INITIATORS HANDBOOK

mixBioPells

MIXBIOPELLS INITIATORS HANDBOOK



Project coordination

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mixBioPells
Market Implementation of extraordinary biomass pellets

Coordinated by: DBFZ

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Participating countries

In most European countries, the market integration of alternative biomass pellets (e.g. made of straw, agricultural or food processing residues) is still hindered by various constraints. To overcome these constraints and to strengthen the drivers, promising market introduction concepts will be identified to enhance the relevance of alternative pellets in Europe. Thus, the MixBioPells project provides up-to-date market information for alternative and mixed biomass pellets based on a comprehensive data collection for representative European countries and regions (see above) which are available at

www.mixbiopells.eu

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1 INTRODUCTION

Currently, biomass combustion in Europe is dominated by the utilisation of wood fuels. However, caused by the growing demand for material and energy related use wood is getting scarcer nowadays. Consequently, alternative solid biomass like straw is experiencing growing interest as alternative fuel source. In most European countries preliminary activities in industrial as well as in public sectors have been started to integrate these alternative solid biofuels. However, the market integration of alternative biomass pellets is still hindered by various constraints. Initiators are facing several specific challenges that they have to cope with. To overcome the constraints and strengthen the drivers for the enhancement of alternative pellets utilisation in Europe, the handbook will help initiators to plan their projects in a realistic and successful way. Thus, the handbook provides information for the production and utilisation of:

- alternative biomass pellets and briquettes made of biomasses and biogenic residues except wood and wood processing residues and
- mixed biomass pellets and briquettes made of mixtures of raw materials from Group 1, 2 or 3 according to the definition in EN 14961).

Since kind and potential of the available raw materials and the legal and economic conditions differ significantly between the European countries and even between the regions of one country, general aspects, approaches and recommendations for the planning and realisation of alternative and mixed pellet supply chains will be described in the **first part of the handbook**. Depending on the initial situation, the general way to build-up alternative pellet initiatives will be quite different for the key actors. Thus, different approaches will be outlined according to the three most common initial situations (Table 1).

Table 1: Most common initials situations to start alternative and mixed biomass pellet projects

Initial situation	**Initiating key actor**	**Goal**
Availability of cheap and/or unused alternative raw materials	Raw material supplier	Added value due to the utilisation of agricultural residues or side products from feed production industry as alternative raw materials for fuel pellet production (and utilisation)
Scarcity and high price level of woody raw materials for pelletizing	Pellet producer	Opening and entering new market possibilities with the production of alternative and mixed biomass pellets beside the established wood pellet market
Heat demand that is to be covered by boilers fired with alternative and mixed biomass pellets	Heat supplier or planner of heating systems	Installation and operation of a heating system fired with alternative and mixed biomass pellets to guarantee cost effective heat supply with biofuels that are less expensive than high quality wood pellets

1 INTRODUCTION

Within the approaches both industrial scale as well as small and medium scale will be covered. During the build-up of each alternative pellet initiative several aspects have to be considered. The aspects are allocated to different categories and for each category detailed information based on the results of the MixBioPells project from the seven European partner countries will be given combined with sources and links for further information if applicable.

The **second part of the handbook** will provide the initiators with specific advices and Best Practice Examples according to their national conditions. To do so, the initiators will be enabled to classify their own conditions and to evaluate the existing constraints and drivers concerning to their situation. Accordingly, they will be enabled to find out which of the four possible frameworks applies to their conditions. The recommendations will be classified according to the framework and should therefore also be useful for users from third countries. For each framework fitting “Case Studies” and “Best Practices Examples” will be provided in the appendix. Additionally the national conditions for the partner countries are included as an overview. In this way, the key actors are supported both with recommendations for their situation and with examples on already realised projects that provide insight in problems and solutions of other key actors that have had to face similar problems.

Further information is available on the website **www.mixbiopells.eu**.

PART I:

„General approach for pellet initiatives"

2 THE INITIAL SITUATION

Dear Initiator,
If you are considering or planning to start a project for alternative and mixed biomass pellet production or utilisation this handbook will guide you through the preparation of such a project and will provide you with helpful information and recommendations. Several aspects like raw material issues, technology and legal aspects as well as economics have to be considered for any project. However, depending on your initial situation they will arise in different order.

Commonly, the starting point of alternative and mixed biomass pellet projects is one of the following three distinct initial situations:

A) You are a raw material supplier with cheap and unused residues or side products from agricultural and feed production industry that could be used as alternative raw materials for fuel pellet production aiming at profitable utilisation concepts.

B) You are a pellet producer who has the ambition to change to alternative and mixed biomass pellet production reacting to the increasingly tight market for wood pellets and decreased availability of cheap woody raw materials.

C) You are a heat supplier, planner of heating systems or a procurement manager looking for cost effective, CO_2-neutral fuels for power plants with the aim to change a fossil fired system to a renewable and economical feasible solution fired with alternative biomass fuels.

For each of the initial situations a flow chart is provided that will guide you through the general way to plan your project. But before looking at the flow charts, please consider two important questions:

1) What capacity range, either

   I) industrial scale combined heat and power production or

   II) small and medium scale heat production,

   are you aiming for?

Perhaps you are already sure about your selection. Otherwise, you can consider major advantages and disadvantages for each capacity range that are summarised in Table 2 and which could help you with the decision. Furthermore, the amount of available raw materials, the characteristics of the raw materials and the heat demand can be important for your selection.

Table 2: Advantages and disadvantages of industrial scale and small and medium scale production

Industrial scale CHP production	**Small and medium scale heat production**
Advantages: • Possibility for tailor made technology solutions • Clear support measures • More options to use alternative raw materials • High operation hours can be more easily achieved Disadvantages • Usually more strict legislative regulations • Higher logistic effort • Lower social acceptance • Higher effort to get legislatory approval	Advantages: • Solutions on regional level • Relatively constant raw material qualities • Close integration of local key actors • Less public concerns • Lower effort for legislatory approval Disadvantages: • Less options due to availability of local raw materials • Ready-made technologies are required • High operation hours only if there is a constant heat demand

The utilisation of alternative and mixed biomass pellets can be more challenging than the utilisation of the common fossil or wood fuel options. Thus, it is important to have a supportive framework to handle these challenges and to overcome possible hurdles and obstacles. A less supportive framework with high legal restrictions and a high bureaucratic effort can endanger the success of your project. Similarly, financial support and incentives are helpful to ensure overall viability. Therefore, you should figure out beforehand if the framework in your country or region is favourable or not. The answer that you give to the following questions gives you a first hint on the possible success of an alternative and mixed biomass pellet project and indicates with what effort you should go through the steps of this guidebook (Table 3).

2) Does the legal and economic framework in your country or your region support the utilisation of alternative and mixed biomass pellets?

Table 3: Recommendations for the utilisation of the guidebook under different frameworks

Supportive Framework	**Framework causing difficulties concerning legal and/or economic aspects**
In case you plan your project under a supportive framework the flow chart is a good guide and you can follow it in detail.	Under less or little supportive frameworks please go only quickly through the flow chart. You can follow it in more detail if you have ideas and possibilities how to overcome the challenges caused by the less supportive framework.

But how can I find out if the framework in my country or region is supportive or not?

From the analysis that has been done in the MixBioPells project the combination of financial support and favourable legal conditions can be taken as supportive framework. Firstly, you have to check if there are financial support options available for your aspired capacity range. If you don't already know you can find information on available support options of the seven European partner countries (AT, DK, FI, DE, IT, ES, SE) within chapter 3.4.3. For the other European countries the NREAP assessment can be used as source of information: www.repap2020.eu.

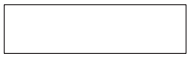
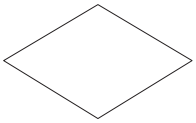
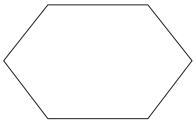
As indicator for favourable legal conditions on industrial scale you can take the existence and operation of industrial scale plants for alternative and mixed biomass pellet utilisation, as well as the construction and installation of further plants. For small and medium scale dust emission thresholds above 100 mg/Nm^3 is a good indicator for overall less restrictive, i.e. supportive legal conditions.

All initiators planning alternative and mixed biomass pellet projects in the context of less supportive frameworks have to involve local authorities in the early stages of the planning. Furthermore, the Best Practise Examples from countries with the same framework should be studied. The contact to key actors involved in Best Practise Examples of the MixBioPells project or to other key actors with experience in this field that you might know is strongly recommended.

2.1 Flow charts for the initiation of alternative and mixed biomass pellet projects

If you have answered the previous questions you can use the flow charts below which suggest a routine for the initiation of an alternative and mixed biomass pellet project starting from one of three different initial situations described in chapter 1. The flow charts display a stepwise process. Different symbols are used to indicate tasks that have to be fulfilled or decisions that have to be made, see Table 4. Usually, after a "yes" decision you can continue while after a "no" decision you often have to look into further information.

Table 4: Description of the symbols

Symbol	Explanation
	Starting or final point
	Line and direction of progress
	Incoming path after a task that had to be completed
	Task
	Decision with yes/no option or either/or option
	Connecting point if the flow chart spans more than one page
	Indicates the further steps that have to be followed in the flow chart

During the build-up of each alternative pellet initiative several aspects have to be considered. The aspects are allocated to different categories and for each category detailed information based on the results of the MixBioPells project from the seven European partner countries will be given combined with sources and links for further information if applicable. To indicate from which category necessary information can be obtained the according symbols will be depicted with the associated filling. Each colour represents and guides to one category. The allocation of the colours is shown in Table 5.

Table 5: Allocation of the colours

Colour	Category
	**Raw materials and fuels:** Within this category you will find information on alternative raw materials, the available potentials and the characteristics of these raw materials which influence the fuel properties. Furthermore, key actors lists of fuel producers and suppliers and links for further information can be found.
	**Legal framework:** Within this category you will find information on licensed fuels, emission thresholds and product standards for alternative and mixed biomass pellets. Additionally, possible sources for further information will be suggested.
	**Pelletizing and combustion technologies:** Within this category you will find information on possible problems connected with the production and utilisation of alternative and mixed biomass pellets. Furthermore, information on available pelletizing, combustion and flue gas cleaning technology and links for further information will be provided. At the end, key actors lists of manufacturers for pelletizing, combustion and flue gas cleaning can be found.
	**Economics:** Within this category you will find information on costs associated with the alternative and mixed biomass pellet production and utilisation and on available support options. Furthermore, links for further information will be provided.

There are different key actors involved for the realisation of an appropriate supply chain for the alternative and mixed biomass pellets production and utilisation. These key actors must operate closely together during all project phases to ensure the success of the bioenergy project. The key actors that are most commonly involved are:

- **Raw material suppliers**
- **Pellet producers and -suppliers**
- **Manufacturers and developers of pelletizing, combustion and flue gas cleaning technology:** Developers and manufacturers have to address the special properties of alternative raw materials during alternative and mixed biomass pellet production and utilisation.
- **Research groups:** Many research activities are still needed and on-going. Research institutions can contribute to provide necessary information and help in solving special problems.
- **Administration and Policy:** An early communication with representatives from administration and policy is crucial to achieve public acceptance and to get the legal permission for the operation of the plants.
- **Heat supplier and customer**
- **Planner**
- **Combustion plant operators**
- **Investors and funding agencies**

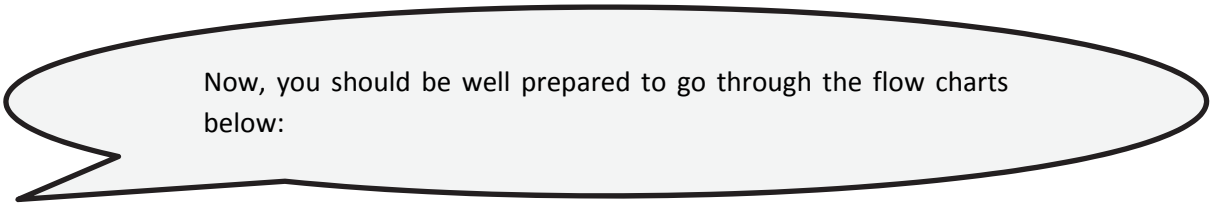
2 THE INITIAL SITUATION

You can consider two different general approaches for the utilisation of alternative and mixed biomass pellets:

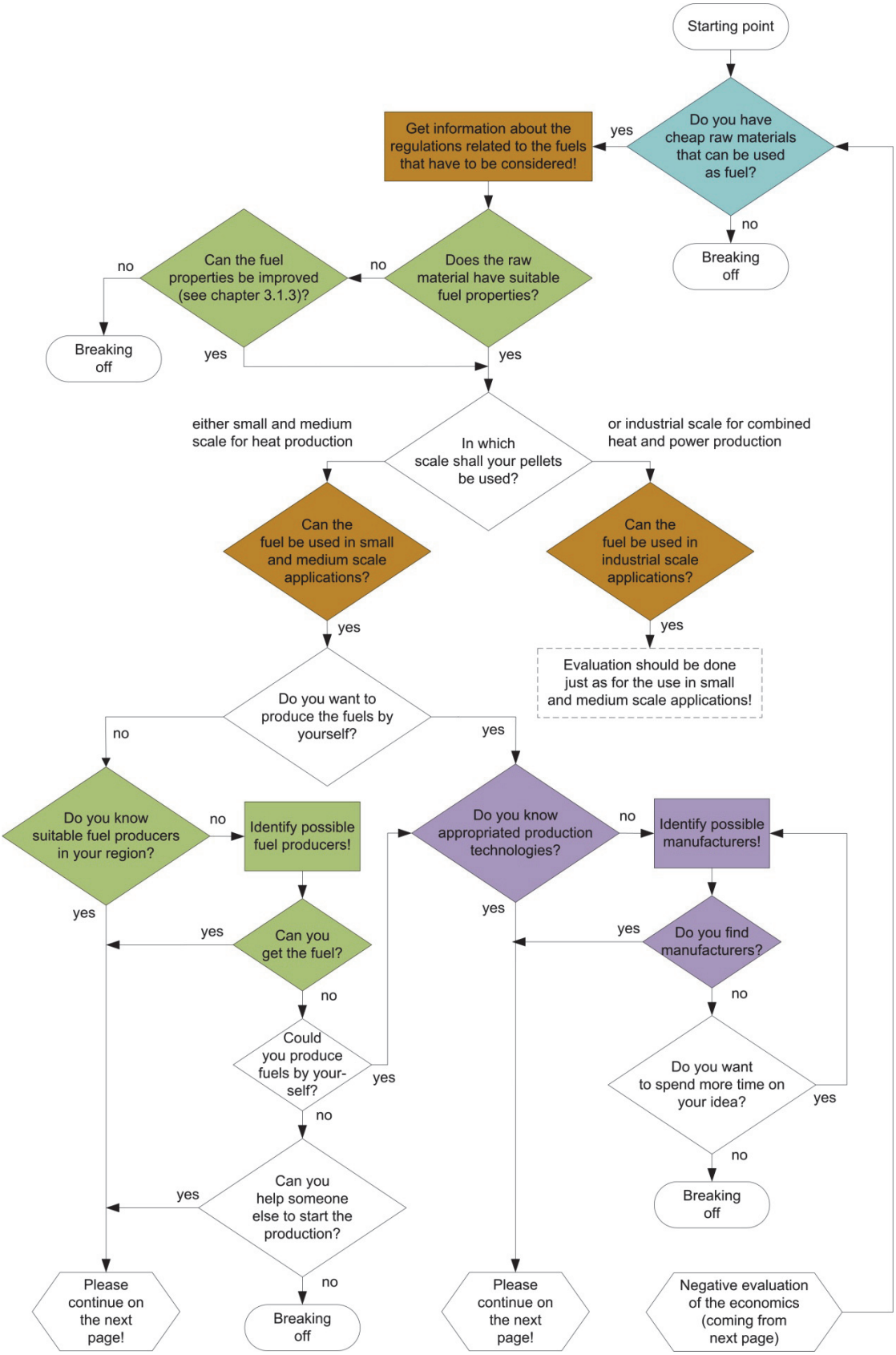
- Pellets according to an existing product standard, where the quality assurance should be given by adding different additives to compensate the yearly and regional variations in the critical properties, pellets will be traded and sold all over Europe.
- Production of regional blends with varying properties to be sold to well-known regional customers and where the combustion settings of the boilers need to be adapted.

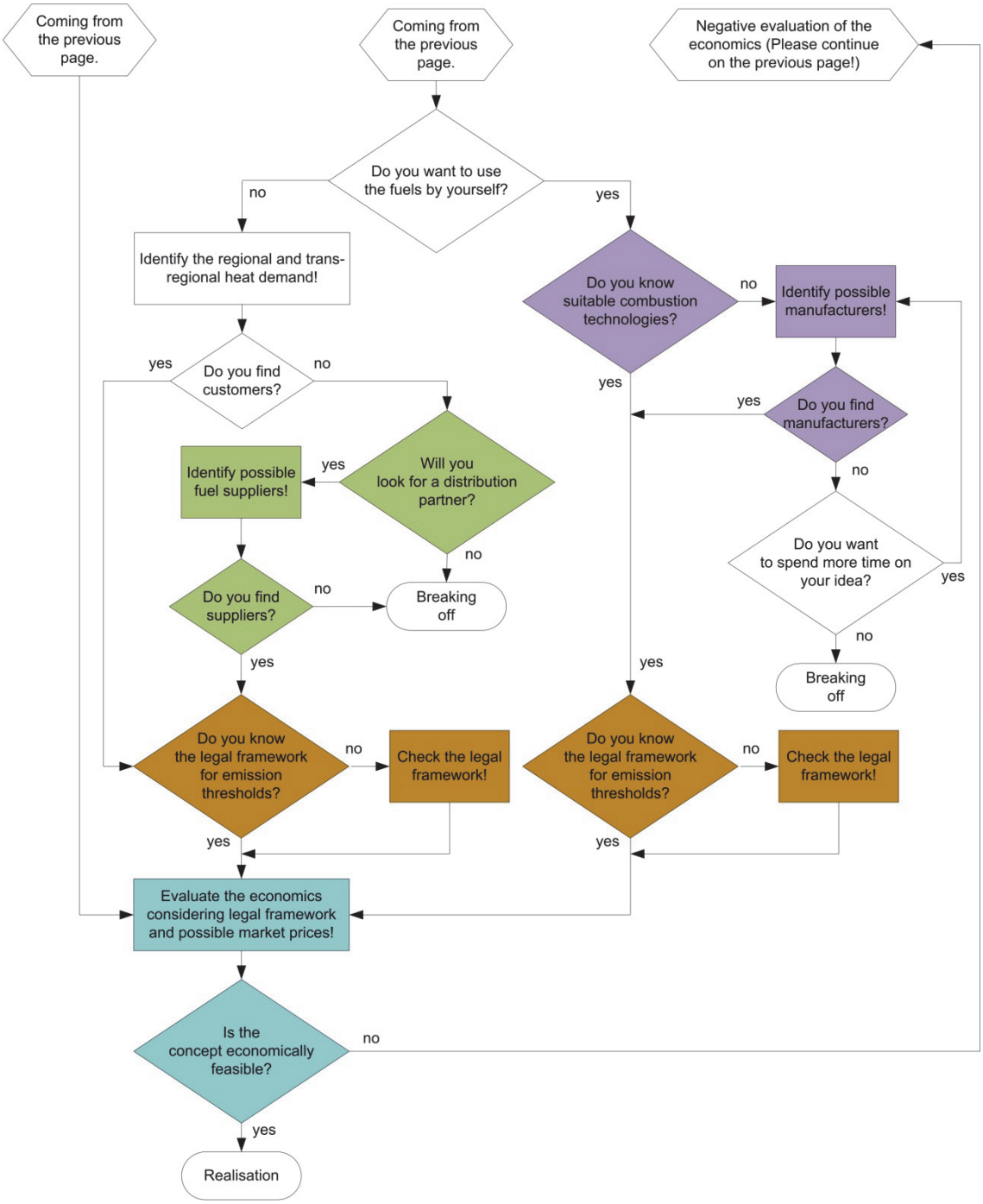
To figure out which concept is useful, the amount and characteristics of available raw materials as well as the heat and electricity demand based on the following utilisation concepts must be aligned:

- Heat generation in small combustion appliances smaller than 100 kW,
- Heat generation medium scale heating systems (100 kW – several MW),
- Combined heat and power production in industrial scale systems.

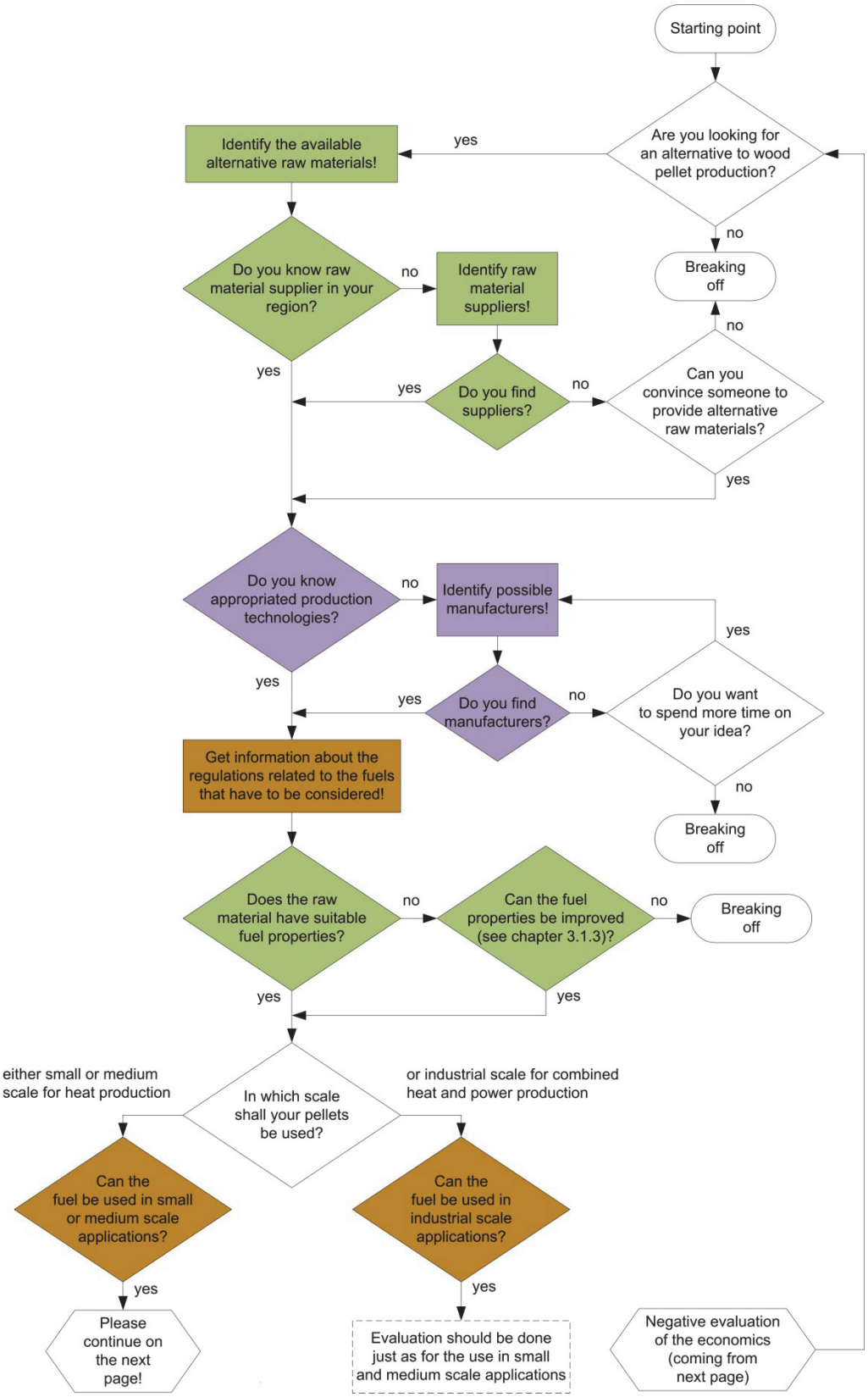


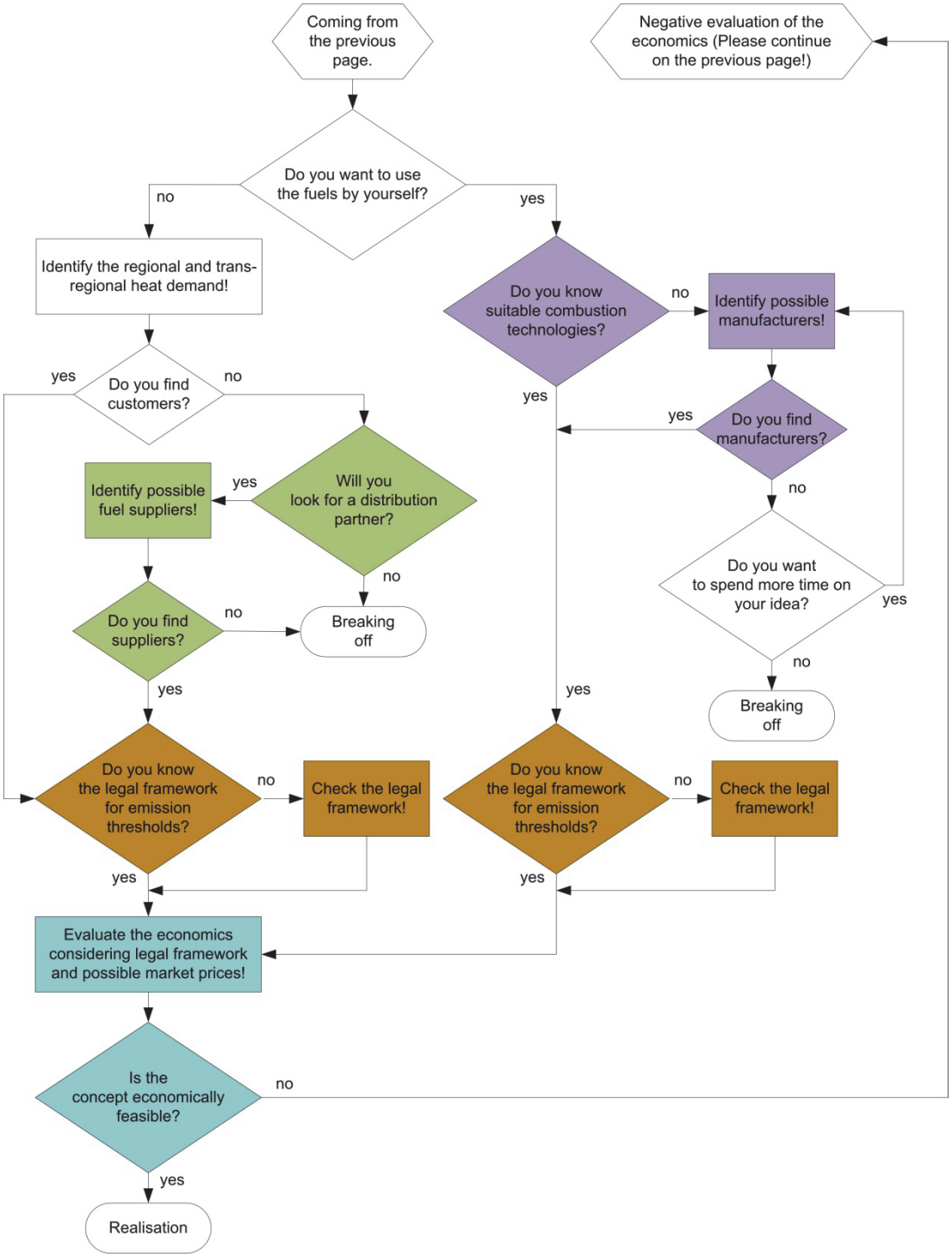
A) If you are a raw material supplier with cheap and unused raw materials for fuel pellet production aiming at profitable utilisation concepts, please use the following flow chart.



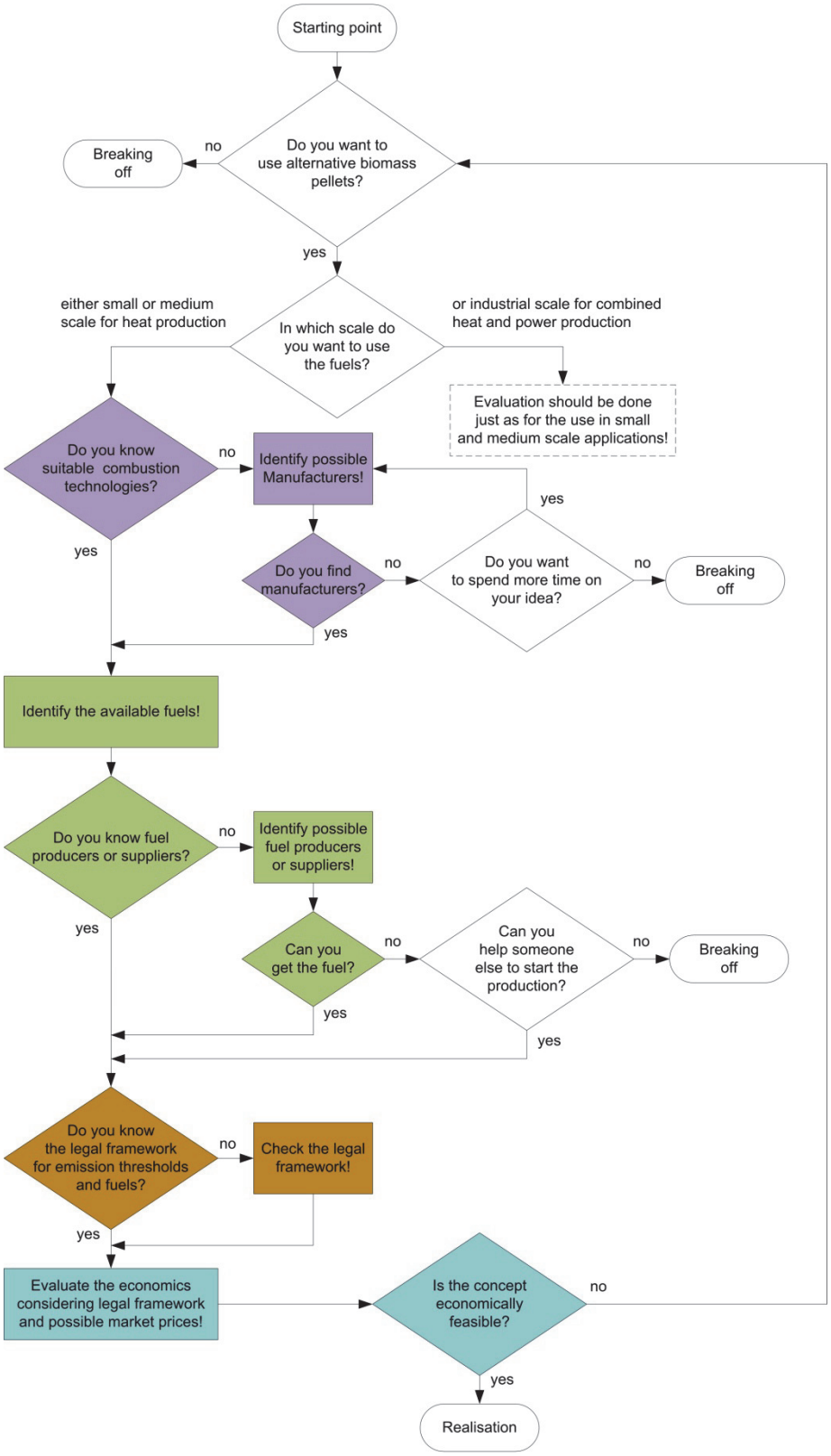

Coming from the previous page.
Coming from the previous page.
Negative evaluation of the economics (Please continue on the previous page!)
Do you want to use the fuels by yourself?
no
yes
Identify the regional and trans-regional heat demand!
Do you know suitable combustion technologies?
no
Identify possible manufacturers!
yes
Do you find customers?
yes
no
yes
Do you find manufacturers?
Identify possible fuel suppliers!
yes
Will you look for a distribution partner?
no
Do you want to spend more time on your idea?
yes
Do you find suppliers?
no
Breaking off
no
yes
yes
Breaking off
Do you know the legal framework for emission thresholds?
no
Check the legal framework!
Do you know the legal framework for emission thresholds?
no
Check the legal framework!
yes
yes
Evaluate the economics considering legal framework and possible market prices!
Is the concept economically feasible?
no
yes
Realisation

B) If you are a pellet producer who has the ambition to change to alternative and mixed biomass pellet production reacting to the increasingly tight market for wood pellets and decreased availability of cheap woody raw materials, please use the following flow chart.




Coming from the previous page.
Negative evaluation of the economics (Please continue on the previous page!)
Do you want to use the fuels by yourself?
no
yes
Identify the regional and trans-regional heat demand!
Do you know suitable combustion technologies?
no
Identify possible manufacturers!
yes
Do you find customers?
yes
no
yes
Do you find manufacturers?
no
Identify possible fuel suppliers!
yes
Will you look for a distribution partner?
no
Do you want to spend more time on your idea?
yes
no
Do you find suppliers?
no
Breaking off
yes
Breaking off
yes
yes
Do you know the legal framework for emission thresholds?
no
Check the legal framework!
Do you know the legal framework for emission thresholds?
no
Check the legal framework!
yes
yes
Evaluate the economics considering legal framework and possible market prices!
Is the concept economically feasible?
no
yes
Realisation

C) If you are a heat supplier, planner of heating systems or a procurement manager looking for cost effective, CO_2-neutral fuels for power plants with the aim to change a fossil fired system to a renewable and economical feasible solution fired with alternative biomass fuels, please use the following flow chart.



3 CATEGORIES

3.1 Raw materials and fuels

From the MixBioPells project you can get detailed information on available raw materials in certain regions of seven European countries and their characteristic. They are compiled in the Biomass Report of the project. A broader European picture can be found in the project results of EU-BioNet 3. If you want to start a project it is important for you to find out from local raw material suppliers what unused biomasses or residues are available and in what amount. Possible local raw material suppliers could be any key actors which are dealing with agricultural products and residues. These are e.g. farmers, local farmer cooperatives and companies processing agricultural raw materials (e.g. flour mills, sugar producers, producers of fruit juice). Some of these actors have problems to get rid of their residual materials; some even have to pay for the disposal. Pellet producer will use the raw materials for alternative and mixed biomass pellet production. They could come from the area of wood pellet production, from the pelletizing of alternative materials as litter or fodder or could be new key actors in this field. Due to the more difficult characteristics of alternative raw materials experience with the pelletizing of these materials is of great relevance. Furthermore, the characteristics and the raw material costs have to be figured out. If you need further help for the gathering of the above information a good source are national research institutions with focus on biomass research.

For small and medium scale heating appliances only a few alternative fuels, e.g. straw, are used so far. Most of the alternative fuels are used in dedicated industrial CHP plants or for co-firing in varying fuel proportions.

3.1.1 Raw material potentials

Within the MixBioPells project the potentials of the three most relevant raw materials have been estimated for each partner country and compared with results from previous studies. The results of the comparison are shown in Figure 1. To get an overview about the total amounts of alternative raw materials that are available in the partner countries the potentials of the five raw materials with the highest relevance in the partner countries have been summed up (Figure 2). Several raw material types are available in too small amounts (e.g. olive cake, shea waste, mash from breweries, olive stones, almond shells, reed canary grass and rape seed press cake). Thus, their potentials are compiled and indicated as “others” in Figure 2.

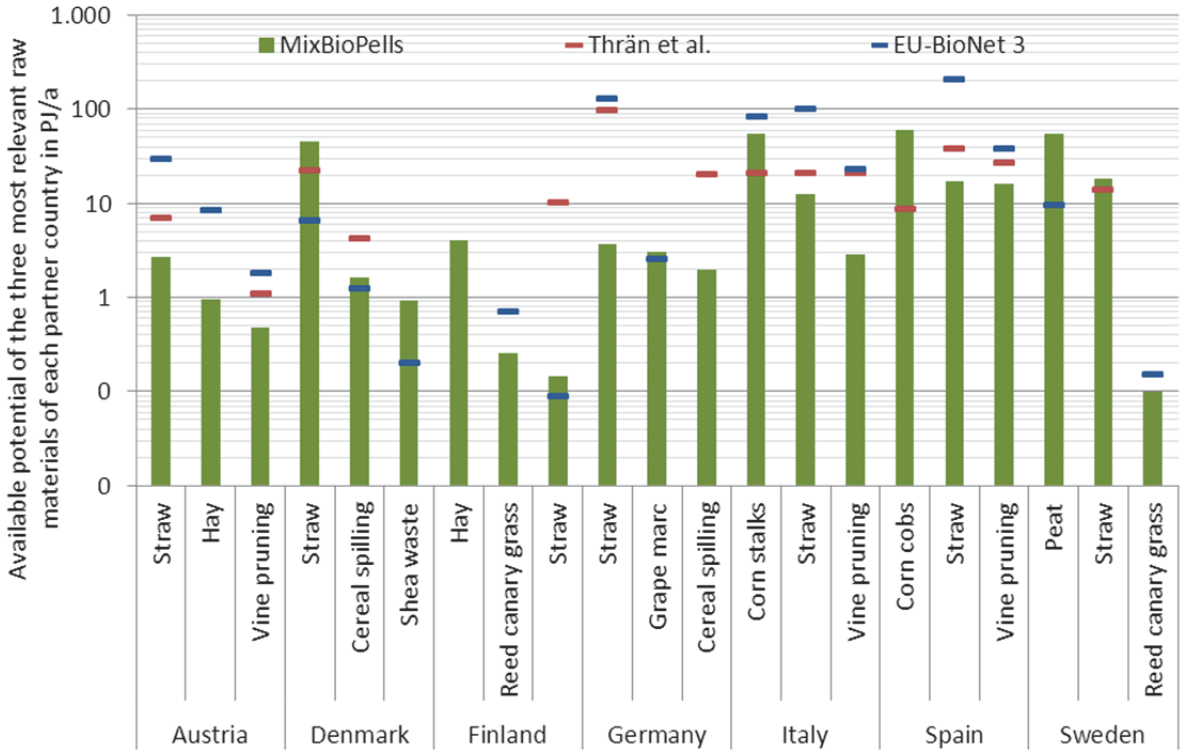


Figure 1: Comparison of the results on available potentials for selected raw materials in seven European countries with results from other studies

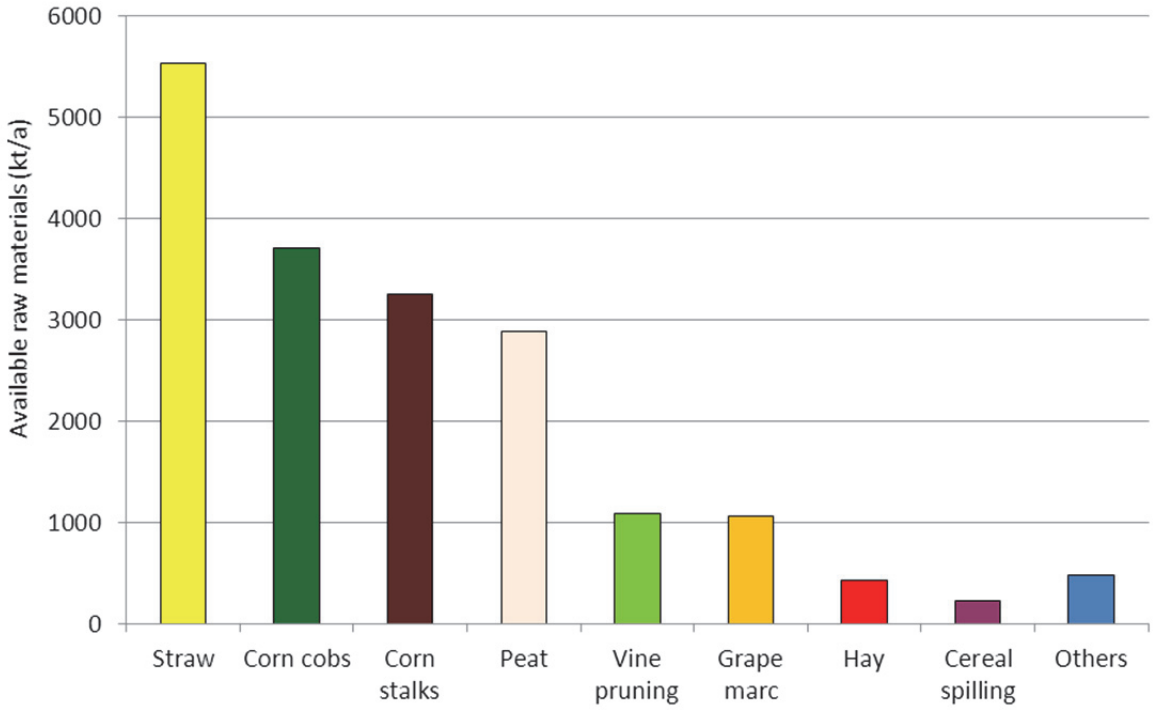


Figure 2: Most relevant raw materials according to the analysis within the MixBioPells project

3.1.2 Raw material properties

Raw material properties of non-woody biomasses are considerably different from the characteristics of woody biomasses. In general the ash content of non-woody biomass is higher and at the same time ash melting temperatures are found to be lower. High levels of nitrogen, sulphur, potassium and chlorine are often present in alternative biofuels. These elements can form harmful gaseous emissions like NO_x, SO_2, HCl as well as particulate emissions. Moreover, sulphur and chlorine play a major role in corrosion reactions. Table 6, Table 7 and Table 8 gives an overview about the raw material properties relevant for the standardisation and for the combustion of selected raw materials. If available, the range of the data is listed, other values are average values. Single values are especially indicated. Please keep in mind that the data provide only a reference. The exact properties of your concrete raw materials have to be determined by appropriate analysis according to the existing European standards for solid biofuels.

Table 6: Combustion-relevant fuel properties

Kind of biomass	Net calorific value	Ash content	Water content	Ash softening temperature	N	S	Cl
	MJ/kg db	% db	%	°C	% db	% db	% db
Miscanthus	17.5-17.9	1.6-3.0	7.5-14.0	820-1172	0.20-0.43	0.02-0.09	0.02-0.13
Reed canary grass	17.5-19.0	4.5-6.0	10.0-15.0	1150-1650	0.30-0.60	0.07-0.08	0.03-0.04
Hemp	19.1-19.6	1.6-2.3	56.6	1200-1250	0.30-1.40	0.06-0.10	0.02-0.30
Straw	17.0-19.0	4.4-7.0	9.0-15.0	800-900	0.30-0.80	0.06-0.12	0.03-0.05
Vine pruning	17.5-18.2	2.2-3.5	15.0	795-1200	0.50-0.75	0.02	0.05-0.07
Corn cobs	16.5	1.0-3.0	6.0-7.0	1100	0.40-0.90	0.03	0.02
Corn stalks	16.6-.17.5	11.0-17.0	15.0-18.0	1250	0.70-0.90	0.08-0.10	n.a.
Cereal spilling	16.5	9.8-10.0	10.0-12.0	1055	1.20-1.70	0.20	0.16-0.3
Hay	18.3	5.5	15.0	820-1150	1.60	0.04	0.09
Rape straw	18.5	3.4	15.0-25.0	n.a.	1.48	0.20	n.a.
Rape press cake	20.8	6.5	9.0	860-1115	5.39	0.36	0.01
Grape marc	18.4-20.8	3.5-11.0	50.0-60.0	1300	1.80-2.20	0.09-0.13	0.02-0.03
Olive residue	17.9-18.3	9.0-12.0	35.0-45.0	1310	2.50	0.15	0.06
Olive stones	16.0-19.0	<1	10.0-12.0	n.a.	<0.01	n.a.	n.a.
Almond shells	17.9-18.6	9.0-12.0	35.0-45.0	1395	0.45-2.50	0.09-0.15	0.02-0.06
Shea waste	18.5[1]	6.0[1]	13.0[1]	n.a.	2.60[1]	0.30[1]	0.10[1]
Carragenan waste	16.6[1]	10.0[1]	80.0[1]	n.a.	0.30[1]	0.70[1]	0.30[1]
Mash from breweries	20.0	4.0	80.0	n.a.	3.30	0.20	0.00
Digestate	15.4	16.5	15.0-20.0	n.a.	2.20	0.60	0.56
Peat	16.5	4.0	10.0-17.0	n.a.	1.20	0.12	0.03

[1] Single value; db…dry basis; n.a….not available

Table 7: Main ash forming elements in mg/kg (dry basis)

Kind of biomass	Al	Ca	Fe	K	Mg	Na	Si	Ti
Miscanthus	79[1]	1600-1790	92-120	3410-7200	300-600	31.5[1]	3930[1]	4-40
Reed canary grass	200-600	900-2000	13849	2300-4330	600-730	200-350	22280-22800	360
Hemp	111	13400	120	15400	2000	130	2100	0
Straw	60-130	2950-3300	120	7120-10000	630-1030	100-120	9000-19300	0
Vine pruning	140-774	4240-10900	390-625	2940-7660	820-840	180-415	4500-5350	64-66
Corn cobs	60[1]	400[1]	70[1]	8500[1]	290[1]	<50[1]	1100[1]	250[1]
Corn stalks	140	7390	680	8190	500	800	14200	70
Cereal spilling	700	2050-5000	500	5380-1340	1170-1400	300	26100	10
Hay	200	5600	60	14000	1740	1000	15000	0
Rape straw	n.a.	n.a.	n.a.	5800[1]	n.a.	170[1]	n.a.	n.a.
Rape press cake	13	3640-6500	0	8890-14100	220-4700	68	750	0
Grape marc	1330	200-6460	1140	7710-18160	60-1100	50-400	720-5260	90
Olive residue	868	7390	670	17000	353-500	46-500	2270-16620	11-80
Olive stones	410-1210	2640-7110	240-800	2550-19340	860	550	6240	90
Almond shells	293[1]	4650[1]	227[1]	7870[1]	687[1]	642[1]	2290[1]	25.7
Shea waste	710[1]	3020[1]	570[1]	38100[1]	3200[1]	100[1]	4630[1]	50000[1]
Carragenan waste	1140[1]	19940[1]	440[1]	4710[1]	4000[1]	1700[1]	5470[1]	110000[1]
Mash from breweries	20-100	4600-5530	440[1]	700-1340	2500-4780	200[1]	830-15990	0
Digestate	1940-5300	5800-28900	200-3600	3540-15000	1140-3000	3000-6550	7200-30600	1970
Peat	8000	4600	n.a.	8000-58000	1200	7000-22000	7900	0

[1] Single value; n.a….not available

Table 8: Heavy metals in mg/kg (dry basis)

Kind of biomass	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Miscanthus	<0.17	0.03-0.09	0.81-6.85	1.4-2.0	<0.03	2.0-3.3	0.16-0.95	1.0-25.5
Reed canary grass	2.10	0.30	3.40	9.1	0.03-0.10	1.0	0.10	11.7[1]
Hemp	0.86	0.11	1.21	4.9	0.03	n.a.	n.a.	2.5
Straw	0.31	0.17	6.56	2.1	0.02	2.2	0.18	1.4
Vine pruning	0.30-0.67	0.05-0.20	0.70-6.80	6.2-28.0	0.10	1.1-1.5	1.90[1]	n.a.
Corn cobs	n.a.	<1[1]	4.00[1]	<4[1]	n.a.	2.0[1]	<1[1]	11.0[1]
Corn stalks	n.a.	0.80	8.00	10.0	0.1	3.3	n.a.	n.a.
Cereal spilling	0.10	0.10	4.60	2.2	0.02	7.0	0.00	1.7
Hay	5.40	0.90	6.40	6.2	0.20	1.2	2.00	6
Rape straw	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Rape press cake	0.50	0.40	3.80	4.5	0.03	0.7	0.34	6.4
Grape marc	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Olive residue	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Olive stones	0.09[1]	0.12[1]	7.70[1]	3.9[1]	0[1]	3.7[1].	1.30[1]	5.8[1]
Almond shells	0.20[1]	0.02[1]	7.17[1]	4.5[1]	0.01[1]	3.9[1]	1.18[1]	9.71[1]
Shea waste	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Carragenan waste	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Mash from breweries	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.06	n.a.
Digestate	<0.70	0.22-1.10	15.00-17.35	38.5	0.05	n.a.	0.04	n.a.
Peat	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

[1] Single value; n.a….not available

3.1.3 Improvement of fuel properties

Preconditioning and compacting is applied to improve the characteristics of the fuel both during transport and storage but as well the combustion behaviour. The main influences of the fuel properties on the combustion process are displayed in Figure 3.

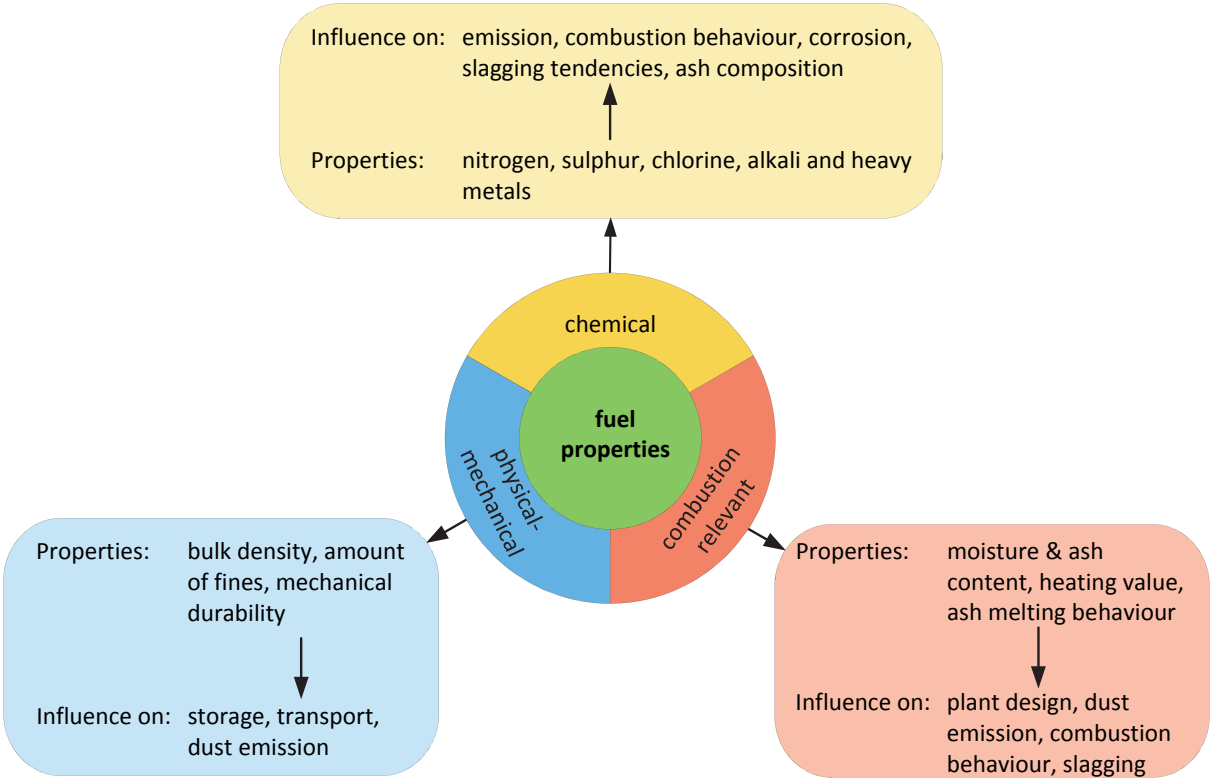


Figure 3: Impact of fuel properties on the combustion process

Primary emission reduction measures aim to prevent or reduce the formation of emissions, slagging tendencies and corrosion. The most important issue is the limitation of critical elements. Using mixtures of different raw materials is one possibility to achieve the required fuel properties, e.g. of product standard EN 14961-6. The mixing ratio often depends on the availability and price of the raw materials. You have to keep in mind that:

1 Good mixing of the component fuels is very important in order to ensure, for example:
   - a stable combustion
   - avoidance of local sintering
   - adjustment of fuel properties resulting from the combination of different raw materials.
2 Raw materials that differ widely in particle size/form may require special treatment, such as milling or separate raw material feeding systems.
3 Wide differences in moisture content between the fuels may require special fuel feed arrangements.

Furthermore, the chemical composition of the used raw materials is of great relevance. As a general rule:

4 Fuels with high sulphur content, such as peat can improve the properties of fuels with high alkali contents.
5 Fuels with high ash melting points can improve the properties of agricultural fuels such as straw and grain screenings with low ash melting points.

A very low proportion (< 2–3 wt.-%) of a "difficult" fuel added to a fuel mix that performs well does not normally cause problems. In some cases leaching, ideally by exposing the raw material to the weather for some time, can significantly reduce the content of critical component. Table 9 gives an overview about guiding values and guiding ranges for elements in biomass fuels and biomass ashes for unproblematic thermal utilisation that can be used as a basis for adjusting the right fuel mixtures. Biomass fuels within the given guiding concentration ranges can be used in modern combustion plants without problems. For fuels with compositions outside the given ranges, additional technological requirements should be considered with regard to national emission thresholds.

Table 9: Guiding values and guiding ranges for elements in biomass fuels and ashes for unproblematic thermal utilisation (according to "The Handbook of Biomass Combustion and Co-firing", van Loo, 2007)

Critical element	Limiting concentration in the fuel, wt.-% (d.b.)	Limiting parameter	Raw materials that repeatedly break the limit	Technological measures to reduce critical impacts
N	< 0.6	NO_x emissions	Straw, cereals, grass, olive residues	Primary measures (air staging, reduction zone)
	< 2.5	NO_x emissions	Waste wood, fibre boards	Secondary measures (SNCR or SCR process)
Cl	< 0.1	Corrosion	Straw, cereals, grass, waste wood, olive residues	fuel leaching, automatic heat exchanger cleaning, coating of boiler tubes, appropriate material selection
	<0.1	HCl emissions	Straw, cereals, grass, waste wood	dry sorption, scrubbers, fuel leaching
	< 0.3	PCDD/F emissions	Straw, cereals, waste wood	sorption with activated carbon
S	< 0.1	Corrosion	Straw, cereals, grass, olive residues	See Cl / Corrosion
	< 0.2	SO_2 emissions	Grass, hay, waste wood	See Cl / HCl emissions
K	< 7.0 [1)]	Ash-melting point, depositions, corrosion	Straw, cereals, grass, olive residues	Against corrosion: see Cl / Corrosion
	–	Dust emission	Straw, cereals, grass, olive residues	Efficient dust precipitation, fuel leaching

[1)] of the ash; SCR…Selective catalytic reduction; SNCR…Selective non-catalytic reduction; d.b.… dry basis

3.1.4 Key actors list

Fuel suppliers and producers

Company	Address	Website	Raw materials	Capacity (t/a)		
				S	M	L
GERMANY						
Pusch AG	Auf der Weid 1-15 56242 Marien-rachdorf	www.agrarstick.de	wood, straw, hay, Miscanthus, digestates, grape marc and mixtures	-	x	-
ABW UG Apoldaer Biomassewerk	Sulzaer Str. 96 99510 Apolda	Not available	Wood, straw, rape press cake, soy bean press cake, hay, Miscanthus, additives and mixtures	-	x	-
Kaliro GbR	Hengemühlweg 204 48432 Rheine	www.kaliro.de	Straw, wood	-	x	-
Lange & Meyer GbR	Wechold 33 27318 Hilger-missen	www.strohpellets.de	Straw	-	x	-
Agrarhandel B+B Müller	Dietinger-strasse 31 78661 Dietingen-Böhringen	www.agrarhandel-mueller.de	Straw, hay	x	-	-
BauerPower	Brunnenstraße 13 65428 Rüssels-heim-Bauschheim	www.energievom land.de	Straw, digestate, Miscanthus	x	-	-
Futtermittel- und Dienst-leistungs GmbH Sonnewalde	Sonnewalder Str. 03249 Goßmar	www.futtermittel-gmbh.de	Straw, additives pellets	-	-	x
Nawaros-Hof Herrmann GmbH	Würzburger Straße 82 97854 Steinfeld	www.nawaros-hof.de	Straw, hay	-	x	-
PLANTAQENZ AG	Lübecker Str. 15 23623 Ahrensbök	www.plantaqenz.de	Straw, digestate, horse manure pellets	-	x	-
AV Handels GmbH	Lohwiesenweg 1 73527 Schwäbisch Gmünd	www.av-biobrennstoffe.de	Wood, straw pellets and briquettes	-	x	-

S… Small < 5,000 t/a; M… Medium < 20,000 t/a; L… Large >20,000 t/a

Company	Address	Website	Raw materials	Capacity (t/a)		
				S	M	L
FINLAND						
Vapo Oy	Yrjönkatu 42, 40100 Jyväskylä	www.vapo.fi	Wood and peat	-	-	x
Biobotnia Oy	Ilveksentie 136, 61760 ILVESJOKI	www.biobotnia.fi	Alternative and mixed biomass	x	-	-
Jalasjärven Lämpö Oy	Lähdetie 2, 61600 JALASJÄRVI	Not available	Wood and straw	x	-	-
PRM-Briketöinti Oy	Reisjärventie 2330 44800 Muurasjärvi	Not available	Alternative and mixed biomass, wood	x	-	-
Leijonapelletti Oy	Vastustie YTJ 31300 TAMMELA	Not available	Alternative and mixed biomass, wood	-	x	-
DENMARK						
Vattenfall A/S	Støberigade 14, 2450 København	www.vattenfall.dk	Straw and wood	-	-	x
DLG	Axelborg Vesterbrogade 4 A 1620 København V	www.dlg.dk	Alternative biomasses	-	-	x
Hjaltelin Agro	Caspar Müllers Gade 32 6000 Kolding	www.hjaltelin.dk	Alternative biomasses	not available		
Verdo	Agerskellet 7 8920 Randers NV	www.verdo.dk	Wood and alternative biomasses	-	-	x
Dangrønt	Industrivej 13 870 Ølgod	www.dangroent.dk	Hay and straw	not available		
ITALY						
Roana Cereali	Via Mario Malfatto 46/a 45010 S.Apollinare	www.roanacereali.com	wood and maize	x	-	-
Produttori Sementi Verona srl	Via Strà 177 37030 Colognola ai Colli	www.produttoripellet.com	Grape marc, vine prunings	x	-	-
Italiana Pellets	Via Cascina Nuova 27050 Corana	www.italianapellets.com	wood	-	-	x
Bagioni Group	Via Serachiedsa 1/C 47122 Forlì	www.gruppobagioni.com	Herbaceous biomass, alfalfa, maize, straw	not available		

S… Small < 5,000 t/a; M… Medium < 20,000 t/a; L… Large >20,000 t/a; n.a….not available

Company	Address	Website	Raw materials	Capacity (t/a)		
				S	M	L
SWEDEN						
Bioenergi i Luleå	Uddebovägen 5 973 23 Luleå	www.bioenergi lulea.se	Wood and peat	-	-	x
Härjedalen Miljöbränsle AB	Södra Hantverksgatan 4 842 31 Sveg	www.hmab.se	Wood and peat	-	-	x
Glommers Miljöenergi	Storgatan 1 930 81 Glommersträsk	www.gmepellets.se	Reed canary grass, wood	x	-	-
Kastebergs Gård	Ösślöv Kasteberg 2, Ljungby	www.kasteberg. com	Wood, straw	x	-	-
Skånefrö AB	Storgatan 1 272 93 Tommarp	www.skanefro.se	Agricultural restproducts, wood	x	-	-
Neova AB	Box 1143 824 13 Hudiksvall	www.neova.se	Wood and peat	-	-	x
Låttra Gård Bioprodukter KB	Låttra Gård 1, 643 93 Vingåker	www.lattra briketten.com	Reed canary grass	x	-	-
SPAIN						
COVAERSA ENERGÍAS	Cuesta Las Piedras 03330 Crevillent	www.briquetas briec.com	Almond shells	-	x	-
AGROFERESTAL NAVA	SL Vegalloba s/n 33520 Nava	www.agroforestalnava.es	wood	-	-	x
ENERPELLET	Larrauri 1 48160 Derio	www.enerpellet. com	wood	not available		
PELLET Asturias	Industrial Park La Curiscada 33877 Tineo	www.pellets asturias.com	wood	-	-	x
AMATEX	Polígono Industrial "La Nava" N-234. 42146. Cabrejas del Pinar SORIA	www.amatex.es	Wood, straw	-	-	x
Orientación sur SL	Av. 1º de Julio, 70 - Local 4 13300 Ciudad Real	www.orientacion sur.es	Vine pruning	-	x	-
NATURFOC	Pol. Ind. La Cava C/ Alfarrasí nº6 46892 - Montaverner	www.naturfoc.com	Wood, prunings	not available		

S… Small < 5,000 t/a; M… Medium < 20,000 t/a; L… Large >20,000 t/a; n.a….not available

Company	Address	Website	Raw materials	Capacity (t/a)		
				S	M	L
AUSTRIA						
FEX ÖKO-Faserverarbeitungs GmbH	Dobermanns-dorferstraße 1 2183 Neusiedl/ Zaya	www.fex.at	Straw	-	x	-
Martin Zimmermann	Bahnstrasse 32 2130 Mistelbach	www.agrar-energie.at	Miscanthus	x	-	-
ADF Miscanthus	Hausleiten 4 3321 Stephanshart	www.adf-miscanthus.at	Miscanthus	x	-	-

S… Small < 5,000 t/a; M… Medium < 20,000 t/a; L… Large >20,000 t/a

3.2 Legal conditions

During the planning of your project you will have to consider the legal conditions at several points. There may be regulations on licensed fuels and waste regulation applying for biogenic residues that could limit the types of raw material usable for energy purposes. Complying with emission thresholds will be an issue to get regulatory approval. Clearly, emission thresholds are more easily to comply with for industrial scale applications for which appropriated flue gas cleaning system are commonly available. However, for small and medium scale applications the situation is different. Though there are a few systems available, an adaption for specific fuels is often required and the additional investments are a more severe drawback for small and medium scale systems.

Unfortunately, uniform European-wide regulations are not yet available neither for alternative and mixed biomass fuels nor for the appropriate combustion units in small and medium scale. Therefore, in many cases you have to find individual solutions with local authorities. Though there are some positive developments (adaption of EN 303-5, product standard EN 14961-6) the situation is still unsatisfying. Similarly, a labelling and certification system especially for small combustion units would help to enhance the utilisation of alternative and mixed biomass pellets. Below, you can find exemplary information on licensed fuels, emission thresholds and fuel standardisation for the seven MixBioPells partner countries.

3.2.1 Licensed fuels

Licensed fuels differ significantly within the partner countries. Possible solid biofuels that can be used for combustion purposes are listed in Table 10. In Austria only standardised alternative and mixed biomass fuels can be used in private, public and industrial sectors. The Scandinavian partner countries Finland and Sweden both have no general guidelines for licenced fuels. Accordingly, there is a tendency to focus on established fuels. In Denmark a specific list with all licensed fuels are included in Danish Act no. 638 on biomass waste. The listed fuels can be used for combustion purposes. In Italy and Spain, only a common definition of biomass exists. However, there is no regulation for the use of biomass for combustion purposes applied.

Table 10: Solid biofuels for combustion purposes

Country	Licensed fuels
Austria	Private sector (valid only in Lower Austria): • > 400 kW: no general legislative framework – individual permission by local authorities • < 400 kW: · in Lower Austria: standardised non-wood biomass up to a Cl-content of 1500 mg/kg (so far standards are available for straw, Miscanthus and energy grain) · Other federal states: no general legislative framework – individual permission by local authorities required Public/industrial sector: • Standardised fuels made of other solid and herbal raw materials from forestry and agriculture such as cereal whole plant, grasses and Miscanthus
Denmark	According to the Danish Act no. 638 on biomass waste: • raw wood, straw, kernels and seeds from fruits, fruit residues, nut and seed shells, untreated cork, grain and seeds, malt, tobacco waste • fuel pellets or fuel briquettes produced exclusively from these raw materials
Finland	No general guideline: • common solid biofuels are wood logs, wood chips and wood pellets • non-woody must be handled individually by the authority as a “special fuel”
Germany	According to Federal Immission Control Regulation No. 4 (> 100 kW): • Straw and other herbal raw materials (e.g. cereal whole plant, grasses, Miscanthus) According to Federal Immission Control Regulation No. 1 (< 100 kW): • straw, whole plants (also pellets), grains (also pellets), energy grain processing residues, husks, culms residues and similar herbaceous biomass substances (like Miscanthus or hay)” • other renewable sources
Italy	According to the environment protection act (D.lgs 152/2006): • biomass is considered as a fuel only if it has not been submitted to any chemical treatment According to legislation on renewable energy promotion (implementation decree of Directive 2009/28): • any biogenic matter, regardless its origin or quality (any biomass from agriculture, forestry or agro-industry, which has been submitted only to a mechanical treatment, can be considered as a fuel)
Spain	According to the “Plan de Energías Renovables”: • biomass from forests, woody agricultural residues (pruning of olive trees, fruit trees and vineyards), • grass agricultural residues (mainly straw and corn maize stover), • residues from agricultural industries (olive stones, almond shells,…), • energy crops (mainly cardoon, sorghum and Ethiopian Canola)
Sweden	No general guideline: • Solid fuels are divided in groups with respect to their origin: forest fuels, peat, agricultural fuels, fuels derived from waste etc.

3.2.2 Emission thresholds

Within the partner countries the threshold values vary significantly in the range from non-existing till highly regulated with low thresholds. In Figure 4 the threshold values of each country are classified as strict, loose and no regulation of threshold values. According to Figure 4 there are significant differences of the legal conditions for different thermal ranges and different countries. Emissions of carbon monoxide (CO), nitrogen oxides (NO_x) and particles are commonly limited in medium and industrial scale combustion plants. Emission threshold values for small scale combustion plants up to 100 kW mainly exist in Germany and Austria. In contrast, emission threshold values of hydrogen chloride and dioxins/furanes exist only in Germany. If there are no regulations in the respective thermal range existing, legal authorities will set the permission and the threshold values at their sole discretion. Finland and Sweden have relatively low emission thresholds particularly for small and medium scale. However, based on the experience with alternative raw material combustion, only selected raw materials are actually used in these countries. Restrictions are rather set at the bottom end (raw material quality) than at the top end (flue gas emission thresholds). The classification of the threshold values indicates whether the use of alternative biomass pellets can be problematic (“strict thresholds”) or in some cases problematic (“loose thresholds”). However, the realisation strongly depends on available combustion and flue gas cleaning systems and the properties of the used fuel. Clearly, emission thresholds are more easily complied with for industrial scale applications for which appropriated flue gas cleaning system are commonly available. However, for small and medium scale applications the situation is different. Though there are a few systems available an adaption for specific fuels is often required and the additional investments are more severe drawback for small and medium scale systems.

If the European Union’s Framework Directive on Eco-Design of Energy-Using Products (Directive 2009/125/EC) is coming into force most national frameworks will be adjusted.

Country	Capacity	CO	OGC	NO_x	SO_2	HCl	Particles	Dioxine/ Furanes
Austria[1] private sector	< 100kW	loose	loose	strict	none	none	loose	none
	100kW - 1MW							
	> 1MW	none	none	none			none	
Austria public and industrial sector	< 100kW[2]	loose	loose	loose	loose	strict	loose	none
	100kW - 1MW[3]		strict					
	> 1MW							
Denmark	< 100kW	none	none	none	none	none	none	none
	100kW - 1MW	loose					loose	
	> 1MW	strict		strict	loose		strict	
Finland	< 100kW	none	none	none	none	none	none	none
	100kW - 1MW							
	> 1MW						loose	
Germany	< 100kW	loose	none	loose	none	none	loose	strict
	100kW - 1MW	strict	strict		loose	strict	strict	
	> 1MW							
Italy	< 100kW[4]	none	none	none	none	none	loose	none
	100kW - 1MW[5]	strict		loose	strict			
	> 1MW[6]		strict				strict	
Sweden	< 100kW[7]	none	loose	none	none	none	none	none
	100kW - 1MW[8]			strict			loose	
	> 1MW		none		strict			
Spain	< 100kW	none	none	none	none	none	none	none
	100kW - 1MW							
	> 1MW							
		mg/Nm³	mg/Nm³	mg/Nm³	mg/Nm³	mg/Nm³	mg/Nm³	ng/Nm³
	strict	<500	<30	<300	<250	<50	<50	<0.1
	loose	<1000	<125	<600	<400	<100	<300	<0.5
	none	-	-	-	-	-	-	-

[1] Threshold values valid in Lower Austria up to 400 kW
[2] Threshold values valid for <400 kW
[3] Threshold values valid for 0.4-1 MW
[4] Threshold values valid for 35-150 kW
[5] Threshold values valid for 0.15-3 MW
[6] Threshold values valid for >3 MW
[7] Threshold values valid up to 300 kW
[8] Threshold values valid for 0.3-1 MW

Figure 4: Classification of existing emission threshold values for the use of non woody biomass up to 50 MW in different European countries (based on 13 Vol.-% O_2)

3.2.3 Product standards

Generally, national quality standards for alternative and mixed biomass pellets or briquettes are not available in the European countries. The European standard EN 14961-6 is or will be included in the national legal frameworks, see Table 11. In Austria, several additional product standards exists which include general requirements on solid biofuels like specification of origin and sources of the raw material and several classes for parameters relevant for the use in small and medium scale applications. The standard ÖNORM M 7139 covers the requirements for energy crops when used for energy purposes and is considered a supplement of the pre-standard VORNORM ÖNORM CEN/ TS 14961. The standard ÖNORM C 4000 cover the requirements for Miscanthus pellets and briquettes and the standard ÖNORM C 4002 covers the requirements for straw pellets. These standards are considered national supplements of the standards ÖNORM 14961 and ÖNORM 15234. Available European standards according to EN 14961 will be included subsequently on national level. Thus, supplements of the EN 14961 are planned: C 4003 and C 4004 (corn cob chips and pellets). Important fuels properties are summarised in Table 11.

Pellets according to EU-standards will probably be more expensive due to certification procedures and possibly higher pre-treatment efforts as well as a more demanding pelletizing process to ensure constant quality and fulfilment of the requirements of the standard. However, these pellets are then applicable for certified combustion appliances that do not require special adaption to the fuel requirements. Thus, overall economics could be still favourable despite the higher fuel costs. In contrast, regional available alternative and mixed biomass pellets could be produced without fulfilling EU-standards. These pellets would be less expensive. However, available combustion technology would have to be adapted to the requirements of the local fuels. This strategy would be particularly suitable on regional level with local contracts for a local fuel. Thus, fuel characteristic would be though critical fairly constant. Thus, the additional costs for adapting the combustion technology could still pay off. Finally, the availability of raw materials for different capacity ranges has been evaluated. This has been realised according to the EN 14961-6. Thus, for small and medium scale utilisation only those raw materials that fulfil the requirements of EN 14961-6: Miscanthus, EN 14961-6: straw and EN 14961-6: reed canary grass well as EN 14961-6: class A should be used (see Table 12). Raw materials that fulfil the requirements of EN 14961-6: class B can be used for medium scale. For industrial scale applications those raw materials with even more critical characteristics should be applied.

Table 11: Requirements of the European product standard EN14961-6

Parameter	Unit	Straw pellets	Miscanthus pellets	Reed canary grass pellets	class A	class B
					Herbaceous biomass, fruit biomass, blends and mixtures	
Diameter	mm	6 to 25	6 to 25	6 to 25	6 to 25	6 to 25
Length	mm	3.15 ≤ L ≤ 50	3.15 ≤ L ≤ 50	3.15 ≤ L ≤ 50	3,15 ≤ L ≤ 50	3.15 ≤ L ≤ 50
Amount of fines	wt.-%	≤ 1	≤ 1	≤ 1	≤ 2	≤ 3
Mechanical durability	wt.-%	≥ 97.5	≥ 97.5	≥ 96.5	≥ 97.5	≥ 96.0
Bulk density	kg/m³	≥ 600	≥ 580	≥ 550	≥ 600	≥ 600
Moisture content	wt.-%	≤ 10	≤ 10	≤ 12	≤ 12	≤ 15
Ash content (550 °C)	wt.-%$_{db}$	≤ 6	≤ 4 / ≤ 6	≤ 8 / > 8	≤ 5	≤ 10
Lower heating value	MJ/kg	Minimum value to be stated	Minimum value to be stated	≥ 14.5	≥ 14.1	≥ 13.2
Ash melting temperature	°C	should be stated	should be stated	should be stated	should be stated	should be stated
Additives	-	Type and amount to be stated	Type and amount to be stated	Type and amount to be stated	Type and amount to be stated	Type and amount to be stated
Nitrogen	wt.-%$_{db}$	≤ 0.7	≤ 0.5	≤ 2.0	≤ 1.5	≤ 2.0
Sulphur	wt.-%$_{db}$	≤ 0.1	≤ 0.05	≤ 0.2	≤ 0.2	≤ 0.2
Chlorine	wt.-%$_{db}$	≤ 0.1	≤ 0.08	≤ 0.1	≤ 0.2	≤ 0.2
Arsenic	mg/kg$_{db}$	≤ 1	≤ 1	≤ 1	≤ 1	≤ 1
Cadmium	mg/kg$_{db}$	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5
Chromium	mg/kg$_{db}$	≤ 50	≤ 50	≤ 50	≤ 50	≤ 50
Copper	mg/kg$_{db}$	≤ 20	≤ 20	≤ 20	≤ 20	≤ 20
Lead	mg/kg$_{db}$	≤ 10	≤ 10	≤ 10	≤ 10	≤ 10
Mercury	mg/kg$_{db}$	≤ 0.1	≤ 0.1	≤ 0.1	≤ 0.1	≤ 0.1
Nickel	mg/kg$_{db}$	≤ 10	≤ 10	≤ 10	≤ 10	≤ 10
Zinc	mg/kg$_{db}$	≤ 100	≤ 100	≤ 100	≤ 100	≤ 100

d.b. … dry basis

Table 12: Comparison of the fuel characteristics of the most relevant raw materials with the thresholds given in EN14961-6 (A – requirements for ash content according to EN14961-6: Miscanthus A < 4 wt.-% d.b.; Straw A < 6 wt.-% d.b.; RCG A < 8 wt.-% d.b.)

Raw material	EN14961-6: Miscanthus				EN14961-6: Straw				EN14961-6: RCG			
	A	N	S	Cl	A	N	S	Cl	A	N	S	Cl
Miscanthus												
Reed canary grass												
Hemp												
Straw												
Vine pruning												
Corn cobs												
Corn stalks												
Cereal spilling												
Hay												
Rape press cake												
Grape marc												
Olive residue												
Almond shells												
Shea waste												
Carragenan waste												
Mash from breweries												
Digestate												
Peat												

requirements of the EN14961-6 can be fulfilled

requirements of the EN14961-6 can be fulfilled in some cases

requirements of the EN14961-6 can be not fulfilled

d.b. … dry basis

Table 12: (continued) Comparison of the fuel characteristics of the most relevant raw materials with the thresholds given in EN14961-6 (A – requirement for ash content according to EN14961-6: class A - A < 5 wt.-% d.b.; class B - A < 10 wt.-% d.b.)

Raw material	EN14961-6: class A				EN14961-6: class B			
	A	N	S	Cl	A	N	S	Cl
Miscanthus								
Reed canary grass								
Hemp								
Straw								
Vine pruning								
Corn cobs								
Corn stalks								
Cereal spilling								
Hay								
Rape press cake								
Grape marc								
Olive residue								
Almond shells								
Shea waste								
Carragenan waste								
Mash from breweries								
Digestate								
Peat								

requirements of the EN14961-6 can be fulfilled

requirements of the EN14961-6 can be fulfilled in some cases

requirements of the EN14961-6 can be not fulfilled

d.b. … dry basis

3.3 Pelletizing and combustion technologies

The characteristics of alternative biomasses differ from woody biomasses. Thus, you will find that the available technology for wood harvest, milling, compacting, handling and combustion is not well suited for alternative raw materials. Instead, special or adapted technology might be required. In some case, know-how from related utilisation paths can be used as basis (e.g. straw and hay pelletizing for forage or litter). However, critical fuel parameters and especially strongly varying fuel characteristic within a single biomass type afford special care and experience that is rarely available. Below, you will find specific information on aspects of the pelletizing, combustion and flue gas cleaning technologies. More detailed information on these topics can be found in the MixBioPells Report on Pelletizing and Combustion Technologies. At the end of the chapter, key actors lists for manufacturers of pelletizing, combustion and flue gas cleaning technologies are provided. If you need information beyond what is given below on the pelletizing and combustion behaviour of alternative raw material a good source are national research institutions with focus on biomass research.

3.3.1 Pelletizing technologies

You will find that alternative raw materials have several properties that could be problematic for their handling (Table 13).

Table 13: Properties of alternative raw materials and resulting problems

Property	**Problems that might result from the property**
higher ash content	• abrasion during the pelletizing process • reduced lifetime of the dies
structural properties (e.g. stalks)	• problems with the feeding system (e.g. blocking)
hardness of the material	• higher energy demand and wear during cutting and milling
different molecular composition	• different compacting properties requiring different dies
varying fuel characteristics and inhomogenous structural features	• handling of these variations requires experience that is rarely available
low energy density	• higher storage and transportation effort

A good possibility to generate a solid biofuel with improved and defined transportation, storage and feeding properties is the agglomeration into pellets or briquettes. Binders can be used to reduce abrasion of dies and to lower the energy consumption during the compacting process. The main advantages of the compacted fuels are summarised in Table 14.

Table 14: Main advantages of the compacted fuels

Quality achieved by pelletizing of the raw materials	**Impact**
flowability	• fully automated feeding of the combustion system is possible
increased bulk density	• less storage space required • improved transportation quality
reduced fines	• reduced risk of solidification by bridging • lower dust explosion risk during transport and supply
fixed mixture	• prevention of separation in heterogeneous raw material mixtures • improved combustion properties

There are two different pelletizing technologies which are most commonly used for alternative raw materials:

- Pellet mills with flat dies: This technology is common for the production of animal feed pellets.
- Pellet mills with ring dies: This technology is mainly used for the industrial production of wood pellets.

More information on preconditioning and pellet production technologies available within the seven European partner countries of the MixBioPells project is available in the Report “Critical Review on Pelletizing and Combustion Technologies”.

3.3.2 Combustion technologies

You will find that the combustion of alternative and mixed biomass pellets can be more challenging than the combustion of wood pellets and possible problems have to be considered. The reasons for this can be found in the composition of alternative raw materials that is significantly different from woody biomass. The main fields of problems for the combustion of alternative and mixed biomass fuels are summarised in Table 15.

Table 15: Main fields of problems for the combustion of alternative and mixed biomass fuels

Property	**Problems that might result from the property**
higher ash content	• problems with ash removal
varying fuel characteristics	• handling of these variations requires experience that is rarely available
higher content of critical elements (e.g. N, S, Cl, K, Na, Si)	• possibly higher emission of harmful gaseous components (e.g. HCl, SO_2, NO_x) and particulate • higher risk of fouling and corrosion on downstream tubes and surfaces • lower ash melting point with increased slagging risk

These problems can be lowered by primary and secondary measures. Reduction of harmful emissions can be obtained by either avoiding creation of such substances (primary measures) or removing the substances from the flue gas (secondary measures).

Primary measures:

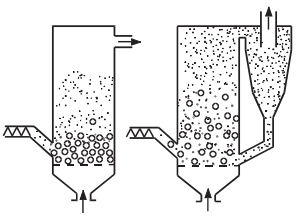
- modification of the fuel (leaching of the raw materials, blending of difficult raw materials with additives or less problematic raw materials) which can also enhance the ash related characteristics
- modification of the combustion process (flue gas recirculation to achieve reducing atmosphere and lower temperature, cooled grates to reduce slagging, automated cleaning and ash removal to prevent slagging and fouling)

Secondary measure:

- flue gas cleaning (see chapter 3.3.3).

Depending on your aspired capacity range you may employ one of the following different combustion systems (Table 16).

Table 16: Combustion systems

Combustion system	**Thermal range**	**Picture**
Horizontal stoker burner	20 kW – 1 MW	
Moving grate combustion system	30 kW – 10 MW	
Water cooled combustion chamber with ash stoker	50 – 800 kW	
Underfeed rotating grate combustion systems	3 – 20 MW	Not available
Fluidised bed firing (a) bubbling fluidised bed with lower gas flow and a defined boundary between the bed and the free board or (b) circulating fluidised bed with higher gas flow and a blurred boundary between the bed and the free board.	(a) 5 – 15 MW (b) 15 – > 100 MW	

More information on combustion technologies including technology profiles of specific combustion systems available within the seven European partner countries of the MixBioPells project are available in the Report on Pelletizing and Combustion Technologies.

3.3.3 Flue gas cleaning technologies

Depending on the emission thresholds secondary measures for the reduction of NO_x, SO_2 or dust may be required. Most of the available flue gas cleaning technologies contributes also to the reduction of HCl, heavy metals and PCDD/F emissions. In principle, secondary emission reduction measures are known and are available for all harmful emission components. However, particularly on small scale their utilisation is rarely cost effective. The possibilities to build-up viable combustion systems with advanced flue gas cleaning increase with the size of the biomass combustion applications.

Small and medium scale applications

If you plan to use alternative and mixed biomass pellets for small and medium scale combustion, then reduction of small particle emission will probably be most critical. There are two different approaches for the reduction of particulate emissions:

- Many boiler manufacturers focus their developments on the optimisation of the combustion chamber as well as the fuel and air supply.
- Another possibility is the use of precipitator technology.

The development of appropriate precipitator technologies is still subject of several on-going research activities. Even for wood stoves and boilers there are only few precipitators available at the market. At the moment, electrostatic precipitators are most common. However, most of the available systems have significantly lower separation efficiencies compared to the industrial applications. So far, filter precipitators are not offered for heating appliances < 100 kW. Some of the precipitator technologies are tested for the use of non-woody and mixed biomass and were adapted to some extend for higher dust concentrations and varying dust characteristics. The selection of the appropriated precipitator technology strongly depends on the characteristics of the particles. You can find a very detailed discussion on this topic including technology profiles of different precipitator technologies in the Report on Pelletizing and Combustion Technologies of the MixBioPells project. The high specific investment and operation costs prevent the widespread usage of technology and cause a low demand.

Industrial scale applications

Emission reduction measures particularly for the removal of particles, NO_x and SO_2 are state of the art for industrial combustion systems. Other components that can also be reduced by secondary measures are HCl, heavy metals and PCDD/F. However, secondary emission reduction measures for these components will not be presented in detail because the solutions are made individually for each plant. Furthermore, information and data about construction, operation and characteristics of the mentioned secondary measures are scarcely available. A list of manufacturers and contact details is included in the following chapter.

3.3.4 Key actors list

Manufacturers of pelletizing technologies

Company	Address	Website	S	M	L	Raw material	PP	BP
GERMANY								
Amandus Kahl GmbH & Co. KG	Dieselstraße 5 21465 Reinbek	www.akahl.de	1	3	5	saw dust, straw	x	-
MÜNCH-Edelstahl GmbH	Weststraße 26 40721 Hilden	www.muench-gmbh.de	-	3	1	saw dust, straw	x	-
Pusch AG	Auf der Weid 1-15 56242 Marienrachdorf	www.agrarstick.de	-	1	1	straw, wood	x	-
Salmatec	Bahnhofstraße 15A 21376 Salzhausen	www.salmatec.de	n.a.			straw, horse dung, greens	x	-
Jumbo Group	Feldbach 25 86647 Buttenwiesen	www.home pelletierer.de	1	-	-	straw	x	-
EcowroXX	Kreuzkrug 44 31604 Raddestorf	www.eco worxx.de	1	-	-	wood, straw, hay, Miscanthus	x	-
Bauer Power	Brunnenstraße 13 65428 Rüsselsheim	www.energie vomland.de	-	1	-	straw, hay, Miscanthus	x	-
Michael Schmitt	Treppenstrasse 1 66740 Saarlouis	www.schmitt-energie.de	5	1	-	straw, sunflower, spelt	x	-
RUF Maschinenbau GmbH & Co. KG	Hausener Str. 101 86874 Zaisertshofen	www.briket tieren.de	5	3	-	straw, all kinds of fiber materials	-	x
Maschinen-fabrik Köppern GmbH &Co. KG	Königsteiner Str. 2 45529, Hattingen	www.koep pern.de	n.a.			n.a.	-	x
Votecs	Olgastraße 13 74072 Heilbronn	www.votecs.de	n.a.			wood shavings, hay	-	x
ADELMANN Umwelt GmbH	Johann-Schöner-Str.73 97753 Karlstadt	www.adel mann.de	n.a.			straw, wood, Miscanthus	-	x
Wessel GmbH Kessel- und Apparatebau	Hagdornstraße 10 46509 Xanten	www.wessel-xanten.de	n.a.			wood	x	-

S… Small <500 kg/h; M… Medium 500-2000 kg/h; L… Large >2000 kg/h; PP… Pellet press; BP… Briquette press; n.a. … not available

Company	Address	Website	S	M	L	Raw material	PP	BP
GERMANY								
EUROPRESS	von-Arenberg Str.1 49762 Lathen	www.europress-lathen.com	1	-	-	saw dust	-	x
FUCHS-ALMABOIS	Hauptstraße 199 79576 Weil am Rhein	www.fuchs-almabois.com	1	-	-	wood	-	x
GHEbavaria Maschinen GmbH	Gebr.-Hofmann-Ring 4 97246 Eibelstadt	www.ghebavaria.de	n.a.			wood	-	x
Gross Apparatebau GmbH	Salzstraße 96-98 74076 Heilbronn	www.gross-zerkleinerer.de	3	-	-	saw dust, hay	-	x
Höcker Polytechnik GmbH	Borgloher Straße 49176 Hilter	www.hoecker-polytechnik.de	3	-	-	cellulosic material	-	x
Nestro-Lufttechnik GmbH	Odenwaldring 9 63934 Röllbach	www.nestro.de	4	-	-	wood, paper	X	x
Reinbold Entsorgungs-technik GmbH	Gottlieb-Daimler-Straße 13 75050 Gemmingen,	www.reinbold.de	8	-	-	saw dust	-	x
Schuko GmbH	Gewerbepark 2 49196 Bad Laer,	www.schuko.de	6	-	-	saw dust, paper dust	-	x
SPÄNEX GmbH	Otto-Brenner-Straße 6 37170 Uslar	www.spaenex.de	10	-	-	wood, paper, biomass	-	x
TH-Alternativ-Energie	Rothelebuch 3 87637 Seeg/Allgäu	www.th-alternativ-energie.de	1	-	-	wood, straw, hay, Miscanthus	-	x
Weimar Maschinenbau GmbH	Gewerbegebiet Bustadt 74360 Ilsfeld	www.weima.com	n.a.			wood, other biomass	-	x
WINKEL Lufttechnik GmbH	Friedhofstraße 54317 Osburg	www.jkf-industrie.de	4	-	-	wood, other biomass	-	x
AGRIFA GmbH	Oldenburger Straße 107 26316 Varel	www.agrifa.eu	5	-	-	wood, straw etc.	-	x
AUSTRIA								
ANDRITZ AG	Stattegger Strasse 18 8045 Graz	www.andritz.com	1	1	1	n.a.	x	-

S… Small <500 kg/h; M… Medium 500-2000 kg/h; L… Large >2000 kg/h; PP… Pellet press; BP… Briquette press; n.a. … not available

Company	Address	Website	S	M	L	Raw material	PP	BP
AUSTRIA								
Albert Knoblinger GmbH & Co. KG	Oberbrunnerweg 10 4910 Ried im Innkreis	www.knoblinger.at	-	-	1	wood	x	-
NEUHAUSER Fürlinger GmbH	Fasanenweg 4 4616 Weisskirchen	www.neuhauser-pelletstechnik.at	2	3	1	wood	x	-
Brikettier-technik Siegel	Lastenstraße 7 9560 Feldkirchen	www.siegel-mb.at	6	-	-	wood	-	x
Wieder-Maschinenbau GmbH	Steindorf, Gewerbegebiet Süd 7, 5204 Straßwalchen	www.wieder-maschinenbau.at	2	-	-	wood,	-	x
ITALY								
General Dies srl	Marialuisa Meneghello Via Strà 182 37030 Colognola ai Colli	www.generaldies.com	3	5	1	wood, straw, hay, other biomass	x	-
Nova Pellet	Via Brescia,56 - Pontevico	www.novapellet.it	2	1	1	wood	x	-
MakXilia s.r.l.	Via Lungofino 187 - Centro Comm.le Ibisco, Blocco B/1 - Citta' Sant'Angelo (PE)	www.MakXilia.it	3	1		wood, cereals, chicken litter	-	x
O.M.A impianti	Via Ponticelli, 51 - Pieve a Nievole (Pistoia)	www.oma-srl.com	3			wood	-	x
Henergeia Helios	Chislaz (Romania)	www.henergeiahelios.com	2	2	1	wood and agricultural residues	x	-
Larus Impianti s.r.l.	Via dei Cascinotti 7 - Credera (CR)	www.pellet.it	1	1		wood and agricultural residue	X	-
MTD srl	Via Volta, 2 - Settimo di Pescantina (Ve)	www.mtdsrl.it	n.a.			wood	X	-
ASCOT	Via dell'Industria 38 - Marano Vicentino	www.ascot-matic.com	6			cellulistic material	x	-
BS Bollareto impianti	Via dell'Industria 16/14 - PORTO MANTOVANO	www.bsbollaretoimpianti.it	12	2		dry and wet biomass	x	x

S… Small <500 kg/h; M… Medium 500-2000 kg/h; L… Large >2000 kg/h; PP… Pellet press; BP… Briquette press
n.a. … not available

Company	Address	Website	S	M	L	Raw material	PP	BP
ITALY								
Costruzioni Nazzareno	Via delle Industrie, 17 - Vacil di Breda di Piave (TV)	www.nazzareno.it	5	1		wood	x	x
Kemyx	Corso Matteotti, 200 - Montecatini Terme (PT)	www.kemyx.it	n.a.			wood and agricultural residue	x	-
La meccanica di Reffo	via Nicolini,1 – Loc. Facca 35013 – Cittadella (PD)	www.lameccanica.it	1	1	2	wood	x	-
CO.MA.FER	Via de Gasperi, 25060 Collebeato Brescia	www.comafer.it	7				x	x
DI PIÙ	Via dellÌnnovazione, 11, 36042 Breganze	www.di-piu.com	4	7	3	wood, biomass residues	-	x
SWEDEN								
Biopress	Kånnavägen 3B 34131 Ljungby	www.biopress.se	2	1		wood	x	-
Bogma	Box 71 523 22 Ulricehamn	www.bogma.com	6	2		wood, straw, grass	-	x
SPC	Skaraborgsvägen 35E 50630 Borås	www.pelletpress.com	3	2		wood, straw, grass	x	-
FINLAND								
Aimo kortteen Konepaja Oy	Pohjolantie 2 84101 Ylivieska	www.murska.fi	1	-	-	wood, other biomass	x	-
DENMARK								
C.F. Nielsen a/s	Solbjergvej 19, 9574 Baelum	www.cfnielsen.com	2	3	1	wood, straw		x
SPAIN: No manufacturers of pelletizing equipment could be investigated.								

S… Small <500 kg/h; M… Medium 500-2000 kg/h; L… Large >2000 kg/h; PP… Pellet press; BP… Briquette press; n.a. … not available

Manufacturers of combustion technologies

Name	Address	Contact details
AUSTRIA		
ETA Heiztechnik GmbH	Gewerbepark 1 4716 Hofkirchen an der Trattnach	Tel.: +43 (0)7734 2288-0 Fax: +43 (0)7734 2288-22 info@eta.co.at
Fröling	Industriestraße 12 4710 Grieskirchen	Tel. +43 7248 / 606 - 0 Fax:+43 7248 / 606 - 600 info@froeling.com
Hargassner GesmbH .	Anton Hargassnerstr. 1 4952 Weng	Tel: +43 (0)7723 - 5274 Fax: +43 (0)7723 - 52745 office@hargassner.at
KÖB- Viessmann Gruppe	Flotzbachstraße 33 6922 Wolfurt	Tel.: + 43 / 5574 6770-0 Fax: + 43 / 5574 65707 office@kob.cc
KWB - KRAFT UND WÄRME AUS BIOMASSE GMBH	Industriestraße 235 8321 St. Margarethen/Raab	Tel:+43(0)3115 6116-0, Fax + 43(0)3115 6116-4, office@kwb.at
GUNTAMATIC Heiztechnik GmbH	Bruck 7, Bruck-Waasen 4722 Peuerbach	Tel.: +43 (0)7276 / 24 41-0 Fax: +43 (0)7276 / 30 31 info@guntamatic.com
RIKA Innovative Ofentechnik GmbH	Müllerviertel 20 4563 Micheldorf	Tel.: 0043 (0)7582 / 686 - 41 Fax: 0043 (0)7582 / 686 - 43
Polytechnik Luft- und Feuerungstechnik GmbH	Hainfelderstr. 69 2564 Weissenbach (NÖ)	Tel: +43 (0)2672 890-0 Fax:+43 (0)2672 890-DW 13
Biokompakt® Heiztechnik GmbH	Froschau 79 4391 Waldhausen	Tel.: +43 7260 4530 Fax +43 7260 45304 gerlinger@biokompakt.com
ITALY		
Termocabi srl	Giuseppe Corbari Via Borghisani 13 26035 Pieve San Giacomo (CR)	Tel: +39 0372 640033 Fax: +39 0372 640354 termocabi@termocabi.it
KWB Italia srl	Horst Stuffer Via T. Edison 15 39100 Bolzano	Tel: +39 0471 053333 Fax: +39 0471 053334 info@kwbitalia.it
Ecoenergie srl	Matteo Pippa Via Leonardo da Vinci 11 36066 Sandrigo (VI)	Tel: +39 0444 751132 Fax: +39 0444 758386 info@ecoenergie.it
ECOMECC	Luca Canovi Via Palladio 1 37063 Isola della Scala (VR)	Fax: +39 - 0457300175 ecomecc@nuovacft.it

Name	Address	Contact details
SPAIN		
Hargassner Ibérica SL	Ciudad Tecnológica Valnalón C/ Hornos Altos, s/n 33930 - Langreo - Asturias	Tel: 984 28 19 65 Fax: 984 28 16 21 info@hargassner.es www.hargassner.es
INJOCA	Pol. Ind. Los Pozuelos, Parc. 47 23660 Alcaudete (Jaén)	Tel: 953708036 www.injoca.es
RCB	Calle: 32 nº 119 Catarroja, 46470 Valencia	Tel: 961270450 Fax: 961267211 rcbboiler@telefonica.net www.calderasrcb.com
LASIAN Tecnología del Calor, S.L.	Políg. Ind. Las Norias, parcela n.º 7 50450 Muel (Zaragoza)	Tel: 976 140 600 Fax: 976 140 522 info@lasian.es www.lasian.es
ÖKOFEN España	Ingeniería de Energías Renovables S.L. Ctra de Villagarcía Lugar de Cachapal, Campañó 36157 Pontevedra	Tel. +34 986 090 288 Fax. +34 687 822 626 info@emisioncero.es www.emisioncero.es
KWB España	HC Ingeniería S.L C/ San Quintín 10, 2º Izda 28013 Madrid	Tel: +34 91 548 30 25 info@hcingenieria.com www.hcingenieria.com
SWEDEN		
Ariterm Group AB	Flottiljvägen 15 392 41 Kalmar	Tel +46 (0) 480-442850 Fax +46 (0) 480-442859 info@ariterm.se
Hotab	Hedentorpsvägen 16 291 62 Kristianstad	Tel. 044 - 21 84 00 info@hotab.se www.hotab.se
Agromat	AGROMAT Sweden AB Gottåkrav. 14 B 236 41 Höllviken	Tel.: 070- 600 48 00 FAX: 040- 45 05 20 agromat@telia.com www.agromat.se
Järnforsen Energi System AB	Ryttarevägen 18A 302 62 Halmstad	Tel: 035- 17 75 50 Fax: 035- 17 75 59 info@jf-energi.se
KMW ENERGI i Norrtälje AB	Baldersgatan 16 B 761 21, Norrtälje	Tel: 0176-20 56 00 info@kmwenergi.se
Petrokraft AB	Gräddgatan 3 412 76 Göteborg	Phone +46 31 83 06 80 Fax +46 31 40 16 59 www.petrokraft.com

Name	Address	Contact details
FINLAND		
Ariterm Oy	Uuraistentie 1 41301 Saarijärvi	Tel. +356 14 426 300 ariterm@ariterm.fi
Säätötuli Oy	Keskustie 30 61850 Kauhajoki	Tel: +356 207 299 300 info@saatotuli.fi
HT Enerco Oy	Punojantie 1 42800 Haapamäki	Tel. 010 774 5000 Fax. 010 774 5095
Tulostekniikka Oy	Pietari Brahentie 24 43700 Kyyjärvi	Tel. 010 2299000 Fax. 010 2299009 www.tulostekniikka.com
Metso	Fabianinkatu 9 A 00130 Helsinki	Tel +358 20 484 100 Fax +358 20 484 101 www.metso.com
DENMARK		
Maskinfabrikken REKA A/S	Vestvej 7 9600 Aars	Tel. (+45)98624011 Fax. (+45)98624071 reka@reka.com www.reka.com
HS Tarm A/S	Smedevej 6880 Tarm	Tel. +45 97371511 Fax +45 97372434 info@hstarm.dk www.hstarm.dk
LIN-KA MASKINFABRIK A/S	Nylandsvej 38 6940 LEM ST.	Tel. +45 97341655 Fax. +45 97342017 linka@linka.dk www.linka.dk
Burmeister & Wain Energy A/S	Lundtoftegårdsvej 93A 2800 Lyngby	Tel +45 39 45 20 00 Fax +45 39 45 20 05 info@bwe.dk www.bwe.dk
Twin Heat	Nørrevangen 7 9631 Gedsted	Tel.: +45 9864 5222 Fax.: +45 9864 5244 kontakt@twinheat.dk
Vølund Babcock & Wilcox	Falkevej 2, 6705 Esbjerg 7614 3400	Tel. +45 76 14 34 00 Fax +45 76 14 36 00 www.volund.dk

Name	Address	Contact details
GERMANY		
A.P. Bioenergietechnik	Träglhof 2 92242 Hirschau	Tel +49 (0)9608 9230128 Fax +49 (0)9608 913319 info@oeko-therm.net www.oeko-therm.net
Heizomat Gerätebau-Energiesysteme GmbH	Maicha 21 91710 Gunzenhausen	Tel. +49 (0)9836 9797-0 Fax +49 (0)9836 9797-97 info@heizomat.de
WVT Wirtschaftliche Verbrennungstechnik GmbH	Bahnhofstraße 55-59 51491 Overath-Untereschbach	Tel.: 02204 / 9744-0 Fax.: 02204 / 9744 - 27 wvt@bioflamm.de
VKK STANDARDKESSEL Köthen GmbH	Am Holländerweg 21-23 06366 Köthen	Tel.: +49 3496 66 0 Fax: +49 3496 66 605 info@vkkstandardkessel.de
Weiss Kessel-, Anlagen- und Maschinenbau GmbH	Kupferwerkstraße 6 35684 Dillenburg-Frohnhausen	Tel: +49 2771 393 0 Fax: +49 2771 393 294 info@weiss-kessel.de
Nolting Holzfeuerungs-technik GmbH	Wiebuschstraße 15 32760 Detmold	Tel: 05231 9555-0 Fax: 05231 9555-55 info@nolting-online.de
hs energieanlagen GmbH	Am Lohmühlbach 21 85356 Freising	Tel: +49 (0) 8161 - 9796 - 0 Fax: +49 (0) 8161 - 9796 – 49 www.hsenergie.eu

Manufacturers of flue gas cleaning technologies

Company	Product	Type	Range of capacity [kW]	Availability on the market	Website
GERMANY					
Schräder Abgastechnik	AL-Top	E	< 100	x	www.schraeder.com
Karlruhe Institute of Technology	CAROLA	E	< 100	-	www.kit.edu
Schiedel AG	-	E	< 100	-	www.schiedel.de
TH Alternativ-Energie GmbH	Feinstaubkiller	E	< 100	x	www.feinstaubkiller.com
A.P. Bioenergie-technik	-	E	< 100	x (in preparation)	www.oeko-therm.net
OekoSolve (Schräder Abgastechnik)	OekoTube (FUTUTErefine)	E	< 100	x	www.oekotube.ch
RuFF-Kat GmbH	RuFF-Kat	E	< 100	x	www.ruff-kat.de
Spanner Re²	SFF	E	< 100	x	www.holz-kraft.de
Spartherm Feuerungs-technik	Airbox	E	< 100	x	www.spartherm.de
WVT – Wirtschaftliche Verbrennungs-Technik GmbH	Bioflamm® MK	CF	50 - 5000	x	www.bioflamm.de
WVT – Wirtschaftliche Verbrennungs-Technik GmbH	Bioflamm® R	CF	30 - 400	x	www.bioflamm.de
Schräder Abgastechnik	KERA Top	F	< 100	-	www.schraeder.com
Kliewe	Open lamellar filter	F	< 100	-	www.kliewe.de
WVT – Wirtschaftliche Verbrennungs-Technik GmbH	Bioflamm® MF	F	30 - 2000	x	www.bioflamm.de
A.P. Bioenergie-technik	-	F	> 100	x	www.oeko-therm.net

E… electrostatic precipitator; CF… dust precipitator using centrifugal forces; F… dust filtration; FC… flue gas condensation

Company	Product	Type	Range of capacity [kW]	Availability on the market	Website
GERMANY					
Bomat Heiztechnik GmbH	Bomat	FC	40 - 2200	x	www.bomat.de
VVS Umwelttechnik	REITHER	FC	> 100	x	www.vss-ut.de
Bschor GmbH	Ökocarbonizer	FC	22 - 400	x	www.carbonizer.de
AUSTRIA					
Advanced Particle Filters	APSenergy TowerFilter	E	50 - 3300	x	www.apf.ag
Advanced Particle Filters	APSenergy RotaryFilter	E	50 - 2000	x	www.apf.ag
KÖB Holzheizsysteme	KRT	F	> 100	x	www.kob.cc
FINLAND					
Oland Heat Tech.	SPRAY-C	FC	< 100	x	not available

E… electrostatic precipitator; CF… dust precipitator using centrifugal forces; F… dust filtration; FC… flue gas condensation

3.4 Economics

If legal approval is possible, i.e. the project feasibility is ensured, realisation then depends on the economic viability. Alternative and mixed biomass pellets production and utilisation projects are mostly accompanied by higher initial costs resulting from critical fuel parameters and characteristics of the alternative raw material. The situation becomes more sever under highly restricted legal conditions requiring advanced technology solutions. Furthermore, costs are often higher since increased efforts and additionally investments are required to comply with statutory requirements. Support options are a useful measure to overcome constraints resulting from the high initial costs. Therefore, the availability of financial incentives and support options is still a key factor.

In the following, you can find information on parameters that influence the fuel costs. You will see to which extent fuel costs and necessary investments contribute to the heat supply costs. The impact of the plant size on the heat supply costs will also be explained. Furthermore, support options which can help to ensure the project viability are described based on the result for the seven European partner countries of the MixBioPells project. More detailed information can be found in the Cost Analysis Report of the project.

3.4.1 Fuel costs

Within the MixBioPells project the fuel costs have been calculated for selected case studies. More detailed information can be found in the Cost Analysis Report of the project. Fuel costs are determined by costs for crop growing, harvesting, transport (up to 50 km), drying and pelletizing/briquetting. As a major part of the annual running costs they have a wide influence on the economy of a heating system. Figure 5 presents the fuel costs identified in the different case studies in € / MWh considering these aspects. Furthermore the fluctuations of fossil fuel prices in the different partner countries are illustrated.

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. Therefore raw materials which do not require intensive drying should be used.

→ Low drying and storage costs are essential to ensure a profitable fuel.

The costs for pelletizing and briquetting amount to 11-32 % of the whole fuel costs. Certainly, these costs strongly depend on the pelletizing/briquetting plant, but also on production parameters and fuel properties.

→ Optimising the pelletizing process in terms of suitable production parameters and raw material mixtures is a large cost advantage.

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. Even medium to large scale alternative heating appliances with flue gas treatment systems are more profitable over service life despite higher investment costs.

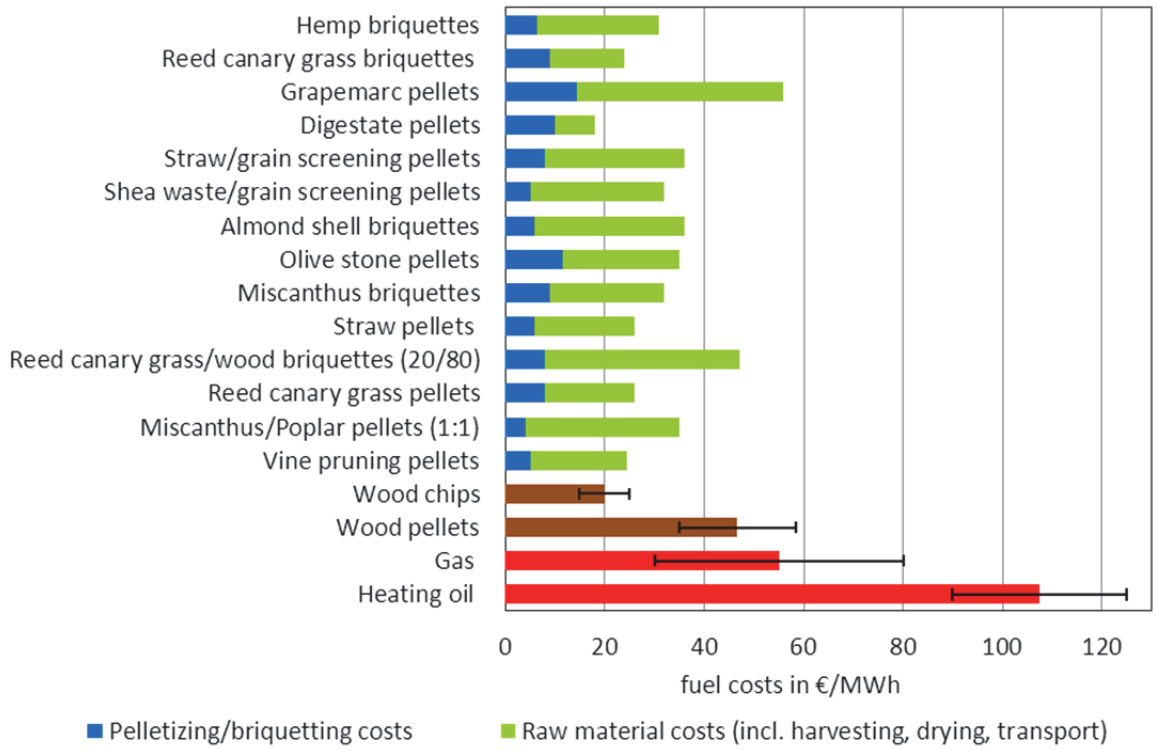


Figure 5: Fuel costs incl. costs of pelletizing and briquetting in €/MWh as well as fluctuations of wood and fossil fuel prices in the various partner countries

3.4.2 Heat supply costs

Within the MixBioPells project the heat supply costs have been calculated for selected case studies. More detailed information can be found in the Cost Analysis Report of the project. The following cost categories have been taken into account, Table 17.

Table 17: Cost categories included in the calculation of the heat supply costs

Investment costs	• boiler • storage room • construction and initial operation • flue gas treatment system • heating grid
Running costs	• fuel costs • auxiliary energy costs • filling flat rate • chimney sweeper costs • maintenance and repair

The investment costs of heating systems for alternative biomass are in general higher than for comparable fossil fuelled heating systems. However, fuel costs as a major part of the annual running costs have a wide influence on the heat supply costs and thus on the economics of heating systems

(Figure 6). Due to the increased impact of fuel costs, medium to large scale heating systems which are operated with alternative pellets are more likely to be profitable than fossil fuel systems. Thus, heating systems operated with alternative and mixed biomass pellets or briquettes are getting favourable after an operation time well below the middle of the service life. For small scale profitability within the service life can only be achieved for a particularly high difference between fossil fuel price and alternative and mixed biomass pellet price.

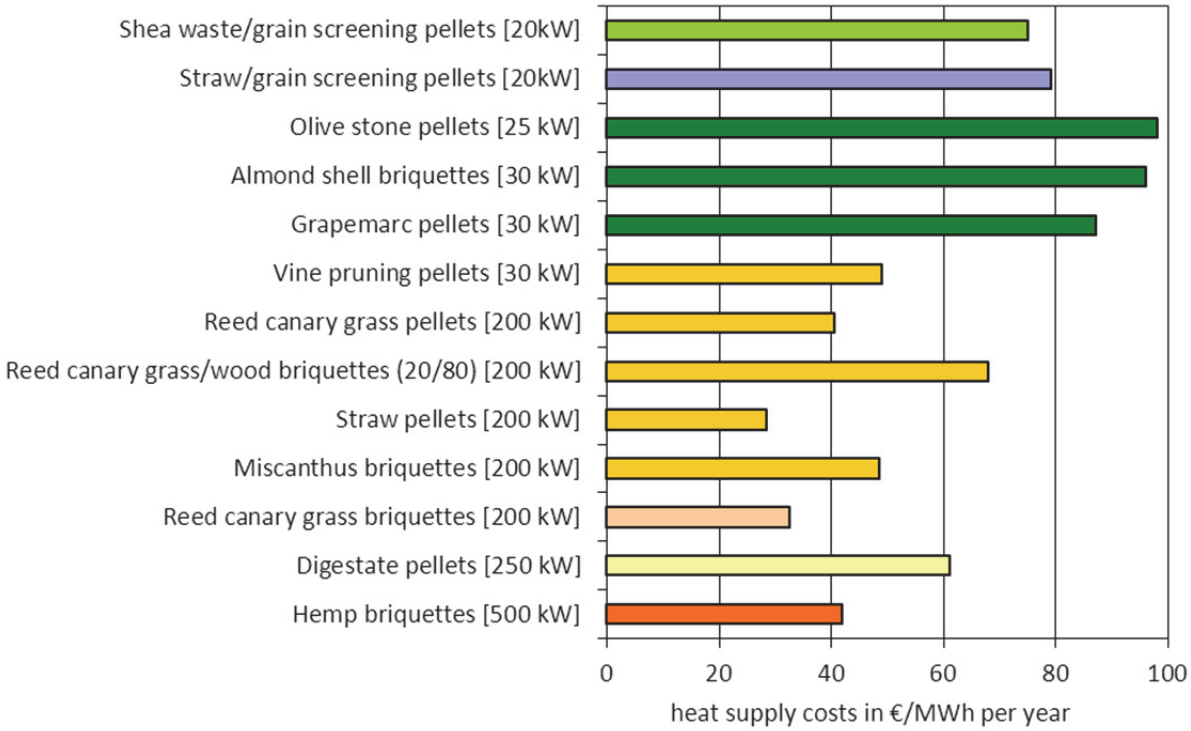


Figure 6: Comparison of heat supply costs of the alternative combustion systems of the case studies in €/MWh per year

3.4.3 Support schemes

There are direct and indirect support schemes to increase biomass utilisation for energy purposes. Indirect methods increase the price of fossil fuel options, e.g. by environmental taxes, greenhouse gas emission trading or the removal of subsidies for coal or nuclear power. CO_2-taxation as indirect support is implemented in Sweden, Finland and Denmark. Among the direct methods there are different options (Table 18).

Table 18: Direct support schemes to increase biomass utilisation for energy purposes

	Price driven	**Quantity driven**
Investment focused	Investment subsidies Tax credits Soft loans	Tendering
Generation based	Fixed feed-in tariffs Fixed premium systems	Green certificates Quota obligations

In the following, the available information is summarised separately for small and medium scale (< 1MW heat production, Table 19) and for industrial scale (combined heat and power production, Table 20). For small and medium scale the existing support measures are almost exclusively investment focused. The partner countries can be divided into two different groups according to their support option in small and medium scale. The used colours indicate the affiliation to the different groups within Table 19:

- Countries providing no support options for small and medium scale biomass utilisation (Denmark, Spain)
- Countries providing support options for small and medium scale biomass utilisation (Austria, Sweden, Finland, Germany, Italy)

Table 19: Available support for small and medium scale biomass utilisation within the partner countries

	ES	DK	AT	SE	FI	DE	IT
Investment subsidies			x	x	x	x	x
Low interest loans					x	x	
Tariffs for used fuels					x		

On industrial scale the support measures are predominantly generation based. The partner countries can be divided into three groups according to their major support strategy. The used colours indicate the affiliation to the different groups within Table 20:

- Countries supporting biomass utilisation preferably with quota obligations and green certificates (Sweden)
- Countries supporting biomass utilisation preferably with feed-in tariffs and/or premiums (Austria, Spain)
- Countries supporting biomass utilisation with a potpourri of supporting measures (Denmark, Finland, Germany, Italy)

The support schemes implemented to realise policies can address the economics of alternative and mixed biomass utilisation. It has to be ensured that the incentives and support options enable the utilisation of the technology that is required to fulfil legal requirements. This is of particular relevance because any project for alternative and mixed biomass utilisation will only be realised if it is economically feasible.

Table 20: Available support for industrial scale biomass use within the partner countries

	SE	AT	ES	DK	FI	DE	IT
Feed-in tariffs and/or premium for produced electricity		x	x	x	x	x	x
Priority/Guaranteed access to the grid				x	x	x	x
Tax exemption	x			x	x		
Green certificates	x						x
Quota obligations	x					x[2]	x
Feed-in tariffs for heat		x[1]					

[1] Only for CHP plants.
[2] Only for new buildings. Obligation for RES use but not particularly for biomass use.

PART II:

„Realisation of alternative pellet initiatives under different frameworks"

4 FRAMEWORKS AND THEIR IMPACT

The legal conditions and availability of support options are key parameters for the following definition of the national frameworks. Thus, to find out to which legal framework the country where you want to start your project belongs to you have to answer only two questions on the basis of the given indicators, Table 21:

Table 21: Indicators for the definition of the frameworks

No.	Question	Scale	Indicator
1	Do favourable legal conditions apply for your country?	Industrial	existence and operation of industrial scale plants for alternative and mixed biomass pellet utilisation, as well as the construction and installation of further plants
		Small and medium	emission thresholds for particulate emission
2	Are there support options for the utilisation of alternative and mixed biomass?	Industrial as well as small and medium	availability

For the **first question** you have to differentiate between industrial as well as small and medium scale use.

For industrial scale application the indicator of favourable legal conditions is the existence and operation of industrial scale plants for alternative and mixed biomass pellet utilisation, as well as the construction and installation of further plants.

➔ *Thus, if there are industrial scale plants running on alternative and mixed biomass pellets and further plants are planned or being build the legal conditions for industrial scale use can be appointed as favourable.*

The thresholds for particulate emission are good indicators for the legal conditions on small and medium scale. If strict limits for dust emission apply there are usually limits for other emissions as well. Furthermore, dust emission thresholds are in general most difficult to comply with for alternative raw material combustion. Thus, low thresholds for particulate emission also limit the possible fuel options for most cases.

The limit to indicate legal conditions for small and medium scale application as favourable is that emission thresholds for particulate emission of ≤ 100 mg/Nm^3 apply.

➔ *Thus, if in your country dust emission thresholds of >100 mg/Nm^3 apply for small and medium scale you can consider your legal conditions as favourable.*

For the **second question** it is only relevant if there are support options or not.

To answer both questions, a digital discrimination is chosen, i.e. you have to select

- if for your country a “yes-option” (indicated by 👍) or
- a “no-option” (indicated by 👎) applies.

In this context, the “yes-option” will be used for conditions that support alternative and mixed biomass pellet production and utilisation. In contrast, the “no-option” indicates conditions that are more likely to hinder alternative and mixed biomass pellet production and utilisation. As a result there are four different possible combinations, Table 22.

Table 22: Possible combinations

Favourable legal conditions	Support options available	Description
👎	👎	This combination indicates that unfavourable legal conditions apply and there are no support options available.
👎	👍	In this case unfavourable legal conditions are accompanied by support options to overcome financial hurdles.
👍	👎	Under this framework there are favourable legal conditions. However, there is also no support option available.
👍	👍	This combination indicates the combination of favourable legal conditions with available support options.

The procedure described above was applied for **small and medium scale** in all seven partner countries of the MixBioPells project (Chapter 4.1). Among the partner countries all four distinct frameworks for alternative and mixed biomass pellets production and utilisation in small and medium scale applications exist.

Accordingly, the procedure described above was also applied for **industrial scale** (Chapter 4.2). Only two distinct frameworks for alternative and mixed biomass pellets production and utilisation in industrial scale applications have been found among the partner countries. Cross subsidisation is hardly an option on industrial scale. There has to be a perspective for the economic viability of the project which has to be provided by appropriated support options. Therefore, under frameworks without support options for industrial scale such projects should not be attempted.

4.1 Determination of the frameworks for small and medium scale

Favourable legal conditions	Support options available	Partner countries for which it applies
👎	👎	Could apply to certain regions of Austria

Description:

This combination indicates that unfavourable legal conditions apply and there is a lack of support options for alternative and mixed biomass pellet utilisation.

This framework is particularly difficult for the initiation of projects based on alternative and mixed biomass pellets. High legal restrictions are implemented increasing the costs for alternative and mixed biomass pellet utilisation. Furthermore, caused by the lack of support there is a low demand for technologies capable to handle more difficult alternative raw materials. This framework could apply to certain regions in Austria since support options for small and medium scale use are granted on federal level and may be subject to changes. The Best Practice Examples and the Case Studies reflect the difficult situation. Straw pellets are produced in Austria with a production capacity of 5,000 t/a. However, there is no demand for the pellets. In another project, based on the commitment of a local farmer a micro heating network with an annual demand of 45 t of hay briquettes has been started and is operated without major problems. In both Case Studies alternative pellet production of less than 3,000 t/a is achieved and the pellets are used locally.

Best Practise Examples: Austria: Annex A1

Case Studies: Austria: Annex A2

National Conditions: Austria: Annex A3

Advice:

Under this framework the initiation of alternative and mixed biomass projects in small and medium scale can hardly be recommended. You have to comply with unfavourable and highly restricted legal conditions and the project has to be realised without support for small and medium scale utilisation. Therefore, serious planning should only be started with a strong commitment of the involved key actors and the support of the local authorities. The access to very cheap raw materials is required and the involvement of customers willing to cover the higher service and maintenance efforts at no additional costs. If you aim at such project despite the difficult framework it seems advisable to plan the projects as side-kicks of already successful businesses.

Favourable legal conditions	Support options available	Partner countries for which it applies
👎	👍	Germany, Italy, Sweden[1)] and certain regions of Austria[2)]

[1)] For medium scale >300 kW; [2)] If federal support options are available.

Description: In this case unfavourable legal conditions are accompanied by available support options for small and medium scale applications to overcome financial hurdles. This framework exists in the context of policies particularly supporting small and medium scale use. The utilisation has to be realised under highly restricted legal conditions. However, support options are implemented to spur the utilisation nevertheless. The increased utilisation of alternative raw materials shall help to overcome or avoid scarcity of the most common solid biofuel wood. An additional political target is the reduced dependency on fossil fuels. The impact of this framework is reflected by the Best Practice Examples. In Germany mixtures of grape marc with vine pruning as well as mixtures of Miscanthus, grape marc, digestate and wood have been pelletized on 3,000 t/a and 5,000 t/a scale. Italian pellet producers successfully realised vine pruning pelletizing on 15,000 t/a scale but as well works on mobile pelletizing units. The Case Studies cover utilisation of grape marc and digestate in Germany, and of vine prunings in Italy.

Best Practise Examples:

Austria: Annex A1

Germany: Annex D1

Italy: Annex E1

Sweden: No Best Practise Example available for medium scale >300 kW

Case Studies:

Austria: Annex A2

Germany: Annex D2

Italy: Annex E2

Sweden: No Case Study available for medium scale >300 kW

National Conditions:

Austria: Annex A3

Germany: Annex D3

Italy: Annex E3

Sweden: Annex G3

Advice: Under this framework a strong commitment of the involved key actors is required for the successful build-up and realisation of the project. The available support options indicate a political will for increased utilisation. However, highly restricted legal condition result in a limited demand and acceptance of alternative and mixed biomass pellets. It seems advisable to plan the projects as side-kicks of already successful businesses.

Favourable legal conditions	Support options available	Partner countries for which it applies
👍	👎	Denmark, Spain

Description: Under this framework there are favourable legal conditions. However, there are no support options available for small and medium scale applications.

Among these countries the small and medium scale utilisation of alternative and mixed biomass pellets is not politically favoured. Instead, policy seems to prefer larger scale use. Therefore, there are no support options available to overcome the problem of higher cost due to alternative and mixed pellet utilisation in small and medium scale. Thus, these fuels are rather used on large scale where higher investment costs affiliated with alternative and mixed biomass utilisation are less problematic. The impact of this framework is reflected by the Best Practice Examples available for Denmark and Spain. Industrial scale pellet production is realised in Denmark based on straw. The current capacity of the Spanish pellet producer is 20,000 t/a using vine pruning as raw material. However, both the capacity and the variety of used raw materials are going to be expanded. In the Case Studies, Spanish key actors tested olive stone pelletizing and successfully realised almond shell briquetting.

Best Practise Examples:
Denmark: No Best Practise Examples available for small and medium scale
Spain: Annex F1

Case Studies:
Denmark: No Case Studies available for small and medium scale
Spain: Annex F2

National Conditions:
Denmark: Annex B3
Spain: Annex F3

Advice: Under this framework larger scale should be preferred. If you still aim at small and medium scale utilisation particularly cheap raw materials with low preconditioning effort should be used to keep fuel costs as low as possible. The legal conditions should be a minor obstacle unless undue bureaucratic hurdles like prolonged approval times hinder the successful realisation. Reduced service life and higher maintenance efforts have to be considered and projects should only be started if the heating plant operator or customers feel able to handle these obstacles. The comparison with prices of common fossil and wood fuel options have to indicate a high cost saving. Economics evaluation has to be done carefully.

Favourable legal conditions	Support options available	Partner countries for which it applies
👍	👍	Finland, Sweden

Description: This combination indicates the combination of favourable legal conditions with available support options.

This framework provides the strongest support for alternative and mixed biomass pellet utilisation in small and medium scale. It can be found in Finland and Sweden. At first sight, this might appear surprising since in Finland and Sweden a large share of heating and cooling is already provided from biomass. However, biomass use in these countries is currently focused on logged and chipped wood. Alternative raw materials are rarely used. Furthermore, despite the large share of biomass in the heating and cooling sector, the Scandinavian countries have ambitious targets requiring enhanced biomass use. Thus, a framework is required to facilitate alternative and mixed biomass utilisation. The still limited use of alternative raw materials is reflected in the Best Practice Examples. Some experience is available for pelletizing of herbaceous biomass using a mobile pelletizing machine in Finland. The pellets are used as fuel by the farmers or sold as fuel or litter. In Sweden, reed canary grass briquettes are produced with a capacity of 3,500 t/a and are provided to local heating plants. The Finnish Case Studies cover reed canary grass pelletizing for local use and production and utilisation of mixed wood-reed canary grass pellets. In the Swedish Case Study reed canary grass briquetting is analysed.

Best Practise Examples: Finland: Annex C1

Sweden: Annex G1

Case Studies: Finland: Annex C2

Sweden: Annex G2

National Conditions: Finland: Annex C3

Sweden: Annex G3

Advice: The acceptance and resulting demand appears to be the largest obstacles in the above countries. Neither legal nor economic conditions should be a major problem. The successful realisation still depends on bureaucratic hurdles that have to be overcome.

4.2 Determination of the frameworks for industrial scale

Favourable legal conditions	Support options available	Partner countries for which it applies
👎	👍	Austria, Germany, Italy, Spain

Description: In this case unfavourable legal conditions are accompanied by support options for industrial scale applications to overcome financial hurdles. This framework exists in the context of policies particularly supporting small and medium scale use but try to limit large scale use as a result of public concerns or in countries for which the bioenergy sector is less developed. Though there are support options available the legal condition and the apparent political will hinder the use of alternative and mixed biomass pellets in large scale. Under this framework, large scale utilisation is not favourable at the moment. The development in the bioenergy sector might change the situation in the future. Nevertheless, the current situation results in the lack of Best Practice Examples for large scale from Austria, Germany, Italy and Spain. Furthermore, only in Italy one Case Study analysed the utilisation of Miscanthus-poplar pellets for a CHP plant.

Best Practise Examples:

Austria: No Best Practise Example available for industrial scale
Germany: No Best Practise Example available for industrial scale
Italy: No Best Practise Example available for industrial scale
Spain: No Best Practise Example available for industrial scale

Case Studies:

Austria: No Case Study available for industrial scale
Germany: No Case Study available for industrial scale
Italy: Annex E2 (only the first Case Study)
Spain: No Case Study available for industrial scale

National Conditions:

Austria: Annex A3
Germany: Annex D3
Italy: Annex E3
Spain: Annex F3

Advices: Under this framework the realisation of alternative and mixed biomass pellet projects is not advisable. If you still aim at the initiation of an alternative and mixed biomass pellet project under these conditions secure heat and electricity demand as well as long-term, low cost supply of the raw materials are highly important. Experienced plant manufacturers and operators should be involved to prevent problems arising from inappropriate plant design. Furthermore, public and local authorities should be involved at early stages.

Favourable legal conditions	Support options available	Partner countries for which it applies
		Denmark, Finland, Sweden

Description:

This combination indicates the combination of favourable legal conditions with available support options for industrial scale applications.

This framework applies for Finland, Denmark and Sweden. In these countries the framework supports large scale utilisation of alternative and mixed biomass pellets. This is reflected by the Best Practice Examples. Industrial scale pellet production is realised in Denmark based on straw. In Finland and Sweden there are large scale plants. However, the respective plants and supply chains have not been selected as Best Practise Examples or Case Studies by the partner countries.

Best Practise Examples:

Denmark: Annex B1

Finland: No Best Practise Example available for industrial scale

Sweden: No Best Practise Example available for industrial scale

Case Studies:

Denmark: Annex B2 (only the first Case Study)

Finland: No Case Study available for industrial scale

Sweden: No Case Study available for industrial scale

National Conditions:

Denmark: Annex B3

Finland: Annex C3

Sweden: Annex G3

Advices:

Looking at the economic and legal conditions there are no objections. In general, secure heat and electricity demand as well as long-term low cost supply of the raw materials are highly important. To ensure a good plant design experienced plant manufacturers and operators should be involved. An early involvement of the public and authorities can enhance the acceptance that is often a critical point for the installation of larger plants

ANNEX A: AUSTRIA

A1 BEST PRACTISE EXAMPLES

Pelletizing straw at FEX

Background

FEX Straw Manufacturing Inc. provides a wide range of straw-based products. The primary product is a horse bedding called STREUfex. All pellets are made of 100 % straw and are produced for material utilisation.

The company made also first attempts to produce straw and hay pellets for the energetic use, which have been successful. Admittedly the demand for these pellets was lacking.

Raw material

Characteristics of the used raw material.

Raw material	Straw (ave.)
Moisture content, wt.-%	14
Heating value, MJ/kg	17.5
Ash melting temperature, °C	1,200
Cost of the raw material, €/t	70
Quantity in the area, t/a	155,000

Straw is a residue from the grain harvest. The area-specific straw harvest is subject to strong weather-related variations. The Lower Austrian average area-specific straw harvest is about 3 t / ha.

The harvest and logistic technologies are well established. Usually the harvested straw will be compressed to bales. For the energetic use of straw, it would be useful to avoid raising the soil during the harvesting operations to reduce the quantity of ash, already quite high in the clean product. During the harvest, the moisture of the product is about 40%; during the storage phase, it reaches 14%. As a result of the low water content the harvested straw is well storable.

In Lower Austria the price for straw was about 67.7 € / t in 2009 and about 76 € / t in 2010. The producer's price for harvested straw was about 70 €/ t in 2010. The straw price depends on the amount of the harvest.

Besides the weather the decisions on agricultural policy will basically affect the available quantity of straw. For example an intensified support of energy crops like rape for esterification can cause a decrease of grain cultivation.

Figure 1: Straw bales

Pelletizing process

Data of pelletizing.

Pelletizing	
Technology type	Ring die
Production capacity in t/a	5,000

Only straw with a water content under 15 % will be taken over. Due to the low water content a drying of the raw material is not necessary. The straw suppliers are mostly farmers of the region (radius<50 km). 20 % of the straw is obtained from two straw dealers.

The bale breaker has a capacity of 5 t/h. The hammer mill has also a capacity of 5 t/h and reduces the straw to 5-20 mm. The company FEX uses a ring die with a production capacity of 2-3 t/h.

Figure 2: Bale braker

The cooling system is a counter flow tower cooler with a capacity of 5 t/h. Fines with a diameter under 4mm are filtered.

The annually production output amounts to 5.000 t and the production costs vary between 80 €/t and 100 €/t. 80 % of the straw pellets are stored in big silos, the other 20 % are stored in bags.

Figure 3: Straw Pellets

Producers view

The company FEX has its own pelletizing unit and a lot of experiences with pelletizing straw. It is located in Lower Austria and in Lumberton/USA.

Figure 4: FEX Straw Manufacturing Inc. in Neusiedl/Zaya

FEX Straw Manufacturing Inc. has participated to MixBioPells project as subcontractor. The objective is to increase the request of straw pellets for the energetic use.

Contact

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Combustion of hay briquettes

Background

Within the project „Biennal monitoring of a small scale combustion plant operated with hay briquettes" in Upper Austria an automatically loaded combustion plant with 78 kW nominal capacity was operated with hay briquettes originating from abandoned meadows and nature protection areas.

Mr. Engleder the operator of the heating plant runs a dairy farm in the region Mühlviertel, a part of the province Upper Austria. The hay briquettes used for combustion are produced with a hydraulic briquetting press on his farm. The raw material used originates from the surrounding municipalities.

Raw material

Characteristics of the hay briquettes used

Parameter (dry basis, average values)	
Moisture content	15 wt.-%
Heating value	16.5 MJ/kg
Ash melting temperature	1050 °C
Ash content	8 wt.-%

The main goal of nature protection areas such as Natura 2000 areas or biosphere reserves is to maintain and preserve the ecological situation by an extensive, environmental friendly and adapted cultivation by the agriculture. At present in Upper Austria the area of the nature protection program "Natura 2000" covers about 750 km².

One obstacle in the fulfilment of the conservation requirements is the usability of the harvested goods in today's intensive agriculture. Due to the late mowing point in time the hay of abandoned/protected meadows has a reduced feed quality and therefore isn't suitable for animal feeding. Other possibilities for the utilisation of that hay are investigated like the thermal utilisation solid biofuel in biogas or combustion plants.

The harvest of hay from extensive cultivated meadows amounts to 3 – 4 tons hay /ha / a. The water content is around 15 % at harvesting point. Due to the fact that the hay from extensive cultivated meadows is a residual product no market price exists.

Briquetting of hay

At the briquetting unit of Mr. Engleder complete hay bales are fed to the bale breaker. The chopped raw material is conveyed to a collection vessel and further to the briquetting press. Due to the low water content a drying of the raw material is not necessary. The hydraulic briquetting press of the type "Holzmag ELAN 25" has a capacity range from 50 - 150 kg per hour depending of the briquettes diameter and length.

The used briquettes have a diameter of 6 cm and a length of min. 3 cm and max. 6 cm. There is no cooling system for the briquettes. The hay briquettes which have bulk density of about 600 kg/m³ are retained in a fuel storage room.

Figure 1: hay briquette – side view

Combustion

Data of combustion.

Technique	automatically feed biomass boiler
Installed capacity	78 kW
Ash handling	reuse on arable land
Final users	4 customers
Operator	Mr. Engleder, farmer

Mr. Engleder operates a local micro heating network with four heat customers. The connected heat capacity amounts to 80 kW. The biomass boiler of the type Gerlinger-Biokompakt AWK ECO 80, has a heat capacity of 78 kW.

Figure 2: combustion unit - Biokompakt AWK ECO 80

The annual demand on the raw material hay briquettes is on average 45 tons.

The results of the two year monitoring project show that the combustion of hay briquettes in a modern automatically feed biomass boiler is technical possible. Without applying additional technical equipment the gaseous emissions CO, NO_x and SO_2 as well as the particulate emissions are equal to herbaceous fuels and below the national threshold values. No negative influence on the boiler efficiency and annual use efficiency where observed when applying hay briquettes as fuel.

The combustion properties are similar to herbaceous fuels. Hay briquettes have a low ash melting behaviour and a high ash content. Modifications in the combustion chamber and at the ash removal system are necessary to avoid slagging and fouling as well as to ensure a continuous as removal.

Operators view

Due to the late harvest time of the hay from nature protection areas like in the program “Natura 2000” the feed quality is low and therefore unsuitable for the utilisation in intensive animal husbandry. The thermal utilisation of biomass from landscape conservation is one reasonable possibility to dispose that residual biomass in an environmental friendly economical arguable way.

Figure 3: unused hay balls in the nature protection area Stainz (Styria)

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A2 CASE STUDIES

Case study 1 “Straw from regional farmers”

Production: The pellets production company uses a ring die technology.

Customers: The customers are the farmers who are the straw suppliers.

Case study 2 “Miscanthus “

Production: The raw material supplier owns a private mechanical briquetting machine.

Customers: Customers have usually a heating capacity between 50 and 500 kW.

The results of the case studies are included in the “Cost Analysis Report” of the MixBioPells project. The report is available at the project website: **www.mixbiopells.eu/en/publications.html**.

A3 NATIONAL CONDITIONS

In Austria, the use is restricted to natural wood due to federal states' prescriptions. Since 1995 the "Art. 15 a B-VG agreement: Precautionary measures regarding small-scale heating systems" controls the implementation of heating systems with a nominal heat output up to 400 kW for residential heating. A draft of an amendment is in progress since 2004, but implementation is proceeding very slowly. So far the utilisation of non-woody biomass fuels in small-scale combustion appliances is only considered in the legal framework of the province of Lower Austria. Only in this region the combustion of fuels based on wood, bark, straw, cereals and mixtures in private sectors is possible if the pellets apply to a product standard. The threshold values are compiled according to the FAV - (Feuerungsanlagenverordnung–combustion plant ordinance). Thus two cases have to be considered:

1) Combustion in private sectors:

parameter	thermal input	CO	OGC	NO_x	particles
unit	kW	mg/MJ			
woody biomass fuels – manually loaded	< 400	1,100 (500)	80 (50)	150 (300)	60
woody biomass fuels – automatically loaded	< 400	500	40 (30)	150 (300)	60

The numbers in parentheses indicate differing emission threshold values for the combustion of non woody biomass (e.g. bark, straw) within a range of 50 – 400 kW according to the "§176 Bautechnik-verordnung (1997)" of Lower Austria. Yearly measurements for CO-emissions are required.

2) Combustion of standardised fuels made of other solid and herbal raw materials from forestry and agriculture such as cereal whole plant, grasses and Miscanthus in public and industrial sectors:

thermal input	CO	OGC	NO_x	SO_2[1]	HCl*	particles
MW	mg/Nm³ (reference oxygen content 11 Vol.-%O_2)					
< 0.4	800	50	500	350	30	150
0.4 < 1	50	20	500	350	30	50[2] 150[3]
1- 2	500	20	400	350	30	50
>2 – 10	350	20	400	350	30	20
>10	30	20	200	350	30	20

[1] does not apply for the combustion of Miscanthus standardised fuels made of other solid and herbal raw materials
[2] woody biomass fuels
[3] Miscanthus standardised fuels made of other solid and herbal raw materials

The emission threshold values apply to combustion of mixed biomass pellets. The implementation of more strict emission threshold values is not planned. If the European Unions Framework Directive on Eco-Design of Energy-Using Products (Directive 2009/125/EC) is coming into force most national frameworks will be adjusted. If there are no regulations existing, legal authorities will set the permission and the threshold values at their sole discretion.

ANNEX B: DENMARK

B1 BEST PRACTISE EXAMPLES

Pelletizing straw & grain screenings at Køge Biopellet Factory"

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 was 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 kilometers outside Copenhagen by Køge Harbour, and the pellets are then shipped into Copenhagen by boat. In 2006 Vattenfall A/S took over the straw pelletplant. The wood pelletplant, now owned by DONG Energy was stopped in 2007. The argument from DONG Energy was that the raw material supply with round timber and wood logs mainly from the Baltic area was too unstable.

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

The investment in 2004 for both the wood pelletplant and the straw pelletplant 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 inhouse 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. The toll bridges to Sweden and to Funen are barrierers 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.

Truck with 24 bales waiting for unloading.

The unloading of straw bales from the truck.

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. Grain screenings are also used as raw material mixed with straw. The quality of grain screenings differs from year to year depending on a wet or dry harvest and depending on the growth conditions during the summer time.

Characteristics of raw material

Raw material	Straw	Grain screenings
Moisture content, wt.-%	13	10
Heatingvalue, MJ/kg	14,5	16,5
Bulk density, kg/m³	130	250
Ash content, wt.-%	5	10
Ash melting tem, C	870	N/A
Raw material costs, €/ 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 4 pellet lines. The production consists of:

- Unloading area with crane for straw
- Short term storage
- Conveyor belts and straw chopper
- Hammer mill and possibility for mixing
- Pelletiser with ring die
- Cooling unit
- Conveyor belt to harbour
- Bulk storage at the harbour
- Large scale bulk loader for ships

There is no drying unit for the raw material in the process line. The percentage of grain screenings mixed with straw depends on what is available. Maximum ration of grain screenings is 20 %.

The pelletizing lines at Køge Biopillefabrik

Bulk storage for straw pellets at the 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 worlds leading companies in the energy sector.

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Combustion of mixed biomasses at Randers CHP

Background

Randers Combined Heat & Power plant was originally commissioned in 1982 as a 100 % coal fired CHP plant supplying the town of Randers in Jutland with electricity and district heating. The CHP plant was originally owned by the municipality of Randers, but is today owned by the company Verdo A/S. The vision for Verdo A/S is to make a profitable growth by producing green energy. The company has many activities in the energy field, among others two pellet production plants in the UK, in Andover in Southern England and in Grangemouth in Scotland. Each pellet plant has an annual production capacity of 55,000 tonnes of wood pellets and 15,000 tonnes of briquettes.

Fuels for the CHP plant

Fuels 2011	Tons	GJ	%
Wood chips	144,896	1,448,960	50.0
Wood pellets	37,865	617,200	21.3
Dry biomass	37,865	617,200	21.3
Coal	8,583	214,575	7.4
Total		**2.897.935**	**100**

Expected fuel consumption in 2011. Source: Verdo A/S

The fuels are renewable fuels as wood chips, wood pellets and dry biomass. The dry biomass is a mix of wood pellets, shea waste, grain screenings, soja waste and sun flower shells. Most of the wood chips is produced on the site from round wood imported from the Baltic area. The main part of the wood pellets is from Verdo's own pellet plants in UK. The rest of the dry biomass is traded on the market. For 7 months in 2010 the CHP plant was using 100 % biomass. Today the coal consumption has dropped as low as 10% on an energy basis and is only used during wintertime. The ambition in Verdo A/S is a 100 % shift to renewable fuels.

The storage for dry biomass at Verdo A/S

The logistic on the site is a daily challenge as the harbour area where the plant is located is quite narrow with few possibilities for expansion. The advantage is that medium size ships, used in the Baltic Sea and on rivers in Germany, Poland and Russia can call directly at the storage facilities of the plant. During hard winters the harbour is frozen giving problems with the limited storage facilities. It is very important to have continuous monitoring of the dry biomass storage, as self ignition has been detected some times.

The wood chipper at Verdo A/S

The CHP plant

The boiler plant consists of two boilers. This provides high operational reliability and good opportunities to adjust the production to the actual district heating consumption. In the Danish context a CHP plant is a small power plant situated at a larger district heating network. The main priority for the energy production is to supply the district heating network. The second priority is the electricity production. The boilers were originally equipped with spreader stokers for coal firing, but in 1994 a gas burner was installed for landfill gas. In 2002 the plant was equipped with pneumatic air spouts for biomass firing. The combustion takes place in suspension and on a travelling grate.

CHP plant data	
Boiler pressure	111 bar
Electrical output	52 MWel
District Heating output	112 MJ/s
Super Heater temperature	525°C
Flue gas cleaning 1	El. Precipitator
Flue gas cleaning2	SO_2 reduction
CO_2 emission 2005	228,400 tons
CO_2 emission 2010	48,300 tons
NOx emission 2010	445 tons
Sulphur emission 2010	8.8 tons
Dust emission 2010	34 tons
Residues. Bottom ash 2010	3,500 tons
Residues. Fly ash 2010	5,960 tons
Residues. Gypsum 2010	141 tons

Source: Verdo. Green Accounting 2010

Bottom ash is used for road construction. Fly ash is reused. Gypsum is used as building materials.

Randers CHP plant with a lot of belt conveyors for fuel handling. The resevoir on the chimney is for the district heating system. To the left the out door storage for chalk used in the de-sulphurisation proces.

Producers view

Verdo A/S believes in green energy produced from carbon-neutral fuels. The best way to demonstrate this is to invest in biomass production and conversion. Verdo A/S is engaged in green solutions, and biomass fuels are characterized precisely by being environmentally friendly. The goal is to deliver green energy using environmentally friendly bio-based fuels. The main goal is to use 100% biomass for energy production round the year. In 2005 the CO_2 emission from the CHP plant was 228,400 tons. The target for 2011 is 20,600 tons.

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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 was 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 kilometers 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.

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 investment in 2004 for both the wood pelletplant and the straw pelletplant 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 inhouse 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. The toll bridges to Sweden and to Funen are barrierers 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.

Truck with 24 bales waiting for unloading.

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 4 pellet lines. There is no drying unit for the raw material in the process line. The % of grain screenings mixed with straw depends on what is available. Maximum ration 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.

Bulk storage for straw pellets at the Køge Harbour

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.

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 worlds leading companies in the energy sector.

Contact:

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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

B2 CASE STUDIES

Case study 1 "Shea waste, rape waste, potato and beet pulp, grain screenings"

Production: The energy utility who is the operator of the CHP plant also intends to own the pelletizing plant.

Customers: CHP plant (Electrical output: 52 MWel. Heat output: 112 MJ/s).

Case study 2 "Straw, grain screenings, peanut shells and corn cobs "

Production: A former wood pellet factory which is rebuild.

Customers: 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.

The results of the case studies are included in the "Cost Analysis Report" of the MixBioPells project. The report is available at the project website: **www.mixbiopells.eu/en/publications.html**.

B3 NATIONAL CONDITIONS

A wide range of renewable sources can be used for the energetic utilisation in combustion systems. In Denmark biomass is defined according to the Danish Act no. 638 of July 3 1997 on biomass waste. Any type of biomass or mix of biomass that is not mentioned in the annex to the act is defined as waste and must be handled and approved according to the EU Waste incineration directive in terms of temperature and retention time in an incineration plant. Furthermore, a waste tax is due. The following biomass is defined according to the Danish Act no. 638 of 03.07.1997:

- raw wood incl. bark, forest wood chips,
- clean wood including shavings and saw dust,
- wood waste from the production and treatment of clean laminated wood,
- straw,
- kernels and seeds from fruits and berries,
- fruit residues,
- nut and seed shells
- untreated cork, grain and seeds, cotton and flax,
- lolly sticks and green pellets (dried grass, clover etc.),
- malt, thatched roofing and tobacco waste,
- fuel pellets or fuel briquettes produced exclusively from wastes.

The emission threshold values for the use of these materials in combustion plants are compiled according to the guidelines for Air Emission Regulation No. 1, 2002 and Act no. 808 of 25.09.2003 about emission from large plants Danish Environmental Protection Agency for Biomasses and the Danish Act no. 638 of 03.07.1997:

Parameter	Thermal input / thermal output	Reference oxygen content O_2	CO	OGC	NO_x	SO_2	Particles
Unit	MW	%	mg/Nm^3				
Value	0.12-1.0	10	500	-	-	-	300
	1.0-50	10	625	-	300	-	40
	> 50 [1)]	6	-	-	300	200	30
	> 50 [2)]	6	-	-	600	400	100

[1)] New plant

[2)] Old plant

The emission threshold values apply to combustion of mixed biomass pellets. The implementation of more strict emission threshold values is not planned. If the European Unions Framework Directive on Eco-Design of Energy-Using Products (Directive 2009/125/EC) is coming into force most national frameworks will be adjusted. If there are no regulations existing, legal authorities will set the permission and the threshold values at their sole discretion.

ANNEX C: FINLAND

C1 BEST PRACTISE EXAMPLES

Pelletizing of straw and grass at Biobotnia Oy

Background

Biobotnia Oy is a company in Jalasjävi, founded in 2009. The company has specialised to production of renewable energy. Company has a mobile pelletizing unit, by witch it is possible to grind and pelletise fibrous grasses and straw, e.g. straws of local grains and reed canary grass. The unit can be reserved for pelletizing of larger storages of bales, in the minimum 100 bales. The mobile machine can crush a complete bale without any preliminary preparations, i.e. complete bales can be fed into the crusher as such.Advances of straw pelleting are that raw material can be densified to 6 – 8 times smaller space. The heating value of the straw pellets is same as that of wood pellets, and it is real renewable energy! Straw pellets can be combusted with stoker burners or in fireplaces with so called "pelletbasket".

Raw material

There are several possible raw materials for fuels in the area; wood, peat, straw, reed canary grass and even mixtures of them. Yield of straw is about 4 – 7 t/ha. In the area there is plenty of fields. Density of round bales is about 110 kg/m^3 and they weight 150 – 300 kg depending mostly on the moisture. Moisture content should be under 20%. There are also bigger bales, the density of which is little higher. The pellets are made of reed canary grass, easily obtainable at the area. The potassium (K) and chlorine (Cl) contents of the plants diminish because these chemicals are water soluble and the reed canary grass will be harvested in spring. In spring the moisture content is about 10 – 15%. After one year's poor storage conditions the moisture content of bales can be up to 40%. Reed canary grass is usually baled with baling machines of the farm and stored in well covered stockpiles. A stockpile is situated on terrain and a truck transports the bales to the market. RCG is a plant which can grow in same, modest place for several years. Price of the reed canary crass, excluding the transport costs, is about 35 €/t.

Characteristics of the used raw material.

Raw-material	Grass (RCG)	Straw (ave.)
Moisture content, %	10 - 35	10 - 25
Heating value, MJ/kg	17.6	17
Bulk density, m^3/kg	90 - 140	80 - 150
Ash content, %	5 - 6	4.5 – 6.9
Ash melting temperature, C	1,125	1,175 - 1400
Raw material costs, €/ t	30 - 50	0 - 30
Quantity in the area, t/a	14,000	8,000

Pelletizing process

The pelletizing process of Biobotnia Oy is mobile. Complete straw or read canary grass bales are fed into the hammer mill of the machine. Hammer mill grinds the straws and the grinded material goes through a screen of Ø18 mm. Screen is rather coarse, but it works fine, if the moisture of bales is under 20%. Belt conveyer feeds a mixing bin and after that the raw material goes to the press. The model of the press is CPM and type of the die is a ring

die. At the moment the producer has ring dies of 60/6 and 60/8 mm.

Pellets from straw and peat mixture.

The model of the press is CPM and type of the die is a ring die. At the moment the producer has ring dies of 60/6 and 60/8 mm. It is easy to pelletise reed canary grass with the die of 60/6 mm. Die 60/8 is little "loose" for straw pellets. Straw pellets include small amount of caoline for better heating results. Machine produces 1.2 – 2 t/h with different raw materials and dies. Pellets are cooled on belt conveyers. In the system there is a bin of 9 m^3, where pellets will gather. The bin has to be emptied every time it becomes full.

Data of pelletizing

Technology type	Mobile unit, ring die
Production capacity, t/a	3,000
Price of pellets, €/MWh (incl. VAT)	35

Producers view

Biobotnia Oy has participated to MixBioPells – project as a test pelletiser. It was made two kinds mixes straw/peat and wood/reed canary grass. A little difficulty was that the batches have to weight and mixed on the ground. In palletising of the straw/peat (50/50%) –mix there were no difficulties with the former 8/60 mm die. The tests of wood/RCG were done with the die of 6/60 mm. In everyday life Biobotnia Oy pelletises batches of 100 bales of straw and reed canary grass to local farmers. A farmer calls to Biobotnia Oy for pelletizing of bales, which adds the order to the next working period of the pelletiser. The costs of the pelletizer vary. The contractor gets his salary per cubic meter of straw material pelletized. In some cases, especially with reed canary grass, pellets are sold the price of day. A 100% read crass pellets are used as litter for horses so this is also one part of the business. There is also a contract between local heat producer Jalasjärven Lämpö Oy and Biobotnia Oy to produce agripellets for district heating. For pelleting it is needed more suitable dies for different raw materials. For a small entrepreneur the purchase of dies is expensive. Also there might be a bigger cooler in the future

Contact

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The mobile pelletizing process: The complete bale can be put to hammer mill. The press is a ring die of CPM.

Combustion of mixed pellets at Ariterm Oy

Background

Ariterm Oy develops, produces and markets heating technology for renewable fuels like pellets, wood chips and firewood. Ariterm Oy has a tradition of hundred years to create environmentally sound, effective and reliable solutions for heating systems.

Ariterm Oy is a leading producer of bioheating systems in Scandinavia, The head office and plant is at Saarijärvi in Central-Finland. Main markets are in Nordic countries.

A view of the boiler production at Saarijärvi plant (Ariterm Oy).

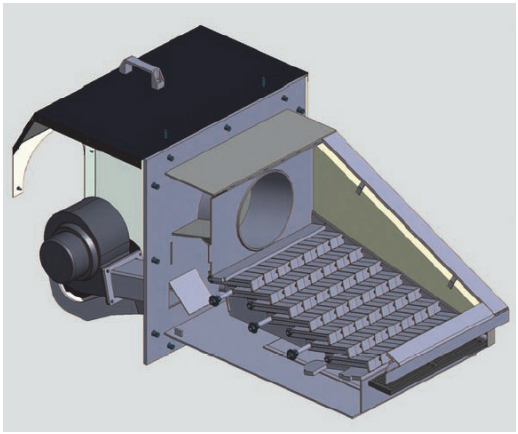
Boilers and burners

The production is certified in accordance with ISO 9001 and 14001 and quality assured in accordance with the highest category of the EU Pressure vessel directive (PED). In all Arimax and Ariterm –boilers is the maximum operating temperature 120°C and the certificate of the pressure device given by INS00-20. The products of Ariterm Oy are on the internet page www.ariterm.fi/en.

Burners of the experiments

Heating experiments of straw/peat (50/50) and reed canary grass/wood pellets were done with two pelletburner; BeQuem pellet burner and the new Aritermin MultiJet-bioburner.

BeQuem -burner has a grate which is fed underneath. During every operating cycle, a small amount of pellets (150 g) is fed from the pellet storage via the external feeding system to the upper connection of the burner. The dosing is carried out by means of a separate dosing auger via the blocking feeder and burner auger to the combustion head. The safety zone is always remains intact even in the event of failure. Wood pellets burner is effective and burning is even, the efficiency is good, bullet proof solution, little ash, little cleaning.



MultiJet – moving grate burner (Ariterm Oy).

The second burner in the experiments was MultiJet 60kW. The burner is able to use wood chip of varying quality, wood and peat pellets, peat and various field fuels. The grate of the burner (40 – 1,500 kW) is fully mobile and this enables the fuel to mix efficiently on its surface. The grate's mobility improves moving the ash from the burning head to the ash compartment, which is useful when using fuel that produces a lot of ash. The grate runs by spindle motor or, in the case of larger burners, hydraulics. The fuel is fed using a two-screwed

feeding system that is essential to the structural fire safety of the equipment.

Results of experiments

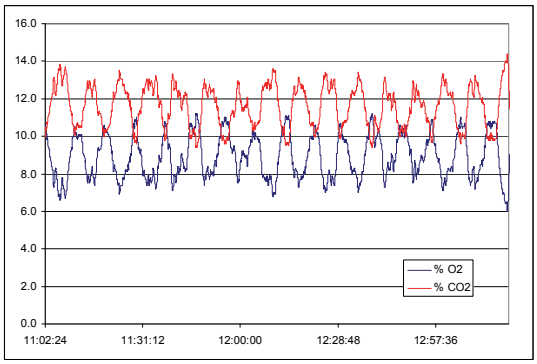
First experiments of the straw/peat (50/50) –pellets were done with a BeQuem bowl burner of 40 kW. Two efforts were done at nominal affectivity, but the bowl fulfilled and choked rapidly. Probably it was lack of primer air. In a small efficiency the bowl burner worked acceptably but fouled little by little. Burning values were low and the carbon monoxide was high. The air holes of burning began to block and the conclusion was, that this type burner is not suitable for straw/peat –pellets. Results were equal also in reed canary grass/wood experiments.

Results from combustion experiences with 60 kW burner.

Pellets	Straw/peat kaolin	Straw/peat without kaolin
CO-content, ppm	15 – 50, peaks 100-200	100 - 200, peaks 1,000
CO_2, %	10 - 14	12 -15
O_2, %	7 – 10.5	5 - 10

Straw/peat –pellets, which included kaolin (2-3 %), was tested a MultiJet burner of 60 kW. Experiment was driven in nominal efficiency and the burner behaved like peat heating. Sintering was become some amount, when the burner was flaked out. During the burning there were not notable amount of slag and the moving grate ejected the small amount of slag from the grate. Generated slag was light and rather easy to brake. Burning values were outstanding, CO about 15 – 50 ppm. The time of the experiment was 5 hours and it was repeated three times.

Experiments were repeated 60 kW MultiJet –burner, but now there was not kaolin as the additive of the peat/straw –pellets. Experiments were done equal way as previous experiments. Sintering was become some amount, when the burner was flaked out. During burning it was created little more slag than in the previous experiment, in which the pellets included kaolin. Moving grate took away the becoming slag. Burning values were still well e.g. CO was about 100 – 200 ppm. Pellets were little softer than pellets including kaolin.



60 kW's burner, straw/peat –mix (50/50%) with kaolin.

Also experiments with mix of wood and reed canary grass will be done with MultiJet burner.

Conclusion

It was used peat/straw –pellets about 1,500 kg in the experiments. Ash became clearly more than wood pellets, but as much as peat-pellets. In practice the pellets which included kaolin were clearly better fuel than pure peat/straw –mix. The experimental pellets are not suitable so called fixed grate burners.

C2 CASE STUDIES

Case study 1 “Reed canary grass from local farmers”

Production: The pelletizing company owns a mobile pellet machine with ring die technology.

Customers: The customers are usually local farmers with boilers from 100 up to 500 kW.

Case study 2 “Reed canary grass mixed with wood (20/80)“

Production: The pelletizing company sells wood and mixed briquettes in big bags or loose (ring die technology).

Customers: Main customers are the farmers of the region and the local district heating plants (from 200 to 2000 kW boilers)

The results of the case studies are included in the “Cost Analysis Report” of the MixBioPells project. The report is available at the project website: **www.mixbiopells.eu/en/publications.html**.

C3 NATIONAL CONDITIONS

In Finland there is no general guideline for licensed fuels. Common solid biofuels are wood logs, wood chips and wood pellets. Non woody biomass is not mentioned and must be handled individually by the authority as a "special fuel". Some farmers use energy grain (barley, oat, rye, wheat) and other herbaceous biomass as fuel. Reed Canary Grass (Phalaris arundinacea) has been grown in Finland for several years and it is used as a supplementary fuel in about 20 power and heating plants. It has also been used as mixture with other solid biomass for pellet production. Additionally, peat pellets are used to some extent.

In Finland no general emission regulations for the use of these raw materials in small scale combustion systems are exist. However, emission threshold values for indigenous fuels (wood, wood waste, peat, straw) are only valid for boilers with a thermal output > 1 MW. If there are no regulations existing, legal authorities will set the permission and the emission threshold values at their sole discretion.

parameter	**thermal output**	**NO_x**	**SO_2**	**particles**
unit	MW	mg/MJ		
value	1 – 5	-	-	200
	5 - 50	-	-	85 - 4/3 (P- 5) [1)]
	50 – 100	400	200 [2)] 400 [3)]	50
	100 – 300	300	200	30
	> 300	150	200	30

1) For grate combustion limit is 200 mg/MJ in power range of 1 – 10 MW

2) Biomass

3) Peat

The emission threshold values apply also to combustion of mixed biomass pellets. The implementation of more strict emission threshold values is not planned. If the European Union's Framework Directive on Eco-Design of Energy-Using Products (Directive 2009/125/EC) is coming into force the Finnish legal framework will be adjusted.

ANNEX D: GERMANY

D1 BEST PRACTISE EXAMPLES

Pelletizing of mixed biomass pellets at Pusch AG

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 license concept "agrarSTICK®" different license holders are producing and marketing alternative pellets based on specific recipes. Therefore these partners are provided with complete production, 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 material

In general mixtures from herbaceous, fruity and woody biomass have been pelletised so far. Since kind 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. Due to these advantages the Pusch AG has developed and manufactured the pelletizing plant PM 6-28 with a production capacity of 1,000 kg/h. The modular design provides 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 w. -% 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.

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. In the region of Rhineland-Palatinate pellets produced from Miscanthus and grape marc have a high potential.

Miscanthus pellets (left) and pellets made from 2/3 Miscanthus, 1/3 Grape marc (right).

The mean values of these pellets are listed in the following table:

Raw material	2/3 Miscanthus and 1/3 grape marc	Miscanthus
Moisture content, wt.-%	6.0	4.0
Heating value, MJ/kg (dry basis)	18.557	17.754
Bulk density, m^3/kg	676	645
Ash content, wt.-% (dry basis)	3.77	2.34
Cost of raw material, €/t	50.00	80.00
Range for price of pellets, €/t (incl. VAT)	100 - 130	130 - 160
Raw material potential in the area, t/a	4,500	2,500

Producers view

To establish the production of alternative (mixed) biomass pellets in several regions in Germany and Europe the marketing of the pellet presses is of great relevance. Important aspects for enhancing regional pellet markets 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 (mixed) biomass pellets is too less.
- Regional market structures do mostly not exist.

Due to these aspects the agrarSTICK® concept will provide the partners with know-how of the production of alternative (mixed) biomass pellets and support for the marketing of their products.

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

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Combustion of grape marc pellets in small and medium scale combustion systems

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 wood. 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 viticulture and vegetable gardening to establish a practical recovery strategy in terms of circular flow economy. The European patent EP 1783195B1 (Process for making fuel from grape marc, particularly in pellet form) is held by RLP AgroScience GmbH.

Figure 1: Grape marc residues

Legal framework

The revision of the German "Renewable energy act" and the market support program for renewable energy provides a challenge for the use of renewable energy in rural areas. In Germany it is necessary to distinguish whether a permission according to Federal Immission Control Regulation No. 4 (4th BImSchV) or No. 1 (1st BImschV) is needed. The recently amended 1st BImschV covers the construction, quality and operation of small scale combustion systems up to 100 kW which do not require any approval. Larger installations (up to 50 MW) are subject to licensing and emission threshold values according to the "Technical Instructions on Air Quality Control" (TA Luft). In combustion plants without permission (according to 1st BImSchV) licensed fuels are "straw, whole plants (also pellets), grains (also pellets), energy grain processing residues, husks, culms residues and similar herbaceous biomass substances (like Miscanthus or hay)" or "other renewable sources".

Table 1: Threshold values

Parameter	Units	1st BImSchV (1st step)	TA Luft
Nominal heat output	kW	≥ 4 – < 100	> 100 – < 1000**
Reference oxygen content	Vol. -%	13	11
dust	mg/m³	100	50
CO		1000 (250*)	250
NO_x		600*	500
SO_2		-	350
HCl		-	30
Dioxine /Furanes	ng/m³	0.1*	0.1

* Threshold value for type tests
** based on thermal input

According to 4th BImSchV no fuels are specified, only a group No. 1.3 "other solid or liquid fuels than coal, natural gas, heating oil

(…)" is named. The requirements of both control regulations are listened in Table 1.

Combustion of grape marc pellets

Grape marc is a manifold structured, heterogeneous mixture which generally consists of approximately 40 % 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. Grape marc pellets and blends with vine wood 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 mixture with vine wood (ratio: 70/30 Vol. -%) are listed in Table 2.

Table 2: Quality parameters of the pellets

parameter	units	grape marc	blend
Moisture content	w.-%	10 - 13	10 - 12
Net calorific value	MJ/kg (dry basis)	19.8	19.0
Ash melting temperature	°C	910	900
Ash content	w.-% (dry basis)	6.5	5.6
N		1.89	1.70
S		0.12	0.14
Cl		0.004	< 0.005

First combustion tests with a small scale underfeed burner has shown a good applicability for the utilisation as a solid fuel.

The grape marc pellets revealed good combustion behaviour which, however, caused some high gaseous emissions. In this context, the total CO-emissions are valid to insufficient air supply or rather insufficient control characteristics of the combustion system.

Figure 2: Combustion of grape marc

However, there may be problems in the combustion as well as increasing NO_x- and SO_2-emissions as a result of increased contents of nitrogen and sulphur. An advantage is a low proportion of chlorine which leads to low formation of HCl-emissions and corrosion, see Table 3.

Table 3: Results of combustion tests with pellets (n.m.: not measured)

parameter	units	grape marc	blend
CO	mg/Nm³ (13 Vol.-% O_2)	3,174	~ 800
NO_x		868	352
SO_2		39	n.m.
HCl		0.4	n.m.
dust		214	n.m.

Slagging tendencies have slightly been occurred during the combustion process but had no negative impact on the bottom ash removal. Although, the dust emissions are high but can be kept with secondary measures. Additionally, blends with vine wood can improve the fuel properties and combustion characteristics.

Operators view

Due to the fact that the licencing of the combustion systems is difficult a demonstration of the technical and economic feasibility for the combustion of blended grape marc pellets has been started in March 2011.

Figure 3: Demonstration plant at AgroScience

Therefore, a HARGASSNER AGROFIRE 30 will provide domestic hot water during summer in addition to an existing 920 kW wood chip boiler for space heating purposes.

The objective is to implement a marketable product in a medium-term period which strengthens a sustainable recycling management and rural economics.

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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.
- 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	20.78	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	0.004	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.

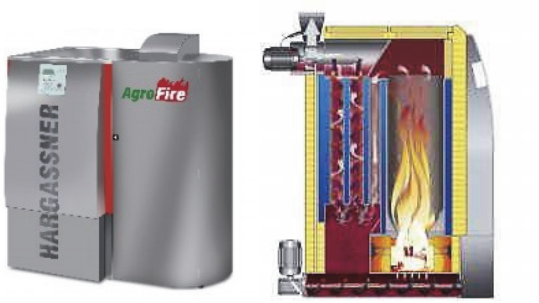

Figure 3: Hargassner Agrofire 30 (www.hargassner.at)

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 NO_x- 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
NO_x		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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D2 CASE STUDIES

Case study 1 “Grape marc”

Production: The pelletizing company owns a pelletizing plant with a modular design.

Customers: Small scale heat plants up to large scale plants.

Case study 2 “Dried digestate “

Production: The pelletizing company owns a pelletizing plant with a modular design.

Customers: These pellets should be used for the combustion in a power range of 300 kW.

The results of the case studies are included in the “Cost Analysis Report” of the MixBioPells project. The report is available at the project website: **www.mixbiopells.eu/en/publications.html**.

D3 NATIONAL CONDITIONS

The definition of biogenic raw material is included in Ordinance on Generation of Electricity from Biomass (Biomass Ordinance – BiomasseV). Biomass within the meaning of this Ordinance shall be taken to mean fuels made of phytomass and zoomass. Thisl also includes products, by-products, residues and waste from phytomass and zoomass whose energy content comes from phytomass and zoomass. Biomass within the meaning of the ordinance includes the following raw materials in particular:

- plants and parts of plants,
- fuels made from plants or parts of plants whose components and intermediate products have all been produced from biomass,
- waste and by-products of plant and animal origin from agriculture, forestry and commercial fish production,
- biological waste within the meaning of Art. 2 No. 1 of the Biological Waste Ordinance (Bioabfallverordnung),
- waste wood, comprising used wood (used products made from wood, wood materials and composites with a proportionally high wood content) or industrial waste wood (waste wood from woodworking and wood processing operations and waste wood from operations in the wood materials industry) which is considered waste.

The following raw materials are not considered biomass within the meaning of this Ordinance:

- fossil fuels and products and by-products made from them,
- peat,
- mixed municipal solid waste from private households and similar waste from other source areas,
- waste wood:
    - that contains more than 0.005% by weight of polychlorinated biphenyls (PCB) oder polychlorinated terphenyls (PCT) within the meaning of the provisions of the PCB/PCT Waste Ordinance (Abfallverordnung) of 26 June 2000 (Federal Law Gazette I p. 923)
    - that contains more than 0.0001% by weight of mercury
    - of other types, if its thermal exploitation as waste for recovery is prohibited under the Closed Substance Cycle and Waste Management Act.
- paper, cardboard and pasteboard,
- sewage sludges within the meaning of the Sewage Sludge Ordinance (Klärschlammverordnung),
- harbour sludge and other waterbody sludges and sediments,
- textiles,
- animal carcasses or parts thereof and products within the meaning of Art. 1 (1) of the Animal Carcass Disposal Act (Tierkörperbeseitigungsgesetzes), which are to be disposed of in slaughter houses pursuant to ordinances enacted thereunder, and substances which occur through their disposal or through other means.

For the use of certain raw materials in combustion plants it is necessary to distinguish whether a permission according to Federal Immission Control Regulation No. 4 (4. BImSchV) or No. 1 is needed. In combustion plants without permission according to 1st BImSchV licensed fuels are “straw, whole plants (also pellets), grains (also pellets), energy grain processing residues, husks, culms residues and similar herbaceous biomass substances (like Miscanthus or hay)” or “other renewable sources”. For No. 4 no fuels are specified, only a group no. 1.3 “other solid or liquid fuels than coal, natural gas, heating oil (…)” is named. The recently amended 1st BImschV (Federal Immissions Control Regulations) covers the construction, quality and operation of small firing systems which do not require any approval according to § 4 of the Federal Immissions Control law (Bundes-Immissionsschutzgesetzes - BImschG). This law distinguishes between installations that are subject to licensing and those that do not need an operation licence.This also includes small combustion systems for the use of non woody biomass with a nominal heat output below 100 kW. Larger installations (up to 50 MW) are subject to licensing, emission limit values according to the “Technical Instructions on Air Quality Control” (TA Luft). The combustion of mixtures is done according to 1.BImSchV §3 Abs.1 No.13. Within the framework of 1.BimschV yearly mesurements for particle and CO emissions are required.The requirements of both control regulations are listened in the following tables.

Emission threshold values according to 1st BImschV (Federal Immissions Control Regulations):

parameter	**thermal output**	**reference oxygen content O_2**	**CO**	**OGC**	**NO_x**	**SO_2**	**particles**	**dioxins / furanes**
unit	kW	Vol.-%	mg/Nm^3					ng/Nm³
straw and other herbal raw materials, non food cereal crops according to 1.BImSchV §3 Abs.1 No.8	≥ 4 – < 100	13	1,000 (250*)	-	600*	-	100	0.1*
other renewable raw materials according to 1.BImSchV §3 Abs.1 No.13			1,000 (250*)	-	600*	-	100	0.1*

* threshold value for type tests

Emission threshold values according to “Technical Instructions on Air Quality Control” (TA Luft):

parameter	thermal input	reference oxygen content O_2	CO	OGC	NO_x	SO_2	Particles	HCl	dioxins / furanes
unit	MW	Vol.-%	mg/Nm^3						ng/Nm³
Straw and other herbal raw materials (e.g. cereal whole plant, grasses, Miscanthus) according to TA Luft chapter 5.4.1.3)	> 1.0	11	250	50*	500	350*	50	30*	0.1*
	< 50		250	50*	400	350*	20	30*	0.1*

* Common value which should be not exceeded (according to TA Luft chapter 5.2)

If the European Unions Framework Directive on Eco-Design of Energy-Using Products (Directive 2009/125/EC) is coming into force the German framework will be adjusted. If there are no regulations existing, legal authorities will set the permission and the threshold values at their sole descretion.

ANNEX E: ITALY

E1 BEST PRACTISE EXAMPLES

Pelletizing straw and cornstalks at Bagioni group

Background

Bagioni Group is a consortium of companies involved in agriculture, livestock and energy sectors. Companies have been engaged for many years in the cultivation and trade of products for animal feed. Afterwards, the group has developed a strong interest in agri-energy, building a biogas plant for electricity production (850 kW_{el}). Part of the heat energy produced by the power plant is used for drying the materials used for pellet productions. This makes possible saving energy and reducing the production costs of pellets and makes the process more sustainable.

Raw material

The company has developed experience in the production of alfalfa pellet material. However, other biomasses are involved (and will be involved) in the production of pellets for energy use. Among them: straw, corn stalks, residues of maize, pruning of trees, plants extirpated and also various types of wood (mixed with other biomasses). The production of these crops is highly variable. In the case of straw, the production can range from 3 to 5 t/ha dry matter, depending on the kind of crop (maize, sorghum,…). The biomass moisture content at harvest time can vary from 30% to 40%. Pruning trees production can range in average from 1.5 to 3 t/ha dry matter depending on the type of training system and the residual crop. The moisture content during harvest time can vary from 40% to 50%. Corn stalks production is over 3.5 t/ha of dry matter. Bulk density of the raw material varies between 120 and 180 kg/m^3. The pellet production process increases the bulk density of about 3.5/4.5 times and improves the stability of the final product with less moisture content. The crops are harvested using different machinery systems. Straw material is available during the summer time (June and July preferably) after the threshing. The material, left in the fields for a short period of time, loses part of the moisture content; then it is stored in covered barns. The product is handled with the traditional transport machinery used for forage. Corn stalks are stored in bales (300 – 500 kg). Good storage conditions could reduce significantly the moisture content of the materials up to 20-25 %. Prices of the material varies between 25 and 35 €/ton (transport excluded). The quality of the material depends on the kind of biomass and the conditions of its working. It's important to avoid picking up the soil from the ground during the harvesting: in this way, the level of ash can be kept low and the consumption of the die for the production of pellets can be reduced. In the following table the characteristics of the materials are shown.

Raw material characteristics.

	Corn stalks	**Pruning tree**
Moisture content wt.-%	35-45	35-40
Heating value MJ/kg	16.5-17.0	17.0-18.0
Ash content wt.-%	6-7	3-6
Ash melting temperature °C	1,200	1,300

Raw material characteristics (continued).

	Corn stalks	Pruning tree
Chlorine wt.-%	0.05-0.06	0.03-0.04
Sulphur wt.-%	0.08	0.01
Nitrogen wt.-%	0.8	0.5
Raw material costs €/t	25-35	40-50

Pelletizing process

The pellet plant of Bagioni Group has a production capacity of 15,000 t/year working on three production lines. Great part of the production is currently used for animal feed. For the production of mixture pellet, made of agricultural residues and wood, the product is loaded onto conveyor belts and then mixed.

Corn stalks & sorghum stalks bales close to the conveyor belt

A hammer mill grinds is used and the material goes through a sieve of Ø20 mm before the drying. This process takes place in a drum rotating cylinder dryer until the material reaches a moisture content of 12-14 %. A belt conveyer transports the raw material to the pelletizing machineries (flat and ring die). At the moment, the producer has ring dies of 6 and 8 mm (28 mm for hard material – 50 mm for soft material) and no additives are used. Model of pelletizing machinery is Matador 30.

Drum rotary drier

The moisture content before the pellet process is between 10-14 % depending on the raw materials. Just produced pellets reach a temperature of 90 °C, then they are cooled by air and the dust is removed from the product. Production costs, without considering the raw material cost, range from 50 to 80 €/t.

Internal view of the pelletizing machine

Producers view

Bagioni group considers the production of pellets for energy an important alternative to the livestock sector. It's interesting to consider that this company can utilize the low-cost heat produced by the biogas plant. This opportunity reduces the cost of the raw material drying and especially for the wood, used with alternative biomasses to obtain a better quality pellet.

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Combustion of alternative pellet in Tomasoni farm

Background

Tommasoni company is a livestock farming in the middle of the Padana plain (Visano - Brescia). The company has got about 400 dairy cows, among which there are many calves fed with formula milk. The preparation of milk requires 85 °C hot water to dissolve the powdered milk; this operation is carried out twice a day. The total production is about 5000 litres of milk per day.

Up to 4-5 years ago, the Tommasoni company used a boiler with a burner fed by heating oil (diesel oil). The burner was then replaced by a new system, developed by Termocabi, fed by pellets made of agri-residues and alternative materials.

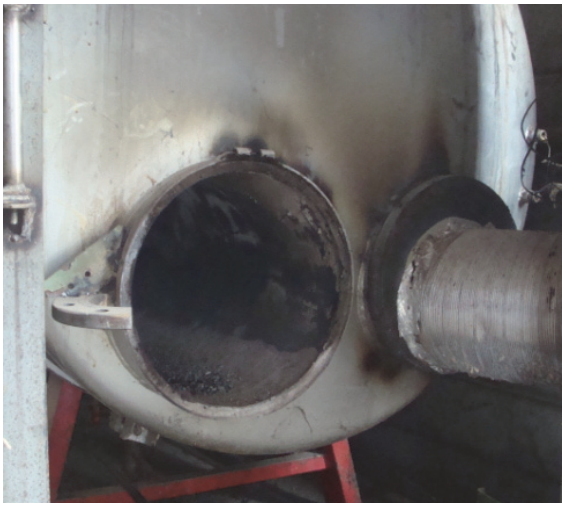
The choice of changing the burner was mainly due to the increase in fossil fuel prices and by the opportunity of finding cheap pellet in the local market.

Internal view of farming

Alternative pellet

The pellets used by Tommasoni are made of various agricultural residues produced in the region, mainly straw, corn stalks and scraps of grain corn. The choice of the type of pellet is made on the basis of its price and quality. The price can range from 130 €/t, for low-quality pellets, up to 190 €/t for a mixture of pellets, made of wood and agricultural residues.

Typically, the purchase of the product takes place in summer, when the price of pellets is much lower than in autumn and winter. The product can be delivered in big bags or in standard bags (15 kg). The bags rarely have labels with enough information on the product quality.



Boiler in the dairy of Mr. Tommasoni.

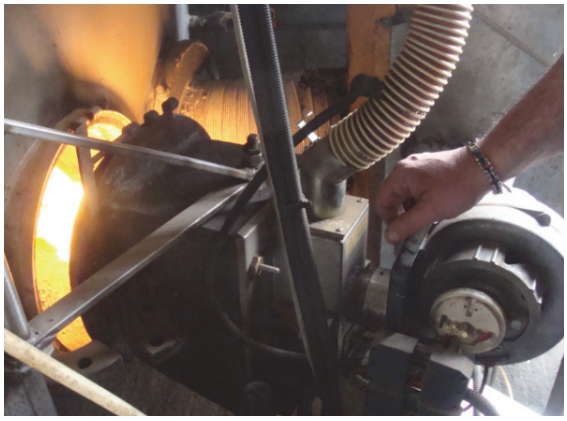
The pellet, in some cases, has a very high ash content (more than 6%): this can be observed directly after burning, when the system of collecting unburned and ash material is emptied.

Raw material characteristics

Parameter	Value
Moisture content wt.-%	< 10
Heating value MJ/kg	16.9
Ash content wt.-%	> 5.0
Ash melting temperature °C	----
Chlorine wt.-%	0.08
Sulphur wt.-%	---
Nitrogen wt.-%	1.2
Raw material costs €/t	130 – 190

Boiler and burner

The burner can supply a power of 50 kWh. It was designed to use pelletized materials made of agricultural residue (AGRIPELLETS Model). The burner is a blown air type, with the horizontal flame in a monoblock structure. The burner can expel the ash material continuously as agglomerated, without interfering with the combustion process. This burner system is also able to use other dry and dense biomasses (moisture content lower than 15 % and bulk density higher than 500 kg/m^3), as grain of maize.



The pellet burner of 60 kW.

Mr. Tommasoni can easily regulate the combustion of this burner: this is mostly important when there is a changing of the pellet type. The parameters that can be handled are: the regulation of primary air, the feeding speed of the burner and the discharge mechanism of combustion ashes. This last system is particularly important to avoid the formation of inorganic aggregates, especially in case of low temperature melting ash.

Producers view

The use of the pellet burner has determined significant cost savings. The initial investment was related to the replacement of the burner (a few thousand euros). In the last year the price of diesel oil has increased from about 60 €/kg to 90 €/kg.

The boiler has not shown particular problems and the adjustment of the burner is quite simple and doesn't take a long time. On average, each year are consumed about 25 tonnes of pellets. The space available for storage in the farm is essential to make purchases of pellets during the period when the price is lower.

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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 equipments 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 equipments 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: typical 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 doesn't 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.

E2 CASE STUDIES

Case study 1 “Miscanthus and poplar”

Production: The pellets are produced (vertical die) and consumed directly in the power plant.

Customers: Power plant or district heating systems are possible customers.

Case study 2 “Vine pruning“

Production: The pellets production company uses a vertical die technology.

Customers: The customers are mainly household heating systems.

The results of the case studies are included in the “Cost Analysis Report” of the MixBioPells project. The report is available at the project website: **www.mixbiopells.eu/en/publications.html**.

E3 NATIONAL CONDITIONS

In Italy, biomass is defined in two different ways:

- According to environment protection act (D.lgs 152/2006) biomass is considered as a fuel only if it has not been submitted to any chemical treatment. In some cases raw materials like poultry litter or byproducts of landscape gardening are excluded from the definition and are considered “byproduct”. The raw materials can be considered for energy purposes as “fuels”. This definition is not an easy-to-apply rule which causes big uncertainties in the market.
- According to legislation on renewable energy promotion (implementation decree of Directive 2009/28) biomass is any biogenic matter, regardless its origin or quality including. Thus, any vegetal biomass from agriculture, forestry or agro-industry, which has been submitted only to a mechanical treatment, can be considered a fuel.

For the energetic utilisation of raw materials considered in Legislative Decree 152/06 (annex X, part V, Section 4 Biomass) the following requirements for the emission threshold values according to Dlgs 152:2006 (Environmental Standards) have to be fulfilled:

parameter	**thermal output**	**reference oxygen content O_2**	**CO**	**OGC**	**SO_2**	**particles**	**NO_2**
unit	MW	Vol.-%	mg/Nm^3				
values	> 0.15 - <1	11	350	-	200	100	500
	> 3 - ≤ 6		300	-	200	30	500
	> 6 - ≤ 20		250/150 [1)]	30	200	30	400
	> 20		200/100 [1)]	10	200	30	400

[1)] Average daily value

There are no specific legal conditions for the combustion of mixed biomass pellets as long as the raw materials are classified as "Biomass" (based on the Dlgs 152:2006) and the requirements for the emissions threshold values are fulfilled. The implementation of more strict emission threshold values is not planned. If the European Unions Framework Directive on Eco-Design of Energy-Using Products (Directive 2009/125/EC) is coming into force the Italian legal framework will be adjusted. If there are no regulations existing, legal authorities will set the permission and the threshold values at their sole discretion.

ANNEX F: SPAIN

F1 BEST PRACTISE EXAMPLES

Vine pruning pelletizing by Orientación Sur Consultoría S.L.

Background

Since 2010, Orientación Sur Consultoría S.L. owns and operates a pellet production plant. The plant has an initial production capacity of 20,000 tons/year. It has been designed to allow for any necessary modifications of the raw material used for pellets production in a short time span. The company aims to achieve a pellets production which is consumed within the national market, as well as its use for heat generation. The production site is based in the village of Valdepeñas, which is located at the Spanish region of Castilla la Mancha, the largest wine production area in the world. Due to the broad variety of biomass goods that can be treated, it is equipped with a pellets combustion laboratory that carries out the pellet design, which varies depending on the combustion technology to be used. Orientación Sur Consultoría S.L. is privately owned company and its R&D&I work is aimed to be the Company´s main value for the future. Orientación Sur Consultoría S.L.´s vision can be summed up as a "THINK GLOBALLY, ACT LOCALLY" philosophy and its main work line is based on making the most of the local resources and use organic waste in a proper way.

Technology used	Ring die press
Production capacity, tons/year	20,000

The market of vine pruning and organic waste is fairly reduced, so even though the possibility of their use is real, the information about its advantages is not reaching the client at the time he/she buys his/her pellets boiler. No information is provided on the various types of pellets that can be used. So far, all produced pellets have been generally called "wood pellets", which has caused confusion among consumers, as not every one of them presented the same behaviour during combustion.

The main raw material is the vine pruning that has been collected at a maximum distance of 15 km from the place. Logistics is quite complex due to two main factors: first, the low density of the raw material and secondly, the average size of the agricultural development plots.

Pruned vine.

Another important factor is the seasonal nature of vine pruning collection, from November to February, for its subsequent manufacturing, as we have to allow for the necessary storage space.

Vine pruning storage.

Raw material

Raw material characteristics

Raw material	Vine pruning
Moisture content, wt.-%	30
Lower Heating value, MJ/kg	17.86
Bulk density, kg/m³	110
Ash content, wt.-%	3 - 5
Ash melting temperature, °C	< 900
Raw material costs, €/t	45
Biomass potential, t/year [1)]	500,000

[1)] Total amount of the annual vine pruning produced within the region is 500,000 t/year.

Pelletizing process

The plant produces about 4 tons per hour depending on the material used. There is one pelletizing line:

- Raw material storage
- Hammer grinder
- Ring matrix pelletizer
- Cooler
- Packaging machine
- Bulk storage tank
- Big bag and standard bag storage

Aerial view of the plant.

Drying is not necessary due to the local climate, which simplifies the industrial process and reduces production costs.

Laboratory with Biokompakt AWK boiler. An adjusted combustion technology is important.

Producer´s view

100 % of the biomass material used by Orientación Sur comes from agriculture or forestry. The company is prepared to integrate several types of locally generated biomass material within its productive process and has worked at developing energy crops with low water consumption needs.

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Combustion of vine pruning pellets at Orientación Sur

Background

The region of Valdepeñas has a wine growing area of 30,000 hectares, producing 20,000 tons vine prunings each year. Most of this biomass is burned on the premise without being used for heating purposes. This practice is subject to sanctions by the Common European Agricultural Policy. Furthermore, it does not produce any benefit for the farmer. At the moment, on lay a minor part of the vine prunning is used to produce a solid fuel suitable for boilers. The combination of available biomass resources and an underdeveloped biomass market as it is in Spain offers great opportunities which is the background basis for the initiative of Orientación Sur.

Southern Spain can be considered as a sub-desert area. Therefore, the possibilities for an agriculture-based energy market are limited to wine growing. Similarly, forestry areas undergo a growth stage and are not a suitable fuel source at the moment.

Vine pruning pellets

Pellets were produced from vine prunnings. However, they do not fulfill the EN product standards. Thus, the properties and the origin of the utilised raw material should be included in the fuel trade name increasing the consumer's awareness. Similarly, the boilers should be labeled according to the fuel types they could be used for.

Characteristics of the vine pruning pellets

Water content, wt.-%	8 - 10
Lower heating value, MJ/kg	17.86
Bulk density, kg/m^3	650
Ash content, wt.-%	3 - 5

The available vine pruning within Spain is 500,000 tons/year.

Pellets made from vine pruning.

Combustion process

The lack of information about the various types of pellets that exist and the different available combustion technologies is a major deficit in Spain. The private or professional owner of a pellet boiler would look for the cheapest fuel without taking into account if the technology is suitable for the fuel. Thus, boiler malfunction and user dissatisfaction is a common problem. Generally, these types of fuels have a clear industrial application. However, users don't see why they shouldn't benefit from this low-cost fuel.

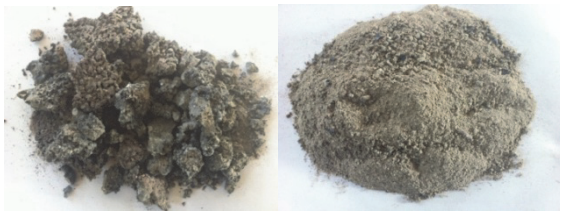
The Spanish boiler & stove market is mostly covered by Austrian as well as Italian manufacturers. A common feature of these boilers is the lack of suitable ash removal systems to transport the ash into the ash box. This is because these boilers are designed for high quality wood fuels with low ash content. Medium scale boilers are usually equipped with moving grates which remove the ash by pushing new fuel in and moving the ashes towards the ash box. This equipment is able to use low quality fuels. However, the user has

still to clean the equipment more frequently. Boilers with horizontal heat exchangers require more maintenance than boilers with vertical heat exchangers. The efficiency during combustion at this equipment is mostly low, as combustion control is generally quite limited. Large scale boilers offer an exceptional combustion control, though they have been designed for fuels in the shape of pellets with very low ash content. Therefore, fuels with higher ash content can cause reduced efficiency and demand long-term stops to clean the equipment, as access to its inner part is very limited or even impossible.

Orientación Sur made several combustion tests, and finally found a technology which was suitable for vine prunning pellets.

*Biokompakt AWK (*www.biokompakt.com*)*

The Austrian manufacturer Biokompakt has an especially designed boiler, which is able to use any type of solid fuel while maintaining combustion efficiency. The AWK Biokompakt boiler proved successfully the combustion of vine pruning pellet, rape pellet, fruit stones, woodchip, straw pellets, bark, etc. The boiler allows regulating combustion efficiently while ensuring an efficient function of the system and keeping a low consumption of the locally obtained fuel.



Pellet ashes from rape pellets (left) and pellet ashes after adjusting combustion parameters with alternative fuels (right).

The combustion tests proved that the pellet ashes in the combustion system don't cause any malfunction problems. However it is possible to optimise the functioning of the boiler adjusting the combustion parameters.

Conclusions

The production of solid fuels as pellets and its local use for heat production is a real alternative to the creation of local jobs and contribution to the waste management of the Spanish agriculture sector. However, fuels produced with local biomass resources are unable to fulfill the actual requirements of the solid biofuel market under the European standard framework.

If a solid fuel standard is established, it should include every possible solid fuel that may exist in order to create an open market, which can be competitive and offer various options to the final consumer. The price paid by the final consumer for alternative fuel can range from 15 to 35% less than for solid fuels subject to the European Standard. The pellet, which is produced from waste is energy and can be used for saving. There are developed commercial technologies ready for use.

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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.

F2 CASE STUDIES

Case study 1 “Olive stones from the food industry”

Production: One pelletizing experiment has been carried out.

Customers: Possible end users are private pellet stove/boiler owners as well as small district heating systems (e.g. hospitals).

Case study 2 “Almond shells from the food industry “

Production: The pelletizing company has studied and tested different processes in order to obtain physically stabile briquettes. The final formula has been patented.

Customers: Possible end users are the industry, farms, industrial bread ovens (restaurants and supermarkets).

The results of the case studies are included in the “Cost Analysis Report” of the MixBioPells project. The report is available at the project website: **www.mixbiopells.eu/en/publications.html**.

F3 NATIONAL CONDITIONS

In Spain there are different types of biomass available for energetic use. According to the PER (Plan de Energias Renovables) the following raw materials can be considered:

- biomass from forests,
- woody agricultural residues (pruning of olive trees, fruit trees and vineyards),
- grass agricultural residues, mainly straw and corn maize stover,
- residues from wood industry,
- residues from agricultural industries (olive Stones, almond shells,…),
- energy crops, mainly cardoon, sorghum and Ethiopian canola.

In Spain, there are no emission threshold values for the use of these materials in combustion plants. Legal authorities will set the permission and the threshold values at their sole discretion by orientating on the legal framework of other European countries, e.g. Germany. If the European Union Framework Directive on Eco-Design of Energy-Using Products (Directive 2009/125/EC) is coming into force, the Spanish legal framework will be adjusted.

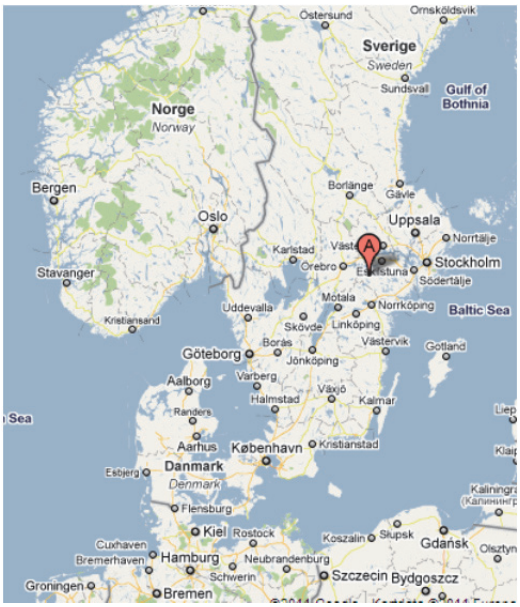
ANNEX G: SWEDEN

G1 BEST PRACTISE EXAMPLES

Briquetting of Canary Reed grass at Låttra Farm, 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 briquettes. A spring harvest usually yields between 4 and 6 tonnes dry weight per hectare under normal conditions. If the crop is harvested early in the spring the dry substance is usually between 80 to 90 percent. Låttra 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 for ley and fallow because many farms in the area have fields with "low productivity" i.e. that do not yield enough profit to warrant growing foodstuffs.



Location of Låttra Farm

Cultivation of reed canary grass (RCG) on Låttra farm

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, the species of RCG and what and if fertilizer is used. The first harvest is taken in the spring two years after sowing and is about 20 % lower than following harvests. The harvest rate is around 4-6 tonnes DM per hectare at normal conditions for a spring crop.

Typical fuel properties 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

Harvest

Reed canary is slain 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. The Bales are afterwards transportetd from the field to the the briquetting hall for chipping and briquetting.

Reed canary grass

Briquetting

Låttra farm has the capacity to produce 3500 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 1000 tonnes of briquettes. The briquettes are taken directly from the silo for delivery to customers.

Briquetting presses

Transport

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

Consumers

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, heating supplier, based in Ulricehamn. TCG builds and operates different kinds of district heating plants. The aim 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. In autumn 2011, TCG will begin work with optimising the plant to be able to use reed canary grass from Låttra Farm.

Problems/ possible obstacles

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.

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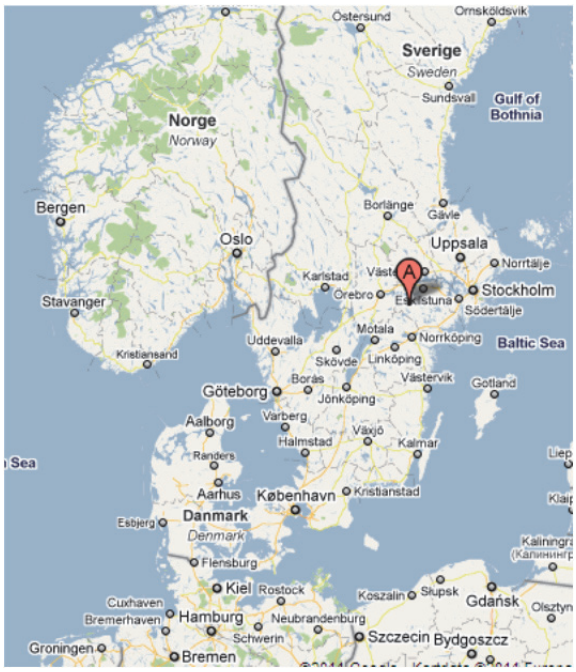
Combustion of Reed Canary grass briquettes at Låttra Farm, Sweden

Background



Location of Låttra Farm

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 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.

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

Reed Canary grass bales

Briquetting

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.

Combustion at Låttra farm

Låttra farm has a Veto Flisomat burner of 120 kW. The Flisomat is equipped with a movable grate mounted in a Danstoker boiler of 230 kW. Reed canary grass briquettes have been combusted successfully in this plant during long-term combustion trials. The ash is disposed through a screw that is going lengthways in the boiler. Since the burner is mounted in a boiler with a greater effect than the burner requires the ash is stored in a good-sized ash drawer. During November-December 2010 reed canary grass briquettes with an ash content of about 6 % were combusted for 5 weeks without any problems with ash in the fireplace. The advantage of the Veto technology is that the installation of moving grate and ash screw is optional, which facilitates the upgrading of existing facilities.

Veto Flisomat (Källa: www.energiteknik.net/pdf/thmSWE.pdf)

Problems/ possible obstacles

The main challenge is equipment that can handle ash rich fuels and to find ways to decrease corrosion.

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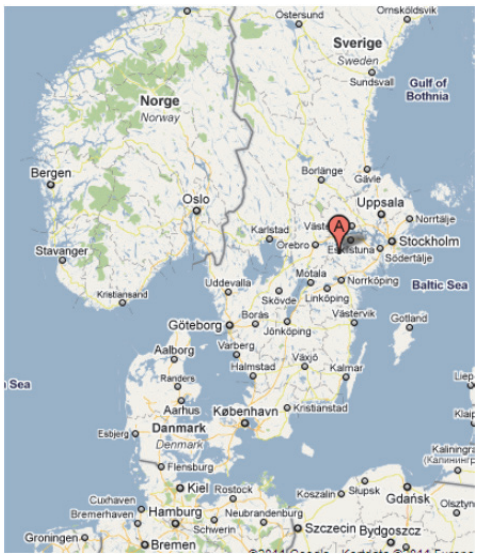
Production and combustion of Reed Canary grass briquettes in Sweden

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

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

Combustion chamber

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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G2 CASE STUDIES

Case study 1 and 2 “Reed Canary Grass”

Production: Any agricultural company running a small commercial briquetting plant.

Customers: Heating plants, public buildings as well as households.

The results of the case studies are included in the “Cost Analysis Report” of the MixBioPells project. The report is available at the project website: **www.mixbiopells.eu/en/publications.html**.

G3 NATIONAL CONDITIONS

The concept “licensed fuel” is not used in Sweden. Solid fuels are divided in groups with respect to their origin: forest fuels, peat, agricultural fuels, fuels derived from waste etc. Furthermore, the term “combustion of alternative pellets” applies only to pure raw materials. If the biomass fuel is mixed with a controlled stream of a well defined waste product, it should be classified as “co-combustion”. For utilisation of a more complex waste fuel the combustion should be classified as waste incineration. If the main purpose of the co-incineration plant is not the generation of energy or the production of material products but rather the thermal treatment of waste, the plant shall be regarded as an incineration plant. Generic emission standards for incinerators are in the form of ordinances, regulations and guidelines. In addition, there are some guidelines for emissions set by the government and parliament. Finally, the practice developed in the examination of plants led to a form of "unofficial" guidelines. More detailed emissions requirements for the incineration of waste takes place, see Environmental Protection Agency regulations for waste incineration (NFS 2002:28) based on the EC Directive 2000/76/EC. In the following tables the emission threshold values are listed according to the used fuel:

Waste fuels (for the use in plants with a fuel capacity < 6 t/h):

parameter	reference oxygen content O_2	NO_x	SO_2	particles	HCl	dioxins / furanes
unit	Vol.-%	mg/Nm^3				ng/Nm^3
value	11	200/400	50	10	10	0.1

Renewable fuels:

parameter	nominal effect	reference oxygen content O_2	OGC	NO_x	SO_2	particles
unit	MW	Vol.-%	mg/Nm^3			
value	< 0.05	10	150/100[6]	n.a.	n.a.	n.a.
	0.05 - 0.3		100/80[6]	n.a.	n.a.	n.a.
	0.3 - 50	13	n.a.	~80	100	100/350[1]
	50 - 100	6	n.a.	400[4]	190[3,5]/200[5]	n.a.
	50 - 350		n.a.	n.a.	190[3,5]/200[4]	n.a.
	50 - 500		n.a.	n.a.	n.a.	100[3]/50[5]
	100 - 300		n.a.	300[4]	n.a.	n.a.
	> 100		n.a.			30[4]
	> 300			200[4]		
	350 - 500				1000-400[2,3]/200[4]	
	> 500				400[3]/200[4]	50[3]/30[4]
	> 500				400[3]/200[4]	50[3]/30[4]

1. within residential areas / outside residential areas; 2. Linear decrease with increasing capacity. SO_2/Nm^3; 3. Existing plants.; 4. New plants.; 5. mg S/MJ fuel.; 6. manual/automatic feeding; n.a. … not available

The following remarks have to be taken into account by the assessment of the emission threshold values:

The Carbon Dioxide Tax was introduced in 1991 in order to provide energy tax incentives for an increased use of biofuels, thereby reducing emissions of carbon dioxide (www.skatteverket.se). In 2005, a system of trading emission allowances introduced in Europe with the aim of limiting carbon dioxide emissions in a cost effective way, see the Act (2004:656) on emissions of carbon dioxide and Ordinance (2004:657) on emissions of carbon dioxide (www.lagrummet.gov.se) No general national requirements on CO exist. The emission threshold values are set individually for each plant by the responsible legal authority (> 300 kW). For the small scale combustion systems up to 300 kW there are emissionn threshold values for OGC- but not for CO-emissions valid.

There are no absolute emission threshold values existing for NOx-emissions. General emissions threshold values are only valid for large combustion plants (NFS 2002:26). In practice, the emission threshold values are set individually by legal authorities where each actor pays or gets paid dependent on its annual emissions level (if the plant generates >25 GWh/year, national law (1990:613)). Lower emission levels result in reimbursement and vice versa.

The emissions of sulphur oxides are regulated by the national Ordinance (1998:946) which includes both direct emissions threshold values and the sulphur content in fuel (www.lagrummet.gov.se). For large combustion plants (> 50 MW thermal input) the emissions of sulphur oxide are regulated by EPA regulations (NFS 2002:26, www.naturvardsverket.se) based on the EC directive 2001/80/EG9. Since 1992, there is a sulphur tax on oil, coal and peat (30 SEK per kg sulphur). The tax incentives both to reduce sulphur content in fuel and to increase treatment of flue gas (www.skatteverket.se).

General requirements for particulate emissions are only valid for large combustion plants (NFS 2002:26). For power plants from 0.5 to 10 MW, the EPA has developed general guidelines (AR 87:2). A level of 100 mg/Nm3 is valid (higher valuesar possible if the combustion plant is located outside urban areas). The implementation of stricter emission threshold values is planned for particle emissions. But no values have been suggested so far. If the European Unions Framework Directive on Eco-Design of Energy-Using Products (Directive 2009/125/EC) is coming into force the Swedish legal framework will be adjusted.