BRANCHES

Boosting RurAl bioeconomy Networks following multi-actors' approaches

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Saija Rasi,Luke

Kirsikka Kiviranta and Kirsi Korpijärvi, VTT

Maider Gómez Palmero,CIRCE

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Case Study

Qvidja farm – Solutions for climate smart food production

Creators: Saija Rasi, Kirsikka Kiviranta, Kirsi Korpijärvi

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Content

CASE STUDY Qvidja farm – Solutions for climate smart food production	
Creators	Saija Rasi, Kirsikka Kiviranta, Kirsi Korpijärvi
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1 Introduction

BRANCHES (Boosting rural bioeconomy networks following multi-actor approaches) is a H2020 "Coordination Support Action" project, that brings together twelve project partners from five European countries, namely Finland, Spain, Italy, Poland and Germany.

The EU-funded BRANCHES project works to increase the flow of information, new ideas and technologies among European agriculture and forestry professionals, especially in rural areas. BRANCHES project aims to promote the implementation of new cost-effective technologies; mobilize more biomass and create innovative business opportunities in rural areas by improving and strengthening the links between bioeconomy practice and science. The project will ensure communication through the two-way flow of information for the transfer of ideas and technologies between scientists and professionals from agriculture and forestry in rural areas.

The valuable knowledge produced by research and development should always be shared far beyond the scientific community. BRANCHES project will integrate selected knowledge on forest and agricultural biomass supply chains with available innovative technologies and best practice cases for bioeconomy solutions with bioenergy conversion systems in a wider bioeconomy context. In all EU countries, best available technologies and practices in bioenergy and bioeconomy in rural areas are presented in easily understandable formats through the national thematic networks launched by BRANCHES.

BRANCHES project will produce and share Practice Abstracts (PAs) from regional best practices useful for the bioeconomy. The selected best practices summarized in Practice Abstracts (PAs) are shared through the project media and collected on the project webpage (https://www.branchesproject.eu/materials/practice-abstracts-and-factsheets). From these best practices, the most promising bioeconomy solutions are presented in Case Studies to further detail the value chain or technology characteristics.

2 Case description

The Qvidja organic farm is an experimental farm that demonstrates and implements regenerative farming practices for food and renewable energy production that take into account both nutrient recycling and carbon sequestration while increasing biodiversity. The regenerative farming practices applied at Qvidja farm provide measures to decrease carbon emissions from agriculture as well as increase the soil organic matter and soil fertility. Such practices include, e.g., lighter tillage, continuous plant cover, rotational grazing, agroforestry, increased biodiversity and cover cropping (Heimsch et al 2021).

In Qvidja farm, all fields (180 hectares in total) are farmed as grassland, which aims to improve the structure of the land. The farm is gradually switching into a crop rotation with the emphasis on native species and nitrogen-binding plants. The effectivity of carbon sequestration in farms is affected by the assortment of carbon-storing plants present on the farm. For example, both, deep-rooted grasses and leguminous plants are excellent at absorbing and storing of carbon. In addition to the assortment of plants, the method of harvesting has also an impact on the amount of stored carbon. For instance, higher remaining grass after a cut allows the plants to continue photosynthesis and enables a faster root recovery. In the fields of Qvidja, the height of the grass is left at 15 cm above ground instead of the previous 10 cm. The carbon sequestration of perennial grass is based on the high number of growth cycles, continuous vegetation cover and on deep and wide root system that bind carbon to the soil. Carbon is also transferred from roots to soil microbes and is retained in the soil once the microbes die. This improves the humus content of the soil.

The carbon dioxide exchange between the atmosphere and a managed forage grassland was studied at Qvidja farm in 2018 and 2020. According to Heimsch et al. (2021),” the Qvidja field acted as an annual net carbon sink and had the potential to contribute to the short-term climate change mitigation”.

Figure 1. The soil before (left) and after (right) experiments where different organic soil amendments were added to soil to improve the structure of clay soil. Photos: Saija Rasi.

Grazing is also an effective method to improve the effectiveness of carbon sequestration of grass and plants. In Qvidja, cows, sheep and horses graze utilizing a hastened pasture cycle, where a large herd graze in a single grazing area only for a short time and then move to another grazing area. This cycling allows the plants to regrow while also keeping the farm animals fed until the cycle is repeated. Agroforestry, a farming method where trees and bushes are cultivated alongside crops, is also an effective method of carbon sequestration. The broader biodiversity of plants in these farmlands also improves the balance of microbes and fungi that are beneficial for carbon sequestration.


Figure 2. Cows and horses grazing at Qvidja farm. Photos: Saija Rasi.

Over 700 ha of forest grow at the Qvidja farm, utilizing the continuous cover forestry method, where the trees are allowed to regenerate naturally. There are also agroforests in the area containing various tree species of different size and age and thus retain their biodiverse ecosystem better than typical cultivated forests.

Figure 3. Forest of different age at Qvidja farm. Photo: Saija Rasi.

Figure 4. Natural wetlands in the areas are kept to increase biodiversity. Photo: Saija Rasi.

The conventional agriculture is heavily relying on fossil energy. At Qvidja farm, this dependency on fossil fuels is decreased by several renewable energy production technologies (Figure 5). All the systems are built in form of experimental facilities to provide information on farm-scale renewable energy production. The utilised energy production options at Qvidja farm are biogas production, biological methanation, wood gasification, wood chip fuelled heating plant, and solar PV.

Figure 5. Qvidja farm provides a research and development environment for various renewable energy technologies. Photo: from video *The farmer isn't the problem, they are the solution* (2022): https://www.youtube.com/watch?v=B6eAbiFlxTM).

Biogas, containing methane and carbon dioxide, is produced when organic matter is degrading under anaerobic conditions. The agricultural residues are good raw materials for biogas production. Treating manure via biogas process can remarkably decrease greenhouse gas emissions as for example methane emissions from open manure storages are prevented by capturing the methane in biogas process and used in energy production. However, manure might need a co-substrate to improve the profitability of the processing. After the digestion process, the nutrient-rich digestate can be used as organic fertilizer in the farm fields. The digestate has good fertilising value and it also helps to maintain or even increase soil organic matter. In Qvidja farm, grass and manure from the farm are used as a feed for the biogas plant. Energy from the biogas unit is utilized in electricity and heat production. In addition, part of the produced biogas is upgraded, after which biomethane can be used as a vehicle fuel.

Figure 6. Biogas plant (left) and grass silos (right). Photos: Saija Rasi.

In addition to the biogas plant, the QPower's biological methanation pilot plant is located at the Qvidja farm. In biological methanation, microbes are utilized to produce methane from carbon dioxide and hydrogen. Process is based on exothermic Sabatier process:

$$4H_2 + CO_2 = CH_4 + 2\ H_2O$$

Hydrogen for the pilot plant is obtained from electrolysis and from the wood gasification unit. As a carbon source, the plant can utilise carbon dioxide from biogas process or carbon dioxide and carbon monoxide from wood gasification unit. The plant's efficiency is 82%. The process operates under temperate conditions; the temperature is 60 – 85 °C and the pressure near ambient pressure.

Figure 7. Biological methanation unit at Qvidja farms. Photo: Saija Rasi.

Wood obtained from forest thinning is used locally at Qvidja farm in a wood gasification unit and in conventional wood chip -powered heat generation unit. The processes provide electricity and heat for the farm.

In the wood gasification unit, wood material from forest thinning is converted into synthesis gas. Gasification is a thermochemical conversion of organic material to product gas at high temperatures with a reduced amount of oxygen (less than in stoichiometric combustion). Product gas consists mainly of water vapour, carbon monoxide, carbon dioxide, hydrogen, and nitrogen, but it also contains impurities such as tar, fine particles, and sulphur compounds. The impurities need to be removed from the gas before end-use. The gas composition depends on the type and construction of a gasifier, fuel used, and process parameters (Sansiwal et al. 2017). In general, gasification is considered as an attractive process to exploit the energy from certain biomass materials for various end products such as heat, electricity, and transportation fuels due to the good conversion efficiency of the process.

Unlike typical wood gasification units, the gasification unit at Qvidja farm is a unique oxygen-enriched gasifier that produces pure and tar-free synthesis gas that can be fed to a methanation unit, or it can be directly used as a fuel in gas engines. High operation temperature (<1000 °C) also ensures an efficient decomposition of other harmful substances (QPower, 2022a). The nominal power of the oxygen gasifier unit at Qvidja is 250 kW and it consumes approximately 250 litres of wood chips per hour (QPower, 2022b).

Figure 8. Gasification unit at Qvidja farm. Photo: Saija Rasi.

Solar photovoltaic (PV) system is one option to increase energy self-sufficiency at a farm. Qvidja farm has invested on a solar PV system with 95kW$_p$ capacity. Solar PV panels convert sunlight into electrical energy. Although Finland is a Nordic country, the solar irradiation levels are similar to the irradiation levels in Poland and Germany. The optimal solar PV system size is farm- and site specific and hence, when sizing a PV system, the power consumption profile of the farm needs to be taken into account. A challenge in Finland is the intermittency of the available solar energy (summer-winter cycles). Therefore, under Finnish conditions, the farm needs to have a relatively high power consumption also during summer time, as the amount of substituted purchased electricity is a key factor for the profitability of the PV system. The solar PV system is well-dimensioned when most of the generated electricity is used directly at the farm, resulting in avoided costs on purchased electricity.

The renewable energy technologies used at Qvidja farm are presented below in Figure 9.

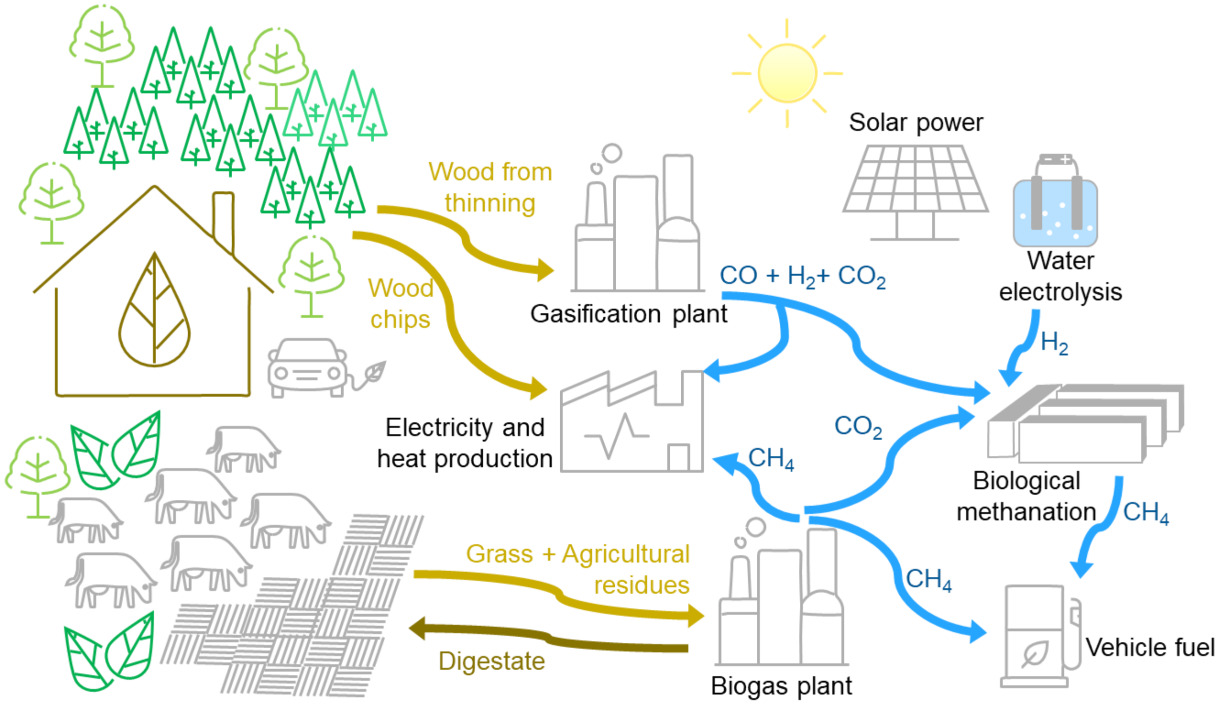

Figure 9. Illustration of energy production at Qvidja farm. It describes the linkages between the main unit operations at the farm.

3 Practitioners' feedback & motivation for development

Climate change has direct and indirect effects on agriculture. On the other hand, agriculture contributes to greenhouse gas emissions. Key motivations at Qvidja farm are to experiment farming practices for food and energy production that simultaneously mitigate climate change, increase biodiversity and minimize nutrient leaching to the Baltic Sea. These targets are reflected in all practices and techniques piloted at the farm.

The methods and technologies piloted at Qvidja farm, described in detail in Chapter 2, aim to decrease carbon emissions from agriculture while taking into account nutrient recycling and carbon sequestration. The carbon sequestration is directly reflected in growth conditions and the security of crop supply. The methods applied at Qvidja also improve the tolerance of the arable land against the extreme weather conditions caused by climate change.

Agriculture is also highly depended on fossil energy. Renewable energy production from agricultural and forest side-streams enable to increase the self-sufficiency, security of supply and circular bioeconomy at farms.

4 Trade-offs between economic, energy and environmental effects for conventional and improved biomass handling approaches

Improving biodiversity is in the focus of all actions done at the Qvidja farm. The technologies and methods piloted and used at the Qvidja farm enable the farm to improve its soil structure, minimize nutrient leaching, increase carbon sequestration and improve energy self-sufficiency. In this chapter, the energy-related trade-offs of bio-based alternatives for conventional energy production in rural regions, especially from an agricultural farm perspective, are discussed.

From the energy perspective, agricultural production generates a variety of bio-based residues and side-streams with energy recovery potential. Harnessing suitable technologies to recover the value of these streams provides several benefits for the farm itself, but also for the local and regional bioeconomy. The bio-based residues and side-streams with valorisation potential can include for instance livestock manure, straw, grass, and logging residues. For example, the energy production potential for biogas from local agricultural and livestock residues is large compared to what is currently being exploited in Finland. Many of the above-mentioned residues and side-streams are already exploited at the Qvidja farm, either via technologies that are already mature (biogas plant, wood gasification) or that are still on a piloting phase or close to commercialization (biomethanation). The premises at Qvidja farm provide a versatile research and development environment for renewable energy technologies that can be used in agriculture to valorise bio-based feedstock. The technologies applied in Qvidja present different solutions that a farm, or a rural entity, can deploy to replace conventional fossil-based fuels.

Generating energy from local bio-based sources improves the energy self-sufficiency at a farm-level and even at a national level. By generating energy from bio-based residues and side-streams, a farm can obtain direct savings from avoided costs related to purchased electricity and fossil fuels. This can improve the overall economic feasibility of the farm. In terms of security of supply, by generating energy, the operations at the farm are less dependent and vulnerable for the price changes in purchased electricity or imported fuels. In addition, in some cases, the excess energy produced can be sold in the form of electricity, heat or transportation fuel. This provides a new source of income for the farmer.

In the case of biogas production, besides energy, the farm can also increase its self-sufficiency on fertilizers as well. Recycled fertilizers from biogas production are used as a fertilizer at the Qvidja farm. During the biogas production process, the nitrogen present in the feedstock is transferred into more soluble form in comparison to ordinary substrate. By using the recycled nutrients as fertilizers on the fields, the demand of purchased chemical fertilizers reduces. In addition, the operation of the farm is less affected by fluctuating market prices of the chemical fertilizers.

Naturally, replacing conventional energy sources with bio-based alternatives, fossil emissions are reduced. The QPower's biological methanation pilot plant at the Qvidja farm takes this one step further, as during the biological methanation process, bio-based carbon dioxide emissions are also mitigated. During the methanation process, carbon dioxide is converted to biomethane with hydrogen from electrolysis and/or from the wood gasification unit. Therefore, the carbon dioxide present in biogas, previously vented to the atmosphere during the combustion of biogas (for heat and/or electricity) or during the upgrading process of biogas into biomethane (used as a transportation fuel) is avoided through the applied technologies.

On the contrary, an important barrier for farms to replace conventional energy production with renewable alternatives are the high capital investment costs for bioenergy production units at a farm-scale, e.g., in the case of a small-, or medium-scale biogas plants. Furthermore, investment costs have significantly increased recently as consequence of inflation and global supply challenges. However, the increased energy prices can reduce the payback time of the investments. In the Finnish case, investment subsidies from Finnish authorities are often needed to make agricultural renewable energy investments financially feasible at a farm-scale.

The on-going research and development work on the biological methanation process at the Qvidja farm is an example of an action to improve the feasibility of bioenergy production. By converting the carbon dioxide from biogas to biomethane, a more valuable product can be generated from the same amount of feedstock while generating value for the previous side-stream.

5 Knowledge transfer potential to other regions

Qvidja farm pilots and demonstrates methods for regenerative and holistic farm management and bioenergy technologies, which have the potential for knowledge transfer and replicability in other regions as well. On the fields, Qvidja aims for carbon-sequestering and biological cultivation. The fields are on grassland, artificial fertilizers are avoided, and crop rotation method, native-species as well as nitrogen-binding plants are used. In the forests, biodiversity is promoted by applying continuous cover forestry, where the trees are allowed to regenerate naturally. As the forests have trees with uneven ages, the forests are more diverse. From a renewable energy production perspective, the renewable energy technologies in Qvidja cover biogas production, biological methanation, wood gasification, wood chip-fuelled energy production, and solar PV.

All the activities, farm management methods and bioenergy technologies, aim to improve the sustainability and feasibility of primary food production while also improving the state of the environment. The methods and technologies can be applied in rural regions where primary agricultural production takes place. The replicability potential of the technologies and methods piloted at the Qvidja farm depend on the characteristics of a farm where the addressed solutions could be implemented. The characteristics can include, among other aspects, the availability of fields and forests, the size of the farm, the availability and quality of residual biomasses, the amount of energy utilization at farm as well as the location of the farm. A farm aiming for carbon-sequestering and biological cultivation or targeting a reduction of fossil fuels does not need to incorporate all ideas demonstrated at Qvidja farm, but the primary producers could choose technologies or methods most suitable for the characteristics of the farm in question.

6 Summary

To conclude, Qvidja farm provides several examples of methods and technologies on how farmers and foresters can promote climate smart food production. Qvidja farm demonstrates methods for regenerative and holistic farm management to improve soil structure, minimize nutrient leaching and to increase carbon sequestration in primary food production. In addition, the farm uses and pilots several renewable energy technologies that can be used in agricultural farms to improve energy self-sufficiency. All work done at Qvidja is done in favor of the climate and the Baltic Sea, biodiversity being the foundation for all actions.

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Case Study

Vineyards pruning valorisation for energy purposes as local strategy to promote circular economy

Creators: Maider Gómez Palmero

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BOOSTING RURAL BIOECONOMY NETWORKS

Content

CASE STUDY Vineyards pruning valorisation for energy purposes as local strategy to promote circular economy	
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1 Introduction

BRANCHES project aims to promote the implementation of new cost-effective technologies; mobilize more biomass and create innovative business opportunities in rural areas by improving and strengthening the links between bioeconomy practice and science. The project will ensure communication through the two-way flow of information for the transfer of ideas and technologies between scientists and professionals from agriculture and forestry in rural areas. The valuable knowledge produced by research and development should always be shared far beyond the scientific community. BRANCHES will integrate selected knowledge on forest and agricultural biomass supply chains with available innovative technologies and best practice cases for bioeconomy solutions with bio-energy conversion systems in a wider bioeconomy context. In all EU countries, existing strategies and best available technologies will be presented in easily understandable formats through the national thematic networks launched by BRANCHES.

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2 Case description

Vilafranca Municipality coordinated a project from 2014 to 2016 called Vineyards for heat co-funded by the European Commission's LIFE Programme (LIFE13 ENV/ES000776), which intended to demonstrate the performance of the biomass circle with pilot tests in two wineries (Codorniu and Vilarnau) and in one area of public facilities in Vilafranca.

VINYES XCALOR

The project aimed to apply and implement a vineyards virtuous circle (VVC) as a local strategy to mitigate climate change contributing to meet the goals to reduce greenhouse gases (GHG) according to the sustainable energy action plan (SEAP) derived from the political commitment and engagement to the Covenant of Mayors. The VVC intends to make profit of vineyards pruning to generate heat and cold for institutional guarantor, in this case, the municipality of Vilafranca.

The objective was to settle the bases to transition the region of Penedes into an efficient low carbon economy area and to contribute to the objective of reducing agricultural emissions by 42 % (roadmap 2050).

After the project has ended, the value chain has evolved to incorporate new actors and improve the value chain design to increase its efficiency.

Vilafranca del Penedès Town Council is located in one of the most important winemaking regions in Catalonia (Spain). Winegrowing in the Penedès region produces 30,000 tonnes of vine pruning waste annually (vine shoots) (Figure 1). This material is usually burned in the vineyards, which does not allow for energy harnessing and causes pollution. Vine pruning waste can easily be transformed into a source of biofuel that has high energy potential.

Figure 1. Location of Vilafranca del Penedès.

The new value chain involves all actors of the biomass value chain, which is key to successfully develop it. The project consortium included the town council of Vilafranca as the coordinator of the project, COVIDES cooperative in charge of the biomass supply, NOU VERD in charge of the biomass management, and INNOVI addressing biomass consumer engagement and promotion. After the project has ended, new actors were involved to further develop the value chain. More precisely, the value chain actors currently involve the Celler Cooperativa La Granada and EM-AVSA, although the municipality is still contributing to further promote the innovative practice.

The main steps of the value chain include:

- Biomass collection and transport to the storage site
- Biomass management: pre-treatment, storage and supply
- Energy production (combustion and ash management)

The technology and equipment currently used along the whole value chain is already commercial (TRL 9).

BIOMASS COLLECTION

The pruning of vine shoots is carried out every year at the end of the grape picking season from the end of November to mid-March by the cooperative La Granada.

During the project, vineyard biomass was collected during the pruning seasons of 2014-2015, 2015-2016 and 2016-2017. A total of 778 hectares were harvested, and a total of 469 tonnes of biomass were obtained. 349 tonnes of biomass were supplied to a boiler at Girada district heating to produce heat. Nowdays, Cooperative La Granada collects the vine shoots from 200 hectares around Vilafranca. The yield varies greatly from 0.7 tonnes per hectare on dry years to 1.2 tonnes per hectare on rainy years, which are significantly more productive.

In terms of the equipment needed to carry out the collection, a key challenge during the project was to find a biomass harvesting system that avoided vine shoots mixing with other materials, thus avoiding additional treatment costs. A pre-pruning machine was designed to vacuum the shoots directly from the plant before they would fall to the ground (Figure 2). The machine was used during several pruning seasons in spur-pruned vineyards and, despite making improvements to the model, the project did not achieve to produce a machine that operated satisfactorily. While the machine was able to carry out the pruning effectively, the mechanism designed to collect the waste was not.

Figure 2. Prototype developed to collect vineyard pruning.

An alternative solution was found by using a different machine that already existed on the market: Peruzzo Cobra Collina, a picking and shredding machine (collector with catcher) that was adapted to collect pruning waste.

Nevertheless, the homogeneity of the material was not optimal and clogging occurrence in the boiler feeding system led to change the collection system. The La Granada cooperative is currently using a regular tractor equipped with an implement which allows the farmer to rake pruning from the rows to the field side (Figure 3 and 4).

Figure 3. Equipment used to rake vineyard pruning.

Figure 4. Vineyard pruning collection.

Once the prunings from a field have been piled, they are placed right next to the road in order to optimize the collection process. A boom truck picks the biomass and transports the biomass to the storage site (Figure 5).

Figure 5. Loading to transport the biomass to the storage site

Although there are many benefits on the social and environmental side, economic feasibility is key and was therefore envisaged when designing and implementing the changes to further improve the value chain (from the initial design). The cooperative La Granada offers two possible services to their associates:

First, the collection of the vine shoots takes place in between rows in the field, piling of the prunings, loading, and transport to the storage site with a total price of approximately 60 euros per hectare (payment from the farmer to the cooperative for the respective service). Second, the farmer takes care of the collection and piling of the vineyard pruning while the loading and transport to the storage site is organised by the cooperative with an approximate cost of 40 euros per hectare. Seeking to adjust the economic feasibility of the value chain, the services prices were increased from previously 50 and 25 euros per hectare, respectively.

Another key aspect of the biomass collection process lies in the planning stage. In many cases, wine-growers' plots are spread across an larger area, thus the collection needs to be planned across the borders of winegrowers in order to maximise the efficiency.

BIOMASS MANAGEMENT

A key role to achieve good quality of the biofuels involves the storage and pre-treatment.

The storage site covers an area of 5,000 square metres and is located at a strategic position that facilitates the supply to the district heating in Vilafranca's La Girada assuring cost competitiveness is achieved by reduced transport costs. The storage site is divided into two differentiated areas. In one part the vine shoots are unloaded and stored in uncovered piles to dry. In the second area the material is chipped and stored under cover within a shed (Figure 6 and 7).

Figure 6. Vineyard pruning storage.

Figure 7. Chipped material storage under shed.

The chipping is scheduled periodically once a certain minimum amount has been collected. In order to perform the chipping, a high-power equipment is used, and chipping is conducted at the storage site (Figure 8).

Figure 8. Chipping.

During the project, the chipping took place at the field, but the machinery used did not reach a sufficient quality of the product. The material produced did not reach the required homogeneity and therefore an additional second chipping or a sieving was necessary. The chipper currently used is able to process around 20 to 30 tonnes during a 4-hour period and a better quality material is obtained, particularly regarding the homogeneity (Figure 8 and 9).

Figure 9. Chipped material.

ENERGY PRODUCTION

A centralized heating system run on biomass in La Girada has replaced heating systems and domestic hot water (DHW) that were produced using natural gas and/or electricity. Fossil-based energy sources have not been eliminated, but they are nowadays only used as back-up.

The installation of the boiler (Heizomat RHK-AK 500) was carried out as part of the LIFE Project and supplied thermal energy to four buildings (Dolors Piera primary school, an educational resource centre, parquet pre-school and alt Penedès Regional Archive). Heat supply began in January 2016. Taking into account the results achieved during the project lifetime, a new building (Ricard Fortuny Sociosanitary Centre) was connected to the Girada district heating network (Figure 10).

Figure 10. Boiler and district heating system.

EMAVSA, a service company, is in charge of the boiler operation and its maintenance. Additionally, EMAVSA and alongside the cooperative La Granada are in charge of organising the biomass supply to run the boiler.

Taking into consideration the boiler performance achieved during the project, some improvements were implemented (Figure 11). Seeking to avoid clogging, a cutting system was installed at the boiler entrance to improve the material size homogeneity.

Figure 11. Additional cutting system.

Additionally, the ash removal in this type of boilers running on biomass, which in average presents a high ash content, was initially carry out manually every second day using a metallic bin. Nowadays, a new container with a capacity of 700 litres was installed, which allows to empty the container mechanically after 10 days (Figure 12).

The deployment of the district heating network calculated during the project revealed an energy reduction of around 153,000 kWh of natural gas and 12,653 kWh of electricity per year. Additionally, the overall reduction of greenhouse gases emissions associated was around 241 tCO_{2eq}.

Figure 12. Ash container.

3 Practitioners' feedback & motivation for development

When installing a biomass boiler that is to be run on agricultural biomass, there are certain technical considerations that need to be taken into account: primarily, the material is not very dense and becomes easily entangled and the ash content is high (Table 1). Therefore, these peculiarities should be taken into consideration during the management and design of the biomass system to avoid operational problems and inefficiencies.

Table 1. Biomass characteristics.

	Average Lower Heating Value	Average bulk density	Average ash content
Vineyard pruning	4,116.21 KWh/t	157 kg/m^3	6.32 %

Agricultural biomass can provide a good thermal performance, although, based on the results achieved, the installation of these boilers in urban areas is recommended when using a centralized (district heating) boiler and when long-term use is envisaged. This will ensure optimum yields and maximum returns on investment.

The keys for replicability in this case include:

- Use commercial (tried and tested) machinery for the collection of vine shoots.
- Collect and manage biomass near to the end-users. The collection process must be planned to be highly efficient. The drying and storage of vine biomass must be strategically located near to the main consumers in order to keep the selling price competitive and to avoid excessive transport costs.
- Large facilities with sustained demand are preferable.
- Technical improvements to boilers and selection of the most adequate equipment according to the biofuel specific characteristics: boilers should have a chain conveyor system in the combustion chamber to counter the fuel's lack of fluidity and with continuous cleaning to avoid unnecessary stops and re-starts.
- Set up of a municipal services company is a key element as it ensures the stability of the project by contributing to ensure energy supply and customer confidence.

Additionally, another relevant aspect concerned the necessity of private and public sector to work together in order to promote and implement the initiative as well as to align all actors involved in the value chain. Based on the municipality experience it is time consuming and sometimes difficult to mobilize agents. Local authorities willing to promote this type of value chain need to clearly define the type of initiative or value chain besides the corresponding business model they intend to develop, taking the region's specific characteristics into consideration. When designing the project, it is essential to set realistic objectives, both in the short and midterm. It is also relevant to involve professionals with the needed expertise to correctly dimension the value chain and assess its suitability and profitability.

4 Trade-offs between economic, energy and environmental effects for conventional and improved biomass handling approaches

This value chain allows to strengthen the link between rural environment and circular economy through the utilisation of by-products to obtain a renewable energy locally.

Various benefits arose associated to the collection of the pruning. Firstly, the economic benefits derived from savings in fuel costs (replacing expensive fossil fuels) due to the substitution with wine shoots (biofuel). Secondly, it implies an environmental benefit due to the reduction of emissions derived from the otherwise uncontrolled burning of these vine shoots at the fields. And thirdly, social benefits are created in terms of employment associated to the biomass procurement and logistics.

The achieved benefits also include the reduction of the energy dependency and vulnerability to price changes of imported fossil fuel, increase energy security in the territory, as well as create new jobs based on a green economy. Furthermore, there is an improvement of the air quality in line with the Europe 2050 objectives and the roadmap of the Spanish National Plan of Air Quality and Atmospheric Protection in addition to contributing to an increased awareness regarding circular economy at regional and national level.

Additionally, the carbon cycle is affected since the same amount of CO_2 that has been stored during the vine's lifecycle (carbon dioxide is fixed through photosynthesis in the vine) is returned to the atmosphere. During the vine biomass combustion process, this CO_2 is released once again into the atmosphere and the cycle begins once again. The remaining ash is used as a fertilizer therefore contributing to the circular economy objectives.

Therefore, this value chain based on vineyard pruning allows to obtain a decentralized and local form of renewable energy, de-centralized and local, that reduces dependence on fossil fuels and contributes to promote competitivity and innovation in the area, enhancing and adding value to the economy of the region. The environmental and social benefits derived from the generation of "zero kilometre" renewable energy have turned a side-, or waste-product into an energy resource. Thanks to its good results, this innovative practice is attracting the involvement of other groups interested in promoting a circular economy.

5 Knowledge transfer potential to other regions

It would make a lot of sense to replicate this initiative in places where raw materials (biomass) are generated, which can be reused for energy or other purposes. Areas which concentrate a critical mass of stakeholders devoted to an agricultural activity that yield this type of biomass are key. The targeted value chain focuses basically on forestry or agriculture biomass, which is currently not used, for which a strategy should be designed to recover the material and generate an energy value. In case that most of the stakeholders involved agree and actively participate, the project will more likely be successful.

The current situation set an attractive framework to develop this type of initiative. Nowadays, the society is interested in projects of this type targeting the promotion of local/regional circular economy Currently many governments support such initiatives. At the European level, financial resources have been made available, and municipalities need to be aware of this opportunity. Administrations willing to develop a similar project could participate and apply for this financial support. Best cases example have a key role to promote this type of initiatives in other regions or municipalities, although each site specific characteristics (type of biomass available, existent actors, etc.) need to be carefully considered in order to adapt the strategy accordingly.

6 Summary

In conclusion, the value chain model based on vineyard pruning is a model of circular economy that consists of the use of agricultural biomass from the pruning of vines as a source of renewable energy, which can cover energy demands of the local consumers. By doing so, the vine circle is closed, and a green local economy is promoted in line with the EU's energy and climate goals.