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FORBIOENERGY - Forest Bioenergy in the Protected Mediterranean Areas

Planning sustainable forest-wood-energy supply chain in the protected areas

Appendix 4: Study area report - ITALY

Workpackage 3 - Testing

Activity A.3.8. - Planning sustainable forest-wood-energy supply chain in the protected areas

Deliverable 3.8.1 - Planning sustainable forest-wood-energy supply chain in the protected areas

Authors: Emilio BADALAMENTI, Donato Salvatore LA MELA VECA (Regional Department for the Rural and Territorial Development, Sicily Region), Vittorio LI PUMA (Municipality of Petralia Sottana), Laura COBELLO, Despoina KARNIADAKI, Claudia RUBINO, Carlo SIMONETTI (Enviland srl)

REGIONE SICILIANA
ASSESSORATO REGIONALE DELL'AGRICOLTURA, DELLO SVILUPPO RURALE E DELLA PESCA MEDITERRANEA
DIPARTIMENTO REGIONALE DELLO SVILUPPO RURALE E TERRITORIALE

Municipality of Petralia Sottana

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Contents

1 INTRODUCTION

The Regional Natural Park of Madonie is characterized by a wide environmental diversification and heterogeneity, both lithological, pedological, bioclimatic and land use. In the framework of the activity 3.4, 5 Biomass Districts (BDs) have been identified and described, with the aim to plan the biomass supply chains for energy purposes, in line with the principles of environmental protection, as well as to promote the socio-economic and territorial development (Figure 1).

The identification of BDs will be carried out taking into account the following criteria:

1) Availability of agroforestry resources (potential biomass supply for energy use);

2) Distribution of the road network;

3) Local energy needs (energy demand).

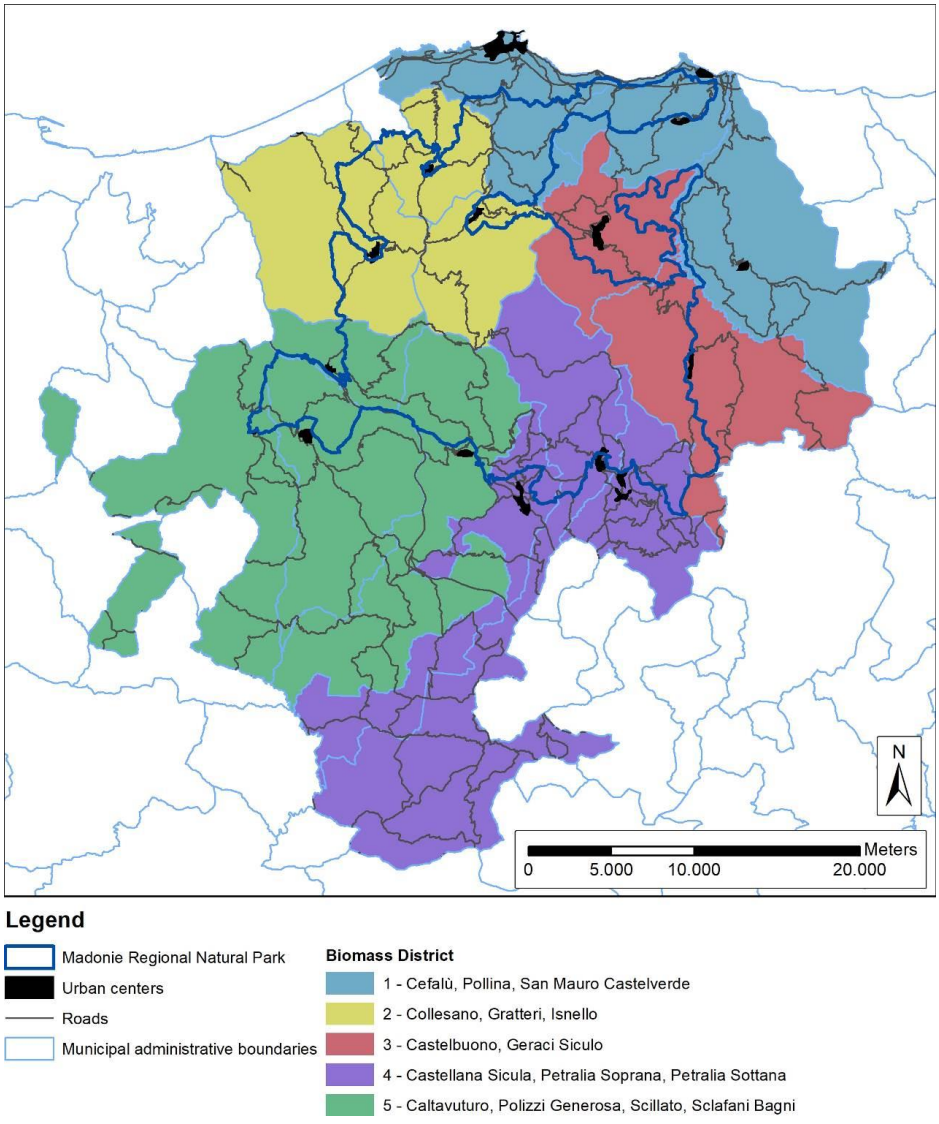

Figure 1 - Identification of the BDs in the Madonie Park.

Forests are largely located in the Madonie Park, within the BDs 2, 3 and 4, with values ranging from more than 86% to more than 99%. The area falling within the Biomass district n. 4 was chosen as the pilot/reference area for the implementation of the activity 3.7. The Biomass District n. 4 falls within three Municipalities: Petralia Sottana, Petralia Soprana and Castellana Sicula. The District area is about 30.700 hectares (Table 2). Petralia Sottana is the Municipality more extended, accounting for 57,8% of the overall District area (about 17.700 hectares), followed by Castellana Sicula, which accounts for 23,6% of the area (about 7.200 hectares), and Petralia Soprana, which covers 18,6% of the District area (about 5.700 hectares). District 4 holds the higher value, with an annual energy need of 161,886 MWh (Table 1). The ratio between the energy needs of the district and the agro-forestry areas effectively present in the district is only 2%, (more lower than in the other districts where this ratio ranges from 8 to 11%) because of the peculiarities of the municipality of Petralia Soprana, characterized from a particularly high energy need (86,672 MWh) as opposed to a very modest presence of agro-forestry available areas (285.78 ha).

Table 1 - Ratios between energy needs and potential woody biomass in each BD.

District ID	Energy needs (MWh)	Ratio between energy needs and available agro-forestry areas (%)
1	125.603	10
2	87.165	8
3	53.712	11
4	161.886	2
5	68.128	8

Table 2 - Overview of the area data of the municipalities and of agro-forestry resources, as well as energy needs used to identify the BDs within the Madonie Regional Natural Park.

District ID	Municipality	Municipal area	Municipal area within the park	Forests[1]			Permanent crops[2]			Total area (forests plus permanent crops)	Energy needs	Energy needs/agro-forestry areas ratio
				Within the park	Outside the park	Total	Within the park	Outside the park	Total			
				a	*b*	*c=a+b*	*d*	*e*	*f=d+e*	*g=c+f*	*h*	*i=g*100/h*
		ha	ha	ha	ha	ha	ha	ha	ha	ha	MWh	%
4	Castellana Sicula Petralia Soprana Petralia Sottana	30.765	8.812	2.736	5	2.740	0	219	219	2.960	161.886	2

[1]Corine Land Cover (classes 311, 312, 313) [2]Corine Land Cover (classes 221, 222, 223) [3]Energy needs not available

2 MAIN STEPS IN ESTABLISHING A WOOD ENERGY SUPPLY CHAIN

Biomass supply chain analyses includes analyses of potentials, present use and possible new biomass projects but also includes all stakeholders along supply chain like forest owners, forest entrepreneurs, transport enterprises, biomass traders, and mainly public customers (Figure 2). Wood biomass production chains did not start from zero but was built from existing organisations or individuals, while only identified missing links were proposed.

Looking from this point of view, the main steps in establishing wood biomass production in our pilot area are:

1st step Analysis of the present situation

2nd step Identification of end-users

3rd step Networking of interested stakeholders

4th step Analysis of the potentials for biomass supply

5th step Economical evaluation of a planned production chain

6th step Evaluation of possible bottlenecks (weaknesses and strengths analysis)

7th step Final recommendations for investors

8th step Technical assistance for project documentation preparation and finding funds for investments

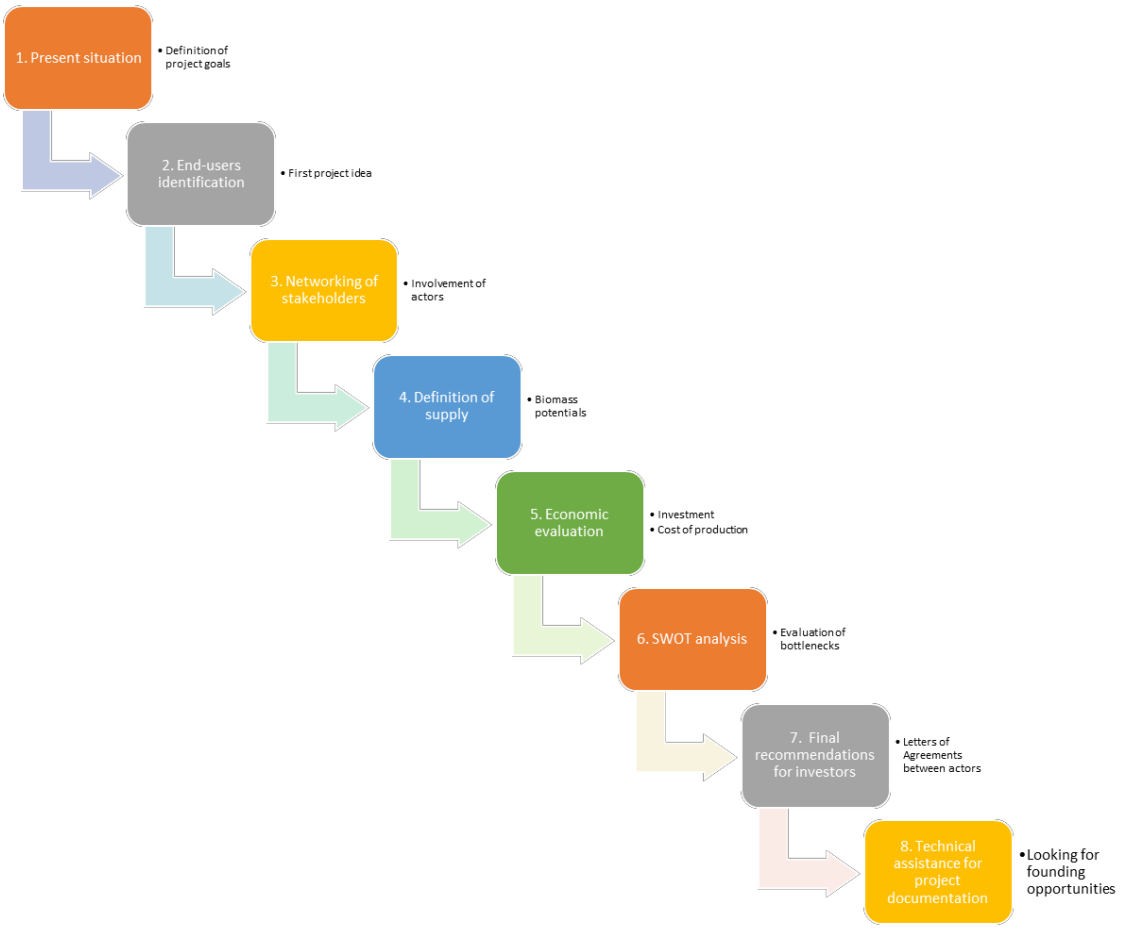

Figure 2 - Steps in establishing biomass production chains

2.1 1th Step: Analysis of the present situation

A simple analysis of the present situation of the market was prepared using existing data (data gathered in the activity 3.4.1, data obtained from the relevant statistical office, public authority, park administration, public forest service and other publicly available data sets).

Collected data were used to get an insight into biomass potentials, existing producers, and existing and potential consumers:

A: Supply side

a) Short overview of the wood fuel market. This kind of informations were already collected in the frame of D3.4.

In the Park of the Madonie there isn't any active chain related to use of residual biomasses resulting from ordinary forestry interventions for energy-related purposes. Locally, the biomasses resulting from intervention on small surfaces are used according to local habits firewoods in private households or in the food service industry (tertiary sector and in particular

for wood fired ovens of restaurants and pizzerie), concerning both private and state-owned woods. Although wood chips and pellets are increasingly exchanged in the local market, they are derived from wood exclusively imported from other areas of the world.

More details about the prices is given in chapter 2.5.3. Wood fuel prices.

b) Wood biomass producers

In the territory of the identified BDs, the number of companies currently operating in the forest sector is rather limited. In recent decades, in fact, due to the changed socio-economic conditions of the area and the exodus towards large metropolitan areas, we have witnessed the abandonment of mountains, forests and the rural areas in general. No forest company is registered in Districts 2 and 5, while in the Districts 1 and 4 only one company per district is found (Figure 3). In District 3, on the other hand, there are 6 companies operating in the forest utilization sector. At present, therefore, in the pilot protected area there are few companies operating in the biomass sector. This represents a strong limitation for the development of sustainable short supply chains for the production of bioenergy. The main information collected through interviews with the forestry companies operatin in the BD is reported in Table 4.

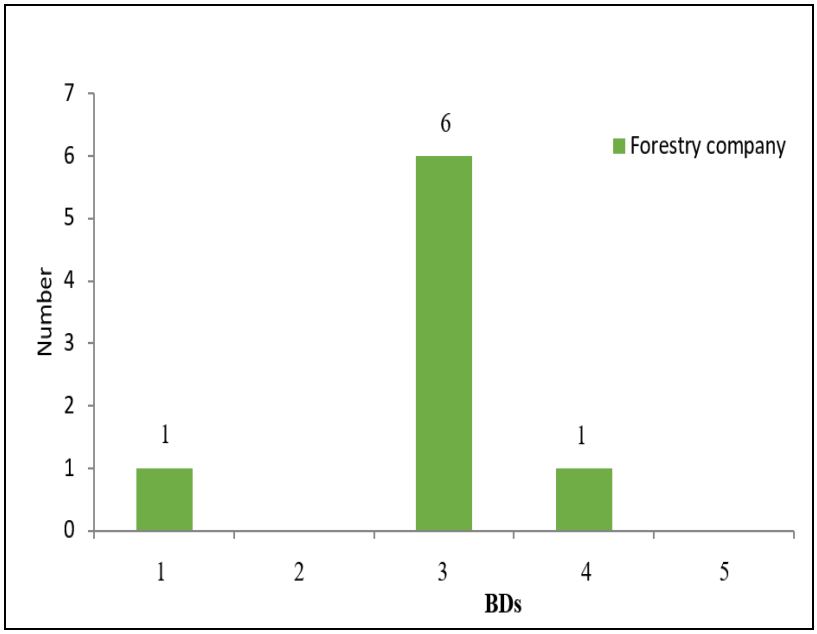

Figure 3 - Number of Forestry Company in the BDs.

Table 4 – Synthesis of information collected through interviews with the forestry companies falling within the Biomass Districts.

Locality	Price (€/kg) (VAT not included, after 1 year of storage)	Average quantity of wood placed in the market in recent years (in quintals)	Wood Provenance	Tree species
Castelbuono	0,19	1000	Nebrodi Mountains, Geraci Siculo	Turkey oak
Castelbuono	0,17	2000	Local woods	Holm oak, chestnut
Castelbuono	0,10	1500	Local woods	Oaks, ash trees, beech, olive
Castelbuono	0,18 (firewood) 1,00 (for coal production)	2000	Nebrodi Mountains	Holm oak
Geraci Siculo	0,16	1000	Nebrodi Mountains, Plain of Catania	Turkey oak, citrus trees, olive
Geraci Siculo	0,16	1000	Nebrodi Mountains, Geraci Siculo	Oaks, ash trees
Petralia Soprana	1,00 (for coal production)	1500	Boschi Madonie Mountains	Holm oak, beech

B: Demand side

a) Existing wood biomass users

The existing wood biomass users are represented by the local habitants that require firewoods for the heating of the private households or for using it in the wood fired ovens of restaurants and pizzerie.

b) Potential wood biomass users

In the Sustainable Energy Action Plans (SEAPs) of the Municipality of Petralia Soprana e Castellana Sicula, that fall in in the district n. 4, none specific action on the biomass valorization is foreseen. Instead, in the Sustainable Energy Action Plan (SEAP) of Petralia Sottana municipality is foreseen, among the strategic actions aimed at the reduction of the CO_2 emissions, the providing of incentives for the energy production from the sustainable use of wood biomass for increasing the energy efficiency of some

public buildings at territorial scale. In particular three specific actions are indicated in the SEAP of Petralia Sottana:

- the replacement of 2 diesel boilers in sport facilities (Municipal swimming pool and Palazzetto dello Sport) with modern high efficient biomass boilers is foreseen (PA_01 Piscina S. Elia – Palazzetto dello Sport).

- the realization of a biomass-fueled cogeneration plant (PA_04 Realizzazione impianto di cogenerazione alimentato a biomassa - Palazzetto tennis “Luigi Cannizzaro”) in the tennis courts of S. Elia. This realization will allow the combined production of electricity and heat through district heating.

- the realization of a mobile station for processing woody biomass and the purchase of machinery for the activities of collection and transformation of the biomass. (PA_12 “Creazione di una filiera corta della Biomassa legnosa”)

C: Other issues

a) <u>Existing environmental and other limitations</u>

In the area, there are several types of restrictions that may limit forest utilization, including naturalistic, hydrogeological and landscape restrictions. The main restriction to which the pilot area is subject to is the environmental restriction, especially deriving from the establishment of the Madonie Regional Park (Figure 4). It covers 28.3% of the District 4. Many Special Areas of Conservation (SACs) are present in the pilot area of the project, including the BDs. Particularly, SACs occupy 29.3% of District 4.

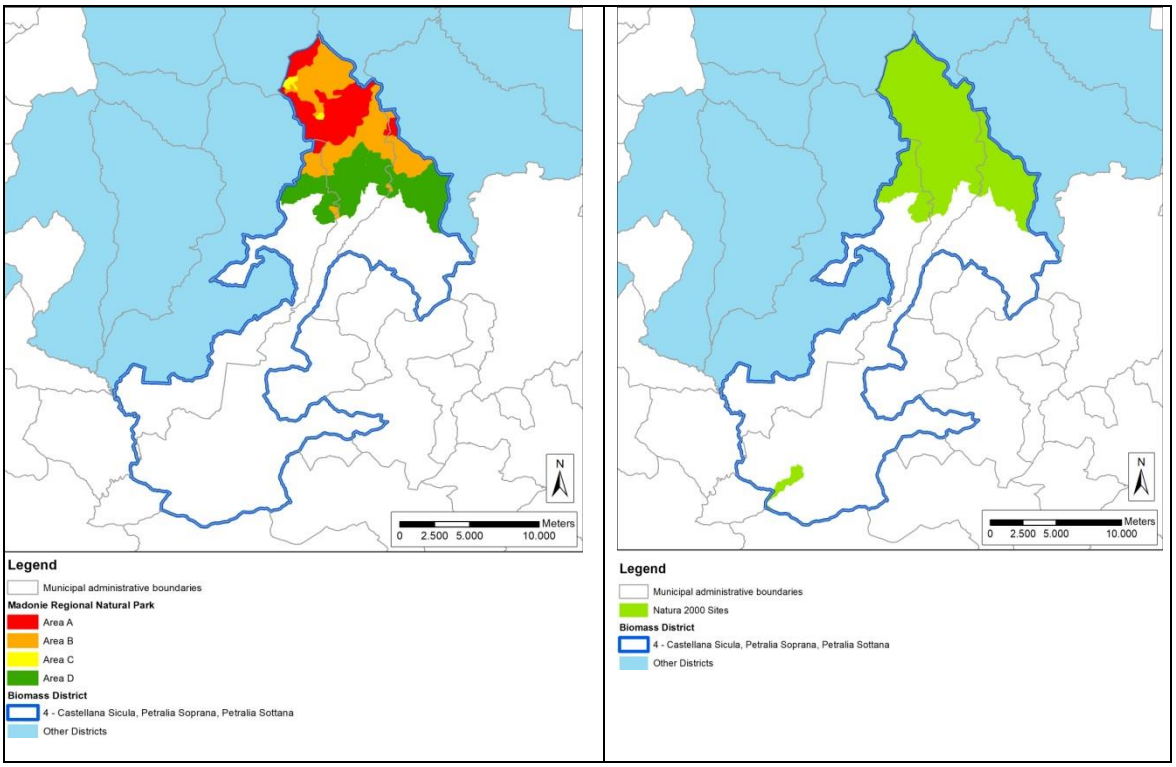

Figure 4 - Environmental restriction deriving from the establishment of the Madonie Regional Park and by the presence of Special Areas of Conservation (SACs) in the BD n. 4.

The hydrogeological restriction and landscape restriction (due to the high naturalistic value and the richness of their ecosystems) apply to the great part of the territory of the BDs and cover respectively 61% and 43.2% of District 4 (Figure 5).

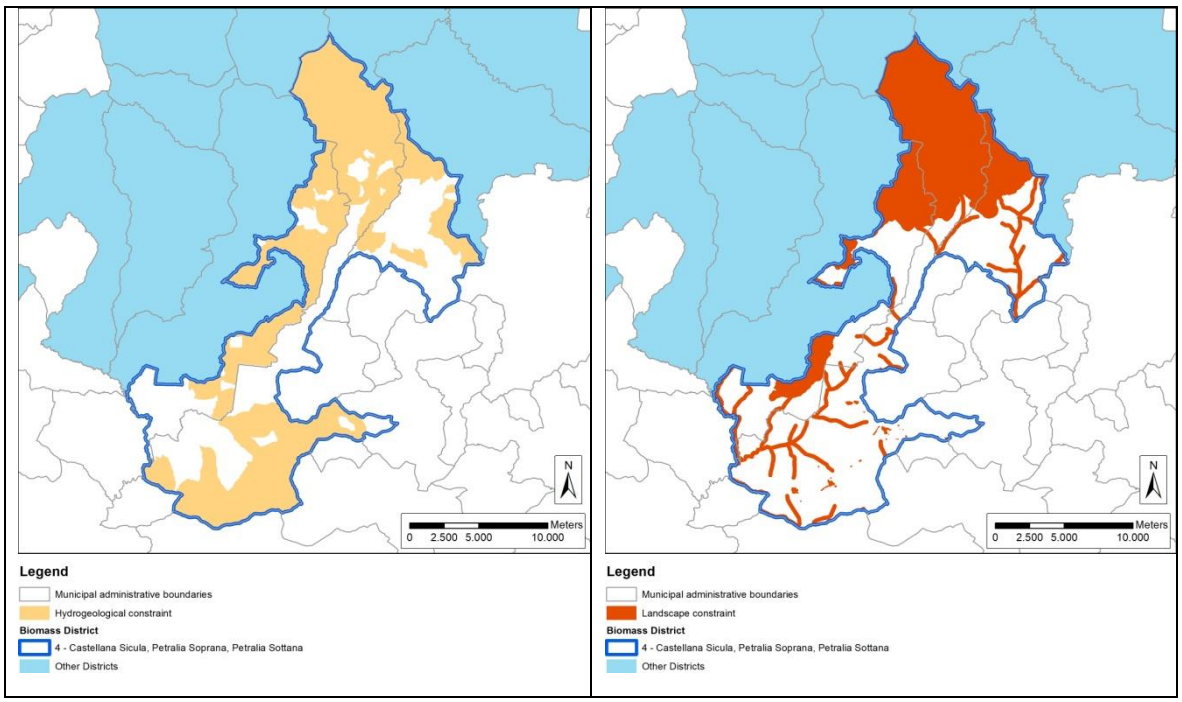

Figure 5 - Area of the BD n. 4 subject to hydrogeological (on the left) and landscape (on the right) restrictions.

If we analyze all the restrictions as a whole, considering the area not subject to any restriction within each BD, notable differences were found (Figure 6). In District 1, only 0.05% of the area is free from any type of restriction, in District 3 the unconstrained area is 3.3% of the total area, in District 4 it is 26.4 % and finally in District 5 it is 8.8%. Conversely, in District 2, the entire area is subject to some type of restriction. Hence, only District 4 has a considerable non-constrained area (about 26% of the total area), whereas in the other BDs the percentage value of the area subject to restrictions is more than 90%.

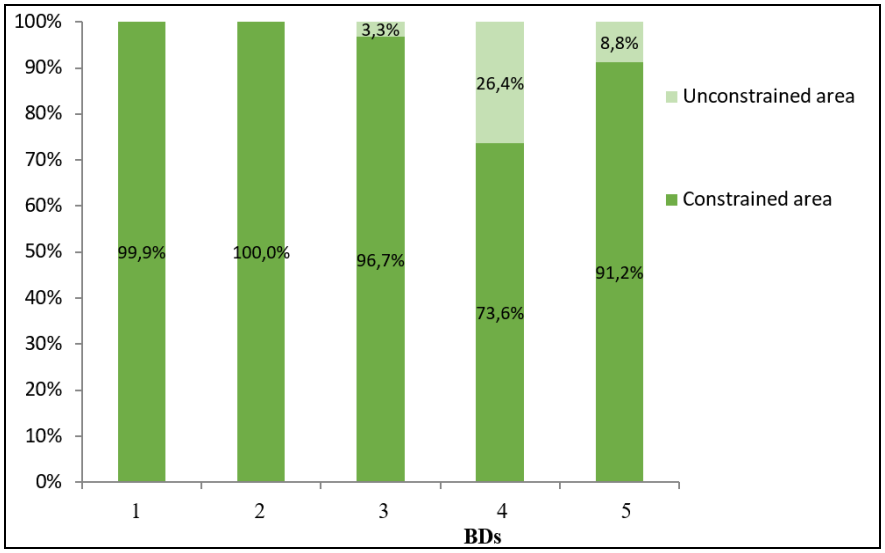

Figure 6 - Constrained and unconstrained area (%) in the BDs. The percentage values lower than 3% are not reported in the graph.

In order to plan the production of energy based on the use of forest biomass, it is very important to analyze and understand the types of restrictions that concurrently are in force in the area of interest. As seen in the previous paragraph, the main restrictions that persist in the territory of the BDs derive from the presence of the Madonie Regional Park, the sites of the Natura 2000 Network, and the hydrogeological and the landscape restrictions. It is apparent that, in general, more restrictions insist simultaneously on the same area, the greater may be the limits imposed on the biomass harvesting.

2.2 2nd Step: End users' identification

The General goal for wood biomass use in the pilot area is the "*Use of the wood residual biomass deriving from the sustainable forest management in the Madonie natural park for energy purposes".* This objective, identified in the Action Plan (Project Activity 3.6) as a general objective, was shared with the main key actors involved in the project. Woody biomass represents an important source of renewable energy within the protected natural areas, which is useful for promoting the development of local communities, while ensuring the safeguard of

the forest resources. Local wood (trunks or branches) has always been used in the Madonie Park by the rural communities as the main source of energy. In recent decades, both wood shavings and pellets, mainly imported from other countries, have been gradually established in the local market, as the local demand for wood products to be used for energy purposes is growing. However, in the Madonie Park there are technical, economic, administrative and social barriers that hinder the creation of a technically efficient, as well as economically and ecologically sustainable, wood-energy supply chain. One of the barriers for the development of the forest sector is the high fragmentation of private property, which makes forest operations uneconomic and forest planning difficult. This condition makes private forest owners unwilling to see in forests an economically viable and exploitable resource.

In the framework of the present project activity (Activity 3.8) it was therefore decided to consider the public forest areas. However this case study represents a “best practice” for the energy use of residual woody biomass deriving from forest management of both public and private forests, taking into account the constraints of the protected natural area.

The Specific goal for the use of woody biomass in pilot area is to “*Support the establishment of forest enterprises and the development of local short biomass chains for the production of bioenergy, promoting the cooperation between private and public actors”.* This objective, identified in the Action Plan (Project Activity 3.6) as a specific objective, was shared with the main key actors involved in the project. The project forecast the establishment of a local forest-wood-energy supply chain that is technically efficient, as well as ecologically and economically sustainable.

A “short” supply chain (the distance between the site of production of the raw material and the sales area is some tens of kilometers) is the only chain able to match the needs of environment and man as it allows the re-entry into the local circuit of the natural and economic resources, with recognized environmental benefits. For this purpose, the proposed case study concerns the creation of a short wood-energy supply chain in the Biomass District No. 4 and in particular in the Municipality of Petralia Sottana, aimed at the biomass supply for fueling the municipal swimming pool.

The implementation of this supply chain will contribute to increase the awareness of the local community on the economic and environmental benefits linked to the forest management for energy purposes. The most important expected social results are linked to the increasing of the local employment and in particular of the skilled labor and local forestry operators, which can be achieved along all the phases of the forest-wood chain, from cutting in the forest, to wood processing and finally the sale of wood products.

The local production and the sale of wood will significantly increase the share of locally produced energy over time, reducing the energy dependence of the territory, both in the public and private sectors. The municipality of Petralia Sottana has planned several actions in the bioenergy sector which were identified in the SEAP. Among these, an intervention which foresees the replacement of a heating oil boiler with a biomass boiler in the premises of the indoor swimming pool and the service of the tennis sport club. (see Annex 1; Figure 7)

Figure 7 – The swimming pool in the municipality of Petralia Sottana which could be feed with the woody biomass deriving from the management of neighbouring forest areas.

Until 2012 this thermal plant was constituted of n. 2 heating oil boilers with a thermal power of 581 kW. The heating system was designed for:

- heating the pool water;
- producing domestic hot water;
- heating the buildings of the swimming pool and of the tennis sport club.

In 2012, a new biomass (pellet) boiler with a total thermal capacity of 857 kW (Efficiency: 80%) was purchased by the Municipality. This boiler never came into operation as the building was closed for renovation.

Therefore, the objective of the project was to define the technical and economic conditions for the conversion of the boiler from pellets to self-produced wood chips, that is from the forest management of public property areas within 3 km from the pool building.

Figure 8 – The decommissioned heating oil boilers (on the left) and the new biomass (pellet) boiler for the swimming pool in the municipality of Petralia Sottana.

2.3 3rd Step 3: Networking of interested stakeholders and providing support for establishment of cooperatives identification

In order to achieve the aforementioned objectives, the involvement of all stakeholders in the Madonie Park is necessary for raising the awareness of the local community on the economic, social and environmental benefits deriving from the sustainable management of forest areas. In the Madonie Park the forest sector, both public and private, is not adequately developed. There are just few companies that carried out forestry jobs; these are not adequately specialized and do not have the necessary technical and economic skills. As a result, they generally do not have enough forest operators and equipment in able to ensure acceptable levels of forest work productivity.

Furthermore private forest properties are generally small and fragmented, and consequently, many forest owners are not interested in managing and using these areas, considering them not much productive or completely unproductive (high operation costs and insufficient revenues). These reasons make the private forest owners reluctant to consider the forests as an economic and exploitable resource.

The involvement of private owners of forest areas is therefore one of the most important steps for the development of this sector. In fact, within the Madonie park, private forests represent an important share (38%) of the entire forest area. The establishment of forms of local cooperation/association between forest owners is an effective solution for facilitating the

creation of short supply chains, as it reduces the costs per surface unit and increases the revenues from the sale of wood.

Therefore, information activities will be necessary for spreading the knowledge on the several economic and social advantages that the cooperation of forest owners can provide, for promoting the active involvement in the forest management and for encouraging the establishment of associations or consortia between private owners. Also in the public sector, the management of the forest resources is not yet oriented towards the efficient wood production (limited purchase of forest equipment, inadequately qualified labour, etc.).

In addition to these limitations of the public forest system, the administrative and legislative restrictions linked to the presence of the protected natural area must be considered. In this direction, the actions to be implemented will focus on the increasing the knowledge and skills of public and private forest operators on the sustainable forest management, on the issues linked to the conservation of forest habitats and on the potential negative impacts that the biomass extraction can produce will have to be prepared.

It will also be necessary to promote initiatives for improving the authorization process related to the forest operations in protected areas and for modifying the regulatory framework of the Park, which currently imposes unitary rules on the whole area, preventing the forest operations also in these areas where these are necessary for favouring the natural dynamics and increasing the protection and conservation of forest biodiversity.

The increasing of skills must also involve other sectors linked to the wood-energy supply chain, as the planning and management of bioenergy plants using the most innovative and efficient technologies. General public and in particular young people should be involved in intensive information activities too in order to increase the knowledge on forest activities in protected areas and on the opportunities deriving from the biomass extraction for energy purposes. Therefore, the proposed case study, which concerns a public building, can constitute a valid example and a best practice that will be spread throughout the whole local community of Madonie Park.

The Transferring activities (WP4) of the Forbioenergy project ensured the exchange of information and knowledge and guaranteed the active involvement of the main local actors, selected at regional and local level, and the transferring of the testing activities results (WP3). The thematic workshops (Technical Panel) have been an useful reference for the implementation of testing activities; training seminars allowed the transferring of the knowledge and results produced in the different phases of the project to a wide audience constituted by public authorities, technicians and professionals.

By the end of the project, two agreements will be signed with the main key actors at regional and local level (Agreement on the Action Plan for unblocking technical and administrative barriers & Agreement on the integration of bioenergy issues in strategies/plans regarding rural areas). The target groups and the first most important steps for achieving the objectives indicated above are reported in Table 5.

Table 5 - Engagement of target groups and first steps for achieving specific goals

Goal	Target group	The first most important three steps
Support the establishment of forest enterprises and the development of local short biomass chains for the production of bioenergy, promoting the cooperation between private and public actors	Sicily Region – Department for Rural and Local Development; Sicily Region – Energy Department, Local Authorities, Madonie Regional Natural Park Authority, forest owners, forest operators.	1. Promotion of the case study of the Municipality of Petralia Sottana 2. Information campaign (articles, seminars, visits to the plants etc) 3. Training activities

2.4 4th Step 4: Analysis of the potentials for biomass supply

The potentially available woody biomass to feed a local forest-wood-energy supply chain derives from the management of forests and permanent woody crops (Corine Land Cover classes 311, 312, 313 and 221, 222, 223, respectively). These land use types represent the main sources of wood fuels. The assessment of the theoretical wood biomass potentials was made on the basis of the field surveys carried out within the framework of the forest management plan (FMP). The FMP has been drawn up within the Biomass District 4 (BD), falling within the municipalities of Petralia Soprana, Petralia Sottana and Castellana Sicula. The connections with the other planning tools (Landscape, Natura 2000 Network, etc.) have been considered, along with the assessment of the impacts of the silvicultural interventions on Natura 2000 habitats and species. In the BD, forests cover about 2,700 ha, accounting for 9% of total BD area, while permanent crops cover only 219 ha (vineyards, fruit trees and berry plantations, and olive groves) accounting for 1% of total BD area. In detail, we report the woody biomass which can be used for energy use from the management of forests. However, it should be kept in mind that also the biomass residuals coming from the ordinary management and tending operations (e.g. pruning, weeding, ecc.) of woody permanent crops (vineyards, orchards, ecc.) could be used to feed the supply chain. As provided in the guidelines, we assessed only the theoretical market potential, i.e. the maximum quantity of wood which could be sustainably cut down and offered on the market. The basic data of the biomass districts and the theoretical potentials of wood biomass from forests and agricultural area were presented in the Deliverable 3.4.1 (Geographical identification and description of biomass districts in the protected areas). The total area of the actively managed forest compartments is about 1,549 ha, of which about 1.320 ha are covered by forest stands. Overall, such forest stands have 356.207 m^3 of growing stock, corresponding to 308.054 t in terms of dry weight of aboveground wooody biomass. Taking into account the objectives of the Project, and the presence of protected areas, the estimate of the woody biomass available for each forest compartment was determined analytically, using a prevalent ecologically-based criterion, and oriented towards the development of more complex, stable and resilient fores stands, and also considering a precautionary principle, i.e. the minimal growing stock. Such choice was also made according to the "Guidelines for the preparation of the Forest Management Plan" of the Sicily Region (D.A. n. 85/GAB/2016). On average, the coefficient of

woody utilization was about 19% regardless of forest category. Within reforestation the highest value was observed (23,3%), while, conversely, the lowest values were recorded in Downy oak and Sessile oak stands, ranging from 13 to 14%. The available biomass was distinguished in biomass for other assortments (mostly firewood) and biomass for energy use (mostly woodchips). Overall, almost 88,000 t of woody biomass are available, about 63% for other assortments and the remaining 37% for energy use. In detail, almost 30,000 t of woody biomass could be exploitable for energy use in a 10 years long time frame (the period of validity of the FMP) (Table 6). Furthermore, considering the period of intervention, about 71% of the biomass available for energy use can be obtained in the first period (within 5 years), while the remaining 29% can be obtained in the second period (within 10 years). Overall, in the first period (within 5 years), more than 59% of the woody biomass for other assortments is available compared to the biomass potentially available for the whole period of validity of the FMP. This difference between the first and the second period is due to the urgency of the forest interventions in conifers reforestation and aged coppices; however it could be partly adjustable as some interventions could be moved from the first to the second period. These data are very important also to establish an efficient and local forest-wood-energy supply chain

Table 6 – The woody biomass available within the Biomass District sorted by assortment type and considering the period of intervention within the validity period of the FMP.

Period of Intervention	Total available biomass (t)	% with respect to total biomass	Biomass for other assortments (t)	% with respect to total biomass	Biomass for energy use (t)	% with respect to total biomass
I	55.539 t	63,2%	34.506 t	59,3%	21.033 t	70,9%
II	32.340 t	36,8%	23.708 t	40,7%	8.632 t	29,1%
Total	87.879 t		58.214 t		29.665 t	

We also provided an estimation of the potential energy obtainable from the effective woody biomass available. Considering a reference value of humidity (U) of the wood of 30%, and that the corresponding calorific value (of the woodchips) is on average: PC_{30} = 3.397 kWh/kg (Francescato et al. 2012), we may assess the theoretical primary energy that can be derived from the sustainable use of the investigated forests. The available woody biomass (29.665 t) may develop an average energy potential of around 100.861 MWh, over a 10 year long time frame. On average, this energy could cover about 16% of the district's annual energy needs (about 161.000 MWh). The energy required to feed the boiler for the swimming pool is 857 kW, while the annual energy need for the swimming pool is about 580.000 kWh (= 580 MW).

The needed wood ranges from about 167 t (wood chips with 25% humidity) to 288 t (wood chips with 35% humidity), according to wood humidity, and considering an energy efficiency of the boiler of 80%. Whatever the case, the biomass obtainable from the SFM the pilot area can by sure feed a short wood-energy supply chain for the swimming pool present in the Municipality of Petralia Sottana in the Madonie Park territory.

2.5 5th Step 5: Economical evaluation of a planned production chain

Before setting up an efficient supply chain we have to cope with the current limitations existing in the Madonie Natural Park. The major limitation is the lack of a currently operating local wood supply chain. Another strong constraint to the setting up of an efficient supply chain is the limited availability of efficient and technologically advanced forest machinery. Due to the limited development and availability of adequate production systems and efficient technologies for the production of biomass and other types of wood assortments, only a simple harvesting system could be realized.

2.5.1 BIOMASS PRODUCTION TECHNOLOGIES – forest production value chains chain

In the Madonie Natural Park, the woody biomass obtainable from the sustainable management of forests could feed a local forest-wood-energy short supply chain providing two main assortments: firewood and woodchips. Hence, we hypothesized two possible production chains. We established a species-specific diameter threshold to differentiate the two woody assortments (see D3.7.1, page 48), following the principle of the cascading use of biomass. The prescribed forest interventions (e.g. thinning in reforestations) were all addressed to primarily meet ecological needs, to improve the quality of forest habitats, to favour the conservation of forests as well as the evolution towards more complex, stable, and diversified forest ecosystems. The work site could be on a forest road near to the felling sites and in the surrounding areas (radius of 50 m) with the help of tractor with winch, forest workers with chainsaw, and possibly processor on tractor and tractors with trailer (if available).
The productive chain starts with felling, then topping and lopping, and cross-cutting of logs by means of a chainsaw could be performed in the felling sites.

cross-cut with a chainsaw with the power of 4 kW. Next follows the collecting and hauling of timber to the forest road with an adapted forestry tractor. An adapted forestry tractor is a

tractor which has been completely upgraded for forestry use (safety frame), has a double drum built-in winch (5 tons), a radio-control unit, and forestry chains at least on its back-rubber tires.

Harvesting systems with low environmental impact, both on biotic and abiotic components of forest ecosystems, were considered. Wood logging is carried out by means of a winch connected to a forest tractor (uphill) or with polyethylene chutes (downhill).

Firewood production chain

The firewood is since long time the most common wood product derived from the utilization of forest areas in the Madonie regional Park, and it is frequently used in private buildings and agricultural holdings. The productive chain starts with felling, topping and lopping, and cross-cut (in pieces 1-1.5 m long) by means of a chainsaw with an average power of 4 kW. These operations are followed by the collection and transport of timber on the forest road. Wood extraction is carried out by means of a winch connected to a forest tractor (uphill) or with polyethylene chutes (downhill). The woody assortments are transported from the forest road to the end user through different means of transport.

Wood chips production chain

Wood chipping on branches could be carried out on tree felling sites by means of small woodchippers, whereas logs could be roadside chipped (if the available space is enough), or in dedicated logistics platforms or in appropriately sized spaces near the felling sites.

We suggest to carry out the wood chipping on branches directly on felling site by means of a small wood chipper. The remaining wood could be chipped in the yard with a dedicated or covered vehicle for the logs below the established diameter thresholds. The choice depends on the presence of adequate space in the forest or logistic platforms for the production and storage of wood chips, and the availability of suitable chippers.

To provide information about the economic evaluation of a supply chain for the production of wood chips, we considered the unitary costs indicated in the guide "Wood and energy" by the Italian Energy Wood Association (A.I.E.L., Francescato et al. 2009).

Table 7 - The main cost of forest operations to produce woodchips, considering average values and referred to 100 tons of wood (from Colmetti, 2016, modified).

Operation	Unitary cost (€ hour^{-1})
Cutting with chainsaw	20
Forest tractor with winch	45 (two forest workers)
Cable crane for wood extraction	80
Wood processing on tractor	35
Wood chipper with high power	170
Transport, tractor with trailer	45
Transport to the plant	50

Based on these economic assessments, the mean cost to produce woodchips in ordinary conditions in Italy is about 54.8 € per tonne of woody biomass.

Figure 9 – The chippers in action in two different phases of work (logs loading and chipping) in dedicated squares out of forest in Sicily.

2.5.2 WOOD FUEL PRODUCERS

The very limited presence on the territory of private companies operating in forestry and biomass sector is one the most limiting factor for the establishment of an efficient supply chain in the Madonie Natural Park. As repeatedly stated, in the territory of the identified BDs the number of companies currently operating in the forest sector is rather limited. In recent decades, in fact, due to the changes in socio-economic conditions and the exodus towards large metropolitan areas, we have witnessed the abandonment of mountains, forests and the rural areas in general. Particularly, only one company is currently operating in the forestry sector within the BD n.4.

2.5.3 WOOD FUEL PRICES

Due to very limited number of companies operating in the forest sector, there is not an active and efficient market of wood. We can only report the information gathered through the interviews with the staff of these companies. Overall, the mean price for firewood ranges from 0,10 to 0,10 € per kg of wood, considering VAT not included, and after 1 year of storage. Conversely, the price to produce coal is of about 1 € per kg of wood.

2.5.4 STORAGE OF WOOD FUELS

The storage of wood is one of the most critical stage of the supply chain. Indeed, the way the wood is stored has deep effects on the wood humidity, which is strongly linked to the quality of wood fuel, as well as on the decomposition and alteration processes by biotic and abiotic agents which may severely damage wood structures and basic components (cellulose, lignin, ecc.). From an economic point of view, it should be considered that humidity is one of the most important trait affecting the quality of woodchips, including the quality classes according to ISO 17225-4 (Classes A1, A2 and B).

The indoor storage is to be preferred as wood is less subject to weather events and is more controlled. Chipping on wood as it is preferable because, on the wood cut in winter, there is already a considerable water loss during the winter months and then, if wood is left until the summer in a sunny place outside the forest, at the end summer it will have reached a water content lower than 30%, thus being suitable for chipping. In conclusion, chipping should be preferentially carried out as the fuel becomes necessary, so that the storage time does not exceed 3-4 months.

2.5.5 INVESTMENT COSTS

Investment costs are one of the main factors that influence the decision of replacing fossil fuels with wood fuels as renewable energy source. In this case study, the municipal authority decided to create a short chain for feeding with wood chip the municipal swimming pool heating system.

In order to monitor the economic advantages of the project, the costs related to the operation and management of the plant fueled by heating oil were estimated and compared with the costs related to the operation and management of the plant fueled by pellet and wood chips (Tables 7-8-9). The costs have been estimated considering an annual energy need of 580.000 KWh.

Tables 7-8-9 – The comparison of the costs to feed the boiler using different possible fuels

Plant fueled by heating oil		
Average annual consumption (2005-2010) of heating oil	lt	about of 60.000
Average cost of heating oil	euro/lt	1,30*
Average annual cost of heating oil	euro	78.000
Annual cost of the plant's maintenance	euro	5.000
Total annual cost	euro	83.000
€/MWh	euro	143,10

*Data source: Ministry of Economic Development - average costs (March-April 2019)

Plant fueled by pellet		
Average annual consumption of pellet (10% wet)	t	circa 138
Average cost of pellet	euro/t	300,00
Average annual cost of pellet	euro	41.400
Annual cost of the plant's maintenance	euro;	6.600
Cost for training course of the operators	euro;	2.000
Total annual cost	euro;	50.000
€/MWh	euro	86,20
Annual savings compared to heating oil plant	euro	33.000

Plant fueled by wood chips (considering the purchase of the wood chip on the market and the self-management of the plant by the Municipality)		
Average annual consumption of wood chips (25% wet)	t	about of 165
Average cost of wood chips	euro /t	120,00
Average annual cost of wood chips	euro	19.800
Annual cost of the plant's maintenance	euro	7.200
Cost for training course of the operators	euro	2.000
Total annual cost	euro	29.000
€/MWh	euro	50,00
Annual savings compared to pellet plant	euro	21.000

In this last hypothesis it is necessary to consider also the costs related to the adaptation of the pellet boiler (already purchased by the municipality of Petralia Sottana in 2012) to wood chips. The costs related to the technical modifications of the boiler, the adaptation of the silo and the coverage of the storage site were calculated. Overall, approximately € 30.000 in initial investment costs have been estimated, of which around 60% can be recovered already in the first year.

Since wide forest areas of public property fall in the Biomass District 4 and the Municipality of Petralia Sottana owns about 1000 ha of these wooded areas, the investment costs were estimated considering the possibility of self-producing wood chips through the sustainable forest management of public forests, rather than the purchase of wood chips.

So, two hypotheses have been defined (Tables 10-11):

- Entrusting the management of the supply chain to an ESCo (Energy Service Company). This hypothesis is considered more effective in the short term;
- Self-management by the Municipality of Petralia Sottana of the supply chain, with the support of a private forest company. This hypothesis is certainly more advantageous but more difficult to be realized in the short term as the municipal authority have to acquire the skills necessary for the management of the supply chain.

Tables 10-11 – Cost analysis with different management options to feed the boiler

Cost analysis - Annual energy need of about 580,000 KWh Plant fueled by wood chips Wood chips deriving from the municipal public forests and management of the supply chain by an ESCo		
Average annual consumption of wood chips (25% wet)	t	about of 165
Average cost of wood chips	euro /t	90,00
Average annual cost of wood chips	euro	14.850
Cost of ESCo	euro	6.500*
Annual cost of the plant's maintenance	euro	7.200
Total annual cost	euro	28.550
€/MWh	euro	49,22
Annual savings compared to the hypothesis of the purchase of wood chips and self-management of the plant by the Municipality of Petralia Sottana	euro	450,00

*costs subject to change

Cost analysis - Annual energy need of about 580,000 KWh Plant fueled by wood chips Wood chips deriving from the sustainable forest management of municipal public forests		
Average annual consumption of wood chips (25% wet)	t	about of 165
Costo utilizzazione forestale (taglio,esbosco, trasporto, cippatura)*	euro /t	70,00
Average annual cost of wood chips	euro	11.550
Annual cost of the plant's maintenance	euro	7.200
Cost for training course of the operators	euro	2.000
Total annual cost	euro	20.750
€/MWh	euro	35,77
Annual savings compared to the hypothesis of the purchase of wood chips and self-management of the boiler by the Municipality of Petralia Sottana	euro	8.250

2.6 6th Step: Evaluation of possible bottlenecks (SWOT analysis)

The SWOT analysis is an effective strategic planning tool useful to highlight the characteristics of a project/programme and the relations with the socio-economic-territorial context in which it is referred to. The SWOT analysis provides a framework useful for the definition of strategic guidelines aimed at achievement of the foreseen objectives.

In the present case study, the SWOT analysis allows to highlight the internal variables of the local system, on which actions can be taken, and the external variables, which can only be kept under control, in order to exploit the positive factors and limit the factors that risk to compromise the achievement of the foreseen objectives.

Table 12 shows Strengths, Weaknesses, Opportunities and Threats identified for the creation of a short wood-energy supply chain in the biomass District n. 4 of the Madonie Natural Park which includesthe Municipality of Petralia Sottana .

Table 12: SWOT matrix with question: „Where do you see main strengths, weaknesses, opportunities, and threats related to wood-energy supply chain in your biomass district?"

Strengths	Weaknesses
- 9% the land of the Biomass District 4 is covered by woodlands; - Request of biomass for heating in the domestic and in the public sectors; - Reliable presence of local partnerships focused to the implementation of the rural development strategy (LAG, National Strategy for the development of internal areas, Union of Municipalities, etc.). - Strong commitment of local institutions involved in a common process to define integrated actions for the development of the forest sector. - Local Energy policy (SEAP) clearly oriented to the development of biomass sector; - Existing regional funding programs (direct and indirect funds - managed by the Region) to encourage	- Reduced size of forest companies in physical and economic terms, with a low level of competitiveness and profitability. - Lack of skilled workforce and insufficient administrative competence of forest areas managers. - Difficulties for forest companies to access credit, with the consequential risk of exclusion from the Rural Development Plan measures. - 61% of the territory of the of the Biomass District 4 is subject to hydrogeological restrictions. - Strict administrative restrictions on forest management in protected areas.

the development of wood supply chains.	
Opportunities	**Threats**
- Implementation of common and shared energy policies in the Biomass District 4 that focus to the use of domestic resources for energy production and allow to reduce the dependency from external energy resources. - Starting-up of an innovation process in forest management and improvement of conservation status of the protected natural areas. - Transferring of knowledge, innovation and good practices regarded biomass short supply chain in all Biomass Districts. - New green jobs opportunities.	- Low deployment of the innovative planning tools and best practices regarded the forests management and the biomass supply chains. - Increase in forest fires - Strong competition for the energy supply, due to the widespread of the natural gas networks. - Low awareness of the economic, environmental and social values of forested areas also in terms of Ecosystem Services offered. - Persisting of inappropriate silvicultural techniques and obsolete equipment. - Low demand of forest biomass for energy production, while high request of firewood.

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4 ANNEXES

4.2. ANNEX 1

An example of a questionnaire for data collection for interested buildings inside the biomass district is presented in table 10.

Table 1: Questionnaire for data collection of interested buildings in the park

Data needed	Public buildings	District heating systems	Park administration buildings
Type of building (school, kindergarten…) and its name or first and last name of the inhabitants	Public pool Sant'Elia/ technical rooms tennis courts, Municipality of Petralia Sottana PP1 Forbioenergy	x	x
Number of potential buildings to be connected to district heating system	2	x	
Address	Sant'Elia country	x	x
Local community	Municipality of Petralia Sottana		
Number of occupants	100	x	
Year of construction/age of building	1989	x	x
Age of windows and doors (carpentry)	1989	x	x
Daily internal temperature	10 °C	x	x
Heating surface [m^2]	1000	x	x
Existing energy source	diesel fuel	x	x
Average annual amount of fuel (during the last 3 heating seasons)	60.000 lt		
Use of energy in kWh/y / power of boiler	857 kw	x	x
Year of installation of existing boiler/age of heating system	2012	x	x
Annual energy source consumption (e.g. litres)	x	x	x
Hot water (with or without boiler)	No	x	x
Energy efficient windows and doors (Yes/No)	Yes		x
Insulation of walls (Yes/No)	Yes		x
Roof insulation (Yes/No)	Yes		x
Energy efficiency measures for whole building (Yes/No)	Yes		x
Year of implementation of energy efficiency measures	2012		x

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E DELLA PESCA MEDITERRANEA
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