D6.4: Flagship success cases update v2

uP_running

Take-off for sustainable supply of woody biomass from agrarian pruning and plantation removal

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ABBREVIATIONS

CERTH: Centre for Research and Technology Hellas

CIRCE: Research Centre for Energy Resources and Consumption

EC: European Commission

EuroPruning: Development and implementation of a new and non existent logistics chain for biomass from pruning

SECB: Scientific Engineering Centre "Biomass"

UFG: University of Foggia

uP_running: Take-off for sustainable supply of woody biomass from agrarian pruning and plantation removal

WP: Work Package

DEFINITIONS

APPR	Agricultural Pruning and Plantation Removal refers to agricultural woody residues produced as a result of agronomic operations applied to vineyards, olive groves, and fruit plantations.
APPR biomass value chain	The set of activities and stakeholders involved in the preparation and use of biomass products obtained out of APPR wood.
Chips	Chipped woody biomass in the form of pieces with a defined particle size produced by mechanical treatment with sharp tools such as knives.
Demo Country	There are four Demo Countries in uP_running project: Spain, Italy, Greece and Ukraine. Demo countries are referred as those countries where demonstrations activities took place.
Hog fuel	Wood that has pieces of varying size and shape, usually more inhomogeneous than wood chips. The main difference from wood chips is that hog fuel is produced by crushing with blunt tools such as rollers, hammers, or flails.
Pellets	Compressed, cylindrical particles of standard dimensions which can be made from various types of biomasses or other materials. Biomass pellets usually have a diameter of either 6 or 8 mm and a maximum length of 40 mm.

EXECUTIVE SUMMARY

The level of Agricultural Pruning and Plantation Removal (APPR) biomass utilization in Europe is very low and far behind that of wood coming from forest. Even though the overall utilization level of APPR biomass is low in Europe, at local or regional level there are successful cases of biomass value chains based totally or partially on APPR biomass. 40 such cases have already been identified by the uP_running project and are recorded in the "Observatory", the web-based tool developed for recording APPR experiences.

uP_running project intends to select a number of value chains for further study and mark them as "flagships" of APPR biomass utilization. A flagship case has the capacity to be thoroughly documented, present a good degree of technological innovation and has the capacity to serve as an example to replicate / imitate in other sites. Success cases showcase the models that can be followed to make APPR use feasible, and are a unique source for extracting lessons learnt and keys for success. Moreover, uP_running flagship cases selection intends to cover as wide a range of end uses and business model formulations as possible, while also considering an appropriate geographical coverage in Europe.

The present report focuses on five flagship cases selected in order to meet the specifications described above. The cases are briefly presented in the table below.

Flagship	Country	APPR type	Type of value chain	Main reasons for consideration as flagship case
EAMEB	Greece	Plantation removal (fruit trees)	Agroservices, biomass (wood chips) to market (power production)	Plantation removal example, large-volume of biomass mobilized, evolution into power production case
ENCE Mérida	Spain	Prunings and plantation removal	Power production (APPR biomass as part of the fuel mixture)	Power production, market-driven case
Gospodarstwo Sadownicze	Poland	Apple tree prunings	Biomass (pruning bales) to market (heating of municipal buildings)	Farmer-driven initiative without self-consumption, tree species used, example of bale utilization

Flagship	Country	APPR type	Type of value chain	Main reasons for consideration as flagship case
Triada-MK	Ukraine	Plantation removal (aerial part of apple trees)	Biomass (wood pellets) to market	Plantation removal example, upgraded biofuel (pellet) production, quick movement from demonstration to commercial operation with uP_running assistance
AgriToppi	Italy	Olive tree prunings	Biomass (wood pellets) to market	Tree species used, upgraded biofuel (pellet) production, quick movement from demonstration to commercial operation with uP_running assistance

Each of the flagship cases mentioned above is described in great detail in annexes to this report. The following information of the success cases mentioned above is available:

- Summary of the case
- Business model
- History and reasons for initiating
- Biomass availability, harvesting and logistics arrangements
- Soil management and impact on agronomic practices
- End use of APPR biomass
- Success factors and obstacles
- Lessons learned
- Future of the value chain

Potential initiators of APPR biomass value chains can study the detailed flagship reports and, after identifying the one most suitable to their needs, can transfer the lessons learned from its experience and start designing and making arrangements for their own cases.

The general lessons learnt by the comparison of the flagship cases attest to the versatility of APPR biomass to be employed in different local conditions and for quite different end-uses. A key feature that has to be remarked is the disruptive vision of the flagship cases initiators, which moved in the opposite direction of the established practices; their perseverance in the face of various obstacles and set-backs is what allowed the flagship cases to materialize and evolve.

TABLE OF CONTENTS

INTRODUCTION

The current report constitutes **Deliverable D6.4 "Flagship success cases update v2"** of the uP_running project. The report is the result of work undergone in **Task 6.3 "Registry of collection experiences and value chains"**.

One of the goals of Task 6.3 is to improve the knowledge regarding successful value chains that are based (totally or partially) on APPR biomass. Several such cases have already been detected throughout Europe and recorded, using the templates developed in Task 6.1, in the uP_running Observatory website.

uP_running project aims to identify at 10 cases which should correspond to best practices regarding APPR biomass utilization. The definition of such a "flagship" cases of APPR value chain is not strict. Generally, a flagship case should consider the following:

- Ability to be thoroughly documented, through publicly available materials and reports, as well as through interviews from the key actors of the value chain.
- Good degree of technological innovation along the value chain, e.g. use of mechanized harvesting for APPR collection, high energy conversion efficiencies, production of upgraded products such as electricity or biomass pellets, etc.
- Ability to serve as an excellent example for replication in other locations.

Deliverable D6.3 presented in detail the first 5 APPR utilization "flagship" cases selected by the uP_running project: Domaine Xavier Muller, Vineyards4heat, ITC Shabo, Pelets de la Mancha / Athisa Group and FIUSIS. The present report covers 5 more flagship cases, aiming to cover an even wider range of business models, APPR biomass types and geographical spread. These 5 cases are the following:

Flagship case	Country	APPR type	Type of value chain	Main reasons for consideration as flagship case
EAMEB	Greece	Plantation removal (fruit trees)	Agroservices, biomass (wood chips) to market (power production)	Plantation removal example, large-volume of biomass mobilized, evolution into power production case
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This Deliverable report is prepared in English. The text of the cases shown in the Annexes is the input to prepare structured, well edited and visual descriptions of each flagship case, which are translated in 7 European languages (Croatian, French, Greek, Italian, Portuguese, Spanish, and Ukrainian).

1 APPR BIOMASS VALUE CHAINS AND THE UP_RUNNING OBSERVATORY

uP_running project focuses on woody biomass originated from permanent crops: agricultural prunings and plantation removal material, APPR biomass for short. Previous investigations suggest that the potential in Europe is huge: 20 to 25 Mt (of fresh biomass) per year from prunings (CIRCE, 2014; Elbersen et al., 2012), 15 Mt of plantation removal wood. Overall, the annual dry matter production can reach 20 Mt/yr (García-Galindo et al., 2016).

Despite this large potential, the actual utilization rate of APPR biomass is very low compared to other types of solid biofuels, such as those originating from forest biomass (widely used for a variety of applications, from domestic heating to large-scale power production) or even herbaceous agro-biomass (examples of cereal straw utilization in power production are relatively few but quite well known and relatively large in size). Technical issues in harvesting and managing APPR biomass are an issue that has been well addressed by previous initiatives, such as **EuroPruning** project (www.europruning.eu); for pruning harvesting, several technical solutions from different manufacturers are available in the market. The prevalence of non-technical over technical issues in the initiation of APPR biomass value chains was highlighted as a final result of the EuroPruning project and it has been reconfirmed in the sector analysis undertaken by the uP_running project (UFG et al., 2017).

In order to promote the energetic utilization of APPR biomass in Europe, uP_running project has designed and is implementing a series of actions, aiming to address the non-technical issues of using APPR biomass. A key message that the uP_running project intends to deliver to stakeholders interested in initiating value chains based on APPR biomass is that, although they may be the first in their region or even country, they are not the first to work in this direction before; others have tried in the past, have succeeded and their example can be a valuable lesson and experience for imitation or improvement.

One of the main ways to achieve this project goal is the **uP_running Observatory**, an online tool for recording and displaying "experiences" related to APPR biomass: field measurements of biomass potential from APPR biomass, mechanized collection of APPR biomass and, finally, actual, operating APPR biomass value chains (CERTH et al., 2016).

The EuroPruning project had already identified 16 existing APPR biomass value chains in Europe (SLU et al. 2016); through extensive surveys and search in their national markets, the uP_running project partners were able to identify 22 more cases and have actually been instrumental in supporting the development of 2 cases. All these cases have been uploaded on the Observatory website, (Figure 1), following data collection using the standardized template developed for this purpose; a detailed overview of the questionnaire is available elsewhere (CERTH et al., 2017). Apart from the Observatory, a short overview of the value chains identified can be found in another project deliverable (CERTH et al., 2019).

The majority of the value chains and the ones largest in size (in terms of APPR biomass mobilized) are located in Spain. However, various cases can also be found in the other three uP_running demonstration countries (Italy, Greece and Ukraine). There are also cases from Germany, France, Poland and Denmark. And even though it is not recorded in the Observatory, it is interesting to note that a pruning to energy value chain has even been found in a winery in New Zealand[1].

The most common business model is the self-consumption one: farmers who mobilize a quantity of their own prunings and use them as fuel for heating their own households or farms. Relatively small-scale heating applications in municipal buildings is also observed in a few other cases. On the other hand, there are also cases of mobilization of large volumes of APPR biomass (for large-scale applications, mostly for power production.

Regarding the type of APPR biomass, most, but not all value chains focus exclusively on prunings. In most cases, prunings from a single tree species (most commonly olives or vineyards) is used as raw material. However, in some of the smaller cases, or some of the very large, power production cases, prunings (and occasionally plantation removal biomass) from whatever trees are available in the farm or area are used.

Finally, it should be noted that most of the value chains reported are fairly recent, with the oldest one having a start date in 2008 and the newest ones in 2017.

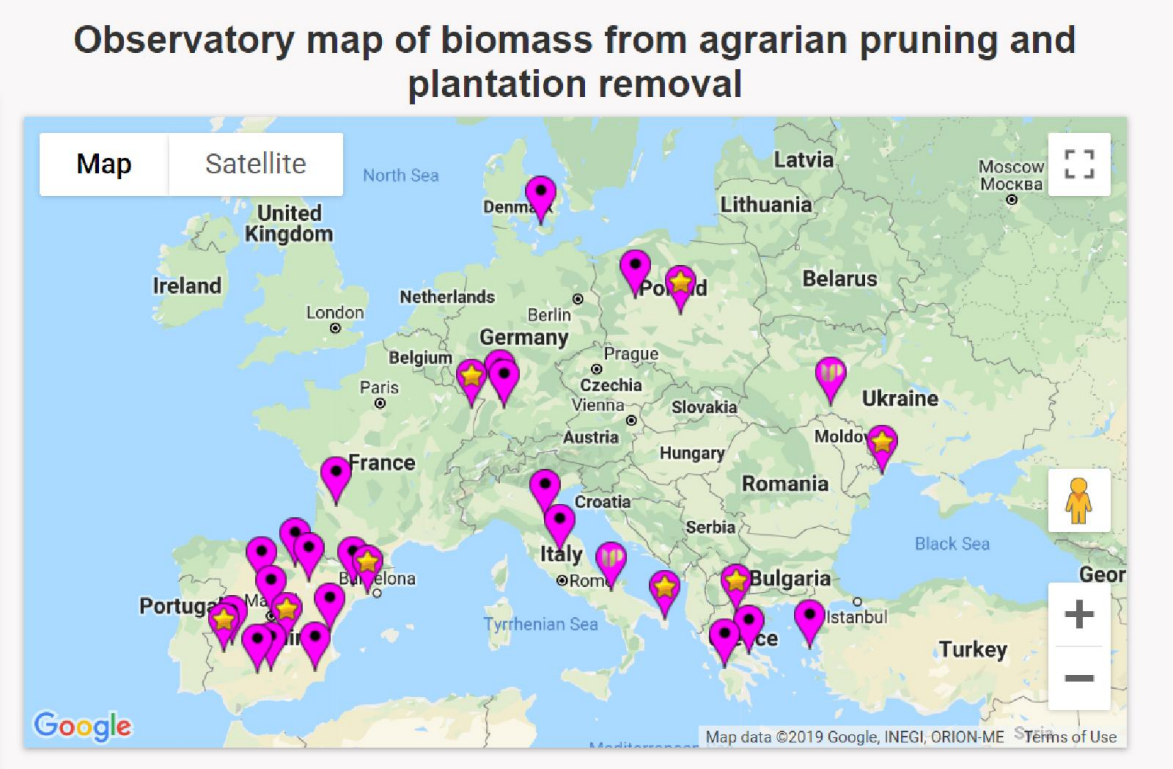

Figure 1. Screenshot of uP_running Observatory displaying identified APPR biomass value chains and flagships (as of June 2019).

[1] Yealands Estate Wines, 2017: www.yealands.co.nz/our-place/winery/this-week-in-the-winery/vine-energy

2 THE UP_RUNNING FLAGSHIP CASES – SECOND UPDATE

Out of the total APPR value chains identified, uP_running project aims to select at 10 **"flagship" cases** which should correspond to **best practices** regarding APPR biomass utilization.

The definition of a flagship case of APPR value chain is not strict. Generally, a flagship case should have the following characteristics:

- Ability to be **thoroughly documented**, through publicly available materials and reports, as well as through interviews from the key actors involved the value chain.
- Good degree of **technological innovation** along the value chain, *e.g.* use of mechanized harvesting for APPR collection, high energy conversion efficiencies, production of upgraded products such as electricity or biomass pellets, *etc.*
- Ability to serve as an **excellent example for replication / imitation** in other locations.

Some additional *ad hoc* criteria were also used for the selection of flagship cases out of all the APPR value chains identified by the uP_running project:

- Coverage of **as wide a range of end uses and business model formulations as possible**.
- **Geographical spread** in various locations in Europe.
- **Consideration of different types of APPR biomass**, both in terms of the permanent crop used (*e.g.* vineyard, olive, fruit trees) as well as both pruning and plantation removal biomass.

Considering the criteria outlined in the previous section, the uP_running consortium has selected a first set of five flagship cases in July 2017. Value chain actors from each flagship case have been interviewed and five detailed flagship reports were produced, following a common format and storyline. The reports were included as Annexes in a dedicated project deliverable (CERTH et al., 2017). The five cases selected were the following:

- **Domaine Xavier Muller** (France): a winery owner, using various logistics implements including a mobile pelletizer unit, to heat his house and farm with vineyard prunings.
- **Vilafranca del Penedés** (Spain): a public-private partnership, supported by the Vineyards4heat LIFE project, for the valorization of vineyard prunings in a municipal district heating system and small wineries.
- **ITC Shabo** (Ukraine): an agro-industry (winery / distillery) using vineyard prunings as a fuel for its steam boiler.
- **Pelets de la Mancha / Athisa Group** (Spain): the world's largest pellet plant using exclusively vineyard prunings as raw material; also producing wood chips.
- **FIUSIS** (Italy): the world's first power plant (1 MW electrical) using exclusively olive tree prunings as fuel.

For the definition of the next round of flagship cases, a similar procedure was used. Considering that four out of the five first flagship cases were using vineyard pruning as a feedstock, an event greater emphasis was placed on covering as wide a range of APPR biomass types as possible.

The following paragraphs provide a short description of each flagship case presented in the Annes of the current report and the reasons for their selection. Also, the common approach and methodology for developing each flagship case report is presented.

2.1 Fuels (chips) to market case: EAMEB

EAMEB is an uP_running flagship case that finds its business model in the sale of wood chips from plantation removal biomass. **EAMEB** started as an agro-service offering uprooting services to fruit tree farmers (mostly peaches) around the city of Veria, in Northern Greece. A change in the local agronomic practices resulted in an increase in the frequency on uprootings and a growing need to handle the large volumes of biomass generated. By investing in a variety of technical implements, including excavators, a quite large forest wood chipper and a small fleet of tractors and transportation platforms, **EAMEB** offers a cost-competitive uprooting service while generating its main revenues from the sales of high quality wood chips, made from the aerial part of the tree and the root off-shots (the root is processed separately and sold as firewood). Reaching a production of 8,000 tons of wood chips per year, the company is doing business with various local end-users. Most recently, it has started a long-term collaboration with a local biomass power plants, as its exclusive supplier of fuel; this will require to further increase the production volume and optimize procedures.

EAMEB is one of the new APPR value chains reported by the uP_running project. Information has been compiled by project partner CERTH in a series of interviews with company representatives.

2.2 The power production case: ENCE Mérida

The **Mérida** power plant of **ENCE** in Extremadura, Spain is an example of another possibility to integrate APPR biomass with power production. Unlike the FIUSIS flagship case (CERTH et al. 2017), which was designed and built from the beginning for a specific type of APPR biomass (olive tree prunings), **ENCE Mérida** was commissioned in 2013 and intended to be used mostly with forest biomass resources. From 2014 onwards though, **ENCE** decided change its fuel supply strategy by placing a strong emphasis on agrobiomass. This change was motivated by the special efforts of the company to ensure a sustainable us of the biomass resources. The company built a decalogue for the sustainable use of biomass, under which the utilization of roundwood for energy had to be abandoned. The company found that agro-residues, particularly APPR biomass utilization could be an opportunity as regard of several facts: cheaper harvesting, good calorific value, local abundance, lack of alternative uses (no other competitive uses) and avoidance of emissions from its uncontrolled burning in the field.

The transition to agrobiomass started first in another biomass power plant of **ENCE** – Huelva – and in 2016 it was applied to **Mérida**. Local circumstances, in particular the large surfaces cultivated

with permanent crops, allowed **ENCE** to finally source up to 49,000 t/y of various types of APPR biomass (prunings and plantation removal from olive trees, vineyards and fruit trees), which correspond to roughly half the volume of agrobiomass burnt and around 30 % of the total fuel mixture on mass basis.

For the sourcing of APPR biomass, **ENCE** is collaborating with various agro-services companies; some of them had previous experience in the handling of forest biomass or even coal. The confidence that **ENCE** could provide to these collaborators allowed the companies to make investments in equipment needed for harvesting and pre-treating the APPR biomass according to the technical specifications of **ENCE**.

ENCE Mérida is one of the new APPR value chains identified by the uP_running project. Information has been compiled by project partner CIRCE in a series of interviews with company representatives.

2.3 Fuels (pruning bales) to market case: Gospodarstwo Sadownicze

The owner of the fruit processing company **Gospodarstwo Sadownicze** in Komorów, Poland wanted to get rid of the winter prunings from his apple orchards to avoid the risk of infection, bacteria and fungi. He also recognized that the on-field burning of residues was a waste and wanted to find alternatives that would involve the energetic utilization of the material.

Faced with two potential alternatives, chipping on-site or baling, the entrepreneur finally decided on the second. There were two reasons for going for this option; first, it was recognized as the fastest and cheapest way to harvest and store the biomass. But most importantly, a local market survey revealed that two straw bale boilers were installed in two local municipal buildings. **Gospodarstwo Sadownicze** demonstrated that the pruning bales could be delivered at a competitive price and with better fuel properties compared to the standard straw bales. The company is delivering about 130 tons of pruning bales (dry basis) to the two municipal buildings on an annual basis, which are used to substitute part of the straw combusted. Thus, taking advantage of the specificities of the local biomass market, **Gospodarstwo Sadownicze** was able to initiate a new business line that can generate some profit, while at the same time solving the issue of their pruning management.

Preliminary information for this value chain was already collected and recorded in EuroPruning Deliverable D5.1 (SLU et al., 2016); an update based on interviews with contact persons the company and with the assistance of Dr. Arkadiusz Dyjakon (Wroclaw University of Environmental and Life Sciences)has been performed by uP_running project partner SECB.

2.4 Fuels (pellets) to market cases: Triada-MK & AgriToppi

Pellets are compressed, cylindrical particles of standard dimensions which can be made from various types of biomasses or other materials. Due to their high bulk and energy density, uniform properties and granularity, pellets can be used easily by various biomass end-users, even at the domestic scale. The pelletization process is however quite energy intensive, and therefore increases the price of the end product, along with its value. Still, producing pellets can be an effective way of

expanding the APPR biomass market. One of the first five uP_running flagship cases, **Pelets de la Mancha (Athisa Group)** was actually based on large-scale pellet production from vineyard prunings CERTH et al. 2017).

Two flagship cases contained in this report are also examples of pellet production from APPR biomass, but of a quite different scope and size to **Pelets de la Mancha**, being small-scale producers. Moreover, different types of APPR biomass are used.

Triada-MK is a multi-profile group of companies operating in Murovano-Kurylivets region, Ukraine. The company manages a significant area of apple trees, of which several hectares correspond to old plantations that have to be uprooted and restructured according to modern agronomic practices. Like in the previous case, the handling of large volume of biomass generated by uprooting represented a problem for the company, while the open-field burning alternative was recognized as a waste of a valuable resource.

The first attempts by **Triada-MK** to mobilize the APPR biomass from the plantation removals was to establish a value chain with direct selling of APPR chips to a local biomass boiler house. However, the high moisture content of the fuel led in an unsatisfactory operation. With the technical assistance of the uP_running process and thanks to the quick initiative of the entrepreneur, the **Triada-MK** flagship refocused on the production of APPR biomass pellets from the aerial part of the tree. A small, second-hand pelletisation line was purchased for this end. First trials and feedback from the end-user resulted in some small modifications in the production line in order to upgrade the pellet quality and make it comparable or better with other types of locally available agro-pellets. The changes were successful and finally long-term supply contract with a local biomass boiler house materialized; **Triada-MK** has sold already 700 tons of pellets to this plant (the major part of its production) and has plans to reach a production of 1,500 tons per year in the near future.

AgriToppi is a family owned agro-services company operating in Foggia province. The company owned a fleet of agricultural machinery and was already involved in performing operations of pruning shredding (intended for soil mulching). However, the company owner had the strong conviction that pruning could represent a resource and not a waste, therefore to be used in producing a new valuable final product. The goal was also to increase the company incomes through diversifying its productive activities.

Receiving technical support and accompaniment from the uP_running project, the company decided to make some modest investments in an integrated harvester-shredding system and a small pelletizing line. The main product of this line of the company are pellets made from olive tree prunings. The quality of the pellets can be quite variable, since olive tree prunings are a complicated biomass resource with variable ash content depending on the harvesting practices (presence of soil, amount of leaves). However, the **AgriToppi** pellets have found their place in the local biomass market since they offer some advantages over other biomass fuels (e.g. no odours compared to olive stones and olive cake).

Both **Triada-MK** and **AgriToppi** are new initiatives that have been partly “triggered” by the uP_running project. They were among the demonstration initiatives supported by the project in Ukraine and Italy and further selected for specific technical support through the accompaniment

services offered by project partners SECB and UFG. Information has been compiled by the respective project partners using as basis the uP_running experiences as well as the commercial operation of these new value chains, as captured through interviews with company representatives.

2.5 Outline of the flagship reports

Each of the five flagship cases described briefly above is presented in greater detail in a specific annex to this document (the "flagship reports"). In order to have a streamlined and comparable presentation of the flagship cases, a standardized structure for the reports was used. The main contents of each section are presented below.

Introduction

The first, introductory section presents a short overview of the flagship value chain and a map showing its location in Europe. The main reasons for its consideration as a flagship by the uP_running project are summarized. A standardized table (Table 1) is used to provide some basic information for the value chain, giving some ideas for its size and impact.

Table 1. Explanation of the "flagship case at a glance" table.

Parameter	Explanation
Location	Municipality and country where the flagship is based.
Type of APPR involved	Prunings, plantation removal or both
Crop species used	Olive trees, vineyards, fruit trees, etc.
Year of initiation	Year when the production line based on APPR biomass started operation
Volume of APPR mobilized	Primary volume of APPR biomass used for the value chain. Not equivalent with the quantity of final marketable biomass products in the case of pellet production.
Surface area with permanent crops mobilized	Area (in hectares) from which the flagship case can source biomass. Along with the previous value, gives an indication of the average field biomass productivity.
Maximum radius of operation	Maximum distance between fields that produce APPR biomass and energy conversion / upgrade site
Main product	Usually heat, electricity or biomass to market, e.g. pellets or chips

Parameter	Explanation
CO_2 emissions avoided (tonnes per year)	Usually calculated using the Fossil Fuel Comparator adopted in the final recast of the RED II Directive for the final product of the value chain (heat or electricity). For Triada-MK and AgriToppi, the emissions avoided were calculated using the "Sustainability Assessment Guidelines and Template" developed by the uP_running project (http://www.up-running.eu/other-materials/). If possible, the emissions related to the value chain were considered, using various approximations.
Number of jobs created	Total number of jobs created for the value chain
Total level of investment	Considers harvesters, logistics components, energy conversion equipment, etc.

Business model

An APPR biomass value chain is built around a specific business model. For a business model to operate smoothly, two requirements should be met.

The first requirement is organizational: each actor involved should have a clear role and responsibility in the value chain. The extend of its involvement can vary depending on the case: for example, in some models farmers have no role other than providing the raw material on which the case is built, in others farmers undertake actions in the logistic arrangements, such as harvesting and transport of biomass. The organizational aspect of the business model for each flagship case is presented in graph form; this provides to reader a clear and easy to understand picture of the overall arrangements.

The second requirement is that each participant in a value chain should have a clear benefit from its involvement. If this is not the case, then there is no motivation to participate. This section of the report presents the benefits to the actors participating in a simple table form. Two types of benefits are outlined: tangible, which can be quantified with specific indicators (e.g., time, money, etc.) and intangible benefits, which are qualitative and/or difficult to measure accurately (e.g., reduced risk of fire, "greener" image, etc.).

The number of jobs created through the value chain is also reported in this section.

History / reasons for initiating

APPR biomass value chains started as an idea and gradually evolved to reach their current status. This section of the flagship report looks into the history of each case. The reasons for initiating the value chain are presented and a short overview of their development is given.

Availability, harvesting and logistics of APPR biomass

Any APPR value chain starts from the field and the biomass generated there. Biomass productivity and harvesting methods used are critical for the overall economics of the value chain; the harvesting techniques employed also have a direct impact on fuel quality and its potential end-uses. The actual steps needed for getting biomass out of the field is often one of the first questions asked when one starts thinking about APPR value chains; therefore, this section provides an in-depth view of these characteristics of the successful flagship cases: typical biomass productivity in t/ha, measures to reduce the moisture content of APPR biomass, harvesting methods and equipment used, storage and transport arrangements.

Soil management and agronomic practices

The management of APPR biomass generated from a permanent crop plantation is an issue faced by farmers. The typical practice for prunings is open-field burning; on-field mulching and incorporation in the soil is employed in several cases.

Despite this fact, the removal of APPR biomass for energetic utilization has been associated with concerns regarding the depletion of organic carbon from the soil and removal of nutrients. The issue is a quite complicated one; the uP_running project is developing some simplified guidelines in order to assess the impact of APPR removal on soil quality.

In this section of the flagship report, the views of the actors involved in the value chain regarding soil management are presented. Moreover, the removal of APPR biomass for energy production is compared with the typical agronomic practices of the area and possible impacts are discussed.

End use of APPR biomass

APPR biomass is quite versatile and can be used as a fuel for different process and at different scales. Heat production can take place at small-scale, domestic boilers or in medium / large scale systems for district or industrial heating. It can be upgraded to tradable forms, such as pellets or chips, and marketed. Or it can be used for power production in units of sufficient size. This section of the flagship report provides an overview of the conversion technologies adopted in each flagship case. Information about the final fuel properties of APPR biomass can be found along with some technical characteristics of the conversion systems, e.g. efficiencies.

Success factors and obstacles

The uP_running flagship cases managed to come to full operation due to several factors that contributed to their success. In all cases, obstacles had to be overcome through the combined efforts of the stakeholders involved. This section of the report gives an overview of both, which can be of great use to new initiators of APPR value chains.

Lessons learned

From the detailed analysis of each flagship case, some valuable lessons can be "distilled". Again, this can be of immense value to initiators who wish to embark on a similar path. The lessons learned are presented in their specific section of the report.

Future prospective

Value chains are rarely static endeavors; they tend to evolve based on the vision of their participants and are influenced by the market conditions. Within the years, a value chain may change focus to other types of resources, consider upgrades in the logistics arrangements or expand to cover new markets and new products. This section of the flagship reports presents the plans for the future of each value chain, as expressed by their main stakeholders.

Contact information

The contact details for the main initiator / actor of the value chain are presented in this section.

3 CONCLUSIONS AND LESSONS LEARNT

The utilization rate of APPR biomass is still very low in Europe; however, 40 actual value chains have been already identified and reported in the uP_running Observatory web-tool (www.up-running-observatory.eu). 10 of these value chains were marked as "flagship" cases by the uP_running project; a flagship case is considered as a paradigm of what the APPR biomass sector can deliver and one of the possible models to imitate or be inspired from when an actor or group of actors wish to initiate their own APPR biomass value chain.

The flagship cases have been selected so as to be representatives of different business models, end-uses of APPR biomass and sizes of the value chain. The first 5 cases were reported in a previous project deliverable; 5 more are included in this one. As a final reminder, the following summarizes these 10 cases by categorizing according to the main market / end-use that the initiator is targeting.

APPR biomass to heat

- **Domaine Xavier Muller** (France): a winery owner, using various logistics implements including a mobile pelletizer unit, to heat his house and farm with vineyard prunings.
- **Vilafranca del Penedés** (Spain): a public-private partnership, supported by the Vineyards4heat LIFE project, for the valorization of vineyard prunings in a municipal district heating system and small wineries.
- **ITC Shabo** (Ukraine): an agro-industry (winery / distillery) using vineyard prunings as a fuel for its steam boiler.

APPR biomass to power

- **Gospodarstwo Sadownicze** (Poland): a farmer-driven initiative, producing apple tree pruning bales that are then sold to local customers for use as a heating fuel.
- **EAMEB** (Greece): an agro-services company producing wood chips from plantation removal biomass that has evolved into the exclusive supplier of a local biomass power plant.
- **AgriToppi** (Italy): an agro-services company that has supplemented its activities by installing a small pelletization line for olive tree prunings, one of the primary agricultural residues it handles.
- **Triada-MK** (Ukraine): an agricultural firm that has initiated a new pelletization line for handling large volumes of biomass generated from the uprooting of old apple orchards.
- **Pelets de la Mancha / Athisa Group** (Spain): the world's largest pellet plant using exclusively vineyard prunings as raw material; also producing wood chips from the same material.

APPR biomass to power

- **FIUSIS** (Italy): the world's first power plant (1 MW electrical) using exclusively olive tree prunings as fuel.
- **ENCE Mérida** (Spain): a larger biomass power plant (20 MW electrical), in which various types of APPR biomass are used as part of the fuel mixture.

The uP_running flagship cases have been intentionally selected to be quite different from each other. The business models employed, level of investment required, logistics arrangements implemented, end-uses targeted and success factors, obstacles and lessons learned vary widely and can be understood from the study of each individual flagship report.

Specific lessons learnt from each flagship case can be found at the end of each flagship report. Some key, general messages from an overall assessment of the flagship cases have been transmitted in the previous deliverable on the flagship cases (CERTH et al., 2017). Flagship cases are often faced at their inception with initial skepticism. By managing to implement changes in agronomic practices and farmers' attitudes and by being able to adapt to changing conditions, a versatile APPR biomass value chain can deliver positive social impacts for several local actors. Moreover, there is no single model to adopt in order to promote the energetic utilization of APPR biomass: the selection depends on local conditions, the presence and the willingness of local actors, the ability to mobilize finance, external factors and opportunities and other parameters. Versatility is therefore a key feature of success APPR biomass value chains.

A final, common message from all 10 flagship cases is related to the perseverance and tenacity of the initiators: they had a clear vision that the current practices of management of APPR biomass resources had to be improved in favor of the local community, the climate, or simply just because they considered the practices of open air burning as absurd, useless or just incorrect. The disruptive vision of the initiators, coupled with a forward movement, is what finally led to a new, local paradigm in the management of agricultural residues.

Lacking a supporting framework, initiators of new APPR biomass value chains will be moved partly by vision, instinct and perseverance of initiators, and not fully by market opportunities. Thus, new value chains will again be isolated examples, rather than parts of a wider movement. Changes in framework conditions – be it market (e.g. increase of forest wood prices) or policy (e.g. ban of open-field burning, support in the role of APPR biomass to promote rural development) – can lead to a more thorough mobilization of local / regional stakeholders towards the adoption of APPR bioenergy solutions.

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5 ACKNOWLEDGEMENTS

The uP_running project team would like to acknowledge the entities involved in the five flagships included in this report, for providing data, input and their cases.

ANNEXES

Annex list	**Title**
Annex I:	EAMEB flagship report
Annex II:	ENCE Mérida flagship report
Annex III:	Gospodarstwo Sadownicze flagship report
Annex IV:	Triada-MK flagship report
Annex V:	AgriToppi flagship report

D6.4: Flagship success cases update v2
Annex I: The EAMEB flagship case

uP_running

Take-off for sustainable supply of woody biomass from agrarian pruning and plantation removal

Grant agreement: 691748
From April 2016 to June 2019

Prepared by: CERTH

Date: 07.06.2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 691748.

Introduction

EAMEB is a private company operating in the wider area of Imathia, in Central Macedonia, Greece, having the main target of treating and trading the biomass produced by the local permanent crop orchards. In particular, EAMEB offers complete services of uprooting fruit trees (mostly peaches) and produces two main tradeable forms of the biomass obtained: wood chips (primary) and firewood (secondary).

EAMEB was selected as an uP_running flagship case of APPR mobilization because it focuses on biomass obtained from fruit orchards removal. It is a very successful case, especially considering the Greek framework, that combines the provision of agro-services to farmers (for plantation removal) with the production of wood chips and other biomass fractions.

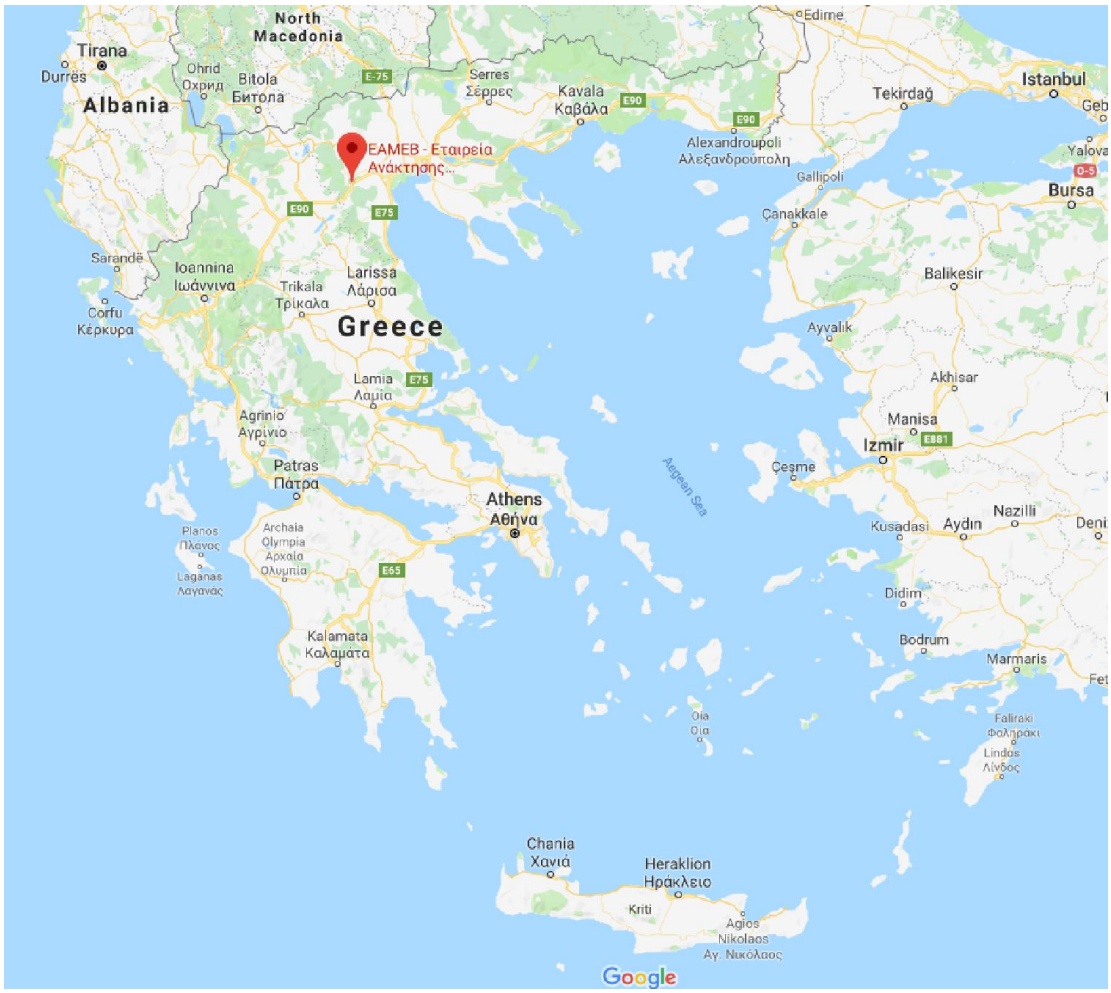

Figure 1. Location of EAMEB (Greece).

Table 1. Overview of the EAMEB flagship case.

EAMEB at a glance	
Location	Veria, Imathia, Greece
Type of APPR involved	Uprooting (primary), prunings (marginal)
Permanent crop species used	Peach trees (primary), apple trees, apricot trees, cherry trees, plum trees
Year of initiation	2011
Volume of APPR mobilized	8,000 t of wood chips per year, ~ 30 % moisture content (coming from aerial part of the tree and root off-shoots) 1,300 – 1,700 m^3 per year of firewood (from root stock)
Surface area with permanent crops mobilized	~ 200 ha on a yearly basis (rotating)
Maximum radius of operation	~ 30 km (centered around the city of Veria)
Main product	Wood chips, firewood
CO_2 emissions avoided[1]	4,625 tCO_{2eq} per year
Number of jobs created	7 (permanent)
Total level of investment	~ 460,000 € in various machines (newly purchased and second-hand) for collecting, treating and transporting biomass

Business model

The EAMEB business model finds its scope, essentially, in the connection between biomass producers, e.g. local farmers, and biomass end-users.

In particular, local farmers have a frequent need for a complete removal of their plantation. Uprooting is usually performed by an excavator and the whole procedure is valued at 1 €/root; if the farmers cannot handle the root material on their own, they would have to pay an additional 1

[1] For the estimation of the CO_2 emissions avoided by the use of wood chips produced by EAMEB, the following assumptions are made:

- Wood chips are used in a biomass power plant with a net electrical efficiency of 26 %. Wood chips have an average moisture of 30 % (LHV of 12.6 MJ/kg) before combustion.
- The plant electrical efficiency is equal to 24.5 %.

The CO_2 savings are calculated using the Fossil Fuel Comparator for electricity production adopted in the final recast of the RED II Directive: 183 gCO_{2eq}/MJ; a default value of 90 % savings is considered taking into account emissions incurred to the biomass fuel logistics.
The energetic utilization of firewood produced by the uprooting operations and the displacement of fossil fuels for heating is not considered in this evaluation, since part of this biomass is expected to be used in installations with very low efficiencies (e.g. open fireplaces).

€/root for the transport to a landfill site. Since the typical planting density is around 450 trees/ha, the total uprooting cost for the producer is 900 €/ha.

EAMEB provides farmers with a competitive, efficient and fast "cleaning" service of their parcels using specialized technical equipment and staff to remove both the aerial part and the roots. As a rule of thumb, if the company estimates (by visual inspection) that the biomass that can be collected from the aerial part of the trees in the field is 100 – 120 kg/tree, then no uprooting or handling cost is charged to the farmers. If the quantity is considered to be lower, then the uprooting service is charged, but at a reduced price compared to the market one. Therefore, by utilizing and bringing added value to the whole biomass fraction, EAMEB can afford to minimize or even completely waiver the uprooting cost to farmers.

On an annual basis, EAMEB provides uprooting services to approximately 200 farmers, covering 200 hectares of land.

The biomass collected from all the fruit plantation removals is managed by EAMEB with the aim to transform it into a commercial form suitable for utilization by various end-users of the area. The main product of EAMEB is wood chips, which will be used as fuel for a 1 MW electrical power plant built in the area. This fuel may also be available to other smaller consumers in the region, e.g. greenhouses and small industries. In smaller quantities, EAMEB also produces firewood suitable for domestic use, mostly from the thicker tree roots; the price of this firewood is around 35 €/m^3, in order to be competitive with other firewood types found in the area but also able enough to cover the expenses of the uprooting process.

By utilizing the whole fraction of the plantation removal biomass, EAMEB has the capacity to market good quality biomass fuels at very competitive prices. Thus, EAMEB can be optimally placed in an industrial biomass market where cheap, lower-quality, imported fuels, mainly sunflower husk pellets, have a strong presence.

The indirect benefits of the operation performed by EAMEB are also important, as the energy utilization of the removal biomass minimizes the risks of uncontrolled disposal and open-field burning.

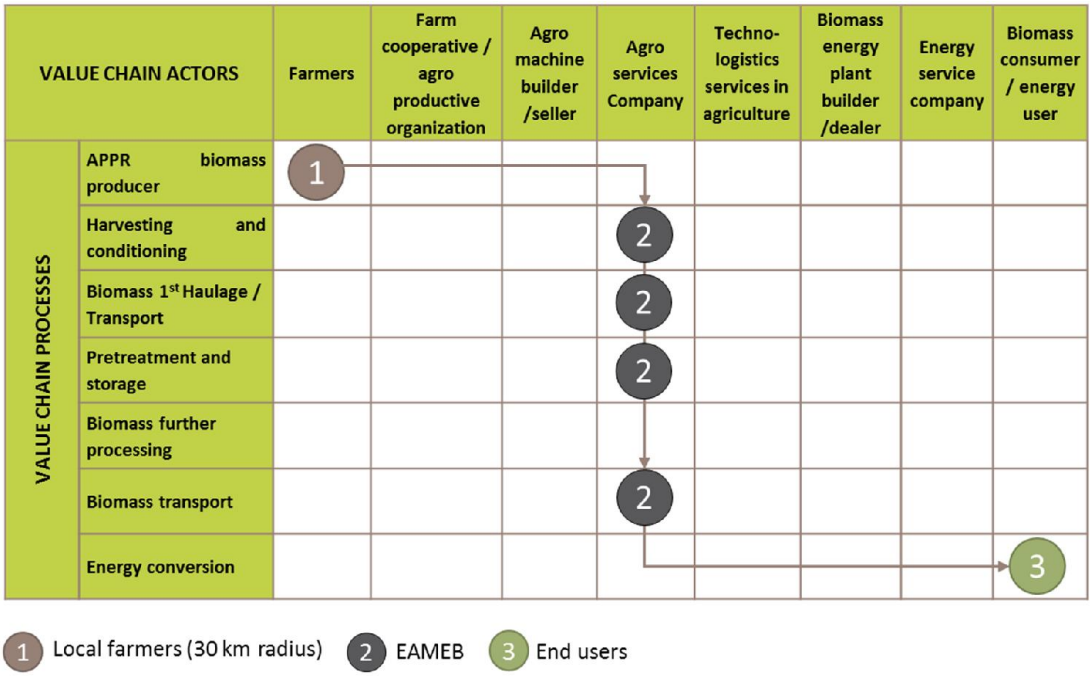

Figure 2. Role of main actors involved in the EAMEB value chain.

Table 1: Benefits of actors involved in the EAMEB value chain.

Value Chain Actor	Tangible benefits	Intangible benefits
Farmers	Save time and money in the management of large volumes of residual biomass	Avoid risks of fires and diseases Reliable uprooting service and clearing of fields
EAMEB (Biomass producer)	High quality biomass raw material collected free of charge Sales of biomass (wood chips and firewood) Sales of agricultural services – plantation removals (under certain conditions)	Development of know-how and availability of basic equipment to be employed in wood management that can be used occasionally for other purposes (e.g. management of forested areas, wood recycling)

Value Chain Actor	Tangible benefits	Intangible benefits
Final end user (biomass power plant)	Guaranteed price for electricity production from biomass Cost-effective biomass sourcing	"Greener" image of the company Closer connections with local community / fewer social objections to the operation of the biomass plants
Local community	Permanent jobs creation	Avoid fire risks Avoid air emissions from uncontrolled burning

EAMEB employs 7 persons on a permanent basis, including the company manager. The workers are organized in teams of 2 or 3 persons when performing uprooting operations, depending on the field conditions.

History / Reasons for initiating

EAMEB is the Greek acronym for the company's full name: Company for Recovery, Processing and Trading of Biomass. It started its operation in 2011 as an initiative of Mr. Giannis Ananiadis, the current company manager.

The main reason for the establishment of EAMEB was a drastic change in the local agronomic practices in the area around Veria. Until 2010, uprooting of the whole fruit trees was not a frequent occurrence; it was mainly implemented with the aim of renewing the tree crop and increasing the fruit production. From 2010 onwards, and due to the large fall in the price of clingstone peaches, a major agricultural product of the area, the producers decided to carry out a large uprooting of old varieties and planting new varieties suitable for table peach production. The frequent fluctuations in the price of this new product shaped a situation where regular uprooting became a local habit of producers and it started to be implemented with much greater frequency.

The vision of Mr. Ananiadis was the establishment of a company that could effectively collect this abundant local biomass source and upgrade it into a tradeable solid biofuel that can be used for energy production.

Since its establishment, EAMEB has gradually purchased the equipment with a total purchase value of around 500,000 €. A critical point in the evolution of EAMEB was the change in its legal form in June 2017 with the introduction of more stakeholders in the company.

Availability, harvesting and logistics of APPR biomass

On a yearly basis, EAMEB handles around 200 hectares of fruit orchards. On average, the biomass production is 50 t/ha, with the exact quantity varying depending on the tree crop type / variety,

age and agronomic practices employed. The aerial part of the trees corresponds to approximately 80 % of the total biomass, with the root system being the remaining 20 %.

EAMEB performs plantation removals all year round. The main period of activity starts at the end of May and reaches its peak from mid-August till the 10th of October.

The first step in the plantation removal process is the cutting of trees with a chainsaw. Cutting time for a typical tree crop (450 trees/ha) is a little over 6.5 h/ha. The aerial part remains in the field for a few days to dry and then treated with a KESLA C645 chipper[2]. The process of chipping is completed at a pace slightly more than 6.5 h/ha. The chipped material is transported to the storage facilities of the company. From there, it is loaded with a backhoe loader or forklift into a truck and transported to the end users.

The procedure employed for the underground part of the trees is as follows: the root is removed by an excavator, loaded on a truck and transported to the open storage. The average duration of an uprooting process is around 10 h/ha. Usually, during that process, the company employs two people (one operator to the excavator and one driver to transport the material to the storage facilities), but in some cases (due to a higher workload or more difficult weather conditions) another person is needed in loading the material. In the storage area, roots are cleaned by a worker using a chain saw. The thicker part of the root is transformed into firewood pieces, while the root offshoots are chipped with KESLA C645 and mixed with the chipped wood from the aerial part. This chipping operation takes place about 2 weeks after uprooting; meanwhile the moisture content decreases to less than 30 %, so that the material can be stored without any problems. It is worth to note that the treatment of the root offshots is more difficult than that of the aerial part of the tree and it requires a more frequent maintenance of the chipper knives.

The wood chips are stored all together; before the transportation to the final consumers, they are sorted by size in a sieving machine constructed by EAMEB. Around 60 % of the particles passing through the sieve correspond to a particle size distribution of G40 or G50 which can be used by various industrial end-users, including the local biomass power plant. An estimated 15 % of the particles corresponds to fine material (G10) which is sold as raw material for pellet production. The remaining 25 % corresponds to oversize particles which are fed again in the KESLA chipper for further size reduction.

Schematically, the main operations required for the fruit tree uprooting and the biomass production are depicted in Figure 3.

[2] Some videos of this process can be seen on the following links:
https://www.youtube.com/watch?v=VT0wvdrbxWA
https://www.youtube.com/watch?v=F4DeHZCZZ14
https://www.youtube.com/watch?v=F4DeHZCZZ14

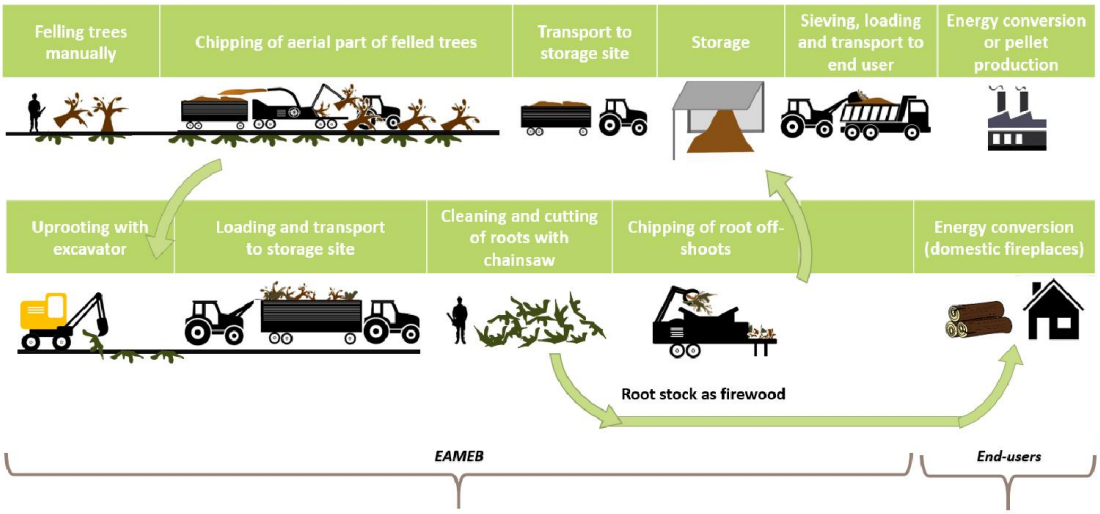

Figure 3. The uprooting and biomass production processes implemented by EAMEB.

Figure 4. Different types of wood chips produced by EAMEB (aerial part + root off shoots). Image source: CERTH.

Figure 5. The excavator during the uprooting process. Image source: CERTH.

Figure 6. Uncleaned roots after uprooting (left picture). Root off-shoots on the left and firewood from root stock on the right (right picture). Image source: CERTH.

In order to operate effectively, EAMEB has in its availability numerous technical implements, the most important of which are the following:

- KESLA C645 chipper with grabbing system (Figure 7), used to treat the aerial part of wood obtained from plantation removal.
- JCB FASTRAC 7200 (Figure 8) and Valtra T190 agricultural tractors, which are primarily used during the uprooting and other field operations. EAMEB owns two more tractors of smaller horsepower, used for secondary purposes within the storage yard.
- SERRAT Biomass 200, an integrated harvesting / shredding system, which is primarily used for collecting the pruning or other small wood pieces from the fields.

- KESLA 305T and KESLA 600 loaders.
- JCB 3CX backhoe loader.
- MERCEDES 1117 truck with a transport capacity of 16 m^3.
- Tilt trailer with transport capacity of 56 m^3.
- Tilt trailer with transport capacity of 27 m^3.
- Forklift.
- Two smaller, manually fed chippers: Junkkari HJ 5 M and Holzhäcksler GEO ECO 17 H.
- Chainsaws and wood cutting benches.

In total, EAMEB has invested more than 460,000 € for purchasing the equipment used for processing and transporting biomass from the uprooting of permanent crops.

Figure 7. KESLA C645 chipper owned by EAMEB. Image source: CERTH.

The operating costs of the whole plantation removal process mostly refer to fuel consumptions and are very variable, depending heavily on the condition of the fields and trees. Transfer of machinery from one field to the other is costly; hence, operation in quite large fields can even reduce the operating costs by half. Lubricants are also frequently applied and can be a significant cost factor. Maintenance of the equipment as well as unexpected failures are also to be considered.

Figure 8. Agricultural tractor of EAMEB, together with loader and platform. Image source: CERTH.

Moreover, EAMEB owns a roofed storage area of 800 m^2 (Figure 9) as well as its own open field of 0.6 hectares for storing biomass and equipment. On occasion, the company also rents more fields, if there is the need to store additional volumes of biomass.

Even though EAMEB possess equipment for the harvesting of pruning on the fields, currently this is not a major part of their operation; less than 1 % of the wood chips produced come from prunings. In practice, EAMEB handles prunings only if the farmers have already formed a large pile of them on the side of the field, so that they can be handled with the KESLA chipper and grabber, same as the aerial part of the plantation removals. EAMEB is interested, in principle, in expanding its business to cover agricultural prunings, since local quantities are significant. However, since the volume of biomass mobilized per hectare is much lower compared to the plantation removal cases, expanding into this type of biomass sourcing would require a very careful planning of the harvesting activities in order to minimize transport of equipment between different fields and associated costs. In such a case, a service fee (estimated order of magnitude: 50 €/ha) would probably need to be charged to the farmers to make the operation profitable. This is not prohibitory, taking into account that producers already pay for a mulching service (see section on agronomic practices below).

Figure 9. Roofed storage area of EAMEB; Mr. Ananiadis on the right. Image source: CERTH.

Soil management and agronomic practices

EAMEB operates in the Regional Unit of Imathia, in Central Macedonia, Greece and particularly in the area around the city of Veria, which is one of the primary peach cultivation centers in Greece. More specifically, permanent crops correspond to more than 40 % of the total cultivated area in Imathia. Peach trees, mostly clingstone peaches used in peach canning plants, correspond in turn to 73 % of the permanent crop surfaces of this area.

As aforementioned, the establishment of EAMEB corresponds to a drastic change in the local agronomic practices. A change in the cultivated tree variety was associated with the need to renew the trees, although it was primarily influenced by the market price of agricultural products (table vs. industrial peach). Therefore, while the expected productive lifetime was usually between 15 – 17 years for each peach tree, 30 years for apples tree and 20 years for plum tree, nowadays it is not uncommon to uproot trees of very young ages (4 years) if the farmers decide on a change of variety or crops species.

Figure 10. Peach trees in bloom in the valley of Veria. Image source: Ritsa Litsa (www.facebook.com/photo.php?fbid=1268063496660355).

Considering the uP_running project guidelines for removal of prunings for energetic utilization [1], local soil conditions in Veria are good: the soil organic matter is usually above 2 %, the annual average temperature and precipitation yield a De Martonne Aridity Index over 20, while the slope of cultivated fields is below 5 %. Additionally, the typical soils for peach cultivation are of clay loam type. It should also be noted that the typical management of prunings by local farmers is via a shredding treatment followed by topsoil incorporation, along with a grass cover of the soil. It should be noted however that EAMEB is mostly dealing with the biomass from the plantation removal (aerial part and roots) which, due to its volume, cannot be easily and economically incorporated in the soil in any case. It is also worth mentioning that the total surfaces treated every year by EAMEB correspond to less than 1.5 % of the total peach orchards in the area of Imathia; hence, it cannot be argued that the removal of biomass performed by EAMEB has a negative impact on the local soil conditions.

End use of APPR biomass

Until now, the main product of EAMEB, wood chips of various sizes (see Figure 4), was mainly assigned as a raw material in the production of pellet and briquette as well as in greenhouse convector units that could handle this material directly.

From now on, EAMEB will be the exclusive supplier of biomass fuel for a 1 MW electrical power plant, located about 15 km away from the company's main facilities. The plant was built by

Bioenegiaki Patridas (www.vioenergiakipatridas.gr). The initial capital invested for the design and construction of the plant amounts to 1,800,000 €, without any kind of subsidy being granted. A constant feed-in tariff of 198 €/MWh is foreseen for the bioenergy produced by the plant. The plant technology is based on a Chinese gasifier (Wuxi Teneng).

Within the immediate plans of Bioenegiaki Patridas is the construction of a second power plant near the municipality of Plateos Imathias, which will also be fed by the EAMEB's wood chips.

The secondary product of EAMEB, firewood from the thick part of the root, is almost exclusively directed to the domestic heating market, where it is used in appropriate appliances such as boilers, stoves and fireplaces.

Success factors and obstacles

A key success factor for the EAMEB's value chain was the high availability of APPR biomass in the area, coupled with the farmers' need to find alternative ways to manage it. EAMEB has managed to create a reliable and professional service for orchard uprooting, while expanding its activities to produce solid biofuels for different types of energy users. The fuel produced combines good quality and low price in such a way that it can be placed on the local biomass market, where there are enough consumers with considerable demand and limited fuel alternatives.

The company's efforts to study the viability of the project as well as to choose the appropriate technical equipment for the collection and management of biomass also played a major role in the success. For this purpose, trips and contacts have been made with companies abroad, from which the supply of specialized equipment was made.

EAMEB did not encounter any insurmountable difficulty since its creation. It should be noted however that the great variability of the field conditions means that not even two plantation removal operations are the same. This requires constant vigilance and fine-tuning of operations in order to maintain the profitability of the company.

Future prospective

The main challenge for EAMEB in the future is to increase the biomass volume treated / produced by 25 – 50 %, reaching a production of 10,000 – 12,000 tons per year. This requirement arises from the need to cover new local biomass demand due to the installation of one – and possibly more in the future – biomass power plant. Increasing biomass production requires an even further optimization in the use of the human and material resources of EAMEB, a challenge which Mr. Ananiadis says is something that the company can look up to.

In early 2019, EAMEB also expects to obtain a recycling permit for wood waste. This will allow the company to expand its activities in the sourcing of other wood fractions, possibly including the handling of green urban waste, something that has not been made possible before.

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[1] uP_running Project ("Take-off for sustainable supply of woody biomass from agrarian pruning and plantation removal"). "Management of pruning residues in a fruit tree plantation: gaining a positive trade-off between soil fertility and bioenergy conversion." 2nd monograph, (June 2019). http://www.up-running.eu

D6.4: Flagship success cases update v2
Annex II: ENCE Mérida power plant

uP_running

Take-off for sustainable supply of woody biomass from agrarian pruning and plantation removal

Grant agreement: 691748
From April 2016 to June 2019

Prepared by: CIRCE

Date: 07/06/2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 691748.

Introduction

ENCE Mérida is a biomass-fired power plant, located in Extremadura, Spain. It is one of the 7 biomass power plants that form the majority of ENCE's installed capacity for renewable energy. The plant started its operation in 2013 and has an installed capacity of 20 MW electric, that allows to reach an annual production of 160,000 MWh, enough to meet the electricity needs of about 70,000 people.

Even though ENCE has historical competencies in the sourcing of wood for cellulose production, the company has pursued since 2016 a policy of a more varied fuel sourcing for its power plant fleet, with emphasis on agrobiomass, including APPR biomass. The Mérida power plant is an example of this policy and currently consumes 49,000 t/y of APPR biomass (both prunings and plantation removals) from various types of permanent crops: vineyards, olive groves and fruit trees. In total, APPR biomass amounts to almost 30 % of fuel mixture (on a tonnage basis), which is the highest share achieved in the biomass power plants of ENCE.

ENCE Mérida was selected as an uP_running flagship case because it corresponds to a case of very large APPR biomass mobilization, which was developed taking advantage of the need of an existing consumer to diversify its fuel sourcing for both market and sustainability reasons.

Figure 1. Photo of Mérida power plant [3].

Figure 2. Location of ENCE Power Plant in Mérida (Spain).

Table 1. The ENCE Mérida power plant flagship case at a glance.

Pelets de la Mancha at a glance	
Location	Mérida, Spain
Type of APPR involved	Both prunings and plantation removal
Permanent crop species used	Vineyards, olive trees, fruit trees
Year of initiation	2013 (plant commissioning); 2016 (sourcing of APPR biomass)
Volume of biomass mobilized (tonnes per year)	168,000 t/y in total, being the share as following: • 45 % from forestry wood • 55 % from agrobiomass (93,000 t/y), see the principal resources in page 7. The APPR biomass represents a half of the agrobiomass sourcing, i.e., 49,000 t/y
Surface area with permanent crops mobilized (ha)	Around 5,000 ha
Maximum radius of operation (sourcing)	Up to 100 km for agrobiomass (average is around 30 - 60 km) Up to 200 km for forestry biomass
Main product	Electricity

CO_2 emissions avoided[1]	81,349 tCO_{2eq} per year; of these, the avoidance of 23,591 tCO_{2eq} per year is due to the sourcing of APPR biomass
Number of jobs created*	24 direct (for O&M) 370 indirect jobs (for biomass supply)
Total level of investment	The total investment was 80.9 M€, from which 64.3 M€ corresponded to the industrial investment (3,215 €/kW_e installed)

** Employment data for the whole plant, not only for agrobiomass.*

Business model

The supply model for the different types of agro-biomass in the Mérida plant involves three main actors: farmers, agricultural services companies and ENCE plant.

The strategy of ENCE is to go directly to the origin, that is, to the owner of the biomass. In the case of APPR biomass, the owner is the farmer or cooperative that generates the wood from pruning and plantation removal operations. ENCE agrees with them to remove the biomass and then hires an agricultural service company and / or a transport company. There are two main alternatives for the collection of woody agricultural biomass:

- Alternative 1: in those cases where it is necessary to enter into the fields in order to carry out a service (remove the plantation, collect the pruning, etc.), the farmer pays ENCE for the service and ENCE subcontracts a company to do it. From the farmers' point of view, the service and its cost are the same as before. The advantage is that the farmer does not have to burn the APPR wood.
- Alternative 2: in the case where the farmers leave the pruning at the field side (as they did in the past to carry out the open burning), ENCE collects the biomass for free (sending a transporter or using their own means).

One of the keys for the effective mobilization of agrobiomass residues in the area has been the existence of a wide variety of companies that provided services to the coal industry, as well as forestry and environmental companies. These companies with experience in the mobilization of coal and biomass, and with useful assets for the mobilization of APPR biomass have reoriented their activity partially towards the provision of agricultural services, in particular pruning and plantation removal collection. These companies have, in many cases, a profile of a young and innovative

[1] For the estimation of the CO_2 emissions avoided in the Mérida power plant case, the following assumptions are made:

- The total biomass consumption is 168,000 t/y. The average lower heating value during combustion is 12.0 MJ/kg.
- No GHG emissions for the operation of the logistics chain are considered.
- The plant electrical efficiency is equal to 24.5 %.

The CO_2 savings are calculated using the Fossil Fuel Comparator for electricity production adopted in the final recast of the RED II Directive: 183 gCO_{2eq}/MJ; a default value of 90 % savings is considered taking into account emissions incurred to the biomass fuel logistics.

company, well connected to the field and the farmers, and interested in developing new businesses. These companies usually have machinery suitable for the extraction of APPR biomass, machinery in many cases already amortized, multi-functional and robust, which they use to perform service to farmers or rent directly.

Figures 3 and 4 show the role of each one of the actors involved in the mobilization of pruning and plantation removal, respectively.

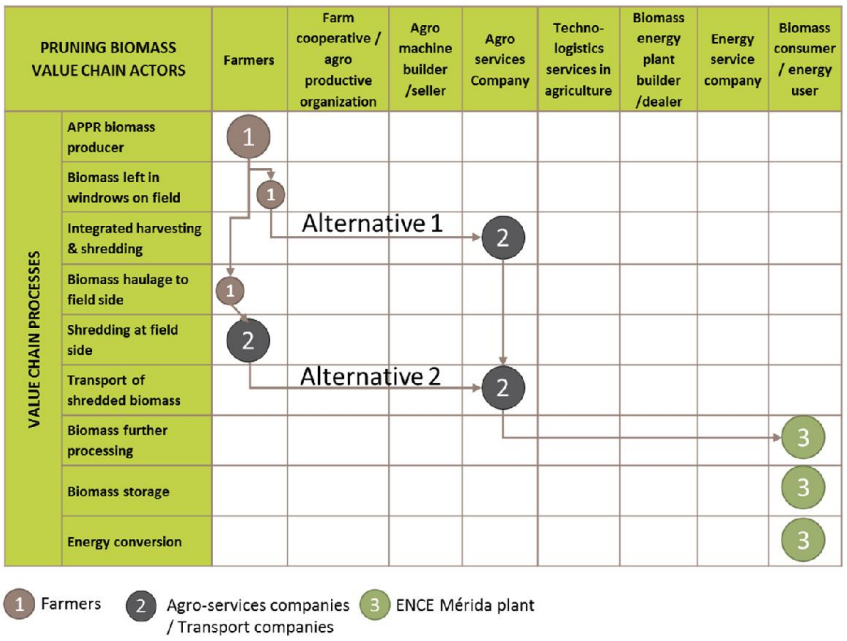

Figure 3. Roles of actors involved in ENCE Mérida pruning biomass value chain (alternatives 1 & 2).

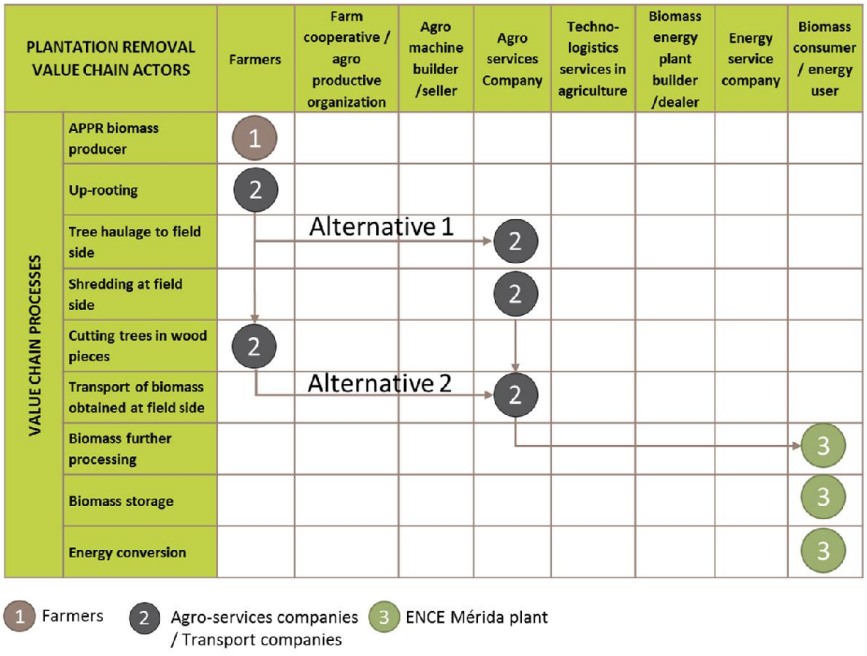

Figure 4. Roles of actors involved in ENCE-Mérida plantation removal wood value chain (alternatives 1 & 2).

The main benefits for each of the three types of actors are shown in Table 2.

Table 2. Main tangible and intangible benefits for the agents participating in the APPR biomass value chain for ENCE.

Value Chain Actor	Tangible benefits	Intangible benefits
Farmers	Saves or does not waste more time than in the previous APPR management. The service is the same as before, except that now farmers have avoided the burning.	Avoid the management of burning permits, and be aware of the weather Avoid the risk of generating a fire Vine and olive: reduces the probability of diseases in the plantation
Agrarian services companies	Economic income New service line that allows the machinery to be amortized more quickly	More diversified activity and dedicated to a new niche market New line of business Stability of the employees
ENCE	Lower logistics and supply costs	Sustainable image of the company Closeness with local authorities and farmers in the area Greater degree of acceptance of the plant in the area

History / Reasons for initiating

ENCE is the largest private forest manager in Spain. The company has a **great experience in biomass supply from forestry and agroforestry management**, due to 60 years of experience in cellulose production. Initially, ENCE developed its biomass power and cogeneration business line in order to take advantage of wood fractions that were not suitable for cellulose production (e.g. bark), while displacing fossil fuels used to produce process heat. The company has continued on this business line and is currently the Spanish leader in biomass power production: in total, ENCE owns 280 MW of installed power with renewable energy, of which 170 MW are from biomass in a total of 7 plants ranging from 16 to 50 MW electrical [1].

ENCE decided to bet on agrobiomass five years ago, starting from its biomass power plant in Huelva. Gradually, agrobiomass became one of the most strategic resources for the company along with others such as forest biomass or energy crops (initially projected as the most favourable alternative for the feasibility of these plants). This innovation in fuel supply was motivated by the advantages that APPR biomass utilization could offer: cheaper extraction, good calorific value, local abundance, lack of alternative uses and avoidance of emissions from its uncontrolled burning in the field. In the particular case of Mérida power plant, the local agricultural characteristics and the large surfaces cultivated with permanent crops allowed APPR biomass to contribute to an even greater share in

the fuel sourcing, amounting to around 30 % of the total biomass used and 50 % of the total agrobiomass, on a tonnage basis.

To ensure a stable supply of agricultural biomass (around 50 % of it coming from APPR), multiple workshops and meetings were held with farmers in the area to explain the advantages of using their biomass for energy recovery instead of burning it on field. The service companies joined the initiative relatively easily by assuring them employment, economic gains, and explaining the value they could have for the region by avoiding greenhouse gas emissions, stabilizing jobs, etc.

Availability, harvesting and logistics of APPR biomass

ENCE currently uses a mix of biomass fuels of 55 % agricultural and 45 % forestry origins in its Mérida plant. The forestry biomass used in Mérida comes mainly from poplar, eucalyptus and pine, using also residues obtained in the forest such as stumps, branches, leaves and bark. The stem is not used in the plant since it is exclusively utilized for sawmills, panels, etc., in order to comply with the sustainability Decalogue of ENCE [2]. Since 2016, ENCE has made a turn-around in its supply strategy, betting on more local biomass, of agricultural or agroindustrial origin, and which had hardly any use at present and represented a management problem for most farmers. ENCE has made a commitment to the re-orientation of its supply, dedicating an important effort, which has allowed that in two years the share of agro-biomass consumption has gone from 10 % to 55 % today. This radical shift has been facilitated by the high availability of agricultural biomass in the area, as well as the work of alignment of actors in the agricultural sector to release different types of agricultural residues. Among them the followings:

- Agricultural woody biomass:
  - Derived from pruning: mainly olive groves and vineyards, but also fruit trees (citrus fruits, stone fruit trees, tropical fruit trees, etc.).
  - Derived from plantation removal: olive groves, citrus fruits, stone fruits, etc.
- Agricultural herbaceous biomass:
  - Cotton and tomato stalks.
  - Straw that has no use for animal feed: mostly corn, rapeseed and rice straw.
  - Residues from tobacco cultivation.
- Agro-industrial residues, including:
  - Olive leaves collected from olive mills.
  - Grape scrap & grape cake.
  - Olive cake.
  - Cork sawdust.
  - Residues from essences production.

ENCE has been able to verify in this transition period from 2016 to 2019 some of the advantages of using biomass from agricultural origin: among them its sustainability, since otherwise some of these resources would be burned in the field (they do not compete with other uses), and the existing agricultural logistics (compared to the more complicated logistics of biomass from forest origin). On the contrary, ENCE has identified the execution times as a limiting factor for agricultural

biomass: the profit margin is very narrow and there must have a very good coordination among the farmers and the services companies in order to provide the service to all. It takes a lot of efforts to move numerous machineries and people at the same time.

The collection of biomass can be carried out according to two main schemes, where ENCE participates as a final consumer, and the transfer of biomass is carried out by service companies. On the one hand, there are companies that offer pick-up service to the farmer and use shredders dragged by tractor that harvest, shred and accumulate the material in a hopper or in a trailed trailer (see Figure 5 and Figure 6). A second alternative derives from farmers accustomed to forward pruning to piles and burn at field side. In these cases, the farmers accumulate the branches in accessible places for the machinery of the service companies, which perform the collection (see Figure 7 and Figure 8).

Figure 5. Overview of the ENCE Mérida plant's pruning value chain (alternative 1- farmers let pruning on field).

Figure 6. Photos of olive pruning collection with a shredder towed by tractor [4].

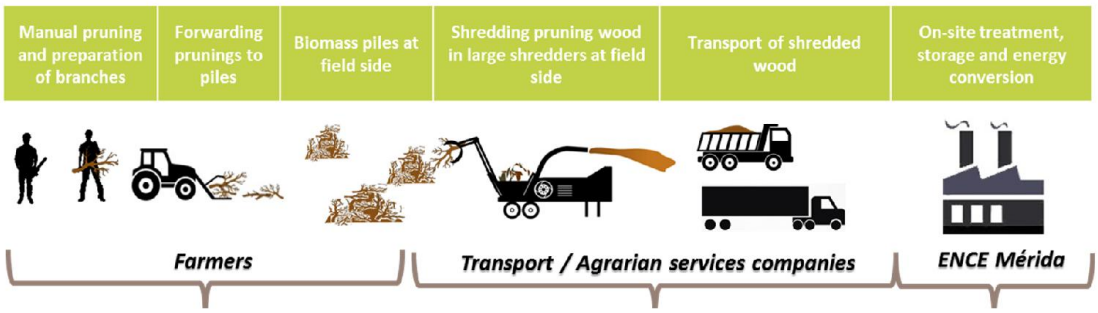

Figure 7. Overview of the ENCE Mérida plant's pruning value chain (alternative 2- farmers forward at field side).

Figure 8. Photos of the collection of fruit pruning branches hauled at field side [4].

On the other hand, the biomass obtained from plantation removal of olive, fruit and vineyards is treated by means of another type of larger machinery to execute both the up-rooting and the haulage (bulldozer, tractors, excavators, etc.) and semi-mobile shredders of high power (mounted on truck/trailer with spider). These machines are transported in an area adjacent to the plantation and perform shredding. This alternative is presented in Figures 9 and 10.

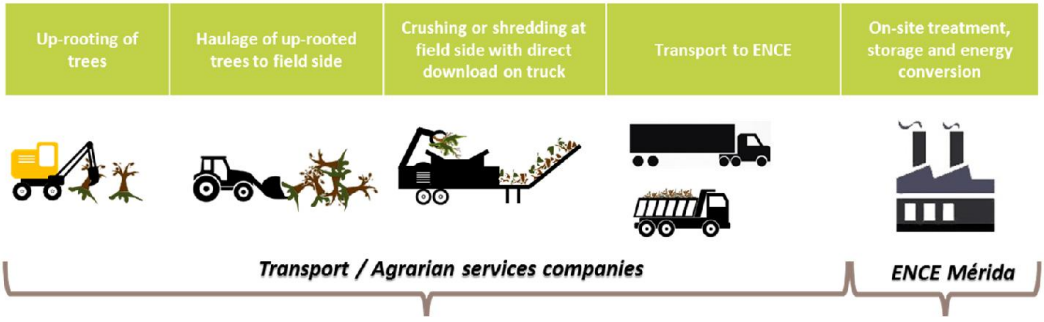

Figure 9. Overview of the ENCE Mérida plant's plantation removal wood value chain (alternative 1): up-rooting, haulage and shredding at field side.

Figure 10. Photos of the intermediate storage of fruit tree removal, and the shredding with direct discharge on truck [4].

The plantation removal biomass is sometimes obtained in the form of tree cutting. This practice was already usual for the preparation of firewood, from both the aerial part and the root. In the present case, the cutting is not separated and classified manually, as is the case when the objective is to produce firewood; rather, it is piled up, mixing pieces of higher and lower quality, and it is loaded on trucks to be transported directly to the ENCE plant. This biomass is crushed and shredded before being fed to the boiler. In some occasions, shredding may also be performed at intermediate storage. Figures 11 and 12 present the way in which this operation is carried out.

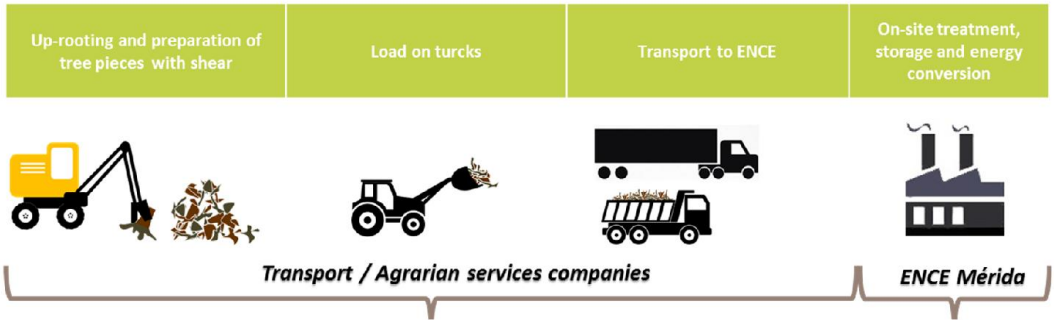

Figure 11. Overview of the ENCE Mérida plant's plantation removal wood value chain (alternative 2): up-rooting and tree cutting.

Figure 12. Photos of the collection of olive groves already up-rooted and cut, and their load on a truck [4].

Soil management

ENCE develops its biomass supply activities according to its own Decalogue for Sustainability [2], in which among others are considered aspects such as:

- Approach and sectorial support, and collaboration with local farmers.
- The forestry stem-based wood is not used (priority is given for sawmills, boards, cellulose, etc.). Diameter greater than 10 cm, or invasive species wood, also are not used.

- Do not compete with other preferred uses of biomass (food, livestock, construction, etc.).
- Do not consume biomass from energy crops that were grown in agricultural land suitable for food production.

In accordance with its sustainability Decalogue, ENCE avoids the use of agricultural residues the removal of which has a negative impact on the "soil" resource in terms of fertility and structure.

Currently, ENCE collects the pruning and plantation removal of about 5,000 hectares in a radius of 60 km around Mérida; this corresponds to only 2.7% of the total area cultivated with permanent crops in this radius. That is why there is no massive call on the whole area cultivated, and that are the farmers or managers of the olive, vine and fruit farms who make the decision on the best destination they can give to their APPR wood residues. In this sense, burning is the usual practice, except in some cases for olive groves. That is why removing the wood from pruning and plantation removal does not mean reducing the current contribution of carbon to the soil.

From the uP_running project, and according to the guidelines and recommendations developed [5], the evaluation of soil conditions is based on the organic matter content of the soil, the texture of the soil, the aridity index of the agro climatic zone (according to *De Martonne Index*), and the type of slope. It is not advisable to remove the pruning in areas with a slope is higher than 5 %, especially in areas subject to aridity and with poorly balanced soils (subject to erosion or compaction). Although the overall set of farms cannot be evaluated easily, it is possible to indicate that the area around Mérida contains both semi-arid and wet zones, always above the minimum limit proposed by uP_running (Martonne Index above 20). On the other hand, among the practices that contribute to maintaining organic carbon in agricultural land, the maintenance of vegetation cover is fundamental. In this respect, the cover on the olive, vine and fruit farms in Extremadura does not carry out any tillage or maintain the vegetation cover (spontaneous or sown) [6]. Likewise, almost 30 % perform a minimum tillage, oriented to eliminate spontaneous vegetation without performing a deep tillage, so that soil carbon losses are limited. That is why the area around Mérida is not *a priori* incompatible with the use of pruning and plantation removal wood, although each case must be observed separately. Hence, the decision is in hands of each farmer or cooperative.

End use of APPR biomass

Biomass of agricultural origin is supplied to the Mérida plant in a multitude of formats. That is why the plant has a classification and treatment system for each type of batch. Thus, in the reception of the material at the plant storage area there is staff that classifies the biomass and that verifies that the delivery note corresponds to the product brought by each truck. According to established quality standards (content of exogenous materials, stones, etc.), the material is accepted or rejected. It is verified that the material is clean and homogeneous (it does not contain a mixture of different types of resources), and it is classified according to its type and format: branches, shredded or pre-shredded material.

If the material that arrives at the storage area is brought by an external supplier, it is paid according to the moisture content of the lot. If the material has been collected by ENCE, the moisture content is not measured.

Once stored in the plant, the cut wood or pre-shredded material passes through a large shredder in order to adapt its particle size to the combustion facility. Then, a conveyor belt and a system of augers are responsible for bringing the biomass to the boiler. This was built by the company TERMISA Energía, and initially designed to operate with woody biomass from Short Rotation Coppice, such as eucalyptus and poplar. The boiler accepts biomass with a moisture content of up to 40 %.

This boiler, initially designed for forestry wood, cannot operate only with leaves and fine particles, i.e., it always needs a certain percentage of wood. Before operating with a new fuel, ENCE always performs some feeding and combustion tests. Currently, the facility operates with a mix of different biomasses, consuming an average of about 18 tons per hour of biomass to produce 20 MW of electricity.

The combustion system consists in a vibrating grate cooled by water, with high speed air injection and temperature, which results in high boiler efficiency of 91 % [6]. Moreover, a specific gas filtering system is used to clean the gas before they are discharged to the atmosphere.

Figure 13. *Photo of ENCE biomass plant in Mérida [6]*

Success factors

The following are the main keys that have allowed the initiative to be implemented and be successful:

- The change in the biomass support framework made that ENCE redirected its supply strategy (initially oriented towards the implementation of forest energy crops), looking for available resources in the short term.
- Quick reorientation of ENCE to include all types of agro-biomass that until now were largely under-utilized.
- Solvency and trajectory of ENCE as a biomass consumer, which generate confidence in the intermediate companies when facing new activities and investments (consumption of agro-biomass ensured to suppliers).

- High experience of ENCE in forest biomass logistics. The new agro-biomass logistics is simpler than forestry, although it needs more speed to be removed from the field so that farmers can continue with their agronomic operations.
- Very high potential of agro-biomass in the area.
- Existence of companies with knowledge and devices to mobilize agro-biomass in the area (companies engaged in forestry work or previously dedicated to coal).
- ENCE's extensive knowledge of the biomass sector, as well as contacts with key agents in the area for its mobilization.
- Farmers are aware that they cannot continue to burn their residues. They prefer to use them for energy, as long as it does not cost them money.

Lessons learnt

- Need for an organization that is very committed internally to put in place the necessary procedures / strategies and provide the appropriate guidelines.
- Establishment of dialogue and trust with farmers and supply companies, so that APPR supply chains can reach a successful conclusion.
- Need to coordinate logistics operations very well so as not to incur extra costs in the supply chain.
- Boiler improvements to work with such a wide range of fuel. Many trials have been carried out (and are still being done). Always work with a certain percentage of wood (be it forestry or agricultural).
- ENCE started from scratch with this agricultural biomass. ENCE had to carry out many tests in the field and find the most appropriate ways to collaborate with farmers, find agreements, identify agricultural service companies that are ready to innovate, etc.

Future prospective

- To continue increasing the percentage of agricultural biomass in the fuel mix.
- To optimize the combustion process so that the greatest possible variety of biomass can be efficiently burned.
- To develop hybrid thermosolar / biomass systems for electricity generation. ENCE has placed a strong bet on this line, buying the 50 MW plant in Puertollano from IBERDROLA.

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D6.4: Flagship success cases update v2 Annex: The Gospodarstwo Sadownicze flagship case

uP_running

Take-off for sustainable supply of woody biomass from agrarian pruning and plantation removal

Grant agreement: 691748

Prepared by: SECB & CERTH

Date: 07.06.2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 691748.

Introduction

The company Gospodarstwo Sadownicze is mainly focused on good quality apples and juice production. The company has 36 ha of apple orchards (main apple tree varieties are Jonica, Jonagored, Jonagold, Fuji, Gala, Mutsu, Golden Delicious, Sampion, Eliza and Idared) in the Mazovia Province – the region of Poland where a quite large biomass potential from pruning is observed. In Mazovia Province more than 103,000 ha of orchards are available, and more than 77,000 ha are apple orchards. It has been calculated that the theoretical regional pruning potential is in the range of 287 GJ/yr.

Gospodarstwo Sadownicze is the local pioneer that started a commercial APPR biomass value chain several years ago. Gospodarstwo Sadownicze is an example of a farmer-driven initiative for APPR utilization; it was selected as an uP_running flagship case for a number of reasons: First, it is based on the most widely cultivated permanent crop in the EU (excluding olive trees and vineyards): apple trees. Moreover, it is an example in which APPR biomass is harvested by a baler and used directly in bale form. Finally, a distinct feature of this value chain is that the biomass collected is not intended for self-consumption even though it is a farmer driven initiative. Rather, the bales of APPR biomass are sold to the municipal administration whose buildings have been successfully heated using this type of biomass since 5 years or even more.

Figure 1: The logo of Gospodarstwo Sadownicze and company's buildings (Source: Gospodarstwo Sadownicze).

Figure 2: Location of the Gospodarstwo Sadownicze.

Table 1. The Gospodarstwo Sadownicze flagship case at a glance.

Gospodarstwo Sadownicze at a glance	
Location	Komorów, Poland
Type of APPR involved	Prunings
Crop species used	Apples
Year of initiation	2013
Volume of APPR mobilized	~ 130 t/y (dry basis) delivered to final consumers
Surface area with permanent crops mobilized	140 – 220 ha (it varies annually)
Maximum radius of operation	Less than 1 km from the company headquarter (baling operation) Around 6 km (considering the bale transport to final consumers)
Main product	APPR biomass in bales used for heating municipal buildings

Gospodarstwo Sadownicze at a glance	
CO_2 emissions avoided[1]	147 tCO_{2eq}/year
Number of jobs created	N/A (all the value chain operations are performed by the employed workers in the company managing the orchard)
Total level of investment	28,500 € for the WOLAGRI pruning round baler 5,000 € for the carriage trolley

Business model

The farming company Gospodarstwo Sadownicze provides for the mobilization of APPR biomass in its apple orchards as well as in the nearby orchards of other farmers. Gospodarstwo Sadownicze is organizing the winter collection of apple tree pruning using an integrated windrowing-harvest-balling technology. The round bales of prunings are left on the internal roads of the farm, near the orchards. The bales dry up until they are loaded and transported to final consumers.

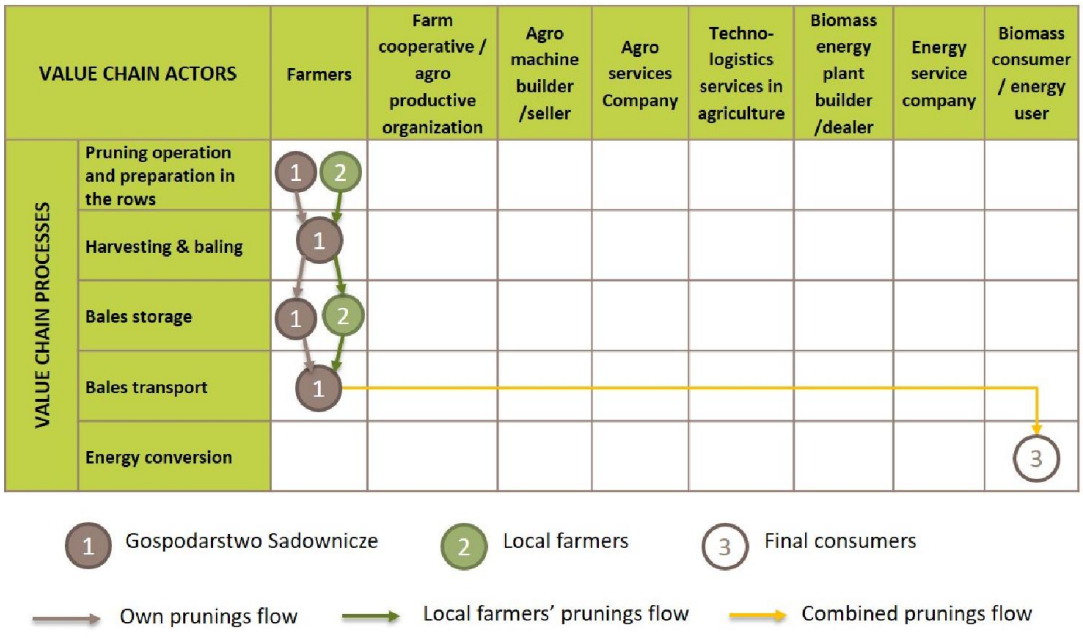

Figure 3: Role of actors in the Gospodarstwo Sadownicze case.

[1] For the estimation of the GHG emissions avoided in the Gospodarstwo Sadownicze case, the following assumptions are made:

- The consumption of pruning bales is 130 t/y (dry basis). The average moisture content during combustion is 15 %, with a typical LHV of 15 MJ/kg.
- No GHG emissions for the operation of the logistics chain are considered.
- The thermal efficiency of the heating boilers is equal to 80 %.

The CO_2 savings are calculated using the Fossil Fuel Comparator for heat production found in Staff Working Document SWD(2014) 259 (also adopted in the latest draft of RED II), which is equal to 80 gCO_{2eq}/MJ.

Gospodarstwo Sadownicze organizes the whole logistics, from pruning (only in its own orchards) to the delivery of the biomass to final consumers. The harvesting and transport machinery (a tractor, a pruning baler and a carriage trolley) are owned by the company. Expenses for harvesting and baling of prunings should be taken into account, conversely there are also savings: "infected" branches are removed from the orchards, lower pesticides are used by the farmer, the productivity and quality of the apples improve, the mulching process is avoided, etc. Gospodarstwo Sadownicze provides a pruning removal service also for other neighbouring farmers and collects the pruning residues free of charge.

The bales of prunings are used for heating the municipal buildings in the village of Wieniawa: the Municipal office and the Secondary School Complex, which are at a distance of about 6 km from the orchards. The pruning-to-heat initiative of the Gospodarstwo Sadownicze has the approval of the local municipal authorities. The final consumers buy the bales under the terms of delivery. The price is estimated as an average price of fuelwood (PLN/Mg d.b.) announced by GUS (Central Statistical Office of Poland). The fuel supply contract is quite flexible; Gospodarstwo Sadownicze is not obliged to deliver any specific number of pruning bales to the end-users, which continue to rely on straw bales, sourced from numerous suppliers, as the main fuel. However, since pruning bales are cheaper than straw bales, the municipal authorities have good reason to prefer this kind of fuel.

Table 2. Benefits for the actors participating in the Gospodarstwo Sadownicze case.

Value Chain Actor	Tangible benefits	Intangible benefits
Gospodarstwo Sadownicze	Get economic margin Save time and money in pruning management	Promote successful utilization case of prunings Avoid risks of fires and diseases "Greener" image of business
Other local farmers	Save time and money in pruning management	Avoid troublesome task in the open-field burning of pruning Reduced risks of disease propagation
Final consumers (municipal buildings)	Lower fuel price, less problems with slagging and fouling of the boilers during the combustion process (in comparison to straw bales)	Diversification of energy sources and decarbonisation of heating systems Support the local energy sources and local economy Improved air quality

History / Reasons for initiating

The prime mover behind the Gospodarstwo Sadownicze flagship case is the owner of the company who wanted to get rid of the winter prunings because of the infection, bacteria and fungi content in the prunning biomass. In the previous pruning management, before the new value chain get

started, prunings were removed from the rows of the orchards and collected in piles using a tractor with a pitchfork. The largest pieces of the prunings were picked out and used as firewood for heating the owner's house. The remaining prunings were burned in piles on-site.

The prime mover is against biomass burning on site considering it is a waste of potential useful energy. Therefore, he considered two options: chipping on-site or baling. He came to the conclusion that baling would be the fastest and cheapest way to harvest and store the biomass. However, before the final decision, he performed a local market assessment to check the consumer demand for biomass bales, e.g. if there were boilers designed for bales combustion in the neighbouring areas. A straw bale boiler was already operating in the municipal office of Wieniawa since 2004; however, the main turning point was the installation of another straw bale boiler in the Secondary School Complex. This increased the number of potential final consumers interested and capable of using the pruning biomass in the form of bales and allowed the farmer to proceed with his intended strategy, since a reasonable return on the required investment could be expected. As a result, Gospodarstwo Sadownicze purchased a pruning baler from an Italian manufacturer. A good argument to be discussed with the final consumers was the fact that the heating price would remain the same, or even lower, with respect to the use of straw as fuel. Such activity would provide a great support to the local community by using local energy sources.

Availability, harvesting, and logistics of APPR biomass

The apple trees are pruned manually twice a year. The main pruning is performed in the winter/spring period (the amount of biomass from the summer pruning is very limited, and is left on the field). Pruning is done manually; after cutting, the workers throw the branches in the middle of the row. All (big and small) winter/spring pruning/branches are harvested using a baler and stored on site along the internal farm roads. As a result, drying of the bales takes place in the open air.

The logistics chain is as follows:

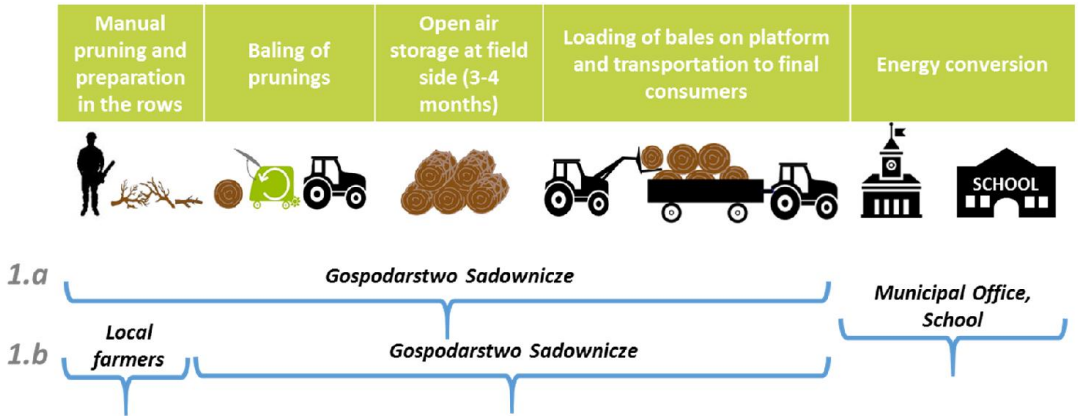

Figure 4: Logistics operations in Gospodarstwo Sadownicze.

The apples in the Gospodarstwo Sadownicze orchards are grown in several separate fields located at a distance of up to 1 km from one another. The age of trees is from 1 to 20 years. They are

planted with the density of 2,800 trees/ha (width between rows is 3.5 m, and the distance between trees along the rows is 1 m).
Usually, 600 to 900 kg (d.b.) of woody biomass from a hectare is obtained during the main pruning (net of collection losses). Before harvesting, prunings lie on the soil from 1 to 30 days depending on the weather conditions.

The farmer is using the baler Columbia R98 by WOLAGRI attached to a 74 HP tractor (KUBOTA M7040) performing an integrated windrowing – harvest – baling operation of APPR biomass. It takes approximately one hour to the baler for 1-hectar of pruning harvesting. The diameter of the bale is 0.9-1.0 m, and its height is 1.2 m with a weight of 0.160-0.180 tons (d.b.). The farmer uses the baler for one month per year. The company itself performed a few minor modifications to the baler in order to have a more efficient baling process for this particular type of prunings.

Figure 5: Baler Columbia R98 (WOLAGRI) used by Gospodarstwo Sadownicze (Source: Dr. Dyjakon, Gospodarstwo Sadownicze).

The estimated losses of biomass are from 5 to 10 %. The remained prunings in the orchard rows are left untreated or mulched during grass cutting.

In the farmer`s opinion, the minimal size of the orchard to be attractive to harvest prunings for energy is 5 ha, and to buy the baler and to use it effectively it is necessary to provide its operation on a surface of more than 100 ha.

The bales of pruning are left at the ground near the orchards in the open air. Here, they are stored for a time frame from 90 to 180 days. During the storage period, the moisture content of biomass is reduced to 12-18 % (depending on the weather/season). There are storage losses of approximately 1 % caused by the biomass degradation.

Figure 6:: Storage of the bales near the orchard (Source: Dr. Dyjakon, Gospodarstwo Sadownicze).

Gospodarstwo Sadownicze provides transportation of the bales of prunings to the boiler houses on request of the final consumers. For this operation, a tractor with a 2-axis transportation platform it is used; it has a volume capacity of 28-30 m^3. One platform can transport 28-30 bales (4.5 – 5.4 t of dry biomass per load). The same tractor does the loading/unloading operations. Alternatively, a forklift to load the bales is in use.

Figure 7:: Transportation platform for bales (Source: Dr. Dyjakon, Gospodarstwo Sadownicze).

The transportation distance of the bales from the storage sites to the boiler houses is approximately 6 km. The price of the pruning bale to the final consumer is 50 PLN/bale, currently equivalent to 12.0 - 12.5 €/bale . Depending on the moisture content, the price ranges from 55 – 69 €/t; for comparison, the price of a straw bale ranges from 60 – 75 €/t (35 – 50 €/t, plus delivery costs).

Soil management and agronomic practices

The agronomic practices applied to the orchards are aimed at preserving the soil quality. Only winter pruning is collected for energy use, in contrast to summer pruning that is left at the field and mulched on the soil. The soil of the orchard is covered by grass, which is mowed as well – thus obtaining a further source of soil organic matter.

Fertilizing and pest management in the fields are accomplished in accordance with IPO (Integrated Fruits Production) and in line with the GLOBAL G.A.B. certification.

Figure 8: Apple orchard of the Gospodarstwo Sadownicze (Source: Dr. Dyjakon, Gospodarstwo Sadownicze).

End use of APPR biomass

There are not large heat or power plants in the area near Gospodarstwo Sadownicze, but there is the potential for middle/small size heating units. The main problem is to convince energy consumers to use such biomass for heating their buildings/houses/offices. The problem of the farmer is to start selling the biomass, because people have doubts about using such a new kind of fuel.

In Wieniawa, the Municipal office and the Secondary School Complex have straw-bale fired boilers, which have been installed in 2004 and 2012, respectively. These consumers decided to start using the pruning bales several years ago. Now, both consumers are satisfied because the LHV of the prunings is higher in comparison with straw. Two bales of pruning equal to three bales of straw. Moreover, there are less problems with slagging and fouling in the combustion chamber of the boiler compared to straw combustion. This latter feature, together with a lower ash content as compared to straw (1 % vs. 3-6 %), represent a positive fuel quality.

Figure 9: Close-up of the apple tree prunings in the bales (Source: Dr. Dyjakon, Gospodarstwo Sadownicze)

The municipal office in Wieniawa has two water boilers with a nominal thermal output of 600 kW and 250 kW respectively. The two boilers together consume about 400 t of biomass (on a dry basis) per year; 40 t (10 %), equivalent to 200 bales/year, are now coming from pruning bales, while the rest from straw bales.

Figure 10: Boiler house in the Municipal office in Wieniawa (Source: Gospodarstwo Sadownicze).

Figure 11: Combustion chamber of the boiler in Municipal office in Wieniawa (Source: Gospodarstwo Sadownicze).

The Secondary School Complex in Wieniawa has two water boilers with a nominal thermal output of 300 kW each. Both boilers consume 352.5 t of biomass on a dry basis annually, of which 90 t (500 bales/year) are pruning bales.

Figure 12: Boiler house of the Secondary School Complex in Wieniawa (left) and bale storage (right) (Source: Gospodarstwo Sadownicze).

Figure 13: Combustion chamber of the boiler in Secondary School Complex in Wieniawa (Source: Gospodarstwo Sadownicze).

No specific issues have been observed with the use of pruning bales as a fuel; it is considered that even higher efficiencies could be reached by the adoption of a gasification boiler.

Success factors and obstacles

The owner of Gospodarstwo Sadownicze is against the burning of prunings in the open fields. He has a strong belief that pruning can be an effective energy carrier while avoiding infections and diseases from leaving the prunings on the field. It brings additional incomes and develops local energy sources for heating. The region is partly independent from external energy sources, and the local biomass market has been developing, which is good for the local community. The owner of Gospodarstwo Sadownicze took 2 seasons to start a new approach in biomass collecting for energy purposes for.

The key success factor was to develop a new value chain under specific local conditions, based on the effective machinery and the use of existing opportunities, e.g. the place near the internal farm roads for the bales storage, on-field biomass drying, etc. The identification of final consumers able and willing to use this type of APPR biomass (bales of prunings) was another key factor for the success of the value chain.

The absence of a deeper pruning processing (such as chipping, pelletizing, etc.), the burning of the whole bale, and the low distance of biomass transportation (up to 6 km) allow minimizing costs as well as reducing significantly greenhouse gas emissions.

The project was implemented with the company's own investment capital. No public funds were used to finance the project.

No major obstacles for the implementation of this value chain were observed; it should be noted, however, that a key issue for the replication of such a chain is the presence of final consumers capable of using biomass in the form of bales and with an interest in using pruning bales.

Lessons learnt

Performing pruning harvesting activities with the baler is a fast and easy way to clean the orchard from branches. Prunings of different sizes are collected and baled.

If prunings and soil are very dry, dust can be a serious threat to the operator's health during pruning harvesting. Protecting the respiratory organs of workers is therefore necessary.

The biomass prices in the local fuel market are stable. However, it is not easy to enter in the market with a "new" fuel. The price of the fuel is of course very crucial; it must be quite attractive from the buyer's point of view.

A market research must be performed obligatory, to be sure that in the long time period there will be final consumers (public or private entities) interested to burn prunning biomass bales. Differently, farmers must take into account the need of purchasing an additional machine (shreeder and pelletisation or bruiquetting devices) to reach the condition to sell a biofuel obtained from pruning. A good market researh is a crucial point to decide about the feasibility of the value chain and its possible final succes.

Future prospective

Finding suitable boilers for the direct combustion of bales (according to manufacturers' requirements) is the preliminary condition for increasing the amount of APPR biomass for energy. In fact, there are not too many combustion/gasification boilers fed with pruning bales near Wieniawa. The Gospodarstwo Sadownicze has found a new consumer for APPR biomass bales recently. The 3rd final consumer (a healthcare house) is located 2 km from the orchard. Some initial discussions and a preliminary agreement has already been reached; no further information regarding this commercial case is available at the moment.

Gospodarstwo Sadownicze is also interested in using APPR for their own self-consumption. The company is still looking for some funding opportunities, considering that the investment would be quite large.

Other farmers in the area visited Gospodarstwo Sadownicze to study their experience. The farmers are still focused only on apple production and have very strong habits concerning APPR usage. Pruning are just obstacles/residues they want to get rid very fast. The pruning-to-energy business is not so attractive yet, and it requires the market research, etc. Farmers do not feel yet the environmental responsibility to change the energy policy in their rural area. Education of farmers could be the way of disseminating the effective usage of APPR biomass for energy purposes.

Contact information and acknowledgements

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The uP_running project team would like to acknowledge the following individuals for providing data, input and their insights for the flagship cases presented in this report. They have agreed to be cited.

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D6.4: Flagship success cases update v2
Annex IV: The Triada-MK flagship case

uP_running

Take-off for sustainable supply of woody biomass from agrarian pruning and plantation removal

Grant agreement: 691748
From April 2016 to June 2019

Prepared by: SECB

Date: 07.06.2019

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Introduction

Established in 2014, Triada-MK is currently a multi-profile group of companies specializing in the cultivation, collection, processing and sale of fresh and frozen berries and fruits. Orchards and berry plantations occupy more than 700 hectares, of which 300 hectares are certified for organic production. Triada-MK has several business directions among which are horticulture, berry growing, beekeeping, and production of directly squeezed juices (marketed in Ukraine as “Miriada Fruits”), cleaned apple cubes and frozen cherries, raspberries (exported under the name “Fruktona”) and apples. Fresh apples and berries are sold in Ukraine under the brand name "Generous Farm".

Triada-MK is in the process of renewing its apple orchards, which led the company to the issue of managing the plantation removal biomass. An alternative management scheme consisting of the production of pellets from the aerial part of the trees was developed since the end of 2017, with the support offered by SECB and UCAB as part of the uP_running project activities in Ukraine. Currently, the production and sales of agrobiomass pellets has become a new business line for the company. The dynamism of the prime mover allowed for this value chain to move quickly from “demonstration” to market operations. For this reason, as well as for the fact that this value chain is based on plantation removal biomass, Triada-MK was selected as ones of the uP_running flagship cases.

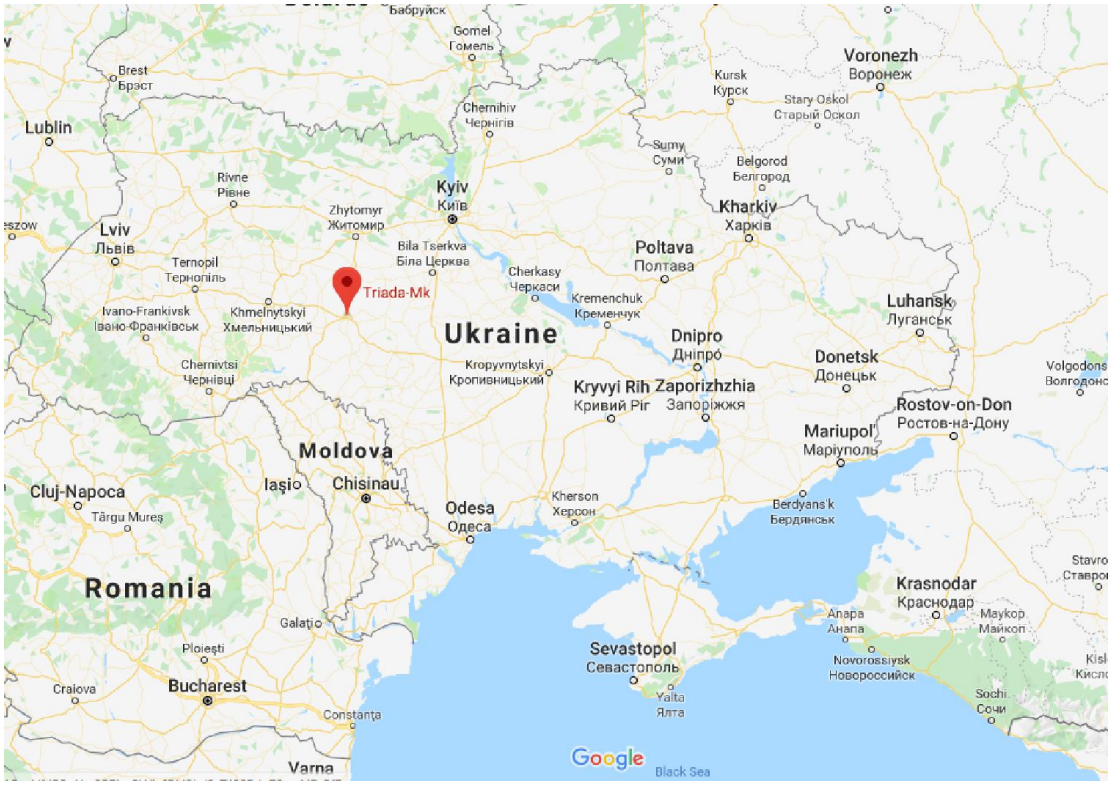

Figure 1: Location of Triada-MK’s orchards.

Figure 2: The logos of Triada-MK trademarks and company's buildings in Murovani-Kurylivtsi.

Table 1. The Triada-MK flagship case at a glance.

Triada-MK at a glance	
Location	Murovano-Kurylivets region, Ukraine
Type of APPR involved	Plantation removal biomass (only aerial part)
Crop species used	Apple trees (from own plantations), plum trees, cherries trees
Year of initiation	2017
Volume of APPR mobilized	Around 1,050 t (of the final pellet product) delivered to final consumers over two heating periods (circa 300 t in the start-up year, and 750 the second season); estimated production to be reached up to 1,500 t per heating season
Surface area with permanent crops mobilized	60 ha (during initial two working seasons); around 65 ha estimated on an annual basis
Maximum radius of operation	17 km from field (uprooting operation) to production facility 100 km (transportation of pellets to final consumers)
Main product	APPR biomass pellets to market
CO_2 emissions avoided[1]	Around 1,000 tCO_{2eq} achieved during initial two heating seasons; estimated savings of 1,430 tCO_{2eq} can be achieved per heating season

[1] The CO_2 savings for the Triada-MK case are calculated using the "Sustainability Assessment Guidelines and Template" developed by the uP_running project (http://www.up-running.eu/other-materials/). The main assumptions and data used in the calculations are as follows:

- Pellet consumption equal to 1,050 t for first two heating seasons; expected consumption of 1,500 per heating season. The average moisture content of the pellets is 10 %, with a typical LHV of 16.4 MJ/kg.
- The fossil fuel and electricity consumptions of the value chain have been calculated by the uP_running team using results collected from the demonstration organized by the project.
- The thermal efficiency of the heating boilers in which the pellets are combusted is equal to 85 %.
- The Fossil Fuel Comparator for heat production is equal to 80 gCO_{2eq}/MJ, as adopted in the final recast of the RED II Directive.

Triada-MK at a glance	
Number of jobs created	N/A (it is done by the employed workers in the orchard)
Total level of investment	124,000 € up to now; it includes the initial purchase of second-hand equipment (primary chipper, secondary chipper, dryer, pellet press). Additional investments already incurred or planned (e.g. new secondary chipper, dryer replacement) are not yet considered.

Business model

For the APPR biomass pellets business line, Triada-MK is the primary actor involved in almost all operations; for some particular tasks, the services of external contractors are employed.

In particular, the uprooting of trees is performed with the assistance of an agro-services company, which supplies the necessary equipment and manpower and is compensated for its services. Following that, Triada-MK uses its own workers and equipment (tractor, chipper, hammer mill, pelletizer, etc.) to perform all other operations of the value chain: cutting of the aerial part of the tree on the fields, loading the biomass and transporting it to its facilities, drying, milling and pelletizing.

Depending on the quantity of pellets requested, Triada-MK is supplying the final product either through its own trucks, or with external transport companies.

The first consumer of the produced pellets is the municipal boiler house in Tyvriv town, subordinated to the Vinnitsa Regional State Administration. Operator of the boiler house that is located at the 100 km distance from the pellet production facility signed a long-term agreement for agro-pellet supply from Triada-MK farm. During the heating season of 2017-2018, the boiler house consumed 300 tons of pellets. During the next heating season (October 2018- April 2019), 750 tons of the produced pellets were sold both to the municipal boiler house in Tyvriv town and to other consumers, and partly used for own consumption. During the first production season the price of the pellets was at the level of 3,000 UAH per ton, VAT included (around 100 €/t). During the second heating season, the price varied from 4100 UAH/t (135€/t) in October 2018 to 3500 UAH/ton (115 €/t) in February 2019.

In the near future, the company considers the possibility to provide a tree uprooting service for neighboring farmers. The total estimated area of old plantations within an 80 km radius is 1,000 ha, which can ensure a continuous APPR biomass supply for pellet production for many years to come.

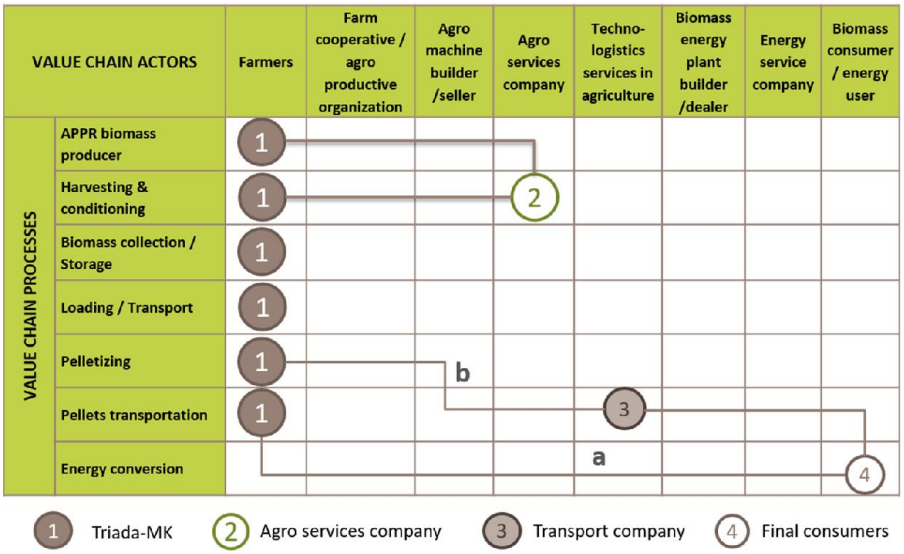

Figure 3: Role of actors in the Triada-MK case.

Table 2. Benefits for the actors participating in the Triada-MK case.

Value Chain Actor	Tangible benefits	Intangible benefits
Triada-MK	Gets economic margin Saves time and money in plantation removal biomass management	Promotes successful case of APPR residues utilization Avoids risks of fires and diseases "Greener" image of business
Final consumers (municipal buildings)	Reduced heating cost	Diversification of energy sources Support of the local energy sources Improved air quality

History / Reasons for initiating

Since the establishing of the new intensive apple plantation in 2014, Triada-MK has faced the problem of uprooting residues accumulation from the old orchards that had to be removed. In 2017, at the time of establishing the value chain, the apple orchards of the company extended at a total area of 430 ha, of which 330 ha correspond to new intensive plantations planted in 2014, and 100 ha are the old plantation still to be uprooted.

Figure 4: New and old apple orchards of Triada-MK.

The first attempts by Triada-MK to mobilize the APPR biomass from the plantation removals was to establish a value chain with direct selling of APPR chips to a local biomass boiler house. However, when the final consumer tried to use the APPR chips, their high moisture content led to an unstable boiler operation; as a result, the consumer discontinued the cooperation. Some part of the residues was collected as a fuel wood and used for heating of municipal buildings in Snitkiv village (village does not have a connection to the natural gas grid). The rest of APPR residues was burned in the piles on-site. The prime mover was against biomass burning on site, considering it a waste of energy.

Production of a high quality biofuel was therefore a requirement in order for Triada-MK to develop a competitive business line for selling APPR biomass for plantation removals. In order to do so, Triada-MK decided to produce pellets from its own APPR wood. At the same time, Triada-MK connected to uP_running initiative, from which it received support for establishing a new value chain focused on APPR wood pellets. Location of the company's orchards in Vinnytsia oblast that has quite high level of bioenergy support by the local authorities and growing solid biofuels market (now more than 370 boiler houses works on solid biomass in the region) creates the opportunities for competitiveness of the agro-pellets production.

Availability, harvesting, and logistics of APPR biomass

The apple orchards of Triada-MK that have to be uprooted are grown in several separate fields which are located at a distance of up to 1 km from one another. The age of trees is around 45-50 years. They are planted with the density of 330 trees/ha (width between rows is 6 m, and the distance between the trees is 5 m).

Field measurements performed with the assistance of the uP_running project team in Ukraine showed that the productivity of the aerial part of fruit trees per hectare ranged from 19.3 to 56.3 t, with an average of 30 t/ha (at 37 % moisture content). As of 2017 therefore, the total amount of wood that could be mobilized from the own uprooted plantations was estimated to be in the range of 3,000 tons.

Figure 5: Field measurements of biomass productivity in apple orchard of Triada-MK by SECB.

The logistics chain of the new case at the base of Triada-MK Company presented below:

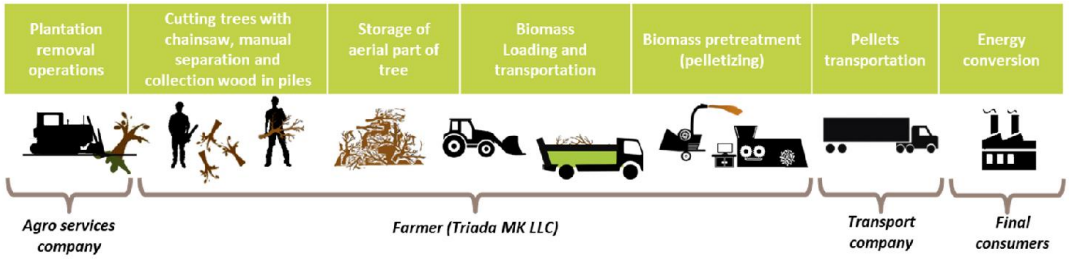

Figure 6: Logistics operations in Triada-MK.

The first operation for the plantation removal is uprooting with a bulldozer equipped with a stump puller. Then, workers with chainsaws cut the above ground part of the trees. Other workers separate stem wood from branches and collect them in the piles on the field side. The stemwood and thick branches are transformed into logs and stored in the uncovered piles and left there for one to a few weeks, depending on the weather conditions and production needs. Afterwards, a tractor with a front loader loads the aerial part of the trees into a tip lorry (dump truck) that transports it to the pelletizing facility of Triada-MK, located at a distance of 17 km from the orchards.

The aerial biomass losses consist of small branches that are left untreated at the field side and are estimated to be in the range of 15 %. The roots of the trees are also left on the field side. During the next up-rooting operations, Triada-MK Company intends to use a new mobile chipper, for treating the small branches, thus producing woodchips out of the branches. This new practice will allow to gather not only the stemwood in form of log pieces, but also the branches in form of woodchips. This will reduce manual labor as well as losses of the total tree biomass.

Figure 7: Uprooted orchard of Triada-MK.

Figure 8: Cutting of the trees on the field.

Figure 9: Loading of the uprooting residues.

Figure 10: Transportation of the biomass (stemwood logs) to the pellets production facility.

Figure 11: Stumps on the field side.

Figure 12: Field after uprooting and collection of the biomass.

At the production facility, APPR wood is accumulated on the covered ground and in covered warehouse. Then, wood biomass is pre-treated through two operations - chipping and drying.

Chipping is provided in two stages. In the first stage, primary chipping takes place in stationary disk wood chipper Hemmel-RM 41.355 with electric engine (production capacity is max 25 m^3/h, input material diameter is max 200 mm). Then, using a belt conveyor, the biomass is transported for the secondary chipping in the rotor-type hammer mill EBR (production capacity is from 2000 kg/h, input material size is 30x50 mm). The obtained fraction of biomass is suitable for pelletization.

Figure 13: Storage of APPR biomass at the pellets production facility.

Figure 14: Chipper Hemmel-RM41.

Figure 15: APPR wood after primary chipping.

Figure 16: Hammer mill EBR.

After the two stages of chipping, biomass is dried in an aerodynamic dryer equipped with heat generators running on biomass (fuel wood from APPR biomass). The crushed dried wood is fed to the hopper of the granulator OGM-1.5 with a productivity of 1 t/h, which presses biomass into pellets.

The pellets are cooled and packaged in big bags, which are stored in a warehouse at production plant. On the request of the final consumers, the formed batch of pellets are transported to the boiler houses. Depending on the requested amount, Triada-MK hires an external transportation company or uses its own lorry transport.

Figure 17: Aerodynamic dryer.

Figure 18: Pellet press OMG-1.5.

Figure 19: Storage of pellets in big bags at the production facility.

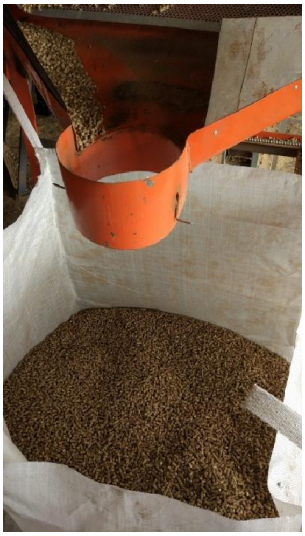

Figure 20: Produced agro-pellets.

Soil management and agronomic practices

The main apple varieties grown in the Murovano-Kurylivets region, Vinnytsia oblast of Ukraine where Triada-MK is located are Red chief, Golden, Idared, Pinova, Pink lady and others.

Agronomic practices used in the new orchards are aimed at preserving soil quality. The orchard is covered with grass that is cut as well, which is a source of organic matter for soil. Application of fertilizers and pesticides in the fields is provided in accordance with Equivalent European Union Standard for Organic Production for third countries (certificate of IOAS) and in line with the certification GLOBAL G.A.B.

Field after up-rooting is plowed, furrowed, sprayed with herbicide of continuous action. Then disking and deep plowing are carried out. After planting of a new intensive orchard, soil treatment is carried out in accordance with the above-mentioned standard.

Currently, the yearly pruning wood from the new intensive apple orchards is collected, chipped with a mobile chipper and used as a mulch for the berry growing. In the future, the surplus of the wood chips left after berry rows covering will be used for biofuel production (either pellets or briquettes). NOTE

End use of APPR biomass

The main characteristics of the first parcel of the agro-pellets from fruit plantation removal biomass produced by Triada-MK are depicted on the following table. The quality is comparable or better than other agro-pellets that can be found in the local fuel market (e.g. sunflower husk pellets).

Table 3. Major properties of the agro-pellets producted by Triada-MK.

LHV		Moisture	Ash	Pellet diameter	Bulk density
MJ/kg (d.b.)	MJ/kg (a.r.)	% w/w (a.r.)	% w/w (d.b.)	mm	kg/m^3 (a.r.)
18.5	15.3	12.6	4.8	Ø 8	530

d.b. dry basis; a.r. as received

After the demo use of Triada-MK agro-pellets, the boiler house of Utility Company "Vinnytsiaoblteploenergo" (15, Liali Ratushnoii Str., Tyvriv town) became a continual consumer of them. Operator of a boiler house signed the long-term agreement for agro-pellets supply. As a result, during two heating periods (2017-2018 and 2018-2019) boiler house consumed 700 tons of Triada-MK pellets.

Municipal boiler house in Tyvriv, which serves the local district heating system, operates biomass boilers with a thermal output of 1 MW. The boiler house is also equipped with natural gas boilers, which work during peak loads.

Figure 21: Close-upof Triada-MK agro-pellets.

Various kinds of pellets were used in the boiler before, including sunflower husk pellets, which had been purchased by the current market prices. During the first demonstration combustion of the Triada-MK agro-pellets, a problem with the formation of ash was found. The quantity of ash formed was visually higher in comparison with the wood pellets that were in use earlier; additionally, the

ash was sintered. In order to reduce the content of ash in pellets and improve its quality, Triada-MK adjusted the composition of the input biomass for granulation and improved the storage facility for the APPR feedstock before the primary chipping. After these improvements, no ash related problems manifested during further use of the Triada-MK pellets.

Figure 22: Boiler house in Tyvriv (Right picture: 1 MW biomass boiler ARS-1000LM).

Success factors and obstacles

The founder and managing director of Triada-MK, Mr. Sergii Ukrainets, is against the open burning of APPR residues. He has a strong belief that the effective way to obtain benefit from own uprooting residues exists. Production of pellets brings additional income to the company and develops local energy sources for heating. Vinnytsia region is on the way to independence from the external sources of energy, and the local biomass market has been developing, which is good for the local community.

The key success factor for the development of the new value chain under specific local conditions is based on the large amount of own feedstock, and the use of existing opportunities, e.g., using of the existing equipment and facilities for plant and warehouse arrangement. Purchasing of second-hand equipment allowed adapting the pelletizing technology for the use of APPR biomass in a short period. Significant reduction of the capital investments let to receive a first margin in a narrow term, and proceed with new investments for technology improvements in the future.

Identification of final consumers able and willing to use agro-pellets from APPR biomass was also a key factor for the success of the value chain.

According to Mr. Sergii Ukrainets, the success factor of starting of agro-pellets production is consolidation of farmers into a cooperative and buying the pelletizing equipment on common funds. Working hours of such equipment are quite limited, and consolidation gives benefits for the farmers.

The value chain was implemented with the company's own money. No public funds or credits were used to finance the project; however, the comprehensive support offered by uP_running allowed

to set up a new business chain and to solve the technical difficulties during the work of equipment for chipping, drying and granulation of wood. Optimization of biomass pre-treatment, optimization and adjustment of equipment to achieve the highest productivity, improving of the management of the logistics were done under assistance of the uP_running project.

Lessons learnt

Production of pellets from the own up-rooting residues could become a good business line for a company that provides agro cultivation and processing and owns some technological equipment and production facilities.

Being-in-use (second hand) pelletizing equipment should be adjusted to the APPR biomass characteristics by modification of pelletizing matrix and rollers, installation of new control system for production parameters.

Special attention should be concentrated on the quality of the final product. Ash content of the agro-pellet should be reduced, e.g. by minimizing the contact with soil during harvesting operations.

The chipping and drying processes at the pellets production facility should be optimized in order to increase the performance of the pressing equipment.

Obligatory market research must be performed to be sure that in the long time period there will be institutions (final consumers) willing to consume agro-pellets. Good market researh is a crucial point determining the final succes.

Price of the final biofuel is also a crucial issue; it must be quite attractive from the buyer's point of view. In comparison to the production of APPR chips, the agro-pellets are more competitive in the local market of Vinnytsia region.

Future prospective

Being the "youngest" of the uP_running flagship cases, the case of Triada-MK has room for further improvements and adaptations in its value chain.

In the future, Triada-MK is planning to deliver uprooting service to other farmers and use both pruning and uprooting residues for biofuel production. This will secure the biomass supply beyond the amount that can be mobilized from the company's own orchards. A new chipper will also be used to collect biomass from thin branches that are now left on the side of the field.

The company also has plans for modernization of the value chain and buying a new pellet press.

The possibility of introducing the fuel briquettes production from lower quality wood, in particular, from thin branches, is also considered. One of the possible scenarios considered by the company in order to increase the quality of its products is to use stem wood from uprooting stemwood for pellets, and branches from uprooting and annual pruning for briquettes.

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D6.4: Flagship success cases update v2
Annex V: the AgriToppi flagship case

uP_running

Take-off for sustainable supply of woody biomass from agrarian pruning and plantation removal

Grant agreement: 691748
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Introduction

AgriToppi is a family farm that offers agro-mechanical services in the Tavoliere Plain (Foggia Province). AgriToppi provides a wide range of specialized mechanical operations on both herbaceous and tree crops through cultivation contracts signed by farmers. Among these operations, a new kind of service was activated few years ago: shredding of orchard prunings followed by the removal and collection of these residues. Considering the agricultural area were the farm is located (the territory of the municipality of Lucera), mainly olive groves and, secondarily, vineyard and almond trees are involved in this kind of operation. The business idea is aimed at enhancing the value of these agricultural residues by producing a biofuel such as pellets (or agripellet, we should say, to distinguish it from that of forest origin). For this reason, the farm invested in the setting up of a bioenergy value chain based on APPR use and agripellets production, converting the shredded wood feedstock into a final energy carrier.

AgriToppi was selected as an uP_running flagship case of APPR mobilization because it focuses on the provision of a new product, widely demanded at both regional and national level: agripellets. Even if this new activity started very recently, it proved to be a very successful case, combining the provision of agro-services to farmers (pruning collection) with the conversion of shredded and inhomogeneous wood into agripellets, a denser, easy to mobilize and more valuable energy carrier. The development of this value chain also benefitted from the support and technical accompaniment offered by UFG and DARe as part of the *uP_running* project activities in Italy.

Figure 1. Location of AgriToppi.

Table 1. Overview of the AgriToppi flagship case.

AgriToppi at a glance	
Location	Lucera, Foggia, Italy
Type of APPR involved	Prunings
Permanent crop species used	• Olive (the olive pellet is sold "pure" as a kind of specialty). • Vineyard and almond tree, together with forest wood, can optionally enter the composition of the pellet, but this latter production is kept separate from the former.
Year of initiation	2016
Amount of APPR mobilized	340 t of pruning wood (20 % moisture) harvested on annual basis; from these, 300 t of agripellets (10% moisture) are produced
Surface area with permanent crops mobilized	~ 150 ha on an annual basis
Maximum radius of operation	~ 30 km (centered around the city of Lucera)
Main product	Pellet made from shredded wood of olive pruning
CO_2 emissions avoided[1]	286 tCO_{2eq} per year
Number of jobs created	• 24 person-months per year of new labour activity, in total, with 6 person-months per year permanently hired outside the family farm
Total level of investment	• 50,000 € - pellet plant purchase; • 12,500 € - shredder/harvester purchase.

Business model

The AgriToppi business model finds its scope, essentially, in connecting the high local availability of pruning and the need expressed by local farmers for a complete and effective removal of the pruning obtained from the management of their fruit tree plantations. Usually, prunings are burnt in the open air in order to avoid the risk of plant pests and diseases. AgriToppi provides farmers

[1] The CO_2 savings for the AgriToppi case are calculated using the "Sustainability Assessment Guidelines and Template" developed by the uP_running project (http://www.up-running.eu/other-materials/). The main assumptions and data used in the calculations are as follows:

- Annual agripellet consumption equal to 300 t. The average moisture content of the pellets is 10 %, with a typical LHV of 16.4 MJ/kg.
- The fossil fuel and electricity consumptions of the value chain have been calculated by the uP_running team using results collected from the demonstration organized by the project.
- The thermal efficiency of the heating boilers in which the pellets are combusted is equal to 85 %.
- The Fossil Fuel Comparator for heat production is equal to 80 gCO_{2eq}/MJ, as adopted in the final recast of the RED II Directive.

with a competitive, efficient and fast "cleaning" service of their parcels using specialized technical equipment and dedicated staff to remove the pruning.

On an annual basis, AgriToppi provides biomass collection to approximately 70 farmers, covering 150 hectares of land within a supply radius of about 30 km far from the company facility. The biomass removal service offered to the farmers is valued at around € 30/ha, which corresponds to approximately, € 15/t of pruning removed. Considering that the all-inclusive cost of pruning shredding and harvesting at the field site amounts to around € 35/t, it is clear that the farmers have a significant cost for the management of their residues when working together with AgriToppi. It should be noted that this fee corresponds to only a small percentage (less than 10 %) of the total revenues of this business line of AgriToppi.

AgriToppi manages the biomass collected from all the fruit plantations with the aim of transforming this feedstock into a commercial solid form biofuel (i.e. agripellets), suitable to be used in multi-fuel boilers for household and/or small industries in the same area. Usually, these boilers are fed with olive stones and exhausted olive pomace.

The selling price of agripellets is the main factor affecting the business plan and the financial profitability of the investment. The price has to be defined considering the fact that the quality of the agripellets produced from prunings is lower than that of forest wood pellets, while they also be competitive with other local fuels.

The price of pellets from forestry varies according to the wood species, heating values and other fuel quality features, its brand and possible certification, as well as the total amount purchased; an indicative value ranges from a minimum of 3 to a maximum of 5 € for a 15 kg bag (corresponding to 200 - 330 €/t). Many pellet producers supply the product in “pallets” (i.e. 70 bags of about 1,050 kg in total); in this case the applied price is lower and in the range from 2.70 to 3.00 € per bag (180-200 €/t).

The price volatility of other solid biofuels, directly completive with agripellets is significant and is directly related to the olive production in the area: a higher price of the olive stones is observed when the olive local yield is very low, as was the case in both 2017 and 2018[2]. The decreased market supply in olive stones strongly increased its price therefore favoring the agripellets market. The detected price of olive stones is, on average, approximately 180 €/t when sold in bulk and 210-220 €/t when sold in bags (15, 20 or 25 kg each). Consequently, it can be argued that there is a slightly greater convenience in buying olive stones than agripellets.

Notwithstanding this economic reason (net of the strong price instability), the final consumer still shows to prefer the agripellets to the olive stones because its storage is easier, the combustion has no unpleasant odor emission and the maintenance of the boiler is less demanding. Furthermore, the pellet market (referring to forest pellets) is very large, strong, and widespread, so that agripellet can be strongly supported by this very positive position. In fact, forest pellet retailers are generally the same as agripellet.

[2] Low olive yields were due to a very aggressive attack by the olive fruit fly (*Bactrocera oleae, Dacus oleae*) that compromised the olive yield.

Considering these boundary conditions, an average agripellets price equal to 230 €/t can be assumed, considering a mix of retailer price (in bag) and wholesaler price (in pallet). With these parameters, the payback time for the total new investments done by AgriToppi (harvester and pellet plant; the company already had in its possession tractors for harvesting, trucks for transport and storage spaces) is less than 4.5 years, indicating the possibility for good financial results. However, the investment risk is still quite high. Besides customer preferences, a strategy that AgriToppi might apply to reinforce its revenues and the (gross) profit of the agripellet activity is to increase the annual total production from 300 to 400 t (that it means reaching the maximum productive potential of the palletization plant).

The value chain is based on a relatively simple organizational model, considering that the agripellet producer (i.e. AgriToppi) deals with both the upstream and downstream of the biomass supply, directly managing the most of the activities foreseen, from biomass collection, transportation, pre-treatment, up to the conversion of shredded pruning in pellet and its final sale.

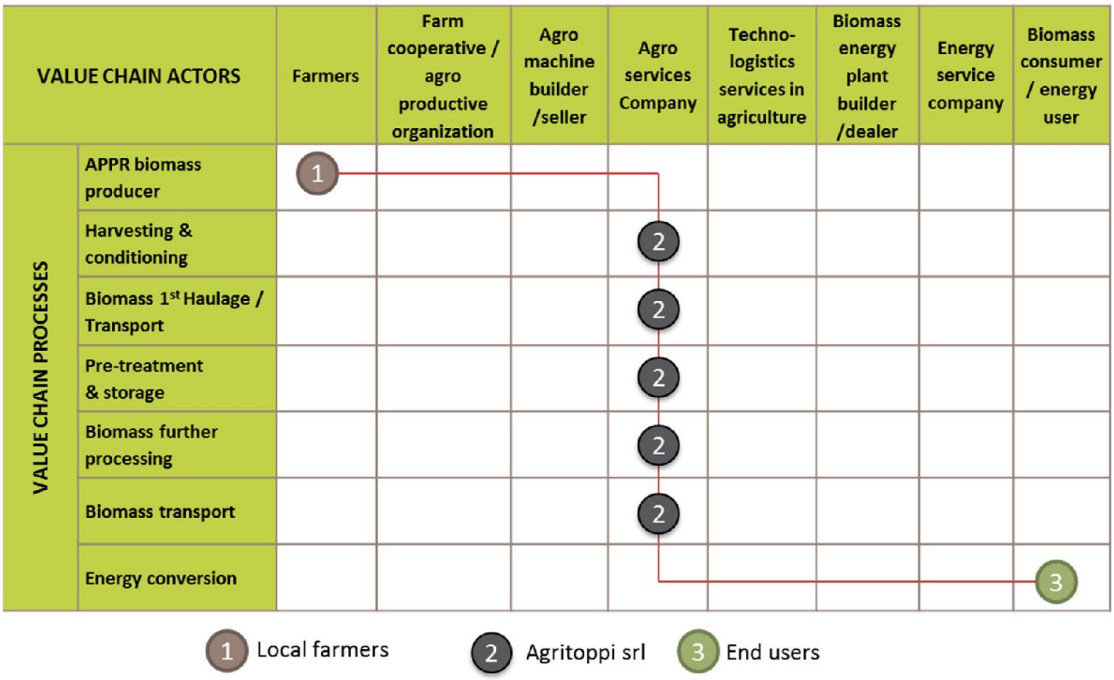

Figure 2. Role of main actors involved in the AgriToppi value chain.

Table 1: Benefits of actors involved in the AgriToppi value chain.

Value Chain Actor	Tangible benefits	Intangible benefits
Farmers	Save time and money in the management of large volumes of residual biomass	Avoid risks of fires and diseases and cleaning of fields
AgriToppi	High quality biomass raw material collected free of charge Revenues from sale of agripellets Revenues from sale of agricultural services	Development of know-how and availability of basic equipment to be employed in the logistic phases
Final end users	Cost-effective biomass sourcing Less odorous emissions	Valorisation of a local biomass resource Greater flexibility in fuel sourcing

The indirect benefits of the operation performed by AgriToppi are also important, as the energy utilization of pruning removed from the fields cancels out the risks of uncontrolled disposal and open-field burning.

An important aspect of the business model is also related to the job opportunities this new productive activity can promote. AgriToppi is mainly a family company and, therefore, job opportunities are mainly addressed to family members. No additional workers have been foreseen in performing the field operations of pruning shredding and harvesting (the number of workers will remain the same although a higher employment rate will be achieved for each of them). For the pellet production activity, a dedicated labor cost was accounted for in the business plan. It is estimated that the additional effort required corresponds to a 6-month period of full salary, *i.e.* ½ person permanently hired.

History / Reasons for initiating

AgriToppi is the Italian name for the company directed by Antonio Baselice. It started its operation in 2016.

The main reason of the creation of this new value chain was the strong conviction that pruning could represent a resource and not a waste, therefore to be used in producing a new valuable final product. The goal was also to increase the company incomes through diversifying its productive activities.

The implementation of the business was facilitated by the fact that Mr. Baselice was already the owner of a fleet of agriculture machinery and implements and therefore had a very good previous experience in managing an agro-service company. Although the original family company was quite expert in performing operations of pruning shredding (intended for soil mulching), prunings were never collected before as feedstock to energy conversion. The purchasing of the Nobili

shredder/harvester was the first step in organizing the new value chain, time before investing in the pelletization plant.

AgriToppi also benefitted from the connections with the *uP_running* project, from which it received technical support and accompaniment. Consequently, AgriToppi decided to purchase in 2016 the pellet facility plant with a total purchase cost (CAPEX) of around 50,000 €.

An extensive review of the activities worked out by AgriToppi concerning the investment performed and the organization of the new bioenergy value chain can be retrieved in a previous project deliverable (D3.2) reporting the demonstration activities and the results of the collaboration within the project framework [1].

Availability, harvesting and logistics of APPR biomass

On a yearly basis, AgriToppi manages around 150 hectares of fruit orchards. On average, the biomass production is 2.0 t/ha, with the exact quantity varying depending on the tree crop type/variety, tree plant density, age and agronomic practices employed.

AgriToppi performs the collection and the harvesting of the pruning approximately from December to April.

The first step is the tree pruning operation. Soon after pruning, the following operation is the windrowing of the pruning residues all along the tree alleys. Generally, the farmers perform both these operations manually. If windrowing is carried out according to the required standards, the collection of pruning by AgriToppi has no costs for farmers. Otherwise, if the activity should be taken directly in charge by AgriToppi, the farmer is in charge of a payment that costs approximately from 30 to 50 cents per tree (around 30 €/ha with respect to field condition). After a partial drying in the open air (from 30-40% to approximately 20% of moisture), prunings are shredded with a shredder-harvesting machine towed by a 100 HP tractor. The machinery model is NOBILI TRP RT 175, which collects the pruning at the soil surface through a pickup drum, performs the pruning shredding and finally discharge the hog fuel into big bags which are sequentially left on the field as soon as they are completely full of shredded wood.

A crucial aspect concerning the procedure of harvesting and shredding pruning residues is represented by the level of humidity of the biomass. This value is usually very high (~ 40 %) immediately after the cutting; however, if the prunings are left for some time at the soil surface, the water content is sharply reduced and the residues gradually dry up in the field. For this reason, it is advisable to harvest and shred the residues at least 20-30 days after pruning. This guarantees (as long as it does not rain) a moisture content of less than 20 %. The further natural drying of the feedstock takes place into the storage platform that is protected by waterproof cover sheets. Moisture values lower than 13 % are reached surely, usually close to 10 %. Hence, no further forced drying needs to be implemented before pelletization.

The harvester has a high harvesting efficiency in the field: the biomass losses left at the soil surface, in fact, is about 4-5 % as compared to the total amount available on the field. However, the time necessary for the collection is higher than that reported in the technical manual, 2.5 h/ha with

respect to a value ranging from 1 to 2 h/ha. The reason argued by the entrepreneur with respect to the choice of this particular harvesting machine is related to the position of the harvester's pick up, which is rather higher than usual. This higher position avoids collecting stones or soil and therefore the harvested pruning is of better quality. Consequently, the final agripellet shows improved quality characteristics.

With respect to the workers employed, an operator is on the first tractor (proceeding with the combined operations of shredding and filling the big-bags); an operator is on the second tractor equipped with a front lifting fork which handles and loads the bags on the truck trailer positioned at the side of the field. The transport of the shredded material to the company storage facility takes place on a truck with a platform for loading the big bags; the shredding is stored indoors.

The heterogeneous dimensions of the shredded wood do not allow proceeding directly to pelletization. There is, instead, the need for a subsequent treatment, which consists of a further shredding of the residues to make them suitable for the final process. The extrusion process leads to the formation of the pellet. The ideal humidity of the shredded material ready to be pressed in the extruder is around 10 %. No dryer is used and the naturally dried biomass feedstock is used directly. Higher or lower values can compromise the success of the pellet production, both by preventing sufficient aggregation and by producing small and irregular sized pellets. The shredded material is pelletized by means of a special plant located in the company facility, SMARTEC PLT 400 produced by SMARTWOOD. The plant is made of a plurality of components that, as a whole, lead to the production of pellet, also including its packaging inside plastic bags. The operations are the following:

- chip extractor by means of an end-less screw;
- humidification pump with tank and nozzle;
- biomass loader assembled with a knife-refiner completed with an iron-remover using magnets;
- 22 kW PLT-400 pelletizer;
- 2 lubrication pumps
- 2 bins (18 Kg) of grease for lubrication
- conveyor belt under press
- pellet cooler
- VBR-300 vibrating screen
- conveyor belt for big bag loading
- filtering battery with 12 bag filters
- big bag holder structure

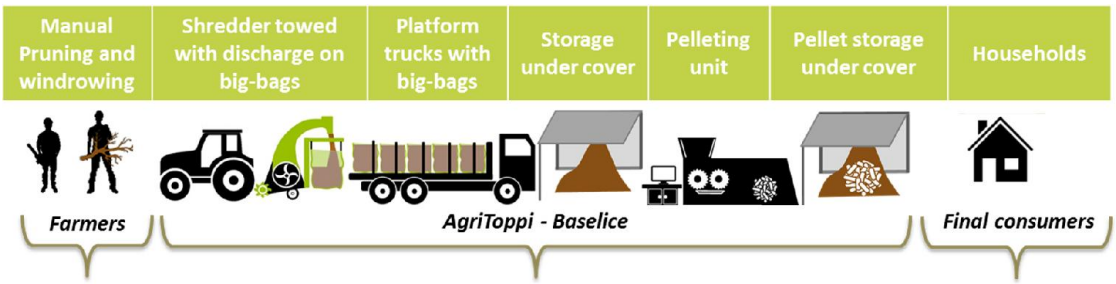

Figure 3. The agripellet production processes implemented by AGRITOPPI.

Once produced, the agripellets are stored indoors inside a shed at the company facility and then packaged and made available for sale at the company facility. The agripellets can be stored in big bag or in plastic bag (15 kg).

Schematically, the main operations required for the fruit tree pruning and the agripellet production are showed in Figure 3.

Figure 4. The Nobili shredder in the field. Image source: UFG.

Figure 5. The big-bag, filled with shredded pruning residues, is left along the tree alleys to be later recovered. Image source: UFG.

Figure 6. The big bags full of shredded prunings are placed on the floor of a truck. Image source: UFG.

Figure 7. Size of the shredded wood obtained by using the Nobili TRP RT 175 harvesting-loading machine. Image source: UFG.

Figure 8. Visit at the pellet production facility of AgriToppi. Image source: UFG.

Soil management and agronomic practices

Considering the uP_running project guidelines for pruning removal and their energy use [2], the soil conditions of the fruit tree plantation from which prunings are extracted should be managed according to an ecologically sound and sustainable criteria.

Considering the local climatic environment, summer season is rather dry while the soil has a limited amount of SOC (Organic Soil Carbon), the latter being a generally observed condition in this Mediterranean region. For this reason, it would not be advisable to withdraw prunings

systematically from the local fields. These critical conditions have also been confirmed by specific analyses carried out which indicate a content of soil organic matter (SOM) of about 1 % or even lower in the fields involved in the supply of prunings. This means that pruning can only be performed partially or, preferably, every other year, depending on the content in SOM. At the same time, soil management operations aiming to increase SOM should be applied in order to preserve and even increase the soil quality. Among these operations, the supply of an organic fertilizer (soil amendment) is of primary importance, also considering the wide range of beneficial effects that could be achieved, not only on the soil structure, but also on microbial processes, as well as on tree growth and their fruit production. Minimum-tillage and a cover crop are also highly recommended and, in the region, several farmers (both olive growers and wine growers) are applying this type of technically advanced interventions, obtaining excellent results (in particular with regard to soil erosion, even where the soil is only slightly sloping). These technical prescriptions have been transmitted to the farmers involved in the pruning supply during the different workshops organized in the frame of the *uP_running* project, also thanks to the direct relationship between Mr. Baselice and the local farmers. Some of these farmers are applying already the guidelines while others intend to apply them in the near future.

Figure 9. Pellet produced by AgriToppi, in bulk, packed in plastic bags of 15 kg, arranged in pallet with 70 bags.

Figure 10. The Nobili combined shredder/harvester and the pellet produced by AgriToppi in different packages. Picture taken at the International Fair of Agriculture in Foggia (April 2019)

End use of APPR biomass

Agripellets produced by AgriToppi are quite similar to wood pellet but some physical and chemical parameters show lower quality as compared to wood pellet. Table 3 presents the values related to two different samples of agripellets from olive pruning, to give an idea of the considerable variability that can be detected among different feedstock lots.

Some specific points that can be made for these agripellets are as follows:

- Moisture should be lower than 10 %; however, this is not always the case due to the lack of forced drying.
- The ash content is the main problem, considering that its value should not be higher than the limit of Class B pellets (2 % dry). Ash content is significantly impacted by the amount of leaves found in the harvested prunings.
- Nitrogen and sulphur and chlorine can also be higher than the threshold values. Again, this appears to be connected with the amount of leaves in the harvested biomass and correlates with the ash content of the pellets.
- Minor elements (not shown in Table 3) are within the limits for wood pellet quality classes. Copper is a notable exception, coming from spraying of olive trees (however, this was not observed in the pellet qualities reported in Table 3).

Table 3. Comparison of two different agripellet qualities obtained during the uP_running demo

Properties of pellets obtained during the demo				
Parameter	**Unit**	**Result**	**Result**	**Analytical standard**
Moisture	% as received	12.84	8.53	UNI EN 18134-3:2015
Calorific value				
High Calorific Value	MJ/Kg, dry	19.67	19.58	UNI EN 14918:2010
Low Calorific Value	MJ/Kg, as received	15.61	16.38	UNI EN 14918:2010
Elemental analysis				
Ash	% dry	3.55	1.71	UNI EN ISO 18122:2015
Carbon, C	% dry	49.85	47.22	UNI EN ISO 16948:2015
Hydrogen, H	% dry	6.45	6.64	UNI EN ISO 16948:2015
Nitrogen, N	% dry	0.75	0.24	UNI EN ISO 16948:2015
Sulphur, S	% dry	0.227	0.185	UNI EN ISO 16994:2016
Chlorine, Cl	% dry	0.132	0.069	UNI EN ISO 16994:2016
Major elements				
Aluminium, Al	mg/Kg dry	280	153	UNI EN ISO 16967:2015
Calcium, Ca	mg/Kg dry	6,439	4,466	UNI EN ISO 16967:2015
Iron, Fe	mg/Kg dry	97	135	UNI EN ISO 16967:2015
Potassium, P	mg/Kg dry	6,023	2,512	UNI EN ISO 16967:2015
Magnesium, Mg	mg/Kg dry	479	338	UNI EN ISO 16967:2015
Sodium, Na	mg/Kg dry	170	88	UNI EN ISO 16967:2015
Phosphorus, P	mg/Kg dry	940	433	UNI EN ISO 16967:2015
Silicon, Si	mg/Kg dry	1,761	1,327	UNI EN ISO 16967:2015

Because of these specific properties, the heating systems and thermal appliances that can be properly used for the combustion of this specific solid biofuel are not the conventional ones used for wood fuels. Suitable boilers for agripellet are available on the market and they are better equipped to deal with the problem of corrosion due to ash melting and particulate emissions due to possible partial combustion. These boilers are conventionally referred to as *multi-fuel boilers*. The current production of agripellet has been improved lowering the ash content by collecting less leaves. This was also possible by letting the field pruning dry for a longer time before shredding. The humidity value and the fuel power (both upper and lower) show levels that are completely similar to forest-based pellets.

On the other hand, the agripellet shows numerous advantages as compared to the shredded or chipped wood, which justifies its higher cost, as well as a prevalent use to feed stoves and boilers for heating domestic environments.

The advantages can be as follows:

- logistics and transport: pellet increases the energy density of the raw material by at least 5 times. In this way a better combustion is obtained together with a considerable advantage in the cost of handling and storage;
- stability of the product: the agripellet, and in any case the pellet in general, unlike the original material, has a very low moisture content, therefore it is not subjected to degradation as well as there are no variation in the lower heating value;
- transforming the by-product into pellets allows to obtain an excellent uniformity of the fuel product and, consequently, to stabilize its chemical and physical characteristics;

However, it should be pointed out that olive stones, olive pomace and almond shells are locally available biofuels that are competitive to agripellet often in terms of fuel quality as well as in terms of price, since they are subject to a lower VAT. Considering therefore the competition in the fuel market for heating, it is interesting to point out some alternative and peculiar uses of agripellet:

- a company specialized in breeding bees and in the construction of bee material is interested in buying agripellet to be used in the process of smoking beehives. The use of smoke tends to calm bees when the beekeeper intervenes in the opening of the hives.
- Another interesting market is the one proposed by a company that produces sausages. The company is interested in buying agripellet for the smoking process of its products.
- Similar is the proposal of a chef (working in Puglia but of American origins) who shows interest in using olive agripellet to feed the barbecue, to achieve better cooking of a particular meat.
- Finally, to complete the review of all possible alternative uses of agripellet, it is worth to mention that pet comfort industries have suggested its use as a "pet litter" (mainly for domestic cats); being a highly absorbent material it can surrogate the use of the so-called “sand box”.

It is quite clear that for these alternative uses the unit price of the product is far higher than its energy use and the production activity certainly more consistent in terms of revenues possibly achieved.

Success factors and obstacles

A key success factor for the AgriToppi value chain was the high availability of APPR biomass in the area, coupled with the farmers’ need to find rapid ways to dispose it.

The company has a strong position in the area, largely because it has steady and lasting relationships with numerous farmers, thanks to the usual activity as mechanical service-company.

In the area, there are about 800 ha of olive groves as well as 200 ha of vineyards. AgriToppi is approximately working 150 ha, which means about 300 t of pruning in total per year. This means a sufficient availability of biomass very close to the farm centre, for both the olive groves and vineyards. A quite large number of farmers entered into a contract with AgriToppi and it was fast and easy to reach the needed amount of biomass supply to start the pellet production.

By managing an agro-mechanical company, the logistic organization is well defined and professionally reliable. Totally new, conversely, was the pelletization process. Pellet is a kind of solid biofuel largely requested in the area and it has a strong market position.

The collaboration with AgriToppi was very professionally satisfying for both the entrepreneur and the *uP_running* partners. Consultancy, first, and technical support in the accompanying activities, soon after, were fundamental in order to promote the setting up and the take-off of this new value chain in the bioenergy sector.

Considering the obstacles, it should be clear that, considering the final consumer, it is necessary to replace the conventional boiler and purchase a multi-fuel boiler, which costs more even if it offers the maximum flexibility in the use of solid biomass (both agripellet and olive stones). Moreover, it should also be considered that wood chips and olive pomace have a 10 % VAT regime in the Italian market, unlike pellets (both forest wood pellets and agripellets) that have a 22 % VAT regime. This can be considered an unfair competition discouraging the use of agripellets and advantaging the use of olive stones.

Future prospective

AgriToppi aims at enlarging the agripellet market towards the owners of industrial boilers (significantly larger in size than household stoves) as well as multi-fuel stoves. In particular, multi-fuel stoves are spreading rapidly, especially in rural areas, and represent a more flexible alternative to pellet stoves. In fact, they can be fed not only by agripellet but also by olive stones, olive pomace, almond shells, etc. This possibility should be considered of great interest, offering a potential expansion of the potential market.

Furthermore, the company owner is also investigating the potential to certify the agripellets according to specific quality standards. The BIOMASUD® quality certification scheme, expanded by the Biomasud Plus project [3] includes quality classes for olive pruning pellets and, in fact, AgriToppi has collaborated in the first pilot implementation of the action in Italy. The first pilot certification has a general positive impact, even if it was found that some quality characteristics of the pellets should be improved. Considering that AgriToppi is constantly improving the handling operations to improve fuel quality, reaching the label limits in a new audit should be possible. Moreover, the adoption of quality assurance procedures and traceability system along the entire supply chain are relevant improvements the entrepreneur is thinking about, also providing assurance to the final end-users.

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