AgroBioHeat

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

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Centre for Research and Technology Hellas / Chemical Process and Energy Resources Institute

CPERI
Chemical Process and Energy Resources Institute

- **Establishment year:** 2012, after merging of two existing institutes of CERTH:
  - Institute for Solid Fuels Technologies and Applicactions (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…

HORIZON 2020

AgroBioHeat

AGRO in LOG

uP_running

BIOFIT
Bioenergy Retrofits for Europe's Industry

MUSIC
Market Uptake Support for Intermediate Bioenergy Carriers

RE4INDUSTRY
Renewable energies for industries

Presentation contents

- 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

Agrobiomass – Definition

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

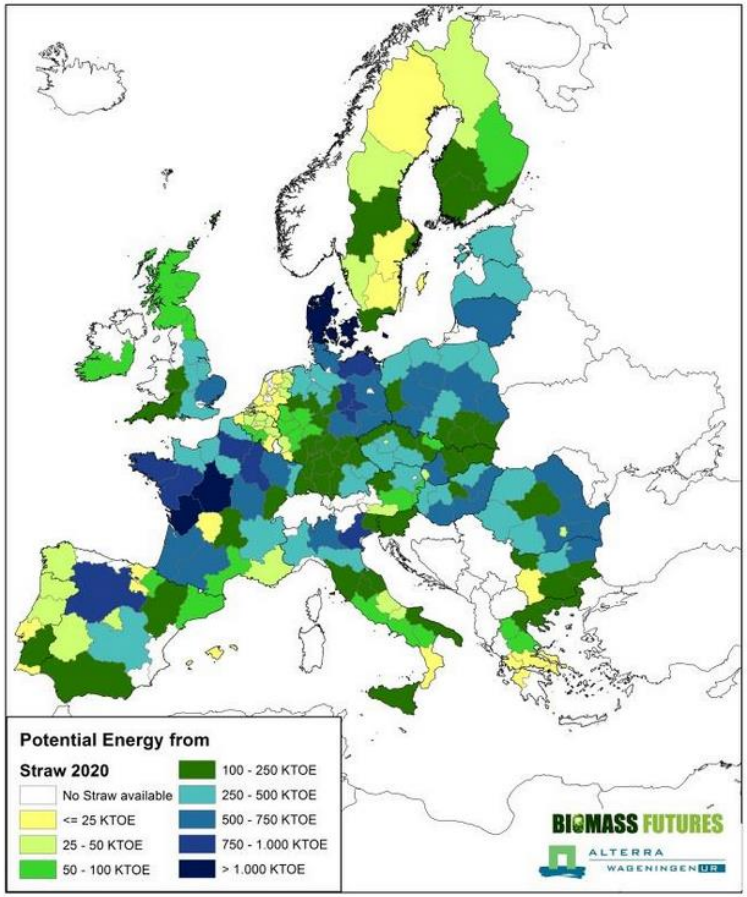
Great range of tradeable forms:

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

Agrobiomass potential in Europe

- **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

Straw potential for Energy – 2020 estimate



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

Agrobiomass current consumption and potential

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

(Sources: Eurostat and Bioenergy Europe's estimates)

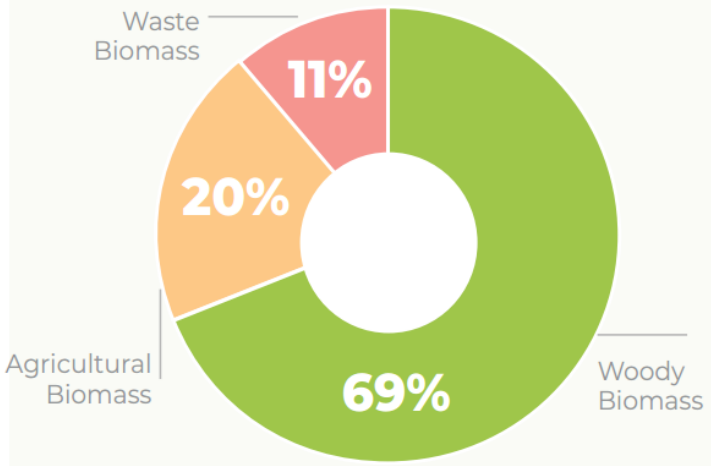


Figure 1 Gross inland energy consumption of biomass in 2018 and potential in 2050 for the EU28 (in Mtoe)

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 as a cost-competitive fuel

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
Olive stones (bulk)	**3.47**
Wood chips (bulk)	2.48

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

Agrobiomass supply chains

Agricultural residues

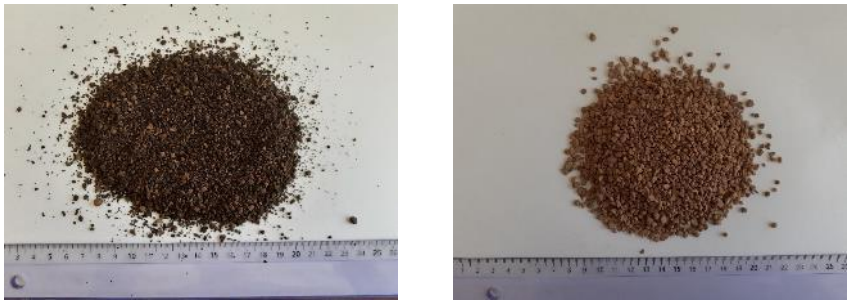
- Available on the field after harvesting of main product or produced as part of agronomic practices (e.g. pruning)
- Herbaceous (straw) or woody (prunings)
- Relatively low yields (< 4 – 5 t/ha), with some exceptions (e.g. orchard uprooting biomass)
- Disposal through open-field burning (mostly banned 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)

Agrobiomass supply chains

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 assorments – 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.

Agrobiomass supply chains

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 eco-system services: phytoremediation of contaminated soils, protection against soil erosion, etc.

Image Source: Terravesta

Images Source: GEA

Agrobiomass combustion technologies

Moving grate boiler

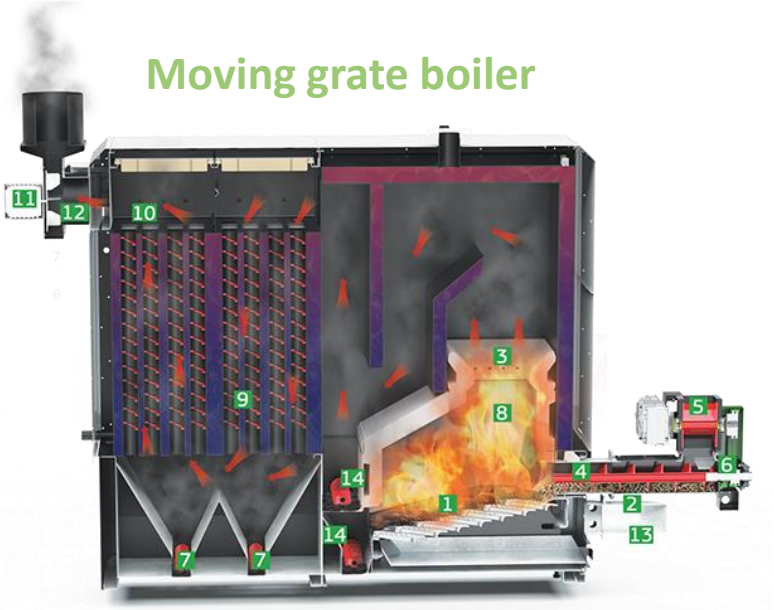


Image Source: Camino Design / PelleTech

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. Lamda sensor
13. Hot air blower for ignition
14. Automated ash extraction

Control and monitoring applications

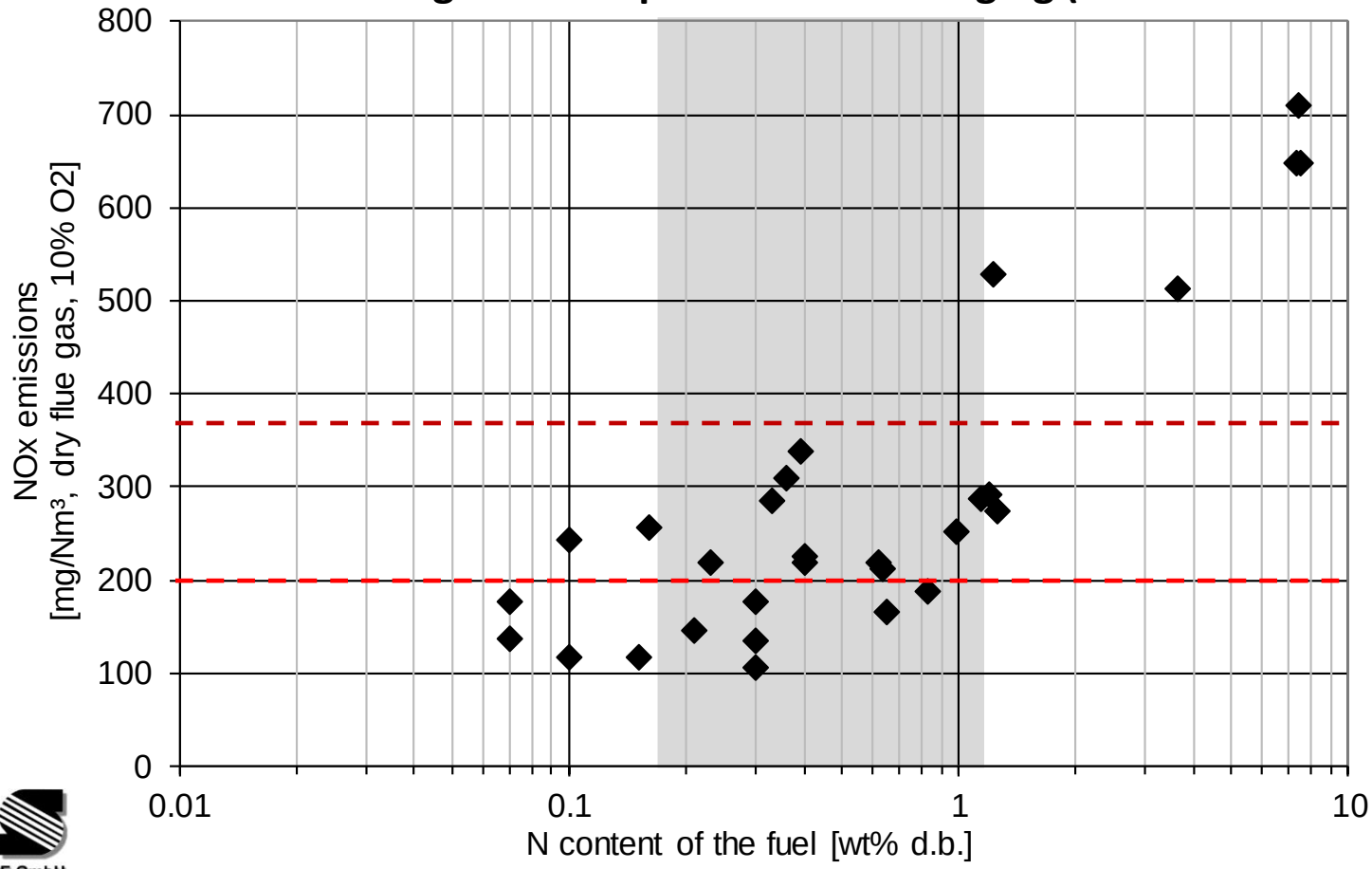
Image Source: Linka

PM abatement: ESPs and bag filters

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

NOx emissions from agrobiomass

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



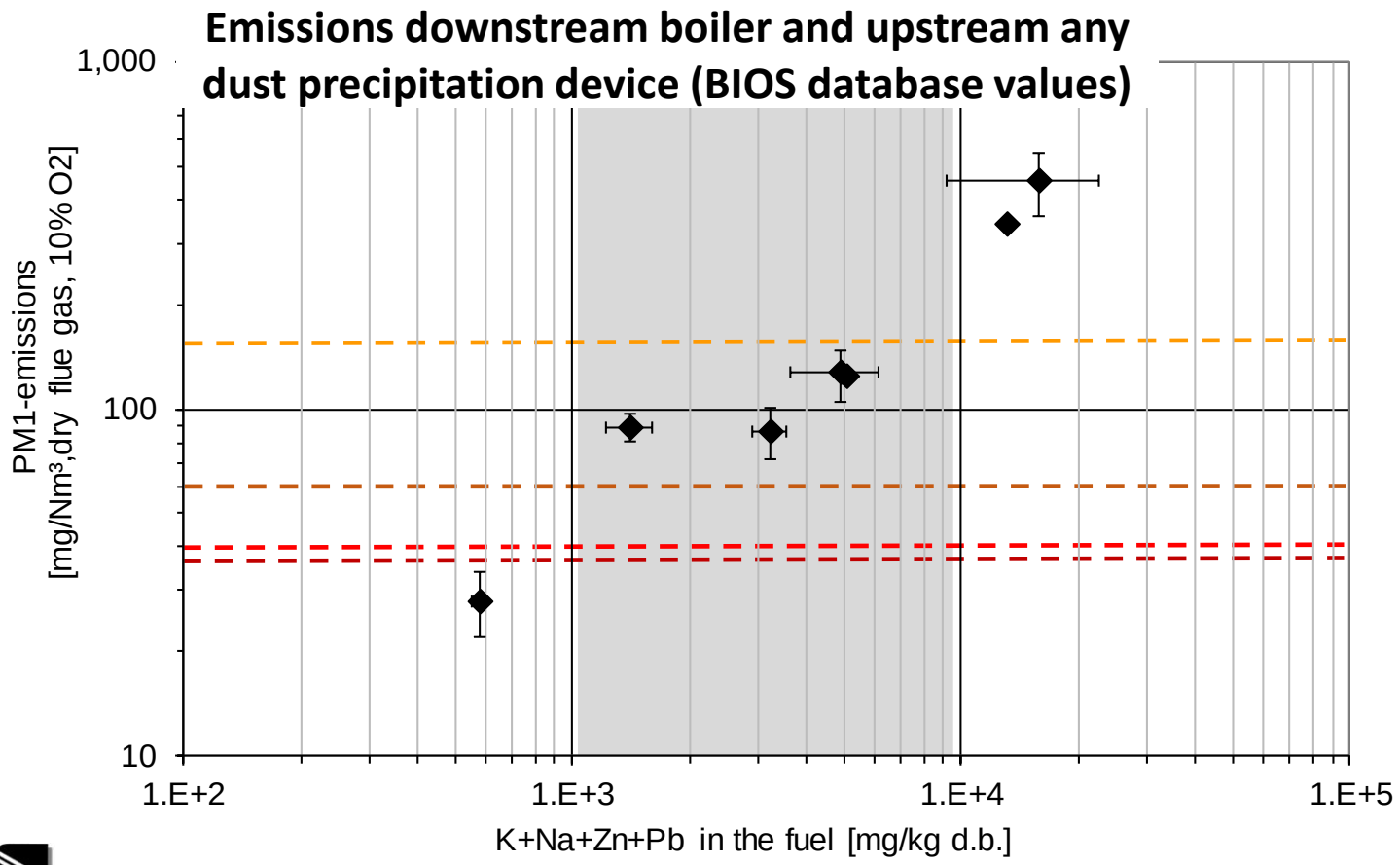
BIOS BIOENERGIESYSTEME GmbH

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

Emission limits:

- Ecodesign Regulation: 200 mg/Nm³ (<500 kW, wood fuels)
- EU-MCP Directive: 367 mg/Nm³ (<5 MW)

PM1 emissions from agrobiomass



BIOS BIOENERGIESYSTEME GmbH

Range of K+Na+Zn+Pb in agrobiomass fuels considered for AgroBioHeat tests (BIOS database values)

TSP emission limits:

- EN 303-5 Class 3: 150 mg/Nm³ (<500 kW)
- EN 303-5 Class 4: 60 mg/Nm³ (<500 kW)
- EN 303-5 Class 5 / Ecodesign Regulation: 40 mg/Nm³ (<500 kW; Ecodesign limit only for wood fuels)
- EU-MCP Directive: 37 mg/Nm³ (<5 MW)

Agrobiomass to energy applications

District heating with agrobiomass

- 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

- Public-private partnership on renewable heating using vineyard prunings in **Vilafrance 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 %.**

Greenhouse heating with agrobiomass

- **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

Other cases - Spain

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

https://agrobioheat.eu/wp-content/uploads/2020/10/AgroBioHeat_D3.1_agrobiomass-heating-facilities_v1.0-1.pdf

Other cases - France

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

Eco2Wacken

2 MW boiler by Compte.R

Corn cobs

https://www.bioenergie-promotion.fr/51630/compte-r-confirme-son-expertise-en-combustion-des-agrocombustibles-solides

Other cases – Ukraine

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

https://agrobioheat.eu/wp-content/uploads/2020/10/AgroBioHeat_D3.1_agrobiomass-heating-facilities_v1.0-1.pdf

Electricity production from agrobiomass

FIUSIS

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

www.fiusis.it
http://www.up-running.eu/wp-content/uploads/2017/10/uP_running_D6.3-Flagship-cases-report-v1_.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

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

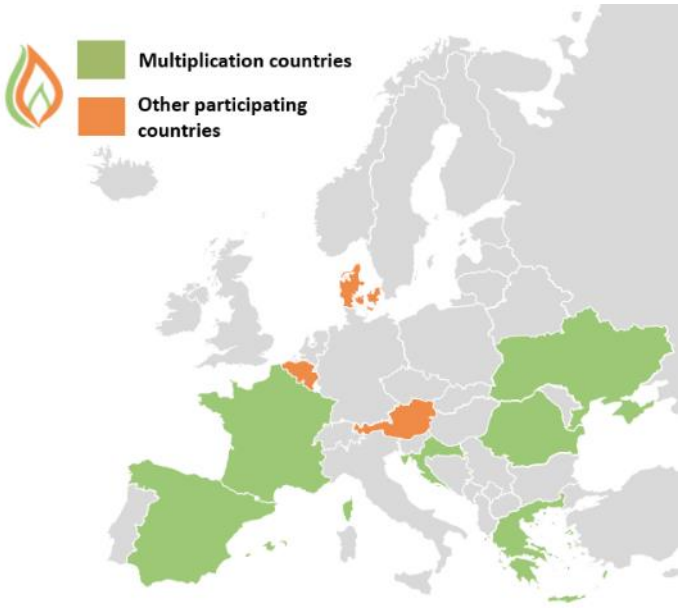
Studstrup Power Station

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

The AgroBioHeat project



⇒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: 1st January 2019 – 31st 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)

CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS; circe RESEARCH CENTRE FOR ENERGY RESOURCES AND CONSUMPTION; BIOS BIOENERGIESYSTEME GmbH

European association (BE)

Bioenergy EUROPE

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

GREEN ENERGY Romanian Innovative Biomass CLUSTER; LABIO Bioenergy Association of Ukraine; Aile initiatives énergie environnement; aveBiom; INASO-PASEGES INSTITOUTO AGROTIKIS & SYNETAIRISTIKIS OIKONOMIAS; ZEZ Zelena Energetska Zadruga

Straw & network expertise (DK)

Food & Bio Cluster Denmark

Social sciences expertise (BE)

WHITE RESEARCH

Agrobiomass facility operator (FR)

Agronergy

AgroBioHeat – approach & strategy

Our approach

Providing Support

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

- ✓ Accompaniment of new initiatives
- ✓ Policy recommendations for revision of Ecodesign Regulation based on combustion tests
- ✓ Trainings to installers

Generating Vision

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

- ✓ Policy roadmaps / recommendations & advocacy actions
- ✓ Increased sector visibility in fairs & expos
- ✓ Social surveys & local / regional workshops & community hearings

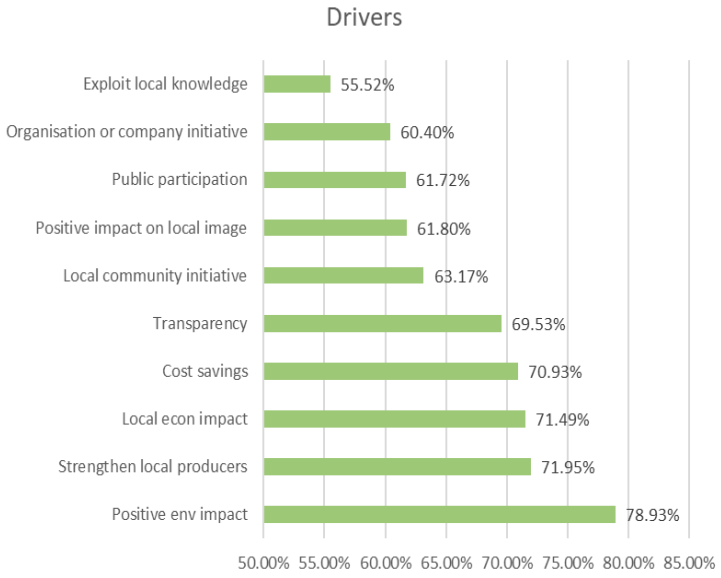
Developing Trust

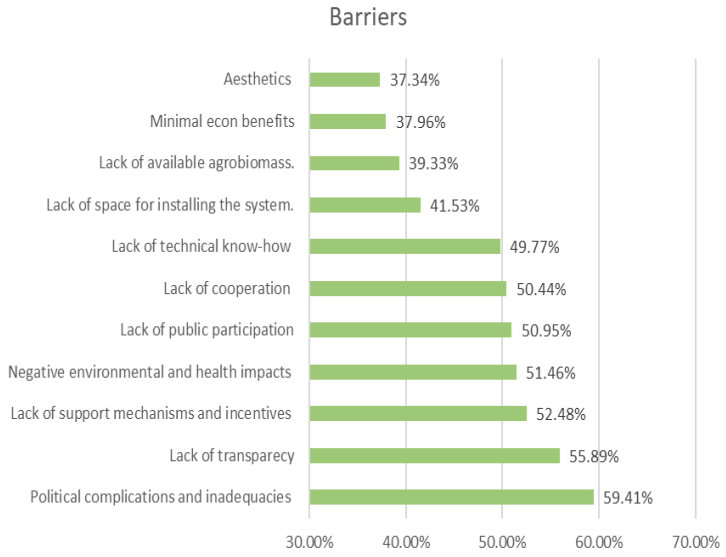
Proof that agrobiomass heating works, that it is economically, environmentally, socially sustainable and that other adopters have succeeded

- ✓ 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)

EU-survey on agrobiomass heating public perceptions

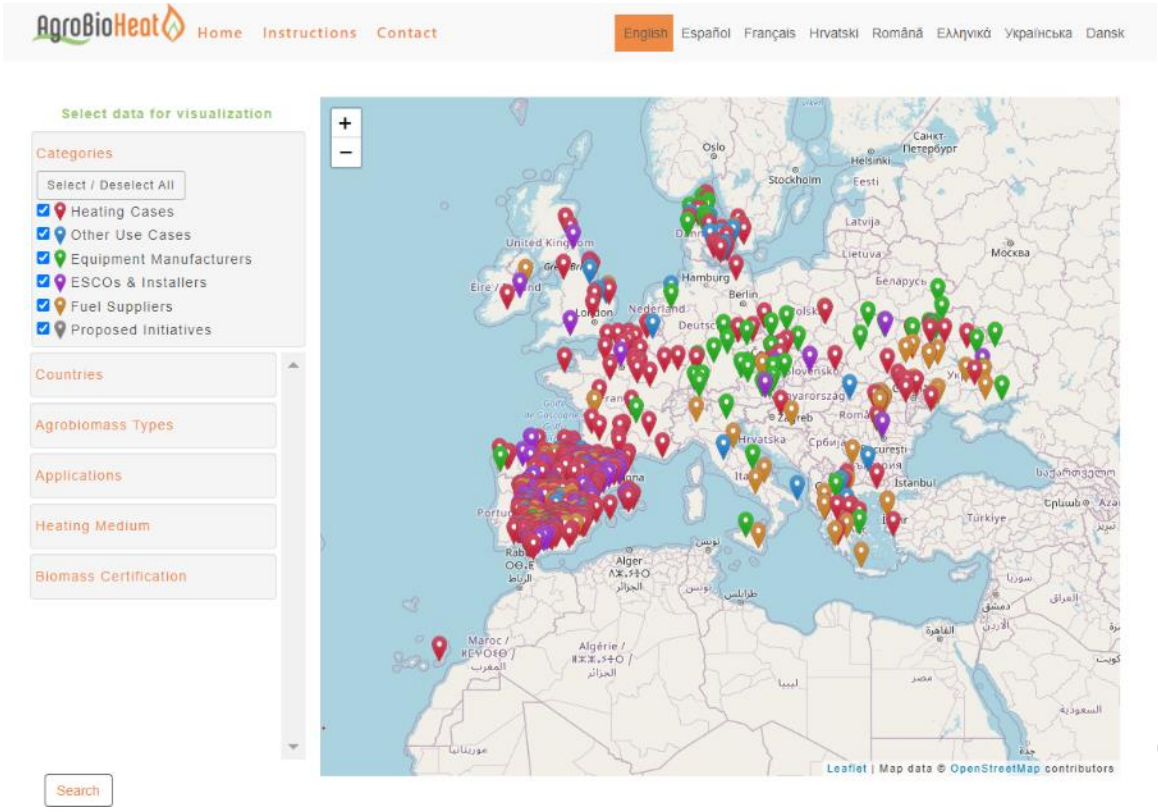
- Running from March to April 2020
- 3,725 responses collected online
- **Key finding: increase of awareness and first-time users leads to increased acceptance**
- Full results available here: https://agrobioheat.eu/wp-content/uploads/2020/10/AgroBioHeat_D5.1_Part-2_European-social-perception-survey.pdf





The AgroBioHeat Observatory

www.agrobiomass-observatory.eu



Up to now more than 1,000 entries

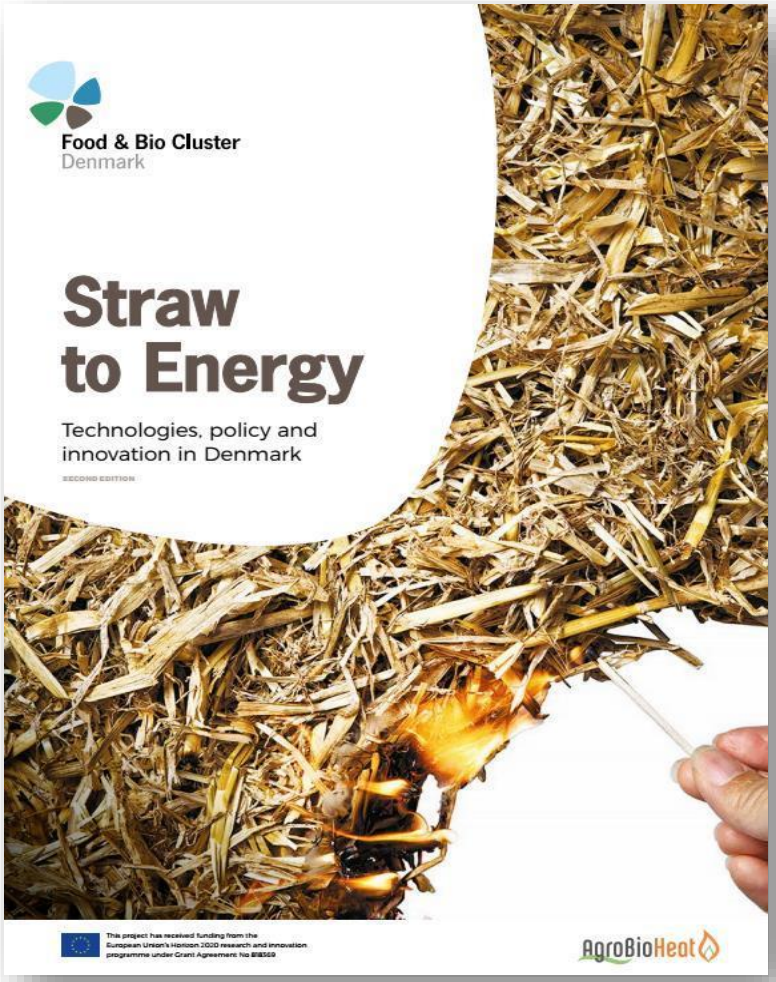
- 679 agrobiomass heating cases (< 50 MWth)
- 51 cases of other types of agrobiomass utilization (power, CHP, industry, large-scale heat, biofuels, bioproducts, etc.)
- 66 equipment manufacturers (mostly boilers and flue gas cleaning systems)
- 108 agrobiomass fuel suppliers
- + others (ESCOs, installers,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

Continuously updated!

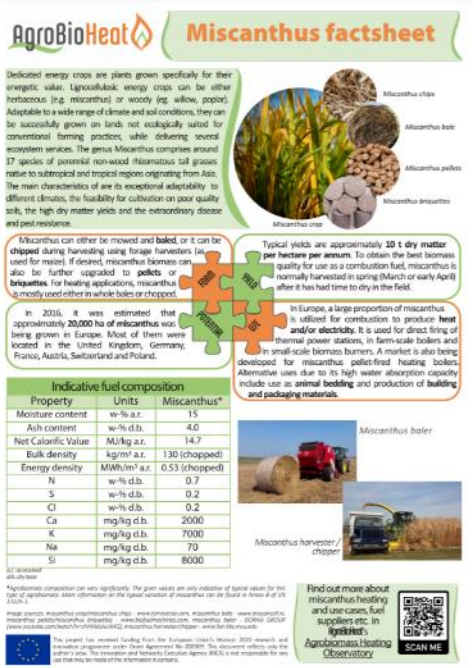
Vilafranca del Penedès (ES) – 27th February 2020

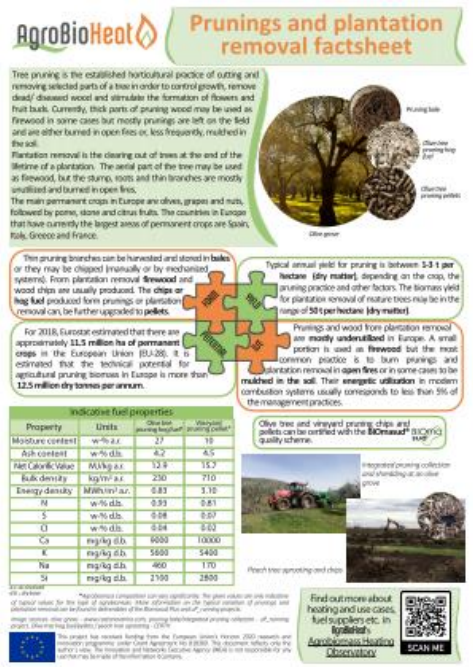
- Workshop on using vineyard prunings for heat / energy production
- Site-visit to “La Girada” district heating of local municipality, fueled exclusively with vineyard prunings / 500 kW Heizomat boiler
- Site-visit to Familia Torres / 2.6 MW biomass boiler coupled with adsorption chiller for cooling / fueled by forest wood chips and vineyard prunings
- Further information: https://agrobioheat.eu/vilafranca-del-penedes-visit/

Straw to Energy Guide & Agrobiomass Factsheets



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





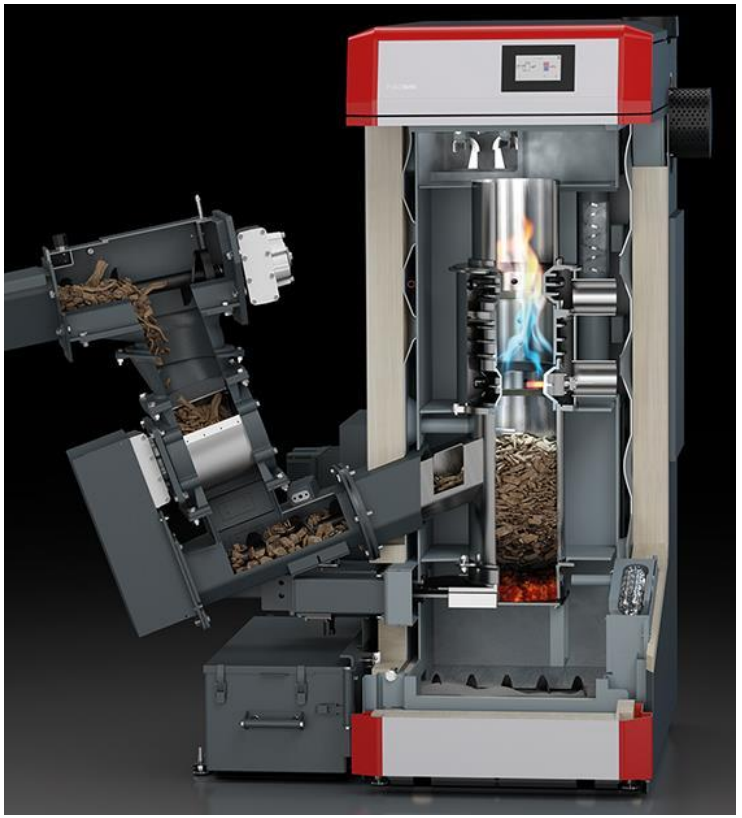
https://agrobioheat.eu/agrobiomass-factsheets/

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

Combustion tests with agrobiomass fuels

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)
- NOx emissions > wood fuels due to higher fuel-N content
- Boiler 1 achieves dust emissions < 27 mg/Nm^3 (full load) without filter
- Boiler 2 requires ESP to achieve dust emissions < 30 mg/Nm^3



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

"Bringing Value to Agrobiomass" B2B matchmaking

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

Concluding remarks

Agrobiomass heating – key points

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

AgroBioHeat

Promoting the penetration of agrobiomass heating in European rural areas

Thank you for your attention!

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