AgroBioHeat

Promoting the penetration of agrobiomass in European rural areas

Grant Agreement No 818369

D5.2: National Strategic Plans

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 818369.

Deliverable Factsheet

Deliverable Factsheet	
Full title	National Strategic Plans
Deliverable Number	D5.2
Work Package	WP5 Providing Europe with a strategy and regulations for agrobiomass heat
Task(s)	T5.2 National Strategic Plan T5.3 National policy workshops & Advocacy actions of current national and European framework conditions
Lead Beneficiary	UABIO
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Version	Final
Date	July 2022
Dissemination level	Public
Language(s)	English (Summary) + National Strategic Plans for each project multiplication country in national languages (Croatian, French, Greek, Romanian, Spanish, Ukrainian)

Acknowledgements and Disclaimer

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The AgroBioHeat 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 authors' view. The European Climate, Infrastructure and Environment Executive Agency (CINEA) and the European Commission are not responsible for any use that may be made of the information it contains.

Abbreviations

Abbreviation	Explanation
AKIS	Agricultural Knowledge and Innovation Systems
EE	Energy efficiency
DH	District heating
DHS	District heating system
ETS	Electronic trade system
FTE	Full Time Equivalent
GHG	Greenhouse gas
NECP	National Energy and Climate Plan
NGO	Non-governmental organisation
NSP	National Strategic Plan
NMVOC	Non-methane volatile organic compounds
RES	Renewable energy sources
SME	Small and medium enterprise
SRC	Short rotation coppice
TSP	Total suspended particles

Project consortium

#	Full name	Acronym
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2	Fundación Centro de Investigación de Recursos y Consumos Energéticos	CIRCE
3	Asociación Española de la Valorización Energética de la Biomasa	AVEBIOM
4	BIOS BIOENERGIESYSTEME GmbH	BIOS
5	Food & Bio Cluster Denmark	FBCD
6	Bioenergy Europe	B.E.
7	Zelena energetska zadruga za usluge	ZEZ
8	Asociatia Green Energy	GEA
9	Institouto Agrotikis kai Synetairistikis Oikonomias INASO-PASEGES	INASO-PASEGES
10	Bioenergy Association of Ukraine	UABIO
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12	Agronergy	AGRONERGY
13	Association d'Initiatives Locales pour l'Energie et l'Environnement	AILE

Contents

List of Tables

Executive Summary

The AgroBioHeat project is committed to identify suitable policy interventions for the promotion of agricultural biomass and the development of rural areas' potential. Almost half of rural heat comes from polluting sources, showing a clear need to promote greener and more sustainable solutions in the context. Agrobiomass can be an enabler of this change, however some new dedicated policies are still needed to ensure better mobilisation and provide local actors with the right instruments to lead the transition. The untapped potential of the agrobiomass sector is clearly recognised in several European scenarios and political incentives must be implemented to encourage the involvement of agrobiomass in energy sector.

The document covers key items related to bioenergy and agrobiomass issues in five EU countries (Greece, Spain, France, Romania, Croatia) and Ukraine. In particular, major technical and non-technical barriers for using agrobiomass for energy and possible ways to overcome them are determined and discussed in the document. The report also presents main results of the economic, environmental and social assessment of impacts of the increased market penetration for agrobiomass heating.

Finally, the core of the document is Policy Recommendations suggested to further mobilize agrobiomass for heat production in the mentioned countries. Five key recommendations stated in the National Strategic Plans are:

1. Development of a National biomass strategy / updating of NECP and other relevant strategies and roadmaps.
2. Development of local / regional action plans.
3. Streamline energy and agricultural strategy and regulations regarding energy crops.
4. Facilitate the mobilization of biomass from agricultural byproducts ensuring environmental compatibility with soil management.
5. Promotion of rural district heating systems.

Introduction

The present document constitutes Deliverable 5.2 “National Strategic Plans” of the AgroBioHeat project prepared within the framework of Task 5.2 “National Strategic Plan”. The aim of the report is to formulate specific policy recommendations for fostering the development of agrobiomass heating sector in five EU countries (Croatia, France, Greece, Romania, Spain) and Ukraine. The present report builds on the work outlined in AgroBioHeat Deliverable 5.1 / Parts 3, 5-9 (Framework conditions in Croatia, France, Greece, Romania, Spain and Ukraine). They identified and analysed specific areas that have a direct or indirect impact on fostering agrobiomass supply, mobilization and end-use: Agrobiomass availability, Rural Development, Logistics and other market considerations, Air quality, Tax breaks, Other support measures targeting heating, Buildings Efficiency, Policy Coherence.

The Strategic Plans reflect some important national features such as the prevailing types of available agrobiomass, existing ways and directions of its utilization; availability or need for implementing (switching to) harvesting technologies to ensure proper collection of the agrobiomass; shares of agrobiomass that can be sustainably used for energy; preferable sectors for energy production from agrobiomass etc. The Strategic Plans are coordinated with main provisions of SECAPs and other related national strategic documents.

Draft plans were shared with relevant stakeholders engaged in WP2 and consulted for the framework analysis in T5.1 to reach their feedback and tune the policy recommendations. Workshops carried out in T5.3 also contributed to this purpose counting with the visions and opinions of a wider set of visions from multiple actor profiles.

1. National Strategic Plan – Greece

Major facts on bioenergy state of the art in Greece

- Bioenergy from solid biomass accounts to around 3.5 % of Greece's final energy consumption (2017).
- The vast majority of biomass in Greece is used for heating: around 17.3 % of the total energy consumption and 57 % of the renewable energy consumption of the sector (2019).
- The domestic sector is the biggest biomass consumer in the country, amounts to 77.6 % out of the 876 ktoe of bioheat (2019).
- Firewood is the main biomass fuel used in the domestic sector; wood pellets and olive oil production residues (exhausted olive cake) also have a relevant share, the latter primarily in southern Greece.
- The industrial sector is the other major end-user of biomass – around 15.9 % of bioheat (2019) and 5.8 % of the total energy consumption of the sector (2017). This is achieved primarily through agro-industries (e.g. olive mills, olive pomace mills, peach canning plants and others) that self-consume their own production residues.
- The agricultural and the commercial / public sectors have only limited shares of biomass consumptions; the use of biomass for the heating of greenhouses is quite well developed.
- District heating has been applied only to a few cities, almost all of them served through heat derived by lignite-fired power plants. Due to the coal phase-out, the smallest of those DH systems has already switched to biomass (wood chips, sunflower husks and agricultural residues). For the others, solutions based on natural gas cogeneration are investigated.
- Electricity production from biomass is supported by a feed-in premium scheme.
- There is no dedicated scheme for promoting heat production from biomass; however, there are possibilities for partial subsidizing the investment in new biomass boilers through several schemes addressing the domestic ("Eksoikonomo"), agricultural (Rural Development Programme) or industrial sectors (e.g. structural funds).

Agrobiomass state of play in Greece

Agriculture contributes about 3.72 % of the Greek GDP (2018). Differences in climate and terrain among different regions and locations allow for a variety of crops to be grown. The Utilized Agricultural Land (UAA) was 3,221 thousand ha, corresponding to 24.4% of the total surface[1]. The breakdown of UAA use is as follows: arable farming 53.3 %; permanent crops 33.6 %; fallow land 11.0 %; vegetables 2 %.

Greece is the EU member state with the highest share of permanent crops in the UAA and the one out of three (along with Cyprus and Portugal) with a share higher than 20 %, according to Eurostat. Greece is a major producer of olive oil (3rd in the EU and globally), edible olives (2nd in EU), peaches (3rd in EU and leader in peach processing), apricots (4th in EU), kiwis (2nd in EU), almonds (3rd in EU), pistachios (1st in EU),

[1] ELSTAT, Annual agricultural statistical survey: 2017, https://www.statistics.gr/en/statistics/-/publication/SPG06/-

vineyards (6th among EU in terms of areas cultivated), as well as several other crop species. The annual theoretical potential of agricultural prunings is estimated to be around 2.35 Mt (dry basis). Larger pieces of prunings are already used as firewood for domestic heating. However, most of the prunings generated on an annual basis are disposed through open fires on the fields. Some farmers have started implementation of alternative treatment methods for incorporating prunings in the soil or using them as soil cover. A few isolated examples of agricultural pruning utilization for energy, mostly after upgrading into pellets, can be found in the country.

Although not among the biggest EU producers, the cultivation of cereals is of major importance to the agricultural sector of the country. The annual technical potential of such herbaceous biomass residues (cereal straw, maize residues) is estimated to be around 2 Mt (dry basis). There are some alternative markets for these residues, mostly for animal feeding and bedding, however practically no major applications for bioenergy production.

Greece is the only EU-member state with a sizeable area devoted to cotton cultivation. Other relevant industrial crops for agrobiomass production are sunflower and rapeseed, which are growing in popularity. The annual technical potential of such residues is estimated to be around 0.95 Mt for cotton residues and 0.28 Mt for sunflower and rapeseed straw. However, this potential remains largely untapped.

Combined, the agricultural residues in Greece amount to an energy potential of around 2.13 Mtoe/y.

There is a significant potential from agro-industrial residues. The most abundant such fractions are the solid residues of olive oil processing – quantities vary from year to year, but they can be estimated as around 0.56 Mt. A large share is self-consumed for the secondary oil extraction at the olive pomace mills, but there are still significant quantities available on the market as a mixture of olive stones and exhausted olive cake, known as “pirinoksilo”. This is used in applications ranging from domestic heating to greenhouses and some industrial applications. Separation of the olive stones from the olive pomace / olive cake is still not widespread in Greece.

Other agro-industrial residues (e.g. peach stones, rice husks, cotton ginning residues, nut shells) are also produced, but are mostly self-consumed by the producing industry and/or used in local applications. Lately, there has been increased interest in the use of sunflower husk pellets in medium-scale applications; quantities are mostly imported.

Cultivation of lignocellulosic energy crops is marginal, apart from some very small plantations and pilot projects. In the past, there was interest in the cultivation of energy crops to be used in co-firing applications for lignite power plants, but these projects did not proceed.

Overall, the agrobiomass – as well as the wider biomass – sector in Greece remains quite undeveloped, despite the significant potential.

A key issue that affects the mobilization of agrobiomass from agricultural residues is the small size of the agricultural holdings – on average 6.6 ha per holding, while more than 90 % of holdings are smaller than 20 ha. This impacts the overall competitiveness of the agricultural sector, which is characterized by low

mechanization levels, low uptake of new technologies, low productivities and low income; the average amount of agrobiomass that can be mobilized by holding is also low.

The long-term, strategic planning for the Greek energy sector[2] foresees an increased mobilization of agrobiomass resources. Depending on the scenario, agricultural residues could contribute with 1.42 – 1.57 Mtoe, while (woody) energy crops could contribute with 1.39 – 2.48 Mtoe by 2050. The area devoted to energy crops could range from 285 to 480 thousand ha (around 8.8 – 14.9 % of the current UAA). The use of biomass will increase in several end-uses (power generation, transport, industry), but is foreseen to decrease for the building and commercial sectors.

However, there is a big gap to be closest between the future projections of biomass mobilization and the actual reality of the agrobiomass state-of-play in Greece. The lack of a dedicated strategy and tailored regulations and support schemes hampers the development of the sector and creates uncertainties as to how the mobilization targets can be reached in the medium to long term.

The development of the agrobiomass heating sector offers one possibility for closing this gap. Agrobiomass heating projects are usually small to medium scale and require sourcing of moderate volumes of fuel. This means that a well-designed project has a lower risk of failure due to supply chain issues and requires a moderate (absolute) amount of capital for implementation. On the other hand, the practical experiences gained from the supply chain operation will allow a better understanding of the challenges associated with biomass supply and will assist in the first steps of the learning curve. Still, developing the Greek agrobiomass heating sector requires overcoming several challenges, both technical and non-technical.

Main barriers for using agrobiomass for energy and possible ways to overcome them

Technical barriers

- *Farmers do not have access to specialized machinery for the harvesting of crop residues, especially agricultural prunings.*

Possible solution: collaborative ownership (e.g. agricultural cooperatives, energy communities or other novel schemes) of harvesting machinery can be a solution. The development of dedicated agro-service companies or business lines is another alternative, but it requires the mobilization of significant volumes to justify the effort.

Another solution is the development of supply chains using already available equipment, such as small chippers for prunings or municipally owned chippers for green waste. Although such solutions will probably require more manual labor than others and may result in higher costs, they could potential still be competitive to fossil fuels if the local conditions are appropriate.

[2] https://ec.europa.eu/clima/sites/lts/lts_gr_el.pdf

- *Space requirements for (agro)biomass storage.*

Possible solution: projects for agrobiomass heating should target rural areas and applications with fewer space limitations. Two technical alternatives can also be considered, although each comes with additional costs: a) upgrading of agrobiomass into agropellets with a higher energy density, b) development of centralized biomass combustion plants and distribution of heat through a DH network.

- *High emissions of pollutants from agrobiomass combustion & other operating issues.*

Possible solution: Use of modern, specialized biomass boilers equipped with appropriate primary and secondary air emission control devices and automation features.

Non-technical barriers

- *Agrobiomass heating solutions require a higher CAPEX (capital expenditure) compared to fossil-based alternatives.*

Possible solution: subsidizing the investment cost for agrobiomass boilers. There are some funding schemes that can be accessed for such a purpose, but not a dedicated instrument. Moreover and especially for the domestic sector there are limited requirements regarding the efficiency and air emission performance of subsidized devices.

- *Low volumes of agrobiomass that can be mobilized by individual farmers.*

Possible solution: Collaborative schemes, such as agricultural cooperatives and energy communities, allow the pooling of agrobiomass resources and the mobilization of sufficient quantities for the operation of agrobiomass heating projects.

- *Low political priority and/or lack of awareness.*

Possible solution: Targeted awareness raising actions (e.g. sites visits / study tours), promotion of existing success cases in Greece and Europe, development of a national biomass strategy and clearer visibility of biomass solutions in strategies and roadmaps of other sectors.

- *Continued practice of open field burning of crop residues, especially prunings.*

Possible solution: Enforcement of stricter rules, coupled with incentives and financial support (e.g. subsidizing the purchase of chippers / harvesters) for alternative treatment methods.

Potential for further development for the production and use of agrobiomass for heating

Within the Greek context, it can be expected that municipalities and municipal level actors could evolve as the “champions” of agrobiomass heating. Solutions could be realized in municipal buildings with high heat demands or even as small DH systems – although it has to be highlighted that there is limited uptake of such systems in Greece regardless of their fuel. This effort can be supplemented to some extent by

actors in the commercial & service sector, for example, hotels in rural areas. Collaboration with other important local value chain actors – in particular the farmers and their cooperatives – would be required.

Agro-industries and greenhouses are among the major existing end-users of agrobiomass in Greece – the former using their own residues, the latter procuring quantities from the market. Still, there is potential to tap into the local agrobiomass resources, both to diversify fuel sourcing and to reduce costs. There are also other, smaller industries that require process heat in the form of hot water, steam or other, which are not directly linked with the local agricultural sector. Again, a collaboration with the primary producers and their associations would be required.

Residential heating with agrobiomass is limited to the use of olive oil production residues – primarily exhausted olive cake. Exhausted olive cake is a very cost-competitive fuel source, but often does not reach its full environmental and energy potential for two reasons: a) there is limited valorisation of the residues, e.g. no separate production of olive stones and hence its fuel properties are mostly suited for industrial rather than residential applications; b) the appliances used for energy production are typically technologically obsolete. Utilization takes place mostly in Southern Greece, which typically has a lower heat demand, and makes it more difficult to justify large capital investments in heating systems. Still, the situation can be improved by promoting the separation and standardization of olive stones from the potential producers and by supporting end-users in upgrading their heating systems to new appliances.

Assessment of impacts of the increased market penetration for agrobiomass heating

The starting point for the assessment of an increased uptake of agrobiomass heating in Greece is the final version of the National Energy and Climate Plan (NECP), submitted to the European Commission in December 2019[3]. Table 1 presents the main figures regarding the energy consumption in 2020 and 2030 of some sectors of interest[4] to AgroBioHeat (RES heating, residential, tertiary, industry) as well as the contributions of specific energy sources (petroleum, natural gas, district heating and bioenergy). It is clear that the projected increase of bioheat is only modest compared to the project increased of renewable heating in total and is mainly expected to come from industrial applications. Equally clear is the projected increase in the use of natural gas for heating and the reduction – but not the total phase-out – of petroleum products.

Table 1: Provisions of Greek NECP regarding energy consumption (in ktoe) for specific sectors and energy carriers.

Sector	2020	2030
RES Heating / total	**1,761**	**2,460**
- Bioenergy for heating	*1,035*	*1,142*
Residential / total	**4,690**	**4,465**

[3] https://energy.ec.europa.eu/system/files/2020-03/el_final_necp_main_en_0.pdf
[4] Detailed data on the agricultural sector energy consumption are not included in the NECP.

Sector	2020	2030
- Petroleum products	*1,260*	*433*
- Natural gas	*432*	*673*
-District heating	*43*	*39*
- Bioenergy	*830*	*860*
Tertiary / total	***2,177***	***2,451***
- Petroleum products	*159*	*112*
- Natural gas	*163*	*214*
- Bioenergy	*9*	*11*
Industry / total	**3,011**	**2,879**
- Petroleum products	*964*	*588*
- Natural gas	*620*	*770*
- Bioenergy	*174*	*227*

The AgroBioHeat target for 2030 is to reach a mobilization of around 100,000 t (dry matter) of agrobiomass residues for heating applications in Greece – up to 38.2 ktoe of additional bioenergy supply. Considering the technical potential of agrobiomass resources as well as the current state-of-play, this target can be considered as ambitious, but also quite realistic.

To some extend – although not very precise – the Greek NECP anticipates increased utilization of agrobiomass resources, e.g. for power generation and industry. The position of the AgroBioHeat Greek partners is that it should be possible to mobilize additional agrobiomass resources for heating applications by 2030, primarily for substituting the use of petroleum (heating oil) in the tertiary sector and petroleum and/or natural gas in the smaller industries.

In the following paragraphs, the main impacts of the targeted agrobiomass mobilization is discussed; three main aspects are considered: a) reduction of air pollutants; b) reduction of GHG emission; c) job creation and other socio-economic aspects.

Reduction of air pollutants

Open-field burning of agrobiomass residues is a significant contributor to the emissions of air pollutants in the Greek countryside. On the other hand, the controlled combustion of agrobiomass in modern heating systems equipped with appropriate primary and secondary measures for emission control results in much lower emissions.

Table 2 compares the annual emissions generated from the combustion of 100,000 dry tons of agrobiomass residues versus the emissions generated from the open-field burning of the same amount of material. It is clear that the controlled burning of agrobiomass does result in a significant reduction of all the pollutants considered (e.g. NOx, CO, NMVOC and TSP).

Table 2: Estimated reduction of emissions from open-field burning of agrobiomass residues due to the deployment of heating installations in Greece.

Pollutant	Annual emissions from agrobiomass heating applications (t/y)	Avoided emissions from open-field burning (t/y)	Air emissions reduction
NOx	150.2	391.0	61.6 %
CO	717.8	8,571.4	91.6 %
NMVOC	257.4	774.4	66.8 %
TSP	173.3	933.9	81.4 %
NOx: Nitrogen oxides; CO: Carbon monoxide; NMVCOC: Non-methane volatile organic compounds; TSP: Total suspended particles			

Note: the calculation was performed using the methodology developed by AgroBioHeat project partner CERTH in September 2020. An update of the emission factors using the results of the combustion tests performed within the AgroBioHeat project and a recalculation of the savings is pending.

Reduction of GHG emissions

The substitution of fossil fuels used in heating applications (heating oil, natural gas) by renewable, carbon-neutral agrobiomass also results in a substantial reduction of GHG emissions. Table 3 presents the GHG emissions avoided by the controlled combustion of 100,000 dry tons of agrobiomass residues in case of substitution of natural gas or heating oil; savings of more than 80 % are achieved in both cases.

Table 3: Estimated reduction of GHG emissions from the substitution of natural gas or heating oil by agrobiomass in heating applications in Greece.

Fuel	GHG emissions (tCO_{2eq}/y)	GHG emission reduction
Agrobiomass	14,341.8	-
Natural gas	80,507.5	82.2 %
Heating oil	116,140.7	87.7 %
Note: GHG emissions from agrobiomass combustion are due to the release of small quantities of CH_4 and N_2O in the flue gases.		

Note: the calculation was performed using the methodology developed by AgroBioHeat project partner CERTH in September 2020. An update of the emission factors using the results of the combustion tests performed within the AgroBioHeat project and a recalculation of the savings is pending.

Job creation and other socio-economic impacts

An assessment of the job creation potential of increased agrobiomass mobilization for heating in Greece can be found in Table 4. The calculation is based on the figures provided by the Deloitte report of 2022[5] for Bioenergy Europe regarding the job impact of the biomass district heating in Europe. It should be noted that around 68 % out of the 268 FTE direct jobs would be local ones related to construction, feedstock

[5] https://bioenergyeurope.org/articles/349-bioenergy-in-tomorrow-s-energy-system-decentralised-solutions-for-a-climate-neutral-economy.html

supply, operation & maintenance of agrobiomass heating facilities. The Greek biomass boiler manufacturers could also provide at least part of the direct jobs related to equipment manufacturing.

Table 4: Estimation of job creation from increased agrobiomass mobilization for heating in Greece.

Impact on jobs	Direct jobs	Indirect jobs	Total
Equipment manufacturing	85	62	**330**
Construction	25		
Feedstock supply	42		
Operation and maintenance	116		
Total	**268**		

Public and stakeholder perception of agrobiomass heating

Apart from the work performed by the AgroBioHeat project, there are limited studies on the public perception of agrobiomass heating, since the issue was more marginal compared to the investigations of social acceptance for wind and solar energy. Some key remarks based on the results of the AgroBioHeat surveys and the previous knowledge and experience of CERTH and INASO-PASEGES are as follows:

Renewable energy experts

- Generally, positive attitude and recognition of the huge potential of agrobiomass resources.
- On the other hand, the realities of biomass mobilization may be lost on those who approach the issue on a strategic level.

Local authorities in rural areas:

- Generally, awareness of possible advantages for the community and local economy in terms of economic growth and job creation.
- However, frequent concerns related to air emission impact of bioenergy projects arise in discussions of municipal or regional councils.
- Biomass and bioenergy is generally low on the political agenda.
- Often, lack of recognition that municipalities could become local champions in the use of agrobiomass.

General public / rural population

- Mostly positive perception or at least absence of negative attitude. Awareness of possible basic advantages for the community.
- Part of the rural population may already be using agrobiomass as fuel (e.g. exhausted olive cake, larger pruning branches as firewood), but mostly in technologically obsolete systems (open fireplaces, low-efficiency boilers, etc.).

General public / urban population

- No specific stance towards agrobiomass in particular.
- Part of the urban population has become biomass end-users, mostly in the form of firewood and wood pellets for fireplaces and fireplace inserts (primarily), stoves and boilers.
- Increased awareness and concern about the health impacts of improper biomass combustion; significant media coverage especially during the winter months.

Producers of agrobiomass (farmers)

- Generally, recognition of possibilities and positive attitude; handling of residues is recognized as an issue that will have to be tackled one way or another.
- Some farmers implement alternative methods for residues disposal (e.g. mulching & soil incorporation, chipping & soil cover). These have lower motivation to switch to a biomass-to-energy model and may have concerns regarding removal of residues from the fields.
- A small minority considers that open-field burning should continue to be tolerated.
- There is some scepticism regarding the organizational aspects and actual financial benefits to farmers from biomass-to-energy models.

Other potential agrobiomass end-users (power plants, agro-industries, industries, and others)

- Primarily motivated by costs and – lately and increasingly – by sustainability concerns.
- If energy production is not their core business, then easier rather than more difficult solutions are adopted: natural gas, commercial biomass suppliers, etc.
- Organizational and cooperation issues may be perceived as bottlenecks to new agrobiomass solutions.

Policy recommendations for Greece

Development of national biomass strategy / updating of NECP and other relevant strategies and roadmaps

Future projections regarding bioenergy use in the Greek NECP and long-term energy strategy remain unclear as to exactly what biomass assortments will be mobilized for which pathways and a specific roadmap for promoting increased utilization of biomass for energy – or other bioeconomy applications – is lacking. The development of a dedicated, national biomass strategy that properly takes into account the potential as well as the specific sector conditions in Greece should be developed and based on it, the NECP projections should be updated.

Development of local / regional action plans

Although it can be an important contributor to the national decarbonisation efforts, agrobiomass heating initiatives will be materialized in the local and regional context. In Greece, the local / regional context has major implications for a set of parameters that affect the development of the agrobiomass heating sector: structure of the agricultural sector, types and volumes of agrobiomass than can be mobilized, climate, population density, volume of industry activity, and others. Therefore, it is suggested that local / regional plans for the (agro)biomass sector are developed; these do not have to be stand-alone documents, but could be integrated in the Municipal GHG Emission Reduction Plans foreseen by the upcoming Climate Law.

Development of local / regional "champions"

Along with local / regional action plans, there is a need to develop local / regional "champions" – best practices of agrobiomass utilization for heating. Such cases can serve as examples for replication / imitation, while also facilitating the learning curve for the development of new projects through the accumulation of operating experience. The gearing of existing funding instruments, such as the Green Fund, towards such activities could facilitate the development of such champions.

Streamline investment support for biomass heating for promotion of modern appliances

While investment support for biomass heating systems is available through various instruments, it is usually not tailored to specific efficiency and emission performance standards – especially for the residential sector. Financial support should continue, but only appliances reaching specific performance standards (e.g. Ecodesign or equivalent) should be eligible for support.

Promotion of rural district heating systems

The district heating sector in Greece remains undeveloped, but it could provide an interesting alternative to the expansion of the natural gas grid, especially in rural and mountainous communities with both high heat demands and high local biomass potentials. Support for the development of small (in the range of a few MWs) biomass DH systems could provide a low-cost heating solutions, while decreasing air emissions both from uncontrolled burning of residues as well as from the older and polluting appliances used in individual households.

Measures to reduce open-field burning of prunings and promotion of alternative treatment methods

As long as the practice of field-burning remains tolerated, huge volumes of agrobiomass in the form of agricultural prunings will be lost every year. The practice is not only a waste of a potential energy resource, but also leads to increased local air pollution and represents a potential fire hazard. A harsher stance versus open-field burning is an option, but there are still practical issues with the monitoring.

Therefore, measures targeting the agricultural sector and encouraging alternative treatment methods for prunings – including their use in bioenergy applications – should be promoted. Launching and even expanding a "frozen" measure in the Rural Development Programme related to the purchase of chippers by farmers can assist in this regard.

Streamline energy and agricultural strategy and regulations regarding energy crops

The long-term (2050) energy roadmap for Greece foresees an increasing role of energy crops in the domestic energy supply. However, short and medium term goals as well as policy instruments promoting their use are lacking. There is also a lack of coordination between the energy and the agricultural strategies – the latter does not really consider energy crops nor does it promote their application. Some practical issues also remain to be solved – farmers switching to woody energy crops should have guarantees that in the future their agricultural land will not change its character and be characterized as a "forest".

Intensification of dissemination & promotion of best practices

Information and awareness raising campaigns on the promotion of the benefits of agrobiomass heating and of existing best practices, both in Greece and in the wider EU, should be intensified, especially towards the potential biomass suppliers (e.g. farmers, agricultural cooperatives, energy communities) and end-users (municipalities, tertiary sector, industries).

Tailored support for modernization of the Greek olive pomace oil industry

While support schemes tailored for the modernization of the primary olive oil mills in Greece have been in place for some time (e.g. for switching from the three-phase to the two-phase system), only minimal

support was provided to the secondary olive pomace mills. Targeted investment support could improve energy efficiency (and hence reduce the quantities of biomass self-consumed) and emissions, and promote the separation of the olive stones as a valuable fuel assortment even for domestic applications.

VAT reduction for biomass fuels

Biomass fuels in Greece are subject to the highest VAT rate of 24 %; natural gas, electricity and heat supplied from DH systems are subject to a VAT rate of 6 %. Reducing the VAT rate of biomass fuels would not only increase the competitiveness of bioenergy, but in addition assist in the establishment of new enterprises working on biomass fuel supply and would also limit the black market trade of biomass fuels, facilitating market monitoring and enforcement of fuel quality standards.

2. National Strategic Plan – Spain

Major facts on bioenergy state of the art in Spain

- Bioenergy accounts for over circa 33% of renewable energy (2018 data) with next the contributions: 80% share for renewable heating and cooling (with 4.225 ktoe) and 5% contribution to the renewable electricity generation (eq. 508 ktoe gross electricity generation).
- Biomass use by industry and for bioelectricity generation is mainly sourced by woodchips, straw bales (as several large power plants operate on this fuel) and bulk agroindustry by products (olive pomace).
- Domestic heating and small applications rely on wood pellets, olive stones and almond shells mainly. As well, firewood, by far the largest fuel in domestic heating, though usually linked to traditional fireplaces and stoves.
- When going to medium sized facilities, woodchips, non-valorised olive stones, and other agroindustry byproducts are relevant agrobiomass fuels.
- Bioheat is principally utilised in residential heating (60%) followed by industry (35%), commercial sector (3%) and other uses (2%).
- The growth of bioheat in last years has been steadily at a rate of +1% annually. The growth underwent an acceleration from 2015 onwards, with annual rates between 2 and 2.5%. This will project a growth of bioheat of +1,100 ktoe towards 2030 (larger than the official figure of the NECP plans of +411 ktoe by 2030).
- District heating is not well developed in Spain, with a lack of coherent regulation, however its expansion has multiplied by a factor of x7 from 2010 to 2020 (from 50 to 350 MW installed).
- Supporting instruments for bioenergy include programs such as: (i) building renovation and efficiency, thus covering part of the expenses of the investment; (ii) decarbonisation of agroindustry and farm sectors with FEADER, LEADER and other Next Generation programs; (iii) local or regional programs for renovating the heating appliances; (iv) for power generation, the inclusion of special regime of renewables, assuring the full electricity sale and a minimum profitability rate.

Agrobiomass state of play in Spain

Spain has a huge potential of agrobiomass due to its great surfaces dedicated to agriculture and its consequent production of many crops and its residues and byproducts derived. In consequence, Spain is one of the most important countries in the world in this aspect. Spain is 1st world producer of olive oil, 3rd world producer of wine, has a great cereal potential, is leader in citric trees and is a very important producer in nut trees. In addition, some of the crops that are grown in Spain have residues or byproducts very interesting for energy uses (olive cake and olive stones from olive oil industry, the prunings from vineyards and olive trees, etc.).

Probably the largest agrobiomass potential in Spain are the multiple byproducts derived from olive tree growth and olive oil extraction in industrial facilities: olive tree prunings, olive stones and olive cake (wet

byproduct after mechanical extraction of olive oil) or exhausted olive cake (dry byproduct of chemical extraction from olive cake). The distribution is basically the south of Spain and main regions where olive trees can be found such as Jaén and Córdoba provinces (in Andalusia).

Vineyards are very present in Spain and almost in every region. The biggest concentration is in Castilla La Mancha and probably one of the world largest area of continuous cultivation of vineyard with circa 500,000 ha. This region counts on with as much surface as other well-known wine producing areas like Duero Ribera and Rioja PDOs, or other concentrated wine producing areas in DOPs sited in Extremadura, Aragón or Cataluña.

The area dedicated to cereal in Spain is impressive, around 6 million hectares; due to the irregularity in the rainfalls in Mediterranean climate areas, years with low productivities (by limited rainfalls) cause rainfed areas to have much lower productivity, leading to lack of straw in some areas. This affects the prices and straw is complementary sourced from France. Main areas of distribution are both large regions in the central Spain called Castilla (Autonomous Communities of Castilla y Leon in the North and Castilla La Mancha in the south).

Another source of agrobiomass with high potential is the fruit trees. Fruit tree plantations like pome and stone fruits are grown in intensive environments and most of land is irrigated to assure no water stress. Production of fruit is usually concentrated in areas historically dedicated to this activity and usually near river basins. Productivity of pruning and frequent rotation of crop variety cause these areas to be relevant locally or regionally as a source of byproducts available for energy use.

Special mention is to be paid to citrus fruit plantations, since Spain is one of the countries with largest production of citric fruits in world. The concentration of citric in the east coast (Castellón, Valencia, Alicante, and Murcia) is of special relevance. From this area, the pruning is abundant due to very intensive cropping systems and good conditions for the vegetative growth of the crops. As well, similar to pome and stone fruits, wood from plantations removals is a relevant source due to frequent renovation.

Dry fruit trees are as well extensive planted in Spain, though only partially irrigated. This causes some areas to present low productivity, and variations in production and growth among years. However, due to the continued crisis in the fruit sector (from 2016 onwards), fruit products are switching from pome or stone fruit trees to almond plantations. New plantations of dry fruits entering in production are much more productive in terms of tons per hectare as they are managed more intensively than traditional dry fruit plantations.

Accordingly, the biomass potential of agrobiomass byproducts obtained from agronomical operations (at field) is presented in Table 5 (based on BIORAISE tool). There, the theoretical and technical potentials are shown. In correlation with the dedicated land, the largest potentials are for rainfed crops (mainly cereal) and irrigated crops.

Table 5: Agricultural biomass potential in Spain (Ceder-Ciemat / BIORAISE, Biomasud Plus project).

Type of Crop	Theoretical potential t DM/y	Available potential t DM/y	% share
Rainfed crops	16,944,193	5,420,661	42.2
Irrigated crops	4,682,592	3,746,230	29.2
Rice crops	394,983	316,204	2.5
Olive plantations	1,819,981	1,455,168	11.3
Fruit plantations	1,411,563	1,129,094	8.8
Vineyards	843,949	675,000	5.3
Crop mixtures	123,225	99,416	0.8
Total Agriculture	**26,220,486**	**12,841,774**	**100.0**

Nowadays, there are several types of agrobiomass that are used. For Spain, especially relevant is the byproducts of olive oil industry and byproducts from nuts industry. Exhausted olive cake (dry, in granular form, or even pelletised) is currently consumed in industry at a rate of 800,000 tons of DM per year. Olive stones are as well very relevant, adding more than 400,000 t DM per year, about 70% for industry uses, and 30% for domestic and small appliances (usually then previously cleaned to make it more suitable). Almond shells market reaches circa 150,000 t/year, principally consumed in farms and industry (more than 90% of its use). Firewood is also relevant, from fruit, vineyards and olive plantations, and an estimate of about 300,000 t is dedicated for firewood in domestic heating. Straw finds a not negligible use for bioelectricity, though for heating purposes the consumption is principally found in farms and agroindustry (alfalfa dehydration facilities and grain drying).

Principal considerations of the current framework

The panorama and the support schemes to renewable energies and bioheat has changed substantially since 2019, and with the entry into play of multiple policies oriented towards 2030, and inspired by the Green Deal, or derived from the plans of recovery from the effects of the COVID pandemic (Next Generation funds). A very condensed identification of such policies and market conditions are summarised below.

1. **The CAP and rural development programs**
   It will further support the decarbonisation. As well the use of agro residues and byproducts as a strategy for carbon sequestration in agricultural soils. Both are complementary. Soil integration is supported by CAP Eco-Schemes in Spain, and energy use through other FEADER and Next generation funds.
2. **Eco-schemes and the promotion of the use of agricultural byproducts as a carbon sink in agricultural soils**

An eco-scheme has been specifically dedicated for incorporating in soils. The payments per practice are very high and for farmers to do the choice of the incorporation into soil is more beneficial economically. However, in areas where it is not compatible because of phytosanitary reasons, the eco-scheme not necessarily will cause a blocking of the supply. Measure applies only to singular farmers, not to wineries, agroindustries.

3. **Biomass and consideration as waste**

   Olive stone already acknowledged during 2021 as byproduct, so not classified as waste. Olive pomace is under review. New coming framework will be less restrictive for agrobiomass byproducts use and for use in energy as end-of residue condition.

4. **NECP – National Integrated Energy and Climate Plan 2021-2030**

   Very aligned with bioheat. Including several measures, already being materialised in financial instruments (decarbonisation of agriculture, renewable heating in buildings, etc.)

5. **National Bioeconomy Strategy**

   The Strategy recognizes the role of biomass for multiple functions and uses, including bioenergy production. Likewise, it emphasizes the high potential of biomass from agricultural and agro-industrial remains and byproducts, and the need to be exploited for the growth of new biological-based activities (including energy). However, energy crops are not mentioned. Different regions count with specific action plans, which causes a good framework for bioeconomy and bioheat.

6. **Air quality up to 2017 and the new PNCCA plan towards 2030**

   The PNCCA program (National Air Pollution Control Program) aims to reduce emissions into air. It is well coordinated with the NECP. It acknowledges the increase of PM emissions in some areas due to expansion of bioheat (under wrong practices). The expansion of bioheat is therefore promoted, but object of regulation and follow-up to ensure good practices and achieving the emissions targets.

7. **Measures and subsidies for renewable heating with agrobiomass**

   Foreseen in the NECP, and already taking place thanks to the Next Generation funding and the Spanish plan of recovery and resilience. Good framework towards 2030, with special availability of funding until 2026.

Main barriers for using agrobiomass for energy and possible ways to overcome them

TYPE	BARRIER
MARKET – DEMAND	**B.01 Absence of demand for some types of agrobiomass (especially for cane, straw, pruning, or biomass from uprooting)**
Driving forces applicable to B.01	• Rural Development Plans that include priorities and instruments to support the bioeconomy • Need for decarbonisation: buildings, services, agriculture, livestock and agribusiness • NECP plans to increase the consumption of biomass for heat and power, and derived measures
AGRICULTURAL SECTOR	**B.02 The agricultural sector without a clear interest in obtaining agricultural byproducts for energy**
Driving forces applicable to B.02	• Increase in supply: Incentives to motivate the good practice of obtaining biomass from agricultural byproducts for energy / bioeconomy (as it is not contemplated under the eco-schemes, possibility of incentive in other regional catalogues of good practices) • Increasing demand: promoting the energy use of agricultural biomass in areas of high potential
AGRICULTURAL POLICY	**B.03 Absence of coordination in good practices for managing the agricultural byproducts: guides, instruments or incentives**
Driving forces applicable to B.03	• Better coordination between different ministries (examples of interactions to develop plans such as NECP and plans on air emissions) • Practical guides for farmer decision-making, not polarized to bioeconomy or to land use, but to the most appropriate and healthy practice for crops and soils. • Increased awareness, sectoral and general interest in renewable energies, clean air, circularity, as well as a quasi-unanimous view that burning agricultural remains is not a good practice.
ENEGY POLICY	**B.04 Absence of specific mechanisms to promote the use of agrobiomass**
Driving forces applicable to B.04	• Increased interest and pressure to use agricultural and agro-industrial byproducts for energy, and to dispose of wood for other uses in the bioeconomy • Strategic proposal in Spain for the collection of pruning (according to measure M1.11 of the NECP) • An agricultural and rural sector that, aware, calls for specific instruments for its byproducts
SOCIAL PERCEPTION	**B.05 Social perception of lack of interest in biomass or agrobiomass compared to other renewables**
Driving forces applicable to B.05	• Growing role of the agricultural sector in the energy sector, together with its influence on policies and media

	• Increase in the renewable energies as promoted by NECP, or the Green Deal and derived lines such as the Renovation Wave (see description in the table abbreviations) will require an unprecedented renewable supply (where the agrobiomass has to find its niche)
SOCIAL PERCEPTION	**B.06 Positions against the use of agrobiomass**
Driving forces applicable to B.06	• Demonstration of the goodness of agrobiomass emissions in modern systems (and comparison of emissions from obsolete systems whether with biomass, diesel or natural gas) • Verified and official information by administration or reference entities on the use of agricultural remains in the soil (positive, negative effects, and risks) • Growing interest in the bioeconomy, which may allow biomass to be repositioned in spaces for inter-sectoral dialogue
TECHNOLOGY	**B.07 Limited supply / little knowledge of modern equipment for use with agrobiomass**
Driving forces applicable to B.07	• High potential of agrobiomass and need for its penetration into small and medium power consumption niches • PNCCA (National Air Pollution Control Program) and derived measures that make it necessary to reduce emissions and foresee the need to renew the fleet of fossil boilers and obsolete biomass stoves and boilers • Need for companies to diversify and take advantage of opportunities for new services or innovation in the framework towards 2030 (Green Deal, bioeconomy, "Renovation Wave", etc.)
ECONOMICS	**B.08 Higher installation costs than for other more standardized biomasses**
Driving forces applicable to B.08	• Instruments to finance the installation of renewable energies • Promotion of shared uses for the improvement of the scale of investment (heat networks, energy communities) • The whole wave of building renovation and decarbonisation
INSTALLERS AND ESCOS	**B.09 Complexity and reluctance of installers and ESCOs**
Driving forces applicable to B.09	• Alternative financing systems for agrobiomass, such as energy cooperatives or ESCO (Energy Service Companies) specialized in air conditioning services with agrobiomass • Demand for agrobiomass by the niches most naturally benefited in the rural environment: agribusiness, services, public facilities, farms and greenhouses • Demand aggregation for larger installations that enable more robust systems • Better knowledge and confidence of engineers and installers can allow to overcome this barrier
QUALITY	**B.10 Disadvantage compared to other standardized biomasses**
Driving forces applicable to B.10	• Greater demand for quality agrobiomass, greater consumer interest in consuming a fuel with adequate characteristics

	• PNCCA (National Air Pollution Control Program) or regulations indicating the need in small consumption to use certified fuels • A market of installers and ESCOs focused on a good use of the agrobiomass

Potential for further development for the production and use of agrobiomass for energy

In respect to the projected growth of bioenergy, the objectives for biomass are marked in the National Energy and Climate Plan for Spain (NECP). As for agrobiomass, there is no specific breakdown. For biomass, objectives are set for bioelectricity, as well as for bioheat as follows:

- Bioelectricity: Increase of 795 installed MW (increase factor of x2.3) involving the use of more than 1,600 ktoe of additional biomass (equivalent to approximately 4.2 million tons of biomass)
- Renewable heat: increase of 3,559 ktoe, estimating that 411 ktoe would be obtained from biomass, implying an increase in heat with the current biomass by a factor of 1.1, for which a mobilization of approximately 1.2 million tons of biomass would be necessary.

The planned increase in the Spanish NECP for biomass focuses very especially on the electrical field. However, this implies a significant rate of increase, doubling the power and consumption of bioelectricity in 10 years. In contrast, for bioheat, the target set by the NECP (growth of 411 ktoe from 2020 to 2030) looks conservative. As a matter of fact, this projection assumes that bioheat average growing rate would be as the average similar to the average growth of the last 10 or 20 years (growing rate of 1% per year). When observing the trends of the last 7 years, it is evident the acceleration of the bioheat progress, with growing rates of 2 to 2.5% per year. If this growing rate is projected towards 2030, it is found that bioheat could contribute with a net growth of 1,100 ktoe (from 2020 to 2030). This trend will apparently continue, and even increase, taking into account the current scenario of rising prices of the electricity, natural gas and heating oil, together with the good policy framework (decarbonisation need as promoted by Green Deal and the availability of Next generation funds). With such expansion, bioheat would lose part of the share in the renewable heat (from 80% in 2018 to 60% due to the enhanced penetration of heating pumps and solar energy), thought it would still remain the main source.

Assessment of impacts of the increased market penetration for agrobiomass heating

Summary of the assessment of environmental and social impacts from the increased agrobiomass heating penetration into Spain market is presented below, assuming a growth of 1,100 ktoe of bioheat towards 2030 (with an increase of more than 750 ktoe of agrobiomass).

Reduction of CO_2 emissions by replacing fossil fuels in heating

The valorisation of the potential agrobiomass (currently not used) will contribute to reduce emission by 2.32 Mt CO_{2eq} per year comparing to gas boiler.

Decrease of GHG emission achieved (%) when replacing fossil fuels				
	Forest chips	Wood pellets	Agrobiomass	TOTAL
Natural gas	82.19 %	82.19 %	82.19 %	82.19 %
CO_{2eq} (Mt/y)	0.73	0.84	1.57	3.14
Gas/diesel	87.65 %	87.70 %	87.65 %	87.66 %
CO_{2eq} (Mt/y)	1.06	1.21	2.26	4.53

Emissions reduction when avoiding burning in open air (at the field)

Most of the agrobiomass expansion for heating would rely on the currently underutilised biomass leftovers that remain on field like straw, pruning or plantation uprootings. Their valorisation would allow avoiding the burning on open field, and therefore, lead to a reduction of the emissions into air due to combustion performed in controlled conditions and with advanced equipment. In total, in 2030, the annual bioheat consumption in respect 2020 with agrobiomass would reach 711 ktoe/yr, thus leading to a huge amount in the reduction of emissions due to avoiding the burning in open fields.

	Herbaceous byproducts	Woody byproducts	Total emission reduction potential	
Parameters	**t/yr**	**t/yr**	**t/yr**	**%**
NOx	1,321	2,168	3,489	-56 %
CO	97,056	67,689	164,746	-93 %
NMVOC*	9,744	4,608	14,352	-76 %
TSP*	6,479	6,631	13,110	-81 %
PM_{10}**	6,449	6,290	12,739	-81 %
$PM_{2.5}$**	6,166	5,865	12,031	-80 %

*** Particulate matter which includes particles that have aerodynamic diameters less than or equal to 10 micrometers (µm) (PM_{10}). $PM_{2.5}$ is the subset of PM_{10} particles that have aerodynamic diameters less than or equal to 2.5 µm.*

Job creation by mobilization of biomass for heating

Mobilisation of the whole biomass potential could lead to creation of 9,711 employments while the agrobiomass could contribute to create around 6,775 employments in rural areas.

Public perception of agrobiomass heating

AgroBioHeat conducted a consultation during 2019 and 2020 at the European level. According to this survey, the southern countries seem to be much more informed about agrobiomass compared to other Europeans. In addition, the survey shows a relationship between this knowledge and age, with older people being the most aware of the term "agrobiomass". In Spain, this better knowledge compared to other countries can be explained due to the higher proportion of older people among the population, especially in rural areas, and the country's agronomic potential. Spain today and traditionally has been the

European leader in agricultural products. Traditionally, the byproducts of these crops and of the associated agro-industries (pomace / pits, almond shells, pine nut shells, etc.) have been used for energy purposes, mainly for obtaining heat.

This better knowledge is a very positive sign for the development of agrobiomass, since the general perception of it, according to the Agrobioheat survey, seems to be greatly affected by previous contact with agrobiomass and the agricultural and rural environment, which generates a more positive attitude towards the use of agrobiomass.

Among the rural population, in Spain the perception is mostly positive, probably due to greater familiarity with what agrobiomass is. On the other hand, among the urban population, the perception is more sceptical about the use of biomass in general, probably due to the lack of information and knowledge.

The results converge with the reactions and social behaviour, since, in general, in Spain there are not many cases of projects rejected due to social pressure. The cases with problems of social rejection were mainly due to the size of the plant (large power plants of 25-50 MW), refurbishment of coal plants (As Pontes with 4×350 MW), or even large capacity district heating networks. Also in many cases, the rejection is mixed with struggles or positions rather of the local political environment and not objective reasons. In general, the position of national NGOs is quite positive towards bioenergy, especially if the scale is relatively small and it is fuelled with local resources.

Among the specific results for Spain of the survey carried out by the AgroBioHeat project, it can be observed that agrobiomass is considered to be worth for investing (48.5% agree and 27. 5% strongly agree); the majority of those consulted agree that an agrobiomass project to obtain heat would have a positive impact on society. In addition, most of those consulted persons consider that they would support/accept a project on agrobiomass heating located near their living place.

Agrobioheat has carried out a series of visits to open dialogue with stakeholders. According to the dialogue established, some specific perceptions have been observed:

- Agricultural sector: more devoted to production of agro-food. Byproducts and leftovers are a topic of secondary interest. In general, they are well aligned. Even though a portion of farmers / farmers' organisation think of use of field byproducts for soil amendment and carbon capture.
- In general, scientists are well aligned with energy use. However, they understand energy use is a low-value use and find other uses in the cascade to be more interesting, though in many cases there are no options in the market to develop the value chains. Soil scientists, agronomists and biologists are divided into those thinking best use is for soil, and those who understand the potential risks for pest and disease establishment if byproducts are left on field systematically.
- Policy makers are usually in favour of general goodness of biomass.
- Environmental authorities (national and regional level) have expressed their concerns regarding the emissions derived from small biomass heating appliances (stoves and boilers). Usually they

know the cases of cities with high impacts on air quality caused by bad practice of bioheat, but not so aware of the good practices and good cases.

- Companies in the sector are principally interested in the market, currently of wood pellets and woodchips, or of olive stones and shells. The market for bioheat in rural areas based on other byproducts or on agropellets is not in their agenda for business; it is perceived as more complicated and as not having a clear demand for these services.
- General society, in general, is open to renewable energy, especially if it is competitive in price. More ready to accept and adopt. Usually, more known forms of bioenergy are pellets and woodchips. However, part of the society, especially in urban areas, has the perception that biomass is polluting and can deplete the natural resources (like forest resources).

Policy recommendations for Spain

Agrobiomass for heating is fully aligned with Spain's key policies and triggers positive effects like the generation of employment in rural areas, the reduction of GHGs, the improvement of air quality, and the promotion of positive externalities. To realise the potential of agrobiomass heating in Spain AgroBioHeat identifies and proposes a series of recommendations. These recommendations are derived as a synthesis of the 41 lines of action obtained after a SWOT analysis, and which have been configured based on extensive consultation with agents in the sector: agricultural associations, cooperatives and associations, regional administrations, central government, energy service companies and installers, equipment and boiler manufacturers, consumer associations, among others.

In order to make these action lines more understandable and transferrable to policy makers, government and organisations, they have been re-arranged and merged into 5 main policy recommendations. They have been explained in form of policy briefs including: recommendation, evidence and need, sub-recommendations (more operative) and summary of targeted actors, instruments, key actors necessary and indicators applicable.

Policy recommendations
R1. Active promotion of renewable heat with agrobiomass in key development niches
R1.1 Increase in renewable heat in agribusiness
R1.2 Promote demand in rural areas through heat networks and decarbonisation municipalities
R1.3 Promote the acquisition of equipment by the domestic sector and services in rural areas
Need and evidence for recommendation R1
Given the special characteristics of the agrobiomass compared to those already established as a pellet or forest woodchips, it is difficult to change from one to another in small and medium-sized facilities. It is therefore necessary to promote new facilities designed for the use of agrobiomass, and that accommodates the immense

existing potential, triggering new businesses and opportunities in rural areas. This is how the agrobiomass can really contribute to the NECP's target of 3,559 ktoe of increase between 2020 and 2030 of renewable heat.

Likewise, the rising price of fossil fuels, the objectives of the Law on Climate Change and Energy Transition, the need to decarbonize niches such as agriculture, livestock, agribusiness or rural municipalities, the very high price that electricity has reached (which may be a condition for the electrification of heat) are conditioning factors that show the need to promote renewable heat with agrobiomass in an active way.

R2. Facilitate the mobilization of biomass from agricultural byproducts ensuring environmental compatibility with soil management
R2.1 Preparation of a dossier of good practices in the management of agricultural byproducts
R2.2 Advice and incorporation of good practices in the use of agricultural byproducts
R2.3 Facilitate access to the machinery and means necessary for the mobilization of the agrobiomass

Need and evidence for recommendation R2

Using the agrobiomass of agricultural and agro-industrial byproducts requires that from the origin the key actors have an adequate framework to do so. In the case of agricultural byproducts (at field), farmers, cooperatives, wineries, etc. may choose either to integrate them into the soil, or to valorise them (energy, compost, fodder, etc.). Alternatively, they may continue the practice of disposal and burning on open fires at field.

The NECP considers two measures necessary to promote its mobilization (M1.11 for pruning; M1.22 for agricultural remains for recycling and recovery). It also includes a complementary measure (M1.25, of agricultural land as carbon sinks) to leave them in the field and increase the organic carbon of the soil. Currently, the CAP strategic Plan in Spain has included, as requested by M1.25, the environmental practice P7 (ecoscheme) of a voluntary nature, which provides an income to the farmer who leaves the agricultural pruning on coverage (foreseen € 71.63 / ha on flat land, up to € 175.86 / ha on slopes of more than 10%). These revenues, compared to those generated by their complementary use for the bioeconomy (€ 40-50/t e.g. for renewable heat), are not well balanced. This support mechanism may tip the balance towards a systematic integration of the byproducts into the soil, in contrast to its use for sustainable uses of the bioeconomy. Some risk is if farmers apply the ecoscheme even in areas where the official bodies (research institutes and extension services) do not recommend integrating the byproducts into the soil, to prevent pests and diseases establishment in the agriculture.

Hence, it is necessary to provide information to advise farmers on best practice, as well as measures to support mobilization, which facilitate its use for the bioeconomy. Likewise, it may be convenient to facilitate funding for acquisition of machinery for the removal, crushing or packaging of agricultural biomass.

R3. Ensuring sustainable and efficient use of agrobiomass
R3.1 Ensuring appropriate installations and quality installers
R3.2 Monitoring and maintenance of facilities
R3.3 Promotion of the use of the agrobiomass suitable for the installation

Need and evidence for recommendation R3

The use of agrobiomass in small and medium power facilities can achieve high levels of efficiency and low levels of emissions. The use of bioheat in new; more advanced technologies can allow significant reductions in emissions (e.g. PM), as marked by the European Environment Agency's own emission factor guidelines. These levels are

achievable by the agrobiomass in already available technologies, as evidenced by measurements made by AgroBioHeat.

The use of agrobiomass requires specific boilers. These technologies are more robust against corrosion, may require more chamber volume (as being more loose, with less energy density), as well as auxiliaries of greater size and cost to feed a more heterogeneous and less dense biomass than that of pellets or wood chips. Thus, these installations involve a higher investment cost, and a good knowledge of the installer so that the operation is correct.

In order for the progress of renewable heat with biomass, in particular with agrobiomass, to fulfil its role as a decarbonisation axis, and at the same time not generate significant impacts on emissions, it is necessary that its use be promoted through good practices. These good practices include: (a) using advanced technologies and subject to efficiency standards, currently available for chips and pellets (EN303 regulation; Regulation 2015/1189 for boilers and 2015/1185 for stoves); (b) use of the appropriate fuel, which may be of the quality certification applicable in certain more homogeneous types for small consumptions such as olive pit; (c) promotion of adequate installations, which are not susceptible to failure, by well-known installers; (d) provision with monitoring and maintenance to maintain operation in proper conditions.

R4. Activating the role of key sectors in promoting the use of agrobiomass

R4.1 Activation and transfer to actors in the agricultural sector

R4.2 Activation and transfer to boiler manufacturers, installers and ESCOs

R4.3 Activation and transfer to municipalities

Need and evidence for recommendation R4

Heat with agrobiomass is viable, and it must be promoted through sustainable practices that ensure good efficiency and minimal impacts. The key players and their potential needed roles are:

- Farmers and agro-industries in terms of obtaining the agrobiomass, its initial mobilisation, as well as its consumption in primary sector applications; with it the agents for the appropriate transfer, the producer organizations and the agricultural organizations, the agricultural support services, the AKIS networks and the agricultural and environmental consultants.
- installers, energy service companies, biomass suppliers, who provide installation and maintenance services as well as the supply of appropriate fuel and play a direct role with the consumer, who is not necessarily an agrobiomass expert, and to whom they can offer appropriate solutions; with them, their organizations, biomass sectors, heating and plumbing installation or energy services.
- Municipalities, as local promoters of facilities or as promoters through their sustainability plans or other instruments; with them, their associations as councils and networks of municipalities.

It is necessary that these actors, directly in contact with the consumer and end user, have a common vision and understanding of their mission to assure good practices and sufficient mobilisation and deployment of agrobiomass. As well the perception of the common benefit of generating new value chains and sustainable uses.

R5. Recognition of the role of agrobiomass for bioeconomy

R5.1 Promote a common vision and the adoption of roles by each sector

R5.2 Generation of interest and social consensus for agrobiomass

R5.3 Promote a sense of responsibility in the use of agrobiomass

Need and evidence for recommendation R5

Urban and rural citizens must understand the role that renewable heat with agrobiomass offers in the short term as an immediate means to mitigate climate change, and the positive externalities it generates. Likewise, these are directly linked to making an adequate use of agrobiomass, so that citizens and society as a whole, identify these good practices, and can responsibly exercise their adoption, or the voluntary or mandatory mechanisms that administrations can design to ensure them.

In addition, it is key that there is an inter-sectoral dialogue, a joint vision that agrobiomass has an important role to play in the medium and long-term plans and policies of the State (decarbonisation, full development of the bioeconomy), and that it must be used under good practices so that its use is sustainable and environmentally compatible. Likewise, so that the roles of the different actors are recognized, and awareness of collaboration and promotion is generated within the natural frameworks in which each sector, its organizations and its actors operate.

3. National Strategic Plan – France / Region Brittany

Major facts on bioenergy state of the art in France

- 38% renewable energies in final heat consumption in 2030 for an inventory of 19.9% in 2018
- In 2050, 400 to 450 TWh of raw biomass resources will have to be mobilized, compared to 180 TWh in 2016
- 230 TWh would come from agricultural biomass, including biomass from agroforestry, for 100 TWh from forest biomass
- Agrofuels are still underdeveloped in biomass boilers
- In 2022, the tension on the wood markets in the broad sense (materials, industrial) could tighten in the medium term the supply of wood boilers if the brakes recalled for mobilizing more material are not lifted (labour, price etc.)
- This finding reinforces the importance of diversifying sources of supply such as agrofuels
- The main source of agrobiomass in Brittany is hedgerows

Main barriers for using wood from hedgerows for energy and possible ways to overcome them

A lack of competitiveness

Possible solutions: To adapt subsidies to the evolution of the energy context and set up new economic models integrating citizen financing. Communicate on the indirect economic benefits of the development of hedgerow's wood.

A feeling of complexity

Possible solutions: communicate to clarify the j around judgement of his subject. Develop the turnkey heat sales service offer to support the design and management of interfaces during design, construction and operation

The fear of the availability of the resource

Possible solutions: create data through the development of management plans while promoting the sustainable management of the hedges and communicate the reality of the figures in an educational way to reassure.

An under-maintained timber resource in Brittany

Possible solutions: Accompany farmers to appropriate themselves the management of their resource by training them and identifying the direct interests of the hedgerows for the farm and the development

clues. Put in place turnkey hedge management solutions for farmers who do not wish to do construction sites.

Fear of negative impacts on the environment

Possible solutions: condition aid, monitor the fleet of boiler rooms and communicate on performance. Publish arguments for the general public to deny untruths

Lack of cooperation between actors and involvement of residents

Possible solutions: make known the various stakeholders from upstream to downstream to project leaders and facilitators in charge of project development. Raise awareness of wood energy among citizens' associations involved in the development of renewable energies and even associate them with project management companies.

Policy recommendations for Brittany / France

Focus on agrofuels: In Brittany, there is no incentive to develop agrofuels except Hedgerows.

	Recommendations	target action	theme action	Implementation
R1.1	Opening up to installations that use other types of biomass	agrofuel	Simplification	not started

Focus on the bocage :

	Recommendations	target action	theme action	Implementation
R1.2	Develop turnkey projects for farmers not interested in operating	bocage	Simplification	in the process of being set up
R1.3	Ensure that the supply of tree maintenance work remains appropriate for intervention in the bocage	bocage	Simplification	under consideration
R2.1	Develop a case for adding value to the farm	bocage	Improving knowledge and information	made
R2.2	Increase awareness of the multifunctionality of the bocage	bocage	Improving knowledge and information	in the process of being set up
R2.3	Improve knowledge of local wood resources	bocage	Improving knowledge and information	made

R2.4	Implementing management plans	bocage	Improving knowledge and information	in the process of being set up
R2.5	Dissemination of information in an educational manner to the general public	bocage	Improving knowledge and information	made
R3.1	Give priority to projects with a real territorial added value and integrate a conditionality linked to the Hedge Label	bocage	Decompartmentalisation of public policies	made
R3.2	Work on the development of the ancillary benefits of using trees as fuel	bocage	Decompartmentalisation of public policies	in the process of being set up
R3.3	Implementation through an exemplary public order that succeeds in mobilising the resources (in wood and in companies) of the territory	bocage	Decompartmentalisation of public policies	under consideration
R3.4	Valuing carbon storage through a Carbon Fund and feasibility study of a local carbon market	bocage	Decompartmentalisation of public policies	under consideration
R3.5	Valuing interactions on biodiversity and water quality (Call for proposals for Payment for Environmental Services)	bocage	Decompartmentalisation of public policies	in the process of being set up
R4.1	grouping together the operators concerned to organise a pooling of work sites	bocage	Consultation	under consideration
R5.1	Promoting all uses of wood on the farm	bocage	Accompaniment and financial support to consolidate the business model	made
R5.2	Encourage the use of certified wood (PEFC or HAIE label) by improving its value on the market	bocage	Accompaniment and financial support to consolidate the business model	made

R5.3	Mechanisation solutions need to be tested and validated	bocage	Accompaniment and financial support to consolidate the business model	under consideration
R5.4	Increase the price of labelled wood to remunerate producers implementing the specifications	bocage	Accompaniment and financial support to consolidate the business model	in the process of being set up
R5.5	Support for hedgerow maintenance at 5 years and beyond	bocage	Accompaniment and financial support to consolidate the business model	under consideration
R6.1	Train woodland owners to advise, train and support them (forestry, agriculture, municipalities) in their management and development.	bocage	Training	in the process of being set up

Focus on wood energy in general in rural areas:

	Recommendations	target action	theme action	Implementation
R1.6	Easing the conditions for financing small projects	wood energy in rural areas in particular	Simplification	made
R1.7	Develop turnkey heat sales services where this service is not already provided by existing players	wood energy in rural areas in particular	Simplification	in the process of being set up
R3.8	Strengthen support for projects using locally produced wood	wood energy in rural areas in particular	Decompartmentalisation of public policies	not started
R4.6	Encourage EPCIs (or SDEs) to acquire the competence of a heating network in order to mutualise the creation of a wood heating network	wood energy in rural areas in particular	Consultation	made

R4.7	Encouraging citizen participation in the creation of local services through project companies is an additional possibility to mobilise local savings	wood energy in rural areas in particular	Consultation	under consideration
R5.12	To set up a monitoring of the boiler room fleet and to offer technical support	wood energy in rural areas in particular	Accompaniment and financial support to consolidate the business model	in the process of being set up
R5.13	Support for clusters of small projects to qualify for the support levels of larger facilities	wood energy in rural areas in particular	Accompaniment and financial support to consolidate the business model	made
R5.14	Support for porting by project companies	wood energy in rural areas in particular	Accompaniment and financial support to consolidate the business model	in the process of being set up
R5.15	Encourage short circuits for a better remuneration of wood by encouraging project leaders to get closer to local actors	wood energy in rural areas in particular	Accompaniment and financial support to consolidate the business model	under consideration
R6.6	Training for boiler room operators/installers	wood energy in rural areas in particular	Training	made

Focus on wood energy:

	Recommendations	target action	theme action	Implementation
R1.4	Simplifying the process	wood energy	Simplification	made
R1.5	Promotion of existing services energy service companies	wood energy	Simplification	made

R2.6	Better dissemination of information to project leaders	wood energy	Improving knowledge and information	in the process of being set up
R2.7	Communication on existing public aid	wood energy	Improving knowledge and information	in the process of being set up
R2.8	Communicate on existing well-functioning boiler rooms	wood energy	Improving knowledge and information	made
R3.6	Articulate all aid schemes by making the eco-conditionality criteria consistent	wood energy	Decompartmentalisation of public policies	under consideration
R3.7	Strengthen environmental criteria to reassure that there is no negative impact on the environment	wood energy	Decompartmentalisation of public policies	made
R4.2	Territorial diagnosis of the actors and tools in place	wood energy	Consultation	under consideration
R4.3	To have regional coherence of the support and aid system without territorial disparities	wood energy	Consultation	in the process of being set up
R4.4	Work on the articulation with engineering and actors in the territories	wood energy	Consultation	made
R4.5	Encourage citizen involvement in projects to improve their acceptability	wood energy	Consultation	under consideration
R5.10	Offer investment support for facilities that are not operating optimally	wood energy	Accompaniment and financial support to consolidate the business model	made

R5.11	Strengthening of territorial coordination through the development of objective contracts between the territories and ADEME	wood energy	Accompaniment and financial support to consolidate the business model	in the process of being set up
R5.6	Long-term sustainability of the programme with a clear vision on the definition of the conditions for support	wood energy	Accompaniment and financial support to consolidate the business model	made
R5.7	Propose more incentive-based subsidies, making it possible to find return times that are compatible with the expectations of project leaders	wood energy	Accompaniment and financial support to consolidate the business model	made
R5.8	Adapting aid to the changing energy context	wood energy	Accompaniment and financial support to consolidate the business model	made
R5.9	Systematically accompany the first heating season	wood energy	Accompaniment and financial support to consolidate the business model	made
R6.2	Mandatory qualification for project management (type OPQIBI 20.08) in the same way as required for feasibility studies.	wood energy	Training	not started
R6.3	Disseminate advice on the design of wood-fired heating systems	wood energy	Training	made
R6.4	Share experiences regularly.	wood energy	Training	made
R6.5	Identify and provide training for potential specifiers (architects, project managers)	wood energy	Training	not started

4. National Strategic Plan – Romania

Major facts on bioenergy state of the art in Romania

- Bioenergy accounts for over 65% of renewable energy, the landscape is hilly in central part with high lignocellulose biomass, while the westernmost and easternmost regions are characterized by plains with higher agriculture biomass.
- Low developed bioenergy sector, as the share of biomass in the total primary electric energy supply is 0.86% (2022).
- Main type of biomass used is wood of forest origin, while a major part of biomass potential consists of agrobiomass (agricultural residues and energy crops).
- Biomass is popular source of energy, mostly in form of firewood with outdated technologies, but best practice examples are appearing based on wood chips, wood pellets and briquettes, nutshell, sunflower husk, vineyard pruning residuals.
- Less application of biomass for power production
- Romania has outdated district heating systems with low energy efficiency, while natural gas remains the main fuel in urban and agglomeration areas.
- There is no existing supporting scheme for bioenergy in Romania.

Agrobiomass state of play in the country

Agriculture receives less and less share in Romania's gross domestic product, which decreased from 10% in 2000s to 4.3% in 2021, but up to 18.5% of the total employment are still working in small and micro-size farms as these farms are mostly focusing on self-sufficiency. The Romanian agriculture has two major sectors: crop production up to 70.8% and animal breeding up to 27.2%. The main agriculture products are cereals, industrial crops, forage plants, vegetables and horticultural crops. Romania has an agricultural capacity of approximately 14.7 million hectares of which only 10 million are used as arable land. Romania ranked second in the European Union in 2020, after France, in terms of corn for grain production with a total of 10.8 million tons as reported by the National Institute of Statistics. On the other hand, Romania continues to rank first in terms of the area cultivated with corn, with over 2.6 million hectares.

Some part of agro-residues (straw, corn stalks and other crop remains) is destroyed by burning on the field, the main purpose being to clear the field for further agricultural operations. Even though it is strictly prohibited by the legislation of Romania, still some burnings take place quite often, which causes air pollution and has a negative effect on soil condition.

Sustainable harvesting of straw and corn stalks from the field, without affecting the humus content of the soil, generally depends on the local climate and soil conditions. Generally, according to the scientific

analysis, in Romania up to 40% of the available straw can be harvested from the field for energy production, without damaging the quality of the soil. This important fact is respected in all related projects and business plans. The cultivation of energy crops has reached a few thousands of hectares in Romania. The total area under energy crops (mainly energy willow, paulownia and miscanthus) is about 8-10 thousands ha in Romania. At the same time, according to the national statistical data, the area of underutilized agricultural land in Romania, which can be used for this purpose, is 495,421.00 ha. The agrobiomass is used for heat production in rural Romania, but there are some companies generating heat and power by CHP plants.

The Romanian agrobiomass market is still underdeveloped, which is a barrier in front of establishment of new agrobiomass to energy projects. The agrobiomass users or potential agrobiomass users are afraid to invest in bioenergy projects because the permanent agrobiomass supply chains are not well-developed on regional and local levels in Romania.

Agrobiomass is mainly used for heat production at greenhouses, in different farms or private households in rural Romania. There is no so-called stimulating tariff or feed-in tariff for biomass to energy projects in Romania. However, there are public funded programs to support the initial investments such as the "POIM OS 6.1. Increasing energy production from less exploited renewable resources (biomass, biogas, geothermal), distribution sector" where the eligible entities/beneficiaries were: large enterprise, operator of heating distribution companies, local public authorities, SMEs, autonomous administrative authorities, or Intercommunity Development Associations. Similar funding sources were the "Energy efficiency for Public Institutes" and "Energy Efficient Homes" launched in 2021 by Ministry of Environment, Forestry and Water.

A target for the use of renewable energy sources in heat production is set in the Romanian Energy Strategy 2016-2030 adopted in 2016. According to this document, at the national level, the final energy consumption in the residential and tertiary sector altogether comprises 45% of the total energy consumption, and approximately 40% of greenhouse gas emissions.

Unfortunately, there is still no available national strategy for the heating sector in Romania; therefore, the share of renewable energy sources in heat production is not defined for the near future. Considering the current structures of renewable heat production and biomass potential in Romania, it is obvious that the targets can be attained only if some significant national energy policy measures are employed.

Main barriers for using agrobiomass for energy and possible ways to overcome them

Technical barriers

- *Farmers and agriculture companies do not have specialized equipment for the collection of crop residues for energy purposes.*

Possible solution: Launch national subsidy or co-financing program for the specialized machinery in agriculture sector. Dedicated public-funded projects should be launched to demonstrate the feasibility of such approaches, demonstration/open days should be organized on harvest of different types of agro-residues (corn cob, corn stalks, grain straw, sunflower stalks and husks) and valorization in energy production.

- *Lack of well-developed and trackable agrobiomass value chains*

Possible solution: Establishment of a dedicated digital platform for agrobiomass and biomass suppliers and customers, with different division such as geographical aspects, type of feedstock, availability, capacities, etc.

- *Difficulties in harvesting and storage; high logistics costs of fuel production*

Possible solution: Establishment of a biomass storage and centres in collaboration with the given local public authorities in the given municipality. In order to reduce the logistic costs, it is crucial to use biomass from local sources. Thus, it is fundamental to build a reliable supply chain from local agrobiomass producers that can provide the quantity and quality of biomass that is requested by the local end-users.

Non-technical barriers

- *Lack of available capitals in agriculture*

Possible solution: the initial investment costs for agrobiomass to energy projects are even higher. Due to the increased energy prices, the end-customers are going to be more open to find alternative solutions for energy supply, but still, a national co-financing program would significantly increase the agrobiomass to energy sector

- *Unclear national policy regarding the use agrobiomass for energy.*

Possible solution: Develop and promulgate the national strategy for thermal energy sector or more specify a national biomass strategy for the use of agrobiomass to energy.

- *Lack of dissemination of successful cases on agrobiomass to energy.*

Possible solution: Holding of dissemination events at agriculture fairs & exhibitions, conferences and all relevant actions on regional and national level including targeted site visits and study tours for the most relevant stakeholders on the national level.

- *Lack of knowledge on agrobiomass energy technologies and stakeholders' belief* that agrobiomass has low calorific energy value, and thus there are difficulties in burning process.
- *Lack of knowledge and awareness of local communities* that creates misconceptions around the use of agrobiomass for heating. Limited knowledge as well as lack of business skills make them more hesitant towards the realization of agrobiomass heating projects.

Possible solution: Dissemination and promotion of good examples in the local communities are very important. In addition, workshops with experienced actors (e.g boiler manufacturers) could provide knowledge on the technology and performance of such projects.

Raising awareness actions that focus on the environmental, economic and social impact could potentially convince people to switch from fossil fuels to agrobiomass.

- *Potential risks for soil caused by the removal of crop residues from fields for energy needs.*

Possible solution: Development of organic fertilizers market including the use of biochar products.

- *Difficulties in bringing to justice those responsible for open burning of crop residues.*

Possible solution: Add financial value for agriculture waste and reason for harvesting the agriculture residues for energy purposes. More control of on-site burning to avoid the burning of agro-residues in the fields.

Potential for further development for the production and use of agrobiomass for heating

In Romania, agrobiomass has significant potential for the production of energy to cover in a sustainable way the local and regional energy demands, first of all in the space heating sector but also the thermal energy in different sectors such as driers, greenhouses, bakeries, and other segments in agrofood and rural tourism sectors. Even if the involvement of agrobiomass into district heating sector would be technically feasible, the dissemination and change in mentality regarding to district heating sector is necessary in Romania.

In the second part of the 20th century, the district heating sector in Romania was well developed in each city and each town; however, this sector has drastically decreased due to low energy efficiency, unmeasurable consumption and lack of transparency. Therefore, the people are well equipped with negative perceptions and no openness to discuss it.

Due to the lower energy efficiency of individual heating systems based on natural gas, some latest trends have been gradual shifting from individual to DHSs, but this approach needs high policy support, which is not provided by the parties. Based on professional experienced gained in GEA, the most sustainable way to apply agrobiomass for energy purposes is to approach small-and medium size rural communities where energy demand is existing while key stakeholders are available who can push forward such innovative project approaches.

Assessment of impacts of the increased market penetration for agrobiomass heating

Summary of the assessment of environmental and social impacts from the increased agrobiomass heating penetration into Romania's market is presented in Table 6. Corn, wheat and sunflower have the biggest positive impact due to their largest available potential, having cultivated corn on 2.56 Mha and wheat on up to 2.15 Mha in 2020. The estimated agrobiomass from corn production is about 5.12 Mt and that from wheat is up to 3.44 Mt.

Table 6: Results of environmental and social impact assessment of increased market penetration for agrobiomass heating in Romania.

Parameters	Straw of cereals and rapeseed	Maize residues	Sunflower residues	Total
Potential available for energy (2020), Mtoe	3.44	5.12	3.36	11.92
Annual Emissions Reductions (%) from burning agrobiomass in boiler vs. field burning:				
NOx	16.6%	83.4%	16.6%	
CO	81.5%	81.5%	81.5%	
NMVOC	42.8%	42.8%	42.8%	
NH_3 (ammonia)	74.6%	74.6%	74.6%	
TSP	72.5%	72.5%	72.5%	
PM_{10}*	73.3%	73.3%	73.3%	
$PM_{2.5}$*	72.9%	72.9%	72.9%	
GHG Emissions Savings (%) compared to:				
natural gas	82.2%	82.2%	82.2%	
CO_{2eq} (Mt/y)	2.6	7.3	2.6	12.5
gas/diesel oil	87.7%	87.7%	87.7%	
CO_{2eq} (Mt/y)	3.8	10.5	3.7	18.0
coal	91.0%	91.0%	91.0%	
CO_{2eq} (Mt/y)	5.3	14.5	5.2	25.0
Creation of jobs	8500	15486	5578	29564

** Particulate matter which includes particles that have aerodynamic diameters less than or equal to 10 micrometers (μm) (PM_{10}). $PM_{2.5}$ is the subset of PM_{10} particles that have aerodynamic diameters less than or equal to 2.5 μm.*

Public and stakeholder perception of agrobiomass heating

Based on the knowledge and practical experience of the Green Energy Association (GEA), public perception of energy production from agrobiomass can be characterized as follows:

Experts, local authorities and entrepreneurs

- Experts for sustainable development in Romania express supportive attitude towards agrobiomass which can substitute the forest biomass and other fossil fuels.
- Soil scientists: mostly passive attitude, some of them have negative attitude due to their fear of possible soil degradation and loss of fertility by the removal of crop residues from the arable lands.
- Local authorities, NGOs and entrepreneurs in rural areas: mostly positive attitude, but superficial knowledge on advantages for the community and local economy.

Consumers, general public

- The decarbonisation of the energy sector in Romania is largely based on the support provided by agrobiomass sources.
- Rural population: positive and neutral perception, but the awareness level is still low. This obstacle is also hindering the investments or the community-based movements towards bioenergy projects on local levels.
- Urban population: mostly neutral attitude because of lack of detailed information on this topic. Generally positive perception if they have to decide between fossil fuels and agrobiomass as renewable source of energy.

Producers of agrobiomass

- Regions with a higher level of crop production and big amount of surplus agro-residues: mostly positive attitude, but low readiness to supply agrobiomass for reliable purchasers/consumers due to some fear of soil depletion.
- Agriculture Stakeholders from a lower soil qualities and small amount of surplus agriculture waste have more neutral or negative perception; they cannot identify the agrobiomass as an additional/alternative source of income or more sustainable business model.

Policy recommendations for Romania

Support for the development of local strategies for green waste management

Issues to be taken into consideration:

- Environmental aspects (landscape maintenance, cleaning of parks, green public spaces, cleaning of riverbeds, pasture cleaning, orchard pruning, vineyard pruning, etc.) – incentives, subsidies from national programs
- Social aspects (job creation for local unqualified workforce) – incentives, subsidies from national programs
- Energy aspects (energy from locally available sources)

Support for the establishment of biomass storage centres, biomass logistic centers at local/micro-regional level

- A centre where the harvested/collected green residues can be transported to and the biomass could be stored and dried.
- Possibility for farmers and local public authorities (who administer service companies responsible for cleaning of parks etc.) to store residues resulted from prunings.
- Possibility for households to transport their garden waste and prunings (lignocellulosic solid biomass) to the logistic centre.
- Separate storage for other type of agrobiomass (if applicable): walnut shell, sunflower husk, straw, corn stalks etc.

To approach: Ministry of Environment/Environment Fund, Environment Protection Agencies, Regional Development Agencies, Local public authorities.

Energy willow crop as a source of agrobiomass – subsidies for cultivating SRC

- Let the farmers plant SRCs in second quality soils and degraded soils.
- Subsidy the relevant stakeholders to establish SRCs as a sustainable source of energy in rural Romania.

Support for the production and valorization of agrobiomass

- Financial support of investments among the agriculture companies and farmers to develop their technical capacities for harvesting, storage and logistics valorization of agrobiomass for energy purposes, specifically for the less utilized biomass sources such as grain straw, corn stalks and corn cobs, walnut shells, sunflower husk, rapeseed stalks, etc. Investments should be supported, especially when project proposals are prepared with local collaboration, e.g. the involvement of local NGOs, public authorities, representative entities of residential sector, etc.

Support for the development and implementation of the "1 village 1 MW" concept

- Small-scale biomass heating systems in rural municipalities using agrobiomass feedstock or mix of prunings and lignocellulose biomass with other agrobiomass:
  - either as individual heating systems
  - or as micro DHS (connecting several public and private buildings)
- Financing programs for local public authorities
- Subsidy program to support the procurement of high energy efficient biomass boilers for households and public buildings - extend "Casa Verde" – "Green Home" subsidy program for private households.

Digital tools for the bioheat market development

- Creation of Digital Biomass Trading Platform or database of existing bioheat projects, systems, providers, and customers.

Include agrobiomass-to-energy, agrobiomass-to-bioeconomy concepts into the local, regional, national strategies

- Strategies of rural municipalities;
- Strategies of Local Action Groups;
- County development strategies;
- Strategies of the National Agency for Mountain Areas;
- Work strategies of the Ministry of Agriculture and Rural Development;
- Work strategies of the Regional Development Agencies.

Dissemination of information, knowledge transfer, increase of social acceptance

- Encourage the environment friendly behaviour (explain, give examples, support to accept and adopt bioenergy solutions, e.g. local token system – vouchers etc.).
- Explain, raise awareness about green solutions and reap the benefits of agrobiomass solutions.

International experience, knowledge transfer, practices in other European agricultural and rural regions, exchange of experience at different levels (national, regional, local level)

- Dissemination of best practice examples from other Member States.
- Exchange of experiences among the national experts and stakeholders.
- Involvement of international experts into project development and project implementation at the regional and local levels.

5. National Strategic Plan – Croatia

Major facts on bioenergy state of the art in Croatia

- The total primary energy production in the Republic of Croatia in 2019, amounted to 200.71 PJ (4 793.8 ktoe), of which energy from firewood and other biomass accounted for 31.3 %, while other renewable energy sources and ambient heat accounted for 10.0 %.
- In the total electricity production, 19.7 % of electricity was produced from renewable sources such as wind energy, small hydropower plants, biomass, geothermal energy, biogas and photovoltaic systems (2019).
- The total installed capacity for pellet production is 470,120 t/yr, out of which around 69 % was exported while the rest was placed on the domestic market (2019).
- Main type of biomass used is wood of forest origin, while a major part of biomass potential consists of agrobiomass (vineyard prunings, olive pomace, and energy crops).
- Biomass for energy is consumed mainly in the form of wood pellets and briquettes, charcoal, wood chips and firewood.
- Biomass is used mainly for heat production at boiler plants.
- Main application of biomass for heat production is in industry and households.
- Generally, heating on agrobiomass in Croatia is not as developed as in other EU countries whilst the majority heats on wood biomass. Moreover, now there are only two producers of agropellets in Croatia, one of energy crops and no manufacturer of stoves and boilers on agrobiomass. Natural gas remains the main fuel for heating.
- Within the Rural Development Programme, and Environmental and Energy Efficiency Fund, users can apply for subsidies to invest in the instalment of the biomass heating.
- In the Law on Renewable Energy Sources and High-Efficiency Cogeneration, for the agrobiomass it is used “Agricultural biomass” term.

Agrobiomass state of play in Croatia

Croatia is a small country in Southeast Europe that has a total surface area of 56,594 km^2 (consisting of 56,414 km^2 of land and 128 km^2 of water), and a population of around 4 million (2019). Insular Croatia consists of over a thousand islands and islets varying in size, 48 of which are permanently inhabited.

With its position in Europe, the northern part of the country has continental climate, with long and warm summers and cold winters, whereas the southern part enjoys a Mediterranean climate. Both are suitable for agrobiomass production due to a variety of soil types. With a variety of geographical features, continental semi-flat to flat region, to Istria region and Dalmatia, bit hilly and rocky, all with fertile ground for different types of productions, has allowed Croatia big agricultural potential that is yet to be discovered.

Croatia can be subdivided between a number of ecoregions because of its climate and geomorphology. The country is consequently one of the richest in Europe in terms of biodiversity: Mediterranean, Alpine, Pannonian and Continental. Total territory of 48.8 % is forest land; of that, 81 % is in the ownership of Croatian Forest (ownership of the Republic of Croatia), while the remaining 19 % belongs to private owners. According to the Croatian Forest, 90 % are overgrown forest land, 7 % not overgrown production, 1 % not overgrown unproductive, and 2 % infertile.

Agriculture is one of the key economic features contributing about 5 % to the Croatian GDP (2017). According to the National Bureau of Statistics, 27.3 % of the total territory is agricultural land (of which 54.5 % belongs to arable land and gardens, 40.6 % to permanent grassland, 4.8 % to permanent crops, and 0.1 % to vegetable gardens).

When looking at geographical distribution, abundance exists in Continental (central part of Croatia), Slavonia (vast of agricultural areas, main agricultural production) and Istria and Dalmatia region (main cultivation olive oil and wine production).

Estimations of biomass production - by aggregate by main categories, biomass potential in the Republic of Croatia is estimated, but not limited to, 78.56 – 148.81 PJ/year (2020):

- Wood biomass: 36.2 – 72.2 PJ/y and over 100 PJ/year if the mobilization measure is applied,
- Tree branches from maintenance of permanent corps: 0.7 - 4.21 PJ/y,
- Agro-residues: 22.93 PJ/y
- Post-harvest residues: 18.44 – 57.93 PJ/y,
- Biogas and biomethane: 5.83 – 11.5 PJ/y,
- Waste: 13.54 – 17.27 PJ/y.

Even though it is strictly prohibited by the legislation of Croatia, there is still the presence of burning agro-residues in the open field. It is generally due to clearing the field for new agricultural production or because of an abundance of residues and no nearby facility where it can be used for heating.

Energy crops in Croatia started to be used in the past few years. According to the BioEnergy Europe reports for Biomass Supply, there is the only energy crop (miscanthus x giganteus) present on the 500 ha surface area. This indicates that the market for the energy crops for heating is still not developed in the country, following compliance of the legal framework. Several studies started to test the potential of the short rotation coppice (willow, poplar, wild millet, robinia).

Due to a major change in EU legislation, a new Law on Renewable Energy Sources and High-Efficiency Cogeneration will be adopted next year, implementing the Directive from December 2018. The Renewable Energy Directive increases the binding target for renewable energy in the total consumption from 27 % to 32 % by 2030, with a revision clause of that target by the end of 2023. Its aim is to empower smaller RES energy producers and shorten the procedure for obtaining RES installation permits from 50 kW to 1 MW to a maximum of one year, through a “one-stop- shops ", and strengthen the energy cooperative. This directive requires member states that all residents, regardless of whether they live in family houses or

buildings, receive the right to produce energy from RES, which is currently not possible in Croatia for apartment buildings.

Main barriers for using agrobiomass for energy and possible ways to overcome them

Technical barriers

- *No domestic stove and boiler manufacturers on agrobiomass.*

  Possible solution: Try-out technologies from different EU countries via Croatian distributors of stoves and boilers.

- *Difficulties in using agrobiomass as fuel due to its peculiar fuel properties.*

Possible solution: Use of modern specialized equipment. Compliance with fuel characteristics requirements and optimal operating modes. Possibility to test and use a combination of different types of agrobiomass to increase efficiency with residues that have smaller humidity value, which can result in better fuel properties.

- *Gasification of the larger areas on a local level*

Possible solution: Mapp and identify buildings and/or organizations who wish to change their way of heating and offer a possibility to use agrobiomass instead of a gas.

Non-technical barriers

- *Undeveloped market for selling agropellets*

Possible solution: Change legal framework and put more focus on agrobiomass, so when applying for national subsidies for use of RES for heating, citizens can have options whether they want to apply for the biomass or agrobiomass. Raising awareness and education by presenting best experience and practices from other EU countries.

- *Unclear state policy regarding the use of agrobiomass for energy.*

Possible solution: Adapt legal framework and put more focus on agrobiomass, so when applying for national subsidies for use of RES for heating in households, citizens can have options whether they want to apply for the biomass or agrobiomass.

- *Difficulties in fund-raising for agro-bioenergy projects.*

Possible solution: Apply for EU incentives via Rural Development Programme (focus on farmers) or LIFE project, which can co-finance half of the instalment (good practices for local municipalities).

- *Lack of dissemination of successful cases on energy production from agrobiomass.*

Possible solution: Holding of education campaigns, arranging dedicated site visits and study tours, presenting at the national events such as fairs, conferences, collaboration with relevant stakeholders.

- *Desaturation of soil with nutrients*

Possible solution: Better management of the agricultural residues; produce more pellets from vineyard prunings, olive pomace and energy crops.

- *Difficulties in bringing to justice those responsible for open burning of crop residues.*

Possible solution: Creation of favourable conditions for harvesting and selling crop residues for energy needs. Local authorities define conditions and deadlines when people can burn residues on fields not to jeopardize public safety and environment.

Potential for further development for the production and use of agrobiomass for energy

Eligible investments within the measures of the Rural Development Program of the Republic of Croatia are largely co-financed by European Union funds through the European Agricultural Fund for Rural Development, while the rest is co-financed by the State Budget of the Republic of Croatia. The implementation of rural development measures within the framework of the Rural Development Program of the Republic of Croatia for the period 2014-2020 has ended with 18 different measures to support citizens, whilst the new program for the period 2020-2030 added one new measure to support rural development.

The new program contains 19 measures aimed at increasing the competitiveness of Croatian agriculture, forestry and the processing industry, as well as improving living and working conditions in rural areas in general. New strategic plan, according to the drafted document Agricultural Strategy 2020-2030, focuses on increasing productivity and resilience of agricultural production to climate changes, strengthening the competitiveness of the agri-food sector, rebuilding the rural economy, improving living conditions in rural areas, and encouraging innovation in the agri-food sector.

All strategic goals are aimed at improving the rural economy, and their fulfilment will contribute to the overall economic development of Croatia. The strategy suggests that this will be achieved by increasing agricultural productivity in an environmentally and climate-sustainable way while strengthening the links between production and the market and creating green energy jobs in the rural economy. The Agriculture Strategy is shaped in an evidence-based planning process, which includes economic analysis and stakeholder consultation, and places great emphasis on innovation as a key factor in improving the economic development of agriculture. Additionally, it takes into account the strategic guidelines from the National Development Strategy and represents a framework for interventions in the sector under the CAP for the period 2023-2027. All activities within this Strategy will contribute to Croatia's broader development goals.

Environmental Protection and Energy Efficiency Fund, in the past few years, started to open public calls for energy renewal of the buildings, with a primary focus on the outer layer of the house (roof, thermal

facade, and windows), accompanying secondary focus on heating on pellets, heat pumps and PV installations. Generally, Croatia started to be more welcoming in supporting interested parties in RES and EE implementation via different public calls, such as the Operational Program of Competitiveness and Cohesion, as well as from trading emission units on auction.

Usually, in the public calls, it is said "biomass for heating", and it is not explicitly divided into biomass and agrobiomass (agricultural biomass).

Assessment of impacts of the increased market penetration for agrobiomass heating

According to the *Air Quality Law* (NN 127/19), art. 39., Government of Croatia has brought *Assize on Limit Values of Emissions of Pollutant Substances into Air from Fixed Sources* (NN 42/2021*)*, art. 75., art.92.2 and appendixes 10, 11 and 12, it is presented in the following tables a summary of the assessment of environmental and social impacts from the increased biomass heating penetration into Croatian's market.

Table 7: Categorization of installations (Croatia).

Size of installation	Solid biofuels and fuel from biomass
Small	≥ 0.1 - 1 MW
Medium	≥ 1 - 50 MW
Big	≥ 50 MW

Table 8: Limit Values of Emissions – small installations (Croatia).

Small installations	Gas emissions limit (mg/m^3)
Chimney blackening (Bacharach scale)	1
CO	1000

* Volume fraction: Oxygen 11%.

Table 9: Limit Values of Emissions – for new installations on biomass (Croatia).

Pollutant	Gas emissions limit (mg/m^3)
SO_2	200
NOx	300
PM	20

Table 10: Limit Values of Emissions – for existing installations on biomass (Croatia).

Medium installations	Gas emissions limit (mg/m^3)
PM	150
Sulfur oxides expressed as SO_2	2000
CO	500
NOx expressed as NO_2	500 Vortex deposition: 300 mg/m^3

* Volume fraction: Oxygen 11%.

Public perception of agrobiomass heating

Based on the knowledge, relevant stakeholder meetings and the CATI survey conducted in Croatia on 900 participants, public perception of energy production from agrobiomass can be characterized as follows:

Experts, local authorities and entrepreneurs

- Experts in bioenergy and related areas: mostly positive attitude on condition that agrobiomass is used on a sustainable basis. Missing awareness and general knowledge about the financial schemes for the general public.
- Soil scientists, agronomists: mostly negative attitude due to possible soil depletion caused by the removal of crop residues from the field. Putting more focus into research of energy crops.
- Local authorities and entrepreneurs in rural areas: mostly positive attitude; awareness of possible advantages for the community and local economy. See an opportunity for a good waste management programme (vineyards prunings, orchards residues).

Consumers, general public (based on 900 participants in the CATI survey)

- Around 70 % of citizens recognize and positively perceive agrobiomass as a source of energy, while only 4 % use agrobiomass as a producer or consumer.
- Almost 67 % do not know/are not educated about regulations and legal aspects.
- More than 88 % of respondents are unaware of funding schemes and incentives for biomass heating.
- Only 4 % have a negative perception of the use of agrobiomass for heating.
- 35 % agree that better management of energy efficiency and resources is needed.
- Over 50 % of respondents believe that agrobiomass has a positive impact on the environment and climate, reduces heating costs, develops the local economy, and there is the need to involve citizens in decision-making.
- 85 % know some/little or nothing about RES technologies, while over 90 % do not know enough about agro (bio) heating technologies (50 % use wood for heating, 30 % gas, 20 % electricity).

Producers of agrobiomass

- Regions with a high level of crop production and big amount of surplus agro-residues: mostly positive attitude; readiness to supply agrobiomass for reliable purchasers/consumers; no fear of soil depletion. Undeveloped market, missing end-users, majority of pellets sold abroad (such as Italy).
- Regions with a low level of crop production and small amount (or absence) of surplus agro-residues: mostly negative perception; fear of soil depletion; not ready for big investment, scepticism.

Policy recommendations for Croatia

Creation of the biofuel electronic trade system (biomass exchange)

The basic law for the biofuel electronic trading system is still not adopted in Croatia, and as such, it does not exist. Currently, the Strategic Plan of the Common Agricultural Policy of the Republic of Croatia 2023 – 2027 is being drafted, so we can presume that some new measures could also include recommendations for an electronic trade system in Croatia.

Introduction of state support for growing energy crops

According to the *Law on the Wood Short Rotation Coppice (National Newspapers "*NN" 15/2018), art. 1., the purpose of this Act is to contribute to the energy and economic development of the Republic of Croatia by enhancing security of supply through the use of additional national energy sources; the development of rural areas by stimulating economic activity at the local level by utilizing the additional production potential of agricultural and forest land, and art. 2*.,* crops are considered to be intensive plantations of fast-growing tree species or other plant species grown on agricultural or forest land for a short period of up to eight years between the two fellings or harvest, in order to achieve high biomass yield for energy purposes.

Furthermore, documents prepared within the framework of the *Agriculture and Fisheries Development Strategy of the Republic of Croatia 2020* consider the possibilities and benefits of growing energy crops in the territory of Croatia. It is expected that the new agricultural strategy for the period of 2023-2027, which is currently under development, will encourage the use of these crops (in a way of sustainability, innovation technology, sustainable income).

Introduction of state support for agrobiomass producers

To increase the production of agrobiomass for energy, state support measures should be extended to the agricultural biomass too (i.e. in Croatia the majority of incentives for agriculture comes from the Rural Development Programme).

Development of State strategy for using agrobiomass for energy

Until March 2022, the Strategic Plan of the Common Agricultural Policy of the Republic of Croatia 2023 – 2027 is under discussion, upon which will be available for comments. Then the second round of discussion

is coming to discuss and review given comments and recommendations. Generally, the emphasis is on the overall share of RES in the total energy production and consumption, not only on agro(bio)mass and soil.

Development of Heat Supply Strategy

In Croatia, a Heat Supply Strategy document is not developed yet, but within the Strategic Plan of the Common Agricultural Policy of the Republic of Croatia 2023 – 2027, producer organizations (cooperative, family farms, energy communities) will have an advantage - they will have extra points in the application. In addition, it envisages an increase in the use of electricity and heat from biomass (distributed systems).

Creation of the competitive heat market with fair access of biomass heat producers to heat networks

Development of the heat market in Croatia is defined by the Law on the Heat Market. According to the Law, theoretically, any producer can access the market, but there are no defined tariffs for RES, and biomass has to compete with centralized systems. More focus is put on CHP plants or biogas plants due to EE conditions which should raise their efficiency, but again we have a problem because there are few such plants that are somewhere near the heating grid. Additionally, with the new Strategic plan, investments will be in the value-added products, economic sustainability of agricultural farms, support for the production of electricity and heat from biomass, short supply chains, and AKIS education.

Improvement of the system for biomass heat tariff setting

Setting of biomass heat tariff does not yet exist for thermal energy as such, but does for the CHP plants to increase the overall efficiency of the system. On the other hand, a tariff model for production of electricity from the biomass is present in Croatia, and it has tariff models for small biomass plants (< 1 MW) for distributed grid, and for large biomass plants (> 1 MW) for distributed and transmission grid.

Improvement of control on open burning of stubble remains on fields

It is necessary to enhance the control of open burning of the biomass in the fields. The biomass should be burnt only for the purpose of preventing the spread or suppression of organisms harmful to the plants by implementing fire protection measures in accordance with special regulation. Another possibility is to create favourable conditions for using the residues for energy or bioeconomy purposes.

Improvement of Carbon Tax imposition and administration

This is only now under discussion for the biomass plants.

Intensification of information dissemination activity

Within the Strategic Plan for the 2023-2027, major focus will be put on the AKIS education – as awareness campaigns, workshops, general info, etc.

6. National Strategic Plan – Ukraine

Major facts on bioenergy state of the art in Ukraine

- Bioenergy accounts for over 75% of renewable energy (2020).
- The share of biomass in the total primary energy supply is 4.9% (2020).
- Main type of biomass used is wood of forest origin, while a major part of biomass potential consists of agrobiomass (agricultural residues and energy crops).
- Biomass for energy is consumed mainly in the form of firewood, wood chips, wood pellets and briquettes, sunflower husk (including pellets and briquettes).
- Biomass is used mainly for heat production at boiler plants.
- Main application of biomass for heat production is in industry and households.
- Historically, Ukraine has a well-developed district heating system, though the use of biomass in it is very low. Natural gas remains the main fuel in district heating.
- Supporting instruments for bioenergy include feed-in tariff for power generation and stimulating tariff for heat production.

Agrobiomass state of play in Ukraine

Agriculture is one of the key economic activities contributing over 10% to Ukrainian gross domestic product. Agricultural lands make up nearly 70% of the total area of Ukraine. Agricultural residues (about 10 Mtoe/yr) are abundant, and their amount even grows due to an increase of crops yield. Major parts of agricultural residues are straw of cereal crops (35%) and maize crop residues (32%), the rest being sunflower crop residues (15%), sunflower husk (10%) and rapeseed straw (7%) (2020).

Some part of agro-residues (straw, stalks and other crop remains) is destroyed by burning on the field, the main purpose being to clear the field for further agricultural operations. Even though it is strictly prohibited by the legislation of Ukraine, such burning takes place quite often, which causes air pollution and has a negative effect on soil condition.

Processing of sunflower with the production of oil and generation of husk takes place at oil-extraction plants and other food industry enterprises. Sunflower husk is widely used for the production of pellets/briquettes and energy at oil-extraction plants. A considerable part of sunflower husk pellets is exported.

The cultivation of energy crops has not yet acquired a large scale in Ukraine. The total area under energy crops (mainly willow in some western regions) is about 5000 ha while the area of underutilized agricultural land, which can be used for this purpose, is 3-4 Mha. Biomass of energy crops is used for heat production.

There are no official documents stating what shares of straw and other agricultural residues can be sustainably used for energy. Based on conducted studies, the position of the Bioenergy Association of

Ukraine is that generally up to 30% of the theoretical potential of cereal straw and up to 40% of the theoretical potential of residues from maize and sunflower production can be sustainably used for energy. However, when it comes to a concrete agricultural producer, the issue should be addressed individually based on local conditions.

To date, the agrobiomass market in Ukraine has remained poorly developed, which hampers the implementation of bioenergy projects. Actually, a buyer (consumer) shall look for a producer (seller) of agrobiomass, negotiate a price and make a contract by himself, which usually is not that easy.

Agrobiomass is mainly used for heat production. The only support measure for agrobiomass heating is so-called stimulating tariff. This tariff is applied for economic entities that produce heat from biomass for population and state-financed institutions. The stimulating tariff is 90% of the tariff for heat produced from natural gas.

A target for the use of renewable energy sources in heat production is set in the Concept for the implementation of the state policy in the heat supply sector (the Heat Supply Concept) adopted in 2017. According to this document, the share of renewable energy sources in heat production should reach 30% in 2025 and 40% in 2035. Considering the current structures of renewable heat production and biomass potential in Ukraine, it is obvious that the targets can be attained only under the considerable contribution of agrobiomass.

Main barriers for using agrobiomass for energy and possible ways to overcome them

Technical barriers

- *Agricultural producers do not have specialized machinery for the harvesting of crop residues for energy purposes.*

Possible solution: Development of market (increase in demand) for the specialized machinery. Try-out of technologies for the collection/supply of different types of agro-residues (maize stalks/cobs, sunflower stalks) within some dedicated pilot or demonstration projects.

- *Difficulties in the arranging of agrobiomass «collection-supply» chains.*

Possible solution: Application of the best international and national experience and practice. Try-out of basic technologies and approaches within some dedicated pilot or demonstration projects.

- *Difficulties in using agrobiomass as fuel due to its peculiar fuel properties.*

Possible solution: Use of modern specialized equipment. Compliance with fuel characteristics requirements and optimal operating modes. A gradual shift from using straw of cereal crops to maize crop residues as the latter have better fuel properties.

Non-technical barriers

- *Underdeveloped biofuel market.*

Possible solution: Introduction of biomass exchange, preferably similar to Lithuanian Baltpool.

- *Unclear state policy regarding the use agrobiomass for energy.*

Possible solution: Development and promulgation of the state strategy for the use of agrobiomass for energy.

- *Difficulties in fund-raising for agro-bioenergy projects.*

Possible solution: Introduction of the target state support for harvesting/collection of agro-residues for energy and growing energy crops.

- *Lack of dissemination of successful cases on energy production from agrobiomass.*

Possible solution: Holding of education campaigns, arranging of dedicated site visits and study tours.

- *Potential risks for soil caused by the removal of crop residues from fields for energy needs.*

Possible solution: Development of organic fertilizers market including the use of digestate from biogas plants.

- *Difficulties in bringing to justice those responsible for open burning of crop residues.*

Possible solution: Creation of favourable conditions for harvesting and selling crop residues for energy needs. Increase of actual responsibility for open burning of agro-residues.

Potential for further development for the production and use of agrobiomass for heating

In Ukraine, agrobiomass has considerable potential for further development for the production and use, first of all in the heating sector, which represents a significant part (about 50%) of the total energy consumption. One of the promising directions is the involvement of agrobiomass into district heating.

Historically, Ukraine has had a well-developed district heating (DH) system, which still accounts for about 50% of the whole heat supply. Especially DH remains quite actively functioning in big cities. Some latest trends have been gradual shifting from DH to the individual or autonomous heating, which we consider unjustified in most cases and resulting in deterioration and degradation of the DH system. In our opinion, the DH system should be preserved and further developed into efficient district heating. For Ukraine, one of the possible ways to achieve efficient DH is to widely deploy agrobiomass in it. This idea is in line with the main targets on heat supply from RES set in the current Heat Supply Concept.

Assessment of impacts of the increased market penetration for agrobiomass heating

Summary of the assessment of environmental and social impacts from the increased agrobiomass heating penetration into Ukraine's market is presented in Table 11. Straw of cereals and rapeseed has the biggest positive impact due to its largest available potential (4.0 Mtoe of the total 9.4 Mtoe of agro-residues in 2020) and better fuel properties compared to other types of agrobiomass.

Table 11: Results of the assessment of environmental and social impacts of the increased market penetration for agrobiomass heating in Ukraine.

Parameters	Straw of cereals and rapeseed	Maize residues	Sunflower residues	Total
Potential available for energy (2020), Mtoe	4.0	3.0	1.4	8.4
Annual Emissions Reductions (%) from burning agrobiomass in boiler vs. field burning:				
NOx	42.5%	19.1%	24.2%	
CO	92.5%	82.1%	83.2%	
NMVOC	77.3%	44.5%	48.0%	
NH_3 (ammonia)	73.7%	75.3%	76.9%	
TSP	77.0%	73.3%	75.0%	
PM_{10}*	77.7%	74.1%	75.7%	
$PM_{2.5}$*	77.3%	73.7%	75.4%	
GHG Emissions Savings (%) compared to:				
natural gas	82.2%	82.2%	82.2%	
CO_{2eq} (Mt/y)	8.3	6.1	2.9	17.3
gas/diesel oil	87.7%	87.7%	87.7%	
CO_{2eq} (Mt/y)	11.9	8.8	4.2	24.9
coal	91.0%	91.0%	91.0%	
CO_{2eq} (Mt/y)	15.2	11.3	5.3	31.8
Creation of jobs (*results based on biomass DH*), FTE	36 002	26 567	12 606	65 175
GDP impact (*results based on biomass DH*), MEUR	1 510	1 115	529	3 154

** Particulate matter which includes particles that have aerodynamic diameters less than or equal to 10 micrometers (µm) (PM_{10}). $PM_{2.5}$ is the subset of PM_{10} particles that have aerodynamic diameters less than or equal to 2.5 µm.*

Public and stakeholder perception of agrobiomass heating

Based on the knowledge and practical experience of the Bioenergy Association of Ukraine, public perception of energy production from agrobiomass can be characterized as follows:

Experts, local authorities and entrepreneurs

- Experts in bioenergy and related areas: mostly positive attitude on condition that agrobiomass is used on the sustainable basis.
- Soil scientists: mostly negative attitude due to their anxiety of possible soil depletion caused by the removal of crop residues from the field.
- Local authorities and entrepreneurs in rural areas: mostly positive attitude; awareness of possible advantages for the community and local economy.

Consumers, general public

- Rural population: mostly positive perception or at least absence of negative attitude. Awareness of possible basic advantages for the community.
- Urban population: mostly no reliable information and knowledge on the matter. Circumspection regarding the possibility and reliability of energy production from agrobiomass as compared with fossil fuels.

Producers of agrobiomass

- Regions with a high level of crop production and big amount of surplus agro-residues: mostly positive attitude; readiness to supply agrobiomass for reliable purchasers/consumers; no fear of soil depletion.
- Regions with a low level of crop production and small amount (or absence) of surplus agro-residues: mostly negative perception; all crop residues should be used for agricultural needs; fear of soil depletion.

Policy recommendations for Ukraine

Development of the National Bioenergy Strategy

In 2019, the Council of National Security and Defence of Ukraine made a decision that it was necessary to revise the existing Energy Strategy until 2035 (adopted in 2017) with the extension of the time horizon covered by the Strategy until 2050. Thus, we consider it rational to elaborate the National Bioenergy Strategy emphasizing the use of agrobiomass for energy as an integral part of the revised Energy Strategy of Ukraine until 2050.

Development of the Heat Supply Strategy

Based on the existing Heat Supply Concept (adopted in 2017), it is recommended to elaborate a more detailed document such as Heat Supply Strategy until 2050. The Strategy should cover all the sectors of heat consumption (DH, individual consumers, industry) and provide quantitative targets with the timing of their achievement. These targets include, in particular, the share of DH systems and efficient DH systems in the total heat supply; the share of heat from RES including heat from biomass; the share of heat losses in heat networks, etc.

Creation of a biofuel electronic trade system (biomass exchange)

It is recommended to introduce an electronic trade system for solid biofuels through electronic auctions ensuring quality of the biofuels being traded. First, it is necessary to adopt the basic law required for the establishment of the biofuel ETS in Ukraine. The draft law has been elaborated with a considerable contribution of the Bioenergy Association of Ukraine (UABIO). When the basic law is passed, several related by-laws should be developed and adopted.

Creation of the competitive heat market with fair access of biomass heat producers to heat networks

Creation of the competitive heat market with the introduction of auctions for heat producers requires amending the current legislation, first of all, the Law of Ukraine “On Heat Supply”. The required amendments have been elaborated with a considerable contribution of UABIO. They provide the introduction of the competitive heat market, ensure non-discriminatory access of independent producers to DH networks, and introduce bidding for the purchase of heat from independent producers. It is recommended to consider and adopt the suggested amendments to the Law of Ukraine “On Heat Supply”. After that, it is necessary to elaborate and adopt several related by-laws.

Improvement of the system for biomass heat tariff setting

Heat produced from biomass and intended for population and budget-financed institutions is supported by a stimulating tariff in Ukraine. The tariff is 90% of the tariff established for the supplier of heat produced from natural gas for the respective category of consumers. The stimulating tariff was introduced in 2017 and considerably contributed to boosting heat production from biomass. Later it turned out that the tariff might not be the best option for biomass plants < 1 MW and required some revision. We suggest enabling the producers of heat from biomass to choose their tariff setting procedure (“the 90% principle" or "cost +"). More generally speaking, we consider it necessary to create the competitive heat market where heat tariffs are determined at auctions for heat producers. The respective draft law has been elaborated.

Introduction of state support for growing energy crops

Along with the State Agency on Energy Efficiency and Energy Saving of Ukraine, UABIO participated in the elaboration of a draft law and some supporting materials required for the introduction of state support for growing energy crops. The draft law is now under consideration by Ukrainian Parliament, the recommendation being to adopt it as soon as possible. When the law is passed, a by-law required for its operation should be elaborated and adopted as well.

Introduction of state support for agrobiomass producers

Another way to encourage the producers of agrobiomass for energy is to extend the existing state support for certain agricultural activities to harvesting agrobiomass, production of biomass/biofuels and

implementation of bioenergy projects. It is recommended to provide a part of the funds of the state decarbonization fund (the creation of which is envisaged by draft Law No 4347 of 09.11.2020) to support agro-bioenergy projects.

Improvement of control on open burning of stubble remains on fields

It is necessary to tighten liability for the open burning of stubble remains on the fields. Another option is to create favourable conditions for using agro-residues that are generated on fields for energy or bioeconomy.

Improvement of Carbon Tax imposition and administration

In Ukraine, biomass combustion plants pay CO_2 emission tax. The tax is not high but gradually increasing. As the situation contradicts the concept of biomass CO_2–neutrality equalizing biofuels with fossil fuels, we recommend that biomass should be exempted from CO_2 emission tax as soon as possible. On the other hand, it is necessary to improve the administration of the Carbon Tax in order to support renewable energy projects, including agro-bioenergy projects. We also recommend full-scale reform of the CO_2 tax with the transition to the classic energy tax with taxation of carbon content in the fuel at the time of its entry into the customs territory or the first sale.

Acknowledgements

Authors of the Deliverable express their gratitude to policy makers and other external actors from Greece, Spain, France, Romania, Croatia and Ukraine for their feedback on the respective National Strategic Plans.