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BOOSTING RURAL BIOECONOMY NETWORKS

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Boosting RurAl bioeconomy Networks following multi-actors' approaches

Deliverable

D3.1 Report on drivers and barriers for implementation of bioenergy technologies in rural areas, 1st version

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DISCLAIMER

1. Executive summary

This Report on drivers and barriers for implementation of bioenergy technologies in rural areas (1st version) describes the methodology on how the Practice Abstracts and related drivers and barriers are formulated, collected and analysed in the BRANCHES project. In addition, this report provides an example on how the drivers and barriers are elaborated for one topical group formulated based on the topics covered in Practice Abstracts. As creating Practice Abstracts and elaborating related drivers and barriers continues in BRANCHES after the submission of the 1st version of the report, the final conclusions and remarks on the drivers and barriers of bioenergy technologies in rural areas are not drawn until final, i.e., 2nd version of the report. In the final report, the findings of bioenergy related drivers and barriers in rural areas are summarized in a form that is understandable for practitioners. The final conclusions are delivered and distributed via national thematic networks (NTNs) established in each project country, namely Finland, Germany, Italy, Poland, and Spain.

2. Deliverable description

This report is the first version of the deliverable “Report on drivers and barriers for implementation of bioenergy technologies in rural areas” and it describes the methodology on how the Practice Abstracts and related drivers and barriers are formulated, collected and analysed. The report is based on the findings during the Practice Abstract (PA) elaboration in *Task 3.1 Screening of currently available mature and novel bioenergy technologies for rural bioeconomies* and discussions in the workshops organized in *Task 3.2 Active share of practical knowledge in workshops of bioenergy technologies*.

The aim of BRANCHES is to efficiently distribute available practice-oriented knowledge to practitioners and from BRANCHES country to country. The specific countries in question are Finland, Germany, Italy, Poland, and Spain. The partners responsible for elaborating PAs can be seen in Figure 1. Furthermore, in WP1, the knowledge sharing is expanded to five (5) collaborating countries (Latvia, Lithuania, Czechia, Portugal and Slovakia). The partners in each BRANCHES country team up to produce PAs for their country to be distributed to other target countries via National Thematic Networks (NTN) established in *Task 1.2 BRANCHES National Thematic Network - NTN strategy and monitoring* and subnetworks established in *Task 1.4 Expanding knowledge transfer to 5 EU collaborating countries*. They also organise workshops to actively share and discuss the findings during the PA elaboration and to connect practitioners and scientist and other relevant stakeholders.

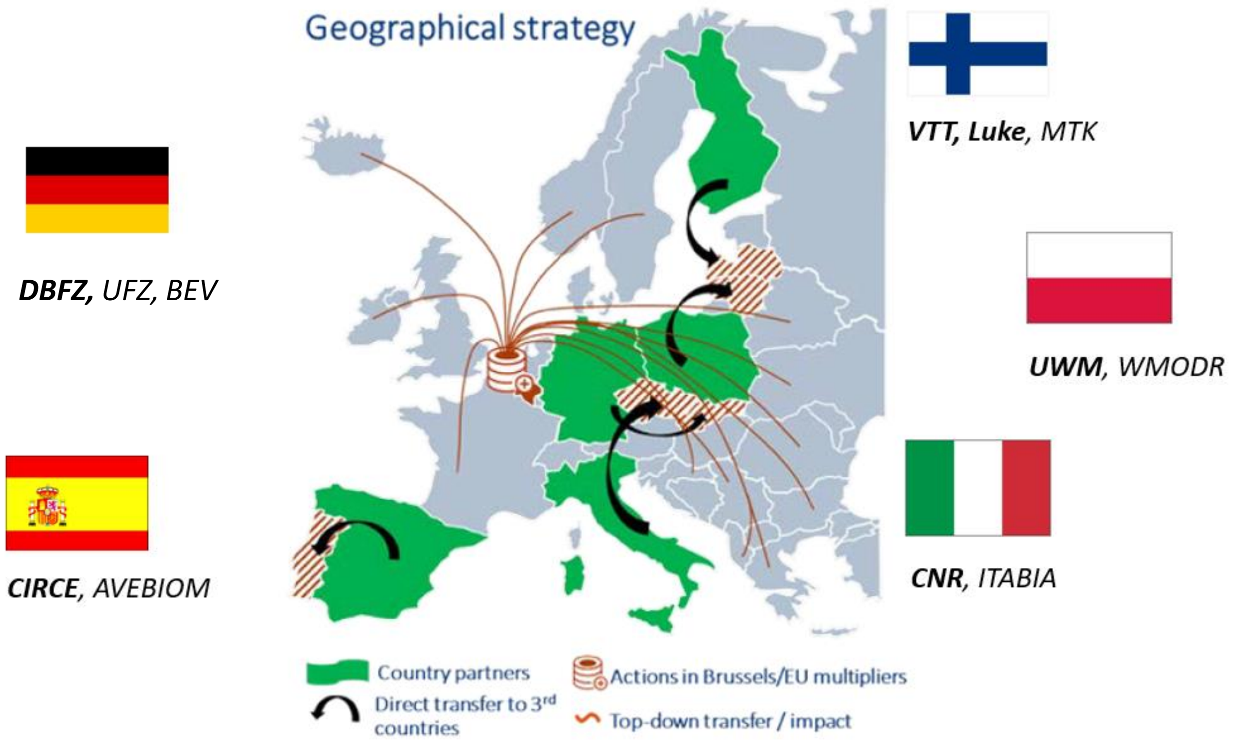

Figure 1. BRANCHES country teams. Organizations marked in bold text represented the Technical Partners (TPs), others represent the Sectorial Partners (SPs).

The partners contributing to PAs discuss the country-specific drivers and barriers for the PA that they are elaborating. The reason, why the practice is in use at the specific country forms a basis for the driver.

However, there might be also barriers for the practice in the project country. The procedure to formulate and collect the barriers and drivers for related Practice Abstracts is described in *Chapter 3. Methodology to produce Practice Abstracts and collect related drivers and barriers.*

Each country team organizes one workshop to discuss the *Task 3.1 Screening of currently available mature and novel bioenergy technologies for rural bioeconomies* findings preferably in conjunction with relevant event gathering multiple stakeholders. Practitioners and technology providers get space to present their solutions and related barriers and drivers. The procedure for reporting the barriers and drivers from the workshops is described in this deliverable in *Chapter 3* as well. In addition, the outcomes of the workshops will be presented in *D3.3 Workshops of bioenergy technologies – Summary report*.

The Report on drivers and barriers for implementation of bioenergy technologies in rural areas is divided into two versions D3.1. (1st version) and D3.5. (2nd version). This deliverable D3.1. is the first version of the report and it describes the methodology on how the Practice Abstracts and related drivers and barriers are formulated, collected and analysed. In addition, this report provides an example on how the drivers and barriers are elaborated for one topical group formulated based on the topics covered in Practice Abstracts. As creating Practice Abstracts and elaborating related drivers and barriers continues in BRANCHES after the submission of the 1st version of the report, the final conclusions and remarks on the drivers and barriers of bioenergy technologies are not drawn until final, i.e., 2nd version of the report. In the final report, the findings of bioenergy related drivers and barriers are summarized in a form that is understandable for practitioners. The final conclusions are delivered and distributed via national thematic networks (NTNs) established in each project country.

3. Methodology to produce Practice Abstracts and collect related drivers and barriers

3.1. Steps of producing the Practice Abstracts

Practice Abstracts (PAs) in BRANCHES are produced by country teams. Technical partners (TPs) of the countries are mainly responsible of writing the PAs, while sectorial partners (SPs) will help the TPs by providing good cases and other inputs e.g., evaluating drivers and barriers for the PA practices and technologies in hand. The PAs are written both in English and in the language of the target country.

3.2. Monitoring and acceptance of the Practice Abstracts

The country teams decide the topic of the PA and inform the Task leader of T3.1 of the topic in question. The Task leader of T3.1 monitors that the PAs cover wide enough range of cases of currently available and novel bioenergy technologies for rural bioeconomy.

The first version of the PA is written into an individual Excel sheet provided by the Task leader. The Excel sheet is formatted based on the EIP-Agri template provided by the European Commission. After the first Excel version of the PA is completed, the PA is sent to Task leader and further to the BRANCHES Management Board for quality control, to ensure that the PA holds no conflicts of interest and that too much repetition is avoided in the presented cases.

After the PA is modified and accepted based on the comments given by the Task leader and the Management Board, the Task leader collects the PAs to the EIP-Agri Excel template. The PAs are delivered to European Commission's Participant Portal in Deliverables *D5.5 First set of practice abstracts* (June 2022) and *D5.8 Second set of practice abstracts* (December 2023). After the PA is accepted by the Task leader and the Management Board, it is also converted to a visual format.

3.3. Dissemination of Practice Abstracts

The Practice Abstracts are disseminated via several channels. The PAs in EIP-Agri format are disseminated via EIP-Agri webpage[1], which is a webpage provided by the European Union. The visual versions of the PAs are disseminated via National Thematic Networks (NTN) and the BRANCHES website[2]. In addition to a wider dissemination, the visual format enables to extend the PA to provide a slightly wider outlook of the case in question. The visual PAs which are disseminated via the NTNs are also translated to the language of the target country.

3.4. Collecting drivers and barriers

In Task 3.1, at least 25 PAs are produced out of currently available and novel bioenergy technologies for the rural bioeconomy. This means approximately five PAs per project country are created. The project country that has produced the Practice Abstract collects drivers (D) and barriers (B) of the practice in question according to the DEPEST approach described later in *Chapter 3.5.* The factors acting as drivers or barriers are mainly obtained from the discussions with practitioner or technology provider while collecting the information for the Practice Abstract. In addition, TPs and SPs can add drivers and barriers according to their knowledge or relevant literature reference they know that is related to the practise. The source of a certain driver or barrier is collected using the coding presented in the Table 1. below.

Table 1. Codes for the source material for drivers and barriers.

Reporting source	Reporting source code
Company	C
Literature	L
Practitioner	P
Research and development institution	RD
Sectoral Partner	SP
Technical Partner	TP
Technology provider	T
Other	O

In addition to the discussions when collecting information for the Practice Abstracts, information on drivers and barriers that affect implementation of bioenergy technologies in rural areas is produced during the national network workshops (T3.2). The workshops are organized by country teams and are open to public. Workshops are organized in the project countries (Finland, Spain, Italy, Poland and Germany) to connect scientists, practitioners, NTNs, technology providers, ESCOs, sectorial companies and associations and technology platforms. Altogether 6 workshops are organized (at least 1 per country). The specific topics of the workshops are decided during the project based on the main interests arising in T3.1. Workshops focus on bioenergy technologies, bioeconomy and the added value they bring for rural development. Participants get considerable space to present their solutions (technology providers) and related drivers and barriers

[1] https://ec.europa.eu/eip/agriculture/en
[2] https://www.branchesproject.eu/materials/practice-abstracts-and-factsheets

(practitioners) in order to contribute to the joint goal of implementation of bioenergy solutions in the rural bioeconomy.

The related drivers and barriers arising from the workshops are also collected. Each project country decides themselves on how the collection of drivers and barriers will take place during the workshop (survey, open discussion, virtual memo-board etc.). The project country is responsible of collecting and analyzing the data and on reporting the findings on drivers and barriers arising from the workshops. In addition, each country is responsible to make sure that the data collection considers all relevant GDPR policies. An example agenda and method to collect drivers and barriers in a workshop is presented in Annex II. However, the agenda and method can vary between the project countries as previously mentioned.

3.5. The DEPEST analysis tool

A DEPEST approach is used to collect drivers and barriers related to the Practice Abstracts. The DEPEST approach composes a methodical qualitative analysis framework used by stakeholders of a given activity for the assessment of the external environment for that activity. In the context of bioenergy and rural bioeconomy, it enables to understand the factors that affect implementation of bioenergy technologies in rural areas. The DEPEST analysis stands for six categories: demographic, economic, political and legal, ecological, socio-cultural and technological. The DEPEST is known also as the DESTEP but differs in the sequence of factors under analysis. Both approaches provide an extension of the commonly applied PEST analysis where political, economic, social and technological factors are combined with demographic and ecological ones. The DEPEST approach is also a slightly different from the PESTEL analysis by inclusion of demographic factors and combining political and legal factors into a single category.

In this report the DEPEST analysis tool is used for collecting the drivers and barriers from the PAs. The DEPEST factors are interrelated and evolve in time (Figure 2).

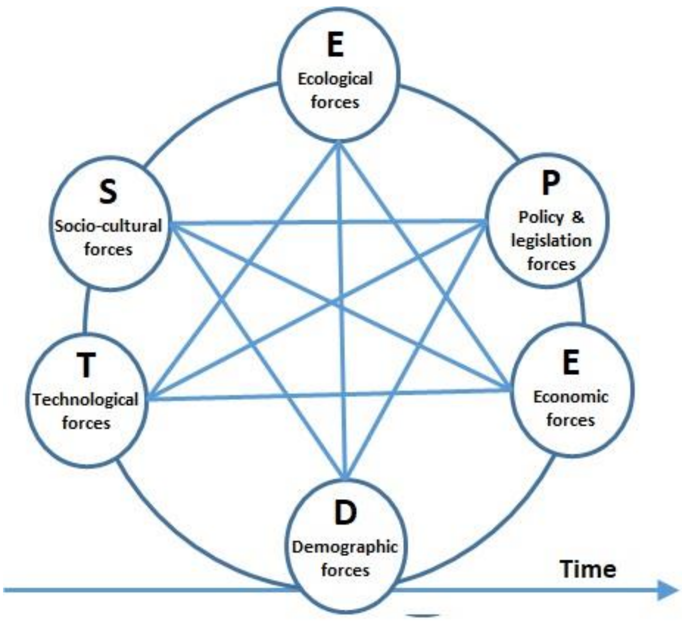

Figure 2. DEPEST in the function of time.

Demographic factors analyse bioenergy-related characteristics of the population. The factors are related to people because their attitudes to bioenergy is the primary reason for implementation. The demographic changes within a rural population may influence the timing and the path on when and how bioenergy technologies will be implemented. Among the main demographic factors there are gender, education, and occupation of household head, household size and structure as well as geographic location.

Economic factors give details of financial conditions of the energy market and economic environment. The factors describe the state of the economy at a given level. They include a set of economic factors related to bioenergy involved stakeholders and energy market.

Political and legal factors are associated with regulations, laws and policies on energy market. Political factors show to what extent the government intervenes in the market and financially supports various activities in development of sustainable energy generation in rural areas. The factors directly affect the local bioenergy infrastructure development (technologies, grids) by legislation and regulations of the market related to sustainability standards, certification and eco-labelling, changes in the law impacting energy market, policy including subsidies for renewable energy development, possibilities of selling electricity by prosumers, legal conditions for connecting a renewable energy source installation to the grid, legal conditions for supporting producers of energy from renewable energy sources.

Ecological factors depict energy-related environmental impacts. There are environmental factors that are associated with the process of renewable energy proliferation such as natural sources depletion, waste generation, ecological safety and impact on health. The type and intensity of environmental impacts depends on the technology used, the geographic location, and other factors. Measures will be related to land use, water use, air and water pollution, wildlife and habitat loss, damage to health and global warming potential.

Socio-cultural factors are values and behavioural tendencies in relation to the bioenergy technologies and energy market. The attitudes of final producers and consumers of renewable energy can be associated with values, level of education, lifestyle choices, personal feelings and behavioural ones. While demographic factors provide an overview of the overall population characteristics, social factors are going deeper into analysis of energy consumer markets: who they are, their limitations, reasons/motivation for the use of bioenergy, use of renewable energy sources in households (on the basis of a literature review or questionnaire research), knowledge of the society about renewable energy sources and the attitude to this type of investment (including inhabitants of rural areas).

Technological factors are associated with innovations and knowledge usage in changing the energy market. Factors are related to the implementation of a given energy generation technology such as TRL, cost-effective energy and economic efficiency, stability of energy supply, maintenance, specificity of an energy business (technology supplier, prosumer, technical services, etc.). On the basis of PAs, the innovativeness of the proposed technologies as well as real or potential barriers will be described. For example, to analyse whether certain bioenergy technologies can be combined in hybrid solutions (e.g., use low-quality electricity for heating, e.g., from wind farms); to point out if there are any additional factors supporting the implementation of a given technology, e.g., the technology uses post-production biomass residues which would otherwise have to be disposed of; to point out other factors that can stimulate implementation or to be a limitation of a specific bioenergy technology. In order to analyse the economic and energy profitability of a specific technology, the analysis is in terms of (i) equipment, machines, devices, etc., (ii) substrates, (iii) energy and (iv) cost.

4. An example of driver and barrier elaboration

4.1. Topical groups for drivers and barriers

For the purpose of this report, the Practice Abstracts are divided into topical groups, under which the drivers and barriers will be summarized. The topical groups are formulated so that each Practice Abstract produced in BRANCHES falls under a topic. However, it should be noted that the topical groups are still subject to change as more PAs are formulated after the submission of this report. The current topical groups under which the Practice Abstract are currently divided are:

1) Biogas and biomethane production
2) Hybrid and farm-scale solutions
3) Bioeconomy in rural communities
4) Heat technologies
5) Advanced thermochemical conversion processes

4.2. Drivers and barriers for biogas and biomethane production

In this report, an example set of preliminary drivers and barriers related to biogas and biomethane production are presented. However, the list is not explicit nor final, as more drivers and barriers related to biogas and biomethane production (among other topical groups presented above) are extracted in the BRANCHES project e.g., in workshops and while creating new Practice Abstracts. The final conclusions and remarks on the drivers and barriers for biogas and biomethane production and the other assessed topical groups of bioenergy technologies are not drawn until 2nd and final version of the report. In the final report, the findings of bioenergy related drivers and barriers are summarized in a form that is easily understandable for practitioners.

When collecting drivers and barriers for a PA, each project country fills a table (Table 2) for the PAs they have produced. In this report, the driver and barrier tables on biogas and biomethane production -related PAs have been combined and preliminary conclusions have been drawn based on the drivers and barriers the project countries have evaluated.

Table 2. Table to collect PA-related drivers and barriers.

	Source	Driver or barrier
Demographic		
Economic		
Policy & legislation		
Ecological		
Socio-cultural		
Technological		

The preliminary list of drivers and barriers covers the following PAs related to biogas and biomethane production:

- PA7: Manure-powered milk logistics
- PA18: Agricultural cooperative biogas plant
- PA27: Farm-scale energy and nutrients circulation through an on-farm micro biogas plant
- PA35: Added value from an agricultural biogas plant

The preliminary list of summarized drivers and barriers according to the DEPEST method for biogas and biomethane production is presented below. In addition to biogas and biomethane production, similar approach to elaborate drivers and barriers for bioenergy technologies in rural areas will be used for the other topical groups as well. The final results will be presented in the 2nd version of the Report on drivers and barriers for implementation of bioenergy technologies in rural areas (D3.5.).

Demographic				
PA#	***Country***	***Claim***	***D=driver B=barrier***	***Conclusion***
PA18	**Germany**	It is challenging to get enough trained workers in the community to operate and maintain the value chain in rural areas	**B**	**Biogas value chains create employment in the community; however, it may be difficult to get enough trained workers to operate and maintain the value chain in rural areas.**
PA18	**Germany**	Biogas and CHP plants are providing employment in the community	**D**	

Economic				
PA#	***Country***	***Claim***	***D=driver B=barrier***	***Conclusion***
PA7, PA27, PA35	**Finland, Poland**	Potential for manure/slurry biogas production in the country is huge compared to what is exploited.	**D**	**Local energy production potential for biogas from local agricultural and livestock residues is huge compared to what is exploited, however, seasonal variability in the resource supply might be a challenge locally.**
PA7	**Finland**	Dairy industry with applicable raw material for biomethane production exist.	**D**	
PA18	**Germany**	Successfully supplying base-load heat and power to the	**B**	**Potential disruptions in base-load energy production from biogas due to variations in the supply of local biomass waste sources can pose a challenge.**

		Theuma municipality with the biogas and CHP units is dependent on the efficiency of sourcing biomass waste streams and susceptible to changes in supply		
PA7	**Finland**	Purchase agreements between dairy farms and logistic companies can be established to guarantee a stable demand for biomethane.	**D**	**Guaranteed and stable demand for biomethane is a prerequisite to make biogas upgrading for biomethane profitable: as an example, a purchase agreement between a dairy farm and a logistic company has been made to secure the biomethane demand.**
PA7	**Finland**	Biogas network expansion is expected increasing the biomethane demand.	**D**	**Chicken-egg problem: biomethane demand needed for investments to biomethane infrastructure and production, on the contrary, biomethane infrastructure and production needed to create biomethane demand.**
PA7	**Finland**	Biomethane production provides a new source of income for the dairy farmer.	**D**	**Biogas and biomethane production provide a new source of income for the farmer (e.g., sold electricity, heat or biomethane)**
PA27, PA35	**Poland**	Profit from the sale of electricity	**D**	
PA7	**Finland**	The dairy farm can increase its energy self-sufficiency by producing its own energy (electricity and heat) from biogas.	**D**	**The farm can increase its energy self-sufficiency by producing its own energy (electricity and heat) from biogas and thus reduce energy-related costs.**
PA27, PA35	**Poland**	Partial energy independence of the farm - lower costs	**D**	
PA35	**Poland**	Rising energy prices improve the profitability of investments	**D**	**Investment cost of biogas production and upgrading units for biomethane are high, however, the profitability is affected by the rising cost of purchased energy. At the moment, the cost of fossil energy is high.**
PA27	**Poland**	Improved production profitability	**D**	
PA7	**Finland**	Investment cost of biogas upgrading unit (for	**B**	

		purification and compression to transport fuel).		
PA27, PA35	**Poland**	High investment costs (especially in Polish conditions)	**B**	
PA18	**Germany**	The implementation of the biogas plant technology requires high investments	**B**	
PA7	**Finland**	Decentralized location of dairy farms increases transportation costs to a centralized biomethane production unit and hence benefits of economics of scale (e.g. feeding the biomethane to gas grid) might be lost.	**B**	**Transportation of agricultural and livestock residues from decentralized locations to centralized location may not be cost-effective and thus reduce the benefits of economics of scale.**
Policy & legislation				
PA#	***Country***	***Claim***	***D=driver B=barrier***	***Conclusion***
PA7	**Finland**	Complex investment support schemes for biogas production and biogas upgrading units.	**B**	**Financial support is still needed for economically feasible biogas production, especially in rural conditions. Absence and/or complex regulation and financial support schemes for biogas and biomethane production hinders implementation possibilities.**
PA18	**Germany**	The construction and expansion of the project were made possible partially by EU and federal state funds under the "European Agricultural Fund for Rural Development" (SMEKUL, 2021)	**D**	
PA18	**Germany**	There is a lack of sustainability reward systems for biogas plants in electricity and heat	**B**	

		markets		
PA27, PA35	**Poland**	Lack of support from the government (authorities) or even the opposite	**B**	
PA27, PA35	**Poland**	No legal regulations or/and insufficient legal regulations	**B**	
Ecological				
PA#	***Country***	***Claim***	***D=driver B=barrier***	***Conclusion***
PA7	**Finland**	The carbon footprint of dairy product production chain decreases with biogas and biomethane production.	**D**	**Biogas and biomethane production bring ecological benefits in heat, power and transportation fuel production (farms) and users (municipalities). This enables to reduce the carbon footprint of overall production chains of companies.**
PA18	**Germany**	The ecological benefits of carbon neutral heat and power are a major catalyst in the implementation of such technologies in rural regions	**D**	
PA27, PA35	**Poland**	The carbon footprint of pig product/cattle production chain decreases with biogas and biomethane production	**D**	
PA7	**Finland**	The reject of biogas production can be utilised as a nutrient decreasing the demand for purchased chemical fertilizers at the dairy farms. In addition, during the biogas process, the manure nutrients are transformed into a more soluble form in	**D**	**When producing biogas from livestock manure, the digestate can be utilised as a nutrient decreasing the demand for purchased chemical fertilizers at the farms. The benefits of utilizing digestate as a fertilizer in comparison to untreated manure are that the manure nutrients are transformed into a more soluble form and odour and potential nutrient runoffs are reduced.**

		comparison to ordinary manure.		
PA27	**Poland**	Digestate - fertilizer - increase in the content of organic matter in the soil	**D**	
PA27	**Poland**	Safe manure/slurry management (less odor, groundwater protection etc.)	**D**	

Socio-cultural

PA#	***Country***	***Claim***	***D=driver B=barrier***	***Conclusion***
PA7	**Finland**	The image of company producing dairy products and dairy farm improves with lower carbon footprint.	**D**	**The image of company becomes more environmentally friendly, when valorising waste streams to energy or when utilizing renewable energy as a fuel.**
PA27, PA35	**Poland**	Company image - as more environmentally friendly	**D**	
PA18	**Germany**	Big parts of the community are involved in the value chains and are benefiting from it: - Farmers finding use for their agricultural and livestock residues - Biogas and CHP plants are providing employment in the community - electricity and heat are produced and sourced locally	**D**	**Biogas value chain involves and brings benefits to many parties of the local community (e.g., farmers find use for agricultural residues, employment in the community through new energy production plants, locally produced electricity and heat)**
PA18	**Germany**	Residents of the municipality have the interest to	**D**	**The increase in the price of the purchased energy has direct and instant effect on the profitability of the farms operations and thus may increase the**

		transition to carbon neutral heat and power		**acceptance and interest on local, renewable energy. In addition, environmental values can have a positive impact in the transition to renewable power and heat.**
PA7	**Finland**	The increase in the price of the purchased energy has direct and instant effect on the profitability of the farms operations and thus may increase the acceptance and interest on local, renewable energy	**D**	
PA18	**Germany**	For the expansion of biogas operation a high manure storage capacity is necessary. This can cause doubts among some members of the community about the smell.	**B**	**Biogas production may be resisted due to residents' doubts on odour, e.g., when high manure storage capacity is required.**
PA27, PA35	**Poland**	Residents' resistance (fears of odor etc.)	**B**	

<table>
<tr><th colspan="5">Technological</th></tr>
<tr><th>PA#</th><th>Country</th><th>Claim</th><th>D=driver
B=barrier</th><th>Conclusion</th></tr>
<tr><td>PA7</td><td>Finland</td><td>Liquefied biogas (LGB) could be preferred as a fuel in heavy transportation over compressed biogas (CBG) as it requires less space in the vehicles. However, liquefying biomethane is not yet economically feasible in small-scale.</td><td>B</td><td>Liquefied biogas (LGB) can be preferred as a fuel in heavy transportation over compressed biogas (CBG) as it requires less space in the vehicles. However, liquefying biomethane is not yet economically feasible in small-scale.</td></tr>
<tr><td>PA18</td><td>Germany</td><td>The operationalized biogas plant provides an energy storage and is base-load capable</td><td>D</td><td rowspan="2">Biogas is a versatile form of energy: can be used as a storage, operated both flexibly and as a baseload. In addition to heat and power, biogas can also be used as a transportation fuel when upgraded to biomethane.</td></tr>
<tr><td>PA35</td><td>Poland</td><td>The possibility of storing biogas and balancing the operation of the power system</td><td>D</td></tr>
<tr><td>PA35</td><td>Poland</td><td>Cogeneration - heat from cogeneration (waste heat) can be transferred to the municipal heating network</td><td>D</td><td rowspan="2">Besides own use, heat from biogas CHP can be fed to the municipal district heating network.</td></tr>
<tr><td>PA18</td><td>Germany</td><td>During the winter months heat is provided to the municipality with the heating grid system.</td><td>D</td></tr>
<tr><td>PA18</td><td>Germany</td><td>Businesses can use the excess heat for drying materials</td><td>D</td><td>Local networks and new businesses can be created around biogas (e.g., woodchip drying plant utilizing excess heat).</td></tr>
</table>

5. Next steps

The second version of Report on drivers and barriers for implementation of bioenergy technologies in rural areas (D3.5.) will provide a synthesized summary of the collected bioenergy related drivers and barriers in the BRANCHES project in an easily understandable form.

The formulation of the Practice Abstracts will continue and hence the work on elaborating drivers and barriers for the Practice Abstracts continues. The drivers and barriers are collected for each Practice Abstract, mainly during the discussions with practitioner or technology provider while collecting the information for the Practice Abstract, but also from national network workshops, where selected PAs are presented. In addition, project partners can add drivers and barriers according to their knowledge or relevant literature reference they know that is related to the practice.

After the Practice Abstracts are finalized, the current topical groups (biogas and biomethane production, hybrid and farm-scale solutions, bioeconomy in rural communities, heat technologies and advanced thermochemical conversion processes) are revisited. The conclusions on the drivers and barriers for implementation of bioenergy technologies in rural areas will be formulated under these topical themes.

6. Summary

This Report on drivers and barriers for implementation of bioenergy technologies in rural areas (1st version) describes the methodology on how the Practice Abstracts and related drivers and barriers are formulated, collected and analysed in the BRANCHES project. In addition, this report provides an example on how the drivers and barriers are elaborated for one topical group (biogas and biomethane production). The drivers and barriers are collected via DEPEST approach, which covers demographic, economic, political and legal, ecological, socio-cultural and technological factors that affect implementation of bioenergy technologies in rural areas. As creating Practice Abstracts and elaborating related drivers and barriers continues in BRANCHES after the submission of the 1st version of the report, the final conclusions and remarks on the drivers and barriers of bioenergy technologies in rural areas are not drawn until 2nd and final version of the report.

Annex I. Covered Practice Abstracts and related drivers and barriers

This Annex includes the Practice Abstracts and their drivers and barriers covered in the 1st version of the deliverable "Report on drivers and barriers for implementation of bioenergy technologies in rural areas". The preliminary list of drivers and barriers covers the following PAs related to biogas and biomethane production:

- PA7: Manure-powered milk logistics
- PA18: Agricultural cooperative biogas plant
- PA27: Farm-scale energy and nutrients circulation through an on-farm micro biogas plant
- PA35: Added value from an agricultural biogas plant

PA 7: Manure-powered milk logistics

Short summary:

Valio is a Finnish dairy and food manufacturer owned by 4,700 milk producers around Finland. Valio aims to achieve carbon neutral milk production by 2035. One solution to reduce the carbon footprint of milk is biomethane production from cow manure generated in the dairy farms. The produced biomethane is able to substitute fossil-based fuels in Valio's logistic chain, such as in milk trucks. Vuorenmaa dairy farm located in Haapavesi, Finland, produces milk for a local cheese factory owned by Valio. For over a decade, Vuorenmaa farm has been producing biogas from cow manure to generate electricity and heat needed at the farm. As for 2021, Vuorenmaa farm is the first dairy farm of Valio, where biogas is also converted to compressed biomethane and is hence also applicable to be used as a transportation fuel.

The annual biogas yield of the farm is around 1,200 MWh of which approximately half is refined to biomethane. A milk truck in Valio's logistic chain has committed to buy biomethane produced at the farm. The truck fills up its tank meanwhile it collects the milk. The guaranteed demand and market for biomethane is essential for cost-effective production of biomethane. Private passenger cars are also able to buy biomethane from the Vuorenmaa farm.

Dairy farm can benefit from biogas and biomethane production in several ways. The produced electricity and heat from biogas increase the energy self-sufficiency of the farm meanwhile biomethane production creates new business opportunities. Biogas production also reduces the need of purchased chemical fertilizers. During the biogas process, the manure nutrients are transformed into a more soluble form in comparison to ordinary manure and are hence applicable as recycled fertilizers in the fields.

Additional information:

Cow manure produced in the dairy farms of Valio composes a great share of the total cow manure amount generated in Finland every year. Currently 20 Valio farms produce biogas for electricity and heat production for the needs of the farms themselves. In the near future, Valio aims to significantly expand and increase the biogas network of dairy farms, in order to efficiently circulate dairy farm manure and to reduce the carbon emissions of the company's own logistics. Valio and Finnish energy company St1 are establishing a joint venture to produce compressed and liquified biomethane mainly from cow manure. The nationwide fuelling station network of St1 will be applied to distribute the produced biomethane. The goal of the joint venture is to produce 1 TWh of biogas from cow manure by 2030. An important prerequisite in achieving the target is a demand of biomethane that is high enough to make the biogas investments profitable. To achieve the demand, the amount of biogas-fuelled transportation fleet needs to increase significantly in Finland in the near future. In addition to utilizing biomethane in substituting fossil-based fuels, Valio aims to reduce the carbon footprint of milk by other means as well. One solution is carbon farming, in which farmers use farming methods which maximize the carbon sequestration capacity of the fields.

Table 1. Drivers and barriers for implementation of PA7: Manure-powered milk logistics.

	Source	Finland
Demographic		
Economic		
Dairy industry with applicable raw material for biomethane production exist.	TP (FI)	**D**
Purchase agreements between dairy farms and logistic companies can be established to guarantee a stable demand for biomethane.	C*	**D**
Biogas network expansion is expected increasing the biomethane demand.	C	**D**[1]
Biomethane production provides a new source of income for the dairy farmer.	C	**D**
The dairy farm can increase its energy self-sufficiency by producing its own energy (electricity and heat) from biogas.	C	**D**
Investment cost of biogas upgrading unit (for purification and compression to transport fuel).	C	**B**
Decentralized location of dairy farms increases transportation costs to a centralized biomethane production unit and hence benefits of economics of scale (e.g. feeding the biomethane to gas grid) might be lost.	C	**B**
Policy & legislation		
Complex investment support schemes for biogas production and biogas upgrading units..	C, L**	**B**[2]
Ecological		
The carbon footprint of dairy product production chain decreases with biogas and biomethane production.	C	**D**
The reject of biogas production can be utilised as a nutrient decreasing the demand for purchased chemical fertilizers at the dairy farms.	C	**D**
Socio-cultural		
The image of company producing dairy products and dairy farm improves with lower carbon footprint.	C	**D**
Potential for manure biogas production in the country is huge compared to what is exploited.	L**	**D**
Demand issues of biomethane due to lack of biogas-fuelled fleet prevents investments on biomethane production in rural areas.	C	**B**
Technological		
Liquefied biogas (LGB) would be preferred as a fuel in heavy transportation over compressed biogas (CBG) as it requires less space in the vehicles. However, liquefying biomethane is not yet economically feasible in small-scale.	C	**B**

*** C here refers to the representative of dairy food producing company, ** Maatalous uusiutuvan energian tuottajana ja käyttäjänä (2021). Ministry of Agriculture and Forestry. Available at: https://mmm.fi/ruoka-ja-maatalous/biokaasu.**

1. In Finland, an upcoming joint venture between a dairy and food manufacturer and an energy company with nation-wide fuelling network is expected to increase the biomethane demand.
2. In Finland, higher investment grant can be obtained if the energy (biogas) is for own use and not sold outside the farm.

PA 18: Agricultural cooperative biogas plant

A partnership between the Theuma municipal government and the Theuma agricultural cooperative creates a supply chain of processing locally sourced agricultural residues in-to biogas. The biogas is utilized in combined-heat-and-power (CHP) units that are capable of producing an approximate annual output of 10,000 MWh of electricity and 10,000 MWh of heat. The created power derived from the biogas is sold to the municipality for use in the public electrical grid and Theuma's heating grid system (approx. 115 households, public buildings, and several small businesses).

The Theuma agricultural cooperative operates on approximately 1970 ha. and produces both livestock manure and crop silage that is collected in fermentation tanks, where bacterial decomposition allows for the collection of biogas (containing approx. 55% methane). The biogas is then burned according to demand either within the biogas plant or two satellite CHP units. The remaining organic and mineral waste material after biogas production is reutilized as an agricultural fertilizer.

Identified disadvantages of the operationalized biogas plant technology include large investment and maintenance costs, the requirement of trained personnel for operations and maintenance, and the lack of sustainability reward systems for biogas plants in electricity and heat markets.

Identified advantages of the operationalized biogas plant technology are focused on the creation of storable energy that is baseload capable (i.e., no fluctuations in energy generation), demand driven, CO_2 neutral, unsusceptible to outside influences, and decentralized and expandable through satellite CHP units.

Additional information:
The implementation of regionally supplied biogas plants allows for small municipalities and enterprises to contribute to the decarbonization of heat and electricity production through a circular supply chain of biogas creation sourced from regional organic residues. The creation and operationalization of the biogas plant in the Theuma agricultural collective provides a model example for implementing the systematic steps necessary for small municipalities to transform their electricity and heating system towards biogas plants powered by regional agricultural waste.

Timeline of Biogas Plant Operation in Theuma Agricultural Cooperative

- 2006 - Agricultural Cooperative Theuma-Neuensalz biogas plant construction
- 2007 - Biogas district heating grid construction
- 2008 - Connection of first satellite CHP unit to district heating grid
    - (Dorfgemeinschaftshaus / Village Community Center)
- 2009 - Connection of second satellite CHP unit to district heating grid (Schule/School)
- 2014 - Operationalization of wood chip drying plant, using waste heat from biogas plant

Table 1. Drivers and barriers for implementation of PA18: Agricultural cooperative biogas plant.

	Source	Germany
Demographic		
It is challenging to get enough trained workers in the community to operate and maintain the value chain in rural areas	P	**B**
Economic		
Successfully supplying base-load heat and power to the Theuma municipality with the biogas and CHP units is dependent on the efficiency of sourcing biomass waste streams and susceptible to changes in supply	TP	**B**
The implementation of the biogas plant technology requires high investments	P	**B**
Policy & legislation		
The construction and expansion of the project were made possible partially by EU and federal	L	**D**

state funds under the "European Agricultural Fund for Rural Development" (SMEKUL, 2021)		
There is a lack of sustainability reward systems for biogas plants in electricity and heat markets	P	**B**
Ecological		
The ecological benefits of carbon neutral heat and power are a major catalyst in the implementation of such technologies in rural regions	TP	**D**
Socio-cultural		
Big parts of the community are involved in the value chains and are benefiting from it: - Farmers finding use for their agricultural and livestock residues - Biogas and CHP plants are providing employment in the community - electricity and heat are produced and sourced locally	P	**D**
Residents of the municipality have the interest to transition to carbon neutral heat and power	P	**D**
For the expansion of biogas operation a high manure storage capacity is necessary. This can cause doubts among some members of the community about the smell (Kölbel, 2019)	L	**B**
Technological		
The operationalized biogas plant provides an energy storage and is base-load capable	TP	**D**
During the winter months heat is provided to the municipality with the heating grid system. Businesses can use the excess heat for drying materials	C	**D**

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PA 27: Farm-scale energy and nutrients circulation through an on-farm micro biogas plant

Short summary:

A cattle farm of Ryszard Strug, located in Poland keeps dairy and meat cattle in a close circuit system, including the full production cycle from birth to dairy or meat production. On average, the farm rears 120 calves, 150 dairy cows and 130 meat cattle and the farm covers 430 ha of arable land. Cattle slurry is the only feedstock supplied to an on-farm biogas plant, which is technologically and functionally integrated with the dairy cows' shed.

During the technological process, slurry is transported to a mesophilic digester. The biogas produced there (60% CH_4 and 40% CO_2), passing through an air lock, electric valve and carbon filter, feeds two electric engines, each with the power of 11 kW. The heat generated in the engine, water-cooled exhaust manifold and combustion gas heat exchanger are used to heat the digester and produce hot water for the internal on-farm use. Digestate is collected in a tank and used for fertilization of the farm's fields.

The on-farm micro biogas plant with the range of electric power from 10-50 kWe has several benefits. The solution promotes prosumerism where the energy consumer also produces energy increasing energy self-sufficiency and mitigating the need to purchase energy.

The solution also promotes ecofriendly activities related to on-farm utilization of generated waste. The micro biogas plant is also an integral part of agricultural production (livestock in this case) securing internal circulation of nutrients in the farm and mitigating emission effects.

Additional information:

This Practice Abstract is an example of an agricultural micro-scale biogas plant with a good replication potential, and which is an integral part of a production process that closes the circulation of organic matter at a farm level. The presented farm with cattle production utilizes slurry at a farm level, reduces the costs of energy and fertilizers, and enriches the fertility of its soils by fertilizing the soils with digestate. Thus, it is an example of both an energy prosumer, when the production and consumption of energy is entirely per-formed on the farm, and an industrial prosumer, when the production and consumption of the fertilizer en-tirely takes place on the farm.

From the social perspective, the micro biogas plant primarily contributes to the reduction of odors from animal production and to the long-term effects of improving the living condi-tions of the local community, e.g., by reducing greenhouse gas emissions and contributing to cleaner air and reduced eutrophication of local waters and soils.

Table 3. Drivers and barriers for implementation of PA27: Farm-scale energy and nutrients circulation through an on-farm micro biogas plant.

	Source	Poland
Demographic		
Economic		
Profit from the sale of electricity	**P, C**	**D**
Partial energy independence of the farm - lower costs	**C**	**D**
High investment costs (especially in Polish conditions)	**C, L**	**B**
Improved production profitability	**P, C**	**D**
Policy & legislation		
No legal regulations or/and insufficient legal regulations	**C**	**B**

Lack of support from the government (authorities) or even the opposite	**C**	**B**
Ecological		
Safe slurry management (less odor, groundwater protection, etc.)	**T, C**	**D**
Digestate - fertilizer - increase in the content of organic matter in the soil	**P, T, C**	**D**
The carbon footprint of cattle production decreases with biogas and biomethane production	**T**	**D**
Socio-cultural		
Residents' resistance (fears of odor etc.)	**C**	**B**
Potential for manure and slurry biogas production in the country is huge compared to what is exploited (może w ekonomicznych – choć w przykładzie Finskim było tutaj)	**L**	**D**
Company image - as more environmentally friendly	**T**	**D**
Technological		
Faster slurry treatment and processing	**C**	**D**
Possibility of obtaining utility water from cogeneration	**C**	**D**

PA 35: Added value from an agricultural biogas plant

Short summary:

The biogas plant BIO-NIK ELEKTRA Sp. z o.o. in Kisielice, with the capacity of 0.999 MWe and 1.1 MWth, launched in 2014, is an integral part of an agricultural farm (1,800 ha). The feedstock used in this biogas plant is maize silage in an amount of 17.5 thousand tons and slurry in an amount of 7,000 m^3 obtained from own arable land and piggery. The biogas plant is a classical installation with sections of harvest, ensiling and storage of maize silage, and the transport of slurry, a fermentation digester and secondary digester, digestate tank, and a cogeneration system with the capacity of 1.2 MW. The average annual production of biogas is 4,300 million m^3, including 8,400 MWh of electricity and 29,733 GJ of heat. The biogas plant has a potential for further improvement of energy efficiency. The biogas plant, while generating revenue from electric power sold to an electrical grid, is also a part of the organic matter circulation on the farm. In addition, some of the heat generated at the plant is used internally on the farm while part of it is sold to the municipal district heating system. The added value of the biogas plant operating on the farm has

- an economic dimension, i.e., the price for sold kilowatt of electric power, own costs of operating the biogas plant plus price for blue certificates,
- an environmental dimension, i.e., digestate mass supplied to the farm’s fields and
- a social dimension, i.e., quantity and price of heat power sold to the district heating system in Kisielice municipality.

Additional information:

Following the principles of good agricultural practice, digestate from the biogas plant is used for organic fertilization of the farm’s fields. According to the current soil analyses, the systematic enrichment of soil with organic matter from digestate has had a positive effect on the concentration of carbon in soil reaching the level of 2.2%, which indicates a significantly higher content of organic matter in soil compared to the values of 1-2% for 56% of arable land in Poland.

Table 4. Drivers and barriers for implementation of PA35: Added value from an agricultural biogas plant.

	Source	Poland
Demographic		
Economic		
Profit from the sale of electricity	P, C	D
Partial energy independence of the farm - lower costs	C	D
Rising energy prices improve the profitability of investments	P, C	D
High investment costs (especially in Polish conditions)	C, L	B
Policy & legislation		
No legal regulations or/and insufficient legal regulations	C	B
Lack of support from the government (authorities) or even the opposite	C	B
Ecological		
Safe manure management (less odor, groundwater protection etc.)	T, C	D
Digestate - fertilizer - increase in the content of organic matter in the soil	P, T, C	D
The carbon footprint of pig product production chain decreases with biogas and biomethane production	T	D
Socio-cultural		
Residents' resistance (fears of odor etc.)	C	B
Potential for manure biogas production in the country is huge compared to what is currently exploited	L	D

Company image - as more environmentally friendly	**T**	**D**
Technological		
Cogeneration - heat from cogeneration (waste heat) can be transferred to the municipal heating network	**C**	**D**
The possibility of storing biogas and balancing the operation of the power system	**C**	**D**

Annex II. An example for collecting drivers and barriers in a national network workshop

Exemplary agenda for the national network workshop

The exemplary agenda presented below is based on the program of the workshop that was held by the UWM scheduled on 8th Dec 2021. The following sequence of discussed themes are planned, and e.g., similar approach can be used in other workshops.

1. Presentation of the network and innovative activities in rural areas in the field of bioeconomy and renewable energy sources based on R&D projects and successful examples of outputs.
2. Presentation of good practices in bioenergy technologies in relation to rural areas in the form of practice abstracts (PAs) by the owners/users/or Technical Partner of BRANCHES of the technology.
3. Panel discussion composed by speakers/practitioners with one of the goals to gather information on D&B from the user perspective.
4. Extension of panel discussion to other participants to gather information on the opportunities and bottle necks related to development of innovative bioenergy solutions in rural areas.
5. Survey on-line for on-line participants and flexible approach for physically present (on-line or paper version).

During the discussions some implementation aspects of technologies (proposed by organizers and provided by the audience) related to presented PAs and indicated during dedicated discussion on D&B will be pointed out accordingly by writing on a black board, flip board, virtual memo-board, i.e.

- Technical feasibility
- Profitability
- Environmental impact
- Public acceptance
- Support programs
- Financial stability of the support
- Other (please specify)

The last 10 minutes of the workshop will be devoted to survey - expected feedback from participants. It can be done online or fulfilling the questionnaire when the participant will be physically present.

The answers to the questions will be collected according to the Likert-type scale with 5 levels of items, i.e., strongly disagree, disagree, neither agree nor disagree, agree, strongly agree.

Exemplary survey for the national workshops

An example of a survey to collect data on drivers and barriers related to the presented bioenergy technologies in rural areas in the workshops is presented in Table 1. The survey is an example questionnaire from a public workshop held in Poland. The survey is conducted during the workshop (online and at place for physically present stakeholders). The collected answers from the survey will be averaged and presented in a visual form by UWM. Besides, some statistics will be estimated to prevent errors that arise when ordered ratings are treated as interval-level measurements. However, the project countries may use another approach during the workshops to collect and gather the data related to the drivers and barriers of the assessed bioenergy technologies.

Table 1. An example survey to collect drivers and barriers of bioenergy technologies in a workshop held in Poland.

Question	Options
Please fill in this evaluation sheet and return it at the end of the workshop.	
1. Why did you register to the workshop?	☐ Speakers ☐ Programme and Subjects ☐ Networking opportunities ☐ Other (please specify)
2. To what extent do you think the workshop meet your expectations?	☐ high ☐ medium ☐ low ☐ hard to say
3. Which of the presented applications do you consider the most innovative (5 PAs elaborated up to now by UWM)?	☐ RES – building the commune system of energy self-sufficiency, Barciany ☐ RES – a communal self-sufficient energy system, Kisielice ☐ Biogas plant – as a biorefinery, BIOGAL, Galiny ☐ Biogas plant – as a part of the local energy self-sufficiency, Bio-Nik, Kisielice ☐ Micro-biogas plant – as an integral part of cattle farm, farm, Kolwiny
4. Which of the presented technologies could be considered by you for implementation and / or application in your own activity/business?	☐ RES – building the commune system of energy self-sufficiency, Barciany ☐ RES – a communal self-sufficient energy system, Kisielice ☐ Biogas plant – as a biorefinery, BIOGAL, Galiny ☐ Biogas plant – as a part of the local energy self-sufficiency, Bio-Nik, Kisielice ☐ Mikro-biogas plant – as an integral part of cattle farm, farm, Kolwiny
5. Which of the following do you consider to be the most important factor influencing the application of bioenergy technological innovations?	☐ Technical feasibility ☐ Profitability ☐ Environmental impact ☐ Public acceptance ☐ Support programs ☐ Financial stability of the support ☐ Other (please specify)

6. What barriers do you think limit bioenergy technology innovation in rural areas?	☐ Limited access to knowledge about available innovations (know-how) ☐ Long and complicated administrative process ☐ Economic factors (profitability, implementation costs) ☐ No technical expertise ☐ Lack of cooperation between the research sector, administration, and practice ☐ Other (please specify)
7. What factors could make you consider introducing innovation to your business?	☐ Quick access to the latest knowledge ☐ Effective agricultural consulting ☐ Financial support ☐ Other (please specify)
8. Do you have questions that have not been answered or additional information that you would like to receive?	Please specify: