of the production of briquettes was made by Hirsmark the year 2001 (Hirsmark 2002). In that study, the production had experienced a negative trend from the year 1995 to 2000. The number of respondents in that survey was low; hence the accuracy of the briquette production mapping was likely to be low. The intention of the present study is to cover the whole range of producers; from small scale to industrial scale.

Knowledge of the briquette market is important in a number of ways. The potential and current users of the product need to be able to judge the development in supply of briquettes. Politicians and other decision makers need a clear picture of the development of energy use in both small-scale, middle-scale and large-scale combustion facilities. Bio energy is a wide and growing field, with an increasing economic significance. The market for bio energy has grown dramatically during the last ten years. The increased concern for climate changes has led to several political initiatives to increase the use of renewable energy, both nationally and globally. In Sweden, tax advantages have stimulated the use of bio energy since the early 1990's. The growth of district heating based on bio energy has increased dramatically during the last few years and large expansions in the sector are being planned and implemented (Swedish Energy Agency, Energy in Sweden 2007, 2007). Hence, there are many political factors that should favor the use of briquettes in Sweden. But does the development in briquette production follow the positive trends in bio energy use in general?

The aim of this study was to show how the briquette production and the market for briquettes are developing and in what way briquettes are being produced in Sweden. This has been achieved through a literature study of production technology, a mapping of the producers and a questionnaire survey that was sent out to the producers. The results are then presented and compared to previous studies in the field.

2. Purpose and scope

2.1 Purpose

The main purposes of this study are to map the Swedish production of briquettes and to examine the development of its markets and customer segments.

Another purpose is to describe how the briquette production process is designed and used in Sweden.

Yet another purpose is to describe the structure of the companies producing briquettes with respect to company type, size, turnover and technology.

Finally, this study describes the competitive conditions for briquettes. Taxes, incentives and political trends will be described briefly.

2.2 Scope

The scope of this study is limited to describing the production volumes of, and technologies and markets for, briquette production in Sweden. Imports of bio fuels to Sweden are commented, but there will be no attempts to map the import flow of briquettes.

Briquette consumption is not emphasized in this study.

The description of the briquette production process is limited to the most common types of briquette production processes used in Sweden. It does not cover all the types of technology available for briquette production. The most common types of equipment are described more thoroughly.

The study does not include any calculations of the potential availability of raw materials for briquette production.

3. Background

In this chapter, an overview of the Swedish energy market is presented. Then, the briquette production and combustion process are described. Finally, an overview of the previous research in the field is presented.

3.1 History of densified biomass fuels

Briquette production is not a new phenomenon, neither in Sweden nor in the world. The first patent of equipment for densified wood products dates back to 1864 and was issued in the United States (written by Halsted & Halsted, 1864, cited by Vinterbäck, 2000). In Sweden, a fully mechanized method for production of briquettes from sawdust and shavings was developed by Heidenstamm. This method was first mentioned in the beginning of the 1920's (Anon, 1901, cited by Vinterbäck, 2000) and used in some Swedish sawmills (Vinterbäck, 2000). The first method for production of binderless briquettes was developed by researchers in European countries (Natividad, 1982, cited by Vinterbäck, 2000). Development of different kinds of briquetting equipment was carried out in several countries around the world during the first half of the 20:th century, e.g. Germany, the United States and Japan (Vinterbäck, 2000). Fuel shortages during World War I and World War II increased the demand for briquettes produced from saw dust and other wood processing residues. After World War II, wood briquettes were driven out of business because of low prices of fossil fuels (Eriksson & Prior, 1990). From the 1960's until the early 1980's, no or a very small production of briquettes was carried out in Sweden due to low oil prices. In the beginning of the 1980's the first expansion of the production took place, but the production decreased in 1986 because of price drop in the oil markets. Hence, the price of oil has been a crucial factor in the competitiveness of bio fuels.

Pellet is another type of densified biomass fuels. They have a smaller diameter and are more adapted to small scale use. The pellets industry has had its ups and downs too. During the 1980's, the investors in the Swedish wood pellet industry overestimated the future demand for pellets. One reason for the unexpectedly low demand was that the burning appliances for residential heating were not good enough yet. They were functioning, but caused problems and needed much attendance. The producers of briquettes did not face the same problem as the combustion took place in conventional combustion equipment converted for burning of bio fuels (Westholm, 1986)

An important company in the Swedish development of briquettes production was Svensk Brikettenergi, SBE. The company was initiated by a company that worked with development of briquette production equipment. With financial help from the company Kinnarp International, SBE was founded in the beginning of the 1980's. SBE leased out their factories to local companies who paid a percentage fee for every ton of briquettes produced (Westholm 1986). The heating season 1986/1987, SBE produced 60 000-70 000 tons which corresponded to 90 % of the Swedish market at that time (Vinterbäck, 2000). Today, most briquette- and pellet production plants previously owned by SBE are run by a Swedish farmers' association, Lantmännen. Another important company is HMAB, which has an annual production capacity of 300 000 tons of briquettes. HMAB initiated its briquette production in 1989 and delivered bio energy to a municipal district heating plant in Uppsala. Today, the plant is owned by the state-owned energy producing company Vattenfall. HMAB is today under a private ownership and the company also produces pellets. The briquettes from HMAB are of a mixed type, produced from a combination of peat and wood materials.

3.2 The Swedish energy market

The Swedish energy policy has played an important role for the investments in bio energy. This chapter briefly introduces the current energy use, means of control for energy use and current trends in energy consumption. Nationally and internationally, political forces are working towards a reduction in the emissions of CO_2. In Europe, the European Commission agreed in March 2007 to reduce the CO_2- emissions by 20 % until the year 2020 compared to the year 1990, increase the share of renewable energy to 20 % until the year 2020 and to decrease the energy consumption by 20 % over the same period (www, European Union, 2007). In Sweden, the government is working in various ways to reduce the anthropogenic climate influence. An example of this is that since the year 1992, bio energy is not subject to CO_2-tax and energy tax whereas fossil fuels used in district heating is subject to these taxes. The various European and Swedish initiatives contribute to an increased interest for renewable energy sources. In the following section, the energy situation in Sweden is described briefly.

3.2.1 Means of control

The Swedish government uses a number of ways to control and influence the energy use and energy market. Four types of means of control is used in Sweden; *administrative means of control* (e.g. laws and emission limits), *economic means of control* (e.g. taxes, subsidies and trade of emission allowances), *information* and *research* (Swedish Energy Agency, Energy in Sweden 2006, 2006). Initially, the purpose of the energy taxes was to contribute to the financing of the public sector, i.e. fiscal taxes, but in later years the purpose has shifted towards desired environmental- and energy goals. The present set of energy taxes primarily has the goals listed below:

- Create good conditions for domestic power production.
- Create driving forces for decreased environmental impact.
- Contribute to a more efficient energy use.
- Favor the use of bio fuels

The energy taxes are the most extensive tools for influence on the energy use. The general energy tax and the carbon dioxide tax are the two most important taxes in this context. The general energy tax is connected to most types of energy except bio fuel and peat. The carbon dioxide tax is paid in proportion to the amount of carbon dioxide emitted by the fuel. All fuels but bio fuel and peat are connected to the carbon dioxide tax.

Energy- and carbon dioxide taxes are not paid in power production. Instead, both taxes are paid by the consumers. In heat production the situation is the opposite since energy- and carbon dioxide taxes are paid in production but not in consumption.

Bio fuels are fully exempted from energy tax, carbon dioxide tax and sulphur tax. Peat is exempted from energy tax, carbon dioxide tax but not from sulphur tax. Hence, bio fuels and peat have powerful competitive advantages in the heating sector compared to many other fuels. The only tax that is connected to bio fuels and peat is VAT (at present 25%). VAT is not paid by industry customers. The fact that bio fuels are exempted from these taxes is an important factor in the domestic competitive environment for briquettes.

The introduction of electricity certificates in May 2003 was intended to support the growth of production of power based on renewable sources. Producers of renewable energy are given a certificate for every MWh of power produced. These certificates can then be sold to electricity users. All electricity users except energy intensive industries are forced to buy certificates corresponding to a certain share of their electricity use. (Swedish Energy Agency, Energy in Sweden 2006, 2006). Power producers using renewable sources can earn money by selling certificates to producers in need of filling their certificate quota.

3.2.2 Energy use in Sweden

An important driving force for the energy development is the greenhouse gas emission trend. Between 1990 and 2003, the emissions of CO_2-equivalents from the Swedish energy system has been relatively unchanged, see Figure 3.1. Since 2003, the emissions of CO_2-equivalents have had a negative trend. The increasing use of heat-pumps, biomass fuels and district heating has contributed to this positive development.

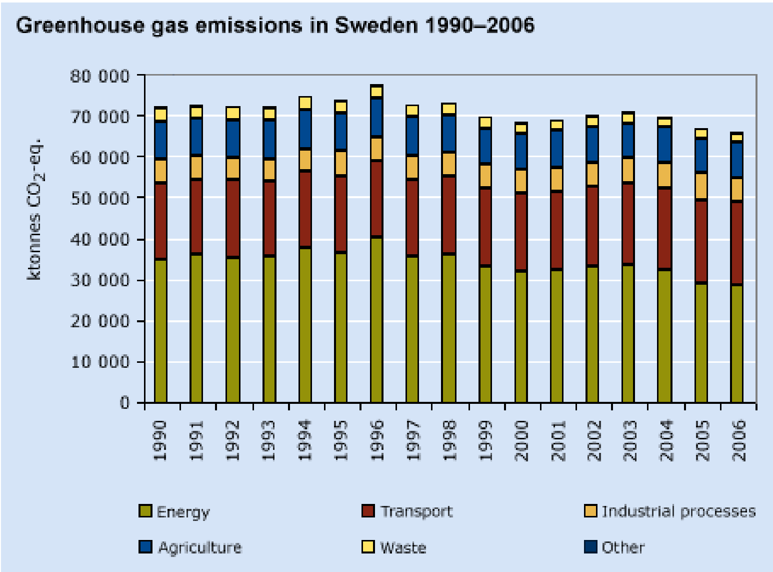

Figure 3.1. CO_2-eqivalents emissions in Sweden 1990-2006 (www, Swedish Environmental Protection Agency, 2007).

The prices of other energy forms are important as they determine the competitive strength of briquettes. Figure 3.2 illustrates the vast differences in price between various energy forms and the effects of taxes and VAT.

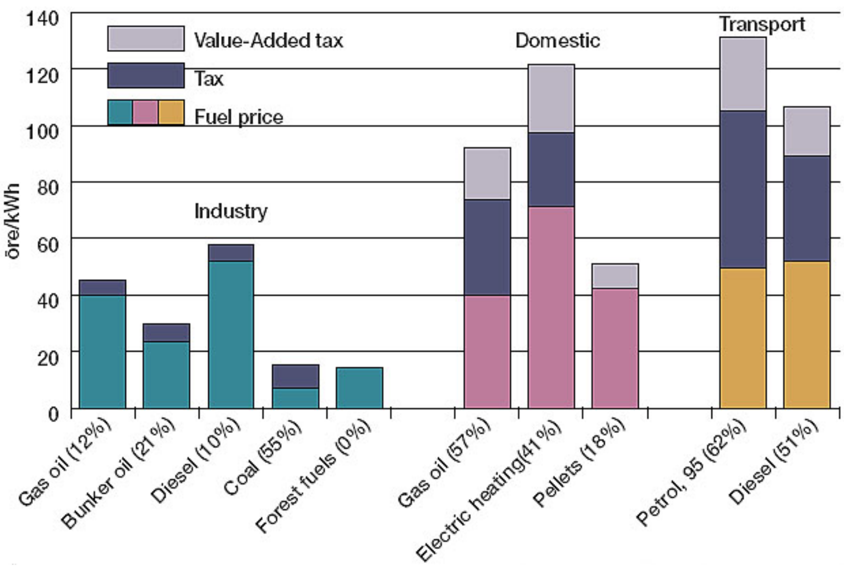

Figure 3.2. End-user prices of fuels for three different customer categories in the year 2006, öre[2]/kWh. The percentage figures represent the total share of taxes for each fuel (Swedish Energy Agency, Energy in Sweden 2007).

Figure 3.3 shows a comparison of the price developments for briquettes/pellets and chipped forest fuels for industrial scale customers during the years 1995 to 2007. The prices for briquettes and pellets are higher than the prices for coal and chipped forest fuels but significantly lower than the prices for gas oil, bunker oil and diesel shown in figure 3.2. (Note that Figure 3.2 and Figure 3.3 have different units).

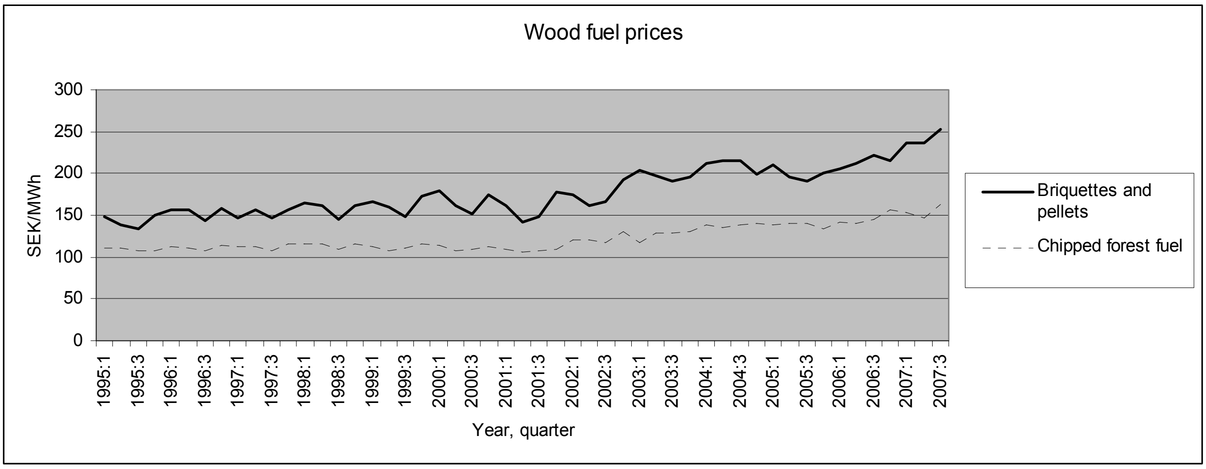

Figure 3.3. Price development for briquettes/pellets and chipped forest fuels for industrial scale customers during the years 1995-2007 (Swedish Energy Agency, 2007, Prisblad biobränslen 1995-2007). The prices are not subject to taxes, and VAT is not paid as long as the fuel is used by industrial customers.

The use of bio fuels in district heating has increased rapidly during the last 20 years (see Figure 3.4). Since the beginning of the 1990's, bio fuels dominate the fuel input to district heating. This development continues through large investments in district heating facilities in Sweden (Swedish Energy Agency, Energy in Sweden 2006, 2006). The bio fuel share of the district heating market is the main market for briquettes. This is where the largest potential for expansion of the briquette consumption is. The aggregate consumption of raw material for district heating was 60 TWh in the year 2004 (www, Svensk Fjärrvärme, 2005). The share of

[2] *Öre* equals cents of SEK

briquettes in the bio fuel category is likely to be low (in the range of 3-4 % in the year 2000) as the production of briquettes in the year 2000 was below 1 TWh (Hirsmark 2002).

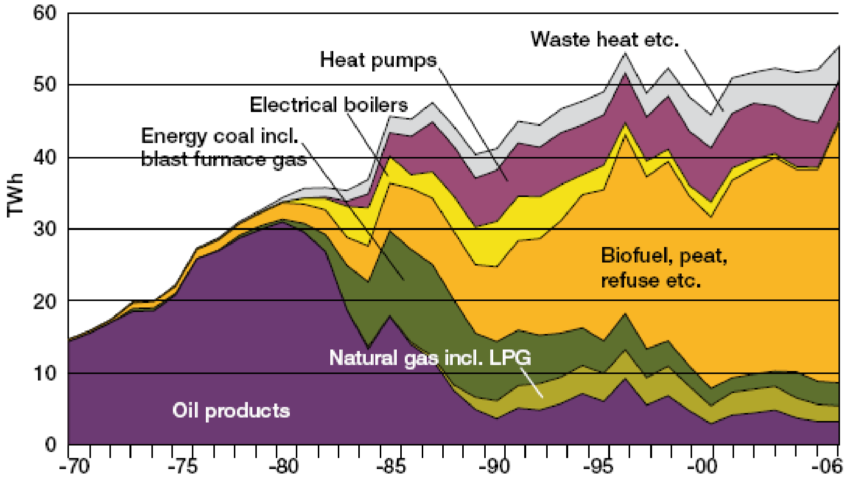

Figure 3.4. Energy input to district heating during the years 1970-2006 (Swedish Energy Agency, Energy in Sweden 2007, 2007).

The composition of the bio fuel input to the district heating system has changed during its development and growth, see Figure 3.5. In the early eighties, waste (in Figure 3.5 denoted refuse) was an important input. The share of waste then decreased, but is again becoming an increasingly important fuel. Wood fuel has been the dominating fuel since the beginning of the 1990´s and is presently the major input to the district heating system, still gaining in share.

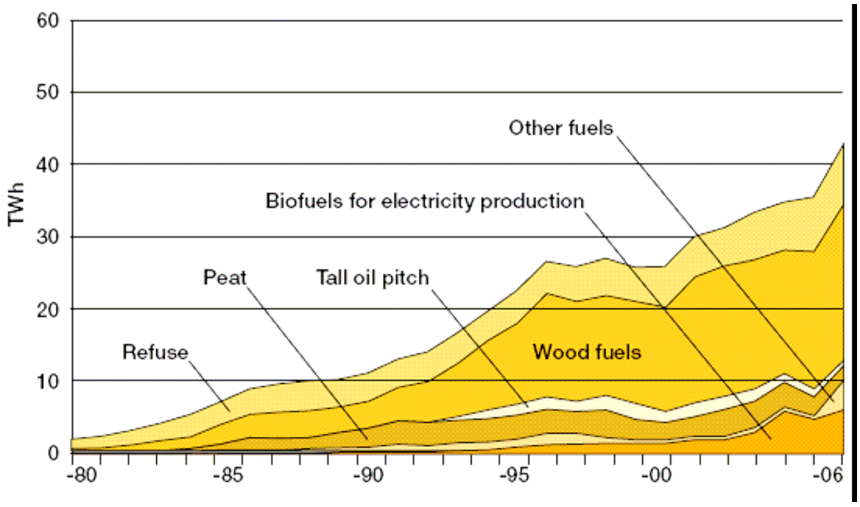

Figure 3.5. Use of bio fuels, peat etc. for district heating during the years 1980–2006 (Swedish Energy Agency, Energy in Sweden 2007).

3.3 Characteristics of the briquette

The main purpose of briquetting a raw material is to reduce the volume and thereby increase the energy density. When densification has taken place, there are two quality aspects that need to be considered. Firstly, the briquette has to remain solid until it has served its purpose (handling characteristics). Secondly, the briquette has to perform well as a fuel (fuel characteristics). The energy characteristics are other important issues when describing and comparing briquettes with other fuels. These characteristics will be described in more detail later in this chapter.

3.3.1 What is a briquette?

Briquettes are densified biomass fuels used for heating in different systems. As shown in Table 3.1, briquettes are significantly larger than pellets. There are a few different definitions of a briquette, but the one used in this study is as follows; *"A Wood briquette is a mass of ground fuel stuff moulded or pressed into a convenient unit with or without the aid of a binder"* (written by Natividad, 1982 cited by Vinterbäck, 2000).

Swedish Standards Institute (SIS) offers standards for solid bio fuels. Table 3.1 shows the size- and proportion requirements for briquettes and pellets according to the standards SS 18 71 23 and SS 18 71 20. The briquettes are divided into three groups, each representing a bundle of specific quality with unique characteristics. The table also shows the standardization requirements for pellets as a comparison.

Table 3.1. The physical characteristics of fuel pellets and briquettes according to the Swedish standards SIS SS 18 71 23 and SIS SS 18 71 20, respectively

Parameter	Standard	Unit	Group 1	Group 2	Group 3
Briquettes					
Diameter[1]		mm	min. 25	min. 25	min 25
Length[1]		mm	>1/2Ø but max. 300	min 10 and max 100	Indicates
Bulk density	SS 18 71 78	kg/m³	≥550	≥450	≥450
Mechanical strength/fines	SS18 71 80	% < 15 mm	≤ 8	≤ 10	≤ 10
Pellets					
Diameter[1]		mm	Indicates	Indicates	Indicates
Length[1]		mm	max. 4 x Ø	max 5 x Ø	max 5 x Ø
Bulk density	SS 18 71 78	kg/m³	≥600	≥500	≥500
Mechanical Strength/fines	SS 18 71 80	% < 3mm	≤ 0.8	≤ 1.5	≤ 1.5

[1] Measurement of 10 briquettes or pellets.

Affiliation to a standard brings several advantages for a producer of briquettes. The buyer of a product can be certain that the product holds the desired characteristics. If the combustion facility or the feeding system for the combustion facility requires particular sizes or shapes of the fuel, the user can choose to buy from a producer that guarantees the characteristics given in the standard. A study in Germany showed examples of benefits derived from standardization of a product. Competitive advantages, possibilities to influence the standardization process and its demands and better relations with business partners were some of the advantages (DIN German institute for Standardization, 2000).

3.3.2 Raw materials

Hirsmark (2002) thoroughly described the raw material base for the production of briquettes. There are a number of materials that can be used for briquette production. Wood residues as saw dust, wood chips, planer shavings, recycled wood and pure wood can all be used after milling. Agricultural residues as straw, hemp or reed canary grass can be used. Short rotation coppice, e.g. Salix can also be used in briquetting processes. Peat is another raw material suitable for briquetting (Hirsmark 2002). There is no data of which raw material is the most important to briquette production. Hirsmark showed that saw dust and planer shavings are the two most common raw materials for pellet- and briquette production though.

3.3.3 Energy characteristics and environmental impact

An interesting and important aspect of energy characteristics is to compare the fuel with fossil fuels in terms of CO_2-eqivalents. Peterson Raymer carried out study of this in Norway (Peterson Raymer, 2005).

In table 3.2, CO_2-equivalents released from briquettes over a life cycle are presented. The briquettes in this particular case are produced in Norway in a plant using saw dust as raw material. The main sources of CO_2-equivalents released are from electricity use in the saw mill and from the combustion of the briquettes. The conditions for the drying and combustion process influence the emissions. For example, hydro power produced electricity used in the saw mill results in lower emissions of CO_2 over the life cycle of a briquette.

Petersen Raymer concludes that with a life cycle perspective, the emissions of green house gases from briquettes, pellets, bark or sawdust are only 5-6 % of the emissions released from a comparable amount of oil. Using 1 GWh of briquettes instead of oil reduces the amount of CO_2-equivalents released with 292 tons - the corresponding amount for pellets is 291 tons. The figures are practically the same as the raw material, the production technology and logistics are similar.

Table 3.2. Energy consumption and green house gas emissions over the life cycle of 1 ton of briquettes (Petersen Raymer, 2005)

	Energy (kWh)			CO_2 (kg)	CH_4 (kg)	N_2O (kg)	CO_2-equivalents (kg)
	Electricity	Fossil fuels	Bio-energy				
Production of sawdust	86	112	0	27.810	0.000	0.004	29
Transport	0	0	0	0.000	0.000	0.000	0
Drying	0	0	68	0.000	0.073	0.000	1
Production	253	0	0	0.000	0.000	0.000	0
Transport to consumer	0	10	0	2.295	0.000	0.000	2
Combustion	0	0	0	0.000	0.300	0.070	22
Sum	340	123	68	30.105	0.373	0.074	54

Arvidsson (1997) conducted a life cycle assessment (LCA) of briquettes, pellets and powder. The study was a case study of the production at the Swedish company Svensk Brikettenergi (SBE). The data from the analysis did not separate pellets, and powder from briquettes; hence the result reflects an average of the three products. Figure 3.6 shows the emission of six important compounds released during the life cycle of 1 MWh of a densified biomass fuel

(DBF). The life cycle includes the following stages: raw material and its transport from the forest to production plant, fuel for drying (including transport), combustion of fuel for drying, power consumption, fuel for loading of trucks, lubrication oil, binding agent additives, test products and waste (Arvidsson 1997).

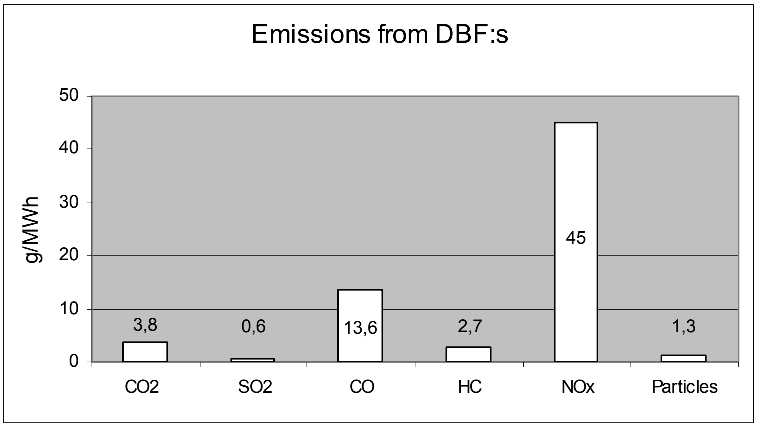

Figure 3.6. Various compounds released during the life cycle of 1 MWh of DBF:s, unit in grams (modified from Arvidsson, 1997).

The result of the energy analysis shows that for production of 1 MWh of DBF:s, the amount of energy needed for production is 1,163 MWh (Arvidsson, 1997). The figures may vary depending on a number of factors, e.g. location of production facility, transport distance of raw material, efficiency in drying process, production equipment and efficiency in logistics. But under the conditions prevailing at SBE at that time, the efficiency ratio was as presented above. Thus, the energy needed for production of briquettes is low and an efficient way of refining the wood material.

3.3.4 Handling characteristics

Handling characteristics are important when considering ways of storing, transporting and handling briquettes. These are mainly determined by shape, density and raw material. The density of a briquette can theoretically reach 1500 kg/m^3, but normally the maximum density of commercial goods stay in the range of 1200-1400 kg/m^3. Mechanical piston presses can generally produce briquettes with a higher density than hydraulic piston presses. Increasing the density of briquettes is likely to be fruitless, as this probably would worsen the combustion characteristics. The geometry of the briquette makes the solid density differ significantly from the bulk density due to air filled space between the briquettes (Eriksson & Prior, 1990). When storing briquettes, the air filled spaces between them reduce the energy density, the bulk density is normally 550-660 kg/m^3 (Swedish Wood Fuel Association, Faktablad Briketter 2007).

Briquettes are sensitive to handling and transport. Depending on production method and raw material, the friability (resistance to mechanical action) will vary. Observations at production plants have showed that the friability is satisfactory in plants using mechanical piston presses, whereas plants using hydraulic piston presses have experienced friability problems (Eriksson & Prior, 1990). This is contradicted by personal communications during this study. According to Peter Franklin at Lantmännen Agroenergi, the briquettes from mechanical production processes easily disintegrate when transported, resulting in dust fall-off and difficulties in possible further transportation (pers. com., Peter Franklin, 2007-06-26). Figure 3.7 shows the difference between newly produced briquettes (left) and transported briquettes (right). The briquettes have been loaded, transported by truck about 150 km and then unloaded.

Figure 3.7. Briquettes before (left) and after (right) transport by truck (photo Johan Karlhager).

The handling characteristics are not only determined by shape, density and raw material. The type of briquette press used in the production also influences the result. Hydraulic presses were developed for use in small scale production and produce a softer, more sensitive briquette. Briquettes from mechanical piston presses are generally harder. On the other hand, mechanical piston presses are more sensitive to foreign particles such as nails or screws. A nail in the raw material would likely destroy parts of the equipment, whereas a hydraulic piston press probably would be unharmed by a nail (Eriksson & Prior, 1990).

Another important aspect of the handling characteristics is the briquettes´ resistance to humidity. Briquettes have a limited lifetime under humid conditions. The reason for this is the water solubility of the inherent binding agent in the briquette, lignin (Eriksson & Prior, 1990).

3.3.5 Fuel characteristics

The energy characteristics describe how the briquette act and what it produce when being burned. The calorific value of briquettes is an important measure of the amount of energy released from every kg when burned. Briquettes are normally priced by weight, but still, the calorific value is the most important factor in determining the competitiveness of the fuel. (Eriksson & Prior, 1990). The calorific value varies with ash- and moisture content, see Figure 3.8. The figure shows that different ash- and moisture contents in briquettes result in different calorific values. Normally, the ash content of wood briquettes is about 0,7 %. The resulting calorific value is 17-18 MJ/kg as the normal moisture content in Swedish production is about 10 % (Swedish Wood Fuel Association, Faktablad Briketter, 2007)

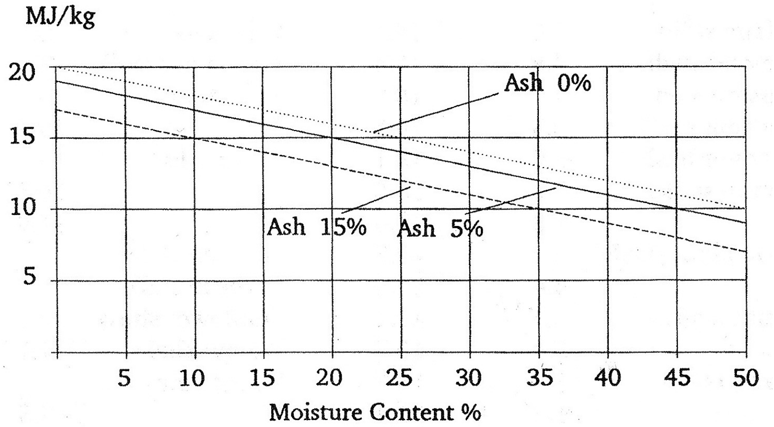

Figure 3.8. Connection between calorific value and moisture content at different ash contents (Eriksson & Prior, 1990).

The energy content in briquettes, pellets and wood chips are compared in table 3.3 below. In this report, values converted from tons to GWh are calculated with the weight / energy content relation of 4,7 MWh/ton stated in Faktablad Briketter (Swedish Wood Fuel Association, 2007).

Table 3.3. Fuel characteristics for wood briquettes, pellets and wood chips (Swedish Wood Fuel Association, Faktablad Briketter, Faktablad Pellets, Faktablad Flis, 2007)

Fuel	Moisture content approximations, %	Energy content, MWh/ton	Density, kg/m3
Briquettes	10 %	4,7	550–650
Pellets	10 %	4,8	600–700
Wood chips	30-50 %	2,25–2,35	250–350

Briquettes do not take up a great deal of space. Densified biomass fuels are efficient in storing, although coal and oil require even less space, see table 3.4.

Table 3.4. Volumes of different fuels needed to replace 1 m^3 of fuel oil (www, Novator, 2007)

Fuel	Volume (m^3)
Fuel oil 1	1
Coal	2,2
Wood pellets	3,4
Wood briquettes	3,5
Straw briquettes	3,9
Wood powder	8,5
Peat, 35% moisture content (peat in pieces)	8,5
Forest fuel, < 35% moisture content	10
Peat, 50% moisture content (milling peat)	10,8
Forest fuel, 50% moisture content	13
Bark, > 50% moisture content	20

3.4 The briquette production and combustion process

The following section is based primarily on the work of Eriksson & Prior 1990. The production process is divided into five steps; drying, comminuting, conditioning, densification and cooling.

3.4.1 Drying

Depending on what raw material is being used in the production, a need for drying may occur. A raw material that has been dried in an earlier production stage (e.g. planer shavings or indoor joinery waste) normally does not need to be dried. The raw material needs to be in a suitable moisture content range during the densification. A moisture content of 8-12 % is normally ideal for wood densification. The maximum allowed moisture content in mechanical piston presses is 15 %, whereas hydraulic systems can handle moisture contents up to 15-30 %, depending on design and manufacturer. If the moisture content is too high, the surface is likely to crack when the briquette leaves the die. There is also a risk that the high water content results in a steam explosion when the pressure and temperature rises in the densification process (Eriksson & Prior, 1990). Moisture contents below 8 % can result in problems with the heat transfer during the densification process (Paulrud, 2004). Depending on the source of the raw material, it might be necessary to dry it before densification. For plants that need to invest in drying equipment, the capital costs of this often constitute up to half of the total capital costs (Eriksson & Prior, 1990). Hence, there are important competitive advantages for producers that do not need to dry their raw material.

Figure 3.9 shows a section of a large scale drying equipment. This equipment is used for drying raw material for pellets and briquettes. Heated air flows through the rotating drum and reduces the moisture content significantly.

Figure 3.9. The inflow section of a rotating drying drum in a briquette- and pellet facility (Photo Johan Karlhager)

3.4.2 Comminuting

The raw material used in production of briquettes must be of a suitable particle size before it enters the densification process. Normally a milling unit is used to reduce the particle size if it is necessary. For wood materials, chipping is usually necessary before milling. The particle size should not exceed 25 % of the diameter of the final product for most densification equipments (Bhattacharya, 1989)

3.4.3 Conditioning

To make the raw material softer and easier to work with in the densification process, superheated steam can be added in the stage between comminuting and densification (Hirsmark, 2002). A softer raw material contributes to binding the material together and results in briquettes that do not fall apart easily.

3.4.4 Densification

There are a few different technologies for production of briquettes; mechanical- or hydraulic piston press densification, screw press densification and roll press densification. A comprehensive review of the briquetting technologies is given by Pettersson (1999). Since the piston press is the most wide spread technology, focus is put on describing this type.

The development of mechanical piston presses started during World War II, even if the basic of the design was carried out already in the 20^{th} century. There have been several patents covering the general design active through the years, but none of these are active today (Eriksson & Prior, 1990).

Figure 3.10 shows the principle of a piston press. The main principle is the same, irrespective of the piston being driven mechanically or hydraulically. The raw material is fed into the cylinder in which the piston is operating. The compression of the raw material is carried out in a discontinuous matter as the piston moves back and forth. The raw material adheres against the material already in the cylinder that is compacted since the previous stroke. As the material is pushed into the narrowing die, its temperature rises significantly due to the high friction forces and increasing pressure. The pressure in the die is in the range of 110-140 MPa. As the compressed material exits the press, the pressure and temperature decreases and the lignin solidifies (Eriksson & Prior, 1990).

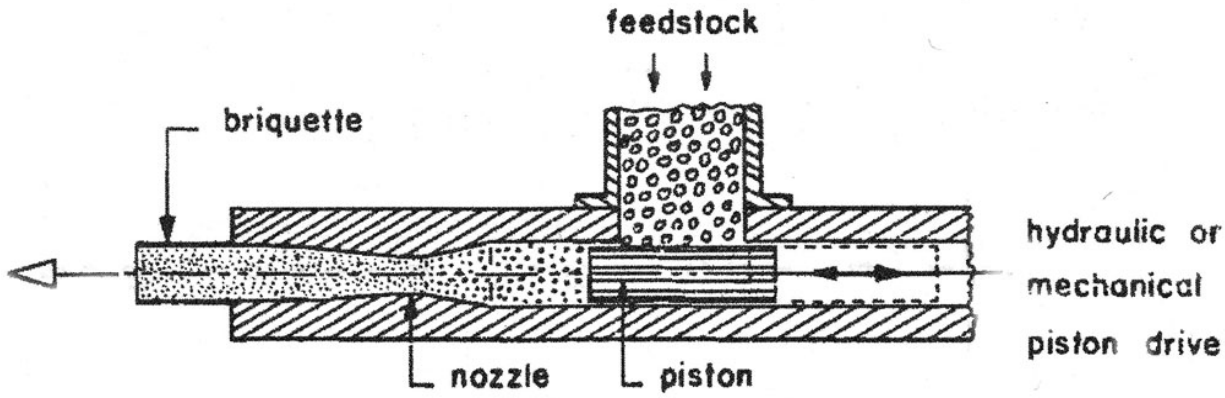

Figure 3.10. The principles of a mechanical or hydraulic piston press (Bhattacharya, 1989)

3.4.4.1 The mechanical piston press

Mechanical piston presses are mostly used for and best suited for briquetting of wood waste. Typical users of this kind of equipment are joineries or saw mills wanting to produce fuel out of their saw dust, planings or shavings.

In systems using mechanical piston presses, the piston is eccentrically mounted on a crank-shaft with a flywheel. Normally, a down-geared electrical motor is driving the rotation of the flywheel. The pistons used in compression are generally ranging in diameter from 40-125 mm. The diameter of the piston often equals the diameter of the final product (Eriksson & Prior, 1990). Some systems have adjustable narrowing of the die, which can be an advantage if the briquette producer wants to change into another raw material or if the raw material is inconsistent, e.g. if the moisture content varies over time. Different raw materials and raw material qualities have different optimal narrowing of the die. The capacity of a mechanical piston press is closely correlated with the die area (Eriksson & Prior, 1990).

Maintenance needs of mechanical piston presses are limited. The machines are normally robust and need very little attendance. The amount of maintenance required varies between different manufacturers and raw materials. Wood materials are more machine-friendly than other materials.

3.4.4.2 The hydraulic piston press

This type of press does not principally differ from mechanical piston presses. The difference is the way the piston is driven. In a hydraulic piston press, the piston is driven by an electrical engine that uses hydraulic oil in order to move the piston. This makes the machine more compact as the fly wheel and crank shaft is eliminated. The raw material is pre-compacted in several steps before the main compacting takes place.

The output of a hydraulic system is lower than that of a mechanical system as the speed of the piston is lower in hydraulic systems. The pressure is also lower than in mechanical presses, resulting in lower briquette density, less durability and less shock resistance.

3.4.5 Cooling

To allow the briquette to cool off in an optimal way, most piston press systems need a cooling track where the material slowly can drop in temperature before they fall apart into desired lengths. This is especially important when mechanical piston presses are used (Eriksson & Prior, 1990). In Figure 3.11, the briquettes are sliding out of the piston press to cool off and to be transported further on to storing. Figure 3.12 shows how the cooled-off briquettes exit the cooling track at a large scale briquette plant in Sweden.

Figure 3.11. Cooling track between briquette press and storing (www.bogma.se).

Figure 3.12. The end pipes of cooling tracks for briquettes (photo Johan Karlhager 2007).

3.4.6 Storing and transport

After cooling, the briquettes are normally stored before combustion. Storing may take place outdoor under roof, indoor, in container or in other ways. The transport from production plant to combustion is often made by truck.

3.4.7 Combustion

Most of the combustion plants for solid fuels can utilize briquettes. Industrial boilers though are most suitable for and convenient with the task. Large scale oil burning plants can be converted with equipment suitable for solid fuel combustion, but the operation is expensive (Eriksson & Prior, 1990). In Sweden, the predominating use of briquettes is in grate fired boilers. This type of equipment is most suitable for biomass fuels with variation in particle size and higher ash contents. It is flexible and can be used both for wood chips, bark and briquettes. In the cases where the briquettes are turned into powder after transport to the heating plant, combustion takes place in specially designed powder burners (Paulrud, 2004).

For plants that can handle both briquettes and unprocessed material, e.g. tree tops and branches, there are a few factors that favor briquettes. The most obvious advantages are the ease of handling and efficiency in transport. But briquettes also have the advantages of being easier to automatically feed into the combustion and are not blowing around in the combustion chamber, a problem associated with unprocessed material that can result in incomplete burning (Eriksson & Prior, 1990).

Briquettes can not only be utilized in industrial scale. Small scale customers can benefit from using briquettes instead of wood in household stoves as well.

For household use, safety- and combustion process issues are important too. A French experiment carried out 1987 examined how briquettes act when burned in household stoves. The rate of weight loss and elongation was measured. The results showed that for hard and dense briquettes, the weight loss during combustion is very slow, the elongation is minimal and they burn without flames for a long time, which make them a good substitute for coal in burning appliances designed for that specific fuel. The results for softer and less dense briquettes shows the opposite; considerable elongation resulting in fast weight loss and thereby shorter combustion time. The latter type of burning behavior was characteristic for briquettes made in hydraulic piston presses (CRA 1987, cited by Eriksson & Prior 1990).

3.5 Previous research

It is difficult to find information about the levels of briquette production in Sweden. The Swedish pellet producers have an association that provides important statistics for the industry, but there are no such compilations to find about the briquette production. There is some global information on DBF:s available from the Swedish Wood Fuel Association, but the information does not separate between different kinds of DBF:s. Hence, up to date facts and figures regarding briquette production alone are not available.

The latest and most comprehensive mapping of the Swedish briquette- and pellet production was carried out the year 2001 by Hirsmark. The study was presented in the year 2002. The study approach was to map the Swedish production of DBF:s and to describe conditions and prerequisites affecting the industry. The study was a part of an EU-project in short called INDEBIF, whose aim was to increase the use of bio energy within the Union. In the questionnaire, most questions treated DBF:s as a whole. This makes it hard to interpret the results with respect to briquettes as many values are averages of pellets, briquettes and wood powder. But the results presented below show values generated from questions concerning briquettes alone.

According to Hirsmark 2002, the production of briquettes during the years 1990-2000 spanned between 163 100 tons and 270 000 tons, see Figure 3.13.

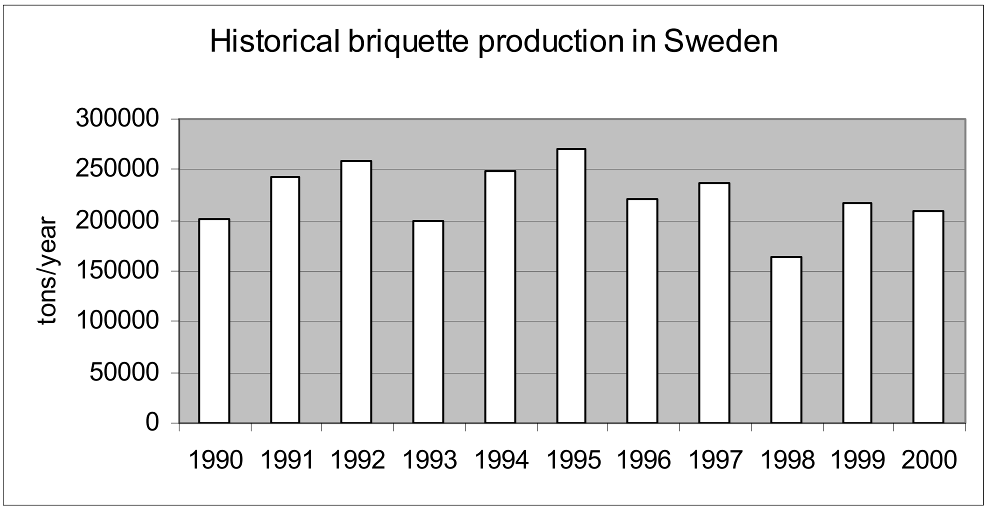

Figure 3.13. The aggregate Swedish briquette production 1990-2000 (Hirsmark, 2002).

During 2000, the structure of the briquette producers was as presented in table 3.5. The number of responding producers was only five, which explains the large gaps between the mean value and the median value and the top value and the median value, respectively. The values show that one or two producers are dominating the market.

Table 3.5. Key figures of the Swedish briquette producers in the year 2000

Maximum production	196 000 tons
Minimum production	400 tons
Mean production	41 900 tons
Median production	4 500 tons
Aggregate production	209 400 tons

The briquette production capacity listed in table 3.6, reveals that the production potential is concentrated to one or two producers, just like in the case with the actual production.

Table 3.6. Key figures of the Swedish briquette production capacity in the year 2000

Maximum production capacity	300 000 tons
Minimum production capacity	3 000 tons
Mean production capacity	75 700 tons
Median production capacity	8 000 tons
Aggregate production capacity	454 000 tons

Hirsmark also mapped in what kinds of combustion facilities the briquettes were used. Three categories of plants were formulated, ranging from small-scale (<100kW), middle-scale (100-1000kW), to large-scale (>1000kW) facilities. This shows that the large dominating producers not only delivered to large scale plants, but also to customers using the briquettes in small residential burning facilities. The responses are shown in table 3.7.

Table 3.7. Number of briquette producers delivering to different customer segments in the year 2000

Segment	Number of producers
Small-scale	5 out of 5 producers
Middle-scale	4 out of 5 producers
Large-scale	5 out of 5 producers

The ownership structure was described in the study and showed that the major briquette producer was owned by Uppsala Energi and Härjedalens Energi. Another producer was owned by a Swedish forest owner's association, Mellanskog. The ownership of the three remaining producers is not specified in the study (Hirsmark, 2002).

The Swedish Wood Fuel Association annually compiles the production of DBF:s in Sweden. It also compiles the import of DBF:s. In Figure 3.14, the aggregate import and production of briquettes, pellets and powder is presented. The amount of imported DBF:s nearly doubled during the three years, whereas the trend in the domestic production is more unclear. The data is based on an annual questionnaire survey carried out by the association.

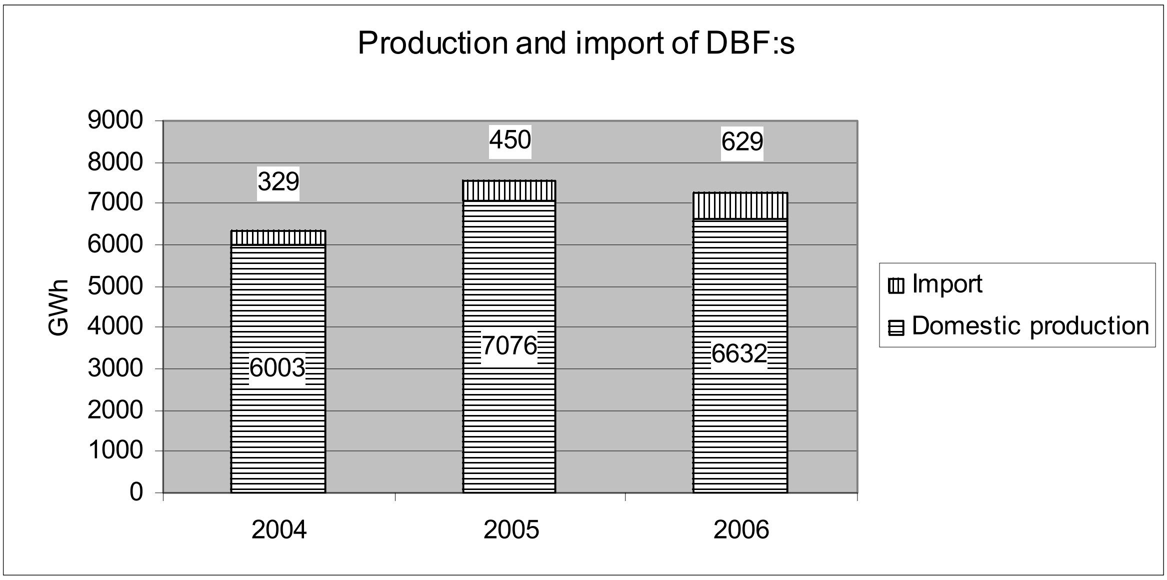

Figure 3.14. The Swedish production and import of densified biomass fuels 2004-2006 (Swedish Wood Fuel Association, Statistikresultat 2005 and 2006, published in 2006 and 2007, respectively).

4. Theoretical basis

The scientist's ambition with a model is not to present final knowledge, but to sketch notions and relate them to each other. (Patel & Davidsson, 1994) In this chapter, models and theories relevant to this study will be presented and the applications to this study are outlined. The focus of the theories is put on strategies, competitiveness and the industry environment.

4.1 Porter's Five force model

Michael E Porter's *Five force model was* developed during the last years of the 1970's and published in 1979. The model is a framework for business- and industry analysis with a focus on strategies and development (Porter, 1998)

Relating a company to its environment is the essence in designing a competitive strategy. The environment surrounding a company is a complex system of economic, social and other factors, but the industry in which the company competes is always the essential and dominating factor that should determine the company's competitive strategy. The goal of a company's competitive strategy in an industry is to find a position where the company can best influence the situation and defend itself against these forces. The starting point of a strategic analysis must be understanding of the structure of the industry in which the company competes.

Five basic competitive forces determine the state of competition in an industry and constitute the parts in the *Five force model*. The profit potential in an industry, measured in long run return on invested capital, heavily depends on the collective strength of these forces. The competition in an industry continually forces the rate of return on capital invested down towards the competitive floor rate. The competitive floor rate represents rate of return of government securities adjusted upward by the risk of capital loss. If a company habitually performs less than this competitive floor rate, it will go out of business because investors will seek other investment alternatives.

The five competitive forces are shown in the model in figure 4.1 below. The forces are:

- The threat of new entrants
- The bargaining power of buyers
- The threat of substitute products or services
- The bargaining power of suppliers
- The rivalry among existing firms

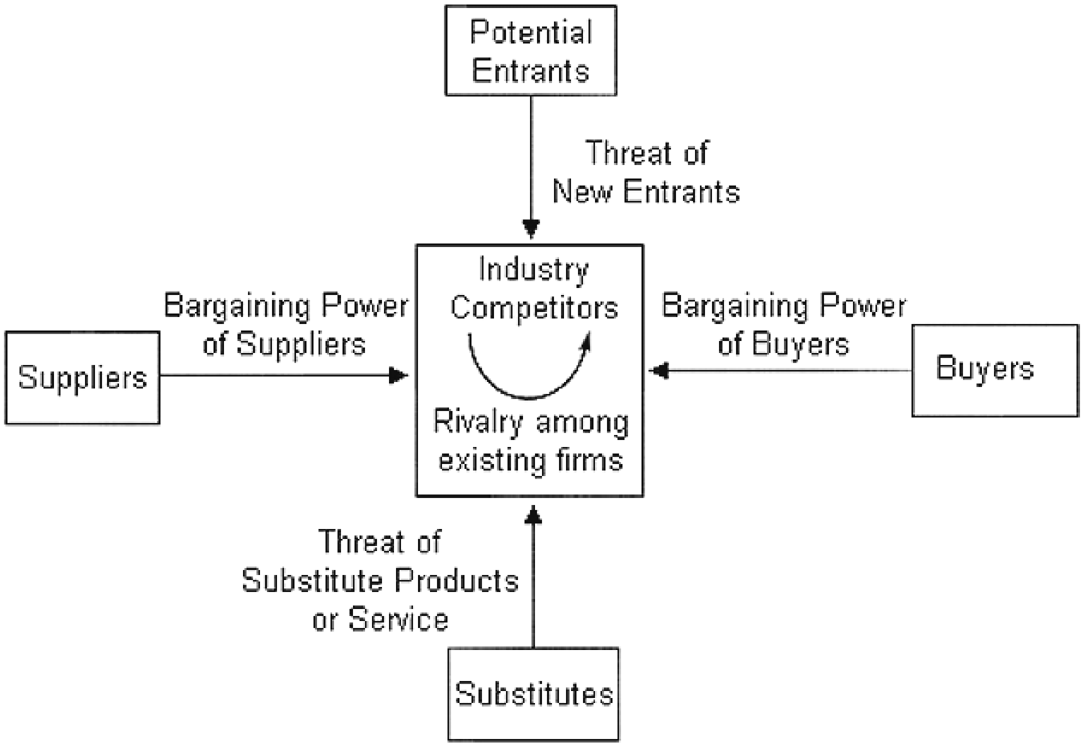

Figure 4.1. Forces driving the industry competition (modified from Porter, 1998).

Together, these five forces determine the profitability and the competitive situation in the industry. The strongest force out of these five is the most important to consider when formulating the company's competitive strategy. The strongest force has the most powerful influence over the competitive situation and taking this force into account is crucial for a successful competitive strategy.

The threat of new entrants is one of the forces. Companies try to build up barriers to protect from new competitors entering the market. The problem with new entrants, from the perspective of a company already in the market, is that they bring new capacity, increase the demand for resources and desire to gain market share. New production capacity can lower the market price for the products or services, increase resource costs and hence lower the profitability. The threat of new operators in an industry is mainly decided by two factors; the barriers to entry and the reaction expected from operators already in the market. The threat of entry is high if barriers to entry are low and / or new operators can expect low resistance from established operators. The sources of barriers to entry are:

- Economies of scale
- Product differentiation
- Capital requirement
- Switching costs for the buyer
- Access to distribution channels
- Cost disadvantages independent of scales
- Government policy

The second force is rivalry among existing competitors. This force occurs as a result of competitors seeing a chance or feeling the pressure of improving their positions in the industry. The following interacting structural factors are the sources of an intensive rivalry:

- Numerous or equally balanced competitors
- Slow industry growth
- High fixed or storage costs
- Lack of differentiation or switching costs
- Capacity augmented in large increments
- Diverse competitors
- High strategic stakes
- High exit barriers

The third force is pressure from substitute products. Substitute products can perform the same function as the product of the industry. The substitutes form an upper limit of the prices companies can charge, hence limiting the potential returns as well. A substitute offering an attractive price-performance ratio, effectively limits the industry profits. The substitute products forming the most dangerous threat to the product of the industry are the products that are produced by industries earning high profits and products that are subject to trends improving their price-performance trade-off with the industry's product.

The fourth force is the bargaining power of suppliers. The base for this power is the suppliers´ ability to raise the prices of the product. In this way, powerful suppliers can take profitability out of an industry unable to increase the price to its customers. Under the following circumstances, the supplier group is powerful:

- Supplier group is dominated by a few companies and is more concentrated than the industry it sells to
- Supplier's product doesn't have to compete with substitute products
- The industry is a relatively unimportant customer of the supplier group
- The supplier's product is an important input to the buyer's business
- The supplier group's products are differentiated or it has built up switching costs
- Supplier group form a threat of forward integration

The fifth force is the bargaining power of buyers. The buyers aim at pushing down prices, get a higher quality and better service through playing the competitors against each other. The result of this is a decreased profitability for the suppliers. Under some circumstances buyer groups are more powerful. These are:

- Buyer group is concentrated or purchases large volumes relative to seller sales
- The product the buyer purchases from the industry represent a significant fraction of the buyer's cost or purchases
- The products the buyer purchases from the industry are standard or undifferentiated
- The buyer faces few switching costs
- The buyer earns low profits
- Buyer form a threat of backward integration
- The product does not determine the quality of the buyers product or service
- The buyer has full information (Porter, 1998)

The *Five force model* will be used to structure the analysis of the environment in which the briquette producers are competing. Each of the five forces will be taken into account and the analysis will aim to show which of the forces constituting the strongest influence over the company's competitive environment. This is important for the formulation of the competitive strategy of a briquette producing company.

5. Method and materials

The mapping of the Swedish briquette producers was carried out through a questionnaire based survey. Since there is a lack of knowledge regarding the briquette market, the study had an explorative character. Both quantitative and qualitative methods were used to process the information, depending on the information obtained by the survey. General knowledge of how to carry out a study and reporting the study was obtained from mainly two sources; the books *Rapporter och uppsatser* (Backman, 1998) and *Att Utreda, forska och rapportera* (Eriksson, 2006). To improve the skills in quantitative methods, the book *Kvantitativ metod från början* (Eliasson, 2006) was used.

Considerations about whether to use quantitative- or qualitative method were made in the beginning of the process of designing this study. Quantitative methods use statistics to describe the characteristics of the population (Patel & Davidson, 1994). A risk with using a quantitative approach is that the survey involves a high degree of rigidity (Johannessen & Tufte, 2003). Qualitative methods can offer a deeper, less fragmentized knowledge and aims at understanding and analyzing the problem as a whole (Patel & Davidson, 1994). In this case, quantitative methods were considered being the best alternative for the survey of the briquette production. The reasons for this were that the data sought for were of a quantitative type. An overview of the industry and its production is best described with quantitative methods.

Two important aspects within the area of survey design are structuring and standardization. The degree of standardization is about how much responsibility is left to the interviewer in designing the questions and the order of the questions. In a fully standardized interview the questions and the order of the questions are decided by the interviewer alone. The degree of structuring reflects in what way the respondent can answer the questions. If the respondent's only possibility to answer the questions is by using fixed alternatives, the question is fully structured (Patel & Davidson, 1994).

In this survey, the questionnaire is fully standardized and has a medium structuring due to the mix of questions with fixed and open answer alternatives. Some of the questions have fixed alternatives, whereas other questions give the respondent an opportunity to formulate answers the way he or she wants. Each question's degree of structuring was partly based on how much the interviewer knew beforehand about the possible answers. Fixed alternatives were given when the interviewer had a presentiment about the possible outcome. In the opposite case, open questions were given. This was made to decrease the risk for limitation of the respondent's options.

5.1 Questionnaire

The questionnaire used in the study was designed to obtain information about the raw material situation, production levels, the technology used in production, the market development and the structure of the companies producing briquettes. The goal of the questionnaire design was to fit the aims of the study and to have a high degree of comparability with results from other surveys, primarily Hirsmark (2002) and a pellet survey carried out simultaneously as the present study. The *Five force model* provided a framework for the questionnaire. The adaptation in accordance to the *Five force model* was carried out by including questions touching on the areas described in the different forces. The results were then analyzed and discussed to describe the competitive situation in the industry.

The design was facilitated by using ideas and theories from literature describing survey methods. Two books were used, (Ejlertsson, 2005. Enkäten i praktiken) and (Dillman, 2000. Mail and Internet Surveys). From these books, practical advice for precise and accurate questions were obtained. Important issues were how to encourage the companies to fill in the questionnaire, in what order to present the questions and how to formulate understandable questions. Important advices were also received from the supervisors from the Swedish University of Agricultural Sciences (SUAS) and Swedish Bioenergy Association (SVEBIO).

An important issue was the comparability of the results with the results from Hirsmark´s study from 2002. The choice and formulation of questions was influenced by the questionnaire questions used by Hirsmark (2002) to be able to compare the results with the results obtained in that survey. Some questions were formulated in exactly the same way as by Hirsmark, whereas other were reformulated to better fit the aims of this study and its focus on briquettes.

A number of the questions used in the questionnaire were formulated and developed in collaboration with a study regarding the production of and markets for pellets in Sweden (Höglund, 2008). The aim of the collaboration was to increase the comparability between the two studies. In order to further enhance the comparability of the results, the classification of customer segments was adapted to the classification used by the Association of Swedish Pellet Producers (PiR).

Before the questionnaires were sent out to the producers, four test questionnaires were sent out to briquette producers in different sizes and with different structure in ownership. The purpose of this test was to improve the reliability of the results. By obtaining indications of the future respondent's opinions about the questionnaire, the reliability was increased. Important issues were the formulation of the questions, the order of the questions, the effort and time needed to answer the questions and to find possible factual errors. The comments from the test questionnaire respondents were taken into account and some changes in the questionnaire were made to make the questions clearer.

The questionnaires were sent out via mail to the Swedish briquette producers. In the envelope, a prepaid reply envelope was attached. If no response was received within 3 weeks, the companies were contacted by phone. If the respondent was unwilling to fill in the questionnaire, questions were asked about the reasons for this to have an indication of any non responding bias. An attempt to obtain the most basic facts about the briquette production (e.g. production volumes, customer segments and trend in production) by phone was realized during the phone call if the respondent was unwilling to fill in the questionnaire.

5.2 Population

The goal with the questionnaire was to determine the trends in the Swedish briquette production. At present, there is no official or unofficial list of briquette producers, hence the identification of briquette producing companies was a key issue. Several different ways were used in order to find the producers, both personal contacts, manufacturers of briquetting equipment and web search. Primarily, company names and addresses were obtained from the customer lists of Bogma and Mared. Bogma is the only Swedish producer of equipment for briquette production and Mared is the only large scale Swedish importer of equipment for briquette production. Together they have a very large share of the market (pers. com., Johan Vinterbäck, 2007-05-04). A few additional companies were found through the member list of SVEBIO. A small number of companies were found through searching for briquette advertisements in industry magazines as e.g. "Bioenergi"[3]. Another source used in the identification process was a list of bio fuel producers published in the year 2007 by SVEBIO (Haaker, Biobränsleleverantörer 2006). Addresses and contact information to the companies were gathered on web pages, mainly www.hitta.se and www.eniro.se. By these means, a list of 141 potential briquette producers was derived.

5.2.1 The process of identifying the true population

A major task of this study was to find the Swedish producers of briquettes. In this part, the process of identifying the true population for the study will be described. The process was started in June 2007 and finished in December 2007.

141 questionnaires were sent out in the first time round. After three weeks, 18 replies had been received. To increase the response frequency, the companies on the original list were contacted by phone. After the phone calls were made, an additional 26 questionnaire answers were obtained.

In the phone contact with the companies, it turned out that a large number of companies on the original list from various reasons did not work with briquette production. Most of the companies were in related businesses but had no briquette production, a few had finished their production of briquettes. These 49 companies were excluded from the population list.

Seven companies were not willing to fill in the questionnaire, but agreed to answer some questions by phone or e-mail. The answers from these brief interviews were transferred to a questionnaire and used in the calculations of the results.

28 companies were never reached, neither by mail, nor by phone.

In the end, 92 companies remained from the original list. These were:

- Briquette producing companies who had responded (written or by phone) (51 companies)
- Briquette producing companies who did not want to respond (13 companies)
- Companies which had not responded, nor been reached by phone (28 companies)

The companies in these three categories constituted the population of the survey. The total response frequency was calculated from this number. The population consisted of the whole scale of producers, from small farms and joineries to large scale production units owned by large companies. In Figure 5.1, the company identification process is described graphically.

[3] Swedish Bioenergy Association, Stockholm

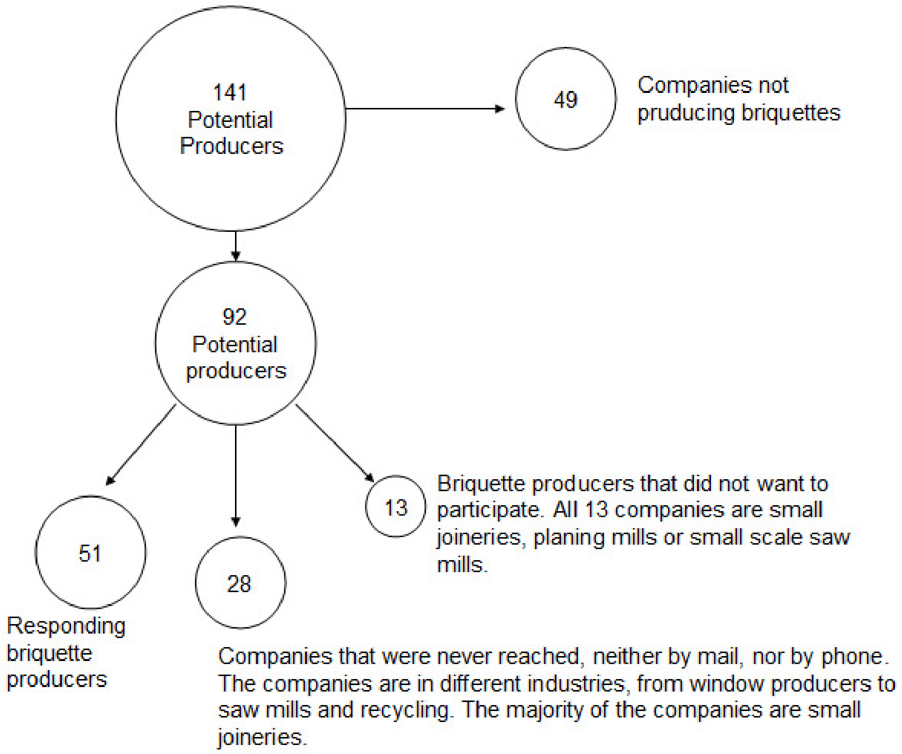

Figure 5.2. The briquette producer identification process. The figures in the circles represent the number of individuals in each group.

5.2.2 Non-respondents

41 producers did not, for various reasons, fill in the questionnaire or answer questions by phone. The population consisted of 92 producers, which in relation to the number of non responding respondents gives a total response frequency of 55,4 %. In appendix 2, the response frequency for each question in the questionnaire is presented. These figures are calculated by dividing the number of responding companies for the specific question with the total number of respondents of the questionnaire (51 respondents).

Web searches were carried out for the names of the companies that were never reached. The results showed that these companies were, with a few exceptions, generally small joineries, small planing mills or small saw mills. These companies are not likely to have a significant influence over the final result of the production levels. For a small number of the companies, no information could be found on the internet.

13 of the contacted companies did not want to participate in the study. They had various reasons for this, but generally they did not think that the survey was relevant as their production levels were very low, ranging from only a few tons per year to 50-100 tons per year. Some of the respondents also stated that they did not have time to fill in the questionnaire. Most of these producers were small scale producers that did not sell the briquettes, they used it for their own heating.

6. Results

In this chapter, the results from the questionnaire survey are presented and divided into five areas. Each area is opened with a short summary of the results. The results are divided into the following areas:

- Raw material
- Production process
- Production levels
- Market development
- Company structures

The formulation of the purpose of this study serves as the basis upon which the results are categorized and presented. The questions are not presented in the results, but can be found in appendix 1. Each result is marked with a number that refers to the number of the question in the questionnaire.

6.1 Raw material

In this part of the results, data related to raw material use are presented. In short, the results show that:

- Planer shavings is the most common type of raw material used
- The majority of the raw material volumes originate from purchase
- The majority of the producers do not experience raw material deficit
- Pellet producers are the most important raw material competitors
- Scots pine and Norway spruce are the most important wood species
- Import of raw material does not occur among the participating companies
- Additives in briquettes are used to very little extent

6.1.1 Raw materials used in production

The raw materials used in the briquette production are shown in Figure 6.1. The producers were requested to rank the raw materials they use in their production. Every respondent was given the opportunity to rank the three most important raw materials. Some of the respondents only ranked one raw material, some ranked two whereas some ranked three raw materials. The result shows that planer shavings is the most important raw material, saw dust the second most important raw material and recycled wood the third most important raw material. The largest producer primarily uses peat and secondarily wood, which makes peat a very important raw material to the production. Of the respondents stating "Other", a few raw materials were pointed out. Four producers stated that joinery waste from cut away wood is the main or secondary raw material. Two producers stated that waste from board or MDF is the most important raw material. Three producers stated that the most important raw material is reed canary grass, dry wood chips and wood polishing dust, respectively. The values do not take into account the amount of briquettes that each company produces, thus, the results are not weighted according to volume (Question No. 28)

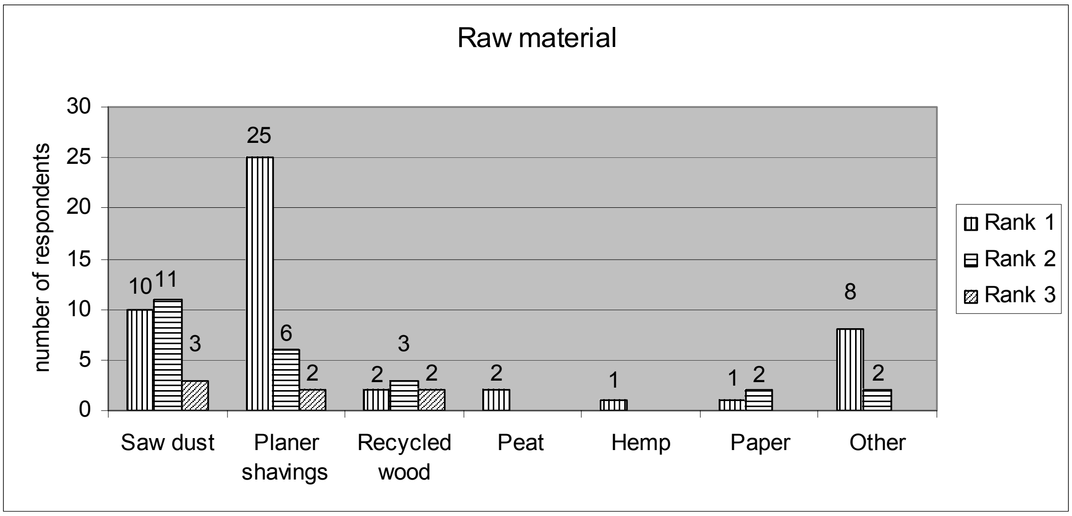

Figure 6.1. The briquette producers' ranking of raw materials. The different categories on the x-axis represent raw materials used in production. Rank 1 is the most important raw material, rank 2 is the second most important raw material and rank 3 is the third most important raw material.

6.1.2 The origin of the raw materials

The origin of the raw material was examined in the study. In table 6.1 and 6.2, the composition of raw material originating from by-products from the company's own production and purchased raw material are shown. The values in table 6.1 and 6.2 differ greatly as the shares in table 6.1 are based on the volume each company produced the year 2006, whereas the values in table 6.2 are mean values not taking into account the annual production of each company. (Question No. 29)

Table 6.1. Aggregate composition of raw material from own production and purchased raw material, respectively. The values are calculated from each company's production the year 2006 and the composition of raw material from its own by-products and purchased raw material. The sum of the production from by-products and purchased raw material is lower than the aggregate production in the year 2006 (279 540 tons) as a few respondents did not state their distribution of raw material origin

Share of raw material originating from own production	22 %
Share of raw material originating from purchase	78 %
Total amount briquettes originating from raw material from own production	59 892 tons
Total amount of briquettes originating from purchased raw material	217 148 tons

Table 6.2. Mean share of raw material from own production and purchased raw material. The values do not take into account the amount of briquettes produced by each company

Mean share of by-product from own production	74 %
Mean share of purchased raw material	26 %

6.1.3 Raw material deficit

A majority of the producers did not experience problems in finding raw material. The results are shown graphically in Figure 6.2. (Question No. 33) Of the respondents stating "Yes", the following causes were pointed out to be of particular importance to the producers:

- Price competition with expanding pellet production (three producers)
- Increased demand in general (one producer)
- Dependence on weather (one peat briquette producer)

- Decreasing production of main product (raw material for briquettes as by-product), one producer

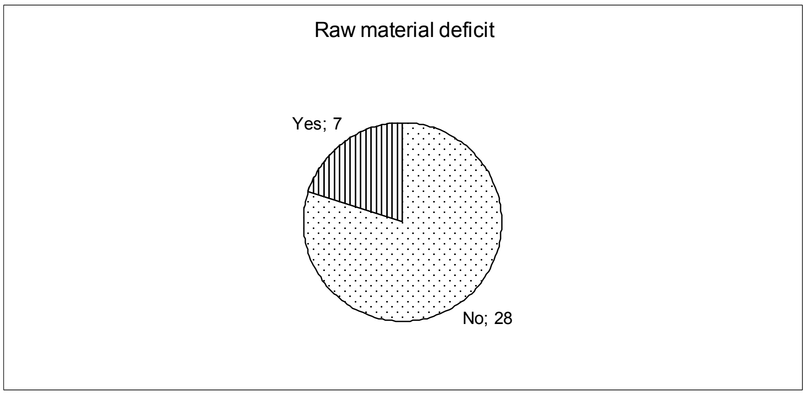

Figure 6.2. Number of respondents experiencing raw material deficit for their briquette production.

6.1.4 Ranking of raw material competitors

The competitive situation for raw material is described in Figure 6.3. The respondents were requested to rank different competing industries with respect to raw material. Every respondent was given the opportunity to rank the three most important competitors. Some of the respondents only ranked one competitor, some ranked two whereas some ranked three competitors. The pellet industry is considered being the most severe raw material competitor to the responding briquette producers. Other briquette producers, heat- and power producers and the board industry are other important competitors. Saw mill industry, pulp- and paper industry, the international market and agriculture are less important competitors. One producer stated "Other", and in this case joineries were pointed out as the most important raw material competitor. (Question No. 18)

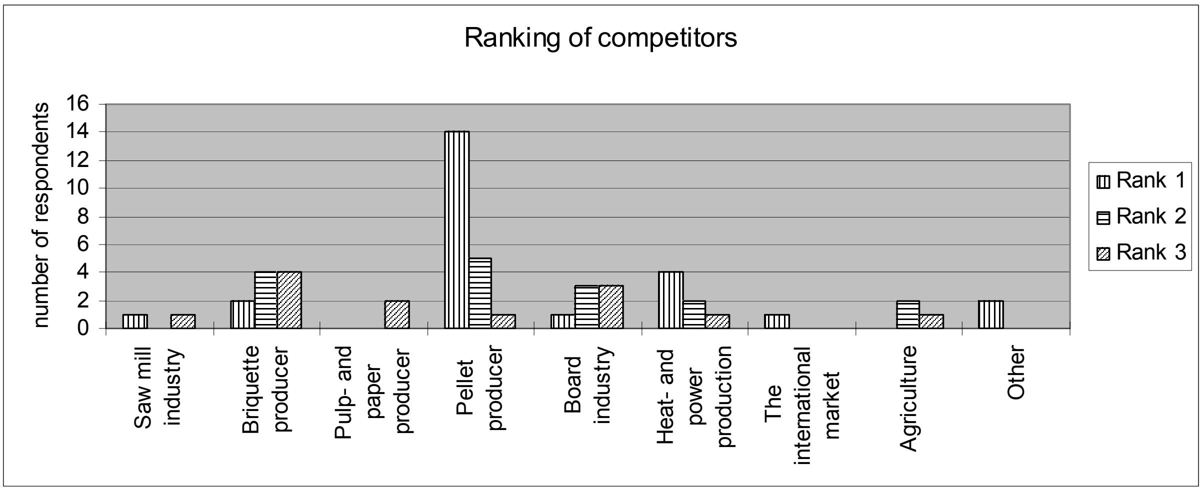

Figure 6.3. The briquette producers' ranking of competitors with respect to raw material. The different categories on the x-axis represent competing industries. Rank 1 is the most important raw material competitor, rank 2 is the second most important raw material competitor and rank 3 is the third most important raw material competitor for briquette production.

6.1.5 Wood species used in production

The wood species that the responding briquette producers use are shown in Figure 6.4. Scots pine (Pinus sylvestris) and Norway spruce (Picea abies) are dominating, while birch is used only to a smaller extent. Of the respondents stating "Other", five are using oak wood as raw material, three are using beech wood and two are using ash wood for briquetting. Other wood raw materials used are walnut wood, maple wood, elm wood, mahogany wood, teak wood and alder wood. All other wood species than Scots pine and Norway spruce are used in small-scale densification only. Peat, board, paper, hemp and mixed sorts of wood are other raw materials pointed out by the briquette producers. Peat is used in large scale by two producers. The values presented below do not take into account the amount of briquettes that each company produces. (Question No. 30)

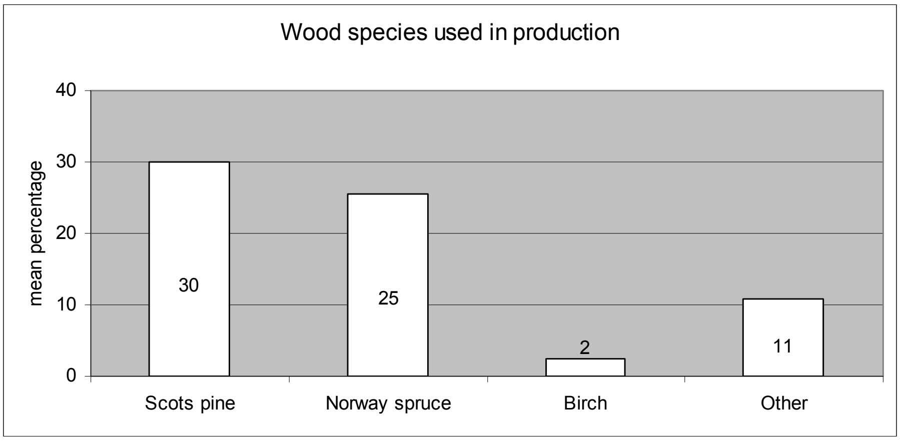

Figure 6.4. Sort of wood used in the Swedish briquette production. The category "Other" also includes other raw materials than wood.

6.1.6 Import of raw material

The respondents were also asked if they are importing any raw material for their briquette production. Of 44 respondents, no one is importing raw material for the production. (Question No. 32)

6.1.7 Additives in briquettes

Only two producers are using additives in the briquette production, see Figure 6.5. A large scale producer (producing about 10 000 tons/year) is using lignin as a binding agent. One small scale producer (producing about 100 tons/year) is using an additive but did not want to reveal what kind of additive he is using. (Question No. 31)

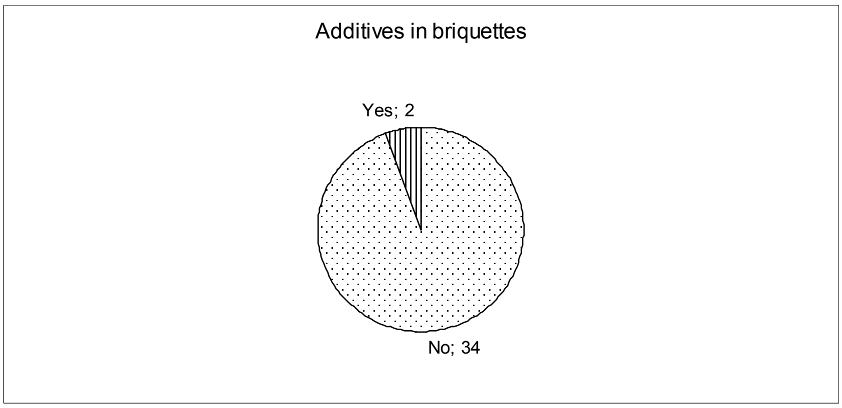

Figure 6.5. Number of producers using an additive in the briquette production.

6.2 Production process, storage and packaging

In this second part of the results, data related to the production process are presented. The results show that:

- Bogma is the dominating briquette press brand
- Indoor storing and bulk delivery are dominating
- Malfunction in the production equipment is the most common reason for production problems

6.2.1 Briquette press brands

Bogma is the dominating briquette press brand, see Figure 6.6. Adelmann and Nazzareno are German brands imported by Mared AB. Of the respondents stating ”Other”, three are using the Danish brand CF Nielsen. Krupp, RUF, Husqvarna and Weima are other brands used in the briquette production. In total, eight different brands are used, even though the contribution of the majority of brands is marginal. A number of producers are using more than one brand in their production. (Question No. 8)

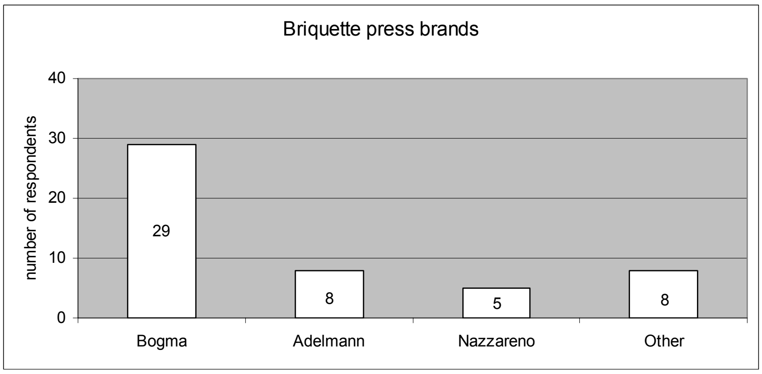

Figure 6.6. Different briquette press brands used by the responding briquette producers.

6.2.2 Types of equipment

The types of equipment used in the briquette production are shown in Figure 6.7. The mechanical piston press is the most common press type. A small number of producers are using drying- and milling equipment. None of the respondents are using conditioning equipment to soften the raw material before densification. Cooling tracks, that allow the briquette to cool off in a desired way after densification, are used by 19 producers. (Question No. 9)

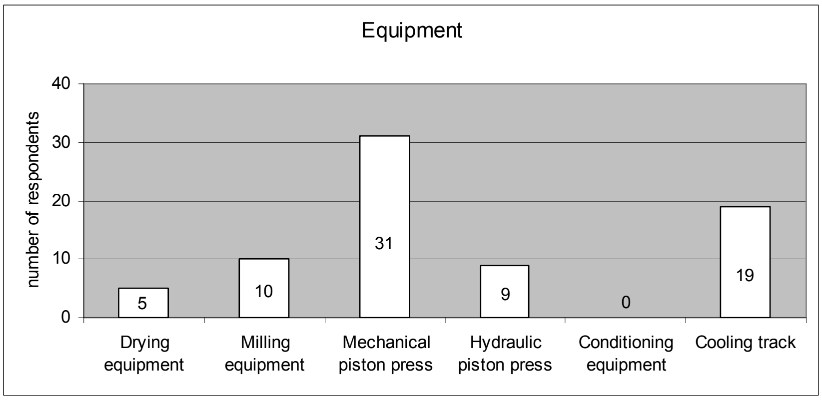

Figure 6.7. Types of equipment used in Swedish briquette production.

6.2.3 Storing of briquettes

The way that briquettes are stored after production is shown in Figure 6.8. Very few producers are using silo as storage, whereas indoor storing is the dominating method. Outdoor storing under roof is usual as well. Of the respondents stating “Other”, five are storing their product in container, one is storing on truck and a last one does not store the briquettes at all. (Question No. 10)

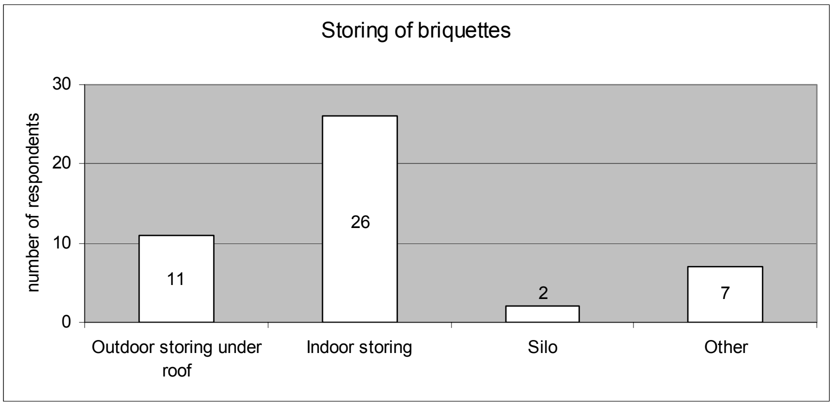

Figure 6.8. Different ways of storing the briquettes among the responding briquette producers.

6.2.4 Packaging of briquettes

The producers pack their products in different ways. It turned out that the most common way to pack the briquettes is not packing them at all, i.e. bulk delivery (see Figure 6.9). This means that they are delivered by e.g. truck or train and tipped at the customer’s storing yard. Of the respondents stating “Other”, five are packing the briquettes in containers and one in 21 kg. cartons. Two producers offered their products in small bags, large sacks and bulk. One producer offered both small bag and bulk production. (Question No. 11)

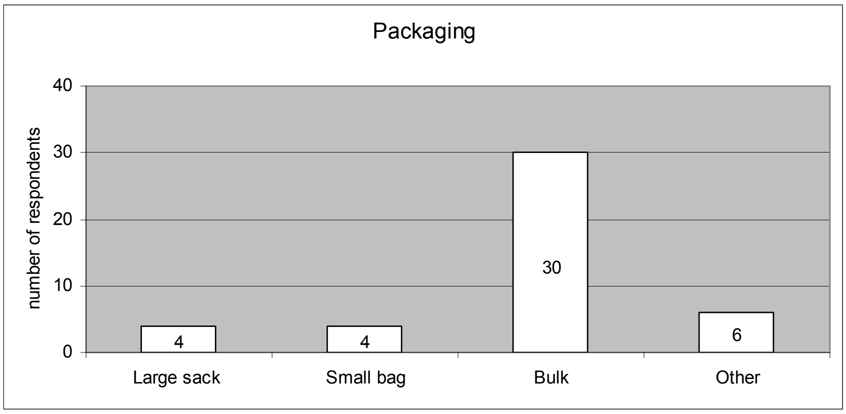

Figure 6.9. Packaging of briquettes among the responding producers.

6.2.5 Production problems

The causes for possible production problems were examined in the study and are presented in Figure 6.10. The category “Other production equipment malfunction”, which includes e.g. the briquette press, was the most frequent cause for production problem with 16 respondents. The alternative “Other” was chosen by six respondents. Of these six, four stated that they have no problem at all in the production, whereas another one stated labor as the most usual problem and a last one stated wearing of the screw feeding system as the major reason for production problems. (Question No. 12)

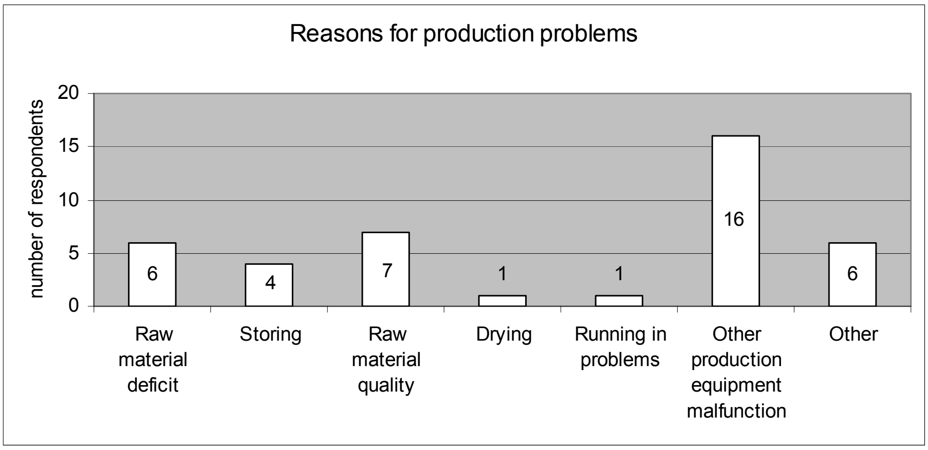

Figure 6.10. The most common reasons for production problems stated in this study.

6.2.6 Distribution of production costs

The cost structure for the whole process of producing briquettes is shown in figure 6.11. The values are weighted mean values for all the producers responding to the question. Each producer's weight in the calculations is based on its share of the production in the year 2006. The values do not separate different categories of producers. Producers with dry raw material and producers with fresh raw material are in the same category. Producers self sufficient in raw material and producers with purchased raw material are in the same category. A division of the producers into different categories could give a more precise cost distribution, a division based on dry / fresh raw material, by-product / purchased raw material, large- / small- scale production and other factors. The variable "Raw material" has the largest variation out of the seven variables. Some of the producers view their waste products as free of charge and state the cost for it to be 0 % of the total costs, whereas other producers have to pay for the raw material. For the latter, the raw material cost constitutes a considerable share of the total costs. The largest producer did not state its cost distribution. (Question No. 22)

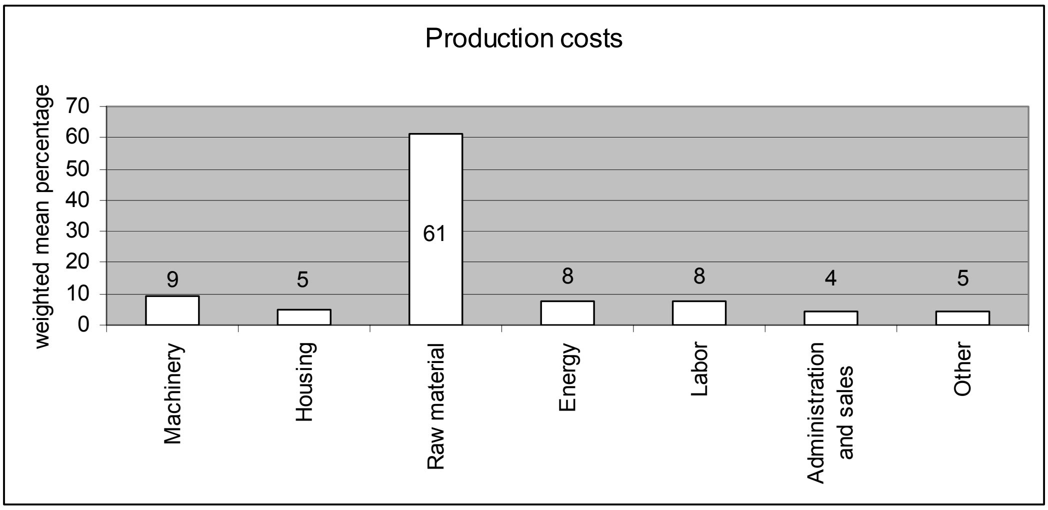

Figure 6.11. Weighted mean percentage share of total costs for briquette production. The values are weighted in relation to each producer's production in the year 2006. The values do not take into account if the producer uses purchased raw material or raw material from own by-products.

6.3 Production levels

In this third part of the result, the results regarding the development of production capacities and actual production volumes are presented. In short, the results show that:

- The production capacity has increased since the year 2000
- The annual production has increased since the year 2000
- The industry is concentrated with one dominating producer
- The storing capacity is roughly half of the production capacity
- Very few producers are planning to expand their production capacity

6.3.1 Production capacity in the year 2007

An important aim in the study was to map the production capacity. The aggregate production capacity for briquettes among the responding producers turned out to be 650 015 tons or 3 055 GWh, see table 6.3. This in an increase from the capacity of 454 000 tons in the year 2000 (Hirsmark, 2002). The average size of a production plant is 15 477 tons, whereas the median size of a production plant is 3 250 tons. (Question No. 4)

Table 6.3. Characteristics of the briquette production capacity

Total production capacity	650 015 tons
Total production capacity	3 055 GWh
Mean production capacity	15 477 tons
Median production capacity	3 250 tons

6.3.2 Annual production

Another main task in the study was to map the annual production of briquettes. The results are shown in Figure 6.12 below. In the year 2000, the aggregate production was 209 400 tons, which is lower than the current production level. The aggregate production in the year 2006 corresponds to approximately 2,4 % of the input to Swedish district heating systems. (Question No. 35)

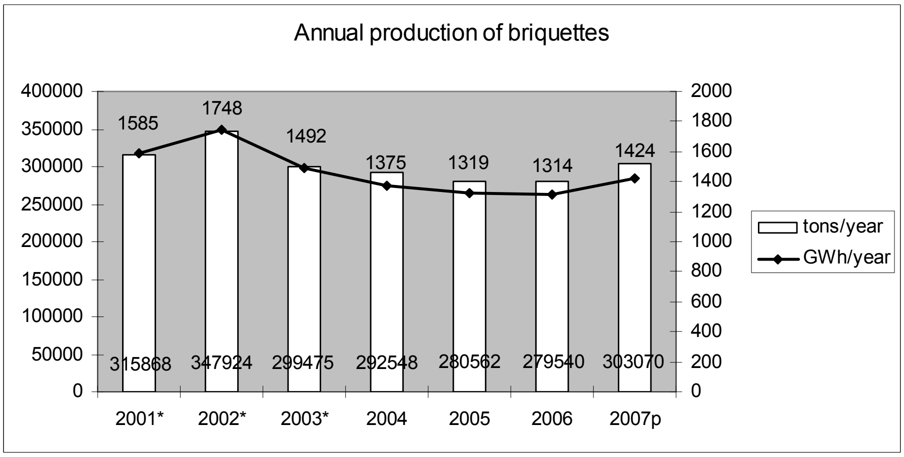

*Figure 6.12. Annual Swedish production of briquettes in tons/year and GWh/year, respectively. *questionnaire values from 2001-2003 are completed with data from Bioenergi No 1 2002, Bioenergi No 1 2003 and Bioenergi No 1 2004, respectively, as the largest producer did not state its production for these years.*

The composition of the different producers forming the aggregate production in the year 2006 is shown in Figure 6.13. It shows that the largest producer has a very large share (43 %), of the aggregate production. A small number of producers has considerable shares whereas most producers are very small, contributing only marginally to the aggregate production. This concentration of the industry is reflected in the mean and median values in the table 6.3 above.

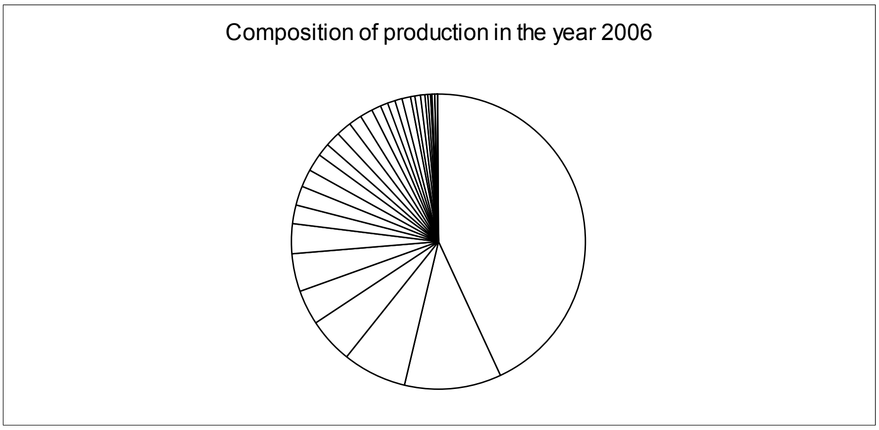

Figure 6.13. The composition of the production of briquettes in the year 2006. Each sector represents a producers' share of the aggregate production.

The producers were divided into eight size classes to describe the structure of the industry. Only two producers' annual production exceed 20 000 tons/year (Figure 6.14).

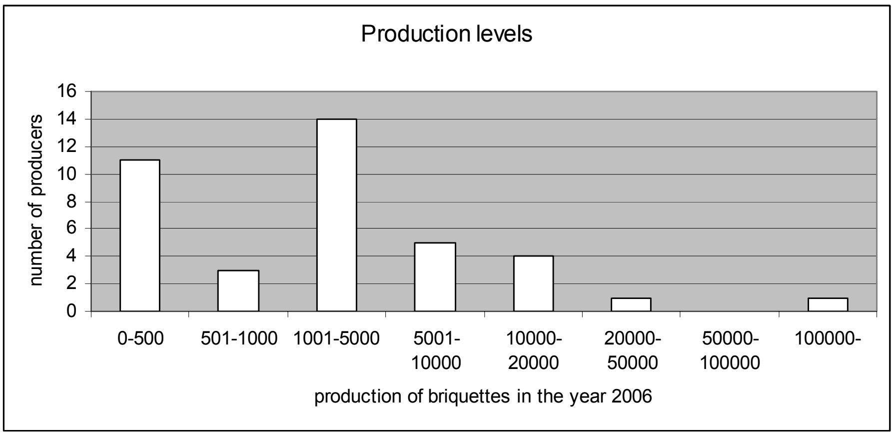

Figure 6.14. Division of the producers into different size classes. The classes represent annual production levels.

6.3.3 Storing

To show how much of the production that is possible to store in the company's own inventory, the respondents were asked to state their capacity for storing of briquettes. The result is shown in table 6.4. (Question No. 5)

Table 6.4. Characteristics of the briquette storing capacity. Mean share is calculated as an average of every producer's production capacity in relation to its storing capacity

Total storing capacity	373 745 tons
Mean storing capacity	10 382 tons
Median storing capacity	335 tons
Mean share of production capacity possible to store	47 %

6.3.4 Expansion plans

The briquette producers were asked about their plans for expansion of their production capacity during the two years to come (2008-2009). The result is shown in Figure 6.15. Three producers are planning to expand their production capacity. One producer is planning to expand the capacity by 2 500 tons/year, a second is planning to expand by 2 000 tons/year and a third producer is planning to expand by 7 000 tons/year. The planned expansion totals 11 500 tons/year, corresponding to 5,4 GWh/year or 3,8 % of the forecasted production in 2007. (Question No. 6)

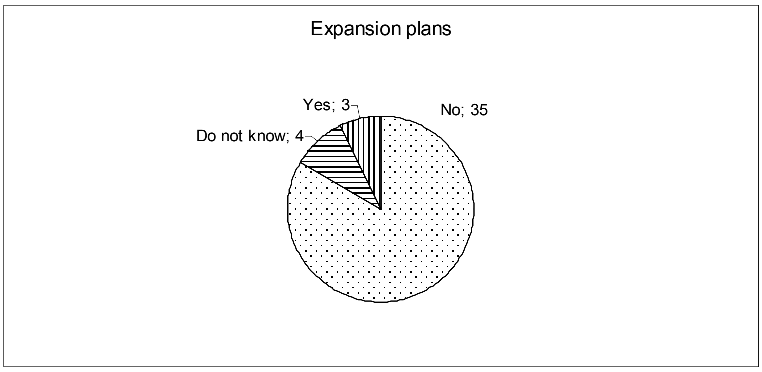

Figure 6.15. The expansion plans of briquette producers in this study. The figures represent the number of respondents belonging to each category.

6.4 Market development

This fourth part of the results presents the result the market development area. In short, the results show that:

- The majority (78 %) of the production is used in large-scale segment
- The largest increase in demand is in the large-scale segment
- The estimated increase of the production is 4,1 % during 2008-2009
- Briquette price is estimated to increase by 19 % during 2008-2009
- The turnover of the briquette production from the responding briquette producers is roughly 250 MSEK
- Small scale district heating is considered being an important opportunity, whereas raw material prices are seen as the major threat to the production.
- Briquette production is a more simple process than pellet production
- Word of mouth is the main marketing method of briquettes

6.4.1 Customer segments

The respondents were asked to specify how large shares of their production that were delivered to three different customer segments. The segment division was based on the power of the furnace used to burn the briquettes. The results in Figure 6.16 and 6.17 show the composition of customer segments in the year 2006 and prognosis for the year 2007, respectively. In Figure 6.16 and 6.17, the category "Non responding" represents the amount of briquettes produced by companies that did not specify to which customer segments their production is delivered. (Question No. 13)

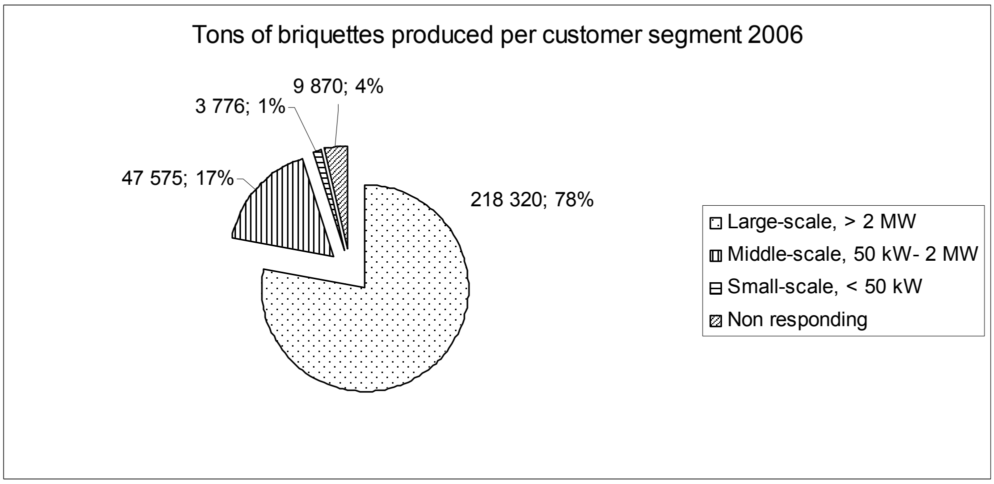

Figure 6.16. Tons of briquettes produced per customer segment in the year 2006. Percentage figures show the segment's share of the aggregate production (279 540 tons).

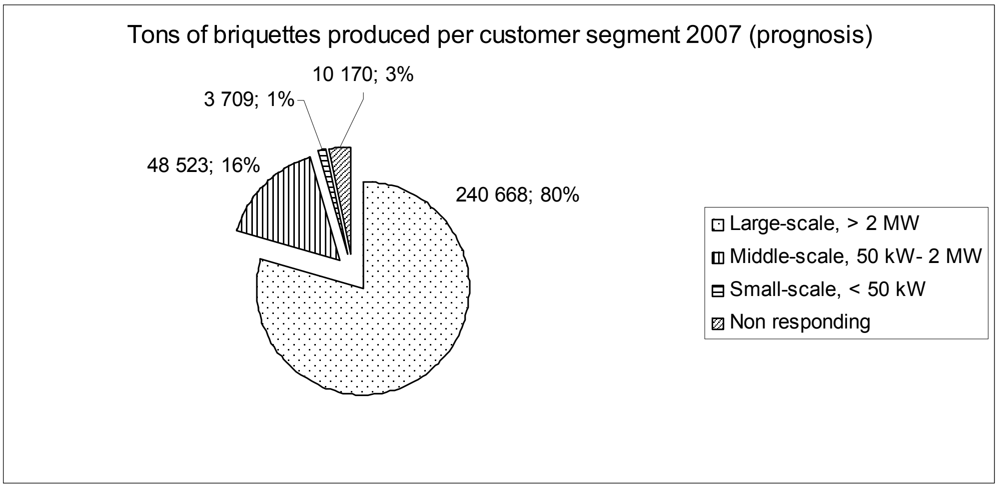

Figure 6.17. Tons of briquettes produced per customer segment in the year 2007. Percentage figures show the segment's share of the aggregate production (303 070 tons). All values are prognosticated by the responding companies in October-December 2007.

6.4.2 Trends in demand in different customer segments

The changes in demand within the different customer segments for briquettes are shown in Figure 6.18. The respondents were able to state their perception of the change in demand to each of the customer segments. Most of the producers only responded to the segments to which they are delivering their products. Hence, the number of responses varies between the customer segments. (Question No. 14)

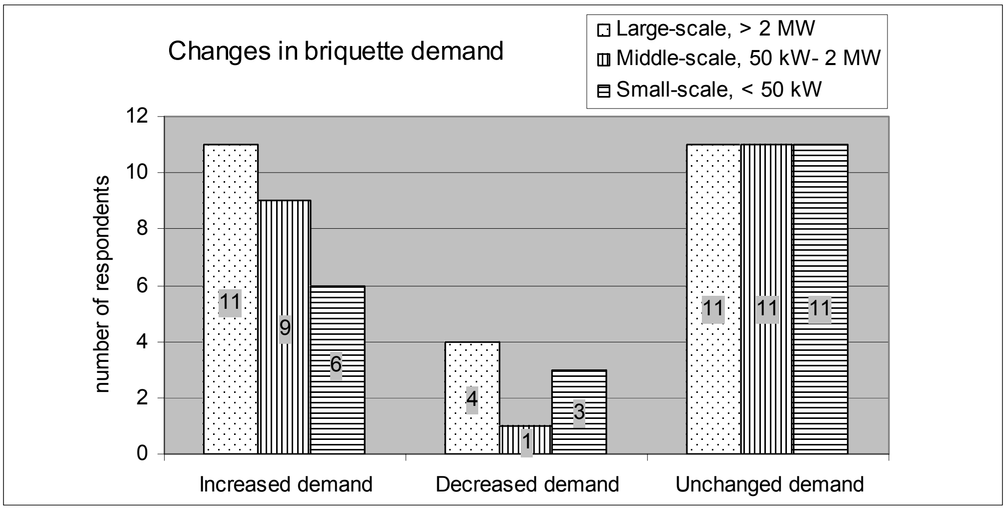

Figure 6.18. Perceived changes in briquette demand within different segments from the year 2000 to 2007.

6.4.3 Estimated change in the company's own production the two years to come

The estimations of the development of the respondent's own production are presented in table 6.5. Each company's estimated change in production was multiplied with its current production. The result indicates that the production will increase by 4,1 % from the year 2007 to 2009. This result is very close to the 3,9 % of planned expansion of the briquette production. 23 producers believe that their production will rise, by on average 24 %. Three producers believe that their production will decrease, with an average decrease by 37 %. (Question No. 15)

Table 6.5. Estimated total change in production the two years to come compared to today's production

Estimated aggregate production in two years (2009)	315 505 tons or 1 483 GWh
Percentage increase in production from 2007 to 2009	4,1 %
Number of respondents with estimated increased production	23
Mean estimated increase in production	24 %
Number of respondents with estimated decreased production	3
Mean estimated decrease in production	37 %

6.4.4 Estimated change in the aggregate Swedish production

The future change in the aggregate Swedish production was subject to approximation in the survey, and the majority of the producers estimate the production to rise between the years 2007 and 2009, see table 6.6. Thirteen producers estimate the aggregate production to rise, by on average 27 %. Six producers estimate the aggregate production to decrease, with an average decrease by 14 %. (Question No. 16)

Table 6.6. The briquette producers' estimation of the change in the aggregate Swedish production from the year 2007 to 2009

Number of respondents estimating an increasing production	13
Mean estimated increase in production	27 %
Number of respondents estimating decreasing production	6
Mean estimated decrease in production	14 %

6.4.5 Estimation of briquette price development

The price of briquettes was also subject to estimation by the producers. The result, presented in table 6.7, shows that the producers expect the prices to rise from the year 2007 to 2009. All 31 responding producers anticipated higher prices. The average estimation is that the prices will increase by 19 % during the two years to come. (Question No. 17)

Table 6.7. The producers' estimation of the change in price of briquettes from the year 2007 to 2009

Number of respondents estimating a higher price in 2009	31
Mean estimated raise in price	19 %
Number of respondents estimating a lower price in 2009	0
Mean estimated decrease in production	-

6.4.6 Turnover

The turnover of the briquette production in the year 2006 was measured in the survey (table 6.8). Figures from three producers who stated "0" as turnover (due to internal use exclusively) were left out in the calculations of the mean- and median values. Turnover figures only cover the briquette production of the responding companies, other activities in the companies are not included. (Question No. 19)

Table 6.8. Characteristics of the turnover from briquette production the year 2006

Aggregate turnover of briquette production	253 627 500 SEK
Mean turnover of the briquette producers	10 567 813 SEK
Median turnover of the briquette producers	2 270 000 SEK

6.4.7 Opportunities and threats to briquette production

An attempt to find the external factors forming opportunities and threats to the briquette production was carried out. The producers were asked to fill in the two most important threats to their production, and the two most important opportunities to the production, respectively. Some producers stated only one threat or opportunity, whereas other stated two threats or opportunities. The opportunities and threats pointed out by the producers are presented in table 6.9 and 6.10, respectively. (Question No. 21)

Table 6.9. Opportunities for briquette production according to the briquette producers

Opportunity	Number of respondents
Small scale district heating	4
Increasing prices for oil and electricity	3
Increasing prices for briquettes	3
Increased main production – more by-products	3
Small scale residential heating	2
Environmental issues	2
Decreasing number of briquette producers	2
Briquette producers switching to pellet production	1
New raw materials	1
Wood deficit	1
Briquette prices lower than pellet prices	1

Table 6.10. Threats to briquette production according to briquette producers

Threat	Number of respondents
Raw material deficit / increasing raw material prices	8
Competition from pellet producers	5
Increasing prices for electricity	2
Briquetting equipment malfunction	2
More briquette producers in the local area	1
Import of briquettes from Asia	1
Our customer reconstructs their combustion equipment	1
Increasing use of raw material as agricultural bedding	1
Unprocessed wood fuels for small scale heating	1
Customer demands for pure wood in the briquettes	
(No threats)	(2)

6.4.8 Advantages and disadvantages for the customer using briquettes instead of pellets

The respondents were asked to describe their opinion of the advantages and disadvantages of using briquettes instead of pellets, from a consumer's point of view. The number of answers from the different producers varied. The results regarding the advantages are presented in table 6.11, and disadvantages in table 6.12. (Question No. 23 and 24)

*Table 6.11. The customer advantages of using briquettes instead of pellets, described by the briquette producers. *not correct according to Swedish Wood Fuel Association; calorific value for pellets is 4,8 kWh / kg, briquettes 4,7 kWh/kg. **One producer stated that the briquettes are milled before combustion, hence there are no advantages compared to pellets, which is also milled before combustion*

Advantages	Number of respondents
Lower price	13
No need for investment in pellet burner / pellet stove	4
Easier to transport	2
More cozy fire than pellets fire	1
Quality differences	1
Higher calorific value*	1
(No advantages**)	(2)

Table 6.12. The customer disadvantages of using briquette instead of pellets, described by the briquette producers

Disadvantages	Number of respondents
Takes more work, no automation equipment available for small–scale use	8
Takes a larger investment in feeding system / more expensive systems	5
Problem with oxygen supply in small-scale combustion	1
Less flexible in combustion facilities	1
(No disadvantages)	(2)

6.4.9 Advantages and disadvantages with briquette production compared to pellet production

To compare briquette- and pellet production, the respondents were asked about the advantages and disadvantages of being a briquette producer instead of a pellet producer. The dominating advantage, shown in Figure 6.19, is that the production process is more simple in briquette production than in pellet production. The respondents stating "Other" points out that briquette production requires less space and less labor than pellet production. (Question No. 25)

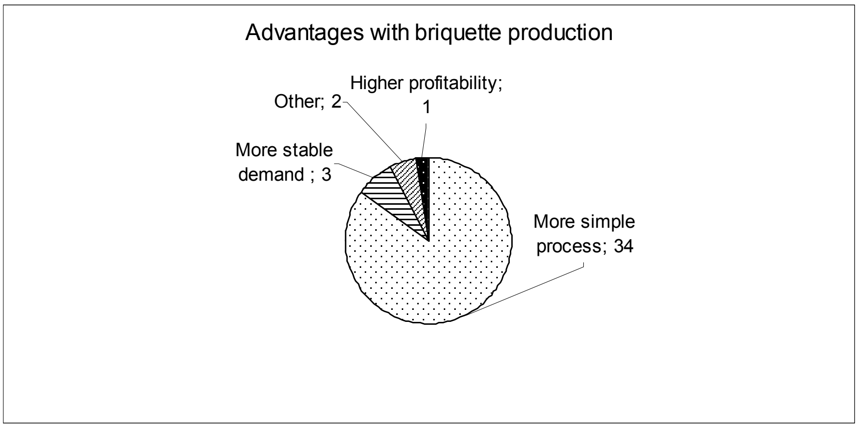

Figure 6.19. Advantages with producing briquettes instead of producing pellets. The figures show the number of respondents selecting each category.

The disadvantages associated to briquette production in relation to pellet production are that the demand for briquettes is more insecure than the demand for pellets. Another disadvantage is that the product is unknown, compared to pellets. The respondents stating "Other" pointed out that the customer's willingness to pay is low, that the market is small with a low number of briquette users, that there is no system for automatic packing of the product and that the customers are powerful and try to press prices downwards. Four producers that stated "Other" commented that there are no disadvantages at all. In Figure 6.20, the distribution of the disadvantages is shown graphically. (Question No. 26)

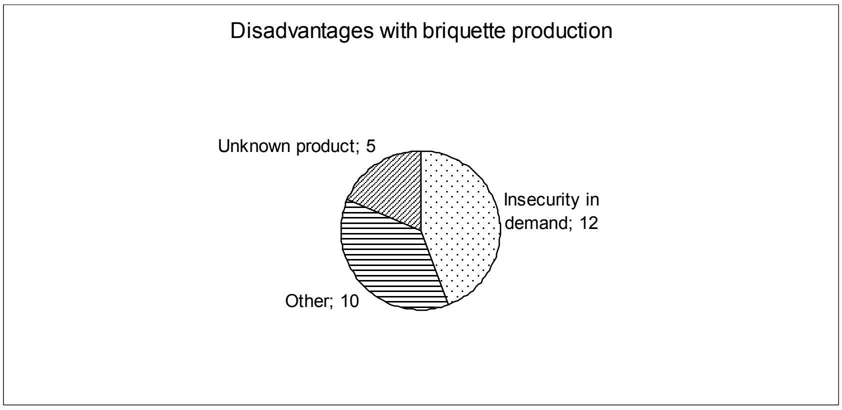

Figure 6.20. Disadvantages with producing briquettes instead of producing pellets. The figures show the number of respondents selecting each category.

6.4.10 Marketing channels

The marketing channels that the briquette producers use are presented in Figure 6.21. Word of mouth is the dominating marketing channel, there are only a few producers using other marketing channels. Of the producers stating "Other", three producers sell their briquettes actively in various ways, another only replies to offers from buyers and a last producer sells his briquettes to a bio fuel trading company. (Question No. 27)

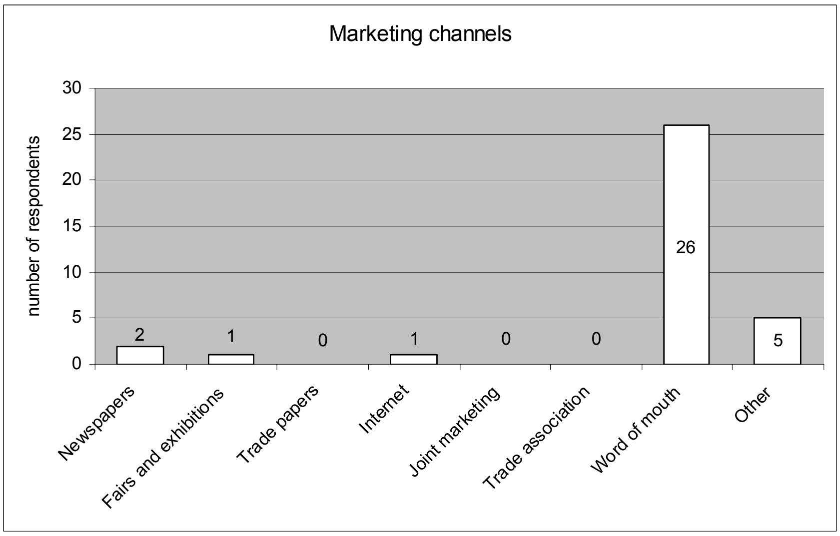

Figure 6.21. The marketing channels used by briquette producers for marketing of their product.

6.5 Company structures

In this fifth and last part of the results, the characteristics of the companies producing briquettes are presented. The summary of the results shows that:

- New small-scale producers are emerging continuously
- The largest investment in briquette production was made in the year 1989
- Joineries are the most common type of company producing briquettes
- Briquetting is seen as an economical way of taking care of by-products in wood industries
- Few producers follow standards for solid bio fuels
- The responding companies have 110 employees working with briquette production

6.5.1 Production start

The starting years of the briquette production plants are shown in figure 6.22. Most plants initiated their production during the 1990´s, but there are also many plants that were started between the year 2004 and 2007. The production capacities installed each year are listed in Figure 6.23. (Question No. 34)

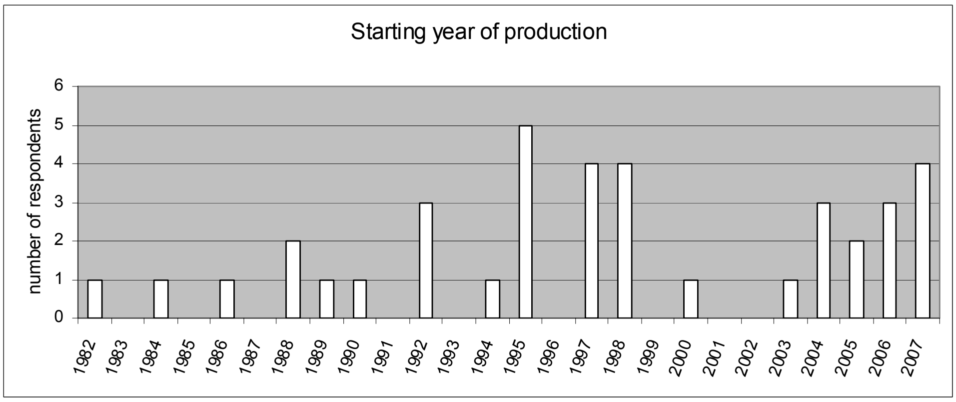

Figure 6.22. Starting year for briquette production in the Swedish production plants. The bars show the number of briquette producers initiating their production during the years 1982-2007.

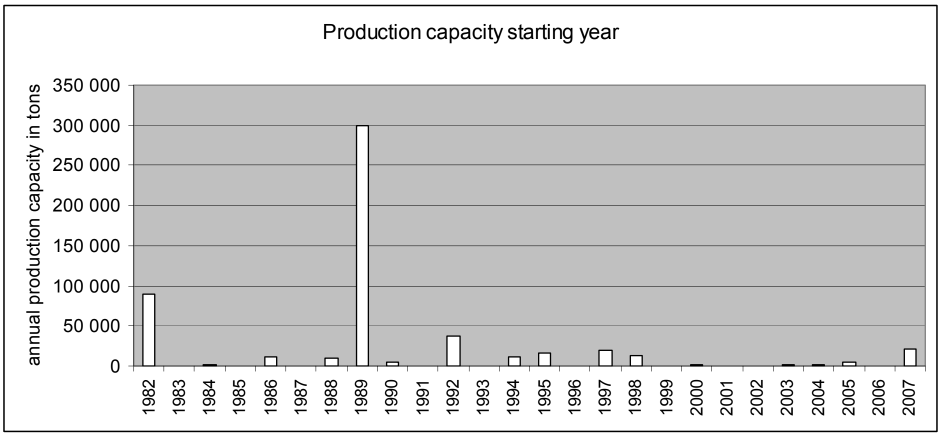

Figure 6.23. Distribution of starting years for briquette production capacity. The bar height represents the total capacity installed each year. The division of the bars shows the composition of the year's installed new capacity.

During this study, 64 confirmed briquette producers were contacted. But the number of responding briquette producers in this study is lower. As 13 of the contacted companies did not want to respond, 51 producers participated in the study. In figure 6.24, the development of the number of producers is shown. The aggregate number of producers is higher than displayed in the figure as 14 producers did not state their production start year.

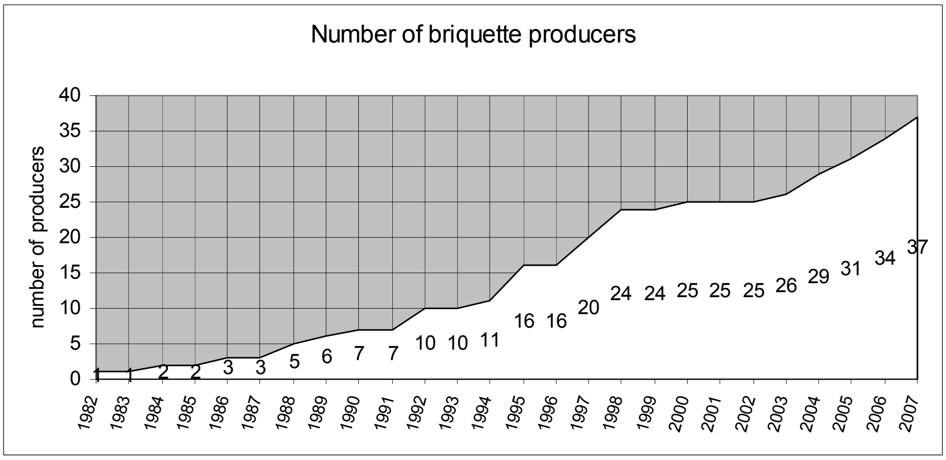

Figure 6.24. The development of the number of briquette producers in this study. The total number of responding producers in the year 2007 are 51, but 14 respondents did not state their year for production start.

6.5.2 Ownership of the production

The ownership structure of the companies producing briquettes is shown in Figure 6.25. The dominating company type is limited companies in different sizes. A small number of briquette producing plants are owned by large economic associations of farmers or forest owners. In most cases, the small limited companies are joineries or planing mills producing briquettes from their waste products. (Question No. 37)

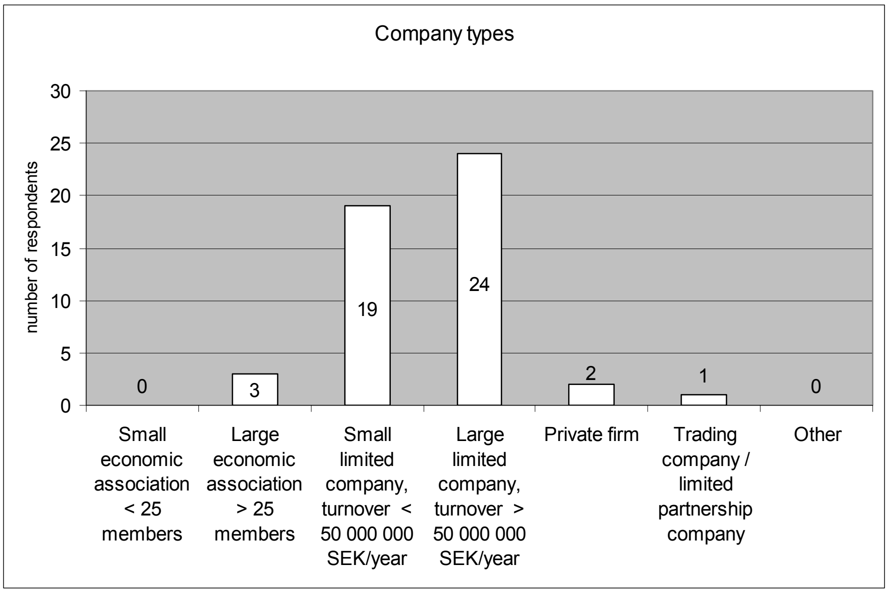

Figure 6.25. Ownership structure of briquette producing companies in this study.

6.5.3 Core businesses

The companies producing briquettes belong to several different industries, see Figure 6.26. Only seven of the responding companies stated that briquette production was their core business. Saw mills, joineries and planing mills in different sizes are common types of briquette producers. Three producers were owned by companies that stated pulp- and paper as their core business, but these briquette producing plants are located at saw mills included in the same company group. Two other producers are owned, either directly or indirectly, by municipal heat- and power producing companies. Fourteen producers stated that they have other core businesses than the alternatives given in the questionnaire, these core businesses are listed in table 6.13. (Question No. 38)

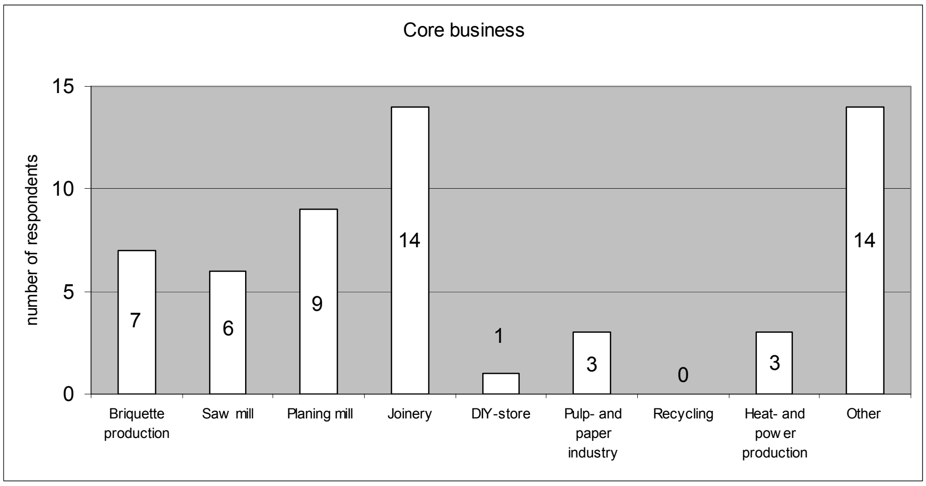

Figure 6.26. Distribution of core businesses of the briquette producing companies in this study. (DIY-store means "Do it yourself store")

Table 6.13. Core businesses of briquette producers stating "Other" in Figure 6.24

Core business	Number of producers
Pellet producer	3
Furniture producer	2
Board producer	2
House producer	2
Agriculture / silviculture	2
Boat producer	1
Paper products	1
Flooring	1

6.5.4 Motives for briquette production if other core business than briquette production

The respondents that did not state briquette production as their core business were asked to state the motives to why they started to produce briquettes. 19 respondents stated that the main reason was that briquette production was considered being a good way to take care of the by-products / waste and that it was believed to simplify the handling of the by-products. Five respondents emphasized the economical benefits with using their waste products as raw material for briquettes. Two of the respondents emphasized environmental factors as crucial in the decision to start briquette production. One producer stated that the convenient storing of briquettes was a crucial factor. A last producer wanted to find a new field of applications for hemp, as other crops had too low profitability. (Question No. 39)

6.5.5 Types of products

The briquette producers are in some cases producers of other types of DBF:s. There are 64 producers of briquettes contacted in this study (of which 51 responded to the questionnaire). Eight companies also produce pellets, whereas there are only two companies producing both "loggs" and briquettes. "Loggs" are brick-shaped DBF:s suitable for small-scale heating in stoves and furnaces. (Question No. 1)

6.5.6 Different types of briquettes

15 respondents stated that they only produce one type of briquettes. Four respondents stated that they produce briquettes of different diameters; 50 mm, 60 mm and 65 mm. Three companies use different raw materials for different types of briquettes; wood and peat in different combinations, and saw dust and reed canary grass in different combinations. The third company with different types of briquettes produces briquettes both from recycled wood and saw dust, using two different diameters. The results are also shown in table 6.14. (Question No. 3)

Table 6.14. The number of respondents producing briquettes in different forms

Different types of briquettes	Number of respondents
No different forms, only one type	15
Different diameters; 50, 60 and 65 mm	4
Different raw materials	3

6.5.7 Production in accordance to standards

Table 6.15 shows the number of companies producing their briquettes according to a standard. Of the responding companies, 19 stated that they do not produce the briquettes according to any standard at all. Four companies believed that the size of the briquette was a standard and stated that they produce briquettes according to the 70-mm standard[4]. Four other companies stated that they produce their briquettes according to the SIS SS 187123 standard. Of those four, one is connected to group 1 within the standard, another stated that they are connected to group 2 within the standard, whereas two of the four respondents did not state which of the groups they are connected to. Three other companies stated that they produce briquettes according to the 75-mm standard. (Question No. 2)

Table 6.15. The number of companies producing their briquettes according to different standards

Standard	Number of producers
No standard	19
70-mm standard	4
SIS SS 187123 group not specified	2
SIS SS 187123 group 1	1
SIS SS 187123 group 2	1
75-mm standard	3

[4] mm- measurements are not standards for briquettes

6.5.8 Labor

The number of employees working with briquette production in this study is 110. The largest producer has 70 employees, the second largest has 13 employees and the third largest has five employees. The distribution over different employee categories (e.g. production, administration and sales) is not specified. Table 6.16 shows some key figures for the employment issues related to briquette production. Part time work is common, 16 producers have 0,5 or fewer employees in their briquette production. The number of employees dedicated for this work in the small scale production is obviously very low. (Question No. 7)

Table 6.16. Number of employees in Swedish briquette production

Total	110 employees
Mean value	3,78 employees
Median value	0,5 employees

7. Discussion

In this chapter, the results of the study are discussed and compared to previous results. The discussion is divided into three areas. The areas are:

- General discussion
- The Five force model – industry analysis
- Survey design discussion

7.1 General discussion

7.1.1 Production level development

The aggregate production of briquettes has increased from 209 400 tons in the year 2000 (Hirsmark 2002) to 279 540 tons in the year 2006, an increase by 33 %. The historical development of the briquette production in Sweden is shown in Figure 7.1, in which data from two different surveys are presented. The production data from the year 1990 to 2000 (Hirsmark, 2002) is somewhat unreliable as the number of respondents in that survey was very low, ranging from one respondent for the years 1990-1999 to five respondents the year 2000. As this study has shown, the number of producers in the year 2000 was at least 25. A possible conclusion to draw from the data is that the mean production of briquettes during the years 2001-2007 is higher than the mean production during the 1990's.

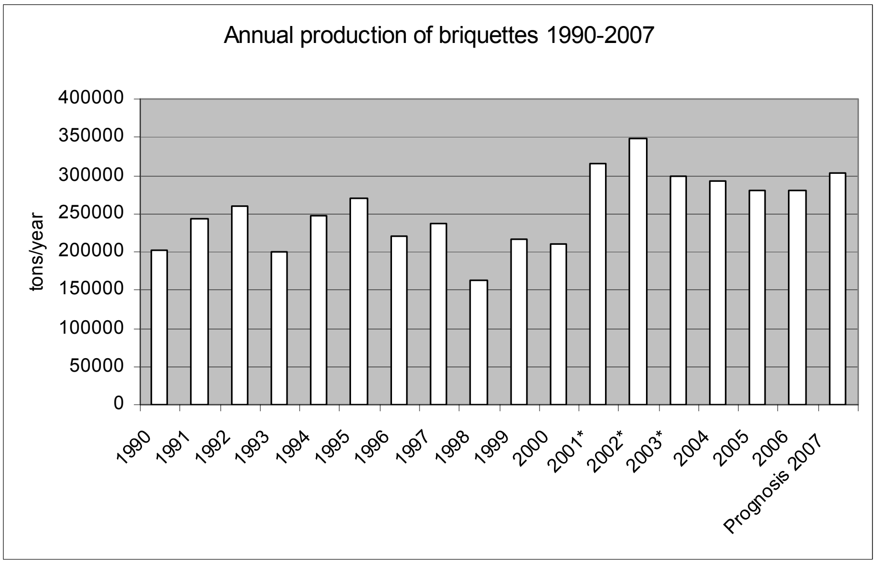

*Figure 7.1. The annual production of briquettes in Sweden between the years 1990 and p2007. *questionnaire values from 2001-2003 are completed with data from Bioenergi No 1 2002, Bioenergi No 1 2003 and Bioenergi No 1 2004 as the largest producer did not state its production for these years. Source for briquette production in the years 1990-2000 is Hirsmark (2002).*

The results from this study show that the production capacity for briquettes has increased from 454 000 tons in the year 2000 (Hirsmark 2002) to 650 015 tons in the year 2007. During the same period, the median size of a production facility has decreased from 8 000 tons (Hirsmark, 2002) to 3 250 tons.

The stability in the actual production and the increase in production capacity may seem surprising as a common belief among people in the industry that has been contacted during this study is that the production has decreased during the last years. A possible explanation could be that the large-scale production has decreased, but that a number of small- and medium-scale producers have emerged and contributed to an increase in the aggregate production.

There seems to be an increasing interest for briquette production. During 2007, the new installed capacity was over 21 000 tons, which is higher than for a long period of time. A large number of companies have started producing briquettes since the year 2000. The capacity is continuously expanding and there are a large number of companies using their by-products as raw material for briquette production. Why does the number of producers increase? A possible explanation is that the increased price for energy has made it more interesting to use the waste products for heating in the company's housing. This is a way of increasing the overall profitability of the company. The costs for heating decreases and the waste is used in an economical way. This explanation is possible for the small-scale producers.

For the larger producers, which do not primarily use the briquettes for their own heating, other factors may determine the decisions. But basically, the prices for other energy sources determine the profitability for the briquette production. An example of a larger briquette producer is a larger saw mill. Saw mills that use their by-products as raw material for briquette production will increase their overall profitability if the customers pay more for the briquettes. Bio energy is gaining in attention and attractiveness. District heating plants are using more and more renewable energy (Energimyndigheten, Energy in Sweden 2006, 2006) and the demand for bio energy increases. Hence, the interest of making money by selling by-products in a densified form is increasing.

For the producers that buy all their raw material, the situation is somewhat different. They are more sensitive to increases in the price of the raw material as these prices constitute a larger share of the company's total economy. They do not have another business to fall back into if the profitability of the briquette production decreases due to expensive raw material. Future investment projects in large scale briquette production needs to secure the raw material supply before execution of the investment plans. If the present increase in demand for wood fuel continues, potential producers of DBF:s may have to broaden the raw material base by considering other types of raw materials than wood fuels. Long term relationships with raw material suppliers will probably be of increasing importance for survival of the DBF producers.

An interesting fact is that the planned expansion during 2008-2009 is 3,8 % of the planned production in 2007. This is very close to the estimated increase by 4,1 % which was calculated based on each company's current production and estimated change in production during the two years to come. This fact strengthens the reliability of the results regarding the future development of production levels.

However, the producers may be overestimating the future increase in the aggregate Swedish briquette production in relation to the actual planned production. A majority, 68 % of the producers, believe in a 27 % increase in the aggregate production, whereas 32 % of the producers believe in a 14 % decrease in aggregate production. Possibly, they tend to believe that other producers than themselves are going to expand their production. This could possibly be explained by that a large number of producers are small-scale producers with limited knowledge of the district heating market, which has a dominating share of the aggregate briquette consumption.

The producers' interests for standards seem to be low. Not only among small-scale producers, but also among the larger producers. As the results showed, there were only few of the producers who were connected to standards. This is surprising, especially that the larger producers showed such low interest. As described earlier, standardization can offer several competitive advantages in marketing of the product. A possible reason to the low degree of standardization could be a low interest from the buyers. Another possible explanation could be that for the smaller producers, affiliation to a standard is a process taking much time and resources from other tasks. For very small producers that use their briquettes for their own heating or sells only to little extent and to small scale customers, standardization is not likely to be necessary.

7.1.2 Raw material

The raw material situation in general seems to be satisfactory at first glance. As 80 % of the producers do not experience a raw material deficit, most producers do not have to worry about their supply. Though, one has to take into account that many of the producers use their by-products as raw material exclusively. This means that they do not experience a raw material deficit in the same way as a producer purchasing its raw material. Raw material purchasing producers are naturally more sensitive to raw material deficit than other producers.

The price competition with pellet producers is mentioned as a source of unrest to the companies. This is an additional indication of that the pellet producers are the largest threat to the briquette industry.

Peat has an important role as a raw material for briquettes, which may be controversial and surprising in the light of the discussion of whether peat being a renewable energy source or not. But the fact is that peat is the most important raw material to the largest briquette producer in Sweden. Another large-scale producer is now using peat as raw material, which makes peat's total contribution to the production considerable.

7.1.3 The briquette - pellet relation

The pellet production has increased steadily during the last 10 years (www, PiR, 2008). The briquette production has had a more moderate development. In Figure 7.3, the production developments of the two types of DBF:s are compared. Figure 7.4 shows that briquettes are being marginalized on the market for DBF:s; the market share is decreasing every year. As the production of briquettes has remained stable or decreased slightly, the expansion of pellet production has forced the briquette's market share downwards. A probable reason for the briquette marginalization is that there are no successful systems for small-scale automation of briquette combustion. The pellet industry has succeeded in design and marketing of systems for small scale combustion. The pellet share has increased in both residential heating and larger combustion facilities (www, PiR, 2008). Compared to the pellet industry, the briquette industry has failed to make their product suitable for small-scale use. Some use of briquettes for open stoves just for the ambience does occur, but the use of briquettes as the main source for heating is likely to be unusual in comparison to the extent to which pellets are used.

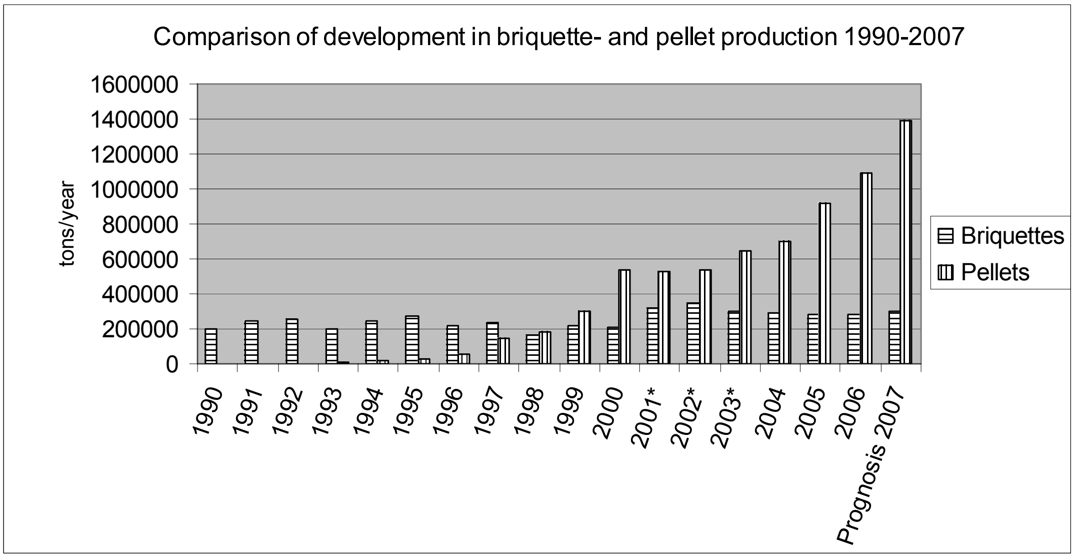

*Figure 7.3 Development of Swedish briquette- and pellet production during the years 1990-2007. *questionnaire values from 2001-2003 are completed with data from Bioenergi No 1 2002, Bioenergi No 1 2003 and Bioenergi No 1 2004 as the largest producer did not state its production for these years. Pellet production figures for the years 1990-1996 has not been found. (Sources: Briquette production 1990-2000: Hirsmark 2002. Briquette production 2001-2007: this study and Bioenergi. Pellet production: PiR).*

The pellet producers are considered being the most important raw material competitors to the briquette producers. As the expansion of the pellet production in Sweden continues, this is likely to deepen during the years to come. In Figure 7.4, the distribution of DBF:s on briquettes and pellets is showed.

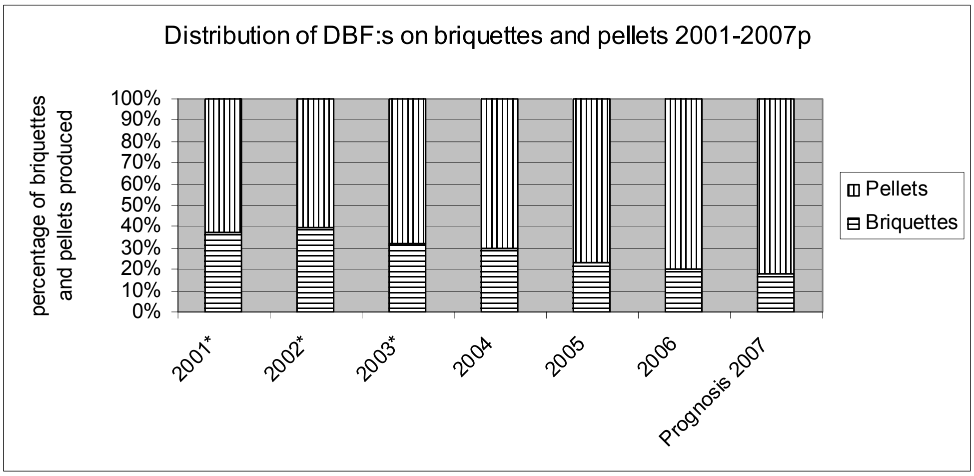

*Figure 7.4. Distribution of DBF:s on briquettes and pellets during the years 2001-2007p. *questionnaire values from 2001-2003 are completed with data from Bioenergi No 1 2002, Bioenergi No 1 2003 and Bioenergi No 1 2004 as the largest producer did not state its production for these years. Source for pellet production data is Höglund 2008.*

7.2 The Five force model – industry analysis

Porter's *Five force model,* presented in a previous chapter, is a framework for analysis of industries or businesses. In this case, the briquette industry is analyzed. Each of the five forces is described based on the data collected in the survey and the conclusions drawn from it. Each force is given a rating, ranging from weak, to somewhat weak, moderate, somewhat strong to strong.

The ***threat of new entrants*** in the briquette industry is somewhat strong. There are a number of motives for this:

- New entrants do not have to invest in a very large unit to be a part of the industry. As this study has shown, small scale production is common and likely to be profitable.
- The degree of product differentiation in the Swedish production is very low, the briquette is a typical bulk product.
- The capital requirement for investment in briquette production is moderate. If the company already has housing and equipment for handling available in other parts of the business, the investment can be very low. For a company starting from scratch, investments are naturally higher.
- The switching costs for a buyer of DBF:s to change supplier are likely to be low.
- A new entrant can easily get access to distribution channels.
- A factor diminishing the threat of new entrants is cost disadvantages independent of scale. Firms already in the industry may have tied up the best located or most suitable raw material suppliers. The raw material used for briquette production has a low value density and thereby it can not be long-range transported. The supply options can be limited for a purchasing briquette producer.

Altogether, these factors point at a considerable risk for new entrants.

The ***rivalry among existing firms*** in the briquette industry is moderate. The motives for this are that:

- A factor that decreases the rivalry is that the capacity does not need to be expanded in large increments. Large increments in capacity may disturb the supply / demand balance.
- Besides, the strategic stakes in the industry are probably low. High strategic stakes can make companies sacrifice a business to favor the overall strategy.
- The industry growth is low, as presented in this study. Companies have to gain in market share to grow which increases competition.
- The exit barriers for the producers are moderate with limited amounts of capital bound in machinery and housing. High exit barriers force the existing companies to stay in business, to some extent.
- The fixed costs and costs for storage are moderate. High costs can force the producers to use all the capacities available to cover the fixed costs.
- The competitors are diverse, varying in size, character and behavior. Companies in industries composed of diverse companies tend to be more irrational and inconsistent in behavior. This may lead to sub optimization of the industry as a whole.
- The product lacks in differentiation, making it a commodity. Price and service will be means of control, pushing prices down.

The sum of the factors determining the rivalry among existing firms indicates that the rivalry is likely to be moderate.

The ***pressure from substitute products*** is a strong force. It is probably the strongest of the five forces in the briquette industry. Hence, this force is the key issue to take into account when formulating the competitive strategy for a briquette producing company. The briquette-pellet relation is previously described in a separate part in this chapter.

- The pellet industry has increased its share of the DBF:s and is a substitute with characteristics similar to those for briquettes. Pellets are suitable both for small- middle- and large-scale heat production and the use of pellets increases rapidly. Pellets are a more well known product than briquettes and suitable for automation in every segment size, favoring the market trend.
- The use of forest fuels or wood chips are increasing on the energy market. The fuel characteristics are not similar, but the costs per MWh (which is the most interesting factor for district heating customers) are competitive. Besides, the supply of forest fuels is increasing as more and more forest owners sell their tops and branches from thinnings and final fellings.

The ***bargaining power of suppliers*** in the briquette industry is likely to be somewhat strong. There are a number of different motives for this:

- The number of suppliers available within the geographical area in which the company is operating is probably low in many cases. This makes it easier for the supplier to raise the price without losing the briquette producer as a customer.
- The producer does not have many substitutes for the supplier's product. This strengthens the suppliers and price increases are facilitated.
- The supplier's product is a very important input to the producer. Access to raw material is crucial for the briquette production.
- A factor weakening the supplier's position is that their product is undifferentiated and that the potential switching costs for the briquette producer are low.

Taken together, these conditions make the bargaining power of suppliers relatively strong.

The ***bargaining power of buyers*** from the briquette industry is a strong force. The following conditions are important in this case:

- The buyer purchases large volumes relative to the briquette producer's sales. This makes the briquette producer more dependant on the buyer, resulting in a better position for negotiating for the buyer.
- The briquettes constitute a significant fraction of the buyer's cost of purchases. Buyers become more price sensitive.
- Briquettes are undifferentiated bulk products. The buyer is likely to have many alternatives and can play the producers against each other.
- If the buyer wants to switch to another fuel, the switching costs are likely to be low.
- The briquette does not influence the quality of the buyer's product, which makes the buyers more price sensitive.

- A factor generally weakening the buyer is that the heat producers earn high profits. Buyers earning low profits are more price sensitive. On the other hand, this factor has limited importance as the briquettes constitute a large fraction of the purchase costs, as already mentioned.

Of the five forces presented, the threat from substitute products is probably the strongest force and the bargaining power of buyers is likely to be the second most powerful force influencing and shaping the industry. These two forces are the most important to consider for a briquette producing company formulating its competitive strategy.

7.3 Concluding discussion

The briquette industry is an industry active in a politically favorable environment. The expansion of the district heating and the national and international ambitions to increase the share of renewable energy puts reliable wood fuels as briquettes and pellets in a good position. Besides, the tax system favors most bio fuels by exempting them from energy taxes. Yet, the production of briquettes has had a moderate development throughout the last decade. There are a number of possible explanations to this unexpected moderate development.

- The increasing competition for raw material has had a negative impact on the profitability of the industry and thereby the investments related to the industry.
- An insecurity of the future demand for briquettes.
- The pellet industry has gained in attention and pellets has become a more well-known and accepted product than briquettes.

Among different people contacted during this study, there seems to be a low belief in the future development of the briquette industry. Many people, with a few exceptions, anticipate decreasing production volumes among large scale producers. This attitude is not reflected in the results of this study though. The trend is that the large producers decrease or keep the production pace, whereas the many emerging companies producing in small scale tend to increase their production, resulting in a relatively stable aggregate production.

The benefits of briquettes need to be communicated in a more offensive way than today. Trade associations related to briquette production could work more actively with marketing of the concept of briquettes to increase the awareness of the briquettes. The lack of marketing of the product may be interpreted as a sign of an underdeveloped industry.

Opportunities associated with the future production of briquettes are e.g. broadening of the raw material base and penetration of the growing small scale district heating market.

The briquette industry is going to meet several challenges in the near future. Raw material competition from an expanding pellet production and other future consumers will be of crucial importance for the performance of the industry. In particular, the producers purchasing their raw material will be sensitive to further price increases for the raw material. The bargaining power of the briquette producers is another crucial factor for the development; the producers are weak in the relation to the buyers of their products and need to strengthen their position.

The smaller producers, using their own by-products as raw material, is likely to face a more promising future, with good profitability as their raw material costs are low. Alternative fields of applications may emerge for the raw material, such as gasification of biomass into ethanol or methanol. If other users of the raw material emerge, it could become more profitable to sell the planer shavings or saw dust instead of refining them internally, all depending on the technologies available and price development for different raw materials and energy forms.

7.4 Survey design

7.4.1 Sources of error

A potential shortcoming in the study is the identification of the briquette producers. There is a risk that there are more producers of briquettes, not included in the population. Producers that are using other brands of machinery, e.g. the Danish brand C.F. Nielsen, which has turned out to have a small number of machines operating in Sweden. Or producers that, by some reason, was not included in the customer lists from Bogma and Mared despite that they are using machinery from those manufacturers.

There are five companies obtained from the address list used in the questionnaire survey whose briquette production has closed down. One of the companies stated that they had sold their equipment back to Bogma, the manufacturer of the machines. The other companies did not know where the machines were. A probable answer is that the equipment has been sold to Bogma or to another briquette producer, either new or existing producer. Hence, there is a risk that the equipment from these four remaining producers is used in production and not covered by this study.

But despite these facts, there is a good chance that the great majority of the producers are in fact included. Two important breakthroughs in the searching for producers were when the customer lists from Bogma and Mared were obtained. Without these, the results would have been more insecure.

Another shortcoming is that there is a possibility that there are producers that has closed down their production during the last years. These producers might have had a contribution of production in the years 2001-2006, but are not likely to have an important contribution to the production in the year 2007. The process of identifying producers was initiated in June 2007 and should cover active producers, as discussed earlier.

7.4.2 What could have been done differently?

A measure that could have improved the reliability of this study would have been to send out the questionnaires earlier than what was actually achieved. This would have given more time to follow up the non responding companies, which probably would have improved the response frequency.

In this study, an attempt to map the production of “Loggs” was carried out. This part of the study had a low priority in the preparations. No effort was put in to identify the loggs producers before the questionnaire was sent out. The assumption before this study was that some of the briquette producers also worked with production of loggs. This turned out to be partly true, but only two producers were found among the briquette producers. Besides, only one loggs-related answer was obtained from the questionnaire. Hence, the loggs-related data from questionnaire is very insecure. The loggs-related data was therefore excluded from the result presentation. To reach the loggs producers, a similar method as used in the identification of the briquette producers could have been used, i.e. contacting machinery manufacturers.

Another interesting view that could have given a better insight into the producers' plans and strategies for the future would have been to ask if they planned to change from briquette production to pellet production. In a possible future follow up survey, this type of future oriented questions would be an important contribution to the understanding of the industry.

7.4.3 Further research

An interesting study would be, as mentioned above, to look into the other side of the market, with a briquette buyer perspective. How do the buyers of bio fuels in district heating plants reason and how do they value briquettes in comparison to other bio fuels as pellets, tops and branches, waste and recycled wood? That would be an important complement to this study.

Another interesting study could be a case study of an emerging briquette producer, preferably a large-scale producer. A study of how the company works with raw material supply strategy, customer relations and marketing. A more profound industry- or business analysis based on the *Five force model* could help explaining and defining the competitive environment.

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9. Appendices

Appendix 1. Questionnaire

Company information

Company____

Is the company part of a group of companies? If yes, which group?__________

Street address____

Postal address____

Phone number____

E-mail____

Web page____

To be able to obtain additional information about the company, please enter your personal contact information:

Your name____

E-mail and phone number_________________________________

Your position in the company______________________________

Production

1. What products do you produce?

- ☐ Briquettes
- ☐ "Loggs" (brick shaped)
- ☐ Pellets

2. Do you produce your briquettes according to a standard? If yes, which standard?

....
.

3. Do you produce different kinds of briquettes? If yes, explain why and describe the different types.

....
…………………………………………………………………………………………………......
……………………………………………………………………………………………………

4. What is your maximum production capacity of briquettes per year?

…………… Ton

5. What is you maximum storing capacity of briquettes?

…………… Ton

6. Do you plan to expand your briquette production capacity?

☐ Yes

☐ No

☐ Do not know

If yes, enter the planned additional production capacity per year.

……..…. Ton

7. How many full time employees do you have totally in production, handling and administration of briquettes?

………………………full time employees

Additional information …………………………………………………………………….....

Production process

8. Which briquette press brands do you use?

☐ Bogma ☐ Nazzareno
☐ Adelmann ☐ Other, what?..

9. What types of equipment do you use in the briquette production?

☐ Drying equipment ☐ Milling equipment
☐ Mechanical piston press ☐ Hydraulic piston press
☐ Conditioning equipment (steam softening)
☐ Cooling track

10. How do you store the briquettes?

☐ Out doors under roof ☐ Indoor storing
☐ Silo ☐ Other, what?........................

11. How do you pack the briquettes?

☐ Small bag ☐ Bulk
☐ Small sack ☐ Other, what?........................

12. Which of the following are the most usual causes for possible production problem?

- □ Raw material deficit
- □ Raw material quality
- □ Running in problems
- □ Storing problems
- □ Drying equipment malfunction
- □ Other production equipment malfunction

□ Other …………………………………………………………………………….

Market

13. Which are your main market segments for briquettes? Fill in the share of your yearly production delivered to the different customer segments.

Large-scale (over 2 MW) ………… % (Heat plants / CHP-plants)

Middle-scale (50 kW – 2 MW) ………… % (Small-scale district heating, schools and industries)

Small-scale (less than 50 kW) ………… % (Residential- and smaller properties)

14. In what way has the demand for briquettes changed since the year 2000?

Large-scale (over 2 MW)
□ Increased □ Decreased □ No change

Middle-scale (50 kW – 2 MW)
□ Increased □ Decreased □ No change

Small-scale (less than 50 kW)
□ Increased □ Decreased □ No change

15. What is your view of the future of you own briquette production? Estimate how your production has changed in two years compared to today. Fill in estimated percentage increase or decrease compared to today's production.

+…………….%
-..…………......%

16. What is your view of how the Swedish briquette production will change the coming two years? Fill in the estimated percentage increase or decrease compared to today's production.

+…………….%
-..…………......%

17. What is your view of how the price of briquettes will change in the coming two years? Fill in the estimated percentage increase or decrease compared to todays price levels.

+…………….%
-..…………......%

18. Which of the following market actors or markets are you main raw material competitor? Place the following alternatives in order of precedence, write 1 for the most important competitor, write 2 for the second most important and write 3 for the third most important competitor.

__ Saw mill
__ Pulp mill
__ Board industry
__ The international market
__ Other briquette producer
__ Pellet producer
__ Heat plants / CHP-plants
__ Agriculture
__ Other, what?……………………………………………

19. Fill in the turnover of the briquette sales during the year 2006.

……………………… SEK

20. Fill in the turnover of the "loggs" sales during the year 2006.

……………………… SEK

21. Which are the two most important opportunities for and two most important threats to your future briquette production?

Opportunities	Threats

22. Fill in the approximate distribution of costs for your briquette production:

Machines	___________%
Housing	___________%
Raw material	___________%
Energy	___________%
Labor	___________%
Administration and sales	___________%
Other	___________%

Comments:

....

……………………………………………………………………………………......

23. What is, in your opinion, the customer **advantage** of using briquettes instead of pellets?

....

…………………………………………………………………………………………......

....

…………………………………………………………………………………………......

24. What is, in your opinion, the customer **disadvantage** of using briquettes instead of pellets?

....

……………………………………………………………………………………………….....

....

……………………………………………………………………………………………….....

25. What is, in your opinion, the **advantage** of producing briquettes instead of pellets?

- ☐ More simple process
- ☐ Higher profitability
- ☐ More stable demand
- ☐ Other; what?

....

……………………………………………………………………………………………….....

26 What is, in your opinion, the **disadvantage** of producing briquettes instead of pellets?

- ☐ Insecurity in demand
- ☐ Unknown product
- ☐ Other; what?

....

……………………………………………………………………………………………….....

27. Which one is the most important marketing channel towards current and potential briquette buyers?

- ☐ Ads in newspapers
- ☐ Participation in fairs / exhibitions
- ☐ Ads in trade papers
- ☐ Ads on the Internet
- ☐ Joint marketing with other briquette producers
- ☐ Marketing through trade organization
- ☐ Word of mouth
- ☐ Other; what?

....

……………………………………………………………………………………………….....

Raw material

28. Which are the most important raw materials for your briquette production? Place the following alternatives in order of precedence, write 1 for the most important raw material, write 2 for the second most important and write 3 for the third most important raw material!

_____Saw dust	_____Recycled wood
_____Planer shavings	_____Peat
_____Wood chips for pulp	_____Hemp
_____Rejected wood chips for pulp	_____Agriculture residues
_____Cutting residues	_____Short rotation coppice (Salix)
_____Rejected pulp wood	_____Paper
_____Pulpwood	_____Plastic
_____Other; what…………………………..	

29. From where do you get the raw material for the briquette production?

By-product from our own production ……... %

Purchased raw material ……... %

30. What sort of wood do you mainly use in your briquette production?

Scots pine…………………………%

Norway spruce………………..……...%

Birch………………………...%

Other………………………..% What?........................

31. Do you use any additives in the briquette production? If yes; what additive?

………………………………………………………………………………………………......

32. Does you company import any raw material for the briquette production?

□ Yes, from the following country / countries: …………………..…………………………………..
□ No

If the company imports raw material, how large is the share of imported raw material in relation to the total raw material use at the briquette production facility ……... %

33. Does the company experience difficulties in finding raw material for the briquette production?

□ Yes
□ No

If yes, what is the main reason for this?
………………………………………………………………………………………………......
………………………………………………………………………………………………......

History

34. What year did the company start producing briquettes?

Year……………………

35. Please fill in your annual production of briquettes during the latest years.

	2001	……………. Tons
	2002	……………. Tons
	2003	……………. Tons
	2004	……………. Tons
	2005	……………. Tons
	2006	……………. Tons
Planned production	2007	……………. Tons

36. Please fill in your annual production of "loggs" during the latest years.

	2001	……………. Tons
	2002	……………. Tons
	2003	……………. Tons
	2004	……………. Tons
	2005	……………. Tons
	2006	……………. Tons
Planned production	2007	……………. Tons

37. How is the ownership of the company?

- ☐ Small economic association < 25 members
- ☐ Large economic association > 25 members
- ☐ Small limited company, turnover < 50 000 000 SEK/year
- ☐ Large limited company, turnover > 50 000 000 SEK/year
- ☐ Private firm
- ☐ Trading company / limited partnership company
- ☐ Other, what?...

38. What is the company's core business ?

- ☐ Briquette- / "loggs"-production
- ☐ Saw mill
- ☐ Planing mill
- ☐ Joinery
- ☐ Other; what?.......................................
- ☐ DIY-store (Do It Yourself)
- ☐ Pulp- and paper industry
- ☐ Recycling
- ☐ Heat- / power production

39. If briquette-/ “loggs”-production isn’t your core business, which were the key reasons for starting to produce briquettes or “loggs”?

....

…………………………………………………………………………………………………....

Thank you for your participation in this study. Please return the questionnaire in the pre-paid envelope before nov 16

Appendix 2. Response frequencies

Question No.	Number of respondents	Response frequency, %
1	51	100
2	27	53
3	23	45
4	42	82
5	36	71
6	42	82
7	29	57
8	44	86
9	40	78
10	43	84
11	39	76
12	36	71
13	44	86
14	29	58
15	37	73
16	22	43
17	31	61
18	24	47
19	32	63
20	1	2
21	19	37
22	26	51
23	20	39
24	19	37
25	34	67
26	26	51
27	31	61
28	45	88
29	47	92
30	37	73
31	37	73
32	44	86
33	35	69
34	38	75
35	44	86
36	0	0
37	46	90
38	47	92
39	27	53

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