AgroBioHeat

Promoting the penetration of agrobiomass in European rural areas

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D5.1: National and European framework conditions

Part 2: European social perception study on agrobiomass heating

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Abbreviations

Abbreviation	Explanation
Clickworker	Online crowdsourcing platform
NIMBY	Not In My Back Yard

Project consortium

#	Full name	Acronym
1	Ethniko Kentro Erevnas kai Technologikis Anaptyxis	CERTH
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
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11	White Research Sprl	W.R.
12	Agronergy	AGRONERGY
13	Association d'Initiatives Locales pour l'Energie et l'Environnement	AILE

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1. Introduction

Exploring the current state-of-the-art of the biomass sector across Europe is essential for providing and developing an effective policy framework towards empowering the market uptake of biomass in the heating sector. Lack of awareness and low social acceptance levels can greatly affect the course of a project and can emerge as significant barriers for alternative fuel adoption. Especially in the case of bioenergy projects that require a complex multi-actor involvement, social acceptance can pose a serious threat to the successful implementation and sustainability of the project.

With the aim to gain insights into the main drivers boosting social acceptance of an agrobiomass heating project, and in order to identify possible barriers and gaps limiting a wider adoption of these initiatives, a large-scale European survey was conducted as part of the AgroBioHeat project. The focus was on capturing awareness levels regarding biomass and its use, social acceptance factors that affect its implementation and any potential differences in perceptions between countries, stakeholder groups, and types of regions. The key findings of the survey will inform the National and EU Strategic plans to take effective policy measures for the promotion of agrobiomass heating projects throughout Europe.

2. Main scope

The European energy system is facing significant changes to meet the EU's climate objectives. The heating sector, responsible for almost half of the EUs total energy consumption, is still heavily relied on fossil fuels with a share of almost 80%. In order to reach EU's decarbonisation objectives, efforts must be focused on increasing the share of renewables in the energy mix. In this regard, penetration of RES in the heating sector and widespread deployment of renewable energy heating technologies is therefore essential.

In this context, bioenergy technologies seem to play a key role in the current energy heating system. It is shown that bioheat is steadily rising, with biomass being the main fuel in a very dynamic and promising market. According to Commission's vision, bioenergy from agrobiomass is expected to grow the most by 2050[1]. Literature shows that especially in rural areas, agricultural waste can be a valuable biomass resource that can be used as an alternative fossil fuel (Jiang et al., 2018). At the same time, bioenergy technologies fuelled with agricultural wastes are mature, and can be used in innovative projects related to renewable energy. As a result, the adoption of bioenergy heating systems using agrobiomass is of increasing interest.

However, public acceptance of alternative energy projects can present many obstacles in such a transition. In the past, it has been shown that public resistance can hinder many risk factors that significantly affect the implementation of projects, either at the beginning or during their operational stage. Social acceptance is therefore a decisive factor in designing and deploying new technologies that aim at disrupting conventional energy market processes. Biomass energy interventions require complex strategies and collective efforts for their deployment, as they involve several supply-chain market actors. Therefore, effective cooperation between all different stakeholders and key actors, combined with public acceptance of such projects, are vital for the successful implementation and sustainability biomass energy projects.

This report aims to shed light on aspects of acceptance and perceptions that exist within the European framework conditions. The structure of the reports is as follows. Section 3 provides an overview of the literature regarding the main factors affecting social acceptance of biomass heating, pointing out the main directions that we have followed for our large-scale survey. Section 4 includes all the essential details regarding the survey approach and the methodology we have used for our analysis. Finally, Sections 5 presents the main outcomes of the descriptive and the statistical analysis. Discussion and overall conclusions are given in Section 6, at the end of this report.

[1] https://bioenergyeurope.org/article/196-bioenergy-europe-essentials.html

3. Theoretical framework

3.1 Definition of social acceptance

To better understand important aspects related to social acceptance of renewable energy and the factors influencing it, several authors consider a three-dimensional approach to define social acceptance (Prosperi et al., 2019; Gaede and Rowlands, 2018; Fytili and Zabaniotou, 2017; Perlaviciute and Steg, 2014; Wüstenhagen et al., 2007). According to this, social acceptance is characterised by the following dimensions:

- **Socio-political acceptance** that refers to the public acceptance of renewable-energy technologies and policies by key stakeholders and policy actors.
- **Community acceptance** which encompasses the specific acceptance of siting decisions and renewable-energy projects by local stakeholders, particularly residents and local authorities.
- **Market acceptance** which explains the adoption of innovative products by consumers through a communication process between individual adopters and their environment. Users may not recognize the new opportunities created by new innovations, and thus, it is necessary to raise their awareness level regarding the potential application of innovative products.

Following this three-dimensional framework, social acceptance has been investigated in various studies, highlighting the fact that stakeholders' interplay in rural development initiatives is a critical factor for adopting new technologies that may disrupt the conventional heating market. Hence, enhancing social acceptance of such initiatives may result in better conditions for increasing the market share of bioenergy systems can be achieved. In order to have a better understanding of the formation of social acceptance, and following the above-mentioned definition, the following section presents the main findings of the existing literature in terms of understanding the factors that drive social acceptance in renewable energy sources and biomass heating projects.

3.2 Factors influencing stakeholders' acceptance

In general, several factors have been identified in the literature influencing social acceptance of renewable energy projects, focusing on behavioural aspects with respect to development and implementation of bioenergy projects. The most frequently reported include socio-economic (income, cost), psychographic (knowledge, attitudes) and demographic factors (age, educational level, etc).

In the first case, multiple **social** and **economic factors** have been identified to affect the acceptance of alternative energy projects (Sovacool and Ratan,2012), including: 1) strong institutional capacity; 2) political commitment; 3) favourable legal and regulatory frameworks; 4) competitive installation and/or production costs; 5) mechanisms for information-sharing and feedback; 6) access to financing; 7) prolific community and/or individual ownership and use; 8) participatory project siting and 9) recognition of externalities or positive public image. Economic factors are usually a key issue when decision criteria or barriers to adoption of an energy project are investigated. Not surprisingly, the higher the cost of an energy alternative solution, the lower its acceptance will be, whereas the higher

the economic benefits people expect, the easier they accept the solution (Perlaviciute and Steg, 2014). Indeed, high investment costs along with lack of financial incentives certainly play an influential role. In general, people are not in favour of paying high prices for green energy, and thus the higher the prices they expected to pay, the less they are willing to adopt the alternative energy system (Ntanos et al., 2018). Economic factors also include economic conditions, as well as economic effects for nearby communities. More specifically, the use of biomass may provide an additional income stream for local farmers, and thus they may contribute to the economic development of their region. Consequently, the sharing of project profits, new employment opportunities, a "green" reputation of the region and thus a broader economic boost to the entire area can affect the adoption of energy projects.

Secondly, **technological factors** that refer to the scale and type of new technologies can also affect public acceptance of new energy projects. The level of knowledge about the new technologies, as well as previous experience with bioenergy technologies can have an influence on public confidence and final adoption of the new technology and the relevant projects. Currently, the level of public awareness is significant low as regards bioenergy comparing to other energy technologies (i.e. solar and wind energy) (Prosperi et al., 2019). As such, people with higher level of knowledge about such technologies and adequate know-how are assumed to be more supportive. Besides that, social acceptance is often higher for small-scale applications than for large-scale systems.

At the same time, **environmental beliefs** and **concerns** also influence social perceptions and general level of acceptance. In this context, active ecological awareness plays a key role in the adoption of alternative energy solutions. People who are more aware or conscious of sustainability issues like climate change are more prone to support alternative energy technologies (Fytili and Zabaniotou, 2017). Moreover, the role of social media in providing information both on benefits and negative consequences is also significant, as due to lack of adequate information, citizens' environmental concerns can be a barrier towards adopting bioenergy, since people more often concern only about negative environmental and quality-of-life impacts, such as air quality, level of CO_2 emissions, landscape deterioration, impacts in the quality of life in the area (Radics et al., 2015).

In addition, social acceptance of bioenergy projects seems to be influenced by **social influence**. Several studies indicate that individuals' opinion acceptance of alternative energy technologies is likely to be influenced by perceptions, the behaviour and recommendations of other individuals such as friends and neighbours (Heiskanen and Matschoss, 2019; Zeng et al., 2019; Ntanos et al., 2018). At the same time, projects that have the support of other stakeholders like recognised industry players, environmental protection groups as well as policy makers are more easily accepted (China et al, 2014). Some additional factors include **public participation, fairness,** and **trust**. More specifically, public engagement and participation in a local bioenergy project seems to increase public acceptance levels (Gaede and Rowlands, 2018). People wish to be informed about and have a say in implementation of energy projects so that decisions regarding energy developments be taken in a fair way and consider their views and needs. At the same time, procedural fairness, transparency, and the extent to which information are provided during the implementation of energy projects can influence social acceptability (Fytili and Zabaniotou, 2017). Besides that, the extent to which people trust, not only the implementation process, but also the institutions and experts that are involved (e.g., project partners,

energy companies, national and local governments, interest groups), is a significant factor for social acceptance, since the use of energy alternatives are supposed to be complex matters that can only be fully grasped by people with specific expertise (Prosperi et al., 2019; Perlaviciute and Steg, 2014).

On the other hand, **individual characteristics** such as age, gender or level of education seems to significantly influence and shape people's perceptions and attitudes (Zeng et al., 2019; Panori et al., 2017; Halder et al., 2015; Radics et al., 2015; Chin et al., 2014). First, evidence indicates that the impact of age appears to be non-linear, as older people are more likely to have a negative disposition towards bioenergy than the younger ones, whereas in some other cases middle-aged or older people can be forerunners in investing in new renewable energy systems. Second, education is also linked with a tendency to adopt alternative energy systems. People with lower education levels are less willing to adopt and pay for bioenergy and other renewable energy systems compared to higher educated. It is also mentioned that educational specialisation, and especially in the fields of engineering and environmental specialisations, are linked to a higher level of adoption. Finally, gender is a key factor, as even though men are better informed about bioenergy issues, women are more supportive and willing to accept bioenergy.

Finally, additional individual factors such as **personal values** and **personality traits** also affect public acceptability of energy projects. Pro-environmental beliefs, attitudes and behaviours that affect acceptability of energy projects are particularly related with four types of values: "biospheric (protecting nature and the environment), altruistic (safeguarding the wellbeing of others), egoistic (safeguarding personal resources such as wealth and status), and hedonic (seeking pleasure and comfort)" (Perlaviciute et al., 2018). Consequently, if people think that an energy project will support their core values, they will easily accept it, whereas, if it seems to threaten their personal values, they will oppose to its implementation. For instance, the individuals who strongly endorse biospheric or altruistic values are generally more prone to act pro-environmentally and accept renewable energy projects. Contrary, people with stronger egoistic or hedonic values, have less pro-environmental beliefs and find renewable energy resources less acceptable. However, in case that pro-environmental behaviours do have egoistic or hedonic benefits, for example when energy savings also imply saving money, these people might react positively towards the implementation of a renewable energy project (Bouman et al., 2018). Core personality traits such as openness and extraversion are closely related with environmental attitudes and affect acceptability of energy projects. More specifically, people with flexible, abstract thinking that can imagine long-term environmental impacts, or those who are sociable and characterised by an energetic engagement with the world and a variety of activities, are more likely to adopt a "green" project (Brick and Lewis, 2016).

3.3 Social perceptions in energy projects

On top of the abovementioned influencing factors, the most important considerations underlying social acceptance of bioenergy projects include the well-known **"**Not-In-My-Back-Yard" effect (NIMBY) (Fytili and Zabaniotou, 2017; Perlaviciute and Steg, 2014). Several studies describe this phenomenon as a usual complex "selfish" behaviour that raises significant opposition for the development of energy projects (Gaede and Rowlands, 2018; Fytili and Zabaniotou, 2017). Based on their studies, while

individuals often consider bioenergy and other alternative energy technologies very important and useful in principle, they nonetheless oppose to the sitting of energy plants and infrastructures in their surroundings as they concern them being harmful or hazardous. People's unwillingness to accept in their area the existence of a bioenergy project is mainly due to lack of sufficient knowledge and adequate information on such projects. In addition, the NIMBY attitude is highly connected with local problems such as regional environmental impacts, traffic, local employment (Devine-Wright, 2005).

In addition, social perception and community acceptance of energy projects are closely related with environmental and quality-of-life impacts that can include possible disruption to the balance of nearby ecosystems, visual impacts such as landscape deterioration, noise pollution and vibrations, and other improvements or deteriorations in the quality of life in the area (Radics et al., 2015). Another common misconception that affect public acceptance of bioenergy projects is the fact the people associate the term biomass with solid urban waste (Prosperi et al., 2019). Besides, the fact that bioenergy needs a combustion process to produce energy creates more misconceptions among people, as they concerning bioenergy projects harmful for their health. Apart from these common misconceptions, people's natural resistance to any type of change can result in low acceptability of energy projects (Perlaviciute et al., 2018). Therefore, there is an assumption that once an energy project is implemented and all the changes are made, citizens will get used to them and eventually accept it. There are examples that indicate that social acceptance increased especially when people feel sufficiently engaged and represented in decision-making and when they experience the benefits. However, literature for energy projects suggests that people who accept a sustainable energy project do not necessarily support it. As such, for an energy transition is necessary people not only to passively tolerate an energy project but strongly support it.

Overall, all the above mentioned misconceptions mostly originate from lack of information on the new technologies, mistrust and suspicion towards key stakeholders, and they significantly affect public perception, which is a determinant factor that significantly affects individuals' acceptance or resistance towards bioenergy projects.

4. Survey approach

4.1 Sample

The survey referred to general public across Europe and it collected 3,725 responses from 22 different European countries. The duration of the data collection was 2 months, from February 2020 to April 2020.

To maximise the outcome and the quality of the survey, the responses were collected in two ways.

First, through crowdsourcing using the Clickworker platform (www.clickworker.com) with a wide pool of users. Crowdsourcing was selected as the most suitable method for reaching many responses at a European level with a relatively low cost. During the data collection period, the responses were monitored regularly, and measures were taken to ensure a balanced distribution between different European countries[2].

Secondly, responses were also collected by exploiting the consortium partners' network and dissemination channels, especially in the multiplication countries (Croatia, France, Greece, Romania, Spain, Ukraine). The questionnaire was translated by the relevant partners to their national languages and uploaded to the EU-survey portal (www.ec.europa.eu/eusurvey) for online dissemination through mailing lists and social media of the consortium partners as well as on the AgroBioHeat website and social media of the project.

4.2 Questionnaire structure

The design of the questionnaire was based on the findings of the literature review presented in the previous section. The draft questionnaire has been reviewed based on the consortium partners' feedback, incorporating, to the extent possible, the views and opinions of the partners about the questions raised in the survey.

The questionnaire was designed with 8 main sections of questions:

- **Introduction to the topic:** An introductory session identifying the familiarity with the term of agrobiomass and its types.
- **Perceptions and Awareness:** This section assessed general perceptions regarding the concept of agrobiomass for heating while also capturing the level of awareness about renewable energy technologies, biomass, and its supply chain.
- **Intention to Act:** The intention to act section includes questions about the potential support an agrobiomass heating project in the respondents' local area would get or not, as well as investigated the relationship between acceptance of the project and the specific type of the agrobiomass used.

[2] Targeted countries for Clickworker platform were the EU-27 member states. Unfortunately, Clickworker did not include coverage of Ukraine at the time of the survey.

- **Drivers:** A list of potential benefits, that would act as drivers for support, of an agrobiomass heating project, measuring their importance in public's opinion.
- **Barriers:** Consequently, a list of potential problems that can derive from a project and may hinder the public's acceptance towards it are presented and measured by the respondents by their significance.
- **Pro-environmental beliefs:** A list of questions assessing the respondents' environmental values and opinions.
- **Personality traits:** Based on the literature, core personality traits such as the Big Five (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism) (John & Srivastava, 1999) are predictors of environmental behaviour while being cross-culturally reliable. The questions in this section are based on Cameron Brick and Gary J. Lewis (2014) measuring Openness and Extraversion.
- **Demographics:** Finally, the last section of the questionnaire includes basic demographic information such as gender, age, country, type of location – i.e. urban or rural area–, type of housing (rented or owned), educational background, occupational status and income. These demographics are used to check for possible correlations between social acceptance and awareness with different socio-economic groups.

The abovementioned sections reflect the main factors affecting stakeholders' acceptance levels, as they have been identified through the literature review process in Section 2. More details about the definition of the composite variables that have been used for our analysis are given in the following methodological section. The overall descriptive characteristics of the sample and the distribution of the collected responses are presented in Section 5.

5. Analysis

5.1 Descriptive analysis

This section presents the main findings regarding the descriptive characteristics of the sample and the responses that were collected throughout the large-scale survey. We aim at highlighting some initial findings regarding some general questions that were included in the survey. Starting from the spatial distribution of responses, Fig.1 shows the four main country groups that have been used for our analysis. These include 4 different clusters: Northern Europe (blue), Western Europe (yellow), South Europe (red) and Central - Eastern Europe (green).

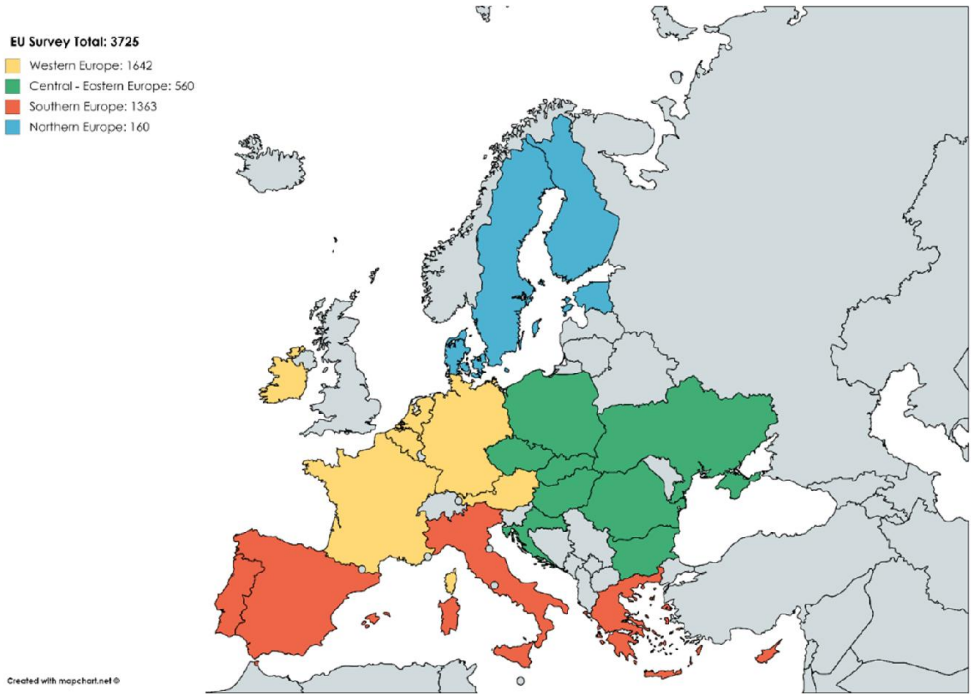

Figure 1: Distribution of the collected responses at European level.

The total number of responses varies for each group and is given in Table 1. More specifically, the Western and Southern Europe have a significantly higher number of responses than Northern and Central Europe. The difference in participation may be due to higher levels of familiarization and active involvement of more technologically developed countries to digital tools, such as crowdsourcing platforms. On the other hand, Northern Europe had the lowest representation in the survey by number of responses. This can be explained by the fact that the northern cluster contained less countries with much fewer population living in this area than the rest of Europe. In the table below an analytical break down of the number of responses collected per country is presented.

Table 1: Sample distribution by country.

	Country	Responses	Percentage
Central Eastern Europe	Czech Republic	35	0.94%
	Hungary	66	1.77%
	Poland	192	5.15%
	Romania	194	5.21%
	Bulgaria	1	0.03%
	Croatia	40	1.07%
	Slovakia	1	0.03%
	Ukraine	30	0.81%
	Other	1	0.03%
	CE Europe Total	**560**	15.03%
Northern Europe	Denmark	43	1.15%
	Finland	42	1.13%
	Sweden	73	1.96%
	Estonia	2	0.05%
	North Europe Total	**160**	4.30%
Southern Europe	Greece	203	5.45%
	Italy	505	13.56%
	Portugal	187	5.02%
	Spain	464	12.46%
	Cyprus	4	0.11%
	South Europe Total	**1,363**	36.59%
Western Europe	Austria	331	8.89%
	Belgium	115	3.09%
	France	346	9.29%
	Germany	533	14.31%
	Ireland	74	1.99%
	Netherlands	243	6.52%
	West Europe Total	**1,642**	44.08%
	TOTAL	**3,725**	**100.00%**

Moving one step further, Table 2 presents the breakdown of responses based on individual characteristics. We can see that our sample is balanced in terms of gender (51.76% men – 46.79% women) and it follows an almost normal distribution considering age and educational level. As expected, persons between 25-34 years old are highly present in the sample (35.25%), together with individuals with tertiary education (63% - including all three tertiary education levels).

Table 2: Sample distribution by individual characteristics (gender, age, education).

Gender	Count	Percentage
Male	1928	51.76%
Female	1743	46.79%
Prefer not to say	32	0.86%
Other	22	0.59%
Total	**3,725**	**100.00%**
Age	**Count**	**Percentage**
18-24	1058	28.40%
25-34	1313	35.25%
35-44	813	21.83%
45-54	396	10.63%
55-64	126	3.38%
65+	19	0.51%
Total	**3,725**	**100.00%**
Education	**Count**	**Percentage**
None	94	2.52%
Primary	111	2.98%
Secondary	1173	31.49%
Bachelor's degree	1306	35.06%
Master's degree	915	24.56%
PhD or higher	126	3.38%
Total	**3,725**	**100.00%**

In terms of familiarity of the term “agrobiomass” and “agricultural biomass”, the results indicate that despite the fact that only a small share (below 20%) of the respondents have an engineering background either in education or professional (Fig.2), most of them are familiar with these terms (71.97%). In fact, most of the participants (89.32%) stated that the provided definition of agrobiomass was in line with their own perception (Fig.3). A more detailed presentation of the results related to awareness is given in Table 3, illustrating all results by individual characteristics’ and country clusters breakdown. As we can see, there are significant differences between the different country clusters, as awareness reaches a peak of 74.17% in the case of Southern Europe, compared to Northern countries were its share is 66.25%. At the same time, there are no significant gender gaps in terms of awareness, fact which does not apply in the case of age. In this case, it becomes evident that there is a significant age gap as we move to younger ages. In fact, the gap reaches 25.17% between groups of participants belonging to the first age group (18-24 years old) and the participants over 65 years old (Fig.5).

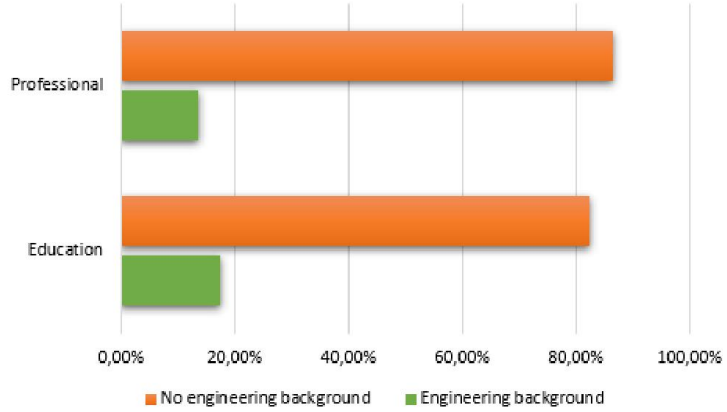

Figure 2: Share of responses related to whether the participants have any engineering background in terms of education and profession.

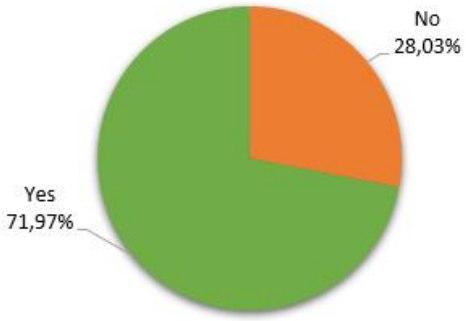

Figure 3: Awareness referring to the main agrobiomass terms.

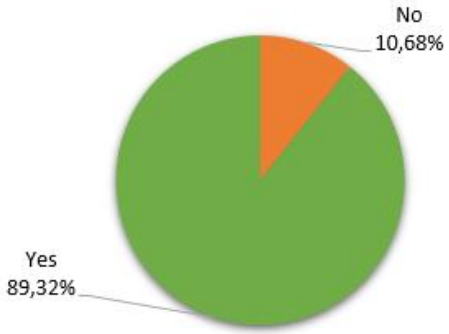

Figure 4: Responses related to whether the provided definition was in line with their perceptions.

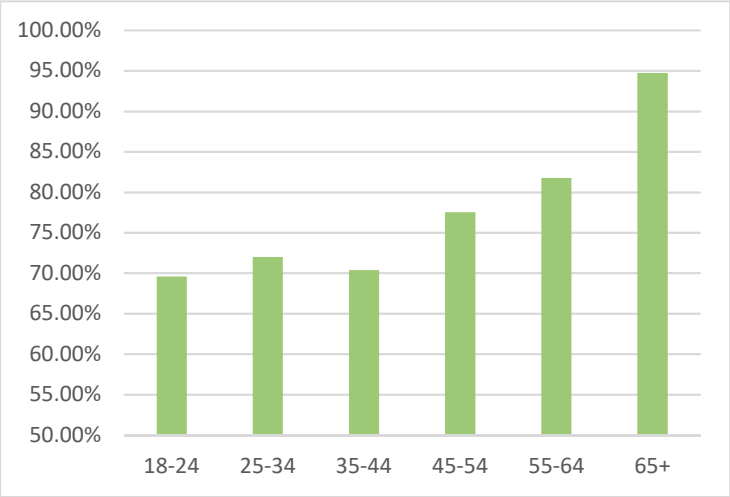

Figure 5: Agrobiomass awareness by age group.

Table 3: Shares related to agrobiomass term awareness by region, gender, and age groups.

Are you aware of the term "agrobiomass" or "agricultural biomass"?			
	Yes	**No**	
Region			
Southern	74.17%	25.83%	100.00%
Central-Eastern	70.89%	29.11%	100.00%
Western	71.07%	28.93%	100.00%
Northern	66.25%	33.75%	100.00%
Gender			
Male	73.70%	26.30%	100.00%
Female	70.28%	29.72%	100.00%
Age			
18-24	69.57%	30.43%	100.00%
25-34	71.97%	28.03%	100.00%
35-44	70.36%	29.64%	100.00%
45-54	77.53%	22.47%	100.00%
55-64	81.75%	18.25%	100.00%
65+	94.74%	5.26%	100.00%
Total	**71.97%**	**28.03%**	**100.00%**

Two additional questions related to awareness and experience were also included in the large-scale survey to capture a more comprehensive overview of the current situation. First, participants were asked to indicate whether they had previous experience with agrobiomass as consumers or producers, and second, they were asked whether they knew that agrobiomass could be an exploitable source for

heating. In the first case, results indicate that only a very small share of the participants had experienced with agrobiomass in the past (21.23%), whereas, in the latter question a large share of people were aware about the applicability of agrobiomass in heating (74.36%).

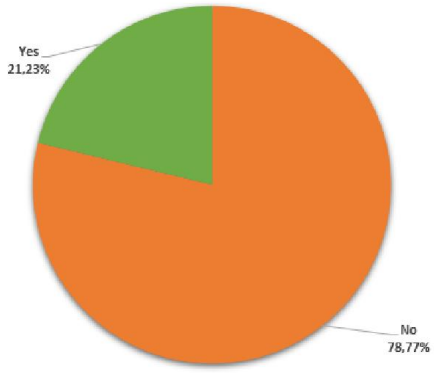

Figure 6: Share of participants with previous experience with agrobiomass.

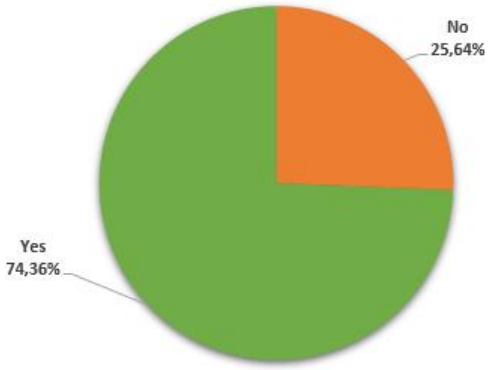

Figure 7: Awareness referring to the applicability of agrobiomass in heating.

The sample was also analysed per type of area of residence. The majority of the respondents came for urban and semi-urban areas while only 15.87% respondents came from rural areas (Table 4). The countries with the highest share of rural respondents were Germany, Italy and Austria (Table 5).

Table 4: Sample distribution per type of area.

Type of area	Percentage
Urban area	45.64%
Semi-urban area	38.50%
Rural area	15.87%

Table 5: Countries with the highest participation in rural respondents.

Countries	Percentage
Germany	2.82%
Italy	2.39%
Austria	2.04%
France	1.88%
Spain	1.29%

In Fig. 8 an analysis is presented of the heating sources the respondents use in their residence, separated by type of area (urban, semi-urban and rural). Differences in the preference of heating sources are easily observed between rural and urban areas. Firewood and wood pellets have much higher percentages in rural areas than in urban. Electricity has the highest percentage of use in all three types of areas, with the highest being in urban areas. This does not necessarily indicate that electricity is their main heating source, as electricity can be easily used as secondary source of heating (air-conditioning units). Natural

gas is second in preference in all areas while fuel oil has a significantly higher share in rural areas than in urban.

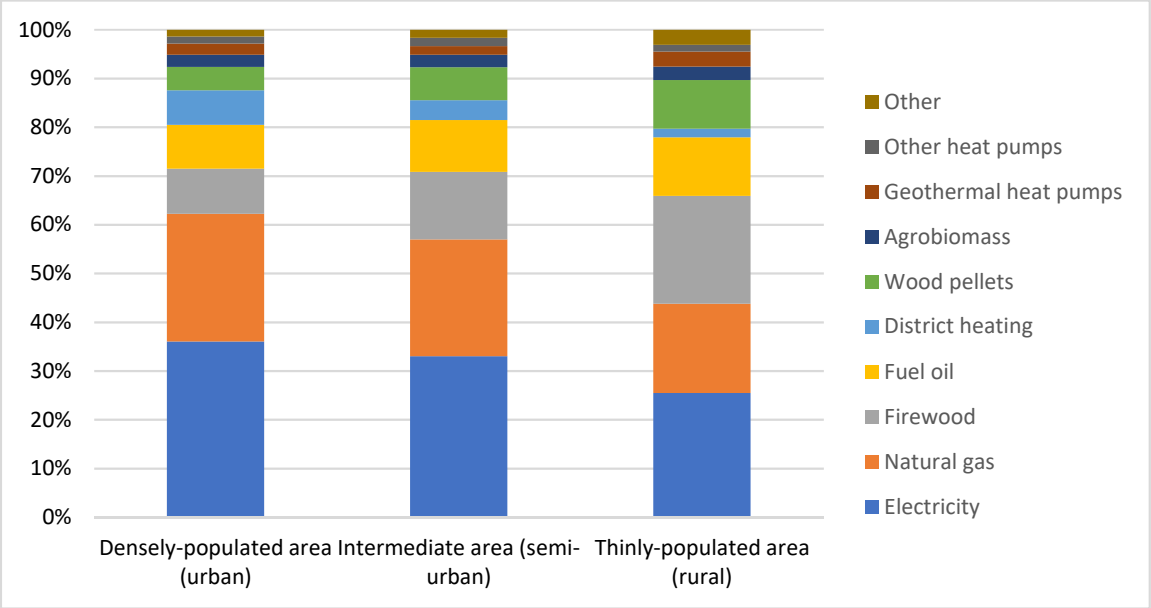

Figure 8: Heating sources per type of area.

5.2 Factor analysis

The next two sections of this report include a detailed presentation of the methods that have been used for further exploring the collected data, in order to get through insights for the factors affecting perceptions and acceptance of agrobiomass projects related to heating. For this reason, we have used a two-step approach that includes first, an extended factor analysis in order to identify the most essential factors that result from combining the different items for each question, and second, an ordered logit model that reveals the main factors affecting general public perceptions.

Factor analysis is a variable reduction process that aims at revealing relationships between several variables within a dataset. Its main goal is to identify clusters of variables that can be jointly used to proxy specific dimensions of the analysis. In our case, we have structured the AgroBioHeat survey in a way that each dimension that we want to explore more thoroughly consists of a set of related items that try to capture different parts of this dimension. More specifically, Table 4 indicates the questions and their individual items that have been used for factor analysis to calculate overall dimensions that we want to consider for out statistical analysis in the next step. Each one of the following questions refers to a specific dimension.

We perform a factor analysis for each of the abovementioned questions, to build our composite variables referring to these dimensions. The results in each case are given below (Tables 5-10) and

include all 3725 participants who have answered the indicated likert-scale questions. For each of the corresponding questions we have highlighted the values that belong to each factor.

Table 6: Structure of questions and their relevant items that have been used for factor analysis.

Question	Items
Q7: How much do you feel you know about the following topics?	Renewable energy technologies Biomass and its use for heating Technologies for biomass heating Financing schemes and incentives for biomass heating Relevant regulations and legal aspects for biomass heating Agrobiomass as an energy source
Q8: Please indicate your agreement with the following statements	I would accept the use of agrobiomass for heating and the construction of the needed facilities, regardless of the distance from my place of living. I would support an agrobiomass heating project near my place of living that uses residues from various agricultural crops for feedstock. I would support an agrobiomass heating project near my place of living that uses by-products from processing of agricultural residues for feedstock. I would support an agrobiomass heating project near my place of living that uses energy crops for feedstock. I would support an agrobiomass heating project near my place of living that uses heat for industrial/agricultural purposes. I would be interested to connect my household/business to a district heating network that uses agrobiomass as a primary energy source. I would be interested to install an agrobiomass heating system directly at my own residence or business.
Q9: Given the case of an agrobiomass heating project/system being developed close to your place of living, the following aspects would be important in helping you accept the project:	Involvement of residents in decision making. Agrobiomass is sourced from local farmers and enterprises. The technology used by the system comes from a local or national manufacturer. Initiated or supported by the local community. Initiated or supported by trusted organisations and/or companies. Improvement of the local community image Positive impact on the environment and climate Cost savings Positive, measurable impact on the local economy Publicly available and transparent information

Question	Items
Q10: What would you consider as the most important barrier (one or more) for developing agrobiomass heating projects in your area?	Lack of cooperation between involved actors Lack of residents' involvement in decision-making Lack of transparent information for the technical and environmental aspects of the project. Lack of technical know-how on setting up an agrobiomass heating system Lack of support mechanisms and incentives for the investment Political complications and inadequacies Lack of available agrobiomass Lack of space for installing the system Minimal economic benefits/cost savings of a project Negative environmental and health impacts Aesthetics
Q11: Please state how important are the following aspects:	Preventing pollution: protecting natural resources Respecting the earth: harmony with other species Unity with nature: fitting into nature Protecting the environment: preserving nature A world of peace: free of war and conflict Social justice: correcting injustice, care for the weak Being helpful to others: working for the welfare of others Equality: equal opportunity for all Social power: control over others, dominance Wealth: material possessions, money Authority: the right to lead or command Influential: having an impact on people and events
Q12: I see myself as someone who:	Comes up with new ideas. Is curious about many different things. Has an active imagination. Likes to reflect and play with ideas. Generates a lot of enthusiasm. Is outgoing, sociable. Has an assertive personality. Prefers work that is routine. Is reserved (reverse).

In Q7 and Q8 we can see that all items included in each question are part of a sole factor, capturing different dimensions. However, in all other cases there are more than one factors rising from each question, referring to different aspects of a more general umbrella theme. The derived factors constitute the baseline upon which we build our ordered logit model in the next step of our analysis. More specifically, Q7 refers to the general knowledge background of each respondent, focusing on deriving information about his/her general informational background before moving on to more specific questions. This question is closely related to general awareness of the agrobiomass heating topic and tries to further investigate the multiple dimensions that it might include. Awareness in our case has a broader sense, encompassing not only technical aspects, but also applications, financing

schemes and regulations. Factor analysis indicates that all items are part of a general dimension related to general knowledge (Table 5).

Table 7: Rotated component loading for Q7 including 6 items.

Component	Factor 1 Awareness
Renewable energy technologies	0,658
Biomass and its use for heating	0,853
Technologies for biomass heating	0,892
Financing schemes and incentives for biomass heating	0,866
Relevant regulations and legal aspects for biomass heating	0,864
Agrobiomass as an energy source	0,866
Eigenvalues	4,204
Number of test items included	6

Moving on to Q8, we aim at seizing additional inputs regarding acceptance. We broaden the notion of acceptance by including items that refer to supporting and interest trigger conditions. The items highlight the importance of distance, but also include trade-offs between distance and boost of local agricultural value chain. Again, all items included in this question can be merged into a single factor capturing overall acceptance attitude of the respondents (Table 6).

Table 8: Rotated component loading for Q8 including 7 items.

Component	Factor 1 Acceptance
Accept regardless of the distance from my place of living.	0,703
Support a project that uses residues from various agricultural crops for feedstock.	0,832
Support a project that uses by-products from processing of agricultural residues for feedstock.	0,817
Support a project that uses energy crops for feedstock.	0,782
Support a project that uses heat for industrial/agricultural purposes.	0,761
Interested to connect my household/business to a district heating network that uses agrobiomass as a primary energy source.	0,684
Interested to install an agrobiomass heating system directly at my own residence or business.	0,678
Eigenvalues	3,972
Number of test items included	7

The following question (Q9) refers to the identification of the main drivers of accepting agrobiomass heating applications. This is indeed one of the core questions included in the large-scale survey providing significant inputs in terms of policy design. As we ca see, the factor analysis results indicate that the items included on our survey in this question can form two discrete factors. The first one refers to local aspects and characteristics that should be strengthened for empowering the adoption of agrobiomass heating projects. In this case, residents' involvement, collaboration between local farmers and enterprises, as well as initiatives supported by local communities, organisations and companies and actions for improving local community image are included in this factor. At the same time, the second factor encompasses items that refer to more general dimensions of agrobiomass heating projects that in case they were improved, they could act as facilitators for boosting the

adoption of agrobiomass in heating. These include positive environmental and economic impacts, cost savings and publicly available and transparent information (Table 9).

Table 9: Rotated component loading for Q9 including 10 items.

Component	Factor1 Local impact	Factor 2 General impact
Involvement of residents in decision making.	0,590	
Agrobiomass is sourced from local farmers and enterprises.	0,636	
The technology used by the system comes from a local or national manufacturer.	0,745	
Initiated or supported by the local community.	0,765	
Initiated or supported by trusted organisations and/or companies.	0,555	
Improvement of the local community image	0,579	
Positive impact on the environment and climate		0,812
Cost savings		0,830
Positive, measurable impact on the local economy		0,692
Publicly available and transparent information		0,580
Eigenvalues	4,413	1,029
Number of test items included	6	4

Alongside the previous questions, Q10 tries to shed light on the main barriers that individuals consider to be important for the adoption of agrobiomass heating projects at a local level. Using factor analysis, we can identify three main types of barriers related to: (i) lack of local support and cooperation in terms of involvement, information sharing and political aspirations; (ii) lack of local resources, including space and agrobiomass; and (iii) general negative effects, related to low cost savings, environment, health and aesthetic interventions. The items shaping each factor are shown below (Table 10).

Table 10: Rotated component loading for Q10 including 11 items.

Component	Factor1 Political	Factor 2 Resources	Factor3 Economic
Lack of cooperation between involved actors	0,705		
Lack of residents' involvement in decision-making	0,656		
Lack of transparent information for the technical and environmental aspects of the project.	0,617		
Lack of technical know-how on setting up an agrobiomass heating system	0,606		
Lack of support mechanisms and incentives for the investment	0,670		
Political complications and inadequacies	0,613		
Lack of available agrobiomass		0,845	
Lack of space for installing the system		0,767	
Minimal economic benefits/cost savings of a project			0,557
Negative environmental and health impacts			0,759
Aesthetics			0,598
Eigenvalues	3,661	1,262	1,025
Number of test items included	6	2	3

The last two questions (Q11-Q12) aim at capturing some of the main pro-environmental values and personality traits of the participants, in order to investigate the ways in which they affect the formation of perceptions of individuals. It is essential to highlight that in both cases we used a well-targeted set of items to identify those individual characteristics, given the limited extend of the questionnaire. Thus, we did not used the full list of the proposed Schwartz Value Survey items (Schwartz, 2003; Steg et al., 2014; Bouman et al., 2018) for the case of environmental beliefs, but instead we selected a set of items to form three different dimensions related to: biospheric, altruistic and egoistic values. The factor analysis clearly revealed these discrete areas, as presented in Table 9. At the same time, we followed a similar process to define the main personality traits for each individual related to openness and extroversion, that might strongly affect perceptions and acceptance. For this process, the items were based on the Big Five approach (John and Srivastava, 1991). The results for the identification of these dimensions are given in Table 10.

A more detailed analysis of the data is given in the next section, where we present the descriptive characteristics of our sample (Section 5.1) and we move on step further towards identifying the main factors affecting overall perceptions for agrobiomass heating projects (Section 5.2).

Table 11: Rotated component loading for Q11 including 12 items.

Component	Factor1 Biospheric	Factor2 Altruistic	Factor3 Egoistic
Preventing pollution: protecting natural resources	0.786		
Respecting the earth: harmony with other species	0.828		
Unity with nature: fitting into nature	0.765		
Protecting the environment: preserving nature	0.812		
A world of peace: free of war and conflict		0.707	
Social justice: correcting injustice, care for the weak		0.827	
Being helpful to others: working for the welfare of others		0.788	
Equality: equal opportunity for all		0.769	
Social power: control over others, dominance			0.807
Wealth: material possessions, money			0.794
Authority: the right to lead or command			0.872
Influential: having an impact on people and events			0.716
Eigenvalues	4.509	2.596	1.056
Number of test items included	4	4	4

Table 12: Rotated component loading for Q12 including 9 items.

Component	Factor1 Openness	Factor 2 Extroversion	Factor3
Comes up with new ideas.	0,688		
Is curious about many different things.	0,767		
Has an active imagination.	0,763		
Likes to reflect and play with ideas.	0,738		
Generates a lot of enthusiasm.		0,759	
Is outgoing, sociable.		0,836	
Has an assertive personality.		0,635	
Prefers work that is routine.			-0,805
Is reserved (reverse).			0,753
Eigenvalues	2,990	1,378	1,223
Number of test items included	4	3	2

5.3 Statistical analysis

This section includes the statistical analysis of the data that were collected throughout the large-scale survey in this task. To estimate the effects of selected parameters on general public perceptions and acceptance measured in a likert scale, we have developed and estimated an ordered logic model.

Following Long and Freese (2003), the ordinal regression model is commonly presented as a latent variable model. In this context, we define y^* as a latent variable ranging from -∞ to +∞, and thus, the structural model is given in eq. (1).

$$y_i^* = \boldsymbol{x}_i^T \beta + \varepsilon_i \quad (1)$$

where y_i^* is the exact but unobserved dependent variable for observation *i*; $\boldsymbol{x}$ is the vector of independent variables; ε_i is the error term, and β is the vector of regression coefficients which we target on estimating. In the case of ordered logit models, we cannot observe y_i^*, but instead we have only observations for the categories of response. In our case, the measurement model for ordinal outcomes is expanded to divide y_i^* into 5 ordinal categories:

$$y_i = m \quad \text{if} \quad \tau_{m-1} \leq y_i^* \leq \tau_m \quad \text{for } m = 1 \text{ to } 5$$

where the thresholds τ_1 through τ_5 are estimated. The probability of an observed outcome for a given set of values of the independent variables of $\boldsymbol{x}_i^T$ corresponds to the area of the distribution where y_i^* falls between τ_{m-1} and τ_m as given below:

$$Pr(y = m|\boldsymbol{x}) = Pr(\tau_{m-1} \leq y_i^* \leq \tau_m|\boldsymbol{x})$$

In our case, we choose to use a set of three dependent variables including aspects of need for more efficient energy management, overall perceptions, and acceptance. The results of the analysis for the three models that we run are presented in Table 13.

As it is shown, most of the identified variables included in our model have been found to be statistically significant when related to the overall perceptions and acceptance. By taking a closer look to the results, we can see that previous experience, awareness and knowledge related to agrobiomass heating applications constitute significant parameters positively affecting all different dependent variables. More specifically, **previous experience** refers to Q3 ("*Do you have experience with agrobiomass as a consumer or producer?*") and captures real experience on agrobiomass heating applications. This parameter is statistically significant both for perception and overall acceptance levels, meaning that higher levels of previous experience result in more positive perceptions and acceptance. At the same time, **awareness** factor encompasses answers included in Q1 ("*Are you aware of the term "agrobiomass" or "agricultural biomass"?*"), Q2 ("*Is the above definition in line with your own perception of agrobiomass?*") and Q4 ("*Are you aware that agrobiomass could be an exploitable energy source for heating?*"), trying to offer a more comprehensive approach to awareness definition. Finally, **existing knowledge** refers to Q7 where the respondents indicated their level of knowledge for a set of aspects related to agrobiomass heating applications (not only technical, but also covering additional aspects of implementation). This is the only factor of this group being statistically significant in all three models using different dependent variables.

Table 13: Ordered Logit model results.

Dependent variables	Need for improved energy efficiency management		Overall perception		Overall acceptance	
Previous experience	0,076		0,186	**	0,285	***
Awareness	0,033		0,502	***	-0,014	
Existing knowledge	0,076	*	0,092	**	0,346	***
Drivers						
Local benefits	0,250	***	0,629	***	0,984	***
General benefits	0,643	***	1,107	***	1,096	***
Barriers						
Economic	-0,030		-0,401	***	-0,483	***
Political	0,189	***	0,175	***	0,141	***
Resource	-0,085	**	-0,086	**	-0,030	
Environmental Values						
Biospheric	0,400	***	0,254	***	0,112	**
Altruistic	-0,032		0,118	**	0,076	
Egoistic	-0,131	***	-0,101	***	0,041	
Personality traits						
Openness	0,348	***	0,210	***	0,163	***
Extroversion	-0,047		0,108	**	0,230	***
Existing sources of heating						
Agrobiomass	-0,041		-0,140		0,198	
District heating	-0,119		0,079		0,094	
Electricity	0,072		0,059		0,050	
Firewood	0,043		-0,109		-0,072	
Fuel oil	-0,031		-0,038		0,057	
Geothermal heat pumps	-0,471	***	-0,163		-0,304	**
Natural gas	0,038		-0,101		-0,074	
Other heat pumps	-0,296		-0,177		-0,032	
Other	-0,217		-0,342	*	-0,408	**
Wood pellets	0,038		0,057		0,209	**
Individual characteristics						
Age	0,109	***	0,059	**	-0,001	
Female	0,076		0,171	***	-0,027	
Education level	0,102	***	0,030		-0,002	
Education as engineer	-0,118		-0,160	*	-0,105	
Professional engineer	-0,059		-0,048		-0,202	*
Income level	0,018		0,013		0,094	
Ownership of residence	-0,099		0,067		-0,150	**
Spatial characteristics						
Population density	0,046		0,013		0,012	
Climate	0,046		0,023		-0,011	
Central - Eastern Europe	-0,761	*	-0,774	**	0,241	
Northern Europe	-0,950	**	-0,689	*	0,156	
Southern Europe	-0,719	*	-0,800	**	0,160	
Western Europe	-1,027	***	-0,900	**	-0,121	

Level of statistical significance: ***p<0.01, **p<0.05, *p<0.1

Moving on to the **drivers** related to agrobiomass heating, our analysis shows that both local and general benefits positively affect general attitudes. More specifically, benefits having a local impact including: (i) the participation of local farmers, enterprises, and manufacturers for agrobiomass resources and technologies; (ii) involvement of residents in decision making; (iii) local community initiatives; and (iv) improvement of the local community image. These are significant driving forces for increased positive perceptions and acceptance, whereas at the same time increase the need for improving the overall management efficiency. The same also applies in the case of benefits with more general impact, such as on the environment, cost savings and transparency. Both results are in line with the existing literature presented in Section 2.

Figure 9 shows an analysis of the importance of the **driving factors** in accepting agrobiomass heating initiatives. The results indicate that the most important driving factor is the potential positive environmental impact that biomass energy projects might have. Secondly, aspects that would benefit the local community and strengthen the local economy have also been found to be important drivers, whereas economic gains from the use of an alternative energy initiative come at fourth place.

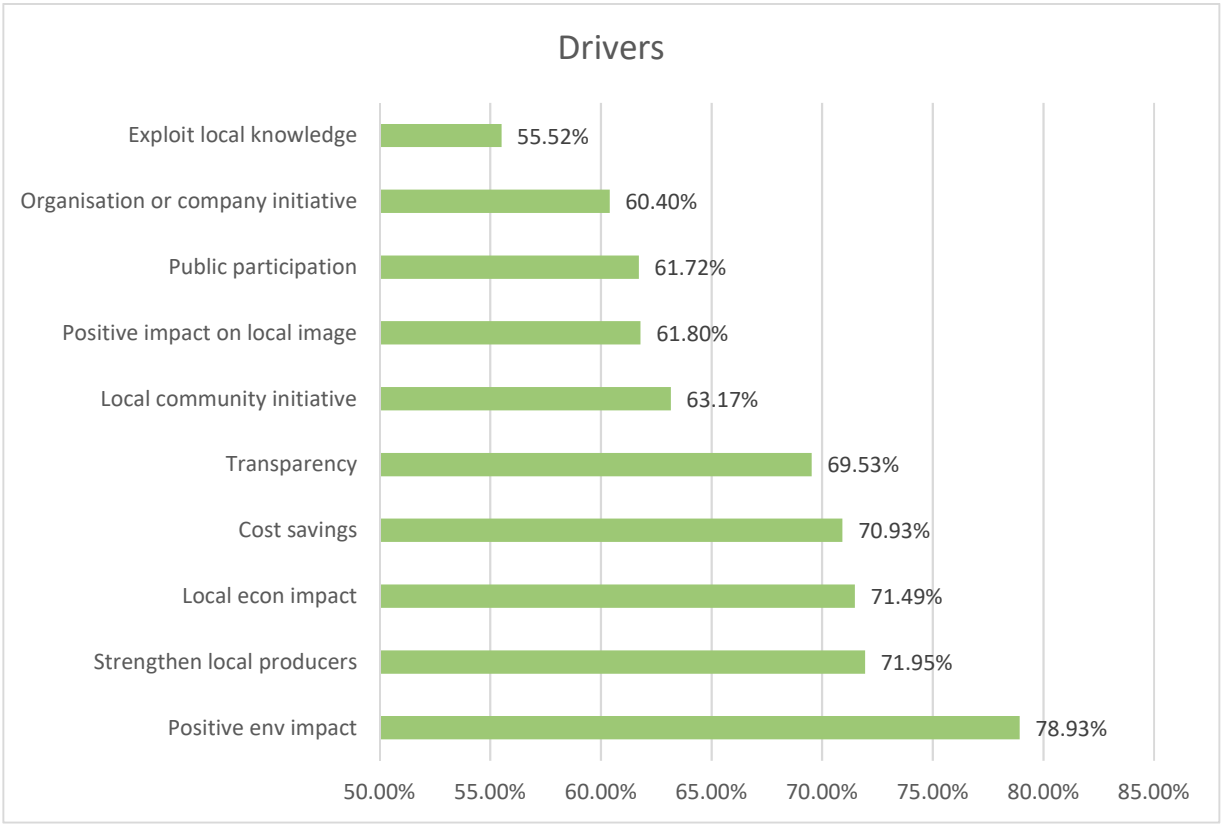

Figure 9: Importance of drivers.

At the same time, economic, political and resource **barriers** have found to be statistically significant. In the case of economic and resource-related barriers we can see that they have a negative impact on the overall perception and acceptance as expected. However, political-related barriers seem to have a

positive impact on our dependent variables. This may result due to the fact that citizens may be more positive in accepting agrobiomass heating projects, in case their local context lacks in terms of cooperation between involved actors, residents' involvement in decision-making, transparency, technical know-how on setting up an agrobiomass heating system or supporting mechanisms and incentives for the investment; as they might expect from these projects to empower all these underdeveloped aspects. Moreover, citizens may also be more sympathetic to agrobiomass heating projects in cases they are highly aware of political complications and inadequacies that might cause negative effects throughout the implementation of these type of projects.

Figure 10 respectively provides some initial insights about the importance of possible barriers regarding the level of acceptance of agrobiomass heating initiatives. Results indicate that political implications and inadequacies are considered the main reasons that may hinder the implementation of such projects. Lack of transparency, as well as incentives and supporting mechanisms, also affect public opinion. To a lesser extent, lack of public participation in the decision-making process, and lack of resources and space, are also considered as barriers. The fear of aesthetic degradation and potential small economic benefits seem to be much less significant barriers.

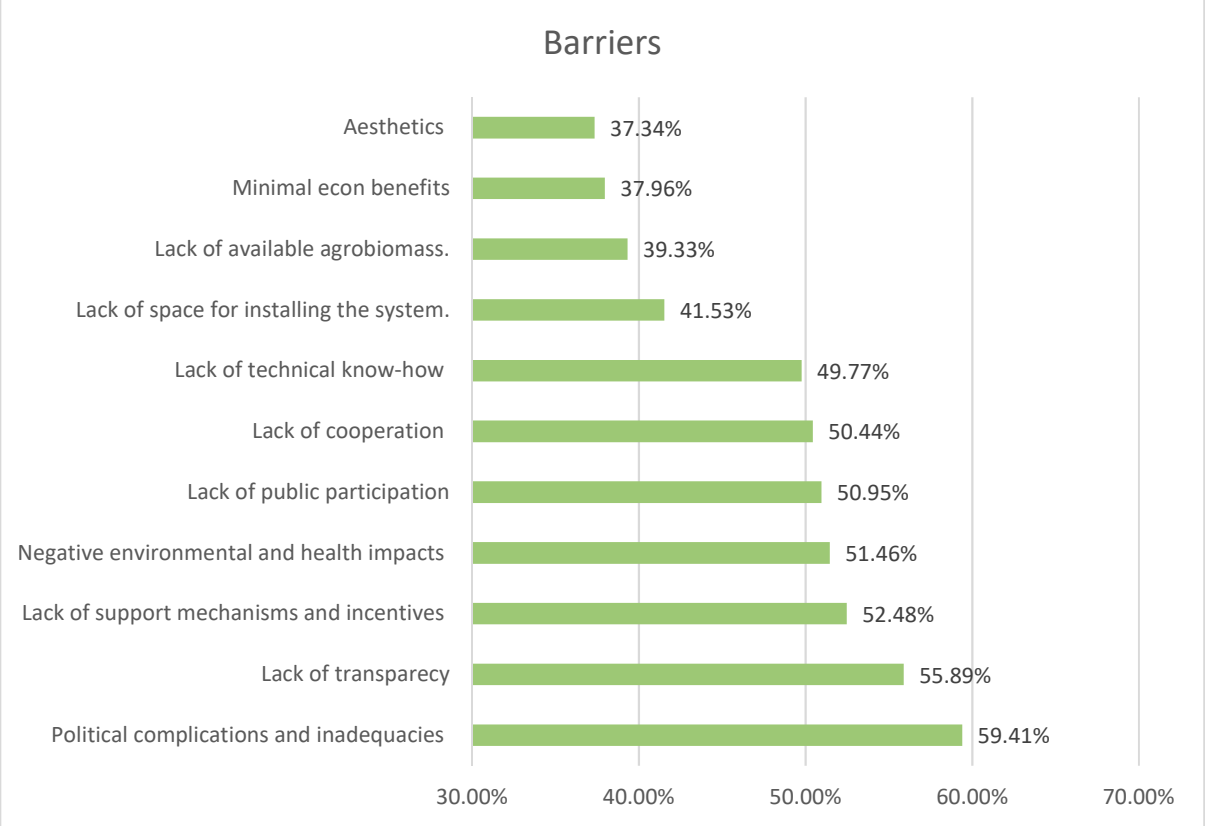

Figure 10: Importance of barriers.

The analysis also shows that **environmental values** having a biospheric and altruistic character positively affect perceptions and acceptance, as expected by the literature. These include aspects of

individual attitudes that are closely related to preventing pollution, respecting the earth, unity with nature and protecting the environment, as well as peace, justice, and equality. On the contrary, egoistic values referring to social power, authority, wealth, and influence, reflect a negative effect on the overall perceptions and acceptance levels. In a similar context, **personality traits** referring to openness and extroversion are significant parameters that can boost individual attitudes towards agrobiomass heating projects or other types of initiatives.

Some **individual characteristics** that have found to be statistically significant with a positive effect are age (higher age groups seem to be more open to agrobiomass heating) and gender (women seem to have a more positive attitude towards agrobiomass heating), both in line with the existing literature. However, we can see that educational level does not have any significant role, together with the engineering background (both educational and professional). At the same time, residence ownership affects negatively the acceptance of agrobiomass projects. Finally, **spatial characteristics** including population density and climate type are also not significant.

6. Summary of key findings

This section provides an overview of the key findings that the survey results have revealed. These findings around public perceptions and attitudes towards agrobiomass and its use for heating can help us understand the gaps and barriers of the market, and what needs to be communicated to build awareness and increase people's interest in agrobiomass heating projects. Further investigation of the public acceptance and awareness will be performed with the local targeted CATI surveys in WP2. Combination of the results of both surveys can lead us to more informed policy recommendations and updated strategic plans, helping us to achieve a wider deployment of agrobiomass heating initiatives across Europe.

In terms of awareness, the results indicate that public awareness around agrobiomass differs across Europe. South Europeans seem to be much more informed regarding agrobiomass, when compared to other Europeans, whilst Northern countries showed the lowest shares of knowledge. At the same time, an age gap is also present, as agrobiomass awareness appears to increase with age with young adults (18-24) being the least aware of the term. On the other hand, no gender gap was observed, as the percentage of awareness for men and women were almost the same. In general, most of the public was familiar with the term (71.97%), even though most of them did not have any affiliation with agrobiomass - either academic or professional.

Moving on, the overall perception seems to be greatly affected by awareness. Higher levels of awareness, previous experience with agrobiomass and existing knowledge related to agrobiomass heating applications indicate more positive attitude towards agrobiomass use. Moreover, perceptions differ a lot when it comes to gender. Even though no gender gap in terms of awareness was observed, women were more likely to have a positive attitude towards agrobiomass than men, something that is also pointed out in the literature.

Regarding the barriers, lack of trust and policy gaps are the key aspects that need to be tackled, as political complications, policy inadequacies and lack of transparency have been found to be the most important barriers for agrobiomass heating projects penetration. On the other hand, aesthetic issues around an agrobiomass installation and possible low economic benefits seem to be less important. With regards to the driving factors, positive environmental and local economy impacts were highlighted as the most important aspects for supporting agrobiomass heating initiatives. Public participation, project transparency and cost savings follow as main driving factors.

The statistical analysis has also shown that Individual environmental values and personality traits significantly affect overall perceptions, as expected by the literature. More specifically, biospheric and altruistic values have a positive impact, whilst egoistic traits have a negative effect on perceptions towards agrobiomass use. Personality characteristics related to extroversion and openness seem to have a strong positive correlation with favourable perceptions. At the same time, older individuals have more positive perceptions towards agrobiomass use, whereas population density and climate are not significant.

In terms of overall acceptance of agrobiomass heating initiatives, previous experience with agrobiomass as well as existing knowledge of agrobiomass heating initiatives have been found to be essential. In other words, people that have come to know agrobiomass schemes and see them in practise tend to be in favour

of them. This is an important insight, as it indicates that higher agrobiomass acceptance can be achieved by raising awareness and first-time users, towards enlarging in that way the group of public that has knowledge and experience with agrobiomass.

Driving factors affecting acceptance are both local and general benefits, such as a positive environmental impact, supporting local economy, strengthening community interactions and social cohesion and participation. On the other hand, barriers hindering the support of an initiative is mostly political and economic, while availability of resources seem to be statistically indifferent in the acceptance. A negative correlation seems to appear between acceptance of an agrobiomass heating initiative and existing users of alternative energy such as geothermal heat pumps and wood pellets. This could be explained by the fact that people that already use alternative energy sources for heating prefer that over agrobiomass. Biospheric environmental values such as respecting the earth and protecting natural resources are linked with high levels of acceptance as well as personality traits regarding openness and extroversion. Finally, ownership of residence is highlighted to statistically affect the overall acceptance of an agrobiomass initiative, something that is already detected in the literature as the NIMBY phenomenon.

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