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Straw in Skåne

The imminent development of the Skåne straw market triggered by the Örtofta Biomass Boiler

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Abstract

Biomass energy production is changing the dynamics of energy and agriculture. Straw, which was once considered a waste product, is now being used to fuel straw biomass boilers. These boilers have existed for some time as small-scale, low capacity farm boilers. In 2010 Lunds Energi Koncern will build a 145 MWh biomass boiler in Örtofta, Sweden. The 80,000 tons of straw required a year will create an exogenous shock to the small straw market.

This paper explores the commoditization and market development of straw in Skåne. Straw boilers in Denmark, the United Kingdom, and Spain are examined for influential factors. A discussion of price indicators is presented, along with an analysis of economic triggers which could influence the regional price of straw. Local conditions and attitudes are also provided by a Skåne farmer survey. The circumstances pertinent to this case indicate a rapidly increasing price of straw concurrent with the institutionalization of a formal straw market in Skåne.

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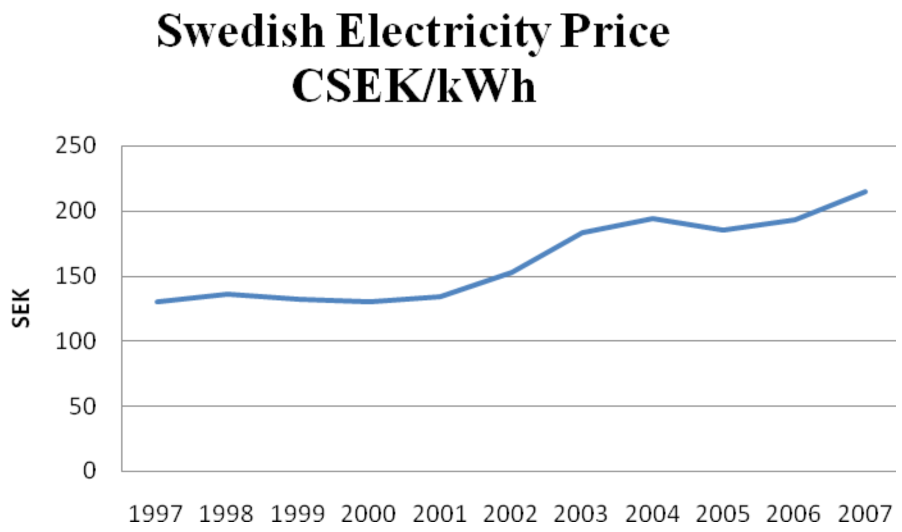
Introduction

Research Topic

The energy market is changing. There is currently strong pressure on energy supplies; rising energy prices and a growing demand for energy create pressure to increase energy supply through innovative means. As electricity prices rise in Sweden (Figure 1) renewable energy sources become increasingly attractive.

Innovative energy solutions such as biomass energy production are being embraced. Biomass energy production is an outspoken priority for the Swedish Government (Ministry of Agriculture, 2008). Bioenergy prospects are strengthened by low emissions and a large supply. The environmental impact of biomass electricity production is lower than fossil fuel alternatives. Emissions contain no sulfur and are carbon dioxide neutral (Flavin, 1994). When crops grow, they absorb carbon dioxide from the atmosphere, thus negating any greenhouse gas emissions that result from burning the biomass (World resources Institute, 2006).

Figure 1



Source: Official Statistics Sweden

Note: Based on household consumers (70 m2, 3 rooms + kitchen), prices include VAT & grid charges

One such biomass solution is the new Combined Heat and Power Plant in Örtofta, Sweden. Among its four biofuel sources is straw, which was previously regarded as a waste product from cereal grain production. The procurement of straw at the scale necessary to fuel the biomass plant will create a scenario never before experienced in the history of Skåne.

Aim & Justification

The 2010 activation of the Örtofta District Heating Plant will create an exogenous shock to the small straw market in Skåne. Because of its unprecedented nature, it could potentially cause disruptive effects to the underdeveloped and virtually non-existent straw market. Of primary concern is the overnight emergence of a new straw market. The absence of such a straw market is due to the fact that virtually all straw is currently consumed by the farmers themselves. Traditionally, straw is used to cover agriculture, feed livestock, and enhance soil composition. The purpose of this thesis is to explore the potential price impacts and consequences of the straw market triggered by the creation of a new District Heating Plant in Örtofta, Sweden.

Research Question

How will the Örtofta Heating Plant instigate the price and development of a straw market in Skåne?

The relevance of this case should not be understated. The Örtofta CHP plant will create penetrating conditions in the local straw market in the immediate future. How the market forces react and mature will provide an unprecedented glimpse into to the fledgling biomass movement.

Scope & Limitations

The value of this study is establish and offer Lunds Energi Koncern[1] economic indicators which may affect the price development of straw in Skåne consistent with the study's specific research question. A rigorous price forecast is not included, nor does it advocate the speculation of a specific price per year- that would simply not be realistic given the current nebulous of the straw market in Skåne. Furthermore, you will not find a statistical analysis of other country's straw market price development herein. Instead, price predictors have been scrupulously examined and compared as fundamental price factors. These price predictors include both supply and demand driven factors: economic indicators such as the global grain price trends influence demand, while supply is impacted by seasonal variations of the cereal grain crop. Furthermore, the costs of straw have been deconstructed and examined in an individual context to illuminate separate straw price components.

[1] This research project was conducted in conjunction with Lunds Energi Koncern as an exjobb, with full supervision, approval, and disclosure from Lunds University.

The purpose of this paper is to uncover economic indicators which will influence the straw price in Skåne. What this study reveals are economic variables which may catalyze the future price of straw. The intentions of this are clear: to assist in the upcoming procurement of straw for the Örtofta CHP in Örtofta, Sweden. The goal of this paper is to serve as an advisory reference as such, and to give foresight to the potential price development of straw in Skåne. It does not take the profitability of Lunds Energy Koncern's energy plants into account, nor is it designed to be read as a road map for straw prices. Rather, it aspires to clarify straw market developments by examining national and international events.

It would also be prudent to mention this paper does not include energy crops nor does it compare the relative merits of energy crops. The reason for this is simple: energy crops, grown specifically for energy conversion, are an entirely different class of goods. While included in the sustainable energy conversation, energy crops are not brought into this study because of the vast distinctions between the two. The energy crop equation is unique because the crops are grown exclusively as a fuel, whereas straw is a by-product of grain and is grown with the purpose of consumption as food. The fact that straw was once considered a waste product and has recently emerged as a valuable commodity offers unique circumstances to study the path dependency and marginal benefits of biomass energy price development.

Why Straw?

Ironically, straw, which was once burned because it was considered a waste product, has great value. Straw is composed of 50% carbon, which is why it can be used as fuel. Although biomass energy production from straw is more expensive than from hydro-electric dams, its benign environmental impact more than makes up the difference, as it is renewable and carbon dioxide neutral (Duft, 2002).

Traditionally, straw has been used to cover agriculture, feed livestock, and enhance soil composition. Virtually all straw is consumed by the farmers themselves. The most common use of straw is to provide structure to the soil. This is also the easiest and least labor intense method of straw management, as it requires no additional input labor. Harvest machines are equipped with a scarifier (also known as a "chopper") which cuts the straw and leaves it in the field. The scarified straw can immediately be ploughed in, thus fortifying the soil mix (Alberta,).

It is important to understand straw is not used as fertilizer as it contains only trace amounts of nutrients. Instead, straw (composed of roughly 50% hydrocarbon) replenishes the soil with organic matter. This carbon rich straw improves the consistency of the soil, essentially acting as insurance ensuring the energy rich biomass content of the soil.

There are several other ways to use straw. Farmers can feed straw to their animals as a replacement for hay. Many farmers in cold climates use straw as cover to insulate vegetables against frost. There is a small market for straw in this capacity- some European examples include the tulip trade in Holland and the Strawberry market. Straw is also useful to spread in barns to reduce mud underfoot.

Many farmers have large yearly surplus of straw. After they use what they need, many farmers would simply burn the excess. But in 1990 an environmental ban went into effect which banned the burning of straw in the fields (Mattson, 2006). At this point excess straw became a disposal burden to some large grain farms. Many resourceful farmers embraced this policy change and built small straw boilers to dispose of the straw while capturing the heat for their personal use. The initial investments to build the costly boilers were motivated by the opportunity to sell surplus energy, in the form of electricity, to the energy company. These farmers were supplying energy to the grid for a profit. Thus the Swedish straw boiler phenomenon was born, albeit on a small and isolated scale.

Methodology

This thesis employs an exploratory research study. The hypothesis development focuses on a relatively modern phenomenon – the value and subsequent price derivation a burgeoning straw market. A case study of the Örtofta District Heating Plant in Skåne is in order. The study includes a qualitative analysis and literature review of past and current straw-burning biomass district heating plants. A cross national study component of the international cases buttresses the case study.

The study is divided into two parts. First, Part A explores straw in a modern biomass context. The merits of straw-burning plants are not without success stories, and in this preliminary section we explore various operations in Denmark, Spain, and the United Kingdom. These cases are more than simple literature reviews- I have approached the author of each to inquire about their personal observations regarding straw price developments. This process was conducted using the author's email addresses generously provided within their respective studies. An introductory email was first sent explaining the nature of the study and asking for their participation. The responses have been compiled into the analysis.

Secondly, Part B will dive into the Skåne case, examining the current state of events, developing empirical data, and forecasting future price potentialities. A recent Swedish University of Agricultural Sciences thesis segues into my study.

I have also had the opportunity to exploit local information gleaned from a quantitative depth survey conducted as a compliment in order to enhance empirical data. The *ad hoc* survey investigates straw pricing by the producers of straw in Skåne. It conveys a representative sample through convenience sampling of the ten largest farms in Skåne. The fieldwork collected responses and observations of the straw producers including their expectations and attitude towards the straw market development in regards to the Örtofta District Heating Plant. This quantitative data was compiled into a formal analysis.

Theory

The foundations of this research project are rooted in mainstream neoclassical economic theory. In addition, concepts from the field of Agronomics have shaped this analysis. Economic historical perspectives have also complimented this straw market development study.

Agronomics is an agricultural branch of economics. It tends to be micro-oriented as it focuses on the optimization of land use decisions faced by agricultural producers. A unique tenant of Agronomics involves an inelastic supply curve. The supply is fixed by the merits of the land (through the yearly harvest) rather than the price. The supply is non-responsive to changes in the price, which is known as zero elasticity (Eatwell, 1987). This phenomenon is counter to traditional economies of scale, where the more of a commodity desired, the lower the unit price. In agricultural terms, the more of a commodity desired, the *higher* the price, because market inventories are fixed. Having a rigid supply accounts for the inverse relationship between supply and price, also known as negative price elasticity (Eatwell, 1987).

This study borrows from the Dahmenian concept of development blocks, including market widening and market suction. The inelastic supply of energy and the current events chronicled in this research project resemble a market suction (or 'demand pull') shift in demand (Kander, 2007).

It is also important to be aware the production of straw is entirely dependent on the production of cereal grain. That is, straw is a byproduct (once regarded as a waste product) of cereal grain production. This is known as a path dependency. The costs associated with growing and producing straw are a marginal cost compared to those of producing cereal grain.

Practical Considerations

The practical considerations of conducting a survey in a language other than my native tongue are complex. To overcome the language barrier I asked the assistance of the two advisors to this project, Astrid Kander[2] and Peter Ottosson[3]. They consulted with me regarding the sample, survey questions, survey translation, and results analysis. Once the questions were finalized, the entire questionnaire was translated into Swedish by a native Swedish speaker. The interviews were conducted via telephone with the assistance of a bilingual family member who translated the individual interview questions and documented the answers and responses.

Terms & Concepts

Bioenergy	Renewable energy made available from materials derived from biological sources; Also known as biofuel.

[2] Astrid Kander is Assistant Professor of Economic History at Lunds University and a researcher at CIRCLE.
[3] Peter Ottosson is the Managing Plant Coordinator at Örtofta District Heating Plant for Lunds Energi Koncern.

Biomass	A fuel where at least 98% of the energy content is derived from plant, animal matter or other substances not derived from a fossil fuel. It includes such fuels as agricultural wastes, forestry wastes or residues, sewage, and energy crops.
Cereal Straw	A by-product of a cereal crop grown for consumption as food. Varieties include mainly wheat, barley and oats but could also include corn, maize, and rye, etc.
Cogeneration	A combustion plant where heat and electricity are generated.
CHP	Combined Heat and Power; Also called cogeneration. A power plant which supplies both electricity and heat.
District Heating Plant	A system for distributing heat generated in a centralized location for residential and commercial heating requirements such as space heating and water heating. The heat is often obtained from a cogeneration plant burning fossil fuels but increasingly biomass, although heat-only boiler stations, geothermal heating and central solar heating are also used. District heating plants can provide higher efficiencies and better pollution control than localized boilers.
Energy Crop	A plant crop grown primarily for the purpose of being used as a fuel. This may be grown on set-aside land provided it is not sold for consumption as food.
Hesston Bale	A rectangular-shaped bale of any given product having the following dimensions: 1.2 x 1.3 x 2.50 meters Density 125-145 kg/m^3 The 500 Kilogram Hesston Bale is the common standard.
Joule	The International System of Units measurement for energy, heat, and mechanical work. One joule is the work done, or energy expended, by a force of one newton moving one meter along the direction of the force. It is also the work done to produce power of one watt continuously for one second; or one watt second. Thus a kilowatt hour is 3,600,000 joules or 3.6 megajoules. 1 joule in everyday life is approximately the energy required to lift a small apple one meter straight up and the energy released when that same apple falls one meter to the ground.
MWe	Electrical Energy.
MWh	MegaWatt hour. A unit of electric energy equivalent to 10^6 watts. A function of time, watts per hour are not calibrated with International

	System of Units. However, it is the preferred unit of measure for electricity suppliers.
OSR	Oil Seed Rape, primarily grown for seed production and used for both human consumption and the industrial oils market. Some crops are grown on set aside land (non-food use) and are sown predominately in the autumn rather than the spring, which gives high yields of both straw and seed.
PJ	Peta Joules. In mathematics and physics, peta is a prefix denoting10^{15} or, 1,000,000,000,000,000. One PJ is the equivalent to approximately 25,000 tons of oil or 68,000 tons of straw.
Straw	See Cereal Straw.
Straw Specific Fuel Consumption	The fuel quantity required to produce 1 kW of electricity.

Translations

<u>Swedish</u>	<u>English</u>
Halm	Straw.
Returtree	Waste wood.
Skogsflis	Woodchips from harvest residue.
Torv	Peat.

Part A: International Data

In order to place Örtofta in an appropriate context, this thesis begins by examining a few similar cases among other European countries, including Denmark, Spain, and the United Kingdom. This literature review will contribute to a broader understanding of biomass production and offer a cross-national perspective outside of Skåne. Denmark, the United Kingdom, and Spain are included in this review.

Denmark

Denmark is the world's leader in renewable energy. Historically, Denmark has enjoyed much cropland yet few forests, thus the rapid development of straw boilers as a major energy source (Flavin, 1994). At the same time, Denmark has made great strides in wind energy innovations and policy. A decentralized approach, generous subsidies, and high fossil fuel taxes have helped foster the renewable energy industries in Denmark.

Of primary importance to this study is the Danish scenario, in which similar circumstances ensued over a decade ago. According to the Danish Technological Institute, the Danish straw-market has burgeoned into two geographically distinct markets, East and West, with the Great Belt toll bridge serving as a barrier between the two (Nikolaisen, 2007). This study includes production statistics, policy information (including taxation and subsidies), fuel price trends (from 1990-2006), a market analysis, and a 5-10 year forecast, all of which will be paramount in the comparative analysis.

Another paper, this one written by the private energy company DONG Energy, further illuminates the use of straw in Danish power plants. June 1986 is revealed as the birth date of Bioenergy in Denmark. This somewhat technical paper provides an overview of eleven straw-fired plants in Denmark (Fenger, 2008).

An article in Energie-Cities.org provides insightful information of Naskov, a Danish plant which, like Örtofta, produces both heat and electricity. Albeit smaller, the plant has been responsible for the formalization of a local straw market. The requirements and responsibilities of the producers and purchasers are clear and concise. A three year contract between the two parties ensures a long term, mutually beneficial negotiations. Bale size, moisture content, and ash removal is also included in the contract (Christensen, 2000).

A final article, published by the EU, boasts of 1.3 million tons of straw converted into energy in Denmark in 2005 (EU, 2007). The 1990 ban on straw burning is given as a contributing factor to the rapid development of straw-burning for energy in Denmark. Furthermore, the paper provides a production cost table, marketing development, and recommendations for adoption of straw burning power plants.

United Kingdom

Following in the footsteps of Denmark, researchers from England have begun to burn the 15 million tones of straw produced yearly into heat and energy. A 2003 study conducted by Anglican Straw gives concrete evidence of the viability of a straw biomass plant in the United Kingdom (Newman, 2003). This paper documents an entire feasibility study and contributes to the underlying economics and financial implications of burning straw.

Spain

A Spanish example also gives credence to the power of straw. The Sangüesa Power Plant, operational as of June of 2002, was built by a Danish firm and designed to operate entirely on straw (EC, 1997). This plant provides 25 Mw of electricity to an industrial sector in the region of Navarro, Spain. This power plant project has witnessed the creation of long term supply contracts with farmers for the 160,000 tons of straw needed yearly. Included in the report is a discussion of economic performance.

An additional Spanish reference was published in 2007 by the University of Alcalá, in Madrid, Spain. This paper juxtaposes bioethanol production with biomass in terms of environmental benefits and economic characteristics (Azqueta, 2007).

Data Bias

The above data sources provide a sense of familiarization with the few straw boilers located on the European Continent. Some shortcomings can be found in the data. One clear criticism which may be raised concerns the nature of the publications themselves. Many of the facts garnered to provide a snapshot of the current state of straw boilers has been derived from material published by the company themselves. Some of these descriptions of the biomass boilers are press releases published by marketing and public relations departments. These testimonials could potentially be biased.

Analysis

Straw biomass boilers have been embraced by a few nations, and they have been successful everywhere they have been implemented. The three geographically distinct areas, Denmark, the United Kingdom, and Spain, each offer success stories. Thus Europe paves the way for international exposure of the biomass potential[4]. In order to compose a clear picture of the current state of straw affairs, the publications from these three countries have been refined in order to uncover lessons applicable to the Skåne straw market development. This analysis focuses on complementarities and distinguishing factors in regards to Skåne.

Denmark

Denmark has paved the way for straw biomass energy production. In 2006, biomass accounted for 11% of the total energy supply -well over the EU average of 4% (Nikolaisen, 2007). The growth of Danish straw consumption since 1980 is staggering: from 5 Petajoules to a whopping 40 PJ, or 2.72 million tons, by 2005 (Mattsson, 2007). As described in Table 1, Danish straw production in 2006 reached 5.5 million tons. This exponential increase from 2005 to 2006 is significantly larger in absolute and relative terms than the increase from 1980 to 2005.

1.3 million tons of straw were converted into energy in Denmark in 2006. As table 1 makes certain, the largest use of straw remains on the farm, as ground cover and soil supplement.

Table 1

Straw production 2006	**1000 tons**
Use on farms	**1,900**
Energy purpose	**1,300**
Ploughed in	**2,300**
TOTAL	**5,500**

Source: Nikolaisen, 2007

[4] Interestingly, no straw-burning electricity generating biomass boilers exist in the USA (Duft, 2002).

Table 2

Straw for energy 2006	1000 tons
Central power plants	500
CHP plants	230
District heating	240
Industry	0
Farms and houses	330
TOTAL	**1,300**

Source: Nikolaisen, 2007

Table 2 catalogs the amount of straw for energy use in Denmark in 2006. The largest bulk, approximately 500,000 tons, is used in large central power plants. Ironically, the second largest category is the small individual straw fired boilers in farms and houses. This contrast highlights the dichotomy between the historic versus modern use of straw boilers.

While the Danish model provides a well-grounded perspective of straw development, one large difference must be noted: the peak production in Demark is significantly larger than in Skåne. The aggregate capacity of Denmark, with its 55 active straw boilers, shadows Skåne's.

High fossil fuel taxes and subsidies have helped foster the rapid development of renewable energy industries in Denmark. The policies established to promote renewable energies seem to be working. This heavy taxation put on fossil fuels, coupled with large subsidies, have given rise to renewable technology investments including renewable energy production (Nokolaisen, 2007).

Two geographically distinct markets have developed in Denmark. Known by their geographical directions, East (Zealand) and West (Jylland-Funen), the Great Belt toll bridge is the barrier between the two. A price difference has emerged with an average of 3.5 Euro/ton higher in the East (Nikolaisen, 2007). I don't anticipate this problem in Skåne because of the generally open landscape. However, it is fascinating to note the regional economic phenomenon in Denmark.

Not only is Denmark one of the world's leaders in renewable energy, the country has postured itself as the leader of sharing its resourcefulness. Denmark has done more to promote the use of biomass in energy supply than any other EU country. Denmark is exporting its biomass technology and management to the rest of Europe. Both of the following international cases, the Ely plant in the UK and the Sangüesa plant in Spain, were built by Danish companies. A Danish company is also currently constructing three straw fired CHP in Germany in Emlichheim, Kyritz and Cloppenburg. The plants will each have a capacity of 50 MJ demanding an annual straw consumption around 100.000 tons at each plant (Mattsson, 2007).

United Kingdom

The United Kingdom offers another source for reflection of the straw development market. The UK could be considered a more appropriate case than Denmark to be used as a source of comparison. An historical similar development allows for a level comparison with Sweden. Historically, small boilers up to 300 kW have existed in the UK, mostly on private farms. This is very similar to the current case in Skåne.

The Ely Power Station was built in 2001 by a Danish firm for Energy Power Resources Limited. It was designed as a straw boiler in order to take advantage of the 15 million tons of straw produced each year in the UK. Generating 38 Mw, the Ely boiler earns the title of the world's largest single straw boiler. The plant was built by a Danish company using biomass boiler technology developed in Denmark (Newman, 2003).

The overnight emergence of the Ely power station and its thirst for 200,000 tons of straw a year demanded an organized straw market where there was none. The ensuing struggle to develop the infrastructure proved to be a challenge. The chaos resulted in importing their initial straw supply from Germany. Once the market coalesced the power station began to rely entirely on local cereal grain straw (Stannage).

In a bold business move, Ely power station created a wholly owned subsidiary to procure fuel supplies. Known as Anglican Straw, it is responsible for the baling, storage, and delivery for over 30% of its total straw needs (roughly 60,000 tons/year). According to the company's literature, Anglican Straw uses an "innovative approach…and created a whole fuel supply infrastructure where none existed before." The mission statement of Anglican Straw is clear:

"Anglican Straw constantly manages its procurement strategy to ensure fuel supplies are always available at the lowest possible cost."

While Energy Power Resources Limited has great control over its resource and suppliers, the current state of affairs is unstable. Anglican Straw is currently paying 35 pounds per ton of delivered straw. However, Anglican Straw is currently in the midst of restructuring its straw product price because of recent increases in fuel and other costs. John Stannage, the business manger of Anglican Straw, was not willing to elucidate on the forthcoming price modification since, "EPR considers the information commercially sensitive."

Spain

The Sangüesa Power Plant in Spain offers further information from a straw biomass boiler, albeit limited. Operational since June 2002, its 25 MWh of electricity production are entirely fueled by straw- 160,000 tons of straw are needed to fuel the plant (EC, 1997). Although Örtofta Central Heating Plant will produce and demand twice the amount of straw, some meaning can be taken from the existence of this plant. Most importantly, this plant offers another example of the importance of long term supply contracts with farmers.

A more recent energy policy publication from Spain is provided by two students from the University of Alcalá. This research project examines environmental impacts alongside agricultural subsidies provided by the European Union. The information most relevant to this straw study involves increasing production costs, decreasing production yields, and a market of increased competitiveness (Azqueta, 2007).

Part B: Skåne

Skåne Data

One of the most valuable tools at my disposal is a recently completed study entitled *Business Development: Local Production of straw fuels for CHP plants*.[5] This detailed analysis of straw in Skåne provides valuable data regarding the straw production capacity in Skåne. The author has investigated various straw metrics in Skåne, including current straw use, which amounts to approximately 50,000 – 70,000 tons of straw a year. The estimated value of the straw crop is 30,000,000 - 40,000,000 Swedish Crowns a year. The total straw harvest is a whopping 200,000 – 300,000 tons a year, which clearly reflects a surplus supply (Mattson, 2006).

The ambitious project includes the framework for the development of an organized straw market. The mechanisms involved include logistics, participants, contracts, and other value-chain assessments in order to formulate the local straw pricing structure. Included in the equation are crop growth, baling, transport, delivery, and storage (Mattsson, 2006). The capacity of the producers and transporters to organize themselves will be paramount to a fruitful straw market. Included in the paper was a focus group of ten farmers who anticipate participating in the straw market in Skåne. Besides discussing the current straw value and volume, this paper provides the foundation for examining the straw market development surrounding Örtofta, Sweden (Mattson, 2006).

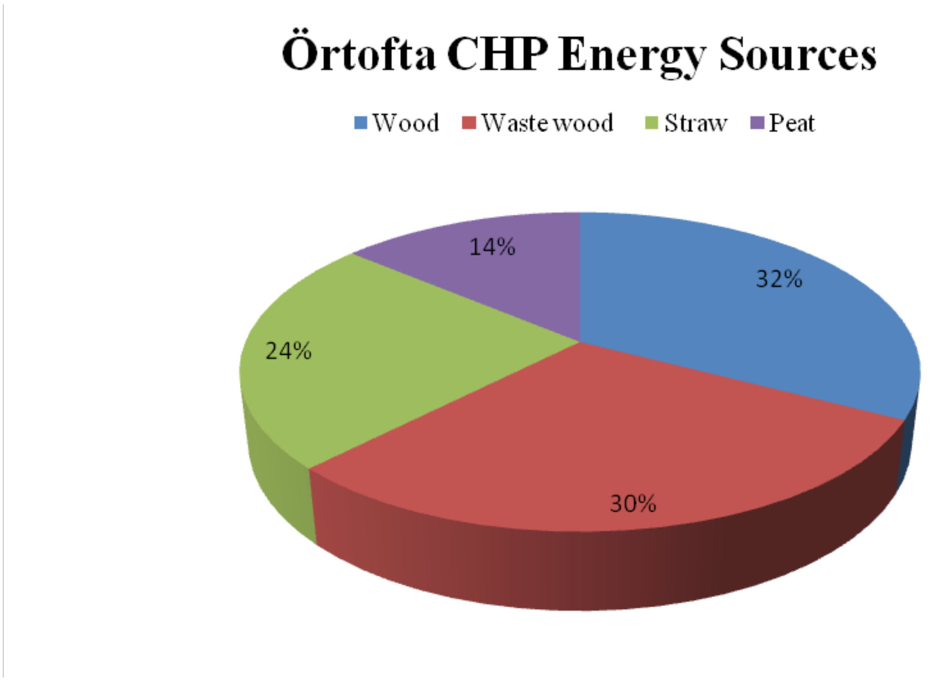
Mattsson's report, produced at Alnarp Agricultural University, is a significant contribution to Lunds Energi Koncern. Their business manager, Fredrick Steineck, composed a forecast report citing Mattsson's findings. Steineck's paper, entitled In-Depth Study of Potential Straw Delivery, details practical and financial matters relating to the Biomass Plant. The internal memo covers procurement, pricing, and operational aspects of the plant (Steineck, 2008). A ten year price prediction is provided with the input of a panel of straw experts. The anticipated price increase is estimated at 3.5% per year, with the possibility of an initial "bump" in 2010 (the year the plant becomes operational) due to the increase in straw demand.

[5] CHP refers to combined heat and power.

Örtofta CHP

Lunds Energi Koncern is investing 2 Billion SEK in the Örtofta biomass burning plant which is scheduled to be operational in 2010. Designed to provide heat and electricity (known as co-generation), Örtofta's two boilers[6] will yield a high volume output- the projected production is 100 Mw of heat and 45 Mw of electricity. The upcoming activation of the Örtofta District Heating Plant will provide both heat and electricity to the approximate 105,000 residents of Lund, Sweden. The sources and volume of consumption to operate Örtofta District Heating Plant will consist of the following:

Figure 2



Source: Lunds Energi Koncern

Table 3

Yearly Consumption Volume	
Wood	400,000 m³
Waste wood	70,000 tons
Straw	**80,000 tons**
Peat	130,000 m³

Source: Lunds Energi Koncern

[6] One boiler, the larger of the two, is a Sand Bed Burner, while the smaller is a traditional Grate Burner. Straw will only be burned in the Grate Burner.

Skåne Straw Supply

While straw is only one of four fuels used at the plant (Figure 2), it is the focus of this study precisely because of the undeveloped straw market in Skåne.

The total straw harvest in Skåne is 200,000 – 300,000 tons a year; however the current straw consumption for individual farm boilers is approximately 50,000 – 70,000 tons of straw per year (Mattsson, 2006). The surplus is chopped and left in the ground as soil enhancer or ground cover. These small private farmers tend to supply their own straw and do not currently contribute to a demand market.

The only organized District Heating Plant purchasing straw in Skåne is in Svarlöv, where 6,000 tons of straw are needed yearly[7] (Steineck, 2008). As highlighted in Table 3, The Örtofta plant will consume 80,000 tons a year and drastically change the shape of the tiny Skåne straw market. The newfound demand in Örtofta corresponds to 150,000 bales, or approximately 24 bales per hour per day.

[7]According to Rolf Leire, who was the plant manager, this plant has recently been purchased by EON and is being converted into a woodchip burning plant.

Price Indicators

Supply

It is not easy to price straw. The complex equation to value straw includes many variables beyond the crop itself. The organic soil composition, propensity for field erosion and field residue, fertility levels, fertilizer trade-off cost, and the value of alternate uses (such as animal feed and bedding) create a supply pricing problem. Each farmer may attach a price to their straw according to their particular needs. Additional costs include the obvious overhead of baling, transporting, delivery, and storage of straw bales (Alberta).

Price Deconstruction

Efforts to deconstruct the straw price equation produce a composite of variables. The components involved each represent an important factor in the final price settled in the straw market. Some of the pieces are more difficult to calculate than others. For instance, it is difficult to value the traditional use of straw left in the field to enhance soil structure. The pricing mechanisms can be decomposed as follows:

Crop Growth – This is the pure cost of growing cereal. It is the least value-intense cost associated with straw. Seasonal variation can greatly affect this cost.

Overhead – This category reflects the individual costs associated with the handling of the straw. Each of these steps is labor intensive and increases the price of straw**.** They include:

Baling – The cost of baling straw in the field into Hesston 500 kg bales. This is accomplished using a machine known as a baler.

Transport – The cost of transporting the collected bales from the field to the plant. This can be done by a tractor or by a truck. This cost is drastically influenced by the price of gasoline.

Delivery– The cost of delivering the load of bales from the transport truck into the facility.

Storage – The cost of warehousing the bales in order to maintain adequate moisture levels. This may be done at the boiler facility or off-site. The alternative to warehousing involves plastic-shrink-wrapped bales which add a significant additional cost to each individual bale, while reducing warehouse cost.

Additional value-chain assessments – This includes other unidentified costs. One such example includes ash removal which must be disposed of in a safe and environmentally friendly way. Denmark requires deliverers to accept ash in return for each delivery consistent with their previous delivery.

Costs

Mattsson (2006) provides insight into the individual cost components in Table 4. This composite price analysis sheds light on the high value of the handling costs compared to the harvesting cost of straw. These handling costs associated with straw delivery are by far the greatest contributor to the price of straw. It is also interesting to note he computes two separate totals, one as a nominal total, and another including the value of straw as a soil enhancer. A price level between 55 – 60 öre/kg was determined as the optimal price level in Mattsson's price analysis in 2006.

Table 4

Component	Calculated cost, SEK öre/kg
Harvesting	7-15
Baling	9-12
Collection & Transport to Storage	11-14
Storage	2-19
Transport to plant	9-12
Total	31-57
Total with Soil Enhancement Value	38-72

Source: Mattsson, 2006

Mattsson provides a second analysis of the costs associated with straw delivery in Skåne in Table 5. This cost breakdown includes two distinguishing factors. First, the price calculations have been calculated as SEK per ton and SEK per MWh as opposed to SEK per öre as in Table 4. This approximate 1:4 conversion rate is used to simplify communication between farmers and energy companies. Farmers tend to price their commodities by weight, while energy companies prefer to speak in terms of potential energy, in this case Mega Watt Hours.

The other distinguishing factor included in Table 5 involves storage price calculations. The storage locations have been separated between inside and outside. This calculation reflects the options between building a warehouse for storage versus storing out-of-doors. The inside cost assumes the price of the storage building either at the plant or off-site. The cost of outside storage includes the cost of shrink-wrapping each bale. This bale dressing protects individual bales against moisture; however, it does not ensure adequate moisture levels. The price difference is significant: Inside storage of straw bales is the single highest component within the cost of straw bales.

Table 5

Activity	Costs: SEK/ ton	SEK / MWh
Harvesting	93	23
Baling	95.4	23.8
Collection	25.7	6.4
Transport to Storage	66	16.5
Storage Inside	190	47.5
Storage Outside	16.7	4.2
Transport to Plant	86.5	21.6

Source: Mattsson, 2006

Procurement

Lunds Energi Koncern has divided the steps necessary in the delivery chain in order to determine their procurement needs. The following four steps should be fulfilled by the straw deliver according to the future Örtofta CHP Plant rules:

- Harvest
- Drying
- Baling
- Transport to Plant

Lunds Energy Koncern will be responsible for the balance of the steps:

- Storage (inside or outside)
- Transport to central storage
- Transport from central storage to the plant
- Load/unload at different places by the plant
- Maintenance of storage facility
- Responsibility to perform what has been agreed upon in the contract

The logistics regarding future straw delivery have been established by Lunds Energi Koncern and include:

Bale weight- 500 kilo Hesston Bale

Moisture content levels- Weight and humidity will be registered in the overhead crane and the energy content will be registered in units of MWh.

Delivery- A large traverse will manage 16 bales at a time, in order to collect 1,900 bales which is the 72 hour payload.

Hours of acceptance- 6 am – 10 p weekdays, between 8 am and 3 pm on sat.

Procurement at Lunds Energi Koncern will rely on the development of a formal straw market. Although this has yet to take place, people have begun to establish an organization to manage straw demand. It will be a matter of time before the results of these initial efforts are felt. But in the mean time, Lunds Energi Koncern plans on taking steps to avoid a chaotic shock to the burgeoning straw market. In order to eliminate an overnight demand, Lunds Energi will slowly grow the local straw demand by a stepped purchasing strategy. This strategy involves purchasing straw in three phases spread over two years. The initial purchases will be of reduced quantities in order to introduce a minimal demand into the area (Steineck, 2008). This stepped strategy will provide a few advantages: they will be able to test the market conditions, stockpile straw for fuel, and avoid an abrupt shock, and posture Lunds Energi as a reputable actor in straw procurement.

Demand

Price Substitutes

Straw is not alone in the biomass price market. Woodchips have become the most popular form of solid biofuel and are the most common District Heating Plant Fuel. It has been predicted the price of woodchips could set a ceiling for the price of straw. The potential price cap could potentially regulate the price of straw. The current price of woodchips in Skåne is about 15 öre/ KWh and 60 öre/kg (Mattsson, 2007).

Skåne is Sweden's Breadbasket. Skåne boasts the highest quality soil and largest average size of farms in Sweden. The crop yields, including cereals, for 2007 are shown in tables 6 and 7. These figures are the highest in each category for the entirety of Sweden. Taken together, Tables 6 and 7 provide a snapshot of the magnitude of agricultural volume in Skåne. Cereal grains are the third most numerous crops in Skåne. While grain is shadowed in volume by sugar beets and potatoes, it is of considerable importance in the larger picture.

Table 6

2007 Skåne Crop Yields, kg/hectares				
Potatoes		**Oilseed Crops**		**Sugar Beets**
Table potatoes	Potatoes for processing of starch	Winter rape	Spring rape	
38 280	38 646	3 292	2 321	48 777

Source: Official Statistics Sweden, 2007

Table 7

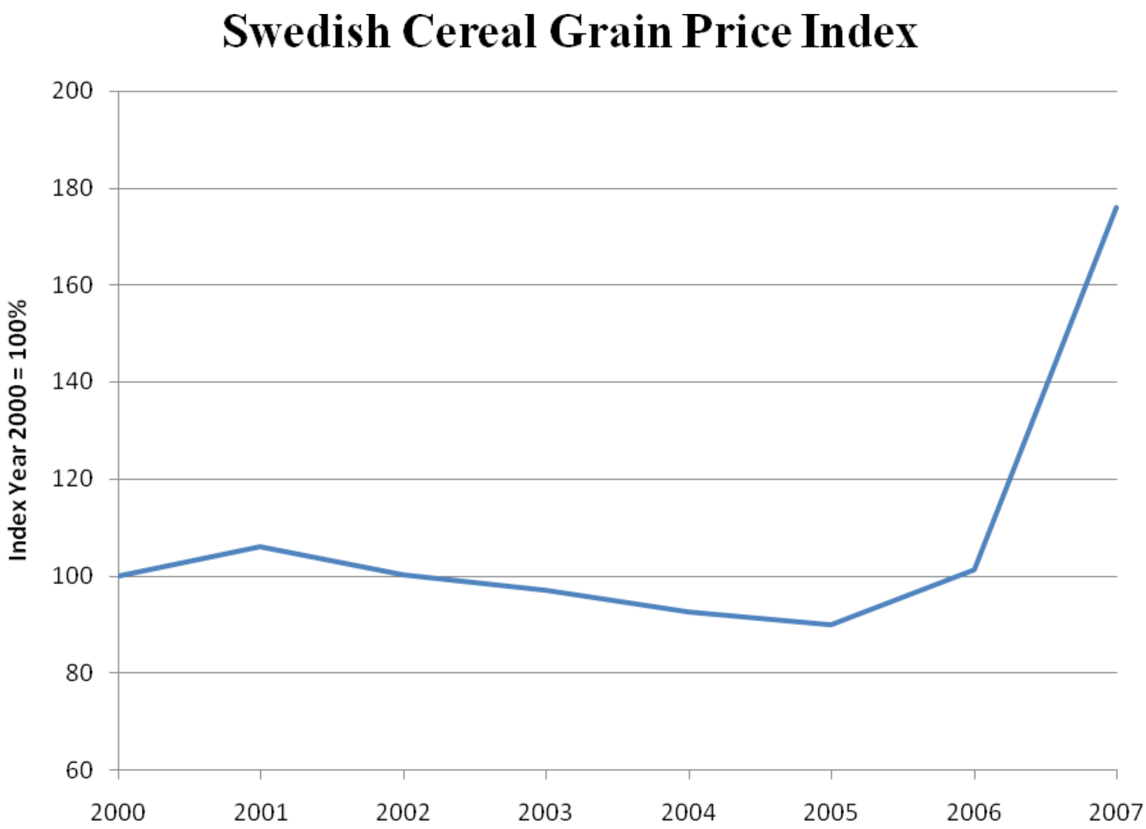
2007 Skåne Cereal Yields, kg/hectares				
Winter wheat	**Spring wheat**	**Winter rye**	**Spring barley**	**Oats**
7 893	6 148	6 911	5 723	5481

Source: Official Statistics Sweden, 2007

The production of straw is completely dependent on the production of cereal grain. This path dependent relationship provides supplementary revenue to grain farmers: the cost of producing straw is marginal compared to the costs of producing grain[8].

[8] See Table 4.

Figure 3

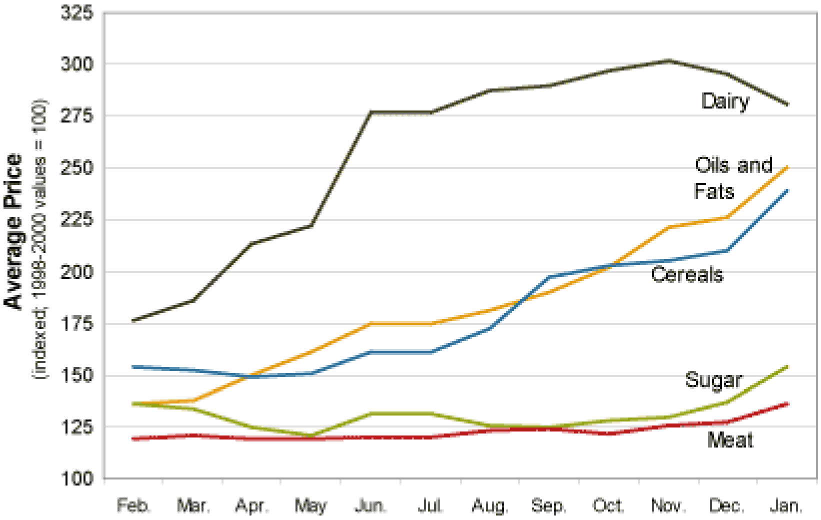


Source: Official Statistics Sweden 2007

Grain prices in Sweden have skyrocketed. Figure 3 illustrates the Swedish Cereal Grain Price index since the year 2000. The prices of cereals increased by roughly 17 % in 2006 compared to 2005 (Official Statistics Sweden), and has continued an incredible upward surge since then. The world market of food prices mimics this alarming trend. Figure 4 reveals a 30% increase in global food prices from 2007 to 2008. Cereal prices have risen by an astounding 50% across the globe (World Resource Institute, 2008).

Figure 4

World Food Price Trend, 2007-2008

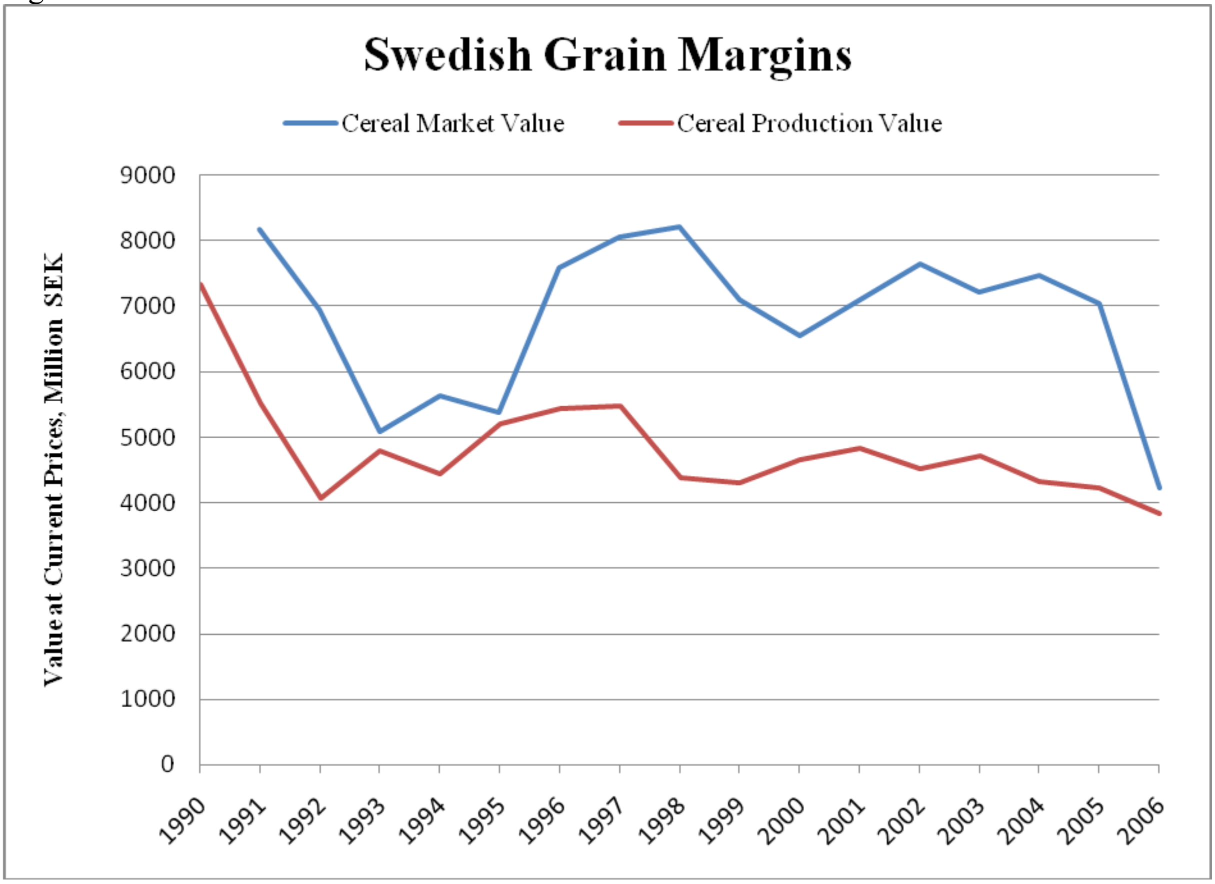


Source: World Resources Institute. Earth Trends, 2008

The given average price for barley has been about 1 SEK /kg for the past seven years, but escalated to 2.6 SEK/kg last year. This extraordinary price trend has been provoked by several separate occurrences. Locally, the 2007 production of cereals decreased by 18 % compared to 2006 because of a decreased yield per hectare due to a dry 2006 season (Official Statistics Sweden, 2007). This point validates the seasonal variations in agricultural production.

On an international scale, the high price heralds the global grain shortage. Rising income levels in the developing world (such as India and China) have instigated an increased demand for meat. Grazing livestock for meat production requires much larger land areas than cereal grain production, thereby decreasing cereal grain harvest area and yields (World Resources Institute, 2008). Furthermore, grain is now competing with biofuel production in the transport sector which amplifies the influence of a spike in the global cereal grain market demand (Wallden, 2007). Both of these points speak to the scarcity of land.

Figure 5



Source: Official Statistics Sweden, 2007

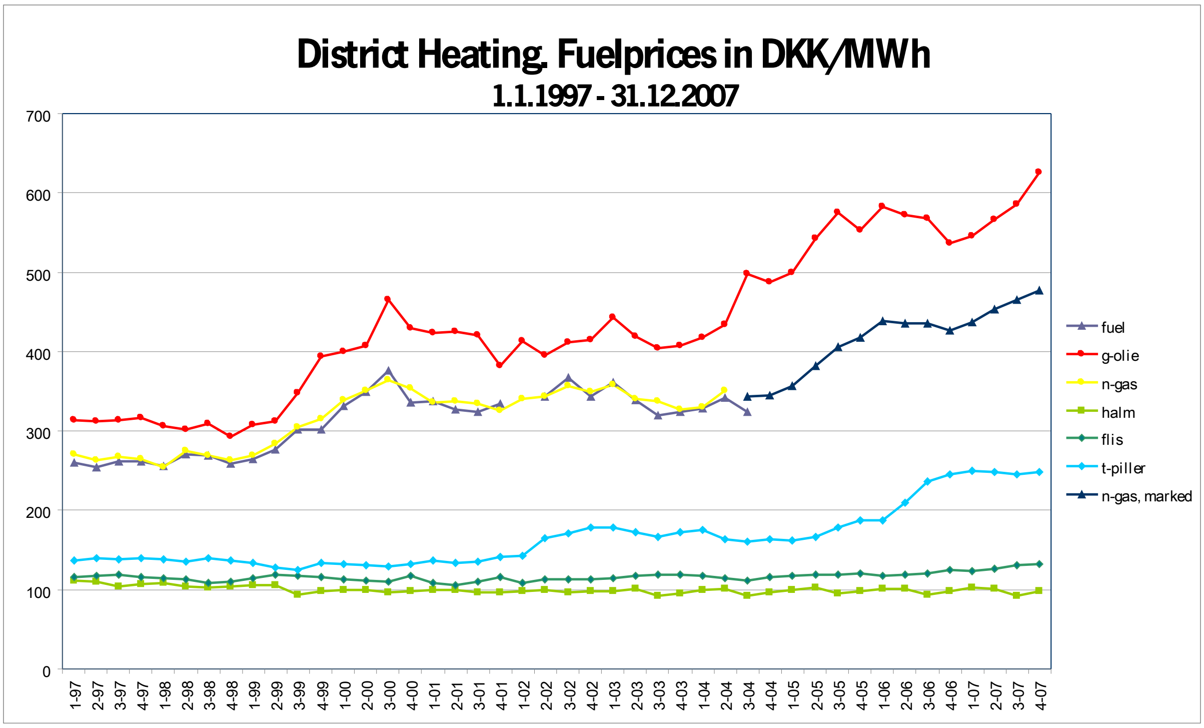
The Swedish cereal grain price escalation is further reinforced by Figure 5. In this 16 year value trend the market value is plotted along with production value. The gap in between the two lines is equivalent to the profit margins in grain. The 2006 figure illustrates a drastic decrease in Swedish grain profits.

There is a counter-argument to the rising straw costs produced by a global grain shortage. It is conceivable to believe the grain shortage will entice farmers to increase grain production (to maximize their profit) thereby increasing production in an effort to saturate the market and potentially decreasing the price (Steineck, 2008).

Danish Price

Danish farmers have historically enjoyed a high market price for straw. This price has remained rigidly stable for almost two decades at around 50 €/ton. This consistent price speaks to market equilibrium, where supply and demand have reached an economic stasis. But some fluctuations have begun to occur: costs have increased, and the price of straw is on the upswing. The average price in 2007 for straw delivered to district heating plants inched up to 53 €/ton (Nikolaisen, 2007). The current price of delivered straw bales in Denmark is between 42-50 DKK öre/kg.

Figure 6



Source: Mattson, 2007

The Danish development of District Heating Fuel prices are represented in Figure 6. The quarterly price for oil, natural gas, straw, woodchips and wood pellets from 1997 to 2007 are graphed. The price reflects the delivered price of the commodity to the heating plant. Figure 6 gives credence to the decade-long stability of the price of straw in Denmark.

Fuel, oil, and natural gas share a similar trajectory, while straw and woodchips parallel each other in Figure 6. A clear price divergence between oil prices and biomass material is also witnessed in Figure 6. This indicates the rising price of fossil fuels has not influenced the price of straw during the past decade.

Export Potential

Danish straw market is a local market with no current import or export opportunities. The future growth of the Skåne market could change this. Having a new supplier within the Öresund region will could create a climate of opportunity and entrepreneurism. If the bale price in Denmark rises above a threshold equal to that of the Swedish bale price plus the additional costs of the Öresund bridge toll and transport, then an export market could ensue in Skåne.

Pellets

Not included in this price explanation are straw pellets. Pellets are not included in the Skåne analysis because they are not needed. The cost of pelletizing straw is substantial. It is simply not justifiable to invest huge amounts of money in an area such as Skåne with so much readily available straw. Nor is it economical to use energy to convert straw into another product.

On the other hand, if the supply of straw were threatened or ruined (in such a case as a seasonal harvest failure), it would be feasible (although costly) to import straw pellets from mainland Europe. Europe has experienced a booming wood pellet market and a concurrent shortage of pellet production. Figure 6 reveals a recent increase in the Danish pellet price. Thus it is safe to assume the price of pellets as a commodity will only increase.

Denmark does not use straw pellets. There is no commercial market for straw pellets in Denmark. However, there is one exception to this rule: The Amager power plant. This plant could not get permission to transport large amounts of straw (130,000 tons) through central Copenhagen. The solution was to turn the straw into pellets near Copenhagen and deliver by ship to Amager power plant (Nikolaisen, 2007). Thus the conversion to bulk pellets was made in this single instance as a solution to strict urban regulations.

Skåne Price

Today's price for straw is in the neighborhood of 25 SEK/MWh (Steineck, 2008). This price reflects straw "in the field", which means left lying on the ground. This price reflects straw prior to any handling and not baled.

Fredrick Steineck, the procurement manager at Örtofta CHP, needs to have a more accurate picture of the baled and delivered price for straw. In order to begin procurement calculations, he has borrowed figures from Denmark. The average price, calculated using current SEK currency conversions, for the third quarter of 2007, is 122 SEK/MWh. This calculation falls on the low side of Mattsson's 42-50 DKK öre/kg, which converts to 126-150 SEK/MWh.

Nevertheless, Lunds Energi Koncern anticipates costs for 2008 to rise to 130-150 SEK/ MWh delivered. Steineck has consulted with experienced straw buyers to formulate a ten-year price prediction. The consensus among them confirms the new boiler in Örtofta will increase demand and increase the price of straw. Based on their input, his findings assume a vague price increase of 50 SEK/MWh within 10 years to 180-200 SEK/MWh (Steineck, 2008).

One of the straw consultants, Hans Stogaard, is the foreman for the Danish Bioenergy Sector. He predicts a slightly larger increase to 160 SEK/MWh for the 2008 season.

Rolf Leire is another straw expert. He has over 20 years of straw procurement experience and was the business manager for the only other straw-fueled plant in Skåne, the Svarlöv District Heating Plant. Rolf is confident the price will rise and possibly even double in the near future.

Fredrick Steineck acknowledges many of these price indicators. His report cites an increased demand in both Denmark and Skåne, along with possible shortages due to seasonal harvest variations, all compounded with an expected rise in production costs. With this information, he forecasts a 3.5% price increase in the price development of straw in Skåne (Steineck, 2008).

Steineck also expects an in initial bump in the price. This bump, according to him, will reflect the high price sparked by the new demand once the plant is put on-line coupled with rising energy costs. This price bump is predicted to last 3-5 years until price equilibrium has been established. The 3-5 year bump will encourage investments and stimulate the emergence of new actors into the straw market (Steineck, 2008).

Skåne Farmer Survey

The Skåne Farmer survey was designed to collect empirical data for this research project. The ten largest farms in Skåne[9] were approached and requested to participate in the research project survey

Survey questions[10] included inquiries into straw production (including volume and uses), willingness to sell, desired price and volume (if any), and whether or not the farmer was aware of the future biomass boiler in Örtofta.

Observations were collected from seven of the ten farms[11]. The results provide key insight into local factors and opinions of the straw market development in Skåne. While only five of the seven were aware of the Örtofta CHP, all seven were involved in the production and harvest of straw. Only three farms gave a specific quantity of yearly straw production (2,600, 1,056, and 3,500 tons/year).

A clear divide was witnessed among farms asked whether or not they would be willing to sell their straw. Only three farms expressed interest in sales, while four of the farms claimed they consumed all of their straw. Two farms interested in selling straw provided amounts and prices: One offered 2,000 tons at 65 öre/ kg min, while the other farm offered 2,300 tons at 60-70 öre/kg. Both of these prices were "in the field" prices, meaning the price for the straw lying on the ground, not baled and not delivered. The second of these two farmers was the only farmer who acknowledged their willingness to bale the straw, for a separate price.

The prices mentioned by both farmers are quite revealing. Taking the average of the two, 65 öre/kg, and converting it into 650 SEK/ton, roughly equals 163 SEK/MWh. This price is significantly higher than any previously predicted. Recall, the current price of *delivered* straw bales in Denmark is between 42-50 DKK öre/kg, which converts to **126-150 SEK/MWh.**

[9] Provided by Länsstyrelsen i Skåne län. See Appendix II for more information.
[10] See Appendix III for individual answers.
[11] It is with self-criticism the author confesses the survey was conducted using contact information provided for the ten largest farms in Skåne, rather the ten largest grain farms in Skåne. The results therefore may be biased towards farms which primarily produce potatoes and sugar beets, for instance, rather than cereal grains, and may explain low straw production figures.

These farmers are placing a value on their straw much higher than anticipated. Fredrick Steineck, the Örtofta procurement manager, predicts a procurement price of 25 SEK/MWh "in the field" and 150 SEK/MWh delivered. Compared to Steineck's predictions, these farmers are asking for the delivered price for their straw still in the field! One potential reason for this high price could be garnered from some of their comments- two farmers mentioned increasing costs. However, the farmers could also be artificially setting the price as high as possible to take advantage of the new demand and maximize their profit. This reactionary behavior could contribute to developmental chaos associated with the price stabilization of the straw market.

The comments made by the farmers also added to the richness of the survey. The comments ranged across a wide spectrum of attitudes and perspectives. Some farmers were excited about the creation of a new demand source and eager to commence straw sales, while others (two, to be exact) were not interested because they already consume all of their straw capacity. Ironically, another of the farms which consumes all of its own straw mentioned they were interested in selling. This perspective gives credence to the present immaturity of the straw market in Skåne and the future potential of straw sales once the price is established.

Summary

The development of the Skåne straw market is inevitable. The mechanisms involved are far reaching and difficult to predict. The economic clues uncovered in this document provide a clear indication that the price for straw will rise.

Without a doubt, the creation of the Örtofta CHP will disrupt equilibrium and shift the demand curve of straw. This market suction shift will lead to an increased price. How long it takes for the area to reach a stable price depends on local and international factors.

A clear consensus among all three international case studies involves rising overhead costs. These sentiments were echoed by the Skåne farmer survey results and will contribute to the upward surge in straw price. If nothing else, transport costs will incrementally rise as fuel prices continue their upward swing.

Grain prices will continue to be influenced by biofuel production in the transport sector. The path dependency of straw will be reflected by a higher price.

The framework for a standardized straw market must be organized. The importance of this fact is evident in Denmark, the United Kingdom, and Spain. The establishment of a straw organization will streamline contract negotiations between the supplier and the energy company. These contracts should detail all of the necessary prerequisites, including bale size, moisture content, delivery times, locations, price levels and time-frame renewals.

Seasonal variations will continue to influence production volumes and price levels. Bad harvest years (such as the dry 2006 season) will command higher straw prices.

The price of straw is expected to remain high until new investments are made attracting innovative behavior and market complementarities.

The detective work conducted in this research paper anticipates the growth and commercialization of straw in Skåne. How the market reacts to the Örtofta CHP plant will be a topic of great interest in the coming years.

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Appendix I

Survey questions

1. Aware of the creation and purpose of Örtofta District Heating Plant?
2. Does the farmer currently produce straw?
3. If so, how much?
4. How much straw (volume) would the farmer be willing to sell, if any?
   Minimum/ Maximum
5. For what price would the farmer be willing to sell straw?
   Minimum/ Maximum
6. Will the farmer sell the straw laying in the field or bale it (Hesston 500 kg bales)?
7. What are the alternative uses of the straw for the farmer?
8. Comments

Appendix II

Skåne Farmer Survey Contact Information

Farm	Farm Location	City Code	City	Phone #
GYLLENKROK THURE GABRIEL	BJÖRNSTORPS SLOTT	24013	GENARP	040-480018
SVALÖF WEIBULL AB		26881	SVALÖV	0512-20355
BARSEBÄCKSFÖRETAGEN AB	BARSEBÄCKS GÅRD	24657	BARSEBÄCK	046-775545
HÖGESTAD & CHRISTINEHOF FÖRVALTNINGS	HÖGESTAD	27197	YSTAD	0417-40100
NÄSBYHOLMS FIDEIKOMMISS AB		27494	SKURUP	0410-22070
SKABERSJÖ GODS AB	SKABERSJÖ GÅRD	23392	SVEDALA	040-444000
TROLLEHOLMS GODS AB	TROLLEHOLM	26890	SVALÖV	0413-73111
RAMEL HANS	ÖVED,ÖVEDSKLOSTER	27594	SJÖBO	046-63006
RÅBELÖFS GODSFÖRVALTNING AB	RÅBELÖFSALLÉN 82-7	29194	KRISTIANSTAD	044-227310
BERGENGREN KARL GEORGE ANDERS	PUGERUP	24395	HÖÖR	0413-33411

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Växel 040/044-25 20 00
Fax 044-25 25 00
www.m.lst.se

Appendix III

Survey Responses

GYLLENKROK THURE GABRIEL

1. Yes
2. Yes
3. 2,600 tons / year. Has 2 Boilers
4. --
5. --
6. --
7. Rörflen
8. Already sells to Lunds Energi Koncern.
   Very Interested in Selling Straw
   Mentioned costs increasing.
   Values straw accordingly: 2.5 kg straw = 1 liter oil.
   1 liter oil = 10 SEK
   10 / 2.5 = 4
   Straw should be worth 4 SEK / kg.

SVALÖF WEIBULL AB

1. Yes- Through a newspaper article
2. Yes
3. Only for their use
4. --
5. --
6. --
7. Rörflen
8. Not interested in selling because of low volume they use all they have

HÖGESTAD & CHRISTINEHOF FÖRVALTNINGS

1. No
2. Yes
3. 1,056 Tons in 2007
4. Willing to sell, no price comments
5. --
6. --
7. --
8. Use all for their own boiler

NÄSBYHOLMS FIDEIKOMMISS AB

1. No
2. Yes – only for soil enhancement
3. --
4. Only for their use
5. --
6. --
7. --
8. Considering Building Skogsflis boiler to sell energy

SKABERSJÖ GODS AB/Skabernäs

1. Yes
2. Yes
3. --
4. 2,000 tons / year
5. 65 Öre per kilo min on the field
6. --
7. --
8. Said he can also sell skogsflis
   Would be interested in selling hästgödsel

TROLLEHOLMS GODS AB

1. Yes
2. Yes
3. --
4. NO
5. --
6. --
7. --
8. Not worth selling, building their own boiler using woodchip.
   Disincentive to produce straw- bad seasons and rain.

BERGENGREN KARL GEORGE ANDERS

1. Yes
2. Yes
3. 3,500 tons / year
4. Yes- 2,300 tons/year
5. 60 – 70 öre / kg. from the field (non delivered)
6. Baled
7. --
8. Use 1,200 self, sell balance
   Would also sell woodchips

BARSEBÄCKSFÖRETAGEN AB
No survey answered

RAMEL HANS
No survey answered

RÅBELÖFS GODSFÖRVALTNING AB
No survey answered

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"Land is the original and indestructible power of the soil."

Ernest M. Fisher
Economic Aspects of Urban Land Use Patterns