



Promoting the penetration of agrobiomass heating in European rural areas

## Sustainable and economic rural heating with agrobiomass: challenges, technologies and success cases



**CERTH**  
CENTRE FOR  
RESEARCH & TECHNOLOGY  
HELLAS

POWER4BIO  
REGIONS FOR  
BIOECONOMY

POWER4BIO WEBINAR SERIES:  
**BIOENERGY**

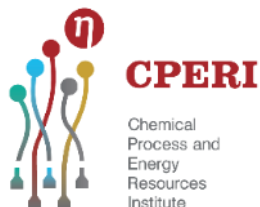
**FRIDAY, DECEMBER 11  
10:00 CET**

Training webinar 1/3:  
High potential value chains. From conversion technologies to business cases

More information: <http://power4bio.eu/webinar-series-bioenergy>



This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 818369. This document reflects only the author's view. The Innovation and Networks Executive Agency (INEA) is not responsible for any use that may be made of the information it contains.



- **Establishment year:** 2012, after merging of two existing institutes of CERTH:
  - Institute for Solid Fuels Technologies and Applications (ISFTA, est. 1987)
  - Chemical Process Engineering Research Institute (CPERI, est. 1985)
- **Director:** Dr. Paris Voutetakis
- **Personnel:** ~ 250 (mostly engineers)
- **Turnover:** ~ 10 mil. € / year (mostly from European competitive projects & industrial services)
- **Offices:** Thessaloniki, Ptolemaida, Athens
- **Research areas (among many others):** solid, liquid and gaseous biofuels, energetic utilization technologies, biomass value chains, antipollution technologies, bio-economy applications...



- Agrobiomass overview: potential, current use, cost, technologies and emissions
- Agrobiomass to energy applications: district heating, greenhouses, other cases
- The AgroBioHeat project and its activities
- Concluding remarks

# Agrobiomass overview

## Agricultural residues

- Herbaceous, *e.g.* straw, maize residues, etc.
- Woody, *e.g.* prunings, plantation removal biomass



## Agro-industrial by-products

- Olive stones / olive cake, nut shells, sunflower husk, rice husk, peach kernels, etc.



## Perennial energy crops

- Herbaceous, *e.g.* miscanthus, switchgrass
- Woody / Short Rotation Coppice, *e.g.* poplar, willow

Great range of tradeable forms:

- Whole bales
- Chips or hog fuel
- Pellets or briquettes
- Granular materials



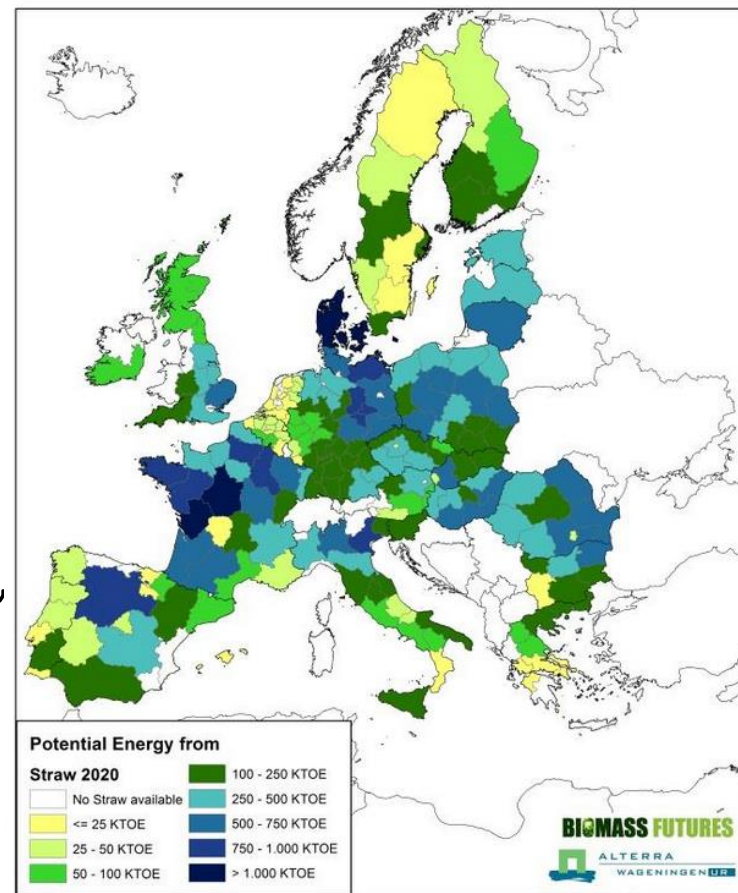


- **Herbaceous agricultural residues:** 168 Mt dry, technical potential / 123.5 Mt dry sustainable potential
- **Agricultural prunings:** 12.5 Mt dry, technical potential
- **Agro-industrial residues:** not insignificant quantities available on the market, e.g. 1.2 Mt of exhausted olive cake just in Spain
- **Energy crops:** currently 117,401 hectares (around 0.07 % of Utilized Agricultural Area), primarily with miscanthus, poplar and willow / Scenarios for covering energy demand estimate potential between 9 and 29 Mha by 2050

**References for agrobiomass potential:**

- Herbaceous agricultural residues: Scarlat et al., 2019
- Agricultural prunings: Dyjakon & García-Galindo, 2019
- Agro-industrial residues: Manzanares et al., 2017
- Energy crops: Bioenergy Europe, 2019, GLOBIOM

**Straw potential for Energy – 2020 estimate**



## Distribution of the different biomass feedstock for energy in 2018 (%)

(Sources: Eurostat and Bioenergy Europe's estimates)

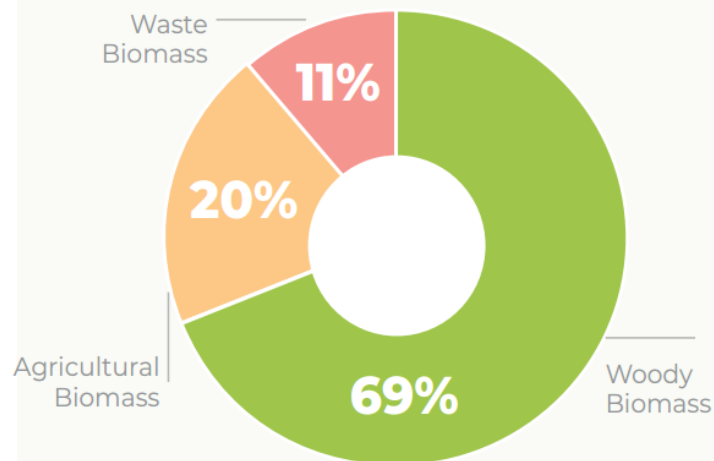
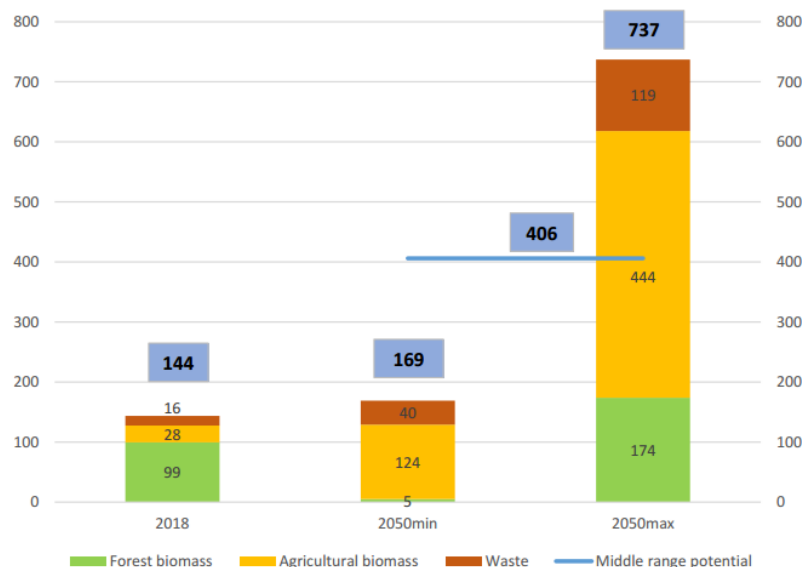


Figure 1 Gross inland energy consumption of biomass in 2018 and potential in 2050 for the EU28 (in Mtoe)



Source: Securing sustainable resource availability of biomass for energy applications in Europe; review of recent literature. Prof. Dr. André P.C. Faaij

- Denmark: straw amounts to 2.25 % of gross energy consumption production and 10.2 % of RES production (2018)
- Significant use of agro-industrial residues in some countries, e.g. exhausted olive cake / olive stones in Mediterranean countries, sunflower husk pellets (Bulgaria, Ukraine, etc.) - market shares may be comparable to wood pellets

Agrobiomass fuels / Spain	Moisture (%)	LHV (kJ/kg)	Fuel Price	
			(€/t)	(c€/kWh)
Straw pellets	6.3	15,940	140	3.16
Corn stover pellet	5.5	14,400	125	3.13
Vineyard prunings (hog fuel)	20.0	13,986	60	1.54
Olive tree prunings (hog fuel)	27.0	12,561	50	1.43
Up-rooted fruit trees (chips)	27.9	12,427	45	1.30
Straw (bales)	11.8	14,761	50	1.21
Exhausted olive cake	15.0	14,985	20	0.48

Commodity fuels / Spain	Fuel Price – 2018 (c€/kWh)
Natural Gas	7.70
Heating oil	7.01
Wood pellets (bulk)	5.06
Fuel oil	4.84
<b>Olive stones (bulk)</b>	<b>3.47</b>
Wood chips (bulk)	2.48

**Source:** AVEBIOM fuel price index / CIRCE & AVEBIOM – AgroBioHeat project



## Agricultural residues

- Available on the field after harvesting of main product or produced as part of agronomic practices (e.g. pruning)
- Herbaceous (straw) or woody (prunings)
- Relatively low yields (< 4 – 5 t/ha), with some exceptions (e.g. orchard uprooting biomass)
- Disposal through open-field burning (mostly banned but still practiced) or soil cover / mulching, for some occasional uses (e.g. animal feeding / bedding)
- Energetic value chains can provide farmers with management solutions
- Harvesting is a critical step of the value chain, affecting both costs and quality



Image Source: CERTH (bottom)

## Agro-industrial residues

- By-products of an agro-industry: pomace mills, sunflower oil production, nut hulling plants, etc.
- No harvesting required
- Usually available at low moisture and as granular fuels or upgraded into pellets / briquettes
- Mostly traded on local/regional markets and sometimes in international ones
- Price affected by quality, seasonal availability and demand
- Easiest option for deployment of new value chains
- Fuel quality certification scheme available for certain assortments – BIOMasud®



Exhausted olive cake (left) vs. olive stones (right).  
Image source: CERTH



Sunflower husk pellets (left) and hazelnut shells (right).  
Image sources: CERTH & EcoCombustibili® / Biom s.r.l.

## Lignocellulosic energy crops

- Cultivated explicitly for a non-food market
- High yields are expected
- Herbaceous (miscanthus) or woody (willow, poplar and other SRC)
- Harvesting required → dedicated equipment might be needed for SRC
- Can provide various other ecosystem services: phytoremediation of contaminated soils, protection against soil erosion, etc.



Image Source: Terravesta



Images Source: GEA



## Moving grate boiler



Image Source: Camino Design / PelleTech

1. Moving grate
2. Primary air blower
3. Secondary air inlets
4. Reinforced auger
5. Automated fuel supply with back burn protection
6. Feed engines
7. Automatic ash extraction
8. Combustion chamber
9. Heat exchanger
10. Heat exchanger cleaning system
11. Forced draught
12. Lambda sensor
13. Hot air blower for ignition
14. Automated ash extraction

## Control and monitoring applications



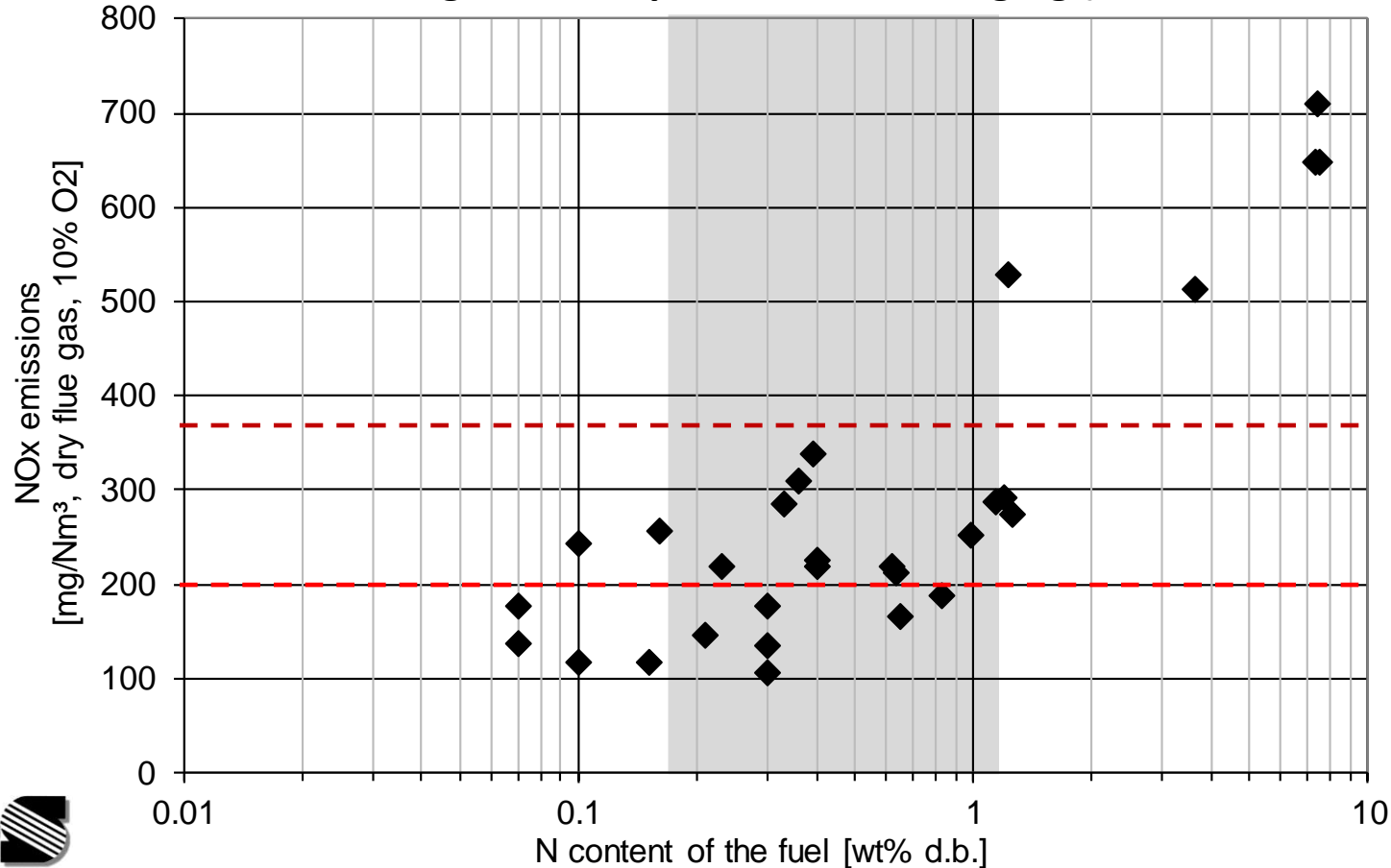
Image Source: Linka


## PM abatement: ESPs and bag filters





Image Source: Oekosolve (left), Justsen (right)

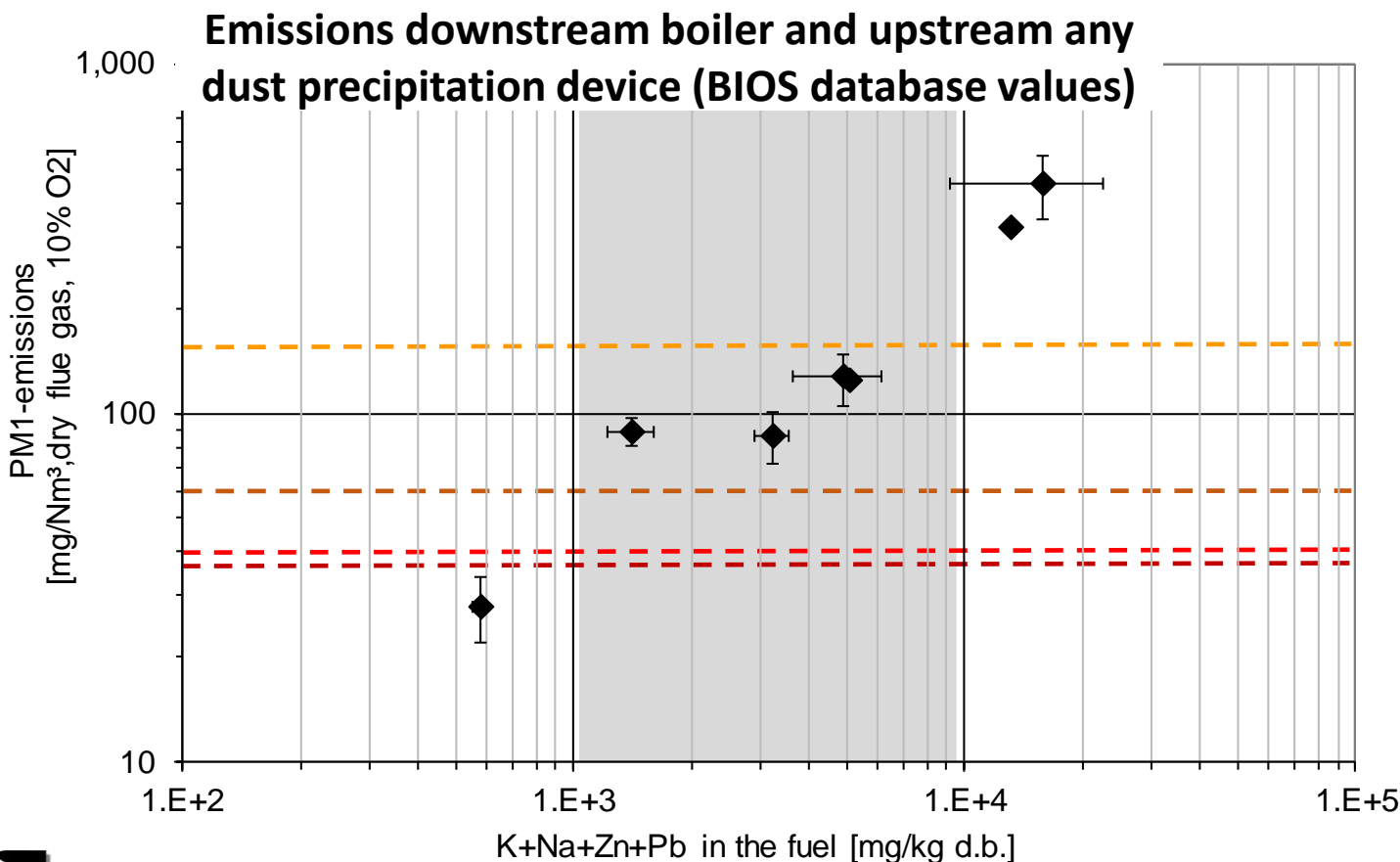
## Emissions of state-of-the-art grate fired plants with air staging (BIOS database values)



 Range of the N-content of agrobiomass fuels considered for AgroBioHeat tests (BIOS database values)

### Emission limits:

-  Ecodesign Regulation: 200 mg/Nm<sup>3</sup> (<500 kW, wood fuels)
-  EU-MCP Directive: 367 mg/Nm<sup>3</sup> (<5 MW)





# Agrobiomass to energy applications

- New straw-fired district heating boiler for **Ulbjerg** municipality (500 inhabitants) in 2016, replacing the natural gas fired boiler
- 1 MW, highly automated biomass boiler from **REKA**, capable of firing straw, wood chips and other biomass (moisture <30 %); equipped with ESP for PM reduction
- Annual cost savings of 128 000 EUR; **up to 50 % savings** compared to natural gas price peaks
- Involvement of local community in boiler selection process and continued approval



**Ulbjerg Landsby**

byen med de mange muligheder...



- Public-private partnership on renewable heating using vineyard prunings in **Vilafranca del Penedes**, Spain
- Initiative supported through the award-winning LIFE project **Vineyards4heat**; in operation even beyond project duration
- Creation of **new social cooperative enterprise** for pruning collection
- Installation of a **500 kW Heizomat boiler** for a municipal district heating network
- Use of up to 300 tons of vineyard prunings per year. Price of 70 EUR/t. **Annual fuel savings between 55 and 85 %.**



- **Dalia greenhouse** in Covasna, Romania
- Originally heated with sawdust; competition with particle board production resulted in development of new chains using **energy willow and wood from pasture clearings**
- Six **Biosistem** biomass boilers, 4 MW in total. More than 85 % efficiency and particle control systems
- Agrobiomass delivery price of 65 EUR/t; annual fuel savings of 20 % achieved



- **AGRIS S.A.** 10 ha nursery plant greenhouse facilities in Northern Greece
- Heating cost up to 13 % of annual costs
- 8 x 1.16 MW biomass boilers installed in 2012
- Current fuel: sunflower husk pellets. Also tested olive tree pruning pellets
- **Fuel saving of up to 20 – 30 %** compared to heavy fuel oil
- Case study for the COWI / CEPS Report “**Competitiveness of the Renewable Energy Sector**”, for DG ENER of the European Commission



### Hotel Los Mallos

250 kW whole straw bale boiler by ACR Ecocalderas



### Secondary School RAMON Y CAJAL

400 kW boiler by ITB

Olive stones, BIOmasud® certified





## ESAT ADAPEI 80

Facility for social and professional integration of adults with disabilities

2 x 200 kW boilers by Hargassner

Miscanthus

[https://agrobioheat.eu/wp-content/uploads/2020/10/AgroBioHeat\\_D3.1\\_agrobiomass-heating-facilities\\_v1.0-1.pdf](https://agrobioheat.eu/wp-content/uploads/2020/10/AgroBioHeat_D3.1_agrobiomass-heating-facilities_v1.0-1.pdf)

## Eco2Wacken

2 MW boiler by Compte.R

Corn cobs

<https://www.bioenergie-promotion.fr/51630/compte-r-confirmer-expertise-en-combustion-des-agrocombustibles-solides>





### ITC Shabo winery / distillery

1.16 MW boiler by Krieger

Vineyard prunings in hog fuel form



### Shopping mall ACADEM-CITY

500 kW & 320 kW boilers by Volyn-Kalvis

Sunflower husk pellets



## FIUSIS

World's first 1 MWe power plant using exclusively olive tree prunings as a fuel



[www.fiusis.it](http://www.fiusis.it)

[http://www.up-running.eu/wp-content/uploads/2017/10/uP\\_running\\_D6.3-Flagship-cases-report-v1\\_.pdf](http://www.up-running.eu/wp-content/uploads/2017/10/uP_running_D6.3-Flagship-cases-report-v1_.pdf)

## VIOENERGIAKI PATRIDAS

1 MWe gasification plant in Northern Greece using wood chips from peach trees plantation removal biomass



[http://www.up-running.eu/wp-content/uploads/2016/10/uP\\_running\\_D6.4\\_Flagship\\_cases\\_report\\_v2\\_FV.pdf](http://www.up-running.eu/wp-content/uploads/2016/10/uP_running_D6.4_Flagship_cases_report_v2_FV.pdf)

## Snetterton Renewable Energy Plant

44 MWe plant in UK. Designed for straw combustion. Long-term supply contracts for miscanthus were instrumental for funding



[www.snettertonbiomass.com](http://www.snettertonbiomass.com)

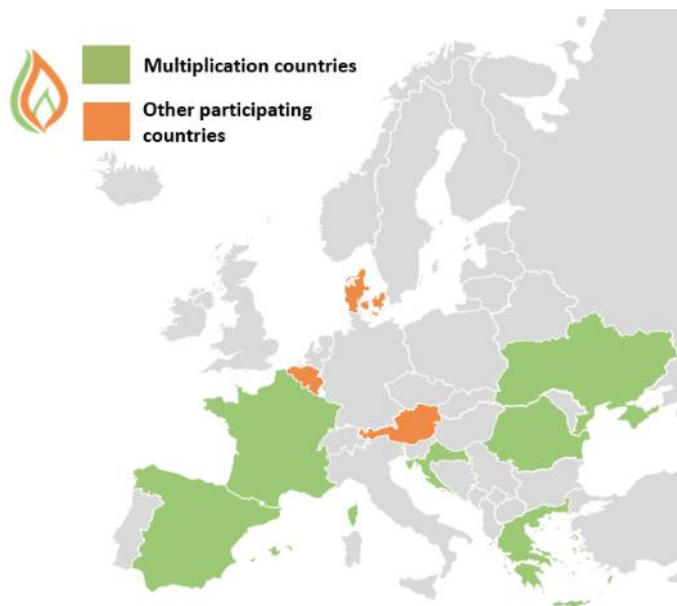
## Studstrup Power Station

700 MWe plant in Denmark. Formerly coal-fired, converted to wood pellets firing in 2016. Straw as part of the fuel mixture, 40-45,000 tons per year expected



<https://orsted.com/en/media/newsroom/news/2019/05/studstrup-power-station-to-use-straw-as-fuel-again>

# AgroBioHeat project & activities



## ⇒ Providing support to develop the use of agrobiomass heating in Europe

- Funding: Horizon 2020, Grant Agreement 818369
- Topic: LC-SC3-RES-28-2018-2019-2020 - Market Uptake support
- Duration: 1<sup>st</sup> January 2019 – 31<sup>st</sup> December 2021
- Total budget / EU funding: 2,998,043.75 € / 2,998,043.75 €
- Project Coordinator: CERTH (Greece)
- Website: <http://www.agrobioheat.eu>

### Technical partners (GR, ES, AT)



### European association (BE)



### National multipliers (RO, UA, FR, ES, GR, HR)



### Straw & network expertise (DK) Social sciences expertise (BE)



### Agrobiomass facility operator (FR)



## Our approach

### Providing Support

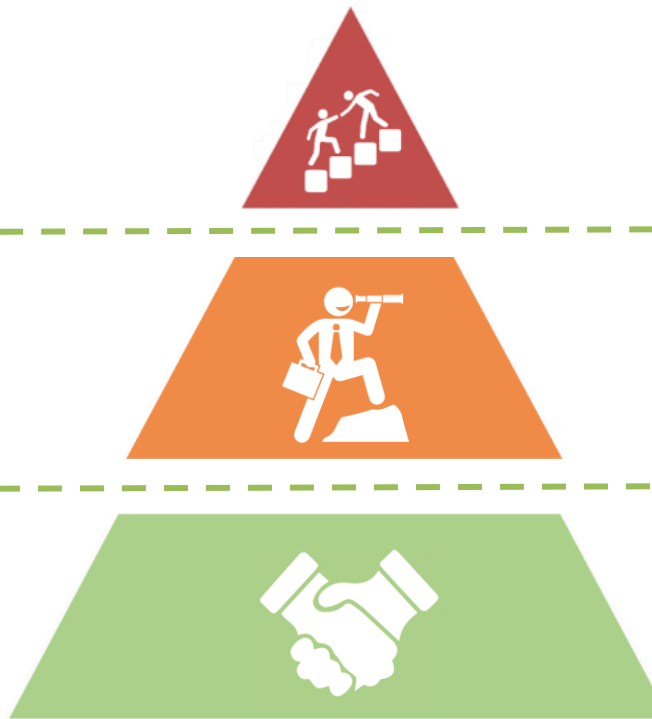
**Targeted actions** for specific stakeholders and policy makers to assist early adopters and create a level playing field

### Generating Vision

**Roadmap / vision** for agrobiomass heating: inclusion in political agenda, business strategies, local and regional development priorities

### Developing Trust

**Proof** that agrobiomass heating works, that it is economically, environmentally, socially sustainable and that other adopters have succeeded

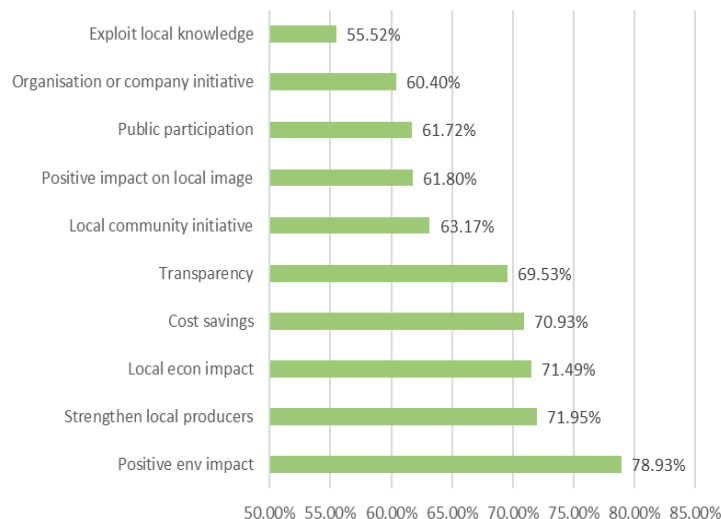


## Our strategy for change

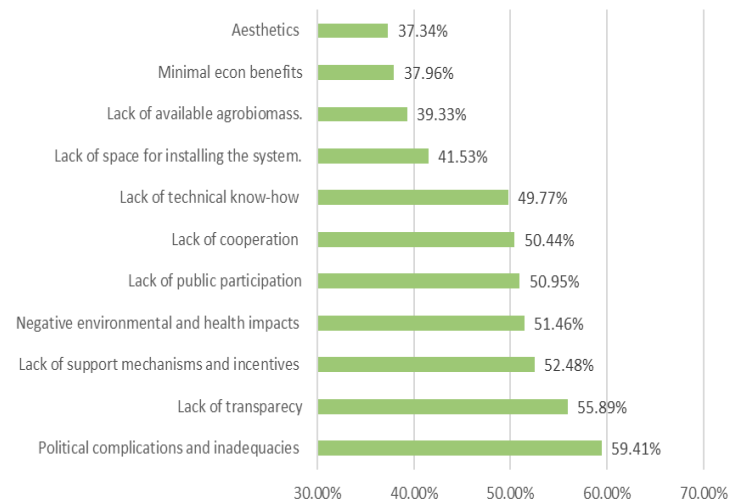
- ✓ Accompaniment of new initiatives
  - ✓ Policy recommendations for revision of Ecodesign Regulation based on combustion tests
  - ✓ Trainings to installers
- 
- ✓ Policy roadmaps / recommendations & advocacy actions
  - ✓ Increased sector visibility in fairs & expos
  - ✓ Social surveys & local / regional workshops & community hearings
- 
- ✓ Agrobiomass Heating Observatory
  - ✓ Visualization and promotion of success cases
  - ✓ Organization of site-visits
  - ✓ Targeted dissemination actions
  - ✓ Performance testing of modern agrobiomass heating devices (lab-scale & operating facilities)

- Running from March to April 2020
- 3,725 responses collected online
- **Key finding: increase of awareness and first-time users leads to increased acceptance**
- Full results available here: [https://agrobioheat.eu/wp-content/uploads/2020/10/AgroBioHeat\\_D5.1\\_Part-2\\_European-social-perception-survey.pdf](https://agrobioheat.eu/wp-content/uploads/2020/10/AgroBioHeat_D5.1_Part-2_European-social-perception-survey.pdf)

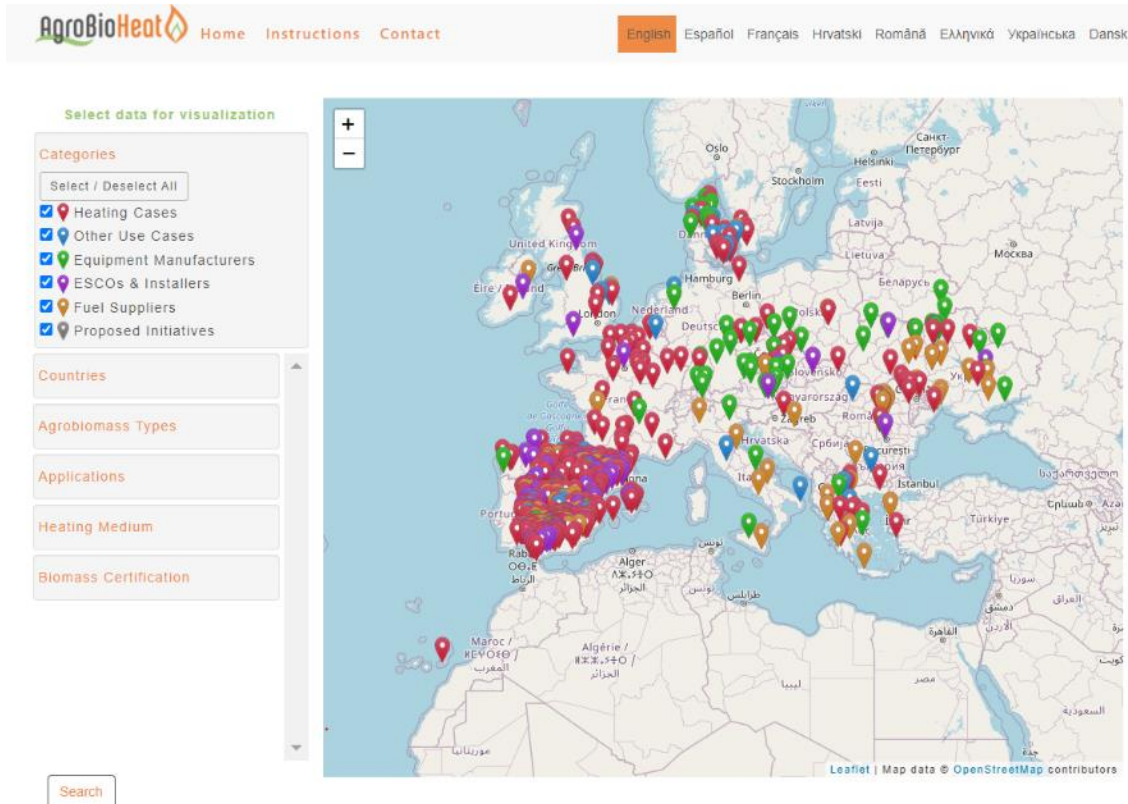
Drivers



Barriers



[www.agrobiomass-observatory.eu](http://www.agrobiomass-observatory.eu)



Up to now more than 1,000 entries

- 679 agrobiomass heating cases (< 50 MWth)
- 51 cases of other types of agrobiomass utilization (power, CHP, industry, large-scale heat, biofuels, bioproducts, etc.)
- 66 equipment manufacturers (mostly boilers and flue gas cleaning systems)
- 108 agrobiomass fuel suppliers
- + others (ESCOs, installers, etc.)

**Continuously updated!**



## Vilafranca del Penedès (ES) – 27<sup>th</sup> February 2020



- Workshop on using vineyard prunings for heat / energy production
- Site-visit to “La Girada” district heating of local municipality, fueled exclusively with vineyard prunings / 500 kW Heizomat boiler



- Site-visit to Familia Torres / 2.6 MW biomass boiler coupled with adsorption chiller for cooling / fueled by forest wood chips and vineyard prunings
- Further information:  
<https://agrobioheat.eu/vilafranca-del-penedes-visit/>

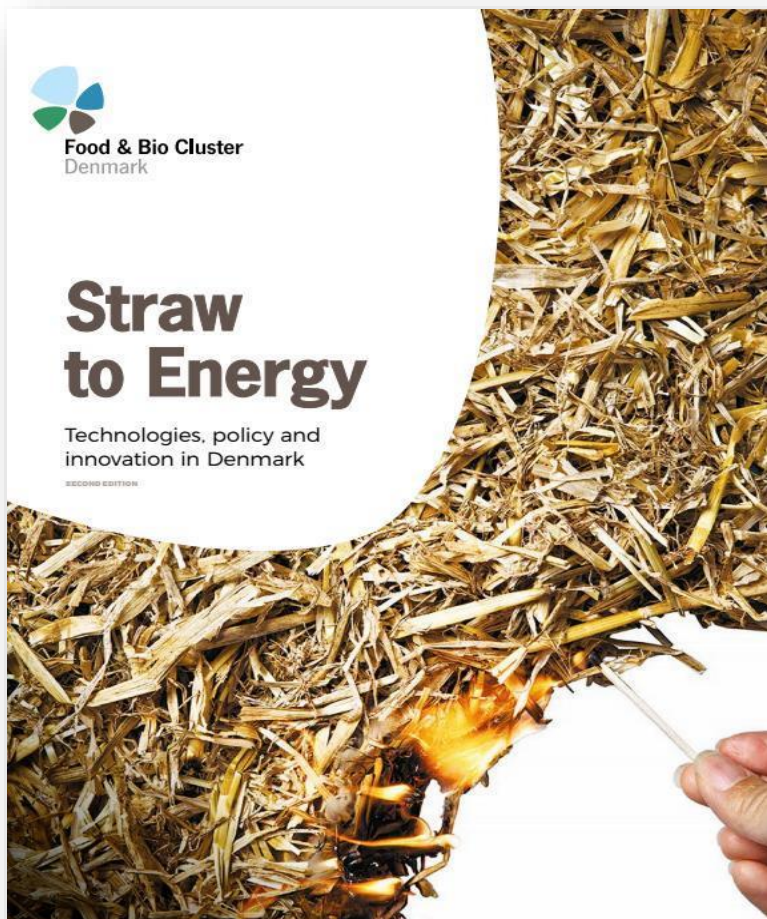


Food & Bio Cluster  
Denmark

## Straw to Energy

Technologies, policy and  
innovation in Denmark

SECOND EDITION



This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 815559



### Miscanthus factsheet

Dedicated energy crops are plants grown specifically for their energetic value. Lignocellulosic energy crops can be either herbaceous (e.g. miscanthus) or woody (e.g. willow, poplar). Adaptable to a wide range of climate and soil conditions, they can be successfully grown on lands not ecologically suited for conventional farming practices, while delivering several ecosystem services. The genus *Miscanthus* comprises around 17 species of perennial non-wood rhizomatous tall grasses native to subtropical and tropical regions originating from Asia. The main characteristics of are its exceptional adaptability to different climates, the feasibility for cultivation on poor quality soils, the high dry matter yields and the extraordinary disease and pest resistance.

Miscanthus can either be mowed and baled, or it can be chopped during harvesting using forage harvesters (e.g. used for maize). If desired, miscanthus biomass can also be further upgraded to pellets or briquettes. For heating applications, miscanthus is mostly used either in whole bales or chopped.

In 2016, it was estimated that approximately 20,000 ha of miscanthus was being grown in Europe. Most of them were located in the United Kingdom, Germany, France, Austria, Switzerland and Poland.

Indicative fuel composition		
Property	Units	Miscanthus*
Moisture content	w-% a.s.	15
Ash content	w-% d.b.	4.0
Net Caloric Value	MJ/kg a.s.	14.7
Bulk density	kg/m <sup>3</sup> a.s.	130 (chopped)
Energy density	MWh/m <sup>3</sup> a.s.	0.53 (chopped)
N	w-% d.b.	0.7
S	w-% d.b.	0.2
Cl	w-% d.b.	0.2
Ca	mg/kg d.b.	2000
K	mg/kg d.b.	7000
Na	mg/kg d.b.	70
Si	mg/kg d.b.	8000

\* Data compiled from various sources. The given values are only indicative of typical values for this type of agrobiomass. More information on the typical variation of miscanthus can be found in Henric & van Veen (2016).

Image sources: *Miscanthus* crop/energy crops: [www.cropscience.com](http://www.cropscience.com); *Miscanthus* bales: [www.cropscience.com](http://www.cropscience.com); *Miscanthus* chopped: [www.cropscience.com](http://www.cropscience.com); *Miscanthus* harvester: [www.cropscience.com](http://www.cropscience.com); *Miscanthus* harvester: [www.cropscience.com](http://www.cropscience.com); *Miscanthus* harvester: [www.cropscience.com](http://www.cropscience.com).

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Typical yields are approximately 20 t dry matter per hectare per annum. To obtain the best biomass quality for use as a combustion fuel, miscanthus is normally harvested in spring (March or early April) after it has had time to dry in the field.

In Europe, a large proportion of miscanthus is utilized for contribution to produce heat and/or electricity. It is used for direct firing of thermal power stations, in farm-scale boilers and in small-scale biomass burners. A market is also being developed for miscanthus pellet-fired heating boilers. Alternative uses due to its high water absorption capacity include use as animal bedding and production of building and packaging materials.



Find out more about miscanthus heating and use cases, fuel suppliers etc. in *AgroBioHeat Observatory*



### Prunings and plantation removal factsheet

Tree pruning is the established horticultural practice of cutting and removing selected parts of a tree in order to control growth, remove dead/diseased wood and stimulate the formation of flowers and fruit buds. Currently, thin parts of pruning wood may be used as firewood in some cases but mostly prunings are left on the field and are either burned in open fires or, less frequently, mulched in the soil.

Plantation removal is the clearing out of trees at the end of the lifetime of a plantation. The aerial part of the tree may be used as firewood, but the stumps, roots and thin branches are mostly unutilized and burned in open fires.

The main permanent crops in Europe are olives, grapes and nuts, followed by pines, stone and citrus fruits. The countries in Europe that have currently the largest areas of permanent crops are Spain, Italy, Greece and France.

Indicative fuel properties		
Property	Units	Prunings and plantation removal*
Moisture content	w-% a.s.	27
Ash content	w-% d.b.	4.2
Net Caloric Value	MJ/kg a.s.	12.8
Bulk density	kg/m <sup>3</sup> a.s.	280
Energy density	MWh/m <sup>3</sup> a.s.	0.83
N	w-% d.b.	0.93
S	w-% d.b.	0.04
Cl	w-% d.b.	0.04
Ca	mg/kg d.b.	6000
K	mg/kg d.b.	5600
Na	mg/kg d.b.	460
Si	mg/kg d.b.	2100

\* Data compiled from various sources. The given values are only indicative of typical values for this type of agrobiomass. More information on the typical variation of prunings and plantation removal can be found in Henric & van Veen (2016).

Image sources: *Prunings* and *plantation removal*: [www.cropscience.com](http://www.cropscience.com); *Prunings* and *plantation removal*: [www.cropscience.com](http://www.cropscience.com); *Prunings* and *plantation removal*: [www.cropscience.com](http://www.cropscience.com).

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Typical annual yield for pruning is between 5-3 t per hectare (dry matter), depending on the crop, the pruning practice and other factors. The biomass yield for plantation removal of mature trees may be in the range of 50 t per hectare (dry matter).

Prunings and wood from plantation removal are mostly underutilized in Europe. A small portion is used as firewood but the most common practice is to burn prunings and plantation removal in open fires or in some cases to be mulched in the soil. Their energetic utilization in modern combustion systems usually corresponds to less than 5% of the management practices.



Find out more about heating and use cases, fuel suppliers etc. in *AgroBioHeat Observatory*

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<https://agrobioheat.eu/agrobiomass-factsheets/>

- Factsheets on sunflower husk pellets, olive stones, miscanthus, nut shells, prunings, straw, SRC
- Factsheets on boilers and flue gas cleaning systems

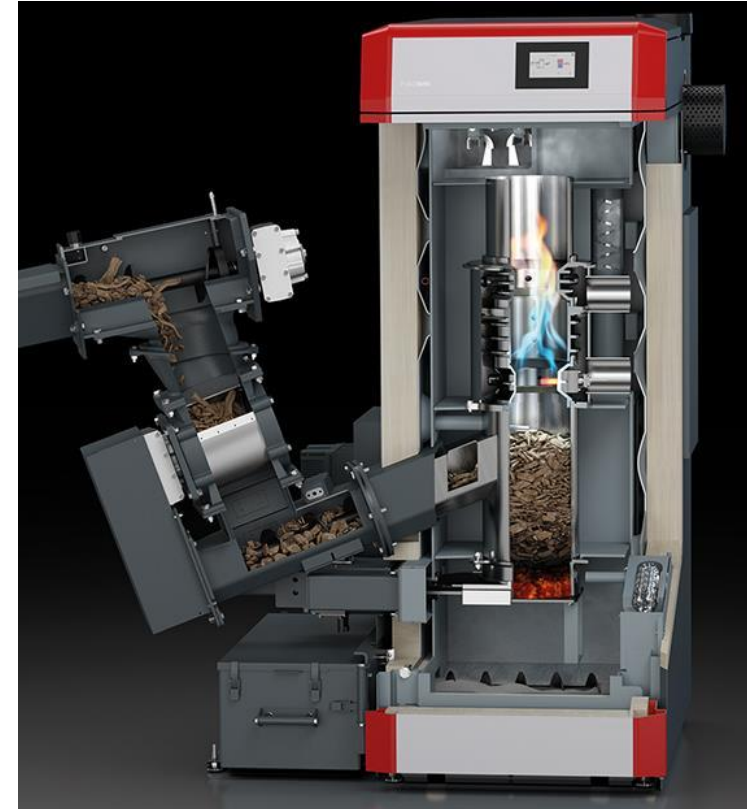
<https://agrobioheat.eu/agrobiomass-guides/>



## First tests already performed at laboratory of BIOS (Austria) – preliminary results

- Boiler 1: innovative extreme air staging concept (Windhager PuroWIN)
  - Fuels: sunflower husk pellets, agropellets, poplar
- Boiler 2: grate-fired furnace coupled with ESP
  - Fuels: olive stones, miscanthus
- Both boilers exhibit very good gas phase burnout (low CO)
- NO<sub>x</sub> emissions > wood fuels due to higher fuel-N content
- Boiler 1 achieves dust emissions < 27 mg/Nm<sup>3</sup> (full load) without filter
- Boiler 2 requires ESP to achieve dust emissions < 30 mg/Nm<sup>3</sup>

→ Together with results from CERTH (Greece) & CIRCE (Spain) informed emissions limits for agrobiomass fuels in Ecodesign Regulation will be proposed



<https://bringing-value-to-agrobiomass.b2match.io/>

Bringing Value to Agrobiomass  
February 10 - February 11, 2021

HomeParticipantsMarketplaceAgenda

LoginRegister

Virtual matchmaking event  
**Bringing VALUE to AGROBIOMASS**  
February, 10 - 11 - 2021  
Participation is FREE  

This project has received funding from the European Union's Horizon H2020 research and innovation programme under Grant Agreement No. 8158369

10 Feb 2021 - 11 Feb 2021  
**Bringing Value to Agrobiomass**

InfoContactHow 1:1 meetings workSupporting projects

Welcome to

## Bringing Value to Agrobiomass

10-11 February, 2021 - 10:00-16:00 CET - Check your timezone [here](#).

Meet potential cooperation partners or technology providers in this 1:1 meetings focused on how to create value from agrobiomass and side streams from food production.

Register now  
Open until 8 February 2021

ORGANISED BY



# Concluding remarks

1. Cost-competitive; meaningful investment with short payback time under right conditions
2. Reduction of GHG through fossil fuel substitution
3. Many different shapes and forms
4. Fitting solution for many different sectors & applications
5. Emissions can be controlled and technical issues can be overcome - with proper technology selection
6. European technological excellency & local fuels





Promoting the penetration of agrobiomass heating in European rural areas

# Thank you for your attention!

## Contact information:



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Visit us at: [www.agrobioheat.eu](http://www.agrobioheat.eu)



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