IEE/09/758/SI2.558286 - MixBioPells

WP 3 / D 3.4.

“Best practice examples” of utilisation chains for alternative and mixed biomass pellets

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With support of the project partners:

Bioenergy 2020+
DBFZ – Deutsches Biomasseforschungszentrum
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

Pelletizing properties of alternative raw material differ from those of wood and adapted technologies are required for the production of alternative and mixed biomass pellets. This is particularly important if pellets according to available standards are to be produced. Similarly, combustion properties of alternative and mixed biomass pellets are usually different from wood. Critical properties of theses pellets can cause problems during the combustion process, e.g. higher emissions of particles, HCl and SO_2 and ash slagging. Thus, appropriate combustion and flue gas cleaning technologies are required for their utilization. To facilitate the market integration of alternative and mixed biomass pellets Best Practice Examples that cover the whole chain are highly valuable. The examples provide information not only on the technical realization but as well on the motivations and the challenges that the key actors were faced with. They give an overview about the actual state of the art for alternative and mixed biomass pellet production and utilization in Austria (AT), Denmark (DK), Finland (FI), Germany (DE), Italy (IT), Spain (ES) and Sweden (SE). Furthermore, they can be used as guideline for future projects.

2 Method

The best practice examples were developed based on existing projects. Based on the experience and technical facts the best practice examples were chosen. In this chapter a short description about the preparation and selection of the best practice examples will be given.

2.1 Preparation of the template for the best practice examples

In the steering group and project meetings, structure and content of the best practice examples were discussed. It was agreed upon to divide the content into five parts

1. Background

- A short description of the company and public facts.
- A short description of the background for the combustion of the used fuels.

2. Raw materials and fuels

- A description of typical characteristics and properties of the used raw materials and fuels.
- A description of the utilization and problems.
- A short description how the pellets were produced or received.
- Transportation and storage of the pellets.

3. Combustion

- A description of the process and the used technology.
- The costs for the combustion of the pellets or briquettes.
- Possible problems and solutions.
- Lessons learned.

4. Producers view

- View of the producer on further developments in the market and technology.

5. Contact details

A MS WORD template including headlines, instructions, place holders for pictures and diagrams as well as tables was prepared by the WP leader and provided to the project partners. According to the available data individual changes in the content were made by the partners. Each partner prepared his best practice example in close cooperation with the selected local industry partner in English which was translated in the national languages of the MixBioPells partner countries and uploaded on the project website. The selection criteria of the best practice examples are described in the following chapter.

2.2 Selection of the best practice chains

Possible best practice chains became apparent based on the regional activities within the MixBioPells project. The final selection was made during the third project meeting in Jyväskylä, Finland in September 2011. For the selection the following criteria were used:

- The best practice chains have to be realized not only anticipated or planned

- The best practice chains should cover alternative raw materials with high relevance for the region.
- The best practice chains have to be relevant for other countries and regions too.
- The best practice chains should address different capacity ranges.
- Chains with mixed biomass pellets are preferred over chains with pure alternative pellets.
- As far as possible different technical solutions for common problems should be covered.
- The best practice chains should reflect the most common constraints and drivers for alternative and mixed biomass pellet production and utilization.

3 Summary

The basic data of the 6 selected best practice examples are summarized in Table 1. The used production and combustion technologies in the MixBioPells partner countries apply to different ranges of capacity.

Table 1: Basic data of the best practice examples for the combustion of alternative and mixed biomass pellets or briquettes

	Denmark	**Germany 1**	**Germany 2**	**Italy**	**Spain**	**Sweden**
Used raw materials	Straw, grain screenings	Miscanthus, grape marc, digestate, wood	Grape marc, vine pruning	Vine pruning	Almond shells	Reed canary grass
Compacting process	Pelletizing	Hydraulic pelletizing	Pelletizing	Mobile pelletizing	Briquetting	Briquetting
Use of mixed biomass fuels	Yes	Yes	Yes	Yes	No	No
Combustion technology	CHP plant	Burner	Grate	Burner	n.a.	Burner
Manufacture, type	n.a.	PH47	Hargassner, Agrofire 30	Thermo-cabi	n.a.	Ökotherm C6
Range of capacity	88 MW electricity, 331 MW heat	47 kW	30 kW	60 kW	100 kW	800 kW
Output	Heat and Power	Heat	Heat	Heat	Heat	Heat

n.a. – not available

Adapted supply chains had to be used to get the alternative raw materials. The compacting characteristics of the alternative raw materials were often a challenge and needed careful optimization of the milling and compacting process. The varying fuel characteristics of alternative raw materials are a major constraint, Table 2.

Table 2: Fuel properties

Fuel	Straw and grain screening pellets	Micanthus, grape marc, digestate, wood pellets	Grape marc / vine pruning (70/30) pellets
Country	Denmark	Germany	Germany
Moisture content, wt.-%	10-13	3-11	10-13
Heating value, MJ/kg	14.5-16.5	17.3-20.8	19.8
Bulk density, kg/m³	n.a.	n.a.	630
Ash content, wt.-%	5-10	2.6-11.3	5.6
Ash melting temp., °C	870 (straw)	n.a.	900
Chlorine wt.-% d.b.	n.a.	0.05-0.3	<0.005
Sulphur wt.-% d.b.	n.a.	n.a.0.04-0.4	0.14
Nitrogen wt.-% d.b.	n.a.	0.3-3.2	1.7

n.a. – not available, d.b. – dry basis

Table 2: Fuel properties (continued)

Fuel	Vine pruning pellets	Almond shell briquettes	Reed canary grass briquettes
Country	Italy	Spain	Sweden
Moisture content, wt.-%	n.a	n.a.	n.a.
Heating value, MJ/kg	17.6	18.6	17.5
Bulk density, kg/m³	n.a.	n.a.	n.a.
Ash content, wt.-% d.b.	2.1-3.5	1.52	5.9
Ash melting temp., °C	>1500	n.a.	1,420
Chlorine wt.-% d.b.	0.04-0.06	0.021	0.04
Sulphur wt.-% d.b.	0.01-0.02	0.01	0.06
Nitrogen wt.-% d.b.	0.5-0.7	n.a.	0.48

n.a. – not available, d.b. – dry basis

Overall, careful adoption of the combustion parameters has to be done for each fuel in order to achieve good combustion characteristics and to keep existing emission thresholds. In summary, considerable experience is crucial to successfully perform the production and combustion of alternative and mixed biomass pellets or briquettes. The main constraints and drivers for the production and combustion of alternative and mixed biomass pellets and briquettes that have been identified within the best practice examples are listed in Table 3.

Table 3: Constraints and drivers for the combustion of alternative and mixed biomass pellets and briquettes

	Identified problems / constraints	**Identified solutions / drivers**
Denmark	• Straw supply can be a challenge since transport from nearby Swedish farmers is rendered unprofitable by the high toll for the bridges. • High ash content of grain screenings limits the share that can be used. • Restrictions on truck transportation of the pellets. For that reason the pellet plant had to be build 45 km away from the power plant.	• Good infrastructure for alternative transport by ship. • Reliable straw supply from farmers in the surrounding area (<140 km). • Environmentally friendly combustion.
Germany 1	• The requirements of the target groups regarding the optimal (regional) mixture are often unknown. • The technical know-how of the key actors for production of alternative and mixed biomass pellets is too less. • So far, regional market structures do mostly not exist. • High NO_x-emision as result of the high nitrogen content in grape marc.	• User-defined pellets from a mixture of raw materials can be produced. • Raw materials with residual moisture up to 30 wt. -% can be used. • No additional grinding (e. g. hammer mill) or pre-treatment processes are necessary for raw materials with a length up to 5 cm. • The production energy is reduced by an efficient plant technology. • Rotating parts are not installed in dirty parts of the pelletizing plant. • NO_x- and dust emissions can be reduced by using the appropriate mixture with less critical raw materials.
Germany 2	• Increased NO_x- and SO_2-emissions as a result of increased contents of nitrogen and sulphur in the fuel • High dust emissions • Licencing of the combustion systems and fuel is difficult	• High potential of unused grape marc and vine pruning in Rhineland-Palatinate • Improvement of sustainable recycling management as well as economic status and job opportunities in rural areas. • An advantage is a low proportion of chlorine in the fuel which leads to low formation of HCl-emissions and corrosion. • Only minor slagging tendencies without negative impact on the bottom ash removal have occurred during the combustion process but had no negative impact on the bottom ash removal. • Blends with vine pruning can improve the fuel properties and combustion characteristics. • Grape marc pellets and blends with vine pruning can fulfil the requirements of the draft of the European standard for solid biofuels (EN 14961-6).

Table 3: Constraints and drivers for the combustion of alternative and mixed biomass pellets and briquettes (continued)

	Identified problems / constraints	Identified solutions / drivers
Italy	• Scattered availability of the unused raw materials increasing the logistic effort. • No suitable harvesting technology available. • High production of combustion residues (ash) to be frequently removed; • Discontinuous availability of alternative pellets. • Lack of a product quality control. • Difficulties to reduce the emissions in the exhausts of small heating plants. • High chlorine and sulphur content increasing the risk of corrosion.	• Development of mobile pelletizing equipment. • Regional entrepreneurs involved in agricultural machinery and biomass sectors have developed equipment for harvesting of grapevine pruning and its utilization to produce energy. • Low cost of the fuel. • More efficient transport and storage operations are possible when using pelletized fuels. • Better quality in comparison to the traditional solid biomass fuels.
Spain	• Difficult compacting characteristics. • Underdeveloped market for alternative fuels. • Lack of or low knowledge about alternative fuel utilisation.	• High potential of unused almond shells. • Favourable fuel characteristics (low moisture content, high heating value etc.). • Own research and development succeeded in finding the appropriate solution resulting in their own patented briquetting technology. • From the replacement of the previous natural gas boilers 50 – 55 % lower costs are expected. • So far, no technical problems during combustion have been observed. • Clean and attractive flame image.
Sweden	• The main challenge is equipment that can handle ash rich fuels and to find ways to decrease corrosion.	• Increased prices for woodchips. • Long-term combustion tests with reed canary grass briquettes were successful.

4 Best Practice Examples

Production & combustion of biomass pellets at Vattenfall A/S in Denmark

Background

Køge Biopellet Factory is a pellet producing plant built in 2004 by the utility company Energi E2. It was built as 2 plants, one producing wood pellets with a capacity of 180,000 tons/year, the other producing straw pellets with a capacity of 110,000 tons/year. The pellets were planned to be used in 2 power plants in Copenhagen: Wood pellets at Avedøre power plant and straw pellets at Amager power plant. It was not allowed by Copenhagen municipality to take this large amount of trucks daily into central Copenhagen. Therefore Energi E2 built the pellet plant 45 kilometres outside Copenhagen by Køge Harbour, and the pellets are then shipped into Copenhagen by boat. In 2006 Vattenfall A/S took over the straw pellet plant. The wood pellet plant was stopped in 2007.

The investment in 2004 for both the wood pellet plant and the straw pellet plant was 50 million Euro (Source: Forskning i Bioenergi, nr. 3, 2004). The straw pellets are not sold in a commercial market, because all pellets are used in-house at Vattenfall A/S. This means that there is no market price for straw pellets in Denmark. There is no information about the production costs.

Raw material

The raw material is straw in big bales of approx. 530 kg each. They are delivered by farmers at Zealand and nearby Islands with a maximum distance of about 140 km.

Truck with 24 bales waiting for unloading.

The toll bridges to Sweden and to Funen are barriers as the toll is at least 160 Euro for a truck, making the business unprofitable for the farmers. The truck takes 24 bales, 12 on the truck and 12 on the trailer in 2 layers. The second raw material is grain screenings delivered in bulk.

Pelletizing straw	Køge Biopellet Factory
Technology type	Ring die
Production capacity, t/a	110,000
Price of pellets, €/MWh	See below
Investment, €	See below

The 24 straw bales are unloaded by a crane taking 12 bales in one lift. During the lift off the water content is measured by micro waves and the weight is measured.

Characteristics of raw material

Raw material	Straw	Grain screenings
Moisture content, wt.-%	13	10
Heating value, MJ/kg	14,5	16.5
Bulk density, kg/m³	130	250
Ash content, wt.-%	5	10
Ash melting temperature, °C	870	N/A
Cost of biomass, €/ t	N/A	N/A
Quantity, t/a 1)	800,000	30,000

1) Straw available for combustion on Zealand is around 800,000 tons

Pelletizing process

The pellet production runs 24 hours a day reaching around 300 tons/24 hours. There are four pellet lines. There is no drying unit for the raw material in the process line. The share of grain screenings mixed with straw depends on what is available. Maximum ratio of grain screenings is 20%.

Transport & storage

The produced pellets are transported by a long conveyor belt to the harbour to a bulk storage waiting for ship transport to Amagerværket in Copenhagen.

Combustion at Amagerværket

Vattenfall A/S has in 2010 finished a larger rebuilt of Unit 1 at Amagerværket for combined coal and biomass use. The capacity of Unit 1 is 88 MWel and 331 MJ/s district heating. The plant has 3 boiler units and the annually designed biomass consumption is 400,000 tons wood and straw pellets.

Bulk storage for straw pellets at the Køge Harbour

Producers view

Vattenfall A/S has more than 40 CHP plants in operation, which partly or totally are fired with biomass. Every year the biomass consumption exceeds 3 million tons, and the amount is increasing. Vattenfall A/S is one of the world's leading companies in the energy sector.

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Amagerværket in Copenhagen is a very large Power Plant supporting the city with district heating and electricity. The plant is designed for both coal and biomass and has advanced flue gas cleaning systems

Production and combustion of mixed biomass pellets at Pusch AG within the "agrarSTICK®" concept

Background

The PUSCH AG provides a comprehensive concept for the decentralized production of mixed biomass pellets from agricultural and woody raw materials. Based on the licensed concept "agrarSTICK®" different license holders are producing and marketing alternative pellets based on specific recipes. Thus, these partners are provided with complete production, combustion, sales and logistics support based on a virtual trading platform for all internal and external business activities.

Based on the „produced in and for the region" -philosophy, the agrarSTICK® will be distributed in the respective region.

Raw materials

So far, mixtures from herbaceous and woody biomass as well as fruit residues have been pelletised. Since characteristics and potential of the available raw materials differ significantly between the regions, a suitable combination of different raw materials and additives has to be developed. Due to the fact that the pelletizing plant PM 6-28 has low requirements on mechanical properties and water content usually no pre-treatment of the raw material is necessary. To ensure a transparent communication with the customers a fuel data sheet will be provided from the production partner.

Pelletizing process

In contrast to pelletizing processes with roller dies a hydraulic press offers less work and cost intensive pretreatment of the raw materials. Therefore, the production of different mixed biomass pellets can be done without changing the press die. The Pusch AG has developed and manufactured the pelletizing plant PM 6-28 applying the hydraulic press concept and a production capacity of 1,000 kg/h. The modular design allows an increase of the production capacity to a maximum of 4,000 kg/h.

Pelletizing plant PM 6-28

The benefits of the technology are:

- User-defined pellets from a mixture of raw materials can be produced.
- Raw materials with residual moisture up to 30 wt. -% can be used.
- No additional grinding (e. g. hammer mill) or pre-treatment processes are necessary for raw materials with a length up to 5 cm.
- The production energy is reduced by an efficient plant technology.

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- Rotating parts are not installed in dirty parts of the pelletizing plant.

Two different products are offered by PUSCH AG - the agrarSTICK® black for the utilisation in public and small industrial combustion plants above 100 kW and the agrarSTICK® yellow for small combustion plants.

Miscanthus pellets

At the moment digestates, Miscanthus, grape marc and wood are the most interesting raw materials. The fuel characteristics are listed in the following Table:

Parameter	Units	M	GM	D
Diameter	mm	20	21	21
Moisture content	wt.-%	3.23	9.78	11.3
Net calorific value	MJ/kg (d.b.)	17.34	20.8	17.6
Ash melting temperature	°C	n.a.	n.a.	n.a.
Ash content	wt.-% (d.b.)	2.66	7.86	11.3
N		0.31	3.2	1.7
S		0.04	0.16	0.36
Cl		0.05	0.04	0.34
K		0.47	2.78	1.59
Na		0.02	0.01	0.01
Ca		0.14	0.83	1.08
Si		1.0	0.28	1.25

M – Miscanthus, GM – Grape marc, D – Digestates, W – Wood, d.b. – dry basis, n.a. – not analysed

Different combustion plants and precipitator technologies are available at Pusch AG to test and optimise the fuel pellets produced within the "agrarSTICK®" concept. Depending on the origin of the raw materials, the critical parameters of the fuel are often high nitrogen, chlorine and sulphur contents causing higher gaseous emissions of NO_x, SO_2 and HCl. Furthermore, higher contents of alkaline metals such as K and Na can cause increased dust emissions which can be lowered by the use of electrostatic precipitators. Therefore, fuel optimisation and an adapted combustion technology are required which is offered by Pusch AG within the "agrarSTICK®" concept.

Combustion appliance PH 47 (left, www.ph-energy.dk) and dust precipitator Schräder Al Top (right, www.schraeder.com)

In the following Table, results from the combustion tests with several fuel pellets in a combustion appliance of PH, Type PH47 with a nominal heat output of 47 kW and a precipitator of Schräder, Type Al Top are listed:

Typical combustion characteristics

Para-meter	**Units**	**M**	**M + 70% GM**	**D**	**D + 50% W**
CO	mg/Nm³ (13 Vol.-% O_2)	15	234	124	70
NO_x		247	556	651	443
HCl		0.5	1.1	73	23
dust		6.3	277	54	18

M – Miscanthus, GM – Grape marc, D – Digestates, n.m. – not measured, W – Wood

Customers

Customers are both the license holders and operators of small and medium scale combustion plants. Based on the license concept “agrarSTICK®” different license holders are producing and marketing alternative pellets based on specific recipes. Based on the „produced in and for the region“-philosophy, the agrarSTICK® will be distributed in the respective region.

Challenges for the future

To establish the production of alternative and mixed biomass pellets in several regions in Germany and Europe the marketing of the pellet presses is of great relevance. Important aspects for hindering an enhanced market relevance of regional mixed biomass pellets are:

- The requirements of the target groups regarding the optimal (regional) mixture are often unknown.
- The technical know-how of the key actors for production of alternative and mixed biomass pellets is too less.
- So far, regional market structures do mostly not exist.

By 2020 a production of 1,000,000 t / a alternative and mixed biomass pellets with 60 to 90 partners is planned by building up a decentralized production network which will be coordinated by Pusch AG.

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Production and combustion of grape marc pellets and blends with vine pruning in small scale appliances

Background

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. This means an oil equivalent of approx. 135 million litres and CO_2 savings of 354,000 t/a. In terms of recycling management, a marketable product should be created to improve the economic status and to offer new job opportunities in rural areas. Based on these political and economic objectives, RLP AgroScience GmbH is developing and realising new processes for the energetic use of solid wastes, residues from viniculture and vegetable gardening contributing to a circular flow economy. The European patent EP 1783195B1 (Process for making fuel from grape marc, particularly in pellet form) is held by AgroScience GmbH.

Figure 1: Grape marc residues (above) and pellets made of 70% grape marc / 30% vine pruning pellets (bottom)

Production of grape marc pellets

Viniculture produces on average 2.5 t of grape marc with a dry matter content of approx. 41 % and 3 t of vine pruning with a dry matter content of 50 %. Grape marc is a heterogeneous mixture which generally consists of solid components such as grape skins, kernels and peduncles. The amount, consistency and quality depend on the pre-treatment of the grape and mash, the type of grape, the weather and stage of maturity as well as putrescence. Utilisation of residues from viniculture as fertiliser to cover losses in humus soil is possible only to limited extend. The main reasons are the seasional and short availability and the increased risk of further fermentation, rot and the related formation of odour, seepage water and mycotoxins resulting from composting. Thus, excess amounts of these raw materials are available and can be pelletised for energy production running through the following steps:

- Cleaning and storage of the grape marc.
- Drying of the cleaned grape marc by using mechanical drainage and thermal drying.
- Crushing of the dried grape marc with mechanical release of the grape seed oil contained in the grape seeds.
- Pelletizing of the crushed grape marc by using a ring die press of Friedli AG, type CLM200 and some grape seed oilas additive to improve the pelletizing characteristics.

Figure 2: Pelletizing plant of Friedli AG, type CLM200

Grape marc pellets and blends with vine pruning can fulfill the requirements of the draft of the European standard for solid biofuels (EN 14961-6). The quality parameters of pellets from grape marc and mixtures with vine pruning (ratio: 70/30 Vol.-%) are listed in the following Table:

Typical fuel properties of grape marc pellets

Parameter	Unit	Grape marc	Blend
Diameter	mm	6	6
Mechanical durability	wt.-%	92 - 95	94 - 98
Amount of fines	wt.-%	5 - 8	2 - 6
Bulk density	kg/m³	650	630
Moisture content	wt.-%	10 - 13	10 - 12
Net calorific value	MJ/kg (dry basis)	19.8	19.0
Ash melting temperature	°C	910	900
Ash content	wt.-% (dry basis)	6.5	5.6
N		1.89	1.70
S		0.12	0.14
Cl		0.004	< 0.005

Combustion at Agroscience

A demonstration of the technical and economic feasibility for the combustion of blended grape marc pellets has been started in March 2011 to guarantee the applicability and facilitate the licensing of the fuel. Therefore, a HARGASSNER AGROFIRE with a nominal heat capacity of 30 kW will provide domestic hot water during summer in addition to an existing 920 kW wood chip boiler for heating.

Figure 3: Hargassner Agrofire 30 (www.hargassner.at)

First combustion tests have confirmed the usability as solid fuel. The grape marc pellets exhibted a good combustion behaviour.

Figure 4: Demonstration plant at AgroScience

An advantage is the low proportion of chlorine, which can lead to low formation of HCl-emissions and corrosion. However, there may be problems by increased NOx- and SO_2-emissions as a result of increased contents of nitrogen and sulphur in the fuel. Though the nitrogen content in the fuel is rather high preliminary combustion tests resulted in comparatively low NO_x emissions (see the following Table):

Parameter	Unit	Grape marc	Blend
CO	mg/Nm³ (13 Vol.-% O_2)	2,735	825
NOx		130	240

Minor slagging tendencies have been observed. However, the impact on the bottom ash removal was negligible. Although dust emission is high, it might be reduced with secondary measures. Additionally, blends with vine prunings can improve the fuel characteristics and combustion behaviour.

Costs

It is planned to provide local farmers of Rhineland-Palatinate with the fuel pellets. Additionally, small district heating plants or public buildings such as schools can be supplied. The raw material costs are about 45 €/t including storage, transport and drying. The pellet price is about 180 to 200 €/t by using a pelletizing plant with a capacity of 1 t/h and a production of 3,000 t/year. Based on a service life of 12 years and an operation period of 3,600 hours/year the costs for the 30 kW boiler are:

Total Investment costs [€]	50,000
Total capital consumptions [€/a]	4,167
Total running costs [€/a]	9,420
Total annual cost [€/a]	13,587
Total costs over service life [€]	163,050

Challenges for the future

The major challenges for the future are:

- The implementation of a marketable product in a medium-term period to strengthen sustainable recycling management and rural economics.
- The establishment of a locally licensed fuel in combustion plants according to 1st BImSchV.
- Adaption of combustion appliances for the handling of ash rich fuels.

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Grapevine pellets production and combustion

Introduction

Large quantities of pruning residues from fruit trees, grapevine and olive cultivations are available in Italy. In the northern part of Italy, in particular, the amount of pruning residues (dry matter), mainly grapevine pruning, is estimated to about 0.7 - 0.8 Mio. t. Particularly, in the Veneto Region, about 70 - 75,000 ha are cultivated with grapevine and produce about 0.1 - 0.12 Mio. t dry matter of biomass residues each year. Thus, regional entrepreneurs involved in agricultural machinery and biomass sectors have developed equipment for harvesting of grapevine pruning and its utilization to produce energy.

Raw material

The grapevine pruning residues are usually collected between January and March. Depending on the harvesting technique, the residues can be baled or shredded; the product is afterwards dried, usually on the sides of the field, until the moisture content reaches about 20 - 25 %. The choice of the different harvesting equipment and technologies is very important because it affects the quality (Table 1) of the product and the following steps: storage, transport and processing of the biomass.

Table 1: Fuel properties (db.. dry basis)

Net calorific value	MJ/kg db	17.6
Ash content	wt.-% db	2.1 - 3.5
Water content	wt.-%	35 - 50
Softening temperature of ash	°C	> 1,500
Nitrogen	wt.-% db	0.5 - 0.7
Sulphur	wt.-% db	0.01-0.02
Chlorine	wt.-% db	0.04-0.06

Pelletizing

The pelletizing process of grapevine pruning can be performed in an industrial plant (Produttori Pellet – Colognola ai Colli (VR)) or directly in the farm. In the first case, a hammer mill is used for particle size reduction and to improve the homogeneity. The mill grinds the pruning biomass passing it through a sieve of Ø 8 mm; the grind can be operated when the raw material moisture content is 15-18 %: this condition is normally realized after a natural drying period of 3 to 6 months. After that, a belt conveyer transports the refined product to a press (220 kW - 2 t/h) with a ring die (30/6 mm). During the pelletizing process, no additives are used. Pellets are cooled by air and then stored in silos. Finally, the product is packed in one big bag or in different 15 kg bags.

Picture 1: grapevine pruning harvester (left) and pellettizing mobile machinery (right).

Pellets can also be produced directly in the farm using mobile pellet presses and hammer mill machineries (General Dies), directly connected to the PTO of a tractor. The biomass is milled to reduce its size down to Ø 8 mm and then fed in the pellet press (ring die - 6 mm) without using additives. The mechanical quality of this pellet is lower than the industrial pellet but it is an interesting solution to reduce the economic and environmental costs of transport.

Costs

A first assessment indicates a cost of 100-120 €/t for the pellet produced by mobile pellettizer. The cost for the industrial pellet is evaluated to 120 -130 €/t. This estimation does not take in consideration the costs of pruning, assuming that the raw material is a residue. During the last winter season (2010), the grapevine pellet prize in the regional market reached about 150-180 €/t for the different packaging.

Combustion

The combustion of alternative pellet causes some problems when used in traditional heating systems, developed for wood pellets. The main problems are: incomplete and not uniform combustion of pellets; low energy efficiency; high quantity of ash produced in the combustion chamber and of pollutants in the flue gas. The most suitable combustion technologies for the alternative pellets are devices with blown air burners or with moving grate. In the first case, the burner separates the gasification phase from the pellet combustion phase and continuously removes the residual ashes. These devices, even of low power (25 kW), can also be implemented in conventional boiler systems, fueled by traditional fossil fuels. The second technology provides a mobile grate where the air distribution system ensures the correct air/fuel ratio needed. The market development of alternative pellets is slow. However, it seems to be continuously growing. Gas emissions were monitored in some small scale boilers. The measured concentration values of CO, NO_x and dust are similar to those of the wood pellet systems and they are generally below the emission thresholds established by the Decree 152/2006 and EN 303-5. However, the results also depend on the abatement systems implemented in the heating device.

Summary

In some of the cases considered in the MixBioPells project, the alternative pellet users have shown a high satisfaction. The most important reasons are:

- low cost of the fuel;
- more efficient transport and storage operations;
- better quality in comparison to the tradional solid biomass fuels;
- more efficient heating systems.

However, the operators highlight also some problems. Among them:

- high production of combustion residues (ash) to be frequently removed;
- discontinuos availability of alternative pellets;
- lack of a product quality control;
- difficulties to reduce the emissions in the exhausts of small heating plants.

Picture 2: Termocabi burner for agri-pellets implemented in a traditional boiler for wood fuels.

Combustion system manufacturers are focusing their attention in the development of heating device technologies that are more efficient and have low pollutant emissions. The corrosion of materials, including the chimney and the internal parts of the boilers, due to the high content of chlorine and sulphur of some biomass residuals, is still a problem that needs to be solved.

Production and combustion of almond shell briquettes in Crevillent, Spain

Background

As a company working in the field of renewable energy Covaersa produces, and distributes almond shell briquettes. In 2009, the world production of almond reached 2.4 Mio t. About half of the world´s total production, come from the United States (1,162,000 t, 49 %) followed by Spain being the second world producer (282,000 t, 12 % of total production), Spain´s production is located at the Mediterranean seaside communities: Catalonia Valencia, Balearic Islands (Mallorca), Murcia, Andalucia and Aragon. The annual almond production varies according to the changing weather conditions. Almond shells have a high heating value, and can be used for energy purpose and other industrial applications.

Almond shells are already used as fuel for bakery furnaces, the ceramic industry and in heating facilities of livestock farming. In order to improve its marketing, the company BRIEC – COVAERSA has decided to use almond shell briquettes. This resulted in a series of difficulties which the company managed to overcome by means of its R&D department.

Raw material

For almond harvest and hulling a so-called "vibrator" is used which is fitted to the tractor truck. It resembles, once expanded, the shape of an inverted umbrella. Before milling the almonds are placed on large open air surfaces to dry "under the sun". Once dried, they are sold to the miller where they are shelled and classified. The discarded shells are piled up and sold to farms and industries.

Raw material characteristics

Raw material	Almond shells
Moisture content wt.-%	2
Heating value, kJ/kg	18,640
Ash content wt.-%, dry basis	1.52
Chlorine wt.-%, dry basis	0.021
Sulphur wt.-%, dry basis	0.01
Mercury, mg/kg	0.013
Amount, t/year	30,000

Pelletizing process

The BRIEC factory has a production capacity of 30,000 t/year. The shells are supplied with trucks, sieved to remove stones and then fed to a silo with a capacity of 45 t by a conveyor belt.

Drying tunnel

From the silo, almond shells are transported with a conveyor belt that is equipped to remove contaminants and metallic impurities to the washing facilities. The shells are washed in two tunnels by soaking in a water bath. Afterwards, the shells are dried in a drying tunnel-vibrating drum with a capacity of 10 t/h to reduce the moisture content to approximately 2 %. Consecutively, the almond shells are passed through a distribution silo where they are fed to the compacting/ pressing and briquetting machinery.

Briquetting machinery

Transportation and storage

The briquettes can be packed either in boxes, big bags or shrink wrapped. The packing type depends on the format of the almond shell briquettes.

Almond shell briquettes

Combustion at the Retirement Home La Purísima in Crevillent

One of the BRIEC company`s clients is Retirement Home La Purísima which is a private retirement home located in the municipality of Crevillent. It belongs to La Purísima Social Enterprise Organization and provides accommodation for 32 people. Its heating boilers have a total installed capacity of 235 kW (2 x 100 kW heating boilers + 1 x 35 kW boiler for hot water supply). The boilers are equipped with feeding screws that are able to disintegrate the briquettes and with a 1500 litres buffer tank. The boilers have been installed three months ago. Thus, it is difficult to estimate the yearly consumption. From the replacement of the previous natural gas boilers 50 – 55 % lower costs are expected. So far, no technical problems during combustion have been observed. Previously, boilers were running only 5 h/d due to cost restrictions and the old people used to be cold. Now, the boilers operate 24 h/d and the old people can spend their twilight years much more comfortable at a much lower price in comparison to gas.

Other uses for briquettes

Almond shell briquettes can also be used as fuel for bakery ovens as well as at the wood-fired ovens of pizzerias. When wood briquettes were replaced by almond shell briquettes in bakery ovens 30 % smaller amount of fuel was required. Domestic heat appliances (e.g. fireplaces, wood boilers) seem to be further interesting options for the utilisation of almond shell briquettes. Due to its low moisture content and high heating value quick heat up can be achieved using very little fuel. Also, the flame image is really clean and attractive. It doesn´t stain the glass of stoves or built-in chimneys.

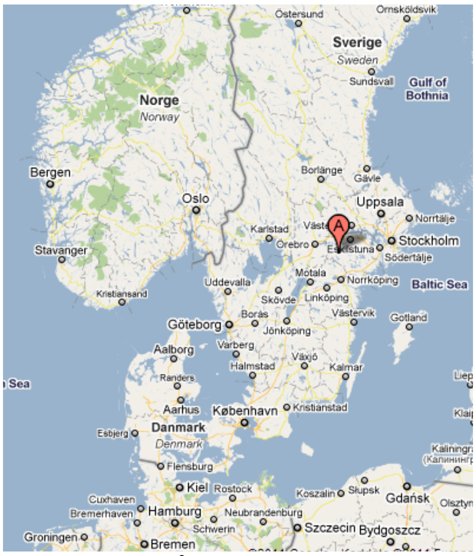
Producer´s view

Covaersa´s aim is to achieve a leading position by means of its Briec brand, both at the national and international biomass markets using a high quality product endowed with such properties and characteristics which will distinguish it greatly from the rest of biomass fuels.

Production and combustion of Reed Canary grass briquettes in Sweden

Background

Due to increasing prices for woodchips and growing competition for raw materials Låttra farm, located about 150 km west of Stockholm, started to look into the possibility to produce reed canary-grass (RCG) briquettes for sale and own use. Låttra Farm grows reed canary grass on 70 hectares and the goal is to increase this to 100 hectares by 2012. RCG is a perennial grass that can be grown throughout Sweden.



Location of Låttra Farm

Growing and briquetting of Canary Reed Grass

Låttra farm has the capacity to produce 3,500 tonnes 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 greater 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 finished briquettes are fed into a horizontal silo with capacity for 1,000 tonnes of briquettes. The briquettes are taken directly from the silo for delivery to customers.


Reed canary grass bales

Typical fuel properties of reed canary grass in spring (db…dry basis).

Net calorific value	MJ/kg db	17.5
Ash content	wt.-% db	5.9
Moisture	wt.-%	13
Softening temperature of ash	°C	1,420
Nitrogen	wt.-% db	0.48
Sulphur	wt.-% db	0.06
Chlorine	wt.-% db	0.04

Customers

There are currently a number of heating plants within a 100 km radius of Låttra Farm 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, based in Ulricehamn. TCG builds and operates different kinds of district heating plants.

Transport

Briquettes are loaded onto trucks at Låttra Farm and transported in demountable containers that connect to the feeding system at Öknas School. Each shipment

contains about 30 tonnes of reed canary grass briquettes.

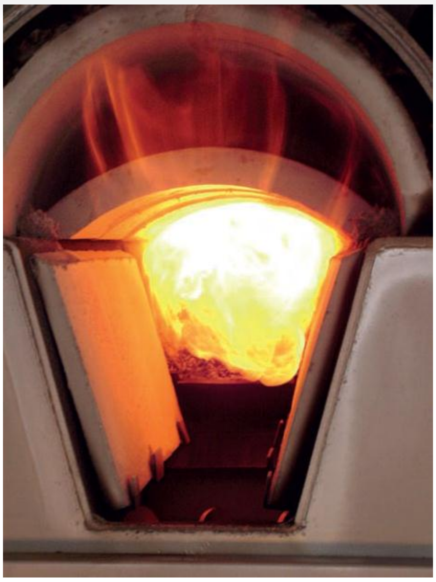
Feeding system at Öknas School

Combustion at Öknas School

The old solid fuel boiler at the Ökna School, which was run on wood briquettes, was exchanged with a new Ökotherm solid fuel boiler (800 kW, C6) suited for ash-rich reed canary grass briquettes during the summer of 2011. In autumn 2011, TCG started to optimise the plant for the of use reed canary grass briquettes from Låttra Farm.

Sörmland County buys thermal heat of TCG to Öknaskolan. This concept is a hassle-free heating alternative. TCG takes care of:

- Maintenance
- Operation
- Alarm management
- Service and maintenance



Combustion chamber

Annually TCG produces approximately 2,500 MWh heat at Öknas School.

Problems/ possible obstacles

The main challenge is to optimize the equipment for handling of ash rich fuels and to find ways to decrease corrosion.

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