AgroBioHeat

Promoting the penetration of agrobiomass in European rural areas

Grant Agreement No 818369

D3.1 Report on identified cases

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Abbreviations

Abbreviation	Explanation
CHP	Combined Heat and Power
DH	District Heating
ESP	Electrostatic Precipitator; equipment used for controlling particle matter (dust) emissions
IED	Industrial Emissions Directive
GHG	Greenhouse Gases
MCP	Medium Combustion Plant Directive
RHI	Renewable Heat Incentive; the main support scheme for promoting installations producing renewable heat in the United Kingdom
SNCR	Selective Non Catalytic Reduction; a secondary measure for controlling emissions of nitrogen oxides (NOx)
SMEs	Small & Medium Enterprises
UNDP	United Nations Development Programme

Project consortium

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12	Agronergy	AGRONERGY
13	Association d'Initiatives Locales pour l'Energie et l'Environnement	AILE

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Executive Summary

Despite its potential to deliver renewable and cost-effective heating for a variety of purposes, agrobiomass is often considered as a more challenging fuel than renewable or fossil alternatives. The purpose of D3.1 is to present an inventory of existing facilities around Europe that have deployed heating systems using various kinds agrobiomass.

Facilities are identified from reference lists of manufacturers, expert knowledge and contacts of the AgroBioHeat project partners and direct contacts with value chain actors.

Key information for each facility has been collected: location, agrobiomass fuels used and form, boiler manufacturer (and other equipment used) and installed capacity. All the data, including supplementary information (e.g. external links) and photos are uploaded on the Agrobiomass Observatory (www.agrobiomass-observatory.eu) developed by the AgroBioHeat project.

Up to June 2020, the AgroBioHeat consortium has identified **126** agrobiomass heating facilities all over Europe.

90 facilities have been detected in the project multiplication countries (Croatia, Greece, France, Romania, Spain and Ukraine) and Denmark.

36 agrobiomass heating facilities have also been identified in several other European countries: Austria, Belgiun, Czech, Ireland, Germany, Moldova, Poland, Slovakia, Sweden, United Kingdom.

Additional information for specific facilities of interest is also presented in this report. An 2nd version of this report will be made available in the second half of 2021, providing information on additional agrobiomass heating facilities identified.

Upcoming project deliverables will provide more detailed information on selected success cases of agrobiomass heating in the form of reports, factsheets and videos. The facilities will be chosen in order to represent a wide set of agrobiomass fuels, end-use sectors as well as appropriate geographical spread.

Introduction

The present document constitutes Deliverable 3.1 “Report on identified cases” of the AgroBioHeat project, prepared in the framework of Task 3.1 “Identification and selection of lighthouse cases”.

AgroBioHeat borrows the concept of “lighthouse” cases from Horizon 2020 projects in Smart Cities; a working definition for the purposes of AgroBioHeat is that a lighthouse case is an existing, operating facility using agrobiomass to produce heat in modern and appropriate combustion systems.

Unlike Smart Cities lighthouses (major and well-known urban centres), agrobiomass lighthouses are local, small-scale initiatives. As a result, they tend to have limited visibility beyond their local setting or a specialized circle of experts which limits their potential to serve as examples for replication and imitation. In order to overcome this, the whole WP3 of the AgroBioHeat project is dedicated to identifying and promoting lighthouse cases of agrobiomass heating in Europe.

D3.1 is the first step in this process, aiming to capture a long-list of relevant agrobiomass heating facilities located in Europe. Section 1 of this report gives a brief overview of the main data sources used for identifying relevant installations and presents the template used for capturing key points for each facility. The template is integrated into the Agrobiomass Observatory.

Section 2 to 8 provide an overview of the heating facilities identified in the project multiplication countries (Croatia, Greece, France, Romania, Spain, Ukraine), as well as project country Denmark, which is worldwide famous for its extended use of straw for energy production. For a small number of agrobiomass heating lighthouse cases identified in each country, additional details and insights are provided. Section 9 presents additional information for other European countries in which agrobiomass heating facilities have been identified. Finally, Section 10 summarizes some key findings and common messages related to the deployment of agrobiomass heat solutions in Europe.

1. Methodology

1.1. Identification and data collection

In almost all European countries, there is no single registry of biomass combustion facilities from which to select the ones using agrobiomass. Therefore, facilities have to be identified through a variety of means: contacting manufacturers that may wish to showcase their references, contacting agrobiomass fuel providers regarding their clients, own knowledge and contacts of the biomass sector as well as internet searches.

In order to streamline data collection, CERTH has created a simplified form to capture the main characteristics of individual agrobiomass heating facilities. The form data focus on technical characteristics that tend to not change over time and that are usually easily available. Table 1 is giving an overview of the data categories.

Table 1: Simplified form for data collection on agrobiomass heating facilities.

Data category	Explanation
Case Name	The name by which the case is most commonly known, e.g. the name of a production facility, of a municipality, etc.
Operator	The name of the facility operator can be provided, if different from that of the owner (e.g. in the case of an ESCO).
Installer	The name of the company that has installed the agrobiomass heating equipment can be provided.
Location	• Location (e.g. nearby city or municipality) • Country • X, Y coordinates (for exact positioning on the map)
Contact details	• Contact email • Contact phone • Website
Logo	The logo of the organization most closely associated with the case can be displayed.
Application	The field refers to the main intended use of agrobiomass heating. The following options may apply: • Agro-industry: facilities used in the production of food and feed, e.g. olive mills, wineries, distilleries, cereal processing, etc. • District heating: distribution of heat over a network to a number of buildings. • Domestic: individual residential buildings / apartments. • Farm: agricultural households, animal farms / stables, and related activities taking place in an agricultural setting (e.g. cereals drying). • Greenhouse: greenhouses, plant nurseries, etc. • Municipal building: individual buildings of municipal ownership. • Service sector: schools, universities, hotels, shopping malls, and any other building belonging in the tertiary sector.

Data category	Explanation
	• Other: any other possibility, not fitting any of the other options (e.g. process industries, pharmaceuticals, manufacturing, etc.).
Agrobiomass fuel (type / subtype)	Refers to the agrobiomass types used in the facility. In addition, a subtype providing further details on the exact origin of the agrobiomass can be used. The following list is mainly used. It is not based on a specific biomass classification, but rather on the frequency of use of its agrobiomass type. Additional types and subtypes can easily be inserted. • Cereal Straw • Prunings: olive, vineyard, fruit, etc. • Plantation removal: olive, vineyard, fruit, etc • Miscanthus • Short Rotation Coppice: willow, poplar, etc. • Nut shells: almond, walnut, pistachio, • Olive stones • Fruit pits • Exhausted olive cake • Sunflower husks • Reed • Corn cob • Others In addition to the above, it is also possible to indicate if a facility is using woody biomass fuels, such wood chips or wood pellets.
Agrobiomass form	Refers to the form in which agrobiomass is **delivered** to the heating facility. The following options may apply: • Bales • Briquettes • Chips • Granular fuel • Hog fuel • Other • Pellets
Equipment used	Refers to the equipment used to generate heat (e.g. biomass boiler), feed / pre-process the fuel on site as well as any flue gas cleaning systems installed. The equipment manufacturer and relevant mode / thermal output (for boilers) can be inserted.
Heating medium	Refers to the way heat is delivered from the biomass furnace to the end-use. Heating mediums can be one of the following: • Hot water; this is the most common format for space heating applications. • Steam; most commonly used in some industrial applications, e.g. distilleries. • Thermal oil; most often used for industrial processes, especially when high temperatures need to be reached.

Data category	Explanation
	• Air; most often used for drying applications and occasionally for space heating of large spaces (e.g. greenhouses). • Hot gas; most often used for direct drying of materials.
Links	Additional links can be provided, e.g. from the websites of manufacturers, installers, news, etc.
Photos	Relevant photographic material and images, e.g. photos from the boiler room, of the fuel used, etc.

1.2. The Agrobiomass Observatory

The information collected in the form described above for each individual case is uploaded on the Agrobiomass Observatory (www.agrobiomass-observatory.eu), an online map tool developed by the AgroBioHeat project.

The Agrobiomass Observatory includes information on biomass heating cases, other use cases (e.g. CHP, power production), equipment manufacturers (e.g. boilers, feeding systems, etc.), ESCOs and installers and fuel suppliers, with a primary focus on agrobiomass. A key feature of the Observatory is the establishment of connections between the different data sources. For example, by clicking on a specific biomass boiler manufacturer, a map of their reference installations can be displayed. In addition, filters can be used to identify cases using a specific type of biomass resource or narrow down results by country and sector of application.

Each data point upload on the Agrobiomass Observatory has its own direct link; the tables in the following chapters provide these links for each individual heating facility identified.

Note: heating facilities for the purposes of this activity are defined as those that produce only heat from combustion plants with total rated thermal input up to 50 MW, which is the upper limit of the Medium Combustion Plant Directive[1]. This excludes the following combustion plants:

- Biomass CHP plants.
- Biomass power only plants.
- Biomass heat only facilities with a total rated thermal input exceeding 50 MW; these facilities fall under the scope of the Industrial Emissions Directive[2].

All of the above, including cases in which agrobiomass is used for other energy purposes (e.g. biogas, 2nd generation biofuels, etc.) are included in the Agrobiomass Observatory as “other use cases”.

[1] Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants
[2] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

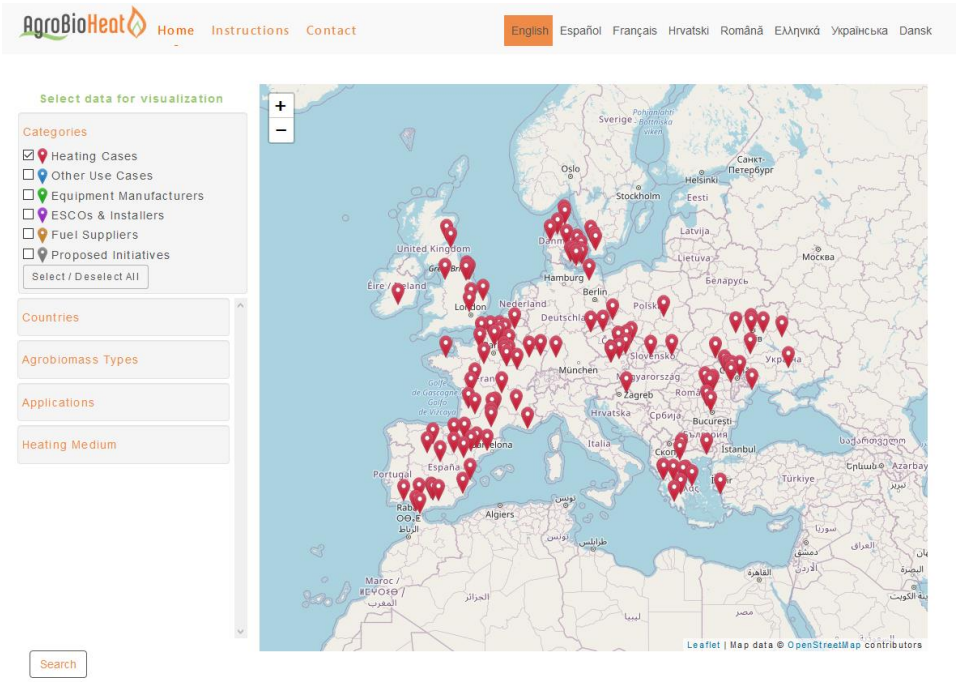

Figure 1: Overview of the agrobiomass heating facilities included in the AgroBiomass Observatory as of June 2020.

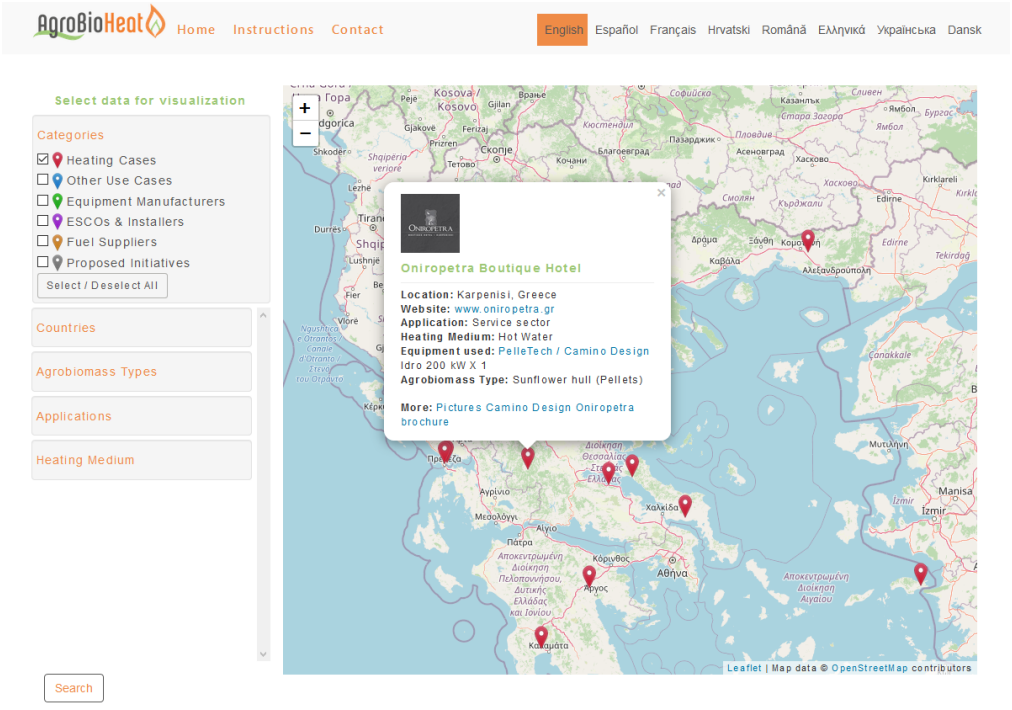

Figure 2: Example of an agrobiomass heating facility on the Agrobiomass Observatory.

1.3.Lighthouse cases

A small number of agrobiomass heating facilities in each country are be labeled as “lighthouse” cases – best examples of the use of agrobiomass for heating in practice. There is no strict definition of what constitutes a lighthouse case for the purposes of AgroBioHeat. However, some key factors that should be exhibited by these cases are: use of appropriate agrobiomass combustion technology (a boiler suitable for the fuel properties), appropriate innovation aspects (e.g. business, technology, fuel supply) depending on the case, unproblematic operation and favorable economics. Ultimately, a lighthouse case has an interesting story to tell that can be narrated by answering the “five Ws and one H”: who, what, when, where, why and how agrobiomass was deployed as a heating solution.

At the initial project stages, not all these questions can be answered in great detail. However, and in order to shed some additional light on lighthouse cases, some specific questions, in addition to those of Table 1 can be answered. The reply to those – even if not always possible to be easily given – can be used to generate some additional insights on each case. These are:

- Typical volume of agrobiomass used in a year / heating; typical moisture content
- Year of facility commissioning
- Type of installation: greenfield (new plant), replacement of existing heating system, expansion of existing heating system
- Whether agrobiomass is the only fuel used in the facility
- Typical level of annual fuel cost savings achieved compared to a reference fuel (usually a fossil one)
- Presence of flue gas cleaning systems
- Any additional interesting aspects (e.g. innovation) – in narrative form

The same data sources as for the initial facility identification can be used. Often, direct contact with the end-users of each facility is required to collect more detailed answers.

2. Agrobiomass heating facilities in Croatia

Croatia is mostly known for its forest biomass resources; 48.8 % of the total territory is forest land compared to 27.3 % of agricultural land. Therefore, even though the agrobiomass potential in Croatia is not insignificant, the agrobiomass sector is lagging behind the forest biomass one.

Despite that, there are a few agrobiomass fuel producers in Croatia and olive stones, nut shells or straw pellets[3] can be found in a few locations. In addition, miscanthus cultivation in Croatia is growing, promoted by companies such as BEECO[4]. Through contacts with these producers, AgroBioHeat project partner ZEZ further investigates good examples of agrobiomass heating that could be identified in the country.

A first example can be found in the greenhouse facility of OPG Ravenšćak, in Bjelovar. The main fuel used is sawdust in a 850 kW; the company has successfully used miscanthus and has plans to start cultivation of the crop from 2021.

Table 2: Agrobiomass heating cases detected in Croatia.

Case name	Application	Agrobiomass	Boiler manufacturer	Installed capacity (kW)	Observatory link
OPG Ravenšćak	Greenhouse	Sawdust, miscanthus	Topling	1 x 850	www.agrobiomass-observatory.eu/Case?id=1321

Figure 3: The greenhouse facility of OPG Ravenšćak (Source: www.cvijeceravenscak.com).

[3] EURO-TIM (www.euro-tim.com) is a straw pellet producer in Slavonia. The company cooperates with Czech boiler manufacturer MultiBio.
[4] http://eng.beeco.hr

3. Agrobiomass heating facilities in Denmark

Denmark is well-known for the energetic use of straw, which is practically the only agrobiomass resource available in the country.

In 2018, straw consumption amounted to 17,606 TJ (more than 1.2 million tons), contributing to 2.25 % of the gross energy consumption and 10.2 % of the renewable energy production[5]. Most of the straw – 33 % in 2018 - is used in a limited number (around 50) of district heating plants with thermal output capacities ranging 0.4 MW to 11 MW (average 3.8 MW)[6]. Small and large-scale CHP plants used 19.2 % and 19.6 % of the straw; most of the remaining quantities are used in more than 7,000 installations serving farms or individual households.

Several individual straw heating plants in Denmark have been identified through boiler manufacturers, either through their reference lists of through direct contacts. A list is presented in the table below.

Table 3: Agrobiomass heating cases detected in Denmark.

Case name	Application	Agrobiomass	Boiler manufacturer	Installed capacity (kW)	Observatory link
Boulstrup-Hou Kraftvarmeværk	District heating	Cereal Straw (bales)	Linka	1 x 2,000	www.agrobiomass-observatory.eu/Case?id=962
Fors A/S / St. Merloese Varmevaerk	District heating	Cereal Straw (bales)	Linka	1 x 4,500	www.agrobiomass-observatory.eu/Case?id=979
Frederiksdal Kirsebærvin	Farm heating	Cereal Straw (bales)	Linka	1 x 400	www.agrobiomass-observatory.eu/Case?id=189
GrønGas Vrå	Other (biogas heating)	Cereal Straw (bales) → olive residues	Justsen	1 x 7,000	www.agrobiomass-observatory.eu/Case?id=874
Hjallerup Fjernvarme	District heating	Cereal Straw (bales)	Linka	1 x 3,000	www.agrobiomass-observatory.eu/Case?id=967
Holmegaard Gods	Farm heating	Cereal Straw (bales)	Linka	1 x 950	www.agrobiomass-observatory.eu/Case?id=1000
Lolland Varme A/S	District heating	Cereal Straw (bales)	Linka n.a.	1 x 6,500 2 x 8,000	www.agrobiomass-observatory.eu/Case?id=984
Midtlangeland Fjernvarme	District heating	Cereal Straw (bales)	Justsen	1 x 7,700	www.agrobiomass-observatory.eu/Case?id=565
Ørnhøj-Grønbjerg Kraftvarmeværk	District Heating	Cereal Straw (bales)	Linka	1 x 1,500	www.agrobiomass-observatory.eu/Case?id=990
Orupgård Gods	Farm heating	Cereal Straw (bales)	Linka	1 x 800	www.agrobiomass-observatory.eu/Case?id=957
Rødbyhavn Fjernvarme	District heating	Cereal Straw (bales)	Linka	2 x 5,500	www.agrobiomass-observatory.eu/Case?id=974
Ulbjerg Kraftvarme	District heating	Cereal Straw (bales)	REKA	1 x 1,000	www.agrobiomass-observatory.eu/Case?id=117
Vennerslund	Farm heating	Cereal Straw (bales)	Linka	1 x 800	www.agrobiomass-observatory.eu/Case?id=193

[5] Danish Energy Agency: Energy Statistics 2018.
[6] http://task40.ieabioenergy.com/wp-content/uploads/2013/09/t40-low-iluc-straw-august-2014.pdf

A case that is of particular interest for AgroBioHeat is **Ulbjerg Kraftvarme**, which supplies the district heating network of the small municipality of Ulbjerg. The straw plant was constructed in 2016 in order to substitute a natural gas-fired boiler. The total investment was in the range of 1 M€, with annual fuel savings in the range of 128,000 €; the reduction of the annual heating bill compared to natural gas was up to 50 % (when natural gas prices were peaking). The boiler was manufactured by Danish company REKA A/S and is equipped with a fully automated straw feeding line and a patented ESP filter that removes 98 % of particle emissions. The boiler can burn other agricultural residues or wood chips with a moisture content up to 30 %.

Figure 4: The straw-fired district heating plant at Ulbjerg (left), the straw boiler (middle) and close-up of the straw bale cutter (left) (Source: Kirsten Krogh and Louise Krogh Johnson).

The examples of **Vennerslund**, **Frederiksdal Kirsebærvin**, **Holmegaard** and **Orupgård** illustrate the versatility of straw heating for farms. Heat is primarily used for space heating of the estate and adjacent properties, but it is also used for season grain drying (Holmegaard, Orupgård), cherry wine production (Frederiksdal) and poultry farm heating (Orupgård). All these facilities use straw boilers with thermal output ranging from 400 up to 950 kW supplied by Linka Energy.

Several larger (thermal output > 1,000 kW) straw heating plants for DH have been identified in Denmark:

- **Midtlangeland Fjernvarme** has installed with a 7,700 kW hot water boiler supplied by Justsen. The plant is also equipped with a urea-based SNCR (selective non-catalytic reduction) deNOx system. The total cost of the project (replacement of the older boiler) was in the range of 25 million DKK (around 3.3 M€)[7].
- **Boulstrup-Hou Kraftvarmeværk**, **Hjallerup Fjernvarme**, **Rødbyhavn Fjernvarme**, **Fors A/S / St. Merloese Varmevaerk**, **Lolland Varme A/S** and **Ørnhøj-Grønbjerg Kraftvarmeværk** use straw boilers supplied by Linka Energy with thermal outputs ranging from 2,000 to 6,500 kW. The boiler manufacturer states that several of these installations have achieved dust emission values way below the MCP Directive limit (40 mg/Nm^3), as well as CO emission values also below the limit (625 mg/Nm^3)[8].

[7] https://justsen.dk/portfolio/district-heating/
[8] www.linka.dk/en/references/

Figure 5: The straw feeding line (left) and the 800 kW straw boiler (right) at Orupgaard Estate (Source: Linka Energy A/S).

Finally, it is also interesting to note the case of the straw heating plant at Grøngas Vrå. The 7,000 kW boiler, supplied by Justsen in 2015 is used to heat the digester of a biogas using local manure, industrial waste products and food residues. In 2018, the boiler was converted to burn olive residues due to drought and poor straw harvests[9].

[9] https://justsen.dk/portfolio/biomass-for-biogas/

4. Agrobiomass heating facilities in Greece

The main agrobiomass fuels used in Greece are exhausted olive cake and sunflower husk pellets.

Exhausted olive cake is produced by pomace mills and large quantities are consumed on-site for own process needs (drying on incoming wet olive pomace). Part of the remaining quantities are usually provided at very low cost to the primary olive mills, which use them as fuel for the production of hot water used in their process (e.g. washing). All the olive mills in Greece use this kind of fuel. Other quantities are made available to other industries, greenhouses or even for domestic heating. In some cases, olive stones are extracted / separated from the pomace. Olive stones have a much lower ash content compared to exhausted olive cake, but usually they are more expensive. Sunflower husk pellets are mostly imported. Their price is quite low, making them a very competitive fuel for various applications. Other agrobiomass fuels used for energy production are also agro-industrial residues such as nut shells, peach kernels, etc. The use of agricultural residues that require field harvesting efforts (e.g. straw, prunings) for heat production is practically non-existent.

The table below summarizes several agrobiomass heating cases that have been detected in Greece, either through contacts with boiler manufacturers or CERTH's own knowledge of the sector.

Table 4: Agrobiomass heating cases detected in Greece.

Case name	Application	Agrobiomass	Boiler manufacturer	Installed capacity (kW)	Observatory link
AGAN Ltd.	Greenhouse	Exhausted olive cake	N.Samaras	5 x 1,163	www.agrobiomass-observatory.eu/Case?id=693
Agricultural Cooperative of Rovies	Agro-industry	Olive stones	N.Samaras	1 x 430	www.agrobiomass-observatory.eu/Case?id=697
AGRIS S.A.	Greenhouse	Sunflower husk pellets	N.Samaras	8 x 1,163	www.agrobiomass-observatory.eu/Case?id=151
Almada	Agro-industry	Nut shells	N.Samaras	1 x 465	www.agrobiomass-observatory.eu/Case?id=824
BIOKARPOS S.A.	Greenhouse	Sunflower husk pellets	PelleTech / Camino Design	3 x 350	www.agrobiomass-observatory.eu/Case?id=1029
Dodis	Greenhouse	Exhausted olive cake	N.Samaras	2 x 1,163	www.agrobiomass-observatory.eu/Case?id=828
EURIMAC	Agro-industry	Rice husk	Artemis Boiler Industry / EKTA	11,000	www.agrobiomass-observatory.eu/Case?id=1132
Hellenic Greenhouse S.A.	Greenhouse	Exhausted olive cake	N.Samaras	2 x 1,163	www.agrobiomass-observatory.eu/Case?id=736
Komotini Paper Mill	Other (paper industry)	Various: Sunflower hull (Pellets), Olive stones, Fruit pits	EKTE	1 x 7,560	www.agrobiomass-observatory.eu/Case?id=1126
Mpazios	Greenhouse	Exhausted olive cake	N.Samaras	6 x 1,163	www.agrobiomass-observatory.eu/Case?id=740
NUTRIA S.A.	Agro-industry	Exhausted olive cake	Alfa Therm	1 x 300	www.agrobiomass-observatory.eu/Case?id=1

Case name	Application	Agrobiomass	Boiler manufacturer	Installed capacity (kW)	Observatory link
Oniropetra Boutique Hotel	Service sector	Sunflower husk pellets	PelleTech / Camino Design	1 x 200	www.agrobiomass-observatory.eu/Case?id=841

AGRIS S.A. is a quite well known case of successful agrobiomass utilization, having been a case for the 2019 study "Competitiveness of corporate sourcing of renewable energy" of the European Commission[10]. The company operates a greenhouse nursery facility of more than three hectares in Northern Greece. In 2012, the company installed eight biomass boilers (total capacity of 9.28 MW). Initially operated with exhausted olive cake, **AGRIS** switched to sunflower husk pellets because it was considered as a superior fuel with no odour problems. The company estimates that the annual heating bill has been reduced by 20-30 %, with the biomass heating system supplying up to 97 % of the total heat demand (in peak demand an older oil-fired boiler is used).

The one-hectare greenhouse facility of **BIOKARPOS S.A.** near Argos, Peloponnese is another interesting case of agrobiomass heating. The company has installed three modern, moving-grate biomass boilers supplied by PelleTech / Camino Design, each with a 350 kW capacity. Currently fuelled by sunflower husk pellets, the company has plans to install additional heating capacity as well as to start using own residues (greenhouse green waste) and chipped agricultural prunings.

Figure 6: Hot air generator using agrobiomass at BIOKARPOS Greenhouse (Source: PelleTech / Camino Design).

[10] https://op.europa.eu/en/publication-detail/-/publication/3c4cd582-c48a-11e9-9d01-01aa75ed71a1

Finally, it is interesting to mention the case of **Oniropetra Boutique Hotel**, which illustrates the advantages offered by agrobiomass heating in the service sector under the correct conditions. The hotel is located in Karpenisi, a mountainous area with cold climate. A 200 kW biomass boiler, also provided by PelleTech / Camino Design, was installed in 2014 and it is currently operated with sunflower husk pellets. The boiler is operated almost throughout the year (at reduced load during summertime), consuming around 75 tons of biomass. According to the hotel management, the investment was in the range of 23,000 € and achieved a payback time of less than 1.5 years.

Figure 7: The Oniropetra Boutique Hotel in Karpenisi (left) and its biomass boiler (right) (Source:Oniropetra & PelleTech / Camino Design).

5. Agrobiomass heating facilities in France

Being the largest producer of several types of agricultural products in the EU, France has both impressive and varied agrobiomass resources. Their utilization for energy production – although nowhere as widespread as that of forest biomass – is not uncommon, as can be evidenced from the long list of facilities detected in the country.

Table 5: Agrobiomass heating cases detected in France.

Case name	Application	Agrobiomass	Boiler manufacturer	Installed capacity	Observatory link
Abbaye Notre Dame d'Ourscamp	Other	Miscanthus	Heizomat	1 x 400	www.agrobiomass-observatory.eu/Case?id=328
Agro Energie Sarl	District heating	Straw	Compte-R	1 x 5,500	www.agrobiomass-observatory.eu/Case?id=1078
CHAVANNES SAS	Greenhouse	Straw	Compte-R	1 x 3,000	www.agrobiomass-observatory.eu/Case?id=1086
Chevresis Maison de Retraite	Municipal building heating	Miscanthus	Heizomat	1 x 400	www.agrobiomass-observatory.eu/Case?id=114
Distillerie Douence SA	Agro-industry	Distillery waste	Compte-R	1 x 6,000	www.agrobiomass-observatory.eu/Case?id=1090
Distillerie Jean Goyard	Agro-industry	Distillery waste	Compte-R	1 x 7,500	www.agrobiomass-observatory.eu/Case?id=1093
Distillerie La Varoise	Agro-industry	Distillery waste	Compte-R	1 x 7,000	www.agrobiomass-observatory.eu/Case?id=1096
Domaine Jean Durup & Fils	Agro-industry (winery)	Vineyard prunings	Compte-R	1 x 300	www.agrobiomass-observatory.eu/Case?id=1059
Domaine Xavier Muller	Farm heating	Vineyard prunings	Guntamatic	1 x 50	www.agrobiomass-observatory.eu/Case?id=367
DUNES / DUNoise Energie Service	District heating	Miscanthus	Compte-R	1 x 3,000	www.agrobiomass-observatory.eu/Case?id=1082
Durepaire	Agro-industry	Straw	Justsen	1 x 4,200	www.agrobiomass-observatory.eu/Case?id=895
ESAT ADAPEI 80	Other (employment centre for people with disabilities)	Miscanthus	Hargassner	2 x 200	www.agrobiomass-observatory.eu/Case?id=331
Hangest-sur-Somme	District heating	Miscanthus	Heizomat	1 x 100	www.agrobiomass-observatory.eu/Case?id=1045
KWS BUZET	Agro-industry	Corn cob	Compte-R	1 x 8,000	www.agrobiomass-observatory.eu/Case?id=1042
La Méaugon	District heating	Hedgerow Prunings	Hargassner	1 x 150	www.agrobiomass-observatory.eu/Case?id=1045
LE NEUBOURG (Lycée)	Service sector	Flax shives	Compte-R	1 x 700	www.agrobiomass-observatory.eu/Case?id=1065
LIMAGRAIN	Agro-industry	Corn cob	Compte-R	1 x 2,400	www.agrobiomass-observatory.eu/Case?id=1039
LYCEE D'EMULATION DIEPPOIS	Service sector	Flax shives	Compte-R	1 x 1,200	www.agrobiomass-observatory.eu/Case?id=1062
Magasin Libre service Agricole – Jardinerie Rieupeyroux	Service sector (agricultural and garden self-service shop centre)	CALYS	VERNER	1 x 50	www.agrobiomass-observatory.eu/Case?id=340

Case name	Application	Agrobiomass	Boiler manufacturer	Installed capacity	Observatory link
MALTERIE SOUFFLET	Agro-industry	Cereal residue	Compte-R	1 x 6,000	www.agrobiomass-observatory.eu/Case?id=1075
MOUGENOT FRERES (ETS HORTICOLES)	Greenhouse	Fruit kernels	Compte-R	2 x1,200	www.agrobiomass-observatory.eu/Case?id=1033
Pierre Fabre	Other (Pharmaceutical industry)	Residues from dried plants	Compte-R	1 x 1,500	www.agrobiomass-observatory.eu/Case?id=1072
POITIERS PAILLE	District heating	Straw	Compte-R	1 x 4,500	www.agrobiomass-observatory.eu/Case?id=1052
RAGT DRUELLE	Greenhouse	CALYS	Compte-R	1 x 600	www.agrobiomass-observatory.eu/Case?id=352
RAZES HYBRIDES	Agro-industry	Corn cob	Compte-R	1 x 8,000	www.agrobiomass-observatory.eu/Case?id=1036
SEM Energie	District heating	Straw	Compte-R	1 x 3,000	www.agrobiomass-observatory.eu/Case?id=1048
Siniat	Other (Production of insulation material)	Flax shives	Compte-R	1 x 3,000	www.agrobiomass-observatory.eu/Case?id=1068
TOP Semence	Agro-industry	Corn cob	Compte-R	1 x 8,000	www.agrobiomass-observatory.eu/Case?id=1045

Several agrobiomass heating cases were provided by the French biomass boiler manufacturer Compte-R as reference facilities. Producing hot water or steam, depending on the client needs, the boilers of Compte-R have found uses in various applications, from district heating, greenhouses, several agro-industries as well as specialized applications, e.g. the production of insulation materials (**Siniat**) or pharmaceuticals (**Pierre Fabre**). Most of the plants are larger than 1 MW in size and utilize agro-industrial residues from own process or sourced from the market; however, examples of straw utilization can also be found, as in the case of the district heating plant at **Poitiers**, which is expected to be operative in Autumn 2020. The cost savings achieved by agrobiomass is a significant factor behind the success and competitiveness of such cases.

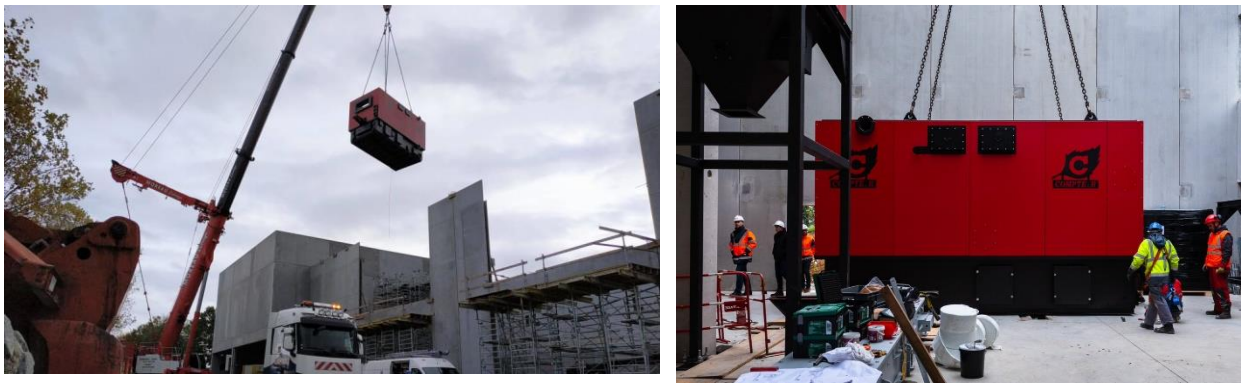

Figure 8: Installed of the straw-fired boiler of Compte-R for the district heating plant at Poitiers (Source: Photo NR).

Other European boiler manufacturers for smaller scale heating facilities, also have a relevant presence in France. For example, Hargassner (Austria) and Heizomat (Germany) are represented by Hargassner France[11] and Saelen Energie[12] respectively. Saelen Energy works in partnership with specific engeniering and installators like Energie &+[13] in western France.

From an agrobiomass fuel perspective, it is interesting to note that the use of miscanthus for heating has taken often well in France. Promoted by the association France Miscanthus[14] and companies such as Novabiom[15], several heating facilities using this energy crop have been detected. AgroBioHeat project partner Agronergy includes in its portfolio of biomass heating plant such as facility at the small town of **Chevresis**, where miscanthus is used to heat a municipal retirement home. Through association with local farmers and the support of the local council which in 2018 decided to switch to agrobiomass heating for their reduction of their bills, as well as through the appropriate choice of biomass boiler and feeding system, the miscanthus boiler in **Chevresis** is delivering affordable heat to the residents of the retirement home.

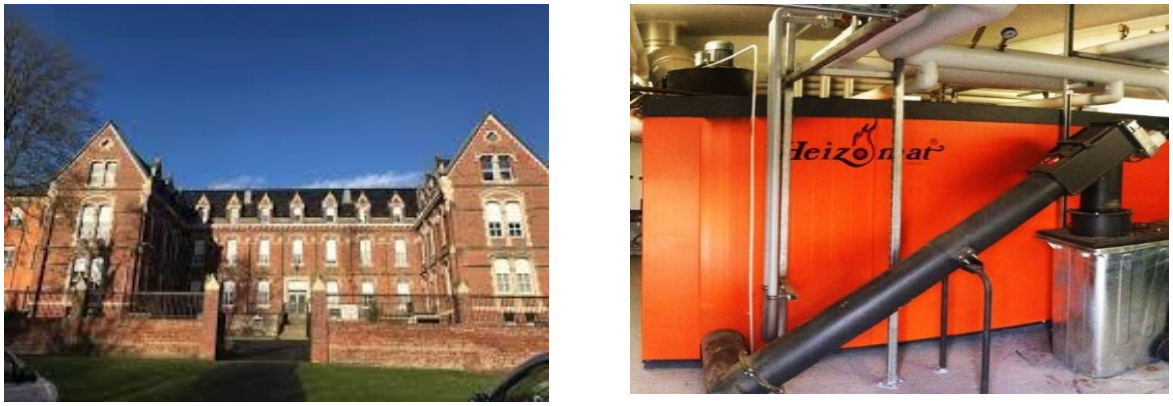

Figure 9: Retirement home at Chevresis and Heizomat biomass boiler installed (Source: Agronergy).

Another success case for the use of miscanthus is the **Abbaye Notre Dame d'Ourscamp**[16]. Deciding to switch to miscanthus heating in 2014, a quick start-up of the boiler at 2015 allowed the Abbey to phase out oil completely. Annual fuel cost savings of 60,000 € were observed, allowing a payback time of less than 5 years for the total investment of 267,000 € (92,000 € for the boiler and 175,000 € for the network and installation). A reduction of 210 tons of CO_2 emissions per year was also calculated. The miscanthus is supplied by a small number of farmers located in a short distance from the monastery.

[11] www.hargassner-france.com
[12] www.saelen-energie.fr
[13] www.ahcs.fr
[14] www.france-miscanthus.org
[15] www.novabiom.com/
[16] www.france-miscanthus.org/temoignage/miscanthus-abbaye-ourscamp

Figure 10: The miscanthus-heated Abbaye Notre Dame d'Ourscamp (Source: France Miscanthus).

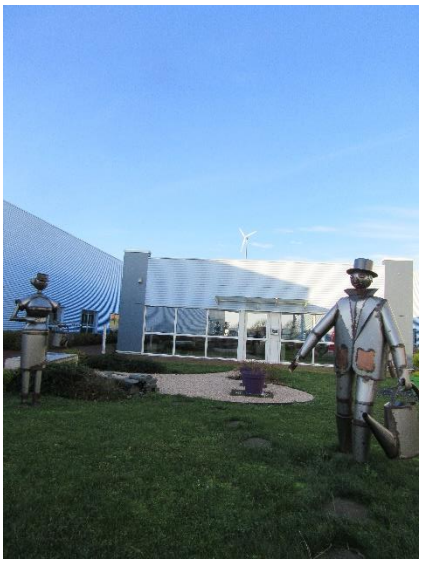

Figure 11: The ESAT ADAPEI 80 facility for social and professional integration of adults with disabilities located near Allaines (left) and the twin Hargassner biomass boilers fuelled with miscanthus (right) (Source: AILE).

Finally, on the side of agrobiomass fuel supply, it is interesting to note the case of the CALYS pellets produced by RAGT Energie[17]. By identifying suitable biomass streams for mixing and applying additives, RAGT Energie is assisting agropellet suppliers to produce a high quality, cost-effective product that can be used even in small-scale installations.

[17] www.ragt-energie.fr/fr/biocombustibles/technologies-calys.php

6. Agrobiomass heating facilities in Romania

Several agrobiomass heating facilities in Romania have been identified by AgroBioHeat project partner GEA and through contacts with boiler manufacturers. A summary is presented in the table below; a wide range of agrobiomass types are used, reflecting the country's varied agricultural sector.

Table 6: Agrobiomass heating cases detected in Romania.

Case name	Application	Agrobiomass	Boiler manufacturer	Installed capacity (kW)	Observatory link
Avicol Prod Consult Ltd.	Farm heating	Sunflower husk, straw	BioSistem	1 x 150	www.agrobiomass-observatory.eu/Case?id=434
Dalia Ltd.	Greenhouse heating	Willow (Chips), Pasture clearing (Chips)	BioSistem	4 x 750, 2 x 350	www.agrobiomass-observatory.eu/Case?id=120
Ecohornet	Hot Air Generator	Agro-pellet and pellet	Ecohornet	1 x 600	www.agrobiomass-observatory.eu/Case?id=487
Enache Utilaje Ltd	Agro-industry	Cereal Straw (Briquettes)	-	2 x 500	www.agrobiomass-observatory.eu/Case?id=769
Fundatia de Tineret LIA Locodeni	District heating	Other (pasture cleaning)	BioSistem	1 x 100	www.agrobiomass-observatory.eu/Case?id=446
Moldova Seminte Remington	Agro-industry	Corn cob	Compte-R	1 x 8000	www.agrobiomass-observatory.eu/Case?id=1024
Municipality of Estelnic	District heating	SRC (willow)	BioSistem	1 x 150, 1X40	www.agrobiomass-observatory.eu/Case?id=442

A prominent case of agrobiomass heating in Romania is the greenhouse facility of **Dalia**. Built in 2007 with funding pre-accession program SAPARD, the greenhouse included from the start six biomass boilers designed to run with sawdust from local wood processing enterprises. From 2015 onwards, sawdust demand for particleboard production started to increase, prompting the company to look for alternative fuel suppliers. These were found in the form of willow energy plantations established by local farmers, as well as by pasture clearing biomass from the nearby mountains. New value chains and businesses were established to serve the fuel supply of Dalia, which amounts to a quantity of 2,000 tons per year, and achieving annual fuel savings in the range of 20 % compared to natural gas. From a technology side, **Dalia** used modern biomass boilers developed by Romanian manufacturer BioSistem, equipped with cyclones for particle emission control.

Figure 12: Dalia Greenhouses, biomass deposit and heating boilers (Source: GEA).

The **municipality of Estelnic** features a 150 kW installed in 2016 under the coordination of GEA and Oxford Research AS from Norway[18]. The boiler provides heat to a small number of local municipal buildings and it is fuelled with wood chips from willow plantations. A quite similar case can be found in **Fundatia de Tineret LIA Locodeni**. The fuel used in that occasion is coming from pasture clearing biomass. It should be noted that this project also has strong social aspects as well, involving local young people with mental disabilities in the collecting and production of biomass. Both cases use boilers provided by Romanian manufacturer BioSistem.

The utilisation of agrobiomass in Cornatelu village, Damovita county started in early 2013 when **Avicol Prod Consult Ltd.** installed a 60 kW boiler to perform experiments on sunflower husks based heating for chicken farms. The initiative was successful, leading to the installation of an additional 100 kW boiler in 2014. Later on, the company further extended its activity and more heat demand appeared, therefore in 2019 was installed an additional 150 kW biomass boiler. The main fuel is sunflower husks from Dambovita region. Moreover, the feeding system was automatized by the installation of three 20 cubic meter silos, connected directly to the boilers. It is worth mentioning that the company realized this agrobiomass based energy supply system with its own capital investment without any subsidy. In this perspective, this is one of the best examples of how a bottom up initiative can become a lighthouse case for other rural businesses, using the regionally available agrobiomass to cover their energy demand.

[18] http://biovill.eu/estelnic/

Figure 13: Agrobiomass boiler (150 kW) and silos for sunflower husks at Avicol Prod Consult Ltd. (Source: Biosistem).

7. Agrobiomass heating facilities in Spain

Spain has one of the most developed agrobiomass markets in Europe. The size and organization of the agricultural and food processing sector favour conditions for mobilization and processing of various agrobiomass fractions in fairly large volumes. Agro-industrial residues such as olive stones, nut shells and exhausted olive cake are used widely with an increasing trend of improving their fuel quality through standardization and fuel quality certification. Apart from those, several heating cases using agricultural residues, both herbaceous (straw) and woody (prunings) are present in the country.

Relevant agrobiomass heating facilities in Spain have been identified through project partners AVEBIOM and CIRCE, through previous experience and contacts with relevant boiler manufacturers, fuel providers and end-users. The table below provides summary data for three prominent and interesting cases.

Table 7: Agrobiomass heating cases detected in Spain.

Case name	Application	Agrobiomass used	Boiler manufacturer	Installed capacity (kW)	Observatory link
Calahorra Mushroom Breeding Farm	Agro-industry heating	Olive stones, wood pellets	INMECAL	2 x 50	www.agrobiomass-observatory.eu/Case?id=1268
CALORDOM Office and warehouse	Service sector	Olive stones	BIOCURVE	2 x 150	www.agrobiomass-observatory.eu/Case?id=1258
Centro de Fisioterapia F.I.R.E.	Service sector	Olive stones	KWB	1 x 22	www.agrobiomass-observatory.eu/Case?id=1231
Centro Deportivo Municipal Grau de Gandia	Service sector	Almond shells, wood chips	FRÖLING	2 x 360	www.agrobiomass-observatory.eu/Case?id=1272
Hostal-Restaurante "Los Arcos"	Service sector	Pine shells, chopped pine cone	TATANO	1 x 115	www.agrobiomass-observatory.eu/Case?id=1283
Hotel BARCELÓ "ISLA CANELA"	Service sector	Olive stones	HERZ	1 x 500	www.agrobiomass-observatory.eu/Case?id=1234
Hotel BARCELÓ "LA BOBADILLA"	District Heating	Olive stones	HERZ	1x400, 1x300	www.agrobiomass-observatory.eu/Case?id=1219
HOTEL LOS MALLOS	Service sector	Cereal Straw (Whole bales)	ACR ECOCALDERAS	1 x 250	www.agrobiomass-observatory.eu/Case?id=915
Hotel-Spa Balneario de la Virgen	Service sector	Olive stones, wood pellets	BINDER	1 x 400	www.agrobiomass-observatory.eu/Case?id=1251
INDUSTRIAL CONSERVERA DE TARIFA S.L.	Agro-industry heating	Olive stones, wood chips	SINCAL	1 x 3200	www.agrobiomass-observatory.eu/Case?id=1242
Invernadero Conil de la Frontera	Greenhouse	Olive stones	TUBOCÁS	3 x 50	www.agrobiomass-observatory.eu/Case?id=1239

Case name	Application	Agrobiomass used	Boiler manufacturer	Installed capacity (kW)	Observatory link
LOS JOVIANES, S.L. Backery	Service sector	Olive stones	KWB	1 x 100	www.agrobiomass-observatory.eu/Case?id=1227
Municipal Sport Centre Torre-Pacheco	Service sector	Almond shells, olive stones, wood pellets	ITB	1 x 400	www.agrobiomass-observatory.eu/Case?id=1293
MUNICIPAL SPORT CENTRE VICENTE DEL BOSQUE	Service sector	Olive stones	BIOCURVE	3 x 125	www.agrobiomass-observatory.eu/Case?id=1254
PISCINA MUNICIPAL MAIRENA DEL ALCOR	Municipal building heating	Olive stones, wood pellets	SMART HEATING	2 x 200	www.agrobiomass-observatory.eu/Case?id=1247
PLANO BOTERO Almond procesing	Agro-industry heating	Almond shells, olive stones, wood chips	HERZ	1 x 180	www.agrobiomass-observatory.eu/Case?id=1286
QUESOS DEL CERRATO [AGROPAL]	Agro-industry heating	Cereal Straw (Pellets)	SUGIMAT S.L.	1 x 2,600	www.agrobiomass-observatory.eu/Case?id=911
Secondary School RAMON Y CAJAL	Service sector	Olive stones	ITB	1 x 400	www.agrobiomass-observatory.eu/Case?id=1297
SUDANELL Domestic heating	Domestic heating	Fruit tree prunings (hog fuel)	Heizomat	1 x 70	www.agrobiomass-observatory.eu/Case?id=1278
Vilafranca del Penedes	District Heating	Vineyard prunings	Heizomat	1 x 500	www.agrobiomass-observatory.eu/Case?id=2

The initiative of **Vilafranca del Penedès** municipality is an emblematic initiative for the energetic utilization of vineyard prunings. Supported by the LIFE+ project "Vineyards4heat"[19], a 500 kW Heizomat boiler was installed in 2016, providing heat through a small district heating network to a small number of municipal buildings. Further details on this case are available in a report of the uP_running project[20]. Vilafranca del Penedès was also selected as the location for a successful workshop of the AgroBioHeat project in February 2020[21].

Quesos del Cerrato is an example of the advantages offered by agrobiomass in the context of a food processing industry, in this case a cheese factory. The factory belongs to the larger group of the AGROPAL Social Cooperative, which also operates a dehydration line for fodder plants and pellet production facilitiy. The fodder-derived agropellets are used a fuel in a steam boiler (4 t/h, 9 bar) used for the cheese production process. The boiler was installed in 2016 by the Spanish manufacturer SUGIMAT, with a total investment level in the range of 500,000 €. Costs savings in the range of 30-40 % have been observed.

[19] www.vineyards4heat.eu
[20] www.up-running.eu/wp-content/uploads/2017/10/uP_running_D6.3-Flagship-cases-report-v1_.pdf
[21] www.agrobioheat.eu/vilafranca-del-penedes-visit

The **Secondary School Ramón y Cajal at Granada** combines building renovation actions (e.g. improvement of insulation) with the installation of a new, highly efficient agrobiomass boiler. The project was supported by the program PAREER+ (FEDER funds); the boiler was installed in 2018 and provided by ITB - Intecbio. The facility uses local, olive stones, which are certified by the fuel quality scheme BIOmasud®. Flue gas emissions have been tested in laboratory conditions and found to be below the limits for wood pellet boilers according to Ecodesign Regulation. The period of return for the investment in the boiler was as short as 2 years thanks to the savings in energy, both from the fuel bill (fuel was up to 50 % cheaper per heating unit in respect to heating oil), and from the lower energy demand thanks to the rehabilitation actions.

Figure 14: Secondary School Ramón y Cajal at Granada (left) and its olive stone boiler (right) (Source: Intecbio).

Finally, **HOTEL LOS MALLOS** is a 4-star SPA resort in a rural area in the pre-Pyrenee mountain range. Located in Murillo de Gallego (Huesca province), it is equipped since 2018 with a 250 kW straw-bale boiler developed by ACR ECOCALDERAS and a cyclone for particle emissions control. Approximately 280 tons of straw bales are consumed annually, sourced from the fields of the resort owners. Considering cost savings in the range of 45-50,000 € (compared to propane gas) and a total level of investment in the range of 90,000 € a very quick payback time was achieved. Thanks to the economics, better heating service is now provided to the spa resort and the experience of comfort for clients has improved, while also improving the sustainable image of the company.

Figure 15: Panoramic view of the Hotel Los Mallos and surroundings (Source: Hotel Los Mallos).

Figure 16: The straw storage and feeding system at Hotel Los Mallos (Source: CIRCE).

8. Agrobiomass heating facilities in Ukraine

Ukraine is a major producer of agricultural products (among the top-10 wheat and corn producing countries in the world) and has therefore huge volumes of agrobiomass resources that can be used for energy production. The country's cold climate as well as its political will to diversify its energy sourcing create favourable conditions for the deployment of agrobiomass heating.

Several agrobiomass heating cases, summarized in the table below, have been detected in Ukraine through the project partner UABIO which has direct contacts with both fuel producers and biomass boiler manufacturers and installers as the national biomass association.

Table 8: Agrobiomass heating cases detected in Ukraine.

Case name	Application	Agrobiomass used	Boiler manufacturer	Installed capacity (kW)	Observatory link
Group of companies "Niva Pereyaslavshchiny"	Farm heating	Cereal Straw (bales)	Linka	1 x 2,000	www.agrobiomass-observatory.eu/Case?id=721
ITC Shabo	Agro-industry	Vineyard pruning	KRIGER	1 X 1,160	www.agrobiomass-observatory.eu/Case?id=167
LLC SOOK	Agro-industry	Apple pomace	KRIGER	1 X 5,000	ww.agrobiomass-observatory.eu/Case?id=774
Myrhorod City Council	District heating	Cereal Straw (bales)	COMPTE-R	1 X 1,000	www.agrobiomass-observatory.eu/Case?id=726
National Scientific Centre "Institute of Mechanization and Electrification of Agriculture"	Service sector	Cereal Straw (bales)	UTEM	1 X 600	www.agrobiomass-observatory.eu/Case?id=549
Poultry Complex «Dneprovskiy»	Farm heating	Cereal Straw (bales)	TTS	2 x 5,000	www.agrobiomass-observatory.eu/Case?id=1148
Uman School #9	Municipal building	Cereal Straw (pellets)	AVERS	1 x 220	www.agrobiomass-observatory.eu/Case?id=451
Shopping mall ACADEM-CITY	Service sector	Sunflower husk pellets	Volyn-Kalvis	1 x 500, 1 x 320	www.agrobiomass-observatory.eu/Case?id=541
Zhytomyr National Agroecological University	Service sector	Cereal Straw (pellets)	AVERS	1 x 220	www.agrobiomass-observatory.eu/Case?id=363

A case of wide deployment of agrobiomass heating in the framework of an entire community is evidenced in the case of **Uman**, a city 83,000 inhabitants with strong agricultural background. Starting in 2004, the local company Avers LLC started a strategic line for producing renewable energy from agricultural biomass, aiming to be able to deliver solutions both in terms of fuel supply (straw pellets) and combustion technology (straw pellet boilers). Due to rising natural gas prices, the **Uman** city council decided to install Avers boilers in in Schools #9, #12 and Kindergarten #21. The process was facilitated by the UNDP project "Development and Commercialization of Bioenergy Technologies in the Municipal Sector in Ukraine", which subsidized the costs for the boiler investments. Annual fuel cost savings of more than 50 % over natural gas can be achieved, thanks to the very competitive straw pellet price. The success of the case has prompted expansion in more municipal buildings in Zhytomyr, Kyiv as well as in Uman itself.

Figure 17: The AVERS straw pellet-fired boiler at Uman School #9 (Source: UABIO).

The **Poultry Complex «Dneprovskiy»** is one of the largest Ukrainian producers of broiler meat and derived product. Since 2012, the company has installed two 5 MW biomass boilers, supplied by Czech manufacturer TTS. Using straw bales as a fuel, cost savings of more than 50 % compared to natural gas are achieved for meeting the large space heating requirements. The boilers are also equipped with fabric filters for particle emission control.

Figure 18: Poultry Complex «Dneprovskiy» (top) and straw handling and feeding at the facility (Source: Dneprovskiy, http://bio.ukr.bio/ru/news/17848).

The agro-industry **ITC-Shabo** is a winery / distillery that has adopted vineyard prunings as a heating source for a 1.16 MWth steam boiler. The steam is used in the production process throughout the year, while in the cold season the boiler is also providing heat for space heating. The boiler consumes up to 1,500 tons per year of vineyard pruning, while also contributing to the sustainability image of the company. Further details on this case are available in a report of the uP_running project[22].

[22] www.up-running.eu/wp-content/uploads/2017/10/uP_running_D6.3-Flagship-cases-report-v1_.pdf

Figure 19: ITC-Shabo and its vineyard pruning-fired boiler (Source: ITC-Shabo, UABIO).

Finally, the example of **Shopping mall ACADEM-CITY** demonstrates how agrobiomass can even be used as a fuel in an urban setting, providing it is supplied in a form of high energy density – in that case, sunflower husk pellets. Located in Kyiv, the shopping mall is producing heat from two biomass boilers supplied by Ukrainian manufacturer Volyn-Kalvis; cyclones are used to reduce the particle emissions.

Figure 20: The ACADEM-CITY shopping mall in Kyiv and one of its biomass boilers (Source: RIOLA Construction Group, UABIO).

9. Agrobiomass heating in other European countries

9.1. Austria

Austria is considered a success case for bioenergy. In 2016, biomass provided 35 % of heat demand, 6.4 % of electricity demand, and 6.7 % of transport fuel demand[23]. Austrian technological expertise on biomass heating is also well established; numerous manufacturers produce biomass boilers, stoves and heating plants. More than 2,300 biomass heating plants are in operation and around half of Austrian households employ biomass heating in one form or another.

Biomass consumption in the Austrian heating sector is primarily based on woody biomass resources: logwood, wood pellets, wood briquettes, wood chips, and others. Agrobiomass resources, residues by-products, or energy crops, are mostly targeted for advanced biofuels production or other use cases. However, some interesting heating cases using agrobiomass fuels have been detected and are summarized in the table below.

Table 9: Agrobiomass heating cases detected in Austria.

Case name	Application	Agrobiomass used	Boiler manufacturer	Installed capacity (kW)	Observatory link
Fernwärme Genossenschaft Stetteldorf reg GenmbH	District heating	Cereal Straw	Polytechnik	1 x 1,000	www.agrobiomass-observatory.eu/Case?id=384
			Agroforst	1 x 3,000	
Miscanthusheizwerk Persenbeug	District heating	Miscanthus (briquettes)	ETA	2 x 200	www.agrobiomass-observatory.eu/Case?id=1184
Miscanthusheizwerk Petzenkirchen	District heating	Miscanthus (chipped)	Binder	1 x 400	www.agrobiomass-observatory.eu/Case?id=1189
			ETA	1 x 200	
Hofamt Priel	District heating	Miscanthus (chipped)	Schmid	1 x 350	www.agrobiomass-observatory.eu/Case?id=1179

The district heating plant at **Stetteldorf** has a 1 MW Poly AgroFire straw-fired boiler of Austrian boiler manufacturer Polytechnik, developed in cooperation with BIOS BIOENERGIESYSTEME GmbH. The boiler was commissioned in 2019 and is mainly operated during the transition period in autumn and spring (the district heating network is not in operation during summer). During the winter season a 3 MW straw-fired boiler (manufacturer: Agroforst) is providing most of the heat, while the smaller 1 MW boiler is only used as a peak-load boiler. **Stetteldorf** is one of several larger straw-fired district heating plants in Lower Austria, but the only one with a boiler of 1 MW or less capacity.

The district heating plants at **Persenbeug** and **Petzenkirchen** are the first biomass heating installations in Austria to use miscanthus as a fuel. The plants were commissioned in 2013 and 2011, using about 185 and 400 tons of miscanthus per year respectively. The plants are operated by nahwaerme.at

[23] https://nachhaltigwirtschaften.at/resources/nw_pdf/schriftenreihe/schriftenreihe-2019-52-bioenergy-in-austria.pdf

Energiecontracting GmbH in collaboration with Miscanthus FARM, a local fuel supplier and operator of a miscanthus briquetting plant[24].

9.2. Belgium

A very interesting case of agrobiomass heating had been identified in **Gembloux**, Province of Namur, Belgium. The local area was frequently afflicted by mud slides. The Wallonian Biomass Association, ValBiom, proposed the cultivation of miscanthus in critical places, since the plant can filter sediments, slow down erosion and promote water penetration into the soil.

A key part of the project was the identification of a suitable end-user for miscanthus, which was found in **Foyer Bothey**, a public-owned retirement home. With an annual heating oil consumption of circa 60,000 litters and a corresponding heating bill of around 40,000 €, switching to a low-cost biomass fuel made economic sense.

A 300 kW biomass boiler was commissioned in 2018; the total investment cost was estimated to be in the range of 100,000 EUR, partly subsidised by the local municipality. Miscanthus has been initially planted in an area of 3.5 ha, expanding to 5 ha in 2019; around 9 ha would be required for full autonomy of the boiler. Currently, the boiler is also supplied by wood chips, which are available in low prices at the regional market.

The agrobiomass biomass boiler in Foyer Bothey has resulted in a reduction of the annual heating bill by 10,000 – 15,000 EUR, thus resulting in a payback time of less than 10 years (without considering the investment subsidy). Annual savings of 184 t of CO_2 are also recorded[25]. Equally important, the success of the project has also triggered replication in at least three other locations in Wallonia, where miscanthus is considered as a crop for mudslide avoidance, water protection or phytoremediation of a landfilling area.

Table 10: Agrobiomass heating cases detected in Belgium.

Case name	Application	Agrobiomass used	Boiler manufacturer	Installed capacity	Observatory link
Foyer Bother	Municipal building heating	Miscanthus (chopped)	Heizomat	1 x 300 kW	www.agrobiomass-observatory.eu/Case?id=858

[24] https://miscanthusfarm.at/www/de/1458/projekte
[25] https://valbiomag.labiomasseenwallonie.be/news/1ere-recolte-de-miscanthus-en-vue-dalimenter-la-chaudiere-dune-residence-pour-personnes

Figure 21: Loading of chopped miscanthus at Foyer Bother (Source: ValBiom).

9.3. Czech

Several agrobiomass heating facilities in Czech have been identified through the websites of Czech boiler manufacturers (Step TRUTNOV, TTS). All the facilities use straw as an agrobiomass fuel. Larger boilers serve district heating networks or greehouses, while smaller straw boilers are supplied in various applications (e.g. farms, mechanization workshop, shops, etc.).

Table 11: Agrobiomass heating cases detected in Czech.

Case name	Application	Agrobiomass	Boiler manufacturer	Installed capacity (kW)	Observatory link
Agos Bio a.s.	Service sector	Cereal Straw	Step TRUTNOV	1 x 190	www.agrobiomass-observatory.eu/Case?id=200
ASTUR Straškov a.s.	Farm heating	Cereal Straw	Step TRUTNOV	1 x 190	www.agrobiomass-observatory.eu/Case?id=246
Florecenter s.r.o.	Greenhouse heating	Cereal Straw	Step TRUTNOV	1 x 2,000, 1 x 1,600	www.agrobiomass-observatory.eu/Case?id=879
Ostrovská teplárenská a.s.	District heating	Cereal Straw	TTS	1 x 1,000	www.agrobiomass-observatory.eu/Case?id=816
Seva-Flora s.r.o.	Other	Cereal Straw	Step TRUTNOV	1 x 190	www.agrobiomass-observatory.eu/Case?id=68
Teplárna Jih	District heating	Cereal Straw	TTS	2 x 5,000	www.agrobiomass-observatory.eu/Case?id=787
Teplárna Sever	District heating	Cereal Straw	TTS	1 x 5,000	www.agrobiomass-observatory.eu/Case?id=779

9.4. Ireland

An interesting case of heating with miscanthus has been detected in St. Mary's Abbey in Glencairn, Co Waterford, Ireland. Starting in 2014, miscanthus cultivation started with the aim to switch from heating oil to a renewable fuel for heating the monastery. Now cultivated in 25 acres (a little over 10 hectares)[26], miscanthus is supplying a Polish supplied boiler. The cost is given as 120,000 € and annual fuel cost savings achieved are around 50 %[27]. This agrobiomass heating project fits together with more sustainability initiatives from the Abbey, including installation of solar panels, recycling domestic waste and preserving wetlands[28].

Table 12: Agrobiomass heating cases detected in Ireland.

Case name	Application	Agrobiomass used	Boiler manufacturer	Installed capacity	Observatory link
St. Mary's Abbey	Other	Miscanthus	metalERG	-	www.agrobiomass-observatory.eu/Case?id=1137

Figure 22: Installation of the biomass boiler and construction of the miscanthus shed at St. Mary's Abbey, Ireland (Source: www.facebook.com/glencairnabbey).

[26] www.irishtimes.com/news/ireland/irish-news/a-year-in-the-life-of-glencairn-abbey-1.3312427
[27] ww.independent.ie/business/farming/rural-life/sisters-are-doing-it-for-themselves-meet-waterfords-farming-nuns-35817750.html
[28] www.glencairnabbey.org/care-of-the-environment/

9.5. Germany

Despite having one of the largest straw potentials in Europe, energetic utilization of this type of agrobiomass resource is fairly limited in Germany. An older study indicated that in 2010 there were about 130 straw heating plants in the country[29], with limited public information available.

A straw heating case that has been identified through the website of manufacturer muetek Systemtechnik is **Geflügelhof Zeeb**, an egg-producing farm in in Reutlingen-Sickenhausen[30]. Since 2012, the farm is operating a 100 kW straw boiler, along with a bale shredder and shredded straw conveyor system. The straw shredder is also producing as animal litter and fine hay as an additive to animal feed.

A very interesting case identified is the district heating plant at Malchin operated by **Agrotherm GmbH**. The key feature of this case is that it uses biomass from rewetted peatlands. Malchin is located at the west end of the Peene valley in Germany, which features 17,810 ha of peatlands. Peatlands are areas of large carbon stock and rewetting them while cultivating suitable biomass species can substantially reduce GHG emissions from the soil. A heating plant using reed canary grass and sedges from the rewetted lands of a local farmer was established in 2014. A 800 kW biomass boiler was provided by Danish manufacturer Linka, suitable adapted to the high ash and chlorine content of the biomass. The boiler operated by **Agrotherm GmbH** supplies heat to the existing district heating network of Malchin. Currently, the project BonaMoor[31] is working on optimizing both harvesting of fern biomass as well as its combustion. A first measurement campaign over a 3-hour period took place in February 2019 using pelletized wetland biomass (sedges, reed canary grass and reed); emissions were found to be below the limits of TA-Luft, the Federal Emmission Control Act[32].

Table 13: Agrobiomass heating cases detected in Germany.

Case name	Application	Agrobiomass used	Boiler manufacturer	Installed capacity	Observatory link
Agrotherm GmbH	District heating	Reed	Linka Energy A/S	1 x 800	ww.agrobiomass-observatory.eu/Case?id=808
Geflügelhof Zeeb	Farm heating	Cereal Straw	muetek Systemtechnik	1 x 100	www.agrobiomass-observatory.eu/Case?id=862

[29] https://veranstaltungen.fnr.de/fileadmin/allgemein/pdf/veranstaltungen/Strohenergie2012/Abstract_Hering.pdf
[30] www.muetek.eu/en/plant-construction/shredded-straw-for-heating-system
[31] BonaMoor is a cooperative research project between Greifswald University, HTW Berlin and Agrotherm GmbH Malchin, funded by the German Federal Ministry of Food and Agriculture - BMEL (FNR Project, FKZ 22404418). Further details: www.moorwissen.de/de/paludikultur/projekte/bonamoor/index.php
[32] Barz, M., Kabengele, G.R., Brandt, A., Wichtmann, W., Wenzel M., Wichmann, S., Oehmke, C., Dahms, T. & L. Bork (2019): Energetic Utilization of Biomass from Rewetted Peatlands. Sakharov Readings, International Sakharov Environmental Institute, BSU, Minsk. 15 p.

Figure 23: Flame inspection at the Malchin heating plant (Source: Greifswald Mire Centre).

9.6. Moldova

Deployment of biomass heating in the Republic of Moldova has been supported by the "Energy and Biomass" Project, funded by the European Union and implemented by the United Nations Development Programme. The Project run in two-stages during the 2011-2018 period and in total supported 233 schools, kindergartens and community centers to install modern biomass heating systems, with a total investment in the range of 10 million EUR.

Some of the boilers installed in the framework of the "Energy and Biomass" Project are operated by agrobiomass fuels. Indicative facilities in the administrative areas of Nisporeni and Ungheni were indicated by the Biomass Energy Cluster of Moldova.

On a larger scale, it is interesting to note the case of the company **Agromaxer**, which operates a 3-ha greenhouse facility heating with a 2,000 kW boiler fuelled by sunflower husk pellets. The facility received the award for "Best Biomass Energy Project" in the EU-EBRD Sustainable Energy Excellence Award 2012[33] for Moldova.

Table 14: Agrobiomass heating cases detected in Moldova.

Case name	Application	Agrobiomass used	Boiler manufacturer	Installed capacity	Observatory link
Agromaxer Ltd	Greenhouse	Sunflower husk pellets	D'Alessandro Termomeccanica	1 x 2,000	www.agrobiomass-observatory.eu/Case?id=1122
Nisporeni rayon	Municipal buildings	Cereal Straw (Briquettes)	Volyn-Kalvis	5 x 420	www.agrobiomass-observatory.eu/Case?id=633
Ungheni rayon	Municipal buildings	Cereal Straw (Briquettes)	Volyn-Kalvis	2 x 140	www.agrobiomass-observatory.eu/Case?id=628

9.7. Poland

Like many other Eastern European countries, Poland has a large agrobiomass potential which is only partly utilized. Large volumes of agrobiomass have been used as co-firing fuel in coal or biomass power plants.

[33] www.ebrd.com/news/2012/ebrd-recognises-best-sustainable-energy-projects-in-moldova.html

Several heating cases using agrobiomass with Poland exist, as attested by the presence of boiler manufacturers that provide heating solutions for straw. However, available information on specific cases is scarce. A few examples are presented in the table below. The DH network of Lubań is fuelled by three straw boilers with a total capacity of 8 MW.

An example of straw heating at municipal buildings is provided by the secondary school complex of the Wieniawa municipality. Two 300 kW each straw boilers (whole bale combustion) have been supplied by Polish manufacturer MetalERG. An interesting feature of this case is that part of the fuel supply is coming from baled apple tree prunings collected and traded by the fruit processing company Gospodarstwo Sadownicze. Further details on the case are available in a report of the uP_running project[34].

Table 15: Agrobiomass heating cases detected in Poland.

Case name	Application	Agrobiomass used	Boiler manufacturer	Installed capacity	Observatory link
PEC Lubań	District heating	Cereal Straw	n.a.	1 x 1,000 kW, 2 x 3,500 kW	www.agrobiomass-observatory.eu/Case?id=944
Wieniawa Secondary School	Municipal building	Cereal Straw (Whole bales), Fruit trees prunings (Whole bales)	MetalERG	2 x 300 kW	www.agrobiomass-observatory.eu/Case?id=426

9.8. Slovakia

Two agrobiomass heating cases in Slovakia have been detected. The plants are connected to district heating networks and are fuelled by straw bales. The boilers have been supplied by Czech manufacturer TTS.

Table 16: Agrobiomass heating cases detected in Slovakia.

Case name	Application	Agrobiomass	Boiler manufacturer	Installed capacity	Observatory link
Detva	District heating	Cereal Straw (bales)	TTS	1 x 3,000	www.agrobiomass-observatory.eu/Case?id=795
		Wood chips	TTS	1 x 6,000	
Trebisovska Energeticka	District heating	Cereal Straw (bales)	TTS	1 x 4,000	www.agrobiomass-observatory.eu/Case?id=801
		Wood chips	TTS	1 x 4,000	

9.9. Sweden

Compared to nearby Denmark, straw use for heating in Sweden is not as widespread and mostly takes place in the region of Skåne. A 2016 report of IEA Bioenergy[35] summarized the country situation as follows:

- At least four DH plants using straw (Skurup, Såtenäs, Trelleborg, Löderup) with a total installed output of about 12 MWth.

[34] www.up-running.eu/wp-content/uploads/2016/10/uP_running_D6.4_Flagship_cases_report_v2_FV.pdf
[35] www.ieabioenergy.com/wp-content/uploads/2018/01/EA-Bioenergy-Task-43-TR2016-05.pdf

- Around 40 medium-scale straw heating plants at farms, around 25 of which in Skåne.
- Around 100 small-scale (typical size around 500 kW).

Farm-scale straw heating plants generally produce heat for their own demands and sell excess amounts to nearby buildings or district heating networks. Some indicative cases identified are presented in the table below.

A general trend observed in recent years is that straw heating plants are retrofitted so as to be able to burn wood chips as well. This trend seems to be connected with droughts experiences all over Northern Europe in 2018 and 2019 and poor straw harvests.

Table 17: Agrobiomass heating cases detected in Sweden.

Case name	Application	Agrobiomass	Boiler manufacturer	Installed capacity (kW)	Observatory link
Björnstorps	Farm heating	Straw (+ wood chips)	Linka Energy	1 x 3,000	www.agrobiomass-observatory.eu/Case?id=1016
Slättäng Gods	Farm heating	Straw (+ wood chips)	Linka Energy	1 x 950	www.agrobiomass-observatory.eu/Case?id=995
Spannarps Säteri	Farm heating	Straw (+ wood chips)	Linka Energy	1 x 1,000	www.agrobiomass-observatory.eu/Case?id=953
Svenstorps	Farm heating	Straw (+ wood chips)	Linka Energy	1 x 4,000	www.agrobiomass-observatory.eu/Case?id=1019

9.10. United Kingdom

Deployment of biomass heating in the United Kingdom has been supported by the Renewable Heat Incentive (RHI) scheme for the Domestic[36] and Non-Domestic[37] (businesses, public sector and non-profit organisations) sectors.

The Non-Domestic RHI scheme is particularly relevant for agrobiomass. The scheme makes payment based on the heat output of a system for a period of 20 years; the equipment must be installed in England, Scotland or Wales on or after 15 July 2009. From 2013m the RHI scheme introduced maximum permitted emission limits for solid biomass boilers[38]: 30 g/GJ of net heat input for dust emissions and 150 g/GJ of net heat input for NOx emissions.

Agrobiomass heating cases in the UK have been identified through information found on the websites of boiler manufacturers (Justsen, Linka) and/or collaborating installers (Manco, draperHEAT). The table below provides a summary. The cases are mostly related to farm heating applications and greenhouses. Straw is the most common fuel used, which in some cases can be supplemented by wood chips.

[36] www.gov.uk/domestic-renewable-heat-incentive
[37] www.gov.uk/non-domestic-renewable-heat-incentive
[38] www.ofgem.gov.uk/system/files/docs/2020/04/non-domestic_rhi_guidance_volume_one.pdf

Table 18: Agrobiomass heating cases detected in the United Kingdom.

Case name	Application	Agrobiomass	Boiler manufacturer	Installed capacity (kW)	Observatory link
AT Bone & Sons Ltd	Farm heating	Cereal Straw	Justsen Energiteknik A/S	1 x 995	www.agrobiomass-observatory.eu/Case?id=905
D C West Farm	Farm heating	Cereal Straw	Justsen Energiteknik A/S	1 x 1,600	www.agrobiomass-observatory.eu/Case?id=892
Easter Grangemuir Farm	Farm heating	Cereal Straw (+ wood chips)	Linka Energy A/S	1 x 995	www.agrobiomass-observatory.eu/Case?id=1005
Edward Baarda Ltd.	Greenhouse heating	Cereal Straw	Linka Energy A/S	1 x 2,500	www.agrobiomass-observatory.eu/Case?id=1010
		Wood chips		1x 995	
FH Wastling & Sons	Farm heating	Cereal Straw	Justsen Energiteknik A/S	1 x 995	www.agrobiomass-observatory.eu/Case?id=561
Glen Avon Growers	Greenhouse heating	Cereal Straw (+ wood chips)	Linka Energy A/S	2 x 995	www.agrobiomass-observatory.eu/Case?id=183
Kelloe Mains Farm	Farm heating	Cereal Straw	Linka Energy A/S	1 x 995	www.agrobiomass-observatory.eu/Case?id=950
Manor Farm	Farm heating	Cereal Straw	Linka Energy A/S	1 x 995	www.agrobiomass-observatory.eu/Case?id=178
Soanes Poultry	Farm heating	Cereal Straw	Justsen Energiteknik A/S	1 x 954	www.agrobiomass-observatory.eu/Case?id=884
Swarbrick Hall Farm	Farm heating	Cereal Straw	Justsen Energiteknik A/S	1 x 995	www.agrobiomass-observatory.eu/Case?id=868

Figure 24: The straw heating plant at F H Wastling & Sons farm (Source: Justsen Energiteknik A/S).

10. Conclusions and future work

Through the efforts of the AgroBioHeat project partners and their network, a large number (> 100) of agrobiomass heating facilities have been identified in Europe. Summary information for each case is available on the Agrobiomass Observatory, while additional facts and highlights for selected cases are presented in this report. From their overall assessment, some critical points can be extracted.

1. Agrobiomass is cost-competitive; a switch to agrobiomass heating can be a meaningful investment

Reduced annual heating cost is a key driver for switching to the use of an agrobiomass fuel. The exact economics of each case depend both on several factors such as the total investment cost, cost of agrobiomass, cost of replaced fuel and total level of energy consumption. It is interesting to note that with appropriate conditions, very quick payback times, often less than 5 years and sometimes even less than 2 years have been detected, even when using highly sophisticated agrobiomass boilers.

2. The use of agrobiomass reduces greenhouse gas emissions through fossil fuel substitution and often enhances resource efficiency

Agrobiomass substitutes fossil fuels such as heating oil and natural gas. By switching to agrobiomass heating, a carbon-neutral resource, equivalent levels of CO_2 savings are generated.

The use of agricultural residues enhances resource efficiency as it creates a new supply chains and revenues for farmers. In the case of miscanthus and SRC, their local utilisation to mitigate soil erosion is then remunerated by energy utilisation

3. Agrobiomass comes in many shapes and forms

“Agrobiomass” is a general term covering a wide range of biomass resources generated from the agricultural or the agro-industrial sector. One of the most commonly agrobiomass types used is straw: examples can be found not only in Denmark, but in most European countries. However, digging deeper, examples of using many other types of agrobiomass can be found: agricultural prunings, various agro-industrial residues (olive stones, nut shells, sunflower husk) and energy crops (miscanthus, SRC). Various physical forms of agrobiomass can also be used: from whole bales, to chips, pellets and briquettes.

4. Agrobiomass heating offers solutions for various sectors and applications

The cases identified showcase how agrobiomass heating can fit the requirements of various end-users, with different requirements. Agro-industrial residues are a “natural” fit and an ideal fuel for the agro-industrial that produce them. Farms and greenhouses, located in agricultural areas, can take advantage of locally available agrobiomass resources. However, they are not limited to that: hotels, municipal buildings, smaller or larger district heating networks, monasteries, process industries are among the cases identified. When supplied at a suitable, higher energy density (e.g. in the form of pellets), agrobiomass can even be used in urban settings!

5. Emissions from agrobiomass combustion can be controlled and technical challenges can be overcome

Agrobiomass often has a reputation as a "difficult" fuel that will cause many operational issues and will lead to high emissions of pollutants. Although the technical challenges of combusting certain fractions of agrobiomass should not be underestimated, it should be clear that the proper selection of technology can mitigate many of the issues and result in increased efficiency as well as enhanced end-user convenience. As far as the emissions are concerned, suitable secondary measures (e.g. ESPs, cyclones, bag filters) can bring down particle emissions from agrobiomass combustion to the levels required by legislation. Unburnt pollutants can be controlled through the proper design of the combustion system, while – at larger scale – even NOx emissions can be further reduced through secondary measures!

6. Agrobiomass heating fuels and technology – made in Europe!

In all cases identified, the manufacturers of the agrobiomass boilers are European companies, in many cases SMEs. The agrobiomass boiler markets are not necessarily organized along national lines: manufacturers of one country sell in third European countries or beyond. On the other hand, the agrobiomass fuel supply is mostly organized on a local / regional level, although examples of cross-border trade do occur. European technological leadership coupled with short, sustainable carbon-neutral supply of agrobiomass is a model for renewable heat production than can be emulated and exported to other countries.

The AgroBioHeat project partners will continue to seek for more agrobiomass heating installations all over Europe and will continue to update the Observatory database. An updated version of this report is anticipated in the second half of 2020.

Moerover, over the coming months, the project consortium will select up to 12 "lighthouse" cases of agrobiomass heating for further study. The selection will be based both on geographical criteria (country coverage of the AgroBioHeat consortium) as well as for their representation of different types of agrobiomass resources and applications, to the greatest extent possible. For each case, a longer report, a factsheet and an informative video are expected to be produced. These materials will provide detailed information on the success factors behind each case, its history, challenges and solutions, value chain organization and impacts.

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