IEE/09/758/SI2.558286 - MixBioPells

WP 2 / D 2.5.

Cost analysis Report

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With support of the project partners

DBFZ – Deutsches Biomasseforschungszentrum
VTT - Technical Research Centre of Finland
SP – Technical Research Institut of Sweden
DTI - Danish Technological Institute
Protecma – Energia Y Media Ambiente S.L.
CTI - Italian Thermotechnical Committee

Supported by the European Commission under the EIE programme

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1. Introduction

1.1 Objective and approach

Objective

Within the MixBioPells project two case studies, representing the whole value chain of alternative pellets, were established for each partner region. Based on these case studies a comparison of the costs of alternative heating systems with commonly used fossil heating system considering the local conditions has been performed.

Approach

In order to set up and establish two case studies which represent the whole value chain of alternative pellets in each partner region, relevant key actors had been invited to the regional start workshops (see D2.1. "Summary review of regional start workshops"). Afterwards the project partners kept in touch with the key actors and supported the establishment of the case studies in the scope of legal possibilities. The method of the cost analysis is described in chapter 1.3.

Furthermore relevant ongoing and previous projects and activities were identified by each project partner. The objective was to figure out if similar calculations had been done before and to get an overview of the applied methods.

In addition a brochure presenting the most important results of the cost analysis was prepared by BE2020+ and translated by each project partner. The target group for this brochure includes raw material supplier, pellet producers, fuel distributors and representatives of administration and policy.

1.2 Ongoing and previous projects

Each project partner was asked to gather information on ongoing and previous projects concerning the topic "cost analysis". Thus, DBFZ and BE2020+ prepared an excel list as template. The content of the identified projects has been discussed by BE2020+ and the project partners in a bilateral way.

The investigations show that there are only few projects and mainly national/regional projects dealing with costs of alternative biomass fuels and cost comparison of small-scale heating systems. Especially in Germany and Austria projects on similar subjects had been carried out. However, for this report the data of the regional case studies are important. Therefore, the data published in the previous and ongoing projects could not be used. However, the national projects were considered for the selection of the most suitable methodical approach for the cost analysis.

Also some international projects were identified:

The European project EUBIONET III and its predecessors boost sustainable, transparent international biomass fuel trade, secure the most cost efficient and value-adding use of biomass for energy and industry, boost the investments on best practice technologies and new services on biomass heat sector and enhance sustainable and fair international trade of biomass fuels. EUBIONET III also investigates price mechanisms for wood fuel. Thus, the EUBIONET III project is an important source for basic information for all tasks of the MixBioPells project. However, it is mainly focused on woody biomass.

Other international projects are “Biomasud”, “Straw for energy production” and ”Options for achieving the target of 45 MTOE from Energy Cropping in the EU in 2010” which aims to design and implement support mechanisms to help developing a sustainable market for solid biomass. However, “cost analysis” is only a negligible part of these projects.

The list with all identified ongoing and previous projects related to the cost analysis can be found in the annex.

1.3 Method cost analysis

Data gathering

BE2020+ prepared the template for the cost analysis and afterwards the data gathering was performed by the project partners. The project partners interviewed the key actors of the case studies in order to provide the data. Thus, the data for the cost analysis are derived exclusively from the key actors of the case studies. Mainly the network meetings in the partner countries were used for the data gathering. In addition several phone calls were necessary to receive the complete required data. The data acquisition was very time consuming for several of the partners.

Data confidentiality and calculation method

One important aspect, which was discussed with the project partners as well as with the key actors in each region, was the data confidentiality. It was agreed that data concerning the cost analysis should only be published preferably anonymously, though everyone involved is aware of the fact that a complete anonymity is not possible because of the detailed description of the case studies. Anyhow, thereby the collection of realistic data was enabled. However, at the time of the data collection the combustion systems of some case studies had not been installed, therefore available data of other similar systems were used for the comparison. Furthermore, a total cost comparison of the CHP plants was not possible, either because no data of a comparable fossil system were available or because these plants were only co-fired with alternative biomass. Also in these cases available data from other, regional used combustion systems were used. Anyhow, this European and transnational aggregation of costs of alternative biomass heating systems is an innovative approach and stands out from the ongoing and previous projects.

Building up on the national ongoing and previous projects and on the discussion at the project meeting in Wieselburg the following methodical approach for the calculation was selected: In order to compare the different heating systems the discounted costs over service life had been summed up, following the approach of a dynamic investment calculation. In this way the investment costs and operating cost can be compared and the most efficient system over service life can be identified. A more detailed description of the calculation method can be found in the annex.

2 Description of the case studies

2.1 Overview of the case studies

Within the MixBioPells project, the project partners established case studies for each region, which represent the whole value chain of alternative pellets / briquettes (Table 1). In the following the case studies are specified and the alternative heating systems are compared with fossil heating systems mostly used in the respective region. The reduced summed up heat supply costs of each heating system will be calculated and illustrated. Thus, the point in time, at which the alternative heating systems are more economic than the fossil heating systems, is identified.

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Table 1: Overview of the case studies

Case study	Raw material	Pelletization/ Briquetting	Customers
ESP 1	Olive stones from the food industry	One pelletizing experiment has been carried out.	Possible end users are private pellet stove/boiler owners as well as small district heating systems (e.g. hospitals).
ESP 2	Almond shells from the food industry	The pelletizing company has studied and tested different processes in order to obtain physically stabile briquettes. The final formula has been patented.	Possible end users are the industry, farms, industrial bread ovens (restaurants and supermarkets).
FIN 1	Reed canary grass from local farmers	The pelletizing company owns a mobile pellet machine with ring die technology.	The customers are usually local farmers with boilers from 100 up to 500 kW.
FIN 2	Reed canary grass mixed with wood (20/80)	The pelletizing company sells wood and mixed briquettes in big bags or loose (ring die technology).	Main customers are the farmers of the region and the local district heating plants (from 200 to 2000 kW boilers).
SWE 1	Reed canary grass	Any agricultural company running a small commercial briquetting plant.	Heating plants, public buildings as well as households.
SWE 2	Reed canary grass	Any agricultural company running a small commercial briquetting plant.	Heating plants, public buildings as well as households.
DNK 1	Shea waste, rape waste, potato and beet pulp, grain screenings	The energy utility who is the operator of the CHP plant also intends to own the pelletizing plant.	CHP plant (Electrical output: 52 MW_{el}. Heat output: 112 MJ/s).
DNK 2	Straw, grain screenings, peanut shells and corn cobs	A former wood pellet factory which is rebuild.	District Heating plants or schools in the countryside and minor industries with biomass boilers. Size of plant is typical from 50 kW to 10 MW.
ITA 1	Miscanthus and poplar	The pellets are produced (vertical die) and consumed directly in the power plant.	Power plant or district heating systems are possible customers.
ITA 2	Vine pruning	The pellets production company uses a vertical die technology.	The customers are mainly household heating systems.
AUT 1	Straw from regional farmers	The pellets production company uses a ring die technology.	The customers are the farmers who are the straw suppliers.
AUT 2	Miscanthus	The raw material supplier owns a private mechanical briquetting machine.	Customers have usually a heating capacity between 50 and 500 kW.
GER 1	Grape marc	The pelletizing company owns a pelletizing plant with a modular design.	Small scale heat plants up to large scale plants.
GER 2	Dried digestate	The pelletizing company owns a pelletizing plant with a modular design.	These pellets should be used for the combustion in a power range of 300 kW.

2.2 Straw pellets for small scale heating systems 30-500 kW (AUT)

Background

The pelletizing company successfully produces straw pellets exclusively for the material use. Now the objective is to establish a supply chain for straw pellets as fuel with farmers as both suppliers and customers. The pelletizing company has already a lot of experiences with the pelletizing of straw and other raw materials such as Miscanthus and hay. In the past, there was no demand for alternative pellets for combustion purposes and thus none were produced for this market.

Value chain

Raw material

The raw material suppliers are about 10 farmers from the region Neusiedl / Zaya. The area-specific straw harvest is subject to strong weather-related variations. The Lower Austrian average area-specific straw harvest is about 30.4 t / ha. Bulk density ranges from 100 to 250 kg / m^3 depending on the kind of harvest and compactation machinery. The harvest and logistic technologies are well established, and usually the harvested straw is compressed to bales. Outdoor storage is much cheaper than indoor storage. However, quality decrease depending on weather conditions has to be taken into account. On the other hand outdoor storage can lead to better combustion characteristics, due to reduced concentrations of potassium and chlorine. Moisture content is not an issue during storage of the straw since the values are generally low.

Pelletizing

The pelletizing company originally producing only litter pellets is responsible for the pelletizing of the straw. Only straw with a moisture content under 15 % is taken over for pelletizing. Due to the low water content a drying of the raw material is not necessary. Local farmers of the region (radius<50 km) provide 80 % of the required straw. The remaining 20 % are obtained from two other straw dealers. The current production capacity amounts to 2,000 t/a straw pellets for heating purpose; the potential production capacity is 6.000 t/a. The pellets have a diameter of 6 as well as 8 mm, the fuel properties are shown in Table 2. The bale breaker has a capacity of 5 t / h. The hammer mill has also a capacity of 5 t / h and reduces the particle size to 5-20 mm. The cooling system is a counter flow tower cooler with a capacity of 5 t / h. Fines with a diameter under 4 mm are filtered.

Table 2: Typical fuel properties of straw pellets

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
17.32	5.71	7.88	n.a.	0.45	0.084	0.123
dm…dry matter, wt.-%...weight %, n.a…not analysed						

Combustion

The ready-made fuel is picked up by the farmers themselves, so the farmers are both the straw suppliers and customers. For combustion, the farmers have to purchase a suitable boiler. For the future the stablishment of the alternative pellets is expected so that not only farmers are appropriate costumers. Guntamatic is a possible technology provider for these boilers. Possible boiler sizes vary from 30 kW to 500 kW.

Constraints and drivers

In the past a company, which is responsible for the distribution of Guntamatic heating boilers, was looking for some straw pellets for their new boiler, but the quality of the pellets from Hungary, Czech and other Austrian producers was not satisfactory. The pellets from this pelletizing company have the right quality, but now potential end customers have to be identified. Furthermore the legal framework has to be clarified.

2.3 Miscanthus briquettes for household systems (AUT)

Background

The initiator, a farmer, is owner of a briquetting plant for Miscanthus and operates a small heat supply system for 6 households. The main objectives within this case study are to support the farmers of the supply cooperation in order to establish a market for their Miscanthus briquettes and to clarify legal matters.

Value chain

Raw material

In this case study farmers of the region Weikendorf, who are members of an agricultural cooperation, want to sell their Miscanthus as briquettes. There are 22 farmers who cultivate an area of 20 ha Miscanthus within a radius of 6 km. Miscanthus has similar requirements as corn, so it needs good agricultural soils with a sufficient water supply. On well water-bearing soil layers an average annually harvest of 17,100 kg / ha over 18 years can be expected. Miscanthus harvested from 1 ha corresponds to 155 loose cubic meters (bulk density of 500kg/m³). After the second year, Miscanthus can be harvested annually in April with a moisture content of about 14 **wt.-**%. Usually a corn chopper is used for the harvest. Because of the low water content there are no problems with the harvest and storage of Miscanthus. The delivery is done with a specially designed conveyor belt wagon, so that the charging can be done without a fan or without major construction efforts.

Briquetting

The chairman of the cooperation owns a mechanical briquetting machine and is responsible for the briquetting of Miscanthus. The machine has a production capacity of 1,000 t / a. Currently he produces about 200 t / a. The Miscanthus briquettes have a diameter of 50 mm and a length between 30 and 100 mm, the fuel properties are shown in Table 3.

Table 3: Typical fuel properties of Miscanthus briquettes

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
17.7	3.1	7.5	1,010	0.24	0.035	0.025
dm…dry matter, wt.-%...weight %						

Combustion

Currently the chairman of the cooperation is the fuel supplier for 6 residential buildings. The objective is to gain more customers and supply buildings with a heating capacity between 50 and 500 kW. For combustion, the following technology providers of boilers can be considered: Fröling, Hargassner, Guntamatic, Gilles, ETA. In this case study Hargassner and Guntamatic are involved.

Constraints and drivers

One problem is the unclear legal framework in order to get the permission to install a boiler for the combustion of Miscanthus. Furthermore only few experiences with the briquetting of Miscanthus exist. Another challenge is to establish the market for Miscanthus briquettes and to find enough customers.

2.4 Heat supply costs for Austrian heating systems

Fehler! Verweisquelle konnte nicht gefunden werden. 1 shows the cost comparison of Austrian heating systems (200 kW). The investment costs of heating systems for alternative biomass are twice as high as the one for the oil boiler, but due to the high fossil fuel costs – in the year 2010/2011 on average 0.08 € / kWh heating oil - the heating systems operated with Miscanthus briquettes as well as straw pellets are getting favourable after three and a half years. As the straw pellets are produced in a larger plant, they are cheaper than the Miscanthus briquettes.

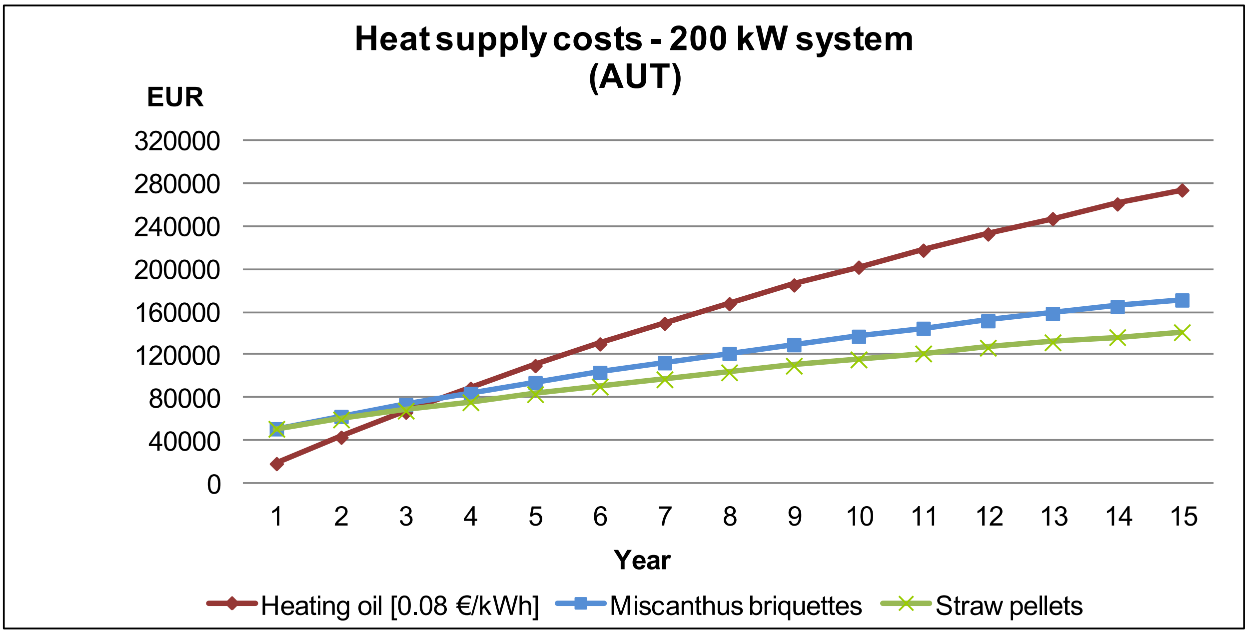

Figure 1: Cost comparison of Austrian heating systems (200 kW)

The Austrian emission control act will result in the requirement of flue gas treatment systems. The additional cost for such systems are considered in a second case study (Figure 2). For these cases, investment return is expected after 4 respectively 5 years. In both cases - with and without flue gas treatment- the use of these alternative pellets is cheaper than the use of heating oil for heat production in a 200 kW system considering a service life of 15 years.

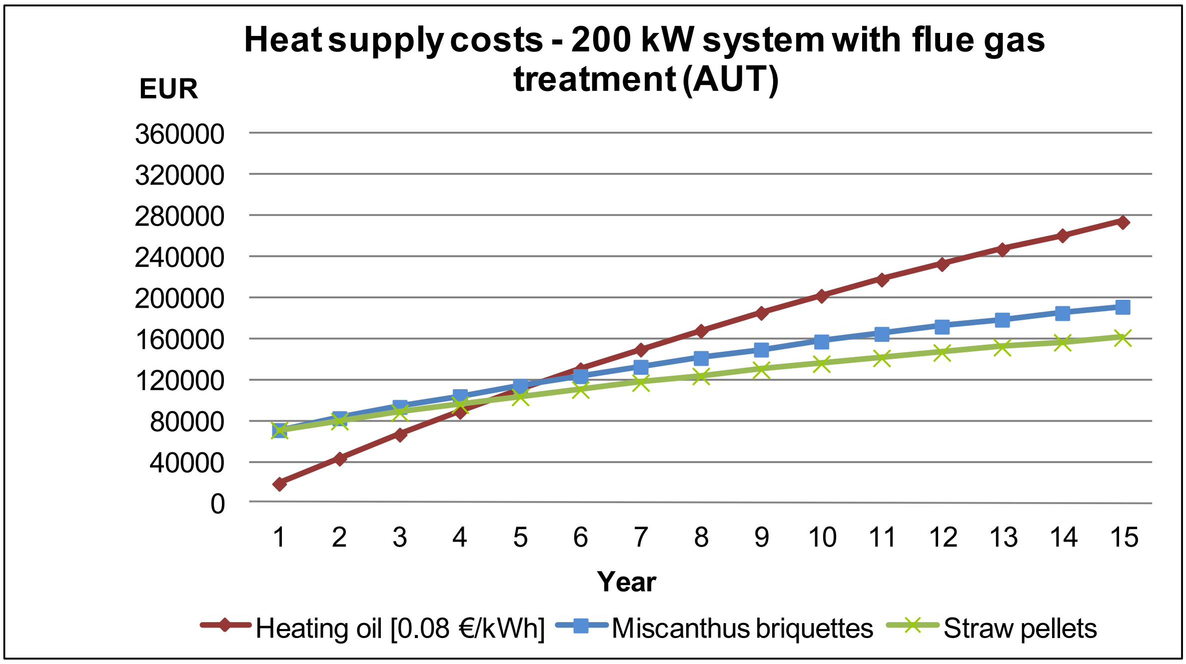

Figure 2: Heat supply costs of a 200 kW system with a flue gas treatment equipment, Austria

If the Miscanthus briquettes respectively the straw pellets are used in a small scale heating system they would be less cost effective. For small scale heating systems the use of heating oil is cheaper until the 11th respectively 14th year of service life (Figure 3). So the straw pellets and Miscanthus briquettes are more suitable for bigger heating systems.

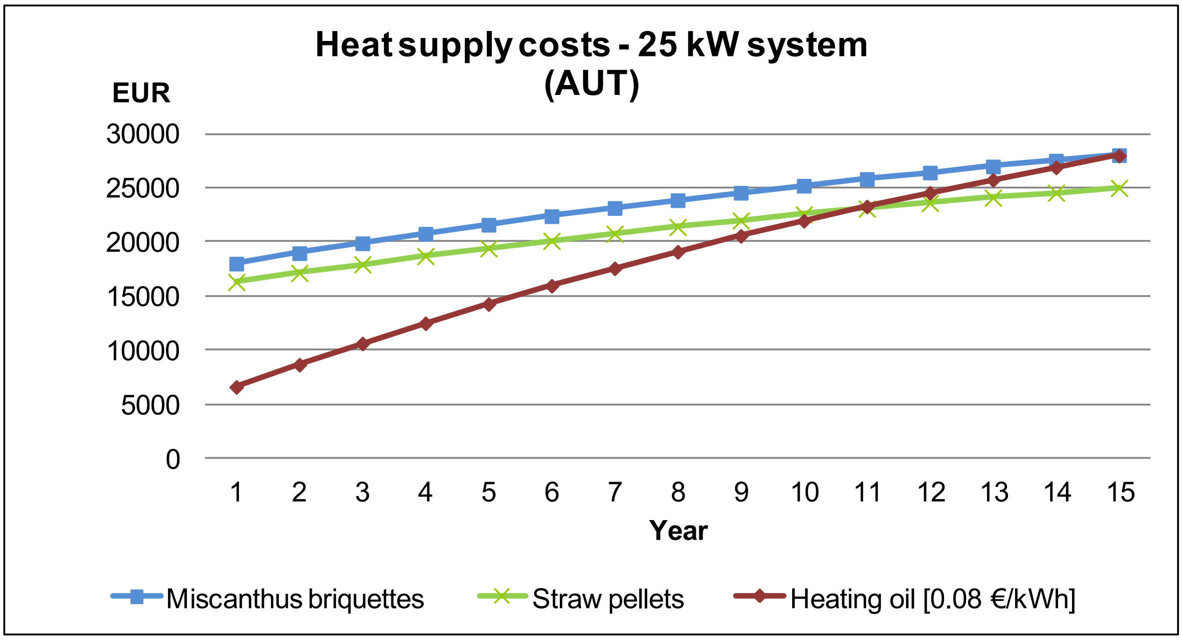

Figure 3: Cost comparison of Austrian heating systems (25 kW)

2.5 Pelletizing biomass residues (DNK)

Background

The heating plant was originally commissioned in 1982 as a 100 % coal fired CHP (Combined Heat & Power) plant supplying the town of Randers in Jutland with electricity and district heating. Today (2011) the coal consumption has dropped as low as 10 % on an energy basis and is only used during wintertime. The ambition is a 100 % shift to renewable fuels. The used renewable fuels are wood chips, wood pellets and dry biomass. The dry biomass is a mix of wood pellets, shea waste, grain screenings, rape waste and sun flower shells. The main part of the wood pellets is from pellet plants, which are located in UK, of the utility.

Value chain

Raw material

The energy utility plans to use agro industrial waste as shea waste (Table 4), rape waste, potato and beet pulp, grain screenings, etc. The raw material is available within a 200 km radius in Denmark. Transport is possible by truck and ship of medium size. There is good access to the Baltic harbours from Randers by ship. Therefore, import is possible during shortage of domestic supply. The suppliers are food and feed industries processing agricultural products. Dry raw materials as shea/rape waste and grain screenings are preferred. The access to rape waste depends on the use in the feed industry and the market price for protein. Sometimes the price is too high for energy purpose. The raw material needs covered storage, and can not be stored in open air. During storage, self-ignition and off-gassing must be considered as possible risk.

Pelletizing

The energy utility intends to purchase and run the pelletizing line within its own premises at the CHP plant. The pelletizing line consists of a milling system, a mixer with possibility to make mixed pellets and to improve the quality with additives. The pelletizing unit is followed by a cooling tower before the pellets are conveyed to storage. The pellets are burned in the CHP plant on the same premises. During periods of overproduction the pellets could be sold to the market. The production is planned to reach a maximum of 100.000 t/a.

Table 4: Typical fuel properties of Shea waste

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
15.7	5.5	13.0	n.a.	2.3	0.28	0.08
dm = dry matter, wt.-%...weight %, n.a…not analysed						

Combustion

The consumers are the citizens of Randers (approx. 50,000 inhabitants) who are supplied with district heating. In addition, electricity is sold to the grid. The CHP plant has the following data:

- Electrical output: 52 MW_{el}.

- Heat output: 112 MJ / s.
- Steam pressure 111 bar. Steam temperature: 525°C.

The plant is situated in the middle of the district heating network.

Constraints and drivers

There is only little experience in Denmark on own production of biofuels in the power plant sector. There is almost no market for alternative pellets of biomass (in relation to wood pellets). This means that there is no competing market where alternative pellets can be purchased, but at the same time there is very little experience to rely on.

The logistic on the site is a challenge as the harbour area where the pellet plant will be located is quite narrow with few possibilities for expansion. The advantage is that medium sized ships, used in the Baltic Sea and on rivers in Germany, Poland and Russia can call directly at the storage facilities of the plant unloading raw materials. During hard winters the harbour is frozen giving problems with the limited storage facilities

2.6 Industrial production of straw-biomass residues pellets (DNK)

Background

A pellet plant has produced wood pellets for several years in Assens in the region of Fyn, but was closed in 2010. The plant is situated nearby the region Jutland where most activities in the field of alternative and mixed biomass fuels takes place. The owner intents to reopen the plant with a straw pellet production if sufficient demand is available.

Value chain

Raw material

Mainly straw in big bales of 500 kg each is used as raw material. Within a 100 km distance from the pellet factory there is a straw surplus of more than 500,000 t/a. The suppliers are large farms or straw entrepreneurs who have many years of experience in baling, transporting and storing straw in big bales for energy purpose. The Danish straw handling system is developed for straw supply to CHP and power plants over the whole year. The power plants have only limited storage facilities, for a weekend, or maximum of 7 days. So an outdoor storage system developed by the farmers makes it possible to deliver dry straw of good quality round the year. This straw supply chain will also be available for pellets production. The straw is delivered on truck with 24 bales in two layers (12 bales on a truck and 12 bales on a trailer). In power plants the bales are unloaded by automatic crane, on smaller plants by front loader. Biomass residues as grain screening are a local waste product and there is easy access to large amounts in the same area where straw is purchased. Peanut shells and corn cobs can also be used as raw material. A possibility is to mix the raw material with Calcium Carbonate in order to increase the melting temperature of the ash.

Pelletizing

The pellet factory is a former wood pellet factory where the equipment can be used with some rebuild. A straw chopper is used to take the big bales apart. A mixer for different raw materials and additives is needed too. There is a rotary drum for drying, milling equipment, a pelletizing machine with a ring die system and a cooling system for the pellets. The pellets will be distributed in either in bulk with trucks or packed in small or big bags. The pellet quality will be in accordance with CEN TC 14961. Capacity: 60.000 tons annually with 7,600 hours of operation. It is very important to have continuous monitoring of the dry biomass storage, as self ignition is a risk. Typical fuel properties of the raw material are listed in the Table below.

Table 5: Typical fuel properties of straw

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
14.5	4.8	15	870	0.67	0.16	0.41
dm……dry matter, wt.-%...weight %						

Combustion

The consumers are district heating plants or schools in the countryside and minor industries with biomass boilers. Typical plant sizes are varying between 50 kW and 10 MW. Export of pellets is a possibility. The market is within 300 km from the plant. It is necessary for the costumers to have a boiler with grate or similar technologies which can handle ash rich fuels (ash content over 4 wt.-%). Private household boilers (10-20 kW) are often not able to burn fuel pellets with an ash contents higher 0.5 - 1 wt.-% dry matter.

Constraints and drivers

The market for alternative pellets of biomass (compared to wood pellets) is almost not existing. This means that there is no competing market where alternative pellets are sold, but at the same time there is very little experience to rely on. The market situation for straw pellets are up to now limited as private end users mainly use high quality wood pellets, and most house hold boilers are not able to burn biomass with an ash content higher 0.5 - 1 wt.-% dry matter.The pellet plant has to be rebuilt and additional equipment is necessary, e.g. a straw chopper and a mixer to mix milled raw material of different types. The storage facilities are limited, and both raw material storage and pellet storage has to be built. The advantage is that the plant has been producing up to 2010 and the processing line is ready for operation.

2.7 Heat supply costs of Danish heating systems

For the cost comparison shea waste respectively straw pellets mixed with grain screenings as fuel in a 20 kW system were chosen. At the present, the heating oil price is very high in Denmark (0,15 € / kWh). Because of the low raw material costs, the price for pellets made from biomass residues amount only 0.14 € / kg.

Therefore, the 20 kW heating systems operated with dried biomass residues are already getting favourable after two and a half years (Figure 4) though the investment costs for alternative biomass heating systems are almost twice as much as the one for the oil boiler.

A cost comparison for the CHP plant which is mentioned in the case study is not possible, because also fossil fuels are co-fired and the plant was built up for using only fossil fuels. Due to the fact that mixed biomass pellets are much cheaper than fossil fuels, the use of these pellets in CHP plants pays off because of lower fuel costs.

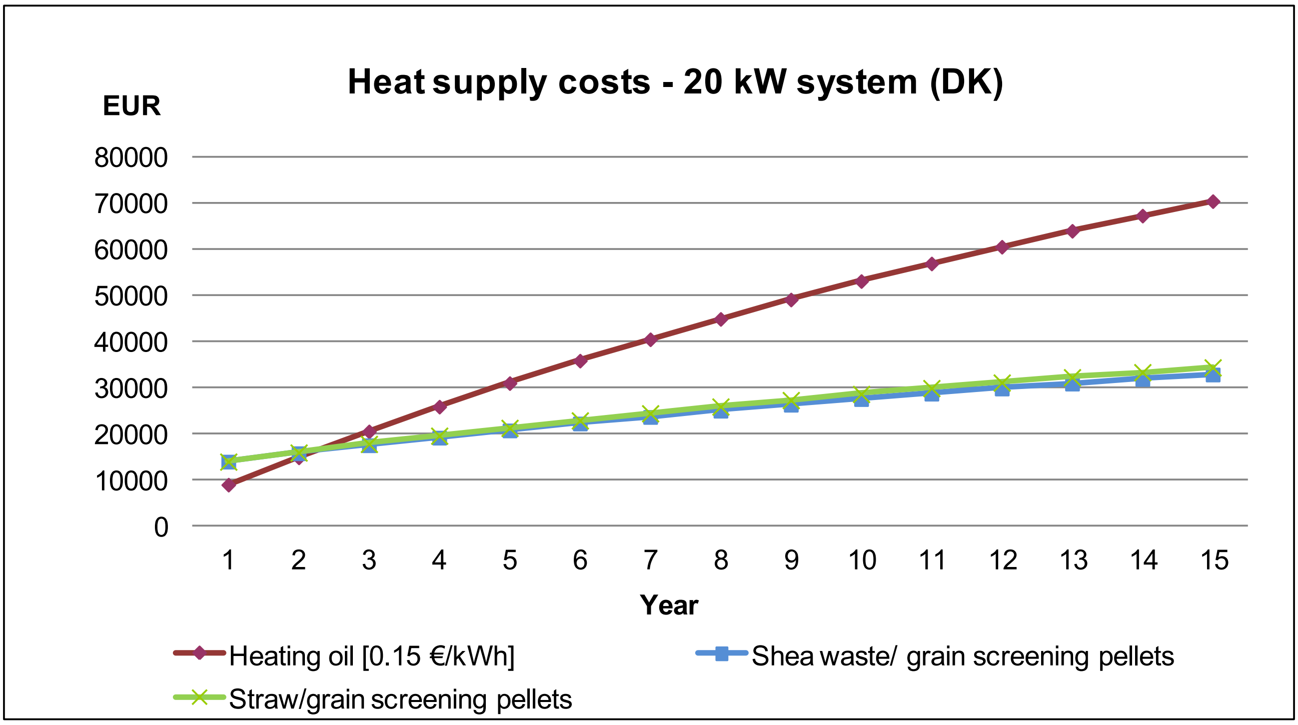

Figure 4: Cost comparison of Danish heating systems (20 kW)

2.8 Reed canary grass-wood briquettes for grate boilers (FIN)

Background

This initiative was started in the beginning of 2011. In autumn 2010 there was a lack of wood material, so the briquette manufacturer wondered which other raw materials could be used. There are no personal costs involved in this project, since the initiators work for their own benefit.

Value chain

Raw material

Two types of raw material, wood and reed canary grass (usually mixed), are used. Dry wood dust from a saw mill is transported pneumatically. The saw mill is located about two hundred meters from the briquette factory.

Reed canary grass (RCG) is bought from local farmers as bales. The cultivation of RCG allows for annual harvest of about 4 t/ha. RCG can grow for several years on the same place and it is harvested annually in the spring. The moisture content is then about 10 – 15 %. RCG is a modest plant and grows in old peat production areas and wastelands with a small amount of fertiliser and water. It is usually baled with baling machines of the farm and stored in well covered stock piles.

Pelletizing

The manufacturer sells wood and mixed briquettes, made of wood and RCG. He developed a method of his own to break the RCG bales (confidential). The briquettes are pressed by an automatic Adelmann / 82 press. Practically no man power is needed for this process. At the factory the briquettes are packed into big bags and part of the production is sold in bulk. Customers either pick up the briquettes from the factory or the producer delivers the briquettes to the clients. In 2010 the production amounted to 1,100 tons. The production capacity of the press is 2,500 t / a. The briquettes have a diameter of 50 mm and a length between 100 and 300 mm. Typical mixed briquette properties are described in the following table.

Table 6: Typical fuel properties of reed canary grass - wood briquettes

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
18	1.5% (mix 20% RCG, 80% wood)	10 -12	1,000 – 1,200	n.a.	n.a.	n.a.
dm……dry matter, wt.-%...weight %, n.a.…not analysed						

Combustion
Main costumers are the farmers of the region. They combust briquettes mixed with wood chips. Also the local district heating plants use briquettes in their grate boilers of 200 – 2000 kW. Most of the clients are inside the circle of 50 km from the factory.

Constraints and drivers

No major problems are seen in using a moderate mixture of wood and reed canary grass. There are plans to increase the percentage of RCG in the mix. However, a shortage of raw material and the quality of the RCG bales are problematic, because the moisture content of bales can vary between 10 – 40 wt.-%.

2.9 Reed canary grass pellets for farms and district heating (FIN)

Background

The energy production chain of this case study includes a mobile pellet machine. For the region a benefit is that local alternative raw material (RCG) can be used for large scale heating systems. In autumn 2010, there were preliminary discussions if the pelletizing of reed canary grass would be possible. The pelletizing of reed canary grass succeeded well and they looked for potential pellets customers.

Objective of the case study is to determine, if it is possible to pelletize larger amounts of alternative raw materials in a short time with a mobile unit.

Value chain

Raw material
Reed canary grass from local farmers within a radius of 20 km is used as raw material. The annual harvest of RCG amounts 3 to 7 t / ha. In spring the moisture content is about 10 – 15 wt.-%. Reed canary grass is usually baled with baling machines of the farm and stored in well covered stock piles. After the pelletising of the raw material,the produced pellets are not stored but immediately sold to the customers, in this case to the energy utility. Trucks are used for the transport of the pellets.

Pelletizing
The operator of the pelletizing plant uses a ring die. The production capacity of the press is about 1.7 – 2 t / h. The advantage of the mobile pelletising plant is that pellets were produced on site. Thus, the logistic effort is reduced Vans, trucks, etc. can be used for delivery of pellets. Typical fuel properties of the pellets are shown in Table 7.

Table 7: Typical fuel properties of reed canary grass pellets

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
17.94	3.1	10-14	1,050 – 1,240	0.88-1.33 spring	0.09-0.17 spring	0.09-0.56 spring
dm……dry matter, wt.-%...weight %						

Combustion

The produced heat is used for residential heating and heating of cattle-houses in farms. For this case study district heating is assumed. Farmers have usually relatively large burners and boilers, 100 – 500 kWh. At the moment most of the units use fixed grates, but there is a trend to moving grates.

Constraints and drivers

Wet bales of reed canary grass, after they have been stored under bad conditions for one year, will slow down the pelletizing process and increase the costs. So for pelletizing it is better to use the RCG of the spring harvest. The price of the pellets was negotiated and agreed, after which everything went fine. A negative factor is that the pelletizing machine had minor problems over the time. At the moment there are no competing markets. Expected problems can be the price of raw material and also the amount of suitable raw material in the area.

2.10 Heat supply costs of Finnish heating systems

Figure 5 shows the cost comparison of Finnish heating systems with a nominal load of 200 kW. In this case the investment costs for the alternative biomass heating systems are not that high, so the systems operated with reed canary grass pellets as well as briquettes are already getting favourable after one and a half year. In Finland alternative biomass is much cheaper than fossil fuel. The price of the heating oil amounts currently to 0.13 €/ kWh. The RCG- pellets are cheaper than the mixed pellets. This is due to the high proportion of wood (80 %) and the cost intensive mixing process.

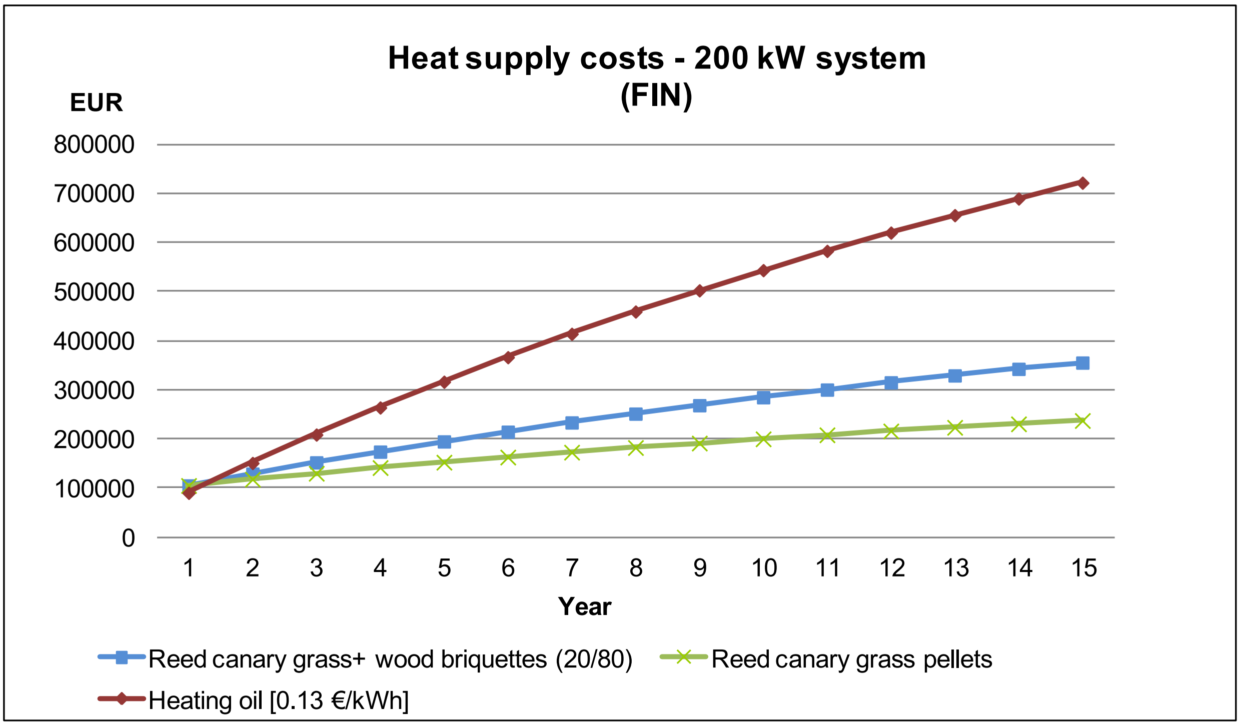

Figure 5: Cost comparison of Finnish heating systems (200 kW)

2.11 Grape marc pellets –implementation of a marketable product (GER)

Background

The objective of this case study is the implementation of grape marc pellets as a marketable product within the framework of 1.BImSchV (Immision control act). Since many key actors have uncertainties regarding the licensing of regular fuels according to 1.BImSchV §3 Abs.1 No.13, this case study could be a reference for other projects and key actors within this framework.

Value Chain

Raw material

In Germany, the total energetic potential of residues from the viniculture is approx. 4.9 PJ including approx. 265,000 t/a grape marc and 318,000 t/a vine pruning. Grape marc is a manifold structured heterogeneous mixture which generally consists of approximately 40 wt.-% solid components such as grape skins, kernels and peduncles. Currently, grape marc is almost exclusively used in the agriculture, e. g. as fertilizer. Since only 30 wt.-% of the humus losses in the viniculture can be balanced by organic fertilizers, an additional purchase of fertilizers such as compost, straw or bark compost is necessary. Furthermore, the utilisation is labour and cost intensive because the residues have a high moisture content up to 65 w. -% and accrue in a short period of about 6 weeks. Thus, a high risk of putrefaction exists during storage linked with odour nuisances, development of vinegar flies and seeping water. Additionally, the use as a fertilizer can promote the propagation of the black rot. A solution of this problem is the drying and pelletizing of the raw material.

Pelletizing

The pelletizing of grape marc and mixtures has already been investigated on ring and flat die presses. Grape marc pellets and blends with vine pruning can fulfil the requirements of the draft of the European standard for solid biofuels (prEN 14961-6). The quality parameters of pellets from grape marc and mixture with vine pruning (ratio: 70/30 Vol.-%) are listed in Table 8. Now a demonstration of the feasibility of the pelletizing line PM 6-28 needs further support. The pelletizing technology has a modular design especially for the production of user-defined pellets from a mixture of input substances without the need for additional grinding (hammer mill). The production capacity is between 1 – 4 t / h.

Table 8: Typical fuel properties of grape marc pellets

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
19.8	10-13	6.5	910	1.89	0.12	0.004
dm……dry matter, wt.-%...weight %						

Combustion

The objective is to implement a marketable product in a medium-term period which strengthens a sustainable recycling management and rural economics within the framework of 1.BimSchV. Since many key actors have uncertainties regarding the licensing of regular fuels according to 1.BImSchV §3 Abs.1 No.13, this case study could be a reference for other projects and key actors within this framework.

Constraints and drivers

The major obstacle are lacks of information regarding the combustion of the pelletised raw materials to justify the certification as a regular fuel within the framework of 1.BImSchV §3 Abs.1 No.13. Thus, the following tasks will be included in the evaluation:

- Combustion tests with grape marc pellets and mixtures with Miscanthus in two combustion systems, e.g. with precipitator.
- Evaluation of the requirements and economics of the yearly measurement program according to §3 Abs.1 No.13 1.BImSchV including different approaches, e.g. field or test stand measurements and the legal consequences.
- Evaluation of economic and logistic aspects of possible utilisation concepts for grape marc pellets.

- Presentation of the results in the working group “solid biofuels” which is actually specifying a positive list of “other renewable solid biofuels” according to 1.BImSchV §3 Abs.1 No.13.

2.12 Digestate pellets for medium-scale heat plants (GER)

Background

BHKWs of biogas plants cannot cover the full heat demand of the heating season. Thus, the combustion of digestate and mixtures of digestates with other raw materials could provide an additional fuel option to fulfil the heat demand and to improve the operation and feasibility of biogas plants.

Value Chain

Raw material

Dried digestate originating from biogas plants mainly operated on maize is used as raw material. Depending on the input materials and the line operation of the biogas plant varying fuel qualities have been observed. These varying fuel qualities can be adjusted by adding other regional raw materials such as woody or non-woody biomass and utilising additives and binders during the pelletizing process.

Pelletizing

The utility is operating about 40 biogas plants with > 500 kW_{el}. The pelletizing line PM 6-28 is to be evaluated for possible fields of application. The pelletizing technology has a modular design especially for the production of customised pellets from a mixture of different input substances without the need for additional grinding (hammer mill). The production capacity is between 1 - 4 t/h. Table 9 shows the typical fuel properties of digestate pellets.

Table 9: Typical fuel properties of digestate pellets

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	**wt.-% dm**	**wt.-%**	**°C**	**wt.-% dm**	**wt.-% dm**	**wt.-% dm**
15-16	**16-20**	**9-10**	**~1,100**	**1.5-3**	**0.3-1**	**0.3-0.9**
dm……dry matter, wt.-%...weight %						

Combustion

The objective is to produce pellets based on digestate and other raw materials. These pellets should be used for the combustion in a capacity range up to 300 kW. Therefore, the following concepts have been figured out: In Germany, many biogas plants are installed and the market expands to other European and non European countries. The basic technology can be widely transferred to other applications, plant manufacturers and system planning engineers.

Constraints and drivers

The major obstacles are:

- uncertainties in developing a suitable integrated concept,
- varying fuel qualities depending on the input materials and the line operation of the biogas plant.

Therefore, pelletizing and combustion tests including fuel and bottom ash analysis will be carried out and evaluated. Based on this, a market analysis and a profitability study for the proposed concepts will be carried out.

2.13 Heat supply costs of German heating systems

Figure 6 shows the cost comparison of German heating systems with a nominal load of 30 kW. To operate this small scale combustion system with alternative pellets is not efficient. The price of the heating oil amounts currently to 0.07 € / kWh. The digestate pellets are cheaper than the grape marc pellets, because it is assumed that digestate can only be used for combustion if it is not longer needed as fertilizer (if the humus balance is alright or legal constraints speak against it).

In contrast, the use of the digestate pellets in a 250 kW system is getting favourable after three years (Figure 7). The 250 kW system operated with grape marc pellets is getting favourable not until 10 years. This is due to the high drying costs for the grape marc.

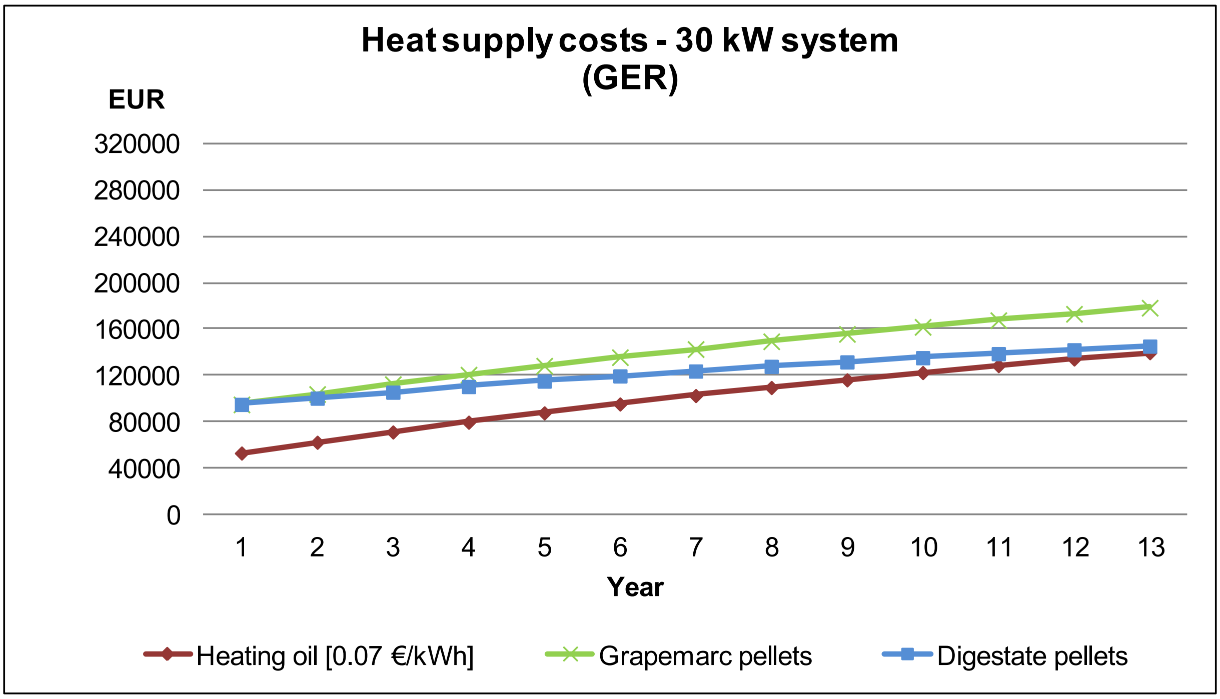

Figure 6: Cost comparison of German heating systems (30 kW)

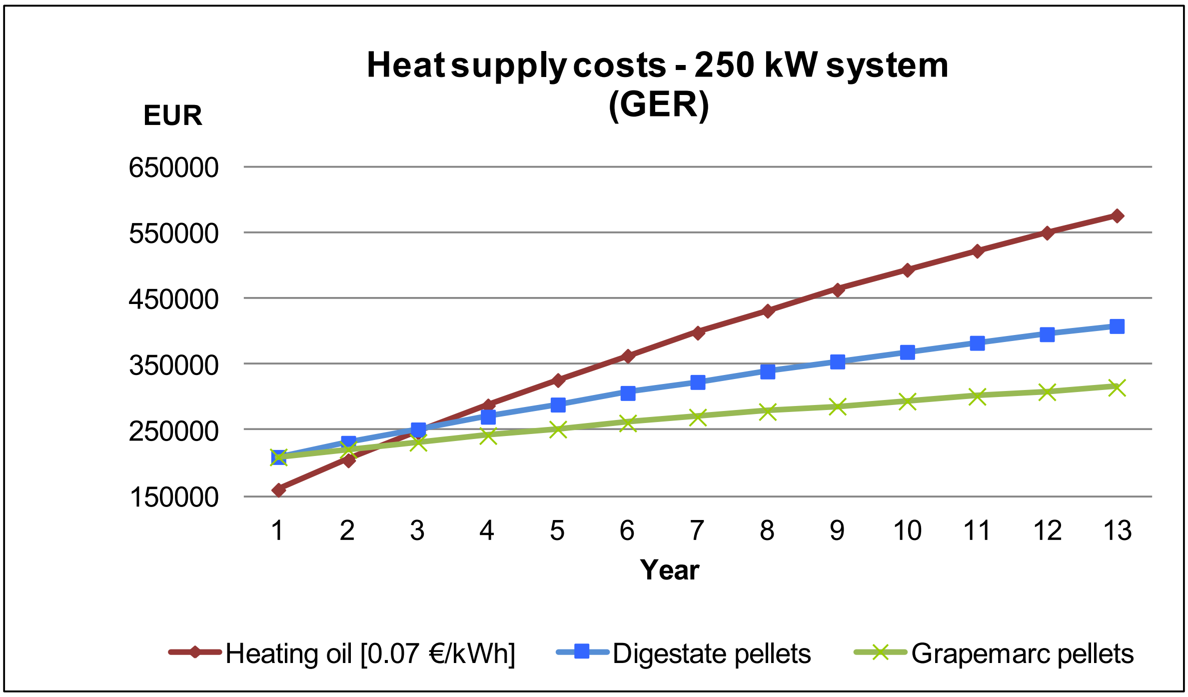

Figure 7: Cost comparison of German heating systems (250 kW)

2.14 Vine pruning pellets for household heating systems (ITA)

Background

Initiator of the case study is a small company in Italy which produces agricultural machines for harvesting vine pruning. During the last two years, the machine model has worked in some vineyards in the province of Verona. The harvested pruning was supplied to the pellet plant for pellet production. These pellets are mainly purchased by local customers to be used in stoves and boilers. The successful sale of this type of pellets motivated the owner of the company to involve pellet machines manufactures in the project, proposing the development of a mobile machine for pelletizing vine pruning directly at the farm.

Value Chain

Raw material

In the region Veneto vine production is widespread. In this context, the company has developed a machine for harvesting vine pruning for pellet production. In this region the annual biomass potentialamounts to 1.5 – 1.8 t/ha on 18,000 ha The pruning is left on the field for some weeks and is usually collected between January and March. During this time the product dries from 50 wt.-% to about 15-20 wt.-% moisture content (bulk density: 300 kg / m^3). The harvester picks up the raw material without clod soil and inert material. These materials would bevery detrimental to the pellets quality (increase of the ash content).

Pelletizing

At present, the pellets are produced with a vertical die for the production of 6 mm diameter pellets. Among the residual biomass, vine pruning appears less problematic in comparison to other agricultural materials, considering the lower ash content and the low level of critical elements (e.g. sulphur and nitrogen). The typical fuel properties are shown in Table 10. The production capacity of the pellet machinery is about 2 t / h and the product is commercialized in 15 kg bags or in big bags. About 100 t of vine pruning pellets have been produced last year and a doubled production is expected in 2011. Moreover, a new mobile pellet mill is under construction, which will be coupled with the p.t.o. of a 50 kW tractor. The pellet production capacity of the mobile pellet machine should be approx. 0.5-0.6 t /h.

Table 10: Typical fuel properties of vine pruning pellets

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
17.6	2.1-3.3	3.5-5.0	> 1,500	0.5-0.7	0.01-0.02	0.04-0.06
dm……dry matter, wt.-%...weight %						

Combustions

The vine pruning pellets are used in household heating systems, mainly in farms and for residential heating. The introduction of a mobile pelletizing machine opens the opportunity to offer a service of producing alternative pellets directly at the farm. In this context, the introduction of a mobile pellet machine seems to be a good strategy - also with regard to the environmental significance (recovery of agricultural waste and energetic use on site – “biomass from short chain").

Constraints and drivers

The handling of combustion emissions are probably the most important aspect for a positive development of this sector. There are no high-performance combustion systems for alternative pellets yet available on the market.

2.15 Miscanthus-poplar pellets in a power plant (ITA)

Background

The farm owner mainly produces cereals for food and forage. He also developed a project for the production of pellets made of Miscanthus and poplar (ratio 1:1) for his own power plant. The raw material needed for the pellet production will be directly produced on the farm. The power plant produces thermal and electrical energy by a Termocabi boiler for agri-pellet and an ORC system. In the project, the thermal energy is mainly produced for private households. In addition, there is also the possibility to use the heat for the dryer system in the pellet plant.

Supported by: Intelligent Energy Europe
Partner: bioenergy2020+ protecma VTT SP CTI Danish Technological Institute DBFZ

Value chain

Raw material

The crops are cultivated on a 120 - 140 ha area and, if best conditions are provided, an annual production of 20 t/ha (dry matter) can be obtained. Poplar is cultivated as short rotation forestry system (more than 6,000 plants / ha). The harvest is usually carried out from November to March. Freshly harvested biomass has a moisture content up to 35-45 %. After the harvest the biomass is chipped.

Pelletizing

The pellets are produced directly at the farm using vertical die pelletizing machinery. At present, the possibility of selling the pellets in the market is not considered. The complete production is used at the farm. The typical fuel properties are shown in the Table 11.

Table 11: Typical fuel properties of Miscanthus-poplar pellets (1:1)

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
17.5-17.8	2.2-4.4	6.0-8.0	> 1,250	0.4 – 0.6	n.a.	n.a.
dm……dry matter, wt.-%...weight %, n.a…not analysed						

Combustion

The combustion technology is based on a blower air horizontal burner designed for agricultural pellets. The boiler consists of three 1 MW burner (3 MW total thermal input). An ORC power plant will produce electricity (400 kW_{el}).

Constraints and drivers

The boiler of the power plant is one of the most critical elements because it affects technical, economic and authorization aspects. Compliance with the emission thresholds has to be ensured to enable regulatory approval: this is the basic element for the system design. Poplar and Miscanthus mixed pellets seem to be a good biofuel, especially for burners designed to be fed with alternative pellets.

2.16 Heat supply costs of Italian heating systems

For the cost comparison first a 30 kW heating system was chosen. The investment costs of the heating systems for the alternative pellets are much higher than the ones of the gas boiler. The price of the gas is currently just 0.07 €/ kWh. Therefore the small scale heating system operated with Miscanthus-poplar pellets is more expensive than the small gas heating system. The system operated with vine pruning pellets is getting favourable after ten and a half years due to the low raw material costs of vine pruning (Figure 8). Drying of the raw material is not necessary.

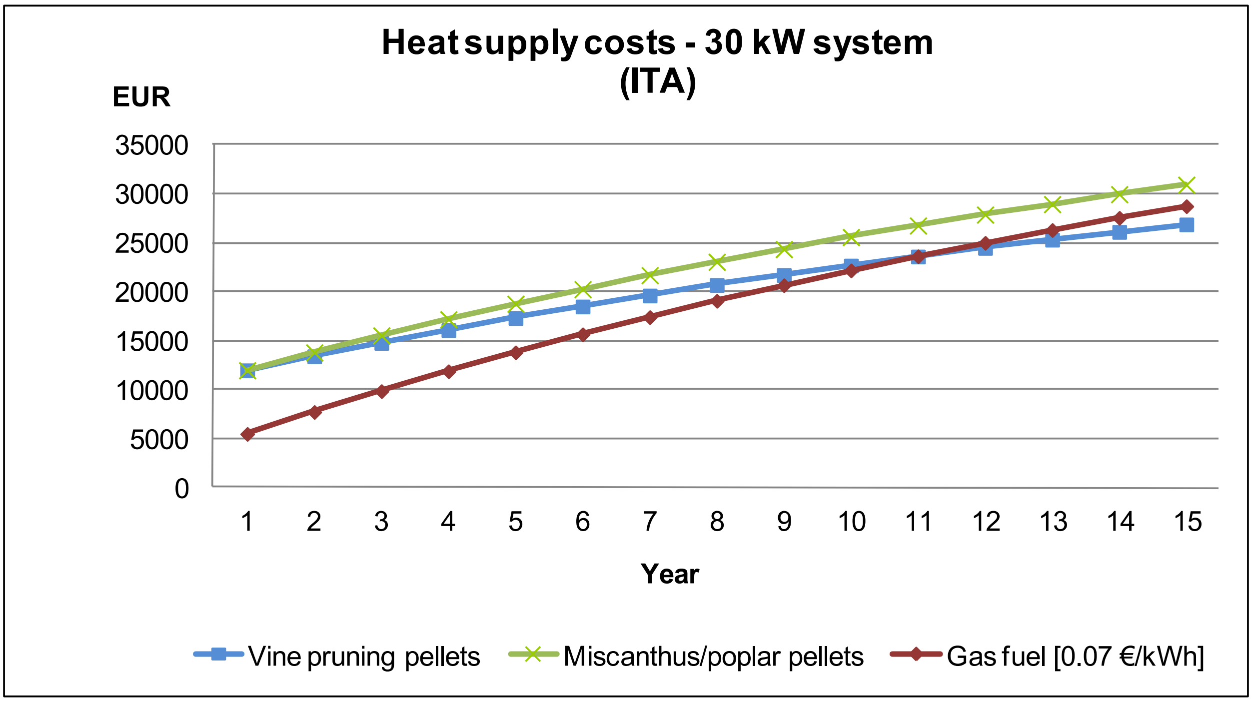

Figure 8: Cost comparison of Italian heating systems (30 kW)

Figure 9 shows that the vine pruning pellets and the Miscanthus poplar pellets are more suitable for larger heating systems. If a 200 kW heating system is used for the combustion, the biomass systems (Miscanthus poplar pellets as well as vine pruning pellets) are getting favourable after two and a half years.

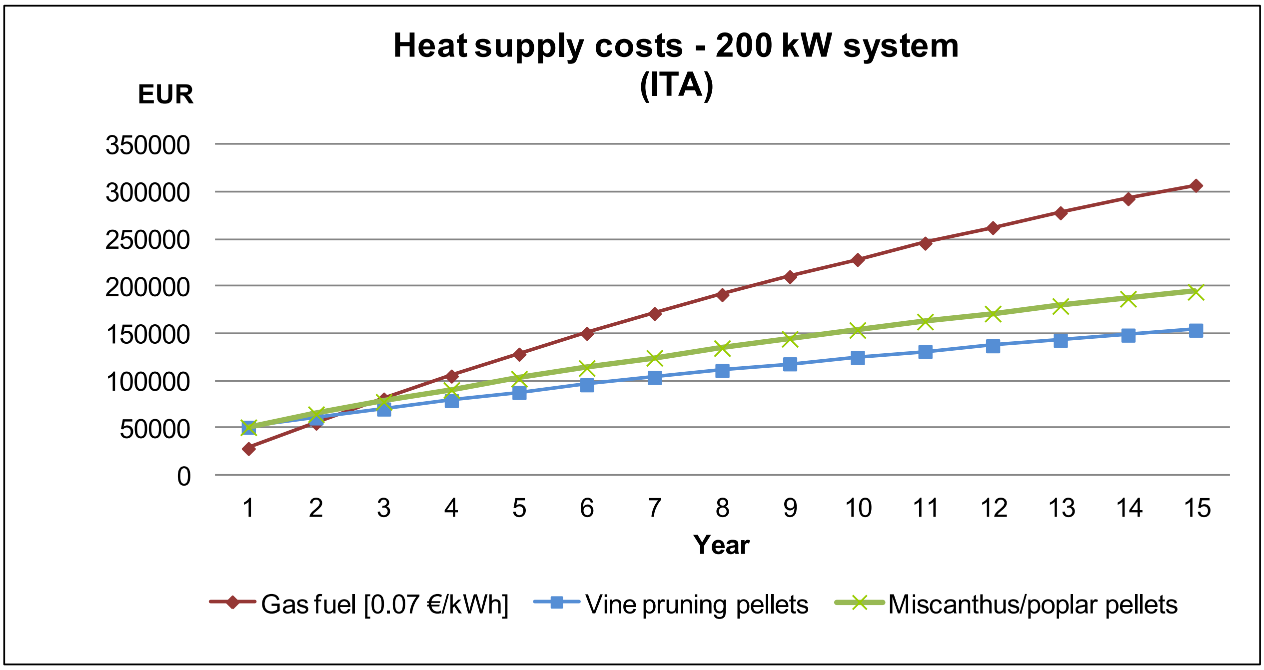

Figure 9: Cost comparison of Italian heating systems (200 kW)

It also profitable to use the biomass pellets in the power plant of the case study, because they are cheaper than the fossil fuel (Table 12).

Table 12: Fuels costs for a 3 MW power plant

Annual fuel costs for the 3 MW power plant		
Vine pruning pellets	**Miscanthus/poplar pellets**	**Gas fuel**
492,000 €	701,200 €	1,750,000 €

2.17 Olive stone pellets for small district heating systems (ES)

Background

Spain produces 880,000 t olive oil per year, which is about 34 % of the world's olive oil production. The world production of olive oil amounts to 2,584,500 t per year. One fuel supplier is interested in producing and selling olive stone pellets. Therefore possibilities for stabilising the characteristics of the olive stones for use in small and medium sized biomass boilers should be investigated.

Value chain

Raw material

Approximately 30 % of the weight of the olive belongs to the olive stone, this means that in Spain, 290,000 t of olive stones are available. Olive stone pellets have a similar heating value to wood pellets. Olive trees are harvested once a year, in autumn. Before using olive stones as fuel, they have to be cleaned and dried. They are sold usually in 15 kg bags or loose, like wood pellets, and the silos can be filled pneumatically. The olive stone pellets are used for small and large scale heating systems. The problem with olive stones is the varying fuel quality and the difficult pelletizing process.

Pelletizing

The pelletizing process of olive stones is complicated due to their characteristics. Olive stones have no natural conglomerate, and previous pelletizing tests have shown problems with the pellet hardness and stability. The aim for the future is to analyse the possibility to mix wood saw dust in different portions in order to improve the final quality of the product.

Table 13: Typical fuel properties of olive stone pellets

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
15.3	<1	12 - 13	800 - 950	n.a.	< 0.1	n.a.
dm……dry matter, wt.-%...weight %, n.a…not analysed						

Combustion

There are a lot of potential customers of olive stone pellets because the market is open towards alternative fuels. However, the end users are not happy with the changing quality, which has created serious combustion problems in many cases. The end users could be owner of small scale heating appliances like pellet stoves or pellet boiler as well as medium to large scale plant operators. Especially for small scale heating appliances a stable and good olive stone quality is mandatory. The price of treated olive stones could be approx. 180 €/t, which is 10 % cheaper than wood pellets (in northern Spain).

Constraints and drivers

The main problem is the pelletizing process of the olive stone, which shall deliver a product equal in quality to wood pellets, and in all cases for a lower price.

2.18 Almond shell briquettes for industrial plants (ES)

Background

Spain produces 63,000 t of almonds per year (world production rises up to 487,000 t/year). An energy company which is located in the Crevillente region of Alicante is interested in briquetting almond shells.

Value chain

Raw material

Approximately 40 % of the weight of the almond belongs to the shell, which means there are approx. 25,000 t of almond shells available per year in Spain. The almond shells don't need any following processing, as they are already relatively dry; they might be grinded a little. The briquettes can be used in medium to large scale boilers. They briquettes are sold loose, can be stored like pellets, and transported in large quantities.

Briquetting

The company has developed its ownbriquetting technology and has studied and tested different processes. The result was a final briquetting formula which was patented. It was extremely difficult to find the correct procedure which guaranteed a physical stability of the briquettes. The typical fuel properties of almond shell briquettes are shown in Table 14.

Table 14: Typical fuel properties of almond shell briquettes

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
18.5	1.51	2	1,375	0.20	0.03	0.12
dm……dry matter, wt.-%...weight %						

Combustion

The end consumers for the almond shell briquettes are industrial plants, farms, industrial bread ovens, restaurants, supermarkets and petrol stations for resale. The company is targeting the international markets. Therefore, it has associated to Svebio (Sweedish bioenergy association) and WBA (International bioenergy association).

Constraints and drivers

The main difficulty is to achieve a solid product with good mechanical and physical properties. Therefore, parameters as the ones for optimal moisture content are important.

2.19 Heat supply costs of Spanish heating systems

The investment costs for alternative biomass heating systems are much higher than the ones for gasoil heating systems. Furthermore the price for gasoil is currently pretty low (0.09 € / kWh) and the processing costs of the olive stone pellets are pretty high, especially the costs for drying and storage. As shown in Figure 10 the heating system operated with almond shell briquettes is getting favourable not until 14 years, the system operated with olive stone pellets after 17 years. It is much more profitable to use these biomass pellets in large scale combustion systems. Figure 11 shows that, compared to a gas oil boiler, the 200 kW systems operated with olive stone pellets and almond shell briquettes are getting favourable after 4 years.

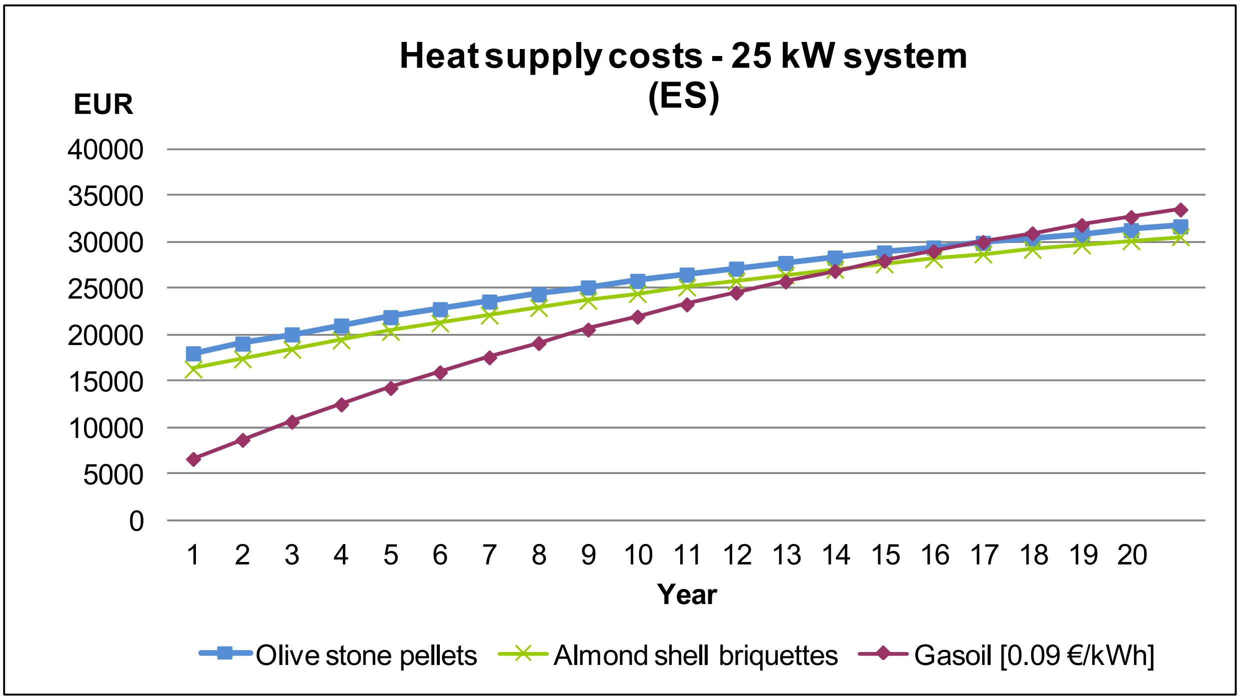

Figure 10: Cost comparison of Spanish heating systems (25 kW)

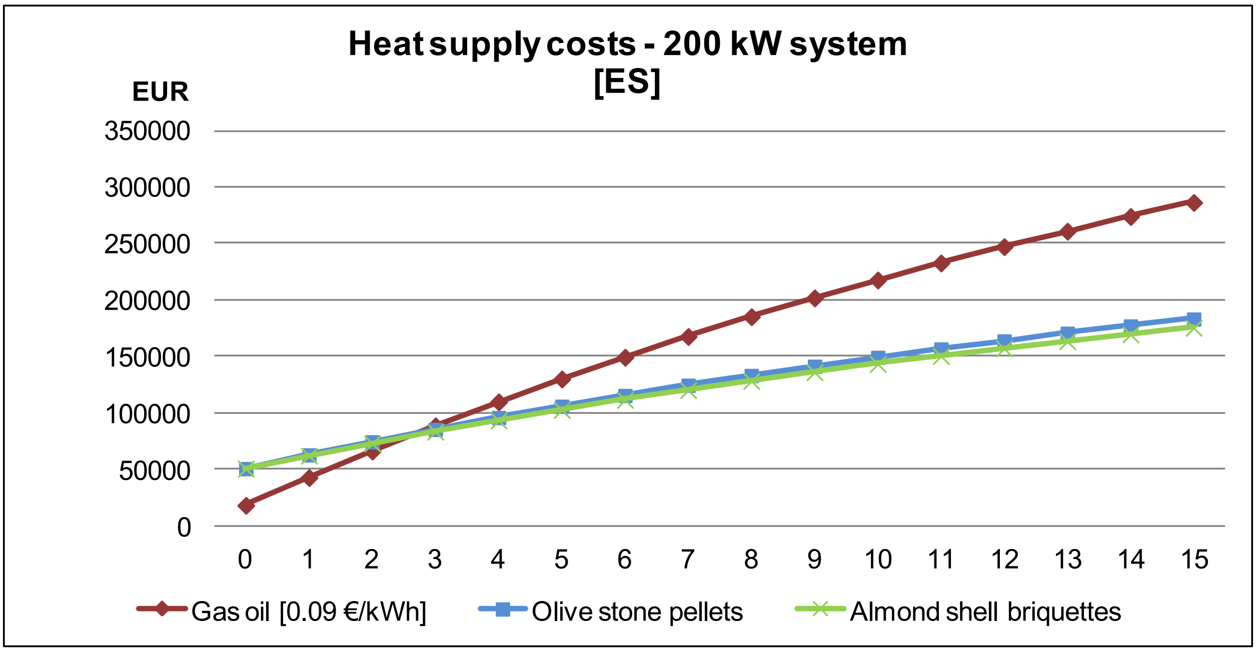

Figure 11: Cost comparison of Spanish heating systems (200kW)

2.20 Reed canary grass briquettes for district heating systems (SWE)

In the two case studies of Sweden the same stakeholders are involved and the same briquettes are produced and distributed. Therefore the two case studies are described in one. One case study focuses on the establishment of a profitable supply chain and market for RGC briquettes. The aim of the other one is to replace one of the older solid fuel boilers which runs on wood briquettes with a new solid fuel boiler suited for ash-rich reed canary grass briquettes during the summer of 2011.

Background

Due to increasing prices for woodchips and growing competition for raw materials the agricultural company located about 150 km west of Stockholm, started to look into the possibility to produce reed canary-grass briquettes. A spring harvest usually yields between 4 and 6 tons dry weight per hectare under normal conditions. If the crop is harvested early in the spring the moisture content is usually between 10 to 20 wt.-%. The farm grows reed canary grass on 70 hectares and the goal is to increase this to 100 hectares by 2012. There is potential to increase the amount of land used for growing RCG in the area around Vingåker and Katrineholm. Nearby land is used as ley and fallow because agricultural use is not profitable enough.

The agricultural company has run a small commercial briquetting plant producing wood briquettes in Vingåker outside Katrineholm since 1994. During the last years it started to look into the possibility to produce reed canary-grass briquettes and to optimize the production chain. The company has tested briquetting and combustion of reed canary grass briquettes. Since autumn 2010 it is working on the establishment of a profitable supply chain and market for reed canary-grass briquettes in the County of Södermanland. In 2010, the Technical Research Institut of Sweden (SP) tested RGC briquettes in a boiler at a school in the region. The trial went so well that it was decided to replace the wood fired boiler to adapt the boiler for the use of fuels with high ash content such as reed canary grass. The idea is to use the plant as test/demonstration facility for full scale testing. The reconstruction will be carried out during summer 2011 to prevent disruption of the activities at the school.

Value chain

Raw material

RCG is a perennial grass that can be grown throughout Sweden. The quality and quantity of the harvest depends on the quality of the soil fertilisation and the species of RCG. The first harvest is taken in the spring two years after sowing and is about 20 % lower than the following harvests. The harvest yield is abound 4 - 6 tons dry matter per hectare. Reed canary is cut during autumn and dries in wedges in the field until spring. In spring the grass is pressed into round or square bales. The goal is to store the bales protected from the weather beside the field to keep storage costs down. Afterwards the bales are transported from the field to the briquetting hall for chipping and briquetting.

Pelletizing

The production capacity of the pelletizing plant amounts to 3,500 tons of wood briquettes per year. The briquetting presses have a capacity for briquetting of reed canary-grass from about 500 hectares. Today briquettes (wood) are supplied to both households (15 %) and larger heating plants (85 %). The bales of grass are cut up in a slow shredder before being shredded further in an industrial grinder. The material is then fed into three Bogma V40 briquette presses which produce briquettes of 40 mm diameter. The typical fuel characteristics are listed in Table 15. The finished briquettes are fed into a horizontal silo with a capacity for 1,000 tons of briquettes. The briquettes are taken directly from the silo for delivery to customers.

The briquettes are loaded on a demountable container and transported to the heating system at Ökna school. Each shipment contains about 30 tons of reed canary grass briquettes.

Table 15: Typical fuel properties of reed canary grass briquettes

Net calorific value	Ash content	Water content	Softening temperature of ash	Nitrogen	Sulphur	Chlorine
MJ/kg dm	wt.-% dm	wt.-%	°C	wt.-% dm	wt.-% dm	wt.-% dm
17.5	5.9	13	1,420	0.48	0.06	0.04
dm……dry matter, wt.-%...weight %						

Combustion

Currently, there is a number of heating plants within a 100 km radius of the agricultural company that use woodchips, wood pellets or briquettes. One of these plants is the briquette-fired plant at Ökna School in

Tystberga, which is run by TCG Teem Combustion Group, heating supplier, based in Ulricehamn. TCG builds and operates different kinds of district heating plants.

Constraints and drivers

The main challenge is the establishment of a profitable supply chain and market for reed canary-grass briquettes especially with regard to storage of raw material before pressing.

2.21 Heat supply costs of Swedish heating systems

In Sweden the alternative biomass heating systems are already favourable after two years (Figure**Fehler! Verweisquelle konnte nicht gefunden werden.** 12). The alternative biomass briquettes are much cheaper than the fossil fuels. The harvest and transport costs for these raw materials are very low in Sweden. Also the price for heating oil (0.12 € / kWh) and the investment costs for an oil boiler are higher than in Central Europe. Besides Reed canary grass briquettes also hemp briquettes are considered for the cost comparison.

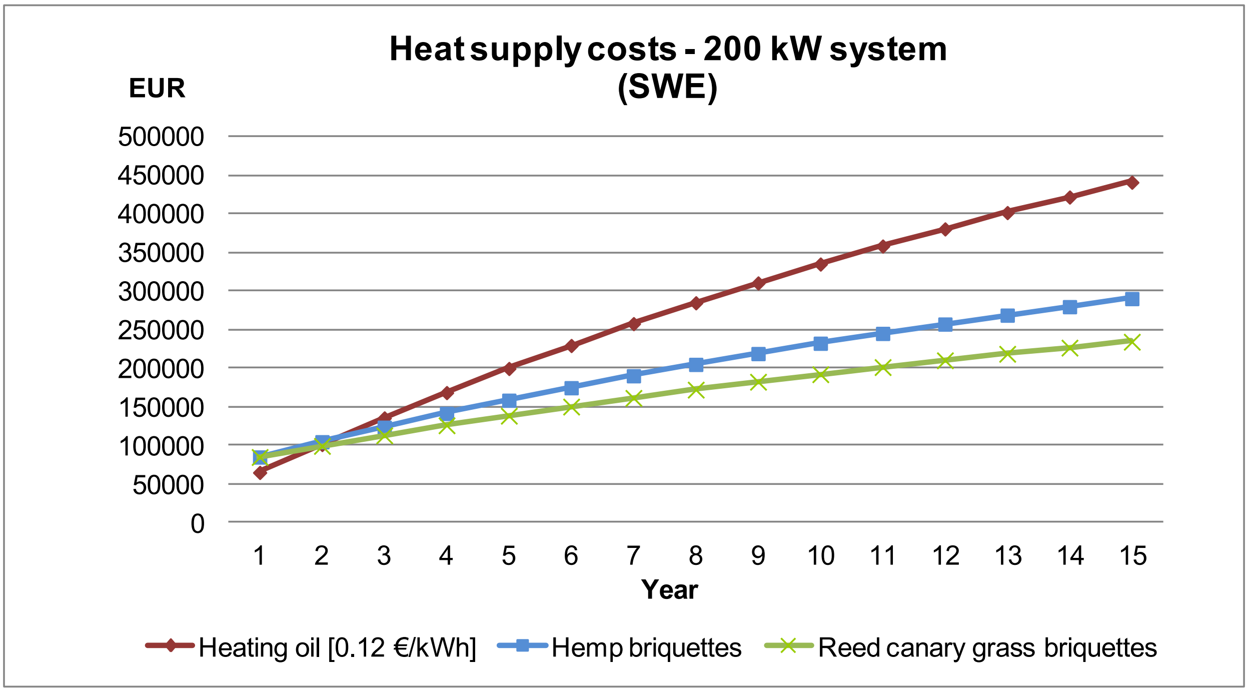

Figure 12: Cost comparison of Swedish heating systems (200 kW)

3 Aspects of economic efficiency

In the following, influencing factors on the economic efficiency of alternative pellets and related heating systems are presented. First, the costs of the different heating systems are compared, particularly in regard of their scale, and illustrated. Afterwards the fuels costs and their economic influence are analysed.

3.1 Heating system costs

Due to the increasing prices of heating oil, the use of agricultural biomass fuels is getting more and more attractive from an economic point of view. Especially in the Nordic countries, the use of alternative biomass fuels is much cheaper than using fossil fuels. However, the cost analysis of the heating systems shows that, regarding economic aspects, biomass pellets are more suitable for medium to large scale heating systems than for small scale boilers. Exemplarily, this is illustrated for the situation in Austria (Figure 13 and Figure 14) Using straw pellets in a 25 kW heating systems pays off only after 10, using Miscanthus briquettes pays off after 14 years. In comparison, the 200 kW systems operated with alternative pellets are getting favourable after 3 and a half year. The fuel costs influence the economic efficiency of larger plants more than the one of smaller plants.

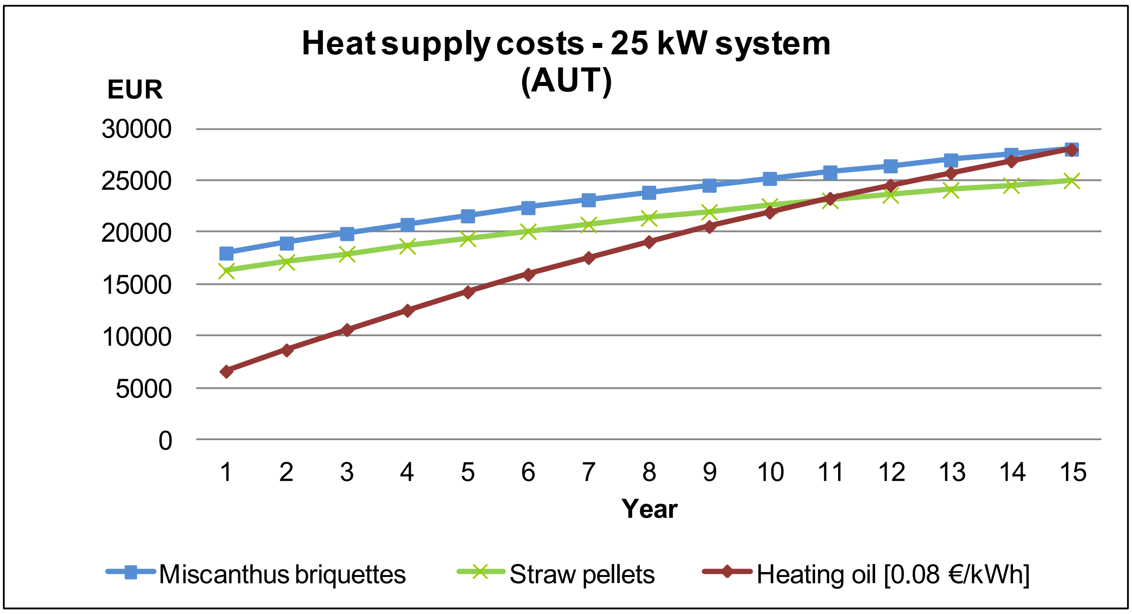

Figure 13: Cost comparison of small scale heating systems in Austria

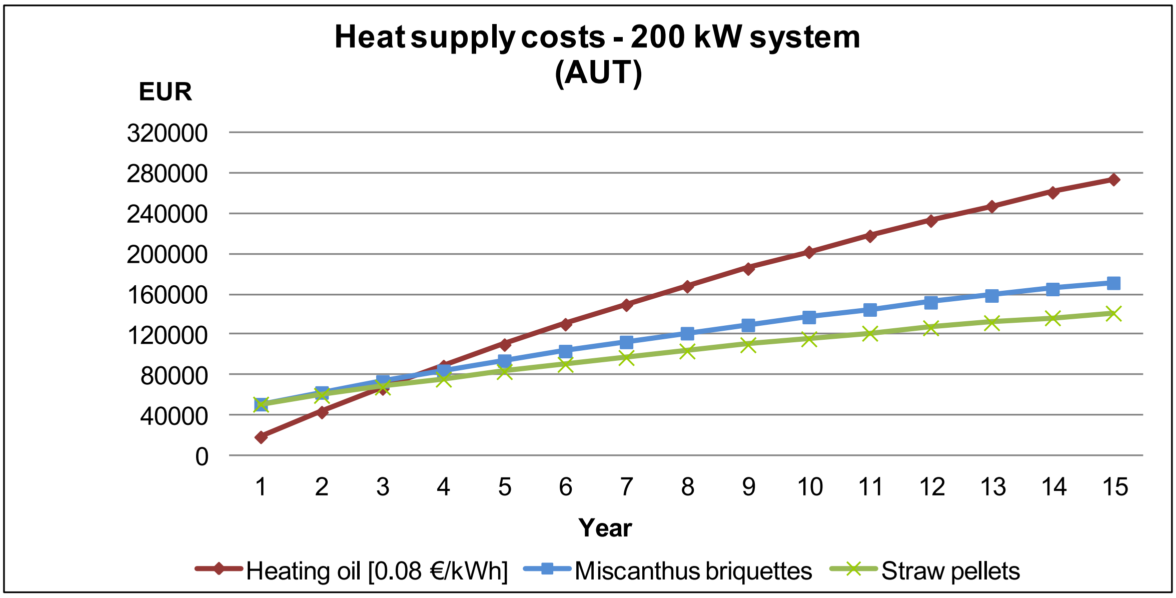

Figure 14: Cost comparison of medium scale heating systems in Austria

The heat supply costs for heating systems of each case study are presented in Figure 15. Apparently, the heat supply costs of small plants are higher than those of large systems, despite consideration of different conditions in the partner regions.

An exception is the system which is operated with vine pruning pellets. This can be explained by the low raw material costs for vine pruning. The heat supply costs of the 200 kW system operated with reed canary grass/ wood briquettes are higher due to the high wood proportion of the briquettes which make them more expensive. The 3 MW system is a power plant and therefore not comparable.

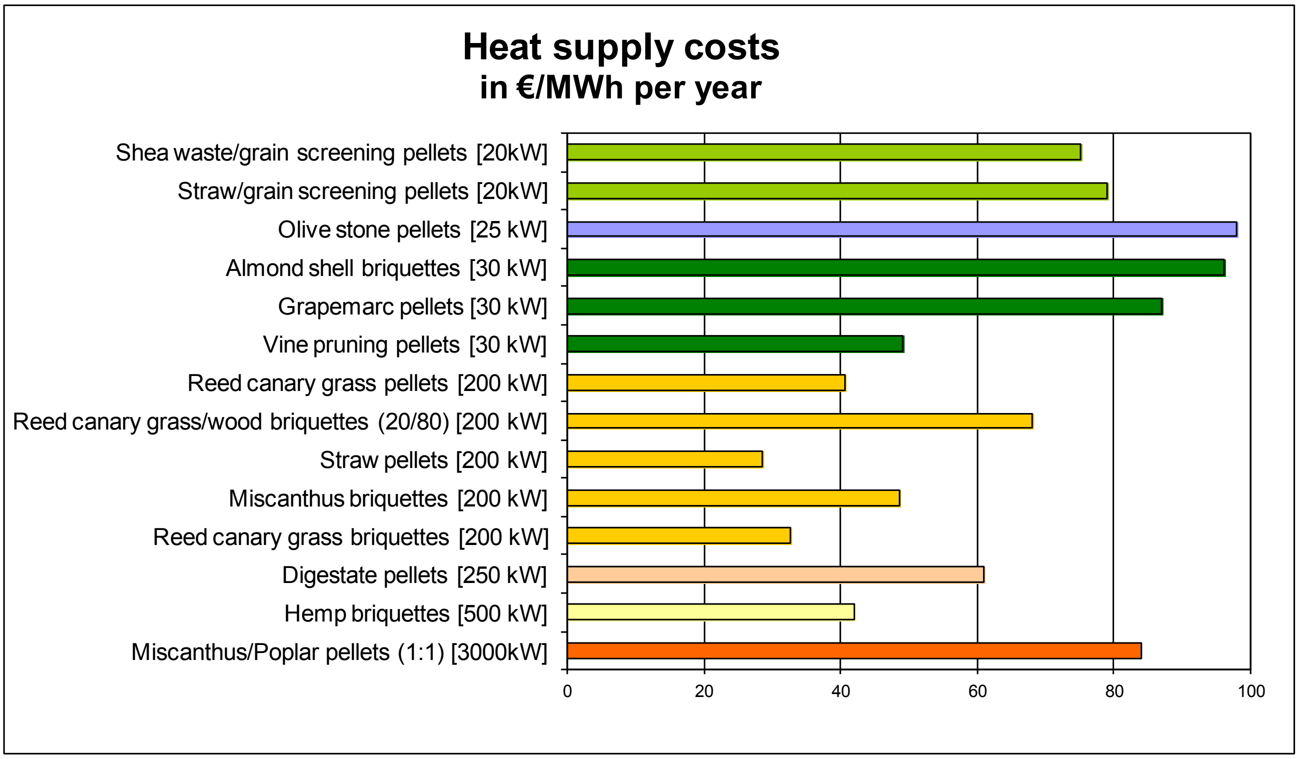

Figure 15: Comparison of heat supply costs for different heating systems of the case studies

3.2 Fuel costs

In the following the fuel costs are compared to wood pellets and wood chips prices of different countries. Furthermore the economic influence of the fuel costs on the heating systems is analysed.

Figure 16 shows the fuel costs in € / MWh including costs for harvesting, transport (up to 50 km), drying and pelletizing/briquetting. The fuel costs amount to 18-56 € / MWh, depending on the used raw material and the pelletizing plant.

The costs for pelletizing and briquetting amount to 11 - 32 % of the whole fuel costs. An exception are the digestate pellets, because it is assumed that digestate can only be used for combustion if it is not longer needed as fertilizer and therefore no raw material costs incur. For this reason only costs for transport and drying have to be taken into account and consequently the pelletizing costs amount to 55 % of the fuel costs. Certainly, the costs for pelletizing and briquetting strongly depend on the pelletizing/briquetting plant. Therefore, **an optimal operation of the plant, especially with regard to the production of mixed raw material pellets, is a large cost advantage**.

The briquetting costs of Reed canary grass / wood are very low, but the high proportion of wood makes the fuel expensive. The grape marc pellets are more expensive than the others due to the high drying costs of the raw material. **Therefore raw materials which do not require intensive drying should be preferred.**

Furthermore, in Figure 15 the fluctuations of fossil fuel prices in the different partner countries are illustrated. **The price for heating oil is much higher than the one for alternative pellets.** Gas as fuel can keep up with alternative pellets in regard to the price in some, especially Southern, countries.

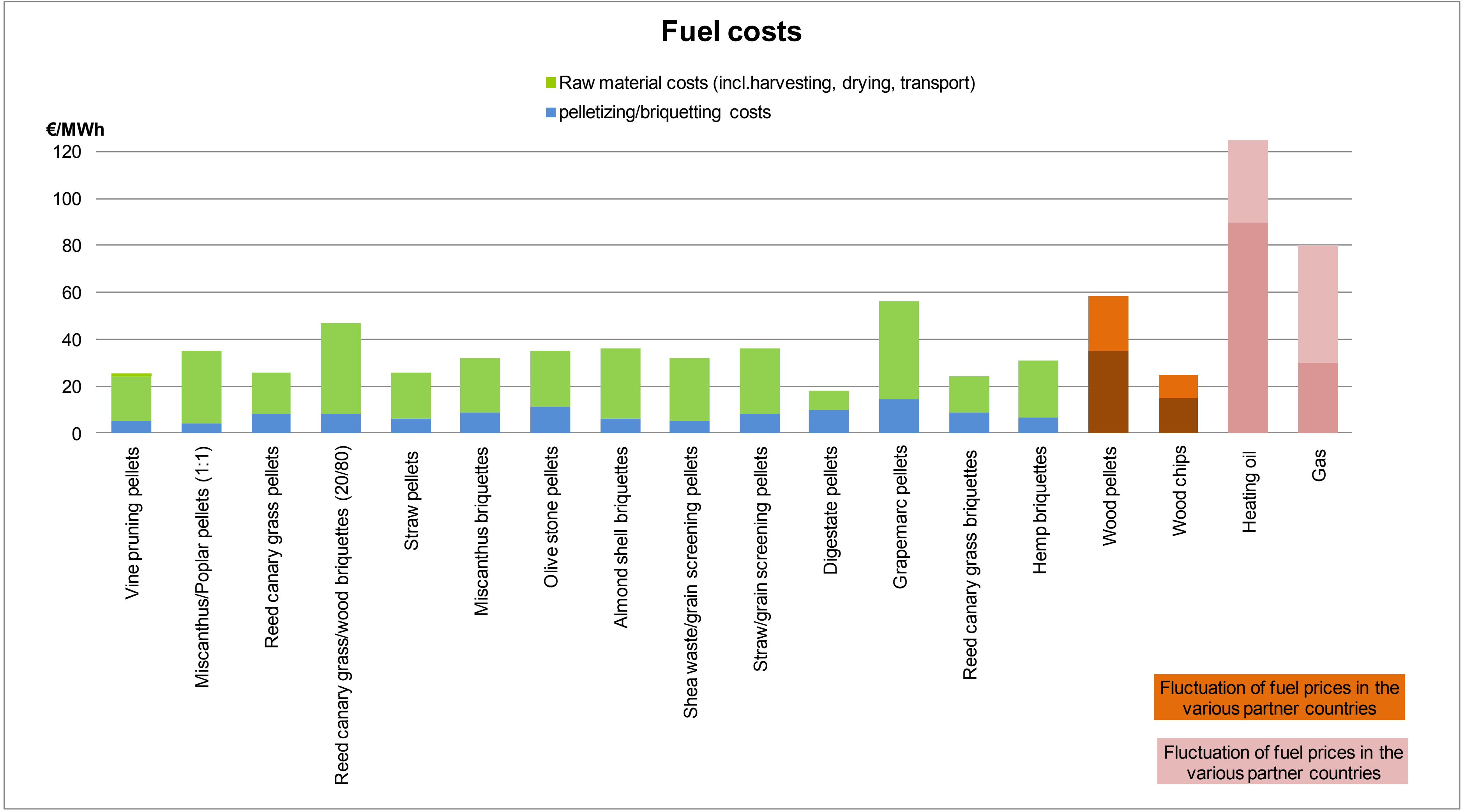

Figure 16: Fuel costs incl. costs of pelletizing and briquetting in €/MWh incl. fluctuation of wood and fossil fuel prices in the various partner countries

3.2.1 Influence of fuel costs

The analysis of the influence of the fuel costs was accomplished on the basis of the Austrian 200 kW heating systems. The fuel costs are a major part of the annual running costs. Thus, they have a wide influence on the economy of the heating systems. Figure 17 shows different price scenarios for the heating oil in Austria. Currently the oil price amounts to 0.09 € / l and the alternative biomass heating systems are getting favourable after 3 and a half years. If the oil price amounts to 0.045 € / l, like in the year 2005, the alternative biomass heating systems would get favourable after four and a half year (straw pellets) respectively after six years (Miscanthus briquettes). If the oil price doubles, like it did from 2005 to 2010, the alternative biomass systems would already get cost-effective after one and a half years (Figure 17).

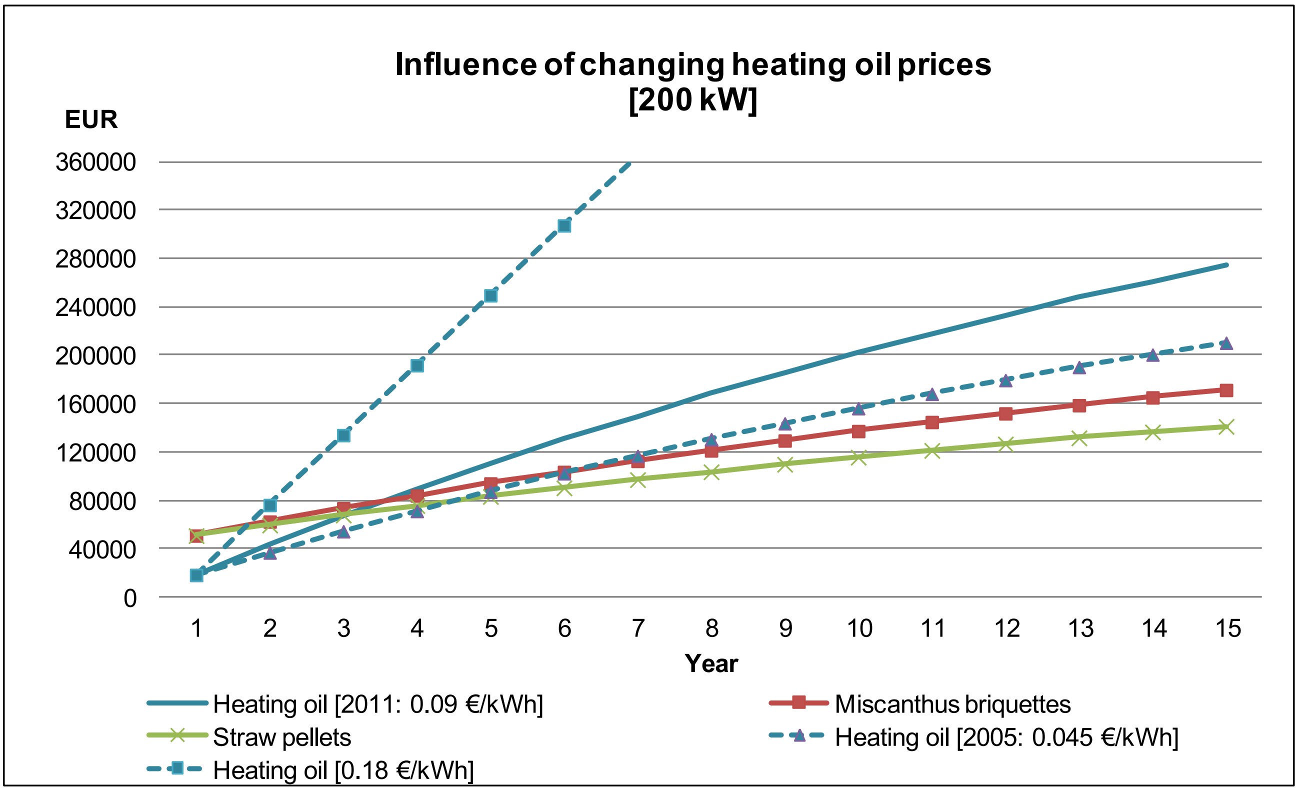

Figure 17: Influence of changing heating oil prices on the profitability of the heating systems (200 kW)

In Figure 18 a straw price change is illustrated. A price change of +/- 10 %, which can be caused by variation of annual yield, has only minor effects on the cost effectiveness of the 200 kW heating system operated with straw pellets. This means, despite higher price fluctuations the use of straw pellets remains profitable.

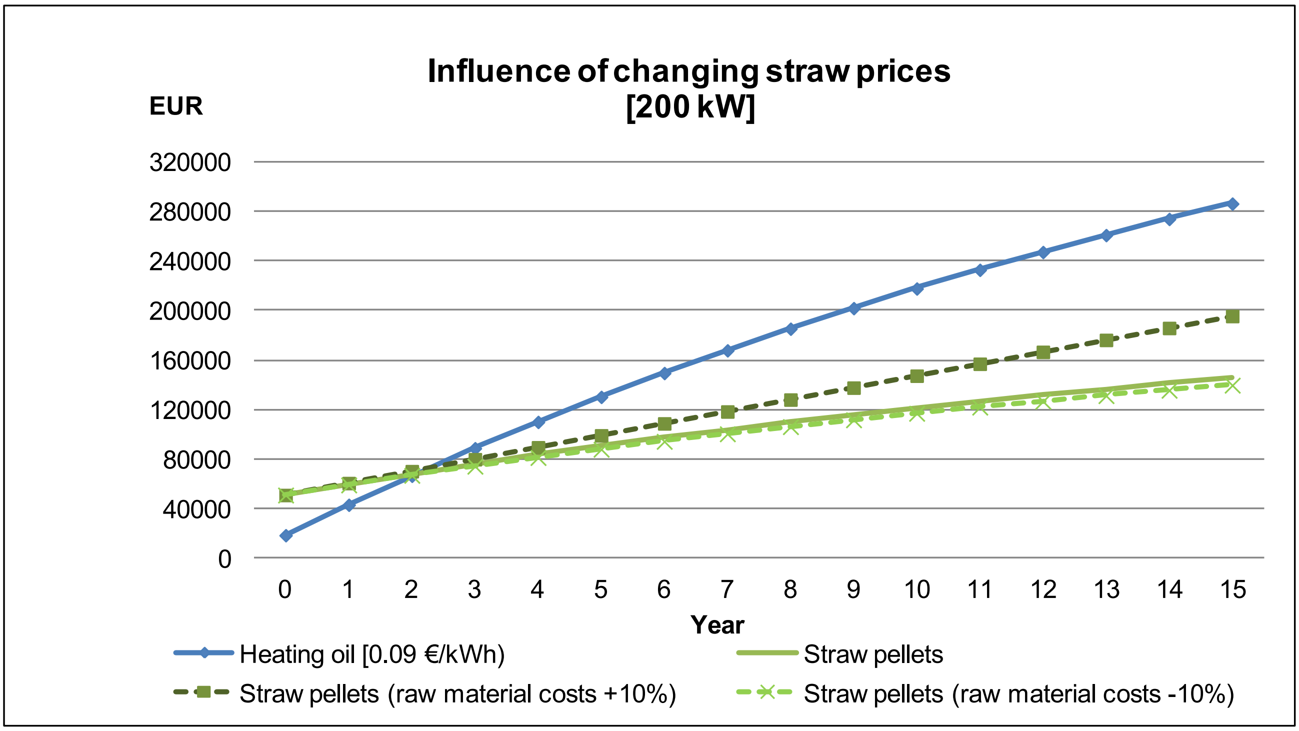

Figure 18: Influence of changing straw prices on the profitability of the heating systems (200 kW)

3.2.2 Comparison of wood and alternative fuels

Figure 19 shows the average costs for wood pellets, alternative pellets and wood chips over all partner countries. On average wood pellets are 25 % more expensive than alternative pellets and alternative pellets are 14 % more expensive than wood chips. **Thus, the wood chips are a strong competitor to alternative pellets.**

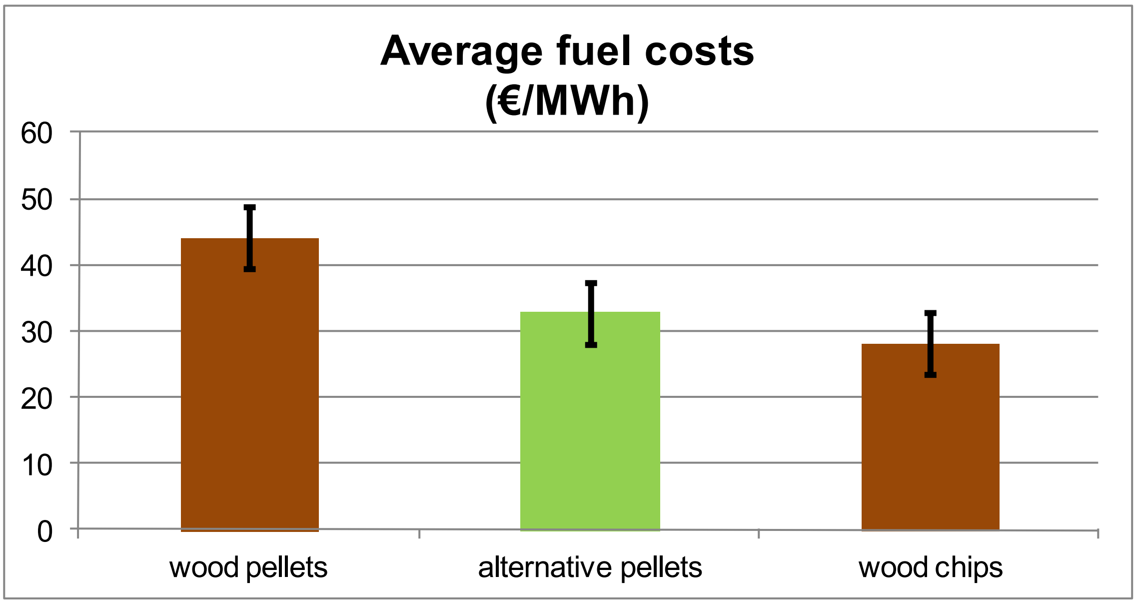

Figure 19: Average fuel costs for wood pellets, alternative pellets and wood chips in seven different European countries in €/MWh

Figure 20 shows the cost comparison of 200 kW heating systems operated with heating oil, wood chips, wood pellets and alternative pellets. The costs for the heating systems operated with alternative pellets are below the costs of the wood pellet systems.

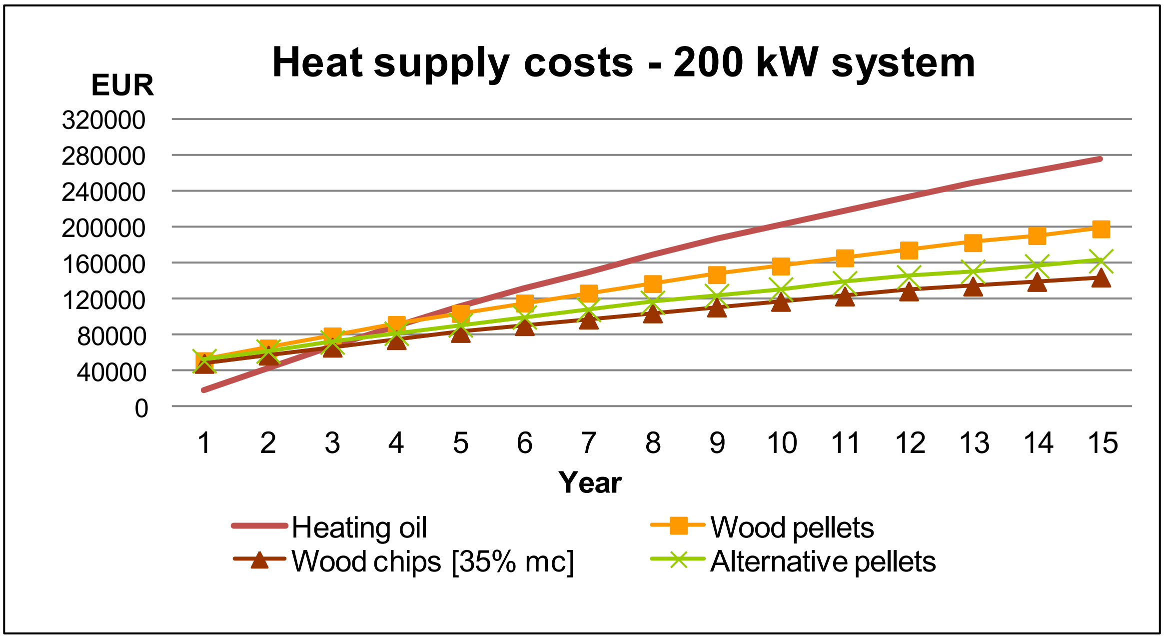

Figure 20: Heat supply costs for a 200 kW system comparing fossil, wood and alternative biomass fuels

4 Conclusion

- Economic aspects, e.g. the costs of alternative fuels and additional investments for technical systems like precipitators and combustion technologies, are crucial for the establishment of mixed biomass pellet production and their use in combustion appliances.

- The investment costs for alternative heating systems are higher than for fossil fuels. However, fuel costs as a major part of the annual running costs have a major influence on the economy of the heating systems. Therefore, medium to large scale heating systems which are operated with alternative (mixed) pellets are more profitable than fossil heating systems.

- Medium to large scale alternative heating applications with flue gas treatment systems are more profitable than fossil heating systems over service life despite higher investment costs.

- The fuel costs amount to 18-56 € / MWh, depending on the used raw material and the pelletizing plant. Necessary pre-treatments of the raw material have a major impact on the pellet prices. Low drying and storage costs are essential to ensure a profitable fuel.

- Concerning alternative pellets and briquettes, the costs for pelletizing and briquetting amount to 11-32% of the whole fuel costs. If the raw materials are mixed, an optimal plant operation must be ensured in order to keep the production costs low.

- Short transport distances have scarcely any effect on the pellet price. Long transport distances only pays off for large scale appliances (<1MW).

- On average wood pellets are 25 % more expensive than alternative pellets and alternative pellets are 14 % more expensive than wood chips. Thus, wood chips are a strong competitor to alternative pellets.

- One important factor for building-up a successful supply chain is the commitment of regional stakeholders. Furthermore, the policy makers are asked to set up a well-defined legal framework in order to provide security to potential investors.

5 Annex

5.1 Calculation Method

In order to compare the different heating systems the authors resorted to the dynamic investment calculation approach, especially on the net present value method. NPV (Net Present Value) is a standard method for using the time value of money to appraise long-term projects. Used for capital budgeting, and widely throughout economics, finance, and accounting, it measures the cash flows, in present value terms, once financing charges are met. In order to calculate the net present value, the discounted cash inflows (income from selling heat) and the discounted cash outflows (investment costs, O&M costs, fuel costs) have to be calculated.

In our case only the cash outflows, which represent the costs of the heating system, had been considered. The average annually rate per cent is assumed to be 5 %. In order to illustrate and compare the data the discounted costs over service life of the heating systems had been summed up and plotted. Based on the figures the most efficient system over service life can be identified.

5.2 List of ongoing and previous projects

Investigation on previous and ongoin projects "Cost analysis"

Country code	Authors	Year	Original name of project	Name of project in English	Participants	Level	Funding	Available language	Short description/evalation of the project etc.
AT	Liebhard, P.	1997	Miscanthus sinensis 'Giganteus' und Getreideganzpflanzen als nachwachsender Rohstoff für die thermische Nutzung.	Miscanthus sinensis giganteus and cereal plants as a renewable raw material for the thermal use	BOKU, AGES	**National**	Niederösterreichsiche Landesregierung, BMLFUW	German	miscanthus, quality analysis, economic and ecologically reflection about dedicated crops
AT	Eder, G.	2007	Perspektiven des Einsatzes landwirtschaftlicher Biomasse in Kleinfeuerungsanlagen unter besonderer Berücksichtigung von Pelletsbrennstoffen	Perspectives of application of agricultural biomass in small scale boilers in particular consideration of pellet fuels	Johannes Keppler Universität Linz, doctoral	**National**	Third party	German	agricultural raw materials in form of pellets for room heating and warm water supply will be indispensable for sustainable energy systems in the future
DK	Panoutsu, P., Nikolaisen, L., Rathbauer, J.	2003	Mulighederne for at nå målet på 45 MTOE energiafgrøder i EU i 2010	Options for achieving the target of 45 MTOE from Energy Cropping in the EU in 2010	CRES, DTI, BLT,	**International**	EU	English	The report shows, that if all set aside land and 10% of the cereal land is cultivated with energy crops 60 MTOE ca be produced.
DK	Nikolaisen, L.	2002	Kvalitetskarakteristik af biomassepiller	Quality Characteristics of Biofuel Pellets	DTI, FORCE,	**National**	DEA	English	This project documents the technical and economic potential of biofuel pellets produced from mixtures of various biomass
DK	Nikolaisen, L.	2005	CO2 neutrale brændslers anvendelighed i kraftværkskedler	Fuels for CO2 reduction in power plants	DTI, FORCE, DTU, DONG Energy	**National**	Energinet.dk	English/Danish	The purpose of the project is to increase the knowledge of bio mixtures fuel quality
DK	Nikolaisen, L. (edt.)	1998	Halm til energiformål	Straw for energy production	DTI, FORCE	**International**	DEA	Danish/English/German	All round technical description of supply chains and combustion technique for straw in both small and large scale boilers.
GER	Harmann H.	2010	Kleine Biomassefeuerungen - Marktbetrachtungen, Betriebsdaten, Kosten und Wirtschaftlichkeit	Small-scale biomass combustion systems - market studies, production data, cost and profitability	DLR, ZSW	**National**	regional	German	
GER	Kiener S.	2010	Bewertung kostengünstiger Staubabscheider für Einzelfeuerstätten und Zentralheizungskessel	Review cost-effective dust collector for individual fireplaces and central heating boiler	LfU,	**National**	regional	German	
GER	FNR (Hrsg.)	2010	Marktübersicht Hackschnitzelheizungen	Market analysis of wood chip boilers	FNR	**National**	BMELV	German	Market analysis wood chips boilers
GER	FNR (Hrsg.)	2010	Marktübersicht Pelletheizungen	Market analysis of pellet boilers	FNR	**National**	BMELV	German	Market analysis pellet boilers
GER	Fachagentur Nachwachsende Rohstoffe e.V. (FNR) (Hrsg.)	2005	Leitfaden Bioenergie	Guideline bioenergy	FNR, IER, TFZ. IE, SEE, BIOS, IVD	**National**	BMELV	German	
GER	Fachagentur Nachwachsende Rohstoffe e.V. (FNR) (Hrsg.)	2007	Bioenergiekleinanlagen	Small-scale biomass plants	FNR, IER, TFZ. IE, SEE, BIOS, IVD	**National**	BMELV	German	
ES	Juan E. Carrasco	2011	OnCultivos: Proyecto Singular y Estratégico para el desarrollo, demostración y evaluación de la viabilidad de la producción de energía en España partir de biomasa de cultivos energéticos	OnCultivos: Viability of the Commercial Production of Energy from Dedicated Crops in Spain	CIEMAT and further 27 partners (among them ABENGOA, ACCIONA,…)	**National**	National	Spanish, English	Viability of the Commercial Production of Energy from Dedicated Crops in Spain
ES	Pablo Rodero	2011	Biomasud	Biomasud	AVEBIOM and further 5 partners	**International**	EU	English, Spanish	The project aims to design and implement support mechanisms to help develop a sustainable market for solid biomass. To achieve this, define minimum requirements of sustainability throughout the value chain for this market. In addition,establish a system to audit and certify compliance with these requirements, as well as traceability system that allows you to manage resources from a global perspective.
SWE	Myringer Å., Petersen M., Olsson J., Rönnbäck M., Bubholz M., Forsberg M.	2009	Identifiering av energiverkens merkostnader vid förbränning av åkerbränslen samt lantbrukarens möjlighet att påverka bränslekvaliteten	The estimated additional costs for combustion of agro fuel and the potential of farmers to influence fuel quality	SP, JTI, Vattenfall	**National**	Värmeforsk	English and Swedish	The main objectives of this study were to identify and calculate the additional costs to energy plants of combustion of agro fuels instead of wood chips, and to determine the potential farmers have to influence fuel quality and thus identify parameters that could be used for pricing in the future. The overall aim is to increase the volume of agro fuels produced.
SWE	Paulrud S., Laitila T.	2007	Lantbrukarnas attityder till odling av energigrödor	Farmers' attitudes to energy crops	IVL, Örebro Universitet	**National**	Energimyndigheten	English and Swedish	The purpose of this study was to analyse how farmers value the the charesteristics associated with growing energy crops. An additional goal was to find out the willingness of farmers to grow energy crops relative to different levels of income and subsidies.
SWE	Lundmark A., Björk L., Wakelin R., Lundmark B.	2008	Rapport Rörflen	Report Canary Reed Grass	GME, Norut Teknologi	**Regional**	European Commission, Bioenergi Nord	Swedish	Collected experience of the GME work with bioenergy issues 1996 - 2008 based on projects dealing with the topic bioenergy in cold climate
ITA	Valter Francescato	2006	Woodland energy	Woodland energy	REG TO, ARSIA, REG ABR, ARSSA, REG FRVG, REG LA, ARSIAL, REG LI, REG MA, ASSAM, REG MO, REG UMB, REG SI	**National**	MIPAF	Italian	Support on the development of the supply agroenergy chain initiatives

ITA	Valter Francescato	2005	Vitis energetica	Energetic grapevine	AIEL, CIA, Te.S.A.F., CATAS, ABEC, Peruzzo, Biocalor	**Regional**	CCIAA	Italian	Cost evaluation of the pruning from grapevine for energy utilisation
ITA	Giampiero Maracchi	2009	Mo.D.E.R.No - Modello di Distretto Energetico Rurale inNovativo	Model of innovative rural energy district	CAS, UNiF, FCS	**Regional**	Toscana Region	Italian	Cost effectiveness on the use of olive pruning for electrical and therma energy
FIN	Eija Alakangas	2011	EUBIONET III – SOLUTIONS TO BIOMASS TRADE AND MARKET BARRIERS	EUBIONET III – SOLUTIONS TO BIOMASS TRADE AND MARKET BARRIERS	VTT, Utrecht University, DTI, SLU, FRN and FJ-BLT	**International**	EU	English	