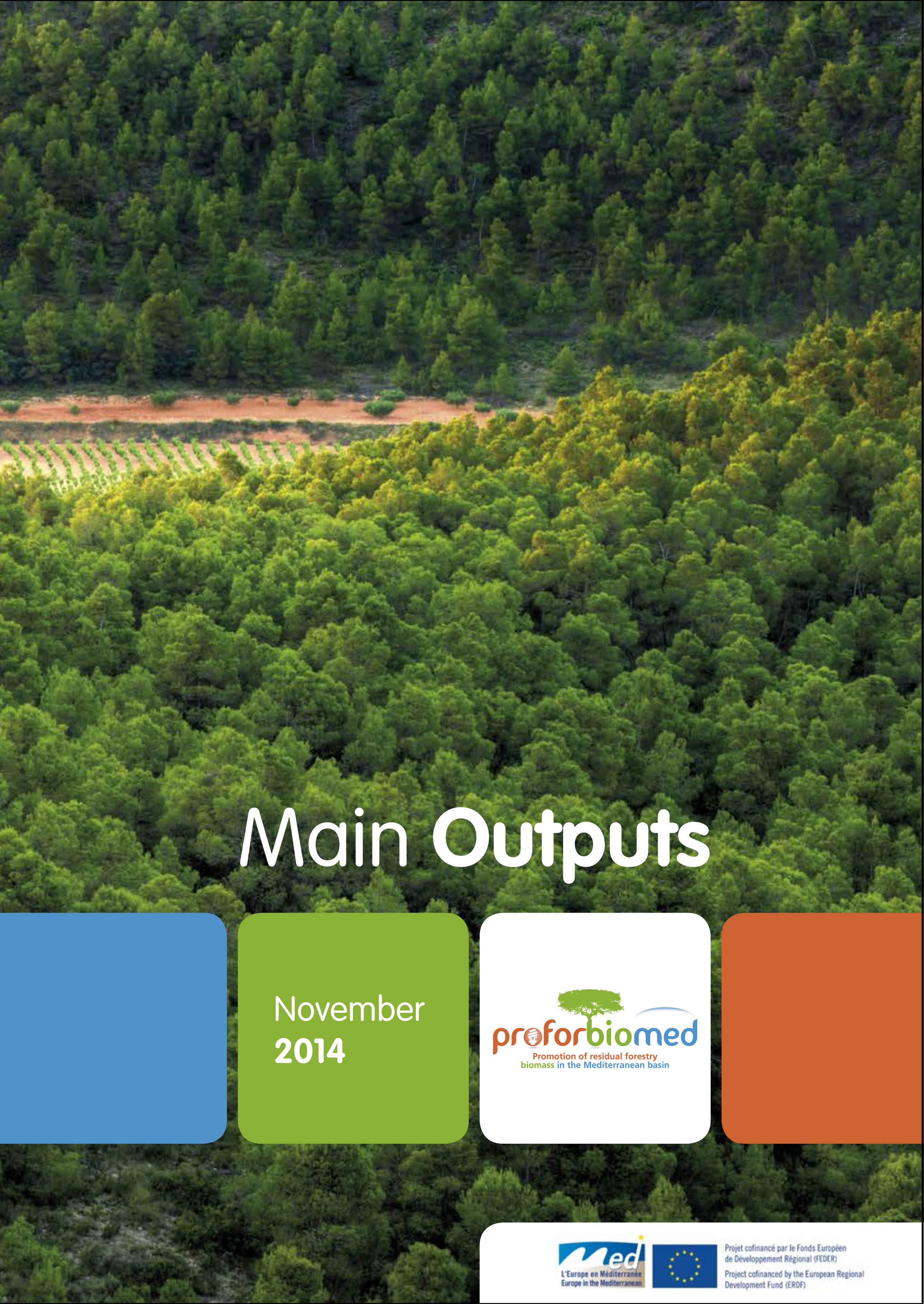

Main **Outputs**

November
2014

proforbiomed
Promotion of residual forestry biomass in the Mediterranean basin

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Europe in the Mediterranean

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Promotion of residual forestry
biomass in the Mediterranean basin

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1. Servicio de Gestión y Protección Forestal. Dirección General de Medio Ambiente. Consejería de Agricultura y Agua. Región de Murcia
2. External expertise
3. Grupo Generala, S.L.
4. Dirección General del Medio Natural. Conselleria de Infraestructuras, Territorio y Medio Ambiente. Generalitat Valenciana
5. Valenciana de Aprovechamiento Energético de Residuos S.A. (VAERSA).
6. PyG Estructuras Ambientales, S.L.
7. Centre Tecnologic Forestal de Catalunya
8. Ingeniería del Entorno Natural
9. Eurovértice Consultores, S.L.
10. Ayuntamiento de Enguera.
11. Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA).
12. Fondazione Lombardia per l'Ambiente (FLA)
13. Association Internationale Forets Mediterraneennes (AIFM).
14. Centre régional de la propriété forestière de Provence-Alpes-Côte d'Azur
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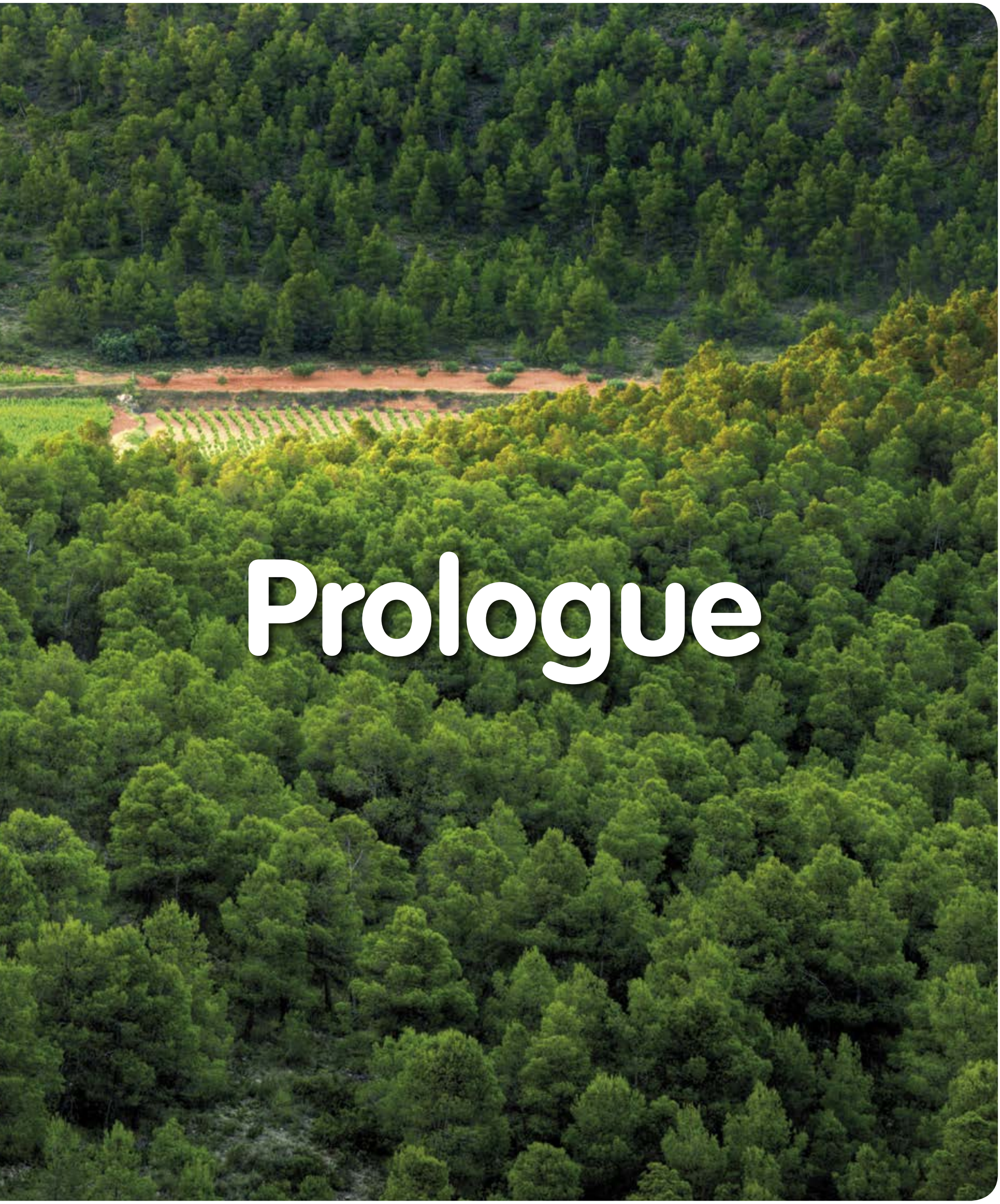

Prologue

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The PROFORBIOMED Project (Promotion of forest biomass in the Mediterranean) started three years ago as one of the three strategic projects of the MED programme for the 2007-2014 period, it was a challenge for two reasons; firstly because it is a project involving 17 partners from many different organisations, which implies a high level of complexity of management, and secondly for being the only strategic project of the MED program in the frame of renewable energy.

Managing a project with partners from 6 different countries means working together with 17 different organizations (universities, institutions, regional governments, municipalities, universities, research centres, etc.), initially it seemed to be an added difficulty for the development of the project, nevertheless, as time progressed and thanks to the human and professional quality of the partners, this challenge has become an advantage that has outweighed the disadvantages, as it is demonstrated by the results obtained by the project .

Biomass is a clean energy as it contributes to the reduction of the carbon footprint, it promotes the development of local economies in the most deprived regions, it increases rural employment, it helps in the conservation of our forests, it improves the pasture rents and the habitats of wildlife and hunting species and it will provide alternative uses for forest products such as cosmetics, medicine, etc.

Biomass is a renewable energy widely disseminated in the countries of northern and central Europe, but in the European Mediterranean context, it has not reach the whole development that would be desirable. PROFORBIOMED has focused in working for the strengthening of biomass energy by developing key factors for the next operational period 2015-2020 factors.

Thanks to projects like PROFORBIOMED and the support policies for renewable energies developed by the EU, the use of biomass will be developed in the southern European countries within the next few years, principally because it is a competitive energy, cheaper than those derived from fossil fuels.

For all that, biomass energy has come to stay. Thus, we have the responsibility of its development occurs in a sustainable manner, with this aim the PROFORBIOMED project has established some bases:

- Developing tools for sustainable forest management and technical forest management plans
- Tools for traceability of biomass complying with European standards
- Feasibility studies of boilers.
- Proposing agreements at European level as the Biomass for Energy Pact.

Through this publication that summarizes some of the activities that have been developed with the project in the last three years, we hope to shed light on their concerns about the biomass.

ACKNOWLEDGEMENTS

This book collects the works in forest management, traceability, designs of industrial facilities, process engineering, etc. of a large number of technicians and researchers, This publication would not have been possible without the existence of the accumulated knowledge that has been generated throughout the project.

For that reason, the guide has benefited from the comments, experience, suggestions and contributions of technicians with extensive experience in bioenergy. Our thanks to all of them.

The project has gathered a great number of exceptional professionals from different disciplines and regions, though they all share the common features of the Mediterranean basin.

I just can say thanks to all the partnership: Regional Development Agency of Murcia Region, Generalitat Valenciana, Municipality of Enguera, Forest Technologic Centre of Catalonia, Institute for Environmental Protection and Research (ISPRA) , Lombardy Foundation for the Environment, Region of Sicily, International Association for Mediterranean Forests, Regional Centre for forest ownership of PACA Region, Institute for the Conservation of Nature and Forest, Agency for solid wastes treatment in Algarve, Business and Environmental Science Research Centre, Region of Western Macedonia, University of Western Macedonia, Agency for planning and development of Patras, Slovenian Forestry Research Institute and Local Agency for Energy of Spofnje Podravje, who participated in the project,

Thanks to all the institution which have supported the project: personnel from the MED Join Technical SSecretariat (Tarja, Maitena and Curzio), from the Ministry of Finances and Public Administrations (Marian Uriarte), also to my colleagues and, of course, to my work team (Remigio, David, Raquel, Ana, Asunción, Mar, Alfonso and Consuelo).

Thank you to all that have made this possible.

Roque Pérez Palazón

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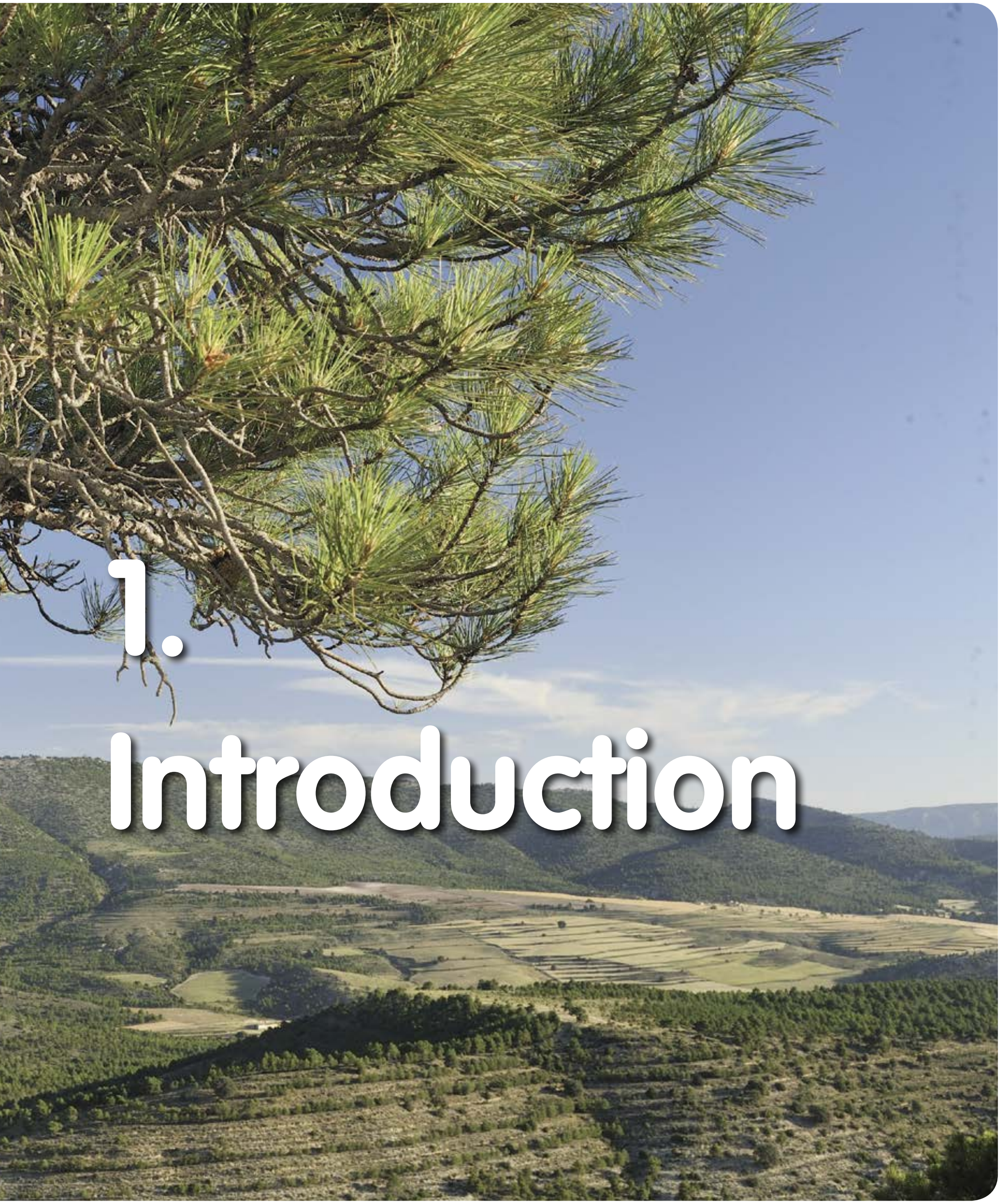
1. Introduction



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The PROFORBIOMED project "Promotion of residual forestry biomass in the Mediterranean basin" (PROFORBIOMED-1S-MED10-009) promotes renewable energies in MED areas by developing an integrated strategy for the use of forest biomass as a **renewable energy** source, recovering the **forest biomass** potential, developing technical and legal aspects and promoting the use of forestry biomass for energy. The strategy relies on the involvement of key stakeholders in a forestry biomass production chain that takes into account sustainability and compatibility with other uses and provides new economic opportunities. It was the only strategic project on renewable energies approved by the MED Programme in 2011, which increases the importance of developing biomass potential in the Mediterranean regions through an integrated strategy.

On the other hand, the new EU Forest Strategy considers forest to be a key resource for rural development, but also "for the environment and biodiversity, for forest-based industries, bioenergy and in the fight against climate change". Sustainable forest management is one of its principles, as is PROFORBIOMED, helping to meet EU Forest Strategy objectives.

Nowadays, wood energy is highly competitive compared with fossil energy sources. As it is a local energy source, it creates social opportunity, promoting local job creation and fostering the forest-energy industry. Furthermore, it is an environmentally-friendly form of energy that helps to reduce CO_2 emissions, as wood burning has a neutral impact on the carbon cycle. It contributes to the conservation and enhancement of European forests: it a continuous decrease of the risk of forest fires in properly managed forests, and therefore, a reduction of the EU's annual forest-fire-fighting budget, in particular for Mediterranean areas.

The specific objectives of the project are:

• To set up integrated development strategies for renewable energies, including technical, logistic and environmental aspects of the biomass production chains, that achieve a sustainable management planning model for the forests in the MED area that improve the governance of rural areas.

• To promote renewable energies as an economic and social opportunity for rural areas, by revitalising the forestry value chain, creating jobs and developing industries linked to the forestry environment.

• To identify and transfer good practices and to develop actions related to the energy use of biomass from forests with sustainable management practices that may be used as examples.

• To identify and involve all relevant stakeholders related to the biomass forestry chain, developing a multi-level network that integrates all related stakeholders, and supports capacity-building of public and private actors, creating sustainable structures and commitments.

• To provide policy makers with the tools needed to design sustainable energy models and forest planning, through appropriate, realistic estimates of potential outputs, best end uses and optimisation of the value chain.

• To promote intelligent energy management systems at local and regional level, adapting the concept of smart grids to biomass production chains, guaranteeing a more secure and efficient supply of energy through the mobilisation of forest biomass.

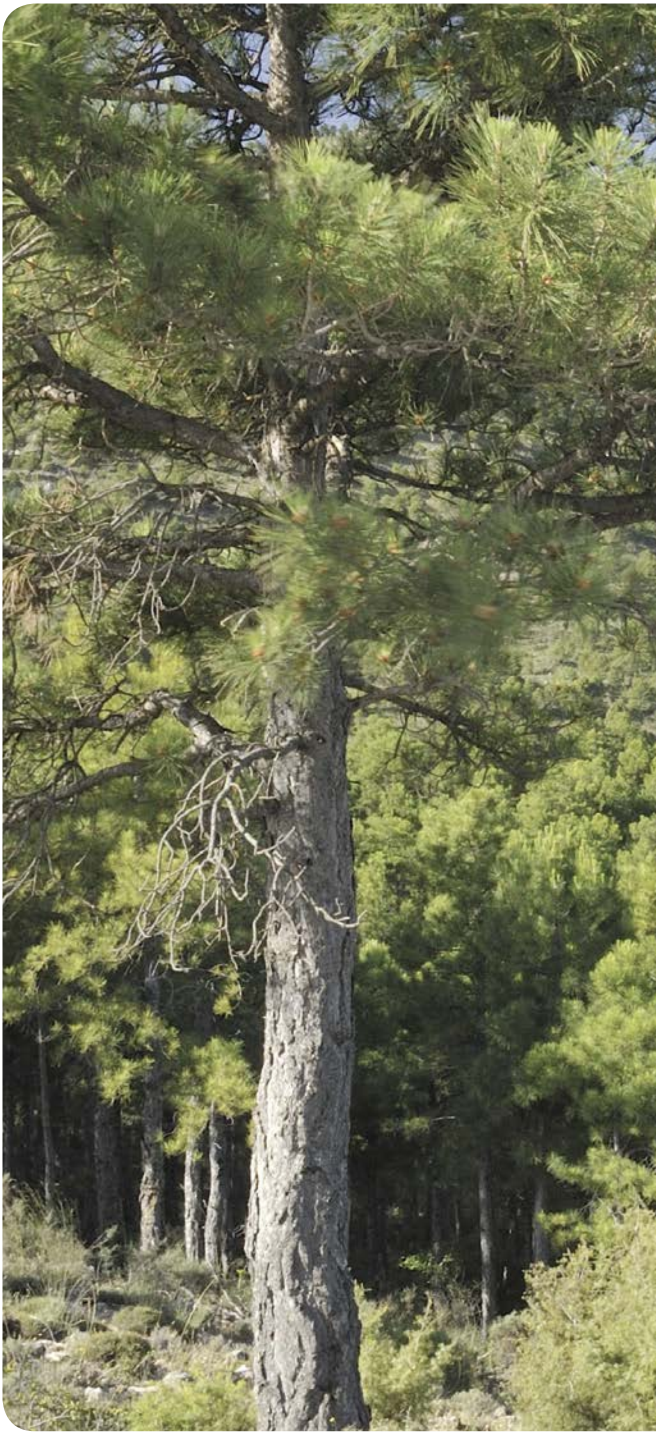
• To propose solutions to cope with the effects of climate change in MED forests.

One of the barriers identified in PROFORBIOMED for the entire Mediterranean zone is the difficulty of collecting biomass from forests. Hence, 13 pilot actions have been developed in order to overcome the main identified bottlenecks, aimed at key topics such as the assessment of the environmental impact of forestry biomass harvesting, traceability systems, Forest Biomass Management Plans, preparation of pre-feasibility studies for biomass plants or district heating/cooling systems, etc.

The aim of this book is to highlight the main outputs and some of the milestones of not only these pilot actions, but also the horizontal work packages, such as the creation of the biomass and bioenergy clusters at local/regional level, allowing local governments, universities, forest owners and companies to combine resources to take advantage of market opportunities that will be driving forces in regional economies.

A challenge for the near future is to find the financial instruments that can further boost implementation of the main results obtained so far. At present, we can already comment on examples of future implementation for which the foundations have been laid in the present, for example the substitution of biomass boilers, based on the pre-feasibility projects for public buildings in several PROFORBIOMED pilot areas.

These results will have high visibility and will be used for drawing up plans and policies at European level.



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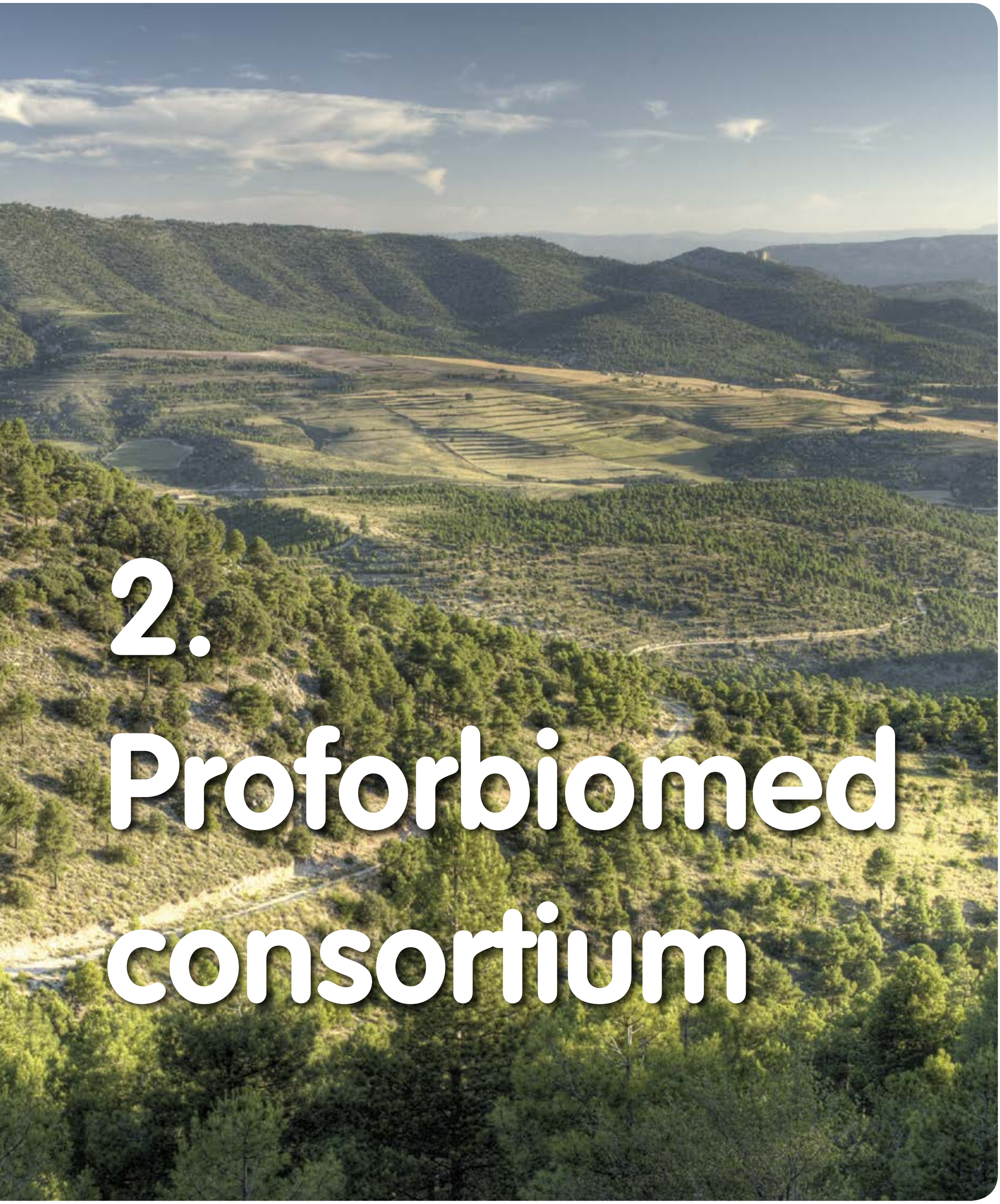

2. Proforbiomed consortium

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PROFORBIOMED has achieved complete geographic coverage, integrating national, regional and local partners covering the largest forested areas in the MED territories, including three national bodies, five regional bodies and three local authorities (in addition to six other organisations). The partnership was formed with the intention of achieving a balance between forest managers, private owners, energy managers, environmental experts and researchers. The partnership includes energy agencies and other related energy stakeholders.

The strategy aims to involve all related stakeholders in the project, to include all the needs of the MED areas and actors in the project and to maximise the transferability of project results. This multi-level approach is replicated in every participating country (Spain, Portugal, France, Italy, Greece and Slovenia); at least two of the different levels (national, regional, local) are represented in each and partners have been chosen to represent different key forest areas and/or to complement the work of the other partner in the same area:

SPAIN: coverage includes regional bodies from three different regions (two in Murcia, Valencia and Cataluña) and a local authority (in the Valencia region), spanning the whole East Mediterranean coast of Spain. All the regional bodies are responsible for forest management, each being, in addition to any other responsibilities, the local authority in charge of forest areas.

FRANCE: a regional body focused on forest ownership (Provence Alpes Côte d'Azur) and an international association for Mediterranean forests, AIFM.

ITALY: a regional environmental body (ISPRA, from Lazio), the regional forest administration of Sicily, and another body (Fondazione Lombardia) with international geographic coverage.

SLOVENIA: a national forestry institution (Slovenian Forestry Institute) and a local energy agency (from the Spodnje Podravje region).

GREECE: a regional body (Western Macedonia), a regional university (Western Macedonia) and a local body (Patras, from Western Greece).

PORTUGAL: a regional university (Algarve) and a local authority (ALGAR, from the Algarve region).

The two internationally-oriented bodies (FLA in Italy and AIFM in France) support the effective transnational approach of the project activities. This transnational approach is also supported by the two universities (Western Macedonia (Greece) and D. Alfonso III (Portugal)) and many of the other participants that have broad experience in transnational activities, including other European cooperation initiatives.

3. Main outputs obtained by the partners

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3.1. Directorate-General of the Environment (DGMA). Region of Murcia. Spain.

3.1.1. Legal name / Contact details

Name of the Organisation: Dirección General de Medio Ambiente. Consejería de Agricultura y Agua. Region of Murcia.

Acronym: DGMA. CARM

Official address, country and region: Dirección General del Patrimonio Natural y Biodiversidad. C/ Catedrático Eugenio Úbeda, 3 - 3ª planta. 30008. Murcia. Spain.

Website: *www.carm.es / www.murcianatural.carm.es/web/guest*

Legal representative: María Encarnación Molina Miñano; Telephone: +34 968 22 89 01/02; Fax: +34 968228904; E-mail: mencarnacion.molina@carm.es

Contact person: Roque Pérez Palazón; Telephone: +34 968 22 89 01/02; Fax: +34 968228904 ; E-mail: palazon.roque@carm.es

3.1.2. Description of the partner's activities/skills relating to biomass

The Regional Ministry is the appointed body in the Region of Murcia for the protection of the Environment and the promotion of biomass. The Directorate-General of the Environment is responsible for managing wood and timber uses, that can be provided by the forests of Murcia for the production of electric and thermal energy, including monitoring good forestry practices, in such a way that any future energy market based on forestry biomass will not develop at the expense of the ecological balance of the forests. As a part of the Regional Ministry of Agriculture and Water of the Region of Murcia, its role is essential for the implementation of policies and institutional changes.

3.1.3. Development of Forest Biomass Management Plans: innovative methodology and custom software.

3.1.3.1. Description of the action

The Directorate-General of the Environment of the Region of Murcia has spearheaded Pilot Action 1.7. "Elaboration of Forest Biomass Management Plans" (Work Package 4 -"setting up integrated strategies for the development of renewable energies"-).

A Forest (biomass) Management Plan is a structured method for achieving the assigned management objectives in a forest, in this case with special emphasis on the harvesting of forest biomass, in an organized and sustainable way, always taking into account preservation of natural heritage.

The drafting and pilot testing of Forest Biomass Management Plans, developed in public and private forests, has been based on current knowledge and on the work developed in other pilot actions. It has gone through analyses of the biomass chain in each site; analyses of the main regulatory barriers for market development; analyses of the main financial instruments in the territory; evaluation and optimisation of the biomass chain to guarantee the sustainability criteria; and analyses of the different types of bodies involved in the project.

Nine partners have been involved in this pilot action. Each has had to develop a forest management plan in order to make their work transferable and applicable throughout the whole MED area.

To complete the final stage of the work, several procedures have been developed to facilitate and integrate common actions into drafting Forest Biomass Management Plans, which can be considered as general outputs of the pilot action:

- Development of a methodology/structure for drafting Forest Biomass Management Plans. To this end, the following documents have been produced:

- Technical Guide for Drafting Forest Biomass Management Plans. This document describes and analyses the content and structure of a Forest Biomass Management Plan.

- General Methodology for Drafting a Forest Biomass Management Plan (summary of common steps). Broadly, this document lists the common stages to be considered in a forest management plan, including both on-site and off-site work.

- Development of a common legal framework to regulate the elaboration of management plans. A basic legislative decree has been drafted for the purpose.

- Web link to consult all the related documents developed during this pilot action by each partner.

Specifically, the Directorate-General of the Environment of the Region of Murcia has developed an innovative methodology for the elaboration of Forest Biomass Management Plans. It is based on a stratified survey, using the data collected in the 4th National Forestry Inventory, thus reducing the field work needed to obtain the required volume of data by almost 50%. This methodology reduces costs and time spent on field work.

Custom software has also been developed, for rapid processing of the collected data. The program calculates the biomass volume and other important results for forest management, based on the collected data and the data added from the 4th National Forestry Inventory.

A further description of the above methodology is available on the PROFORBIOMED website (Spanish and English). The first Forest Biomass Management Plan to use this methodology has been drafted for the "Sierra de Burete" public forest, and is also available on the website (only in Spanish). The Forest Management Plan is focused on north-western Murcia. This area corresponds to the largest areas of forest biomass in the Region, with a continuous pine stand (primarily *Pinus halepensis*).

3.1.3.2. Methodology

The forest inventory methodology designed by the Directorate-General of the Environment of the Region of Murcia, aims to provide, with sufficient accuracy: the management parameters that will be needed for appropriate, sustainable management of forest resources; with minimum expenditure on its elaboration.

It is based on three main premises:

- The availability of plot data collected by the 4th National Forest Inventory (2010).
- The availability of digital mapping related to vegetation types, established during the 4th National Forest Inventory. Its accuracy has been improved to fit this mapping to north-western Murcia and, more specifically, to the forest where the works are going to take place.
- The possibility of carrying out a specific stratified inventory (considering the different vegetation types), complementing the available previously collected data, improves the accuracy of the final results. This sampling can be systematic, random or directed.

The methodology proposed in the forest inventory is stratified directed sampling, designed to reduce costs.

Under this method, the 4th National Inventory plots located in the areas surrounding the studied forest are also considered, but only those that are in areas of similar vegetation to those in the forest. These, when combined with the plots measured specifically in the studied forest and the 4th Inventory plots inside the studied forest, can together provide a sample of sufficient accuracy.

In order for the data from the 4th National Inventory plots to be comparable, it is necessary to update its data to the year in which the rest of the plots are being measured.

The inventory plots must be set in places that are representative of the strata to which they are allocated. The shape of the plots can be selected according to the geometric characteristics of the area in which they are set. In the present example, round plots were chosen, with the radius varying according to stand density and forest type (containing between 15 and 25 trees in every plot). The minimum requested information measured in each plot was its area (ha); the number of the plot and of the measured trees within that plot; and the species of the measured trees and their diameter at breast height (DBH).

A silvicultural report also has to be compiled for each compartment, recording its main characteristics.

The information required for the developed software is the area of the plot, the number of the plot and of the trees that are measured, the species of the measured trees and their DBH. These are thus the data that must be collected in the on-site work.

To compare the collected data with those contained in the National Forest Inventory, the codification for the species and the rest of the data must be similar to those used in the National Inventory.

The key elements of this process are briefly described below:

A. Mapping process

Stratification:

The first step for the design of the inventory is to draw up maps of the vegetation types in the studied forest, allocating them to homogeneous strata; strata definition being a key step in the stratified sampling process.

The designed software calculates its results using the information on each stratum contained in the forest.

The strata definition and classification for the whole Region of Murcia study area was conducted based on the strata definition and classification defined in the National Forest Map (E: 1/25.000), which was created using the data obtained in the 4th National Forest Inventory (2010). Based on this, the strata classification for the Region of Murcia was conducted within the PROFORBIOMED project considering the following parameters: main tree species (species, covered area and growth level); vegetation cover; property (public or private); origin of the forest (natural or from afforestation).

The classification of the strata according to types similar to the ones defined in the 4th National Forest Inventory strata, allows the National Inventory plot data to be used together with those collected in our own on-site work. Both will be used by the designed software to calculate the results.

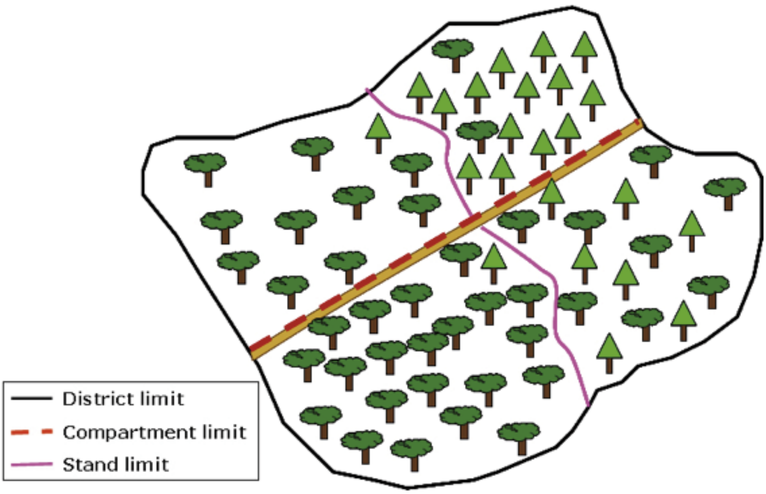

Figure 1. Schematic mangement division

Management divisions:

The criteria used for the definition of the management reference units (compartments) are:

- Clear and well defined limits, using permanent lines: watersheds, water courses, paths, firebreaks, fences, etc.
- Composition and growth level of the different parts of the forest, aiming to to divide it into homogeneous parts.
- Physiography: slope, orientation, edaphology.
- Need of silvicultural treatments; targets proposed.
- Area greater than ten and smaller than 50 hectares, according to current Spanish legislation.

Districts are then formed, joining the compartments, which are defined according to the target forest type and consequently, the forest management objectives that we want to apply in each of them.

Once the compartments have been defined, we can also define the stands inside those compartments. The stands must be considered as the smallest silvicultural management division, within which the same techniques must be applied (type and time of cutting, etc.).

The stands are defined following the limits of the strata delimited in the forest, and consequently, are based on vegetation units/types, distinguished according to their species composition, canopy cover, silvicultural treatments that have been applied, etc. They are the final units where the treatments and actions are planned, and it is very possible they will not be the same for the next period/project.

The management divisions are based first on the definition of stands. These are then combined to obtain compartments, and the compartments are combined to form districts. The stands can easily be obtained by intersecting the strata with the compartment limits.

Since the strata identify homogeneous vegetation units with similar characteristics, the intersection between strata and compartments is a quick method of dividing a compartment into different stands. The software designed with the PROFORBIOMED project bases its calculations on the growing stock in the strata, and it will therefore also be able to quickly calculate the growing stock for the larger management

B. Custom software (calculating tool)

NFI plot selection

The data obtained from the National Forest Inventory are in a table inside the designed software, and have been extrapolated for the coming years, until 2022, using the data collection for the 3rd and 4th National Forest Inventory. The method used for this extrapolation is described in the document *"Forest growth model based on the National Inventory Data for north-western Murcia"*. This way, every forest inventory taken later than 2010 (year of the last National Inventory) can use the 4th National Forest Inventory, thus extending the period of time for which the designed software may be used.

In the software, in addition to the plot data measured directly in the forest during the on-site work, it is also possible to select and use the data of the National Inventory plots that are inside the forest boundaries, as well as those that are outside and whose characteristics may be of interest (strata similar to those in the forest).

Each National Inventory plot will have been given a different weighting according to its distance from the centre of the forest, and will thus have a different relative importance in the calculations.

In the software, the National Inventory plots are selected using a distance gradient. Two distances have to be chosen: all the plots under the shortest distance will have 100% weight in the calculations, and all the plots over the largest distance will have 0% weight. The plots that lie between the two distances will be weighted gradually from 100% to 0%.

Volume equations (growth and height)

Volume equations were drawn up specifically for this project, using the National Inventory data, to be used as a basis for the software calculations.The only datum measured in the on-site work was tree diameter. It was therefore necessary to obtain equations for each species based only on the diameter. The volume equations are used to obtain the biomass and timber growing stock for each of the tree species, using only the DBH of every tree. The equations were obtained through regressions between the DBH (independent variable) and several dependent variables (total height, volume over bark, volume under bark, fuel-wood volume, yearly volume increment), obtaining an equation for each dependent variable. These equations have been calculated for each of the four most commonly harvested tree species in Murcia *(Pinus halepensis, Pinus pinaster, Pinus nigra and Quercus ilex).*

The equations proposed by the National Research and Rural and Food Technology Institute (Gregorio Montero, 2005) were used for the biomass volume calculation.

All these equations were incorporated into the custom software. Consequently, the different dependent variables can be calculated for each tree for which the diameter was measured in the on-site work (total height, volume over bark, volume under bark, fuel-wood volume, yearly volume increment and biomass).

These volume equations can be changed in the program, if the user should decide that the equations included in the program are not suited to the purpose at hand. The following is an example of these equations:

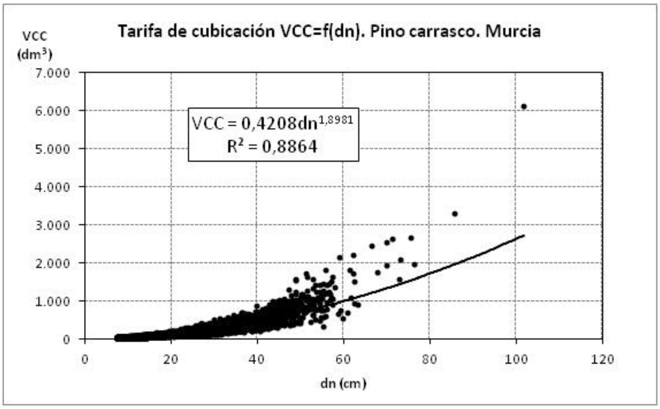

Figure 2. Volume over bark (VOB) equation (*Pinus halepensis*. Murcia)

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Data processing and results

Once the site plots have been measured, the mapping data and the collected tree data are included in the program. The National Inventory plots that are going to be used for the calculations are then selected.

Data processing can then be activated in the program. The calculations can be summarised in the following steps:

- The volume equations are applied to all the trees of each species that were measured in the plots.
- The program calculates the results for each stratum (mean result per hectare) for each of the variables calculated using the volume equations.

The results are presented in several tables:

- Total growing stock for each species
- Growing stock for each diameter class in each species
- Total growing stock for the entire species group
- Growing stock for each diameter class, total for the entire species group
- Sampling errors for species
- Sampling errors for the entire species group

All these results can be selected for a specific part of the management division, or for the whole management division. This choice must be made in advance by the user.

The following flow-chart shows the sequence of calculations used in the data processing:

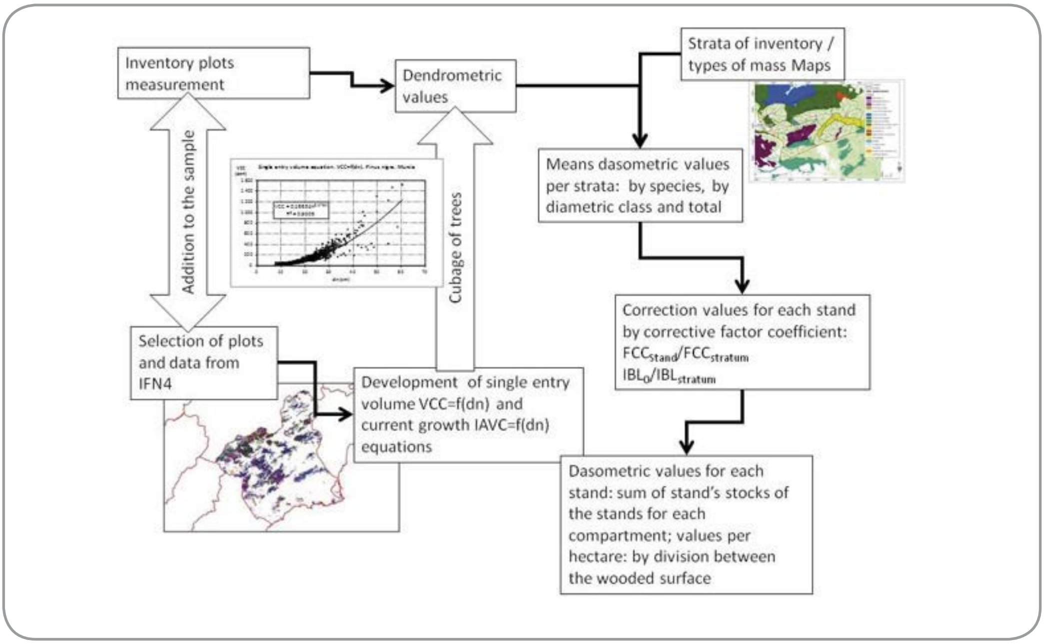

Figure 3. Calculation flow-chart used for data processing

3.1.3.3. Stakeholders involved

One of the main successes of the implementation of this pilot action in Murcia was the transfer of the methodology and the software to private stakeholders, through a training workshop (Murcia, 8th-9th May 2013). The event aimed to promote the use of the innovative software for drafting forest management plans, by sharing information with the technicians who develop the plans for forest owners.

The main objective of this workshop was to train technicians, by providing them with the specific methodology and the tool developed by PROFORBIOMED to facilitate the standardisation of such plans in the Region of Murcia. Other specific objectives were:

1. Fostering forest management through the developed methodology.

2. Developing the forestry sector through the sustainable use of biomass.

The workshop was a real success, attended by over 50 technicians. Attendees showed great interest in using the tool for drafting Forest Biomass Management Plans. The technical staff and companies related to the forest sector will be able to cooperate with private forest owners in Murcia thanks to PROFORBIOMED and its sharing of this useful management tool.

The recent Regional Grants Order on the support of private forests in the Region of Murcia, made it compulsory to have a Technical Forest Management Plan in order to access the grant, to ensure sustainable planning.

Figure 4. Attendees at the training workshop

3.1.3.4. Outputs

As has already been mentioned, the two main outputs have been the innovative methodology for drafting Forest Biomass Management Plans and the custom software. Their use will mean that the field work required to obtain the necessary volume of data is reduced by almost 50%, thus cutting costs and time spent on field work.

In the process of developing the methodology and software, other intermediate outputs were produced, which should also be recorded as PROFORBIOMED outputs/deliverables:

- Technical Guide for Drafting Forest Biomass Management Plans, complete with contents and structure *(http://proforbiomed.eu/publications/project-deliverables/deliverables-workpackage-4/pilot-action-17)*
- Silvicultural treatment simulation.
- Summary of the forest stands growth model.
- Single-entry volume equation for forest species.
- User's manual for the software for assessing growing stock: "Inventory of the Forests of Murcia" (11/07/2013).
- Software for assessing the temperature and precipitation data for north-western Murcia (Bioclimatic diagrams of "Montero de Burgos" software).
- Climate model and bioclimatic diagrams of "Montero de Burgos" for north-western Murcia.
- Forest management criteria to preserve the birds of prey.
- General guidelines for forest management in the Region of Murcia.
- Forest Biomass Management Plans: 6 FBMPs have been elaborated.

3.1.3.5. Impacts

The methodology designed for the forest inventory has provided, with sufficient accuracy, the forest management parameters that will be needed for suitable sustainable management of forest resources, while spending minimum expenses on its elaboration.

Therefore the following advantages of the methodology can be considered as positive impacts for regional forest management:

- Reduced cost of drafting management plans (by approximately 50 %),
- Quicker elaboration of plans.
- Standardisation of plan contents and structure, thus simplifying the subsequent evaluation process.
- More reliable results; on the basis of the elaboration costs and available finance.

Furthermore, according to a recent Regional Grants Order on the support of private forests in the Region of Murcia, it was made compulsory to have a Technical Plan for Forest Management in order to access the grant. As a consequence of this, but also due to the reduced costs of drafting management plans, the number of private forests that are managed has increased. When a forest is managed, silvicultural treatments are planned, fire and pest risks decrease and biomass is mobilised as a new income source in rural areas.

3.1.3.6. Added value of transnational cooperation

Forest biomass represents a great opportunity for forest management in the Mediterranean. The constraints to the sustainability of rural areas (specifically, forested areas), namely those related to property size, low income and fire recurrence, tend to result in reduced investment and abandonment. The possibility of adopting a new productive activity, promoting increased income from forested areas and, at the same time, reducing the fuel load in a large proportion of these areas, is a major breakthrough to their sustainable management.

For some partners this pilot action has been a chance to implement new forest management methodologies. For others, it has been the first step towards including forest biomass exploitation in a management plan, by adapting the methodologies proposed by the former, thus planting the first seed for the creation of a set of silvicultural models designed specifically for this forest activity.

The methodology used by each partner has provided the partnership with extensive knowledge on the development of management plans for biomass and the different methodologies that can be applied. This will undoubtedly have a positive impact on future actions and related projects in all the involved regions. At this point, the present actions of the PROFORBIOMED project represent a great opportunity to test and compare methodologies designed to promote the adoption of new management models.

To sum up, transnational cooperation has made it possible to test of a new set of solutions, thus allowing the pros and cons of different methodologies for each specific area to be analysed. All the solutions and results are being transferred and disseminated for subsequent adaptation.

3.1.3.7. Conclusions and lessons learned

North-western Murcia is the largest area of forest biomass. The traditional silvicultural harvesting applied in this region does not need to be modified with respect to biomass use. The aim of silviculture has traditionally been protection, and the Forest Biomass Management Plan also places the protection objective above production. The silvicultural procedures have not, therefore, required significant modification. The main repercussion is likely to be in terms of forest products: with the promotion of biomass, all the forest products will have a place in the biomass market (wood chips, pellets, etc.), even those considered as "non-commercial wood" in traditional silvicultural harvesting.

Regarding biomass extraction, the "Management Plans for Protected Natural Areas" in north-western Murcia are currently being developed, which include conservation measures and specific actions to protect the species and habitats. The use of biomass is compatible with the uses included in the Plan, provided the rules and guidelines are respected and the management measures carried out.

Biomass use is thus limited by several factors:

- Protected areas criteria.
- Presence of protected flora and fauna, which should be considered when planning and implementing forestry works, generating both spatial and temporal constraints.
- Areas burned by wildfires. The landscape of these areas shows zones of bare soils or excessive vegetation cover, which prevents the development of normal vegetation growth.
- Understocked areas (low density of canopy cover): amount of shade <40%.
- Working in steeply sloped areas (more than 45%) can cause soil erosion.

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Other restrictions are:

- Infrastructure and equipment limitations. There have to be sufficient resources to provide the services and utilities demanded from the forest.
- The topography, and specifically the gradient, affects the technical requirements for performing forestry works.
- Feasibility of forest biomass extraction, which depends on extraction costs (distance, mechanisation, transport, etc.).

Considering the results obtained from the forest management plans drafted within the scope of PROFORBIOMED, it can be affirmed that income from the sale of biomass products (in particular, silvicultural improvement treatment) should cover most of the costs arising from these silvicultural works.

The results of the Murcia Management Plans show that the profitability of forest biomass use is achieved in areas where the amount of biomass extracted exceeds 15 tDM/ha (in general, this value depends mainly on the cost of product transport).

The work on this pilot action, for the Region of Murcia, has led to improvements in the following areas:

- Implementation of the development of Forest Management Plans for all types of forest ownership, for biomass uses.
- Promotion of legislation to encourage the development and use of Forest Biomass Management Plans.
- Rules and standardised documents to facilitate their review and approval.
- Development of a simple, affordable and reliable management plan for all types of forest ownership.
- Increased interest by private owners, who are aware of the need of having a Forest Biomass Management Plan to extract biomass in a sustainable way.
- Promotion of the vision of biomass as a viable resource, which until now was non-existent.

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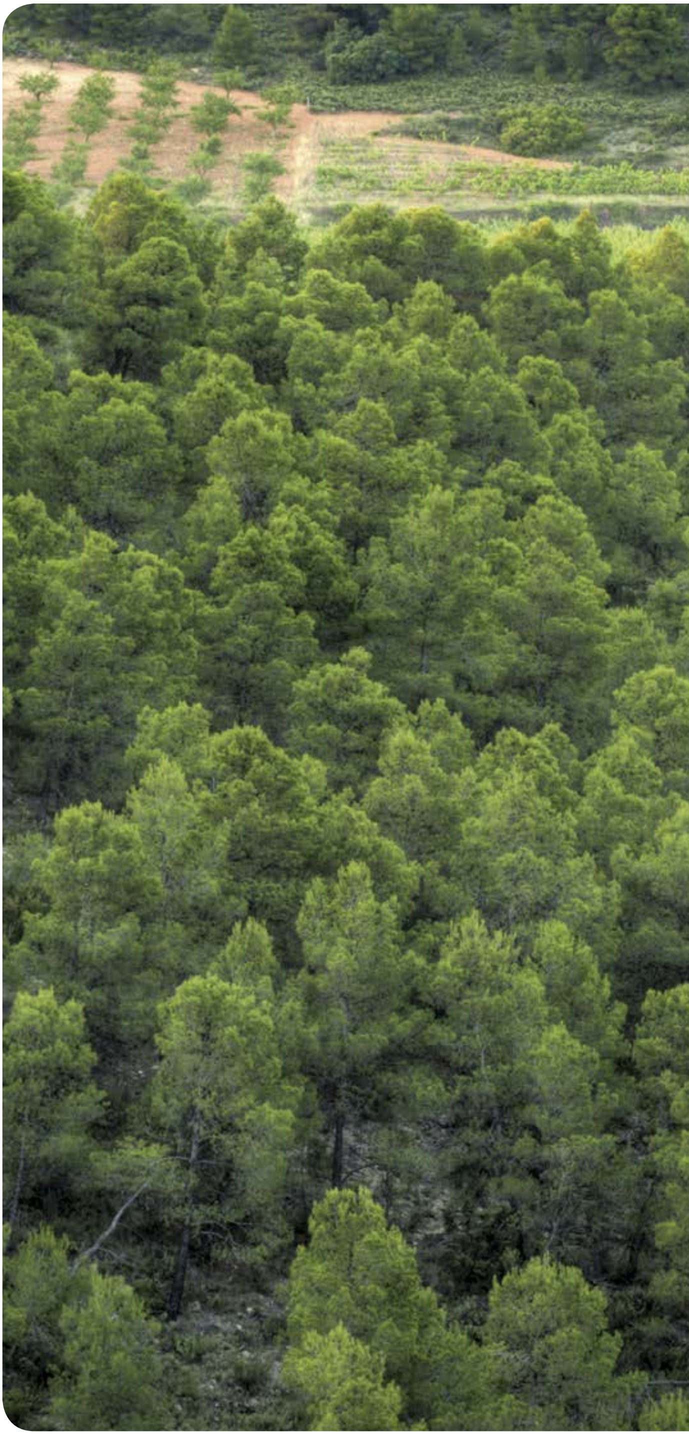

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Forest biomass represents a great opportunity for forest management in the Mediterranean

3.2. Forest Management Service. Directorate-General for Environmental Management. Generalitat Valenciana (GOV). Valencia Region. Spain.

3.2.1. Legal name / Contact details

Name of the Organisation: Servicio de Ordenación y Gestión Forestal. Dirección General del Medio Natural. Conselleria de Infraestructuras, Territorio y Medio Ambiente. Generalitat Valenciana.

Acronym: GOV

Official address, country and region: Dirección General del Medio Natural. Ciutat Administrativa 9 d'Octubre – TORRE 1; C/ Castán Tobeñas, 77. 46018. Valencia. Spain.

Website: *www.gva.es / http://www.citma.gva.es/web/medio-natural*

Legal representative: Emilio González.
Telephone: +34 96 386 60 00
E-mail: www_cit@gva.es

Contact person: Pilar Ara. Telephone: +34 96 120 86 32; E-mail: ara_pil@gva.es

3.2.2. Description of the partner's activities/skills relating to biomass

The Directorate-General for Environmental Management is responsible for planning, running, controlling, coordinating and monitoring the activity of services such as: Wildlife, Forest Management, Management of Protected Natural Areas and Hunting and Fishing.

The Forest Management Service carries out tasks related to the integrated and sustainable management of forest resources, and specifically the public woodland and mountains of Valencia; silvicultural treatments; use of forest income; hydrological and forest conservation and defence; cattle trails; and restoration and landscaping improvements on forest land. Through forest management plans, this service aims to promote and increase the use of biomass resources.

3.2.3. Design of a forestry inventory methodology with LiDAR for forest management plans

3.2.3.1. Description of the action

The GOV partner has collaborated in Pilot Action 1.7. "Development of Forest Biomass Management Plans" (Work Package 4 -"Setting up of integrated strategies for the development of renewable energies"-).

The project consists in producing a forest management plan for the recovery of biomass and the development of a new forest inventory methodology, using LiDAR technology.

The combination of LiDAR technology with the traditional forest inventory aims to improve the quality and precision of forest inventory. Furthermore, this methodology can be used to

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obtain the necessary silvicultural variables for more economic management, as fewer sampling plots are needed in comparison to a conventional inventory.

The acronym LiDAR, Light Detection And Ranging, a remote sensing technology, refers to a laser system of distance measuring used to make precise measurements on a massive scale, which has many applications once the information has been processed. The LiDAR data used for this pilot action belong to the Spanish National Aerial Orthophotography Plan (PNOA) from 2009 and, in this case, were provided free of charge (in other cases, the cost of buying this information needs to be considered). The Cartographic Institute of the Valencia Region is responsible for processing and providing these data.

3.2.3.2. Methodology

The management method for "Sierra Negrete" is stand management. The use of this method increases flexibility, allowing forest management to be adjusted to the characteristic changes of Mediterranean forests.

Taking a forest inventory using LiDAR data requires a component from the traditional inventory method. Firstly, field sampling plots are created to obtain forest data. Secondly, statistical variables are obtained from LiDAR data.

Based on this information, regression models are calculated for each variable in the forest inventory at plot level. The models relate direct variables obtained from processing LiDAR data (explanatory variables), to information collected in-situ using conventional forest inventory techniques (response variables).

Then, based on LiDAR data calculated for the entire forest and using the obtained regression models, forest inventory variables are calculated for the entire study surface area.

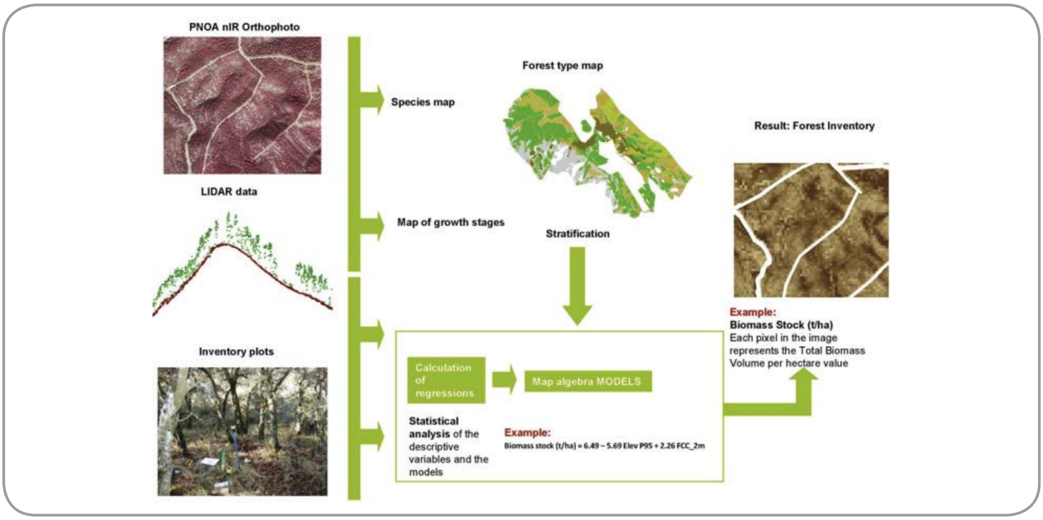

Figure 5. Forestry Inventory Methodology. Forestry variables estimated in an indirect manner using LiDAR data

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- **Forest vegetation map**

The first step is to stratify the forest using different sources of information to map the species and stages of forest development. In this phase, LiDAR data are used to obtain forest canopy cover (FCC).

Inventory strata

To design the forest inventory, forest cover types are mapped, grouping them into homogeneous strata called inventory strata.

The inventory strata are classified according to three main parameters: specific composition of the forest (species), natural age class and FCC.

These parameters are obtained from different maps:

- Orthophotos, 2009 (PNOA).
- Spanish Forest Inventory (IFN3), from 1997 to 2007.
- Boundary reconstruction works by the Valencia Territorial Services Topography and Cartography support service of the Regional Ministry for Infrastructures, Territory and Environment 2011-2012.
- Vegetation Height Model (VHM), based on LiDAR data from the 2009 PNOA.

LiDAR data can be used to generate a variety of digital models of the terrain:

- Digital Elevation Model (DEM): Derived from interpolating the last return points from the terrain.
- Digital Surface Model (DSM): Derived from interpolating the first return points from the terrain and low, medium and high vegetation.
- Digital Vegetation Model (DVM): The difference between the previous models provides a vegetation height model. DVM = DSM - DEM

Based on DVM, pixels with a height over 2 metres are selected to obtain a map of the Forest Canopy Cover (FCC2M), which is used to obtain the inventory strata.

Note: in the technical literature, the digital vegetation model is identified by the abbreviation CHM (Canopy Height Model).

Inventory stratum	Surface area (ha)	Surface area (%)
Pure stand of *Pinus halepensis*, pole and timber stage	2,315	47
Mixed stand with FCC over 40%	1,014	21
Mixed stand with FCC below 40%	611	12
Pure stand of *Pinus halepensis*, regenerated and thicket stage, FCC over 70%	486	10
Pure stand of *Quercus ilex*	337	7
Scrubland	176	4
TOTAL	4,939	-

Table no. 1 Inventory stratum surface distribution

After mapping the strata, the silvicultural report can be produced together with stand delineation. Thus, with final inventory data, relevant changes can be made to obtain a better fit for the stands.

- **Traditional forest inventory**

Sampling plots

Field sampling plots are used to measure silvicultural and forest parameters directly with conventional forest inventory techniques. The plots are circular, with a 10-metre radius to optimise the efficiency of field work operations. Distribution of the sampling plots over the forest follows a regular quadrilateral mesh with 500-metre sides covering the entire study area. The plots for sampling are chosen randomly, discarding plots that are markedly unrepresentative of the forest and avoiding plots at the edge of the stratum.

Inventory stratum	Surface area (ha)	Nº of plots
Pure stand of *Pinus halepensis*, pole and timber stage	2,315	60
Mixed stand with FCC over 40%	1,014	42
Mixed stand with FCC below 40%	611	30
Pure stand of *Quercus ilex*	337	20
TOTAL	4,277	152

Table no. 2 Number of plots per inventory stratum

According to experiments in the technical literature, it is recommendable to prepare at least 20 sampling plots per stratum.

Another important aspect to bear in mind in inventory design is that the plots must be well georeferenced, requiring the use of GPS with submetric accuracy.

Field data

Trees suitable for the inventory have a DBH (1.30 metres) over bark of 7.5 centimetres or more. For trees that fulfil this condition in all the sampling plots, the DBH is measured and the species noted down.From all the trees suitable for the inventory, a subsample of two trees is chosen, taking into account multiple criteria: the selected trees must belong to one of the main species; be non-dominated; have timber on a vertical axis; and be as close as possible to the centre of the plot in the four main cardinal directions.

The following measurements are taken on these sample trees:

- Two crossing DBH (diameter at breast height) measurements.
- Two radial thicknesses of bark.
- Two radial growths corresponding to the last five years, measured using a Pressler increment borer.
- Total height to the tip of the crown with a digital hypsometer.
- The species is determined, as well as the "F" parameter to represent forest scaling of the tree, based on the code established in the Third Spanish Forest Inventory.

Furthermore, for certain *Pinus halepensis* trees, in the group of sample trees, age is determined using the Pressler increment borer, in a representative sample of individuals belonging to the forest's main artificial age classes, in order to establish site quality and evaluate management options based on the study "Tablas de producción para *Pinus halepensis* Mill" (Montero et al., 2000). Information is also gathered in each plot regarding specific composition, natural age classes, vertical structure, main shape of the forest, canopy cover and canopy thickness. A circular concentric subplot with a radius of five metres is also studied, evaluating regeneration and the presence of smaller trees. Supplementary parameters in the form of physical and biotic data are collected to describe the plot, specifically: slope, orientation, stone content, erosion, herbaceous cover, presence of cutting waste and any damage to the stand.

Stock calculation

The variables measured on the sampling plots (DBH, height, number of trees, etc.) are combined with standard rates in order to obtain forest stocks (deferred variables): biomass, timber volume.

Biomass is calculated with the rates proposed by Gregorio Montero (Montero et al., 2005) and published by the Spanish Institute of Agrarian and Food Research and Technology (INIA). It is a generic quality rate applicable throughout Spain, and has been produced using modular values for different sample trees harvested in different geographical locations. Biomass is estimated considering that all timber and non-timber fractions of the tree can be used in full, except for the root.

The timber volume is determined using the rates proposed in the Third Spanish Forest Inventory for the province of Valencia (IFN3, 2007).These rates are generic, produced with average data for the entire surface area of the Spanish peninsula. In order to adjust these rates to the study area, and given that these equations correlate DBH with tree height, height data for sample trees obtained in-situ are used. These data are then used to produce models that infer height in relation to the DBH provided, based on information adapted to the forest. In addition, for the main species, *Pinus halepensis*, a specific rate is created for the forest [a] based on the harvesting of 30 sample trees and commercial timber measurement using the Smalian Method. This procedure improves the precision of the results, compared to a generic rate.

$V\,(m^3) = 0.00005{*}Øn3 – 0.0001{*}Øn2 + 0.0065{*}Øn – 0.0145$ *[a]*

- **LiDAR data processing**

Firstly, the variables derived from LiDAR height distribution data are calculated (percentiles, mean height, standard deviation of heights, kurtosis, etc.) for each plot defined in the inventory. These statistical variables have an intuitive relationship with forest variables (Estornell, 2011). For example, percentile 5 relates to biomass content, height and woodland volume.

Secondly, spectral response variables are calculated from the orthophotographs from the PNOA project (for example, minimum, maximum, average value and standard deviation for the green band per plot). These statistical variables include the nearby infrared band, thereby supplementing the information provided by LiDAR variables in order to improve the models and consequently, the results.

This set of statistical variables forms the list of explanatory variables used to obtain the regression models.

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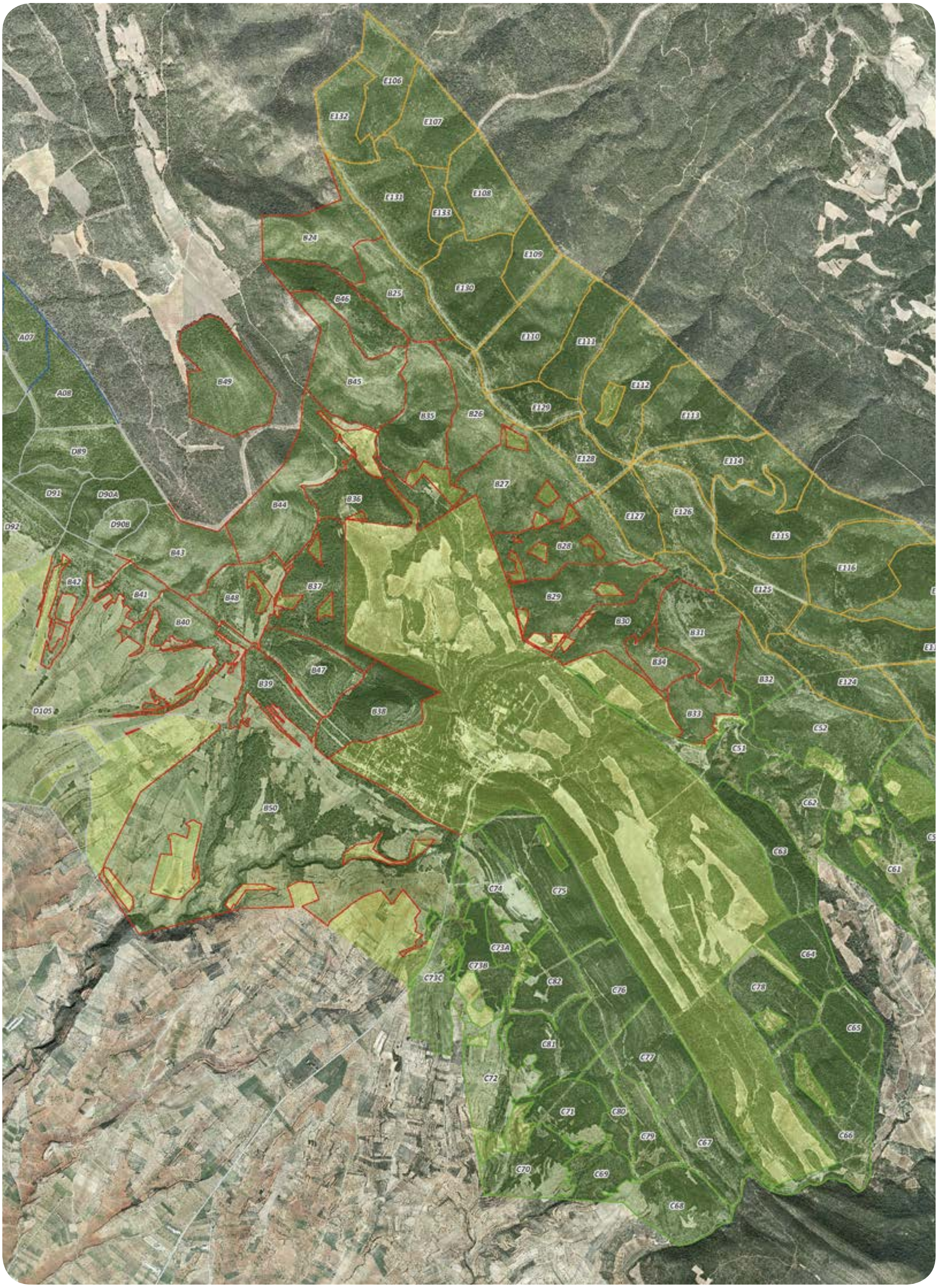

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Variable	Symbol	Characteristics
Percentile 5	P5	Variables related to biomass stock, tree height and volume. Based on the existing relation between those physical variables and the height.
Percentile 10	P10	
Percentile 20	P20	
Percentile 25	P25	
Percentile 30	P30	
Percentile 40	P40	
Percentile 50	P50	
Percentile 60	P60	
Percentile 70	P70	
Percentile 80	P80	
Percentile 90	P90	
Percentile 95	P95	
Maximum height	hmax	
Average height	hm	
Coefficient of variation	Cv	Describes the dispersion of heights of data parcels.
Standard deviation of heights	Hd	This characterises canopy structure based on the distribution of returns. Provides information on the canopy cover factor in the plot.

Variable	Symbol	Characteristics
Asymmetry Kurtosis	g1 g2	This characterises the vegetation structure and its relation to the percentage of bare soil, based on the shape of the height distribution.

Table no. 3 Variables derived from the distribution of heights in the LiDAR data (Estornell J., 2011)

Variable	Characteristics
Gmin	Minimum value of the green band for plot
Gmax	Maximum value of the green band for plot
Gm	Mean value of the green band for plot
Gd	Standard deviation of the green band for plot
Rmin	Minimum value of the red band for plot
Rmax	Maximum value of the red band for plot
Rm	Mean value of the red band for plot
Rd	Standard deviation of the infrared band for plot
IRmin	Minimum value of the infrared band for plot
IRmax	Maximum value of the infrared band for plot
IRm	Mean value of the infrared band for plot
IRd	Standard deviation of the infrared band for plot
NDVImin	Minimum value of the NVDI band for plot
NDVImax	Maximum value of the NVDI band for plot
NDVIm	Mean value of the NVDI band for plot
NDVId	Standard deviation of the NVDI band for plot

Table no. 4 Variables of the spectral responses of the PNOA project orthophotos

LiDAR technology

The sensor used to take LiDAR measurements is normally installed on a plane which sweeps the terrain, emitting laser pulses and measuring the time they take to reach the surface. The direction in which each pulse is emitted and the time they take to reach the surface and return to the sensor are recorded. At the same time a differential GPS establishes the position of the sensor and the Inertial Navigation System (INS) establishes the direction of the measurement system at each moment. Operation of the overall system generates a list of coordinates (X,Y, Height) of the surface with altimetry and planimetry precision of 15 cm.

LiDAR data

The PNOA aims to obtain orthophotographical coverage of Spain based on common technical specifications agreed between the various bodies involved. In the most recent campaign, a LiDAR flight was conducted with an average point density of 0.5 points/m^2, sufficient density for application to forest ecosystem management.

The use of LiDAR data from PNOA significantly reduces processing costs, as it removes the need for specific flights or pre-processing of the data.

LiDAR data, in addition to the planimetric coordinates for each point and height, include other data such as intensity, return number and classification, which are also used in forest inventory calculations.

The classification data assigns a value to each point in relation to whether the point belongs to: ground, vegetation (low, mid or high), building, etc.

- **Regression models**

Forest inventory data referring to biomass stock, timber volume, number of trees, basal area, mean diameter, dominant diameter, mean height and dominant height are calculated using regression models that relate each one of these variables (response variables) to the statistical variables calculated from LiDAR data (explanatory variables).

Multiple linear regressions

With the linear regression procedure more than one independent variable can be used. The statistical technique of multiple regressions has been used in all cases. In accordance with this model or equation [b], the response or dependent variable (Y) is interpreted as a linear combination of a set of k explanatory or independent variables (Xk), each of which is accompanied by a coefficient (βk), which indicates the relative weight of that variable in the equation. The equation also includes a constant (β0) and a random component or residual (**ϵ**). This residual component collects everything that the independent variables are unable to explain, in other words, the difference between the observed and the forecast values.

$$Y = \beta 0\ X1 + \beta 1\ X2 + \beta 2\ X3 + \ldots + \beta k\ Xk + \epsilon \qquad [b]$$

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STRATUM 1 Pure stand of *Pinus halepensis* polewood					
Parameter	Model	R2	Average	RMS	RMS%
BIOMASS	B (T/ha) = 6.49 + 1.01 FCC – 30.6 NVDImin	0.82	47.00	9.79	20.83
VOLUME	V (m^3/ha) = 3.26 + 30.9 g1 - 51.2 NVDImin	0.81	81.84	17.98	21.97
BASAL AREA	G (m^2/ha) = 2.11 + 0.364 FCC - 9.81 NVDImin	0.81	16.04	3.16	19.70
DENSITY	D (trees/ha) = 633 - 9.44 Intensity+ 806 NVDIm	0.54	496.41	175.43	35.34
MEAN DIAMETER	dg (cm) =- 7.52 + 0.327 STD_Ir - 0.652 g2+ 0.240 Int Mean + 0.0650 Transpa-rency	0.67	20.70	3.20	15.46
STAND DIAMETER	do (cm) = 2.77 - 0.499 g2 + 1.43 P90 + 0.382 Gd	0.73	26.58	3.61	13.58
MEAN HEIGHT	Hg (m) = 0.62 - 0.209 g2 + 0.0460 Inten-sity+ 0.106 Gd + 0.333 P90	0.74	8.42	0.89	10.57
STAND HEIGHT	Ho (m) = 5.28 + 0.102 IRd- 0.238 g2	0.73	9.43	1.05	10.68
STRATUM 2 : Wooded mixed stand with canopy cover > 40%					
Parameter	Model	R2	Average	RMS	RMS%
BIOMASS	B (T/ha) = 6.49 - 5.69 P95 + 2.26 FCC	0.79	48.45	15.80	32.61
VOLUME	V (m^3/ha) = - 21.3 + 31.2 Hd - 14.0 P50	0.85	56.01	14.95	26.69
BASAL AREA	G (m^2/ha) = 1.14 + 4.57 Hd - 11.8 NVDImin	0.79	11.31	2.78	24.57
DENSITY	D (trees/ha) = 1036 + 9.24 Return2 - 18.9 Gd	0.57	493.13	152.87	31.00
MEAN DIAMETER	dg (cm) = 16.2 + 4.34 Hd - 12.1 NV-DImin	0.79	17.83	3.21	18.00
STAND DIAMETER	do (cm) = 4.43 + 6.89 Hd - 2.15 P50 + 0.185 Gmin	0.87	23.68	3.42	14.44
MEAN HEIGHT	Hg (m) = 4.72 + 0.0502 Transparency + 0.0574 Gmin	0.79	7.21	1.02	14.14
STAND HEIGHT	Ho (m) = 5.40 + 0.384 Cv - 0.486 P60 + 0.0649 Gmin	0.86	52.88	1.01	1.91

Table no. 5 Regression models of the forestry variables. Strata 1 and 2

STRATUM 3 : Wooded mixed stand with canopy cover < 40%					
Parameter	Model	R2	Average	RMS	RMS%
BIOMASS	B (T/ha) = - 54.1 + 50.1 P50 + 24.1 Hd + 0.929 Int Mean	0.89	49.58	16.51	33.30
VOLUME	V (m^3/ha) = - 23.2 + 13.6 P95 + 29.7 NVDImin	0.88	41.00	13.06	31.85
BASAL AREA	G (m^2/ha) = 16.5 + 2.50 P95 - 0.0855 Gmax	0.90	9.55	2.56	26.80
DENSITY	D (trees/ha) = 1170 + 11.3 FCC - 4.47 Gmax	0.64	399.50	135.63	33.95
MEAN DIAMETER	dg (cm) = 2.64 + 1.75 hmax	0.67	14.19	3.80	26.77
STAND DIAMETER	do (cm) = - 7.98 + 3.01 P95 + 0.0747 IRm	0.79	17.78	4.15	23.34
MEAN HEIGHT	Hg (m) = 1.87 + 0.621 hmax	0.57	5.96	1.69	28.36
STAND HEIGHT	Ho (m) = - 2.81 + 0.816 hmax + 0.0288 IRm	0.66	6.86	1.78	25.93

STRATUM 4 : Pure stand of *Quercus ilex*					
Parameter	Model	R2	Average	RMS	RMS%
BIOMASS	B (T/ha) = - 98.7 + 32.7 Cv + 0.721 IRm - 1.59 Gmin	0.85	61.02	20.43	33.48
VOLUME	V (m^3/ha) = - 1.27 + 8.69 Cv+ 16.9 NVDImin	0.79	17.55	6.06	34.53
BASAL AREA	G (m^2/ha) = - 5.91 + 10.9 AAD + 5.68 NVDImin	0.83	7.20	2.01	27.91
DENSITY	D (trees/ha) = - 661 + 342 P80 + 500 NVDImin + 12.3 Gd	0.74	560.25	175.19	31.27
MEAN DIAMETER	dg (cm) = 2.33 + 2.43 P95	0.68	11.54	1.16	10.05
STAND DIAMETER	do (cm) = 6.56 + 2.60 P95 - 0.610 g^2	0.82	14.04	1.75	12.46
MEAN HEIGHT	Hg (m) = 2.81 + 0.725 P95 - 0.187 g^2	0.70	4.86	0.70	14.39
STAND HEIGHT	Ho (m) = 0.39 + 0.739 P95 - 0.279 g^2 + 31.5 NVDIstd	0.83	5.52	0.62	11.23

Table no. 6 Regression models of the forestry variables. Strata 3 and 4

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In view of the high number of possible explanatory variables, the set of LiDAR data and the spectral responses from the bands in the PNOA orthophotographs, statistical software has been used to select the best sets of variables for each regression model.

"Stepwise" procedure

The software used to obtain the regression models uses the "stepwise" or "step by step regression" method. This procedure begins by introducing all the possible variables in the equation, from which the software first chooses the explanatory variable with the greatest correlation to the response variable. Then the partial correlations between the remaining independent variables and the response variable are calculated; the second variable selected is the one with the greatest partial correlation to the response variable. The procedure continues in this way successively until the defined number of variables is complete, choosing the variables with the greatest correlation and eliminating those introduced if they are no longer statistically significant once new variables are introduced.

- **Model validation**

After the analysis, the statistical validity of each model is verified, ensuring compliance with the principles that confirm the basic hypotheses on the distribution of the response variable, model error distribution and the relationship between model variables.

- Independence: residuals are independent of each other, that is, they are random variables.

- Homocedasticity: for each independent variance value, the variance of residuals is constant.

- Residual normality: residuals follow a normal distribution with mean zero.

- Non-colinearity: there is no exact linear relationship between any of the independent variables.

The coefficient "R^2" is used as a goodness of fit measure in each regression model. The root mean square (RMS) is also calculated for each regression.

- **Map for each model**

When the regression models have been determined and validated for each descriptive variable (biomass, timber volume, number of trees, basal area, mean diameter, dominant diameter, mean height and dominant height) they are then calculated for the entire surface area.

This is done by calculating each statistical value obtained from the LiDAR data (explanatory variables) for each pixel in the study area. This process provides a raster file for each statistical variable.

The coverage of each variable in the inventory is then obtained (response variables) by applying the regression model corresponding to each stratum.

The pixel resolution for calculating the models on the surface area must be similar to the surface area of the field plots, because regression model fit is obtained from the relationship between the data from the field plots and the LiDAR data for each plot.

In this case, the surface area of the field plots is 314 m^2 and the pixel resolution for calculating the models is 324 m^2 (18-metre sides), and so model fit to the entire surface area is correct.

- **Calculation of data by stand**

Based on the coverage calculated in the previous section, forest inventory data are calculated for each stand using averages weighted by the surface area of the stand.

Applying this methodology improves the precision of generalising forest inventory results to forest management units.

3.2.3.3. Stakeholders involved

The Forest Management Plan is a document whose main purpose is to be used by forest technicians as a guide to carrying out necessary works in order to develop long-term sustainable forest management. The methodology developed with LiDAR is therefore intended to be used by these technicians, in order to improve the efficiency of their field inventory work.

3.2.3.4. Outputs

Forest Management Plan of "Sierra del Negrete" → Drafted using the methodology developed with LIDAR. This is a report that gathers all information related to the quantity of biomass as well as the species contained in this forest and their distribution, as well as how to manage them to obtain sustainable growth. This document also shows the various different uses forests may harbour. This document is available in Spanish, on the website.

Design of the forestry inventory methodology with LiDAR → This document shows how to combine new technologies, such as LiDAR, with traditional forestry inventory techniques in order to obtain greater accuracy of data at a reduced cost. It is available in both Spanish and English on the website and some leaflets have also been printed in both languages.

3.2.3.5.Impacts

Combining LiDAR with traditional forest inventory techniques has increased the reliability of the results, due to having continuous data for the forest surface; it has also reduced the number of plots required from the forestry inventory, which in turn reduces the cost of field work.

The aim is to produce the maximum number of forestry areas with built-in biomass data. This information and more, including other possible forest uses, will be brought together in forest management plans.

3.2.3.6. Added value of transnational cooperation

This project has demonstrated the real opportunities that biomass represents as an energy source for the Mediterranean. It has also shown the common problems faced by different countries in this area. To overcome these problems, countries have gathered and pooled knowledge and information, in order to achieve the best solution for each.

In this pilot action, the GOV partner has implemented an improved system for taking forest inventories and has learnt new methodologies used by other partners, which can be reproduced in the Valencia Region in the future in order to improve forest management.

3.2.3.7. Conclusions and lessons learned

Private and public forests should have a forest management instrument approved by the Forestry Administration. For this reason, the tools developed by the GOV partner as part of the PROFORBIOMED project are extremely useful, providing the methodology to both private and public owners to obtain the necessary information about biomass available in their respective forests. The methodology developed using LiDAR, in order to draft forest management plans, has been shown to be more accurate and to reduce field work costs.

The development of forest management plans encourages rural development, with consequent environmental and social benefits.

3.3. Forest Science Centre of Catalonia (CTFC). Spain.

3.3.1. Legal name / Contact details

Name of the Organisation:
Centre Tecnològic Forestal de Catalunya

Acronym: CTFC

Official address, country and region:
Ctra. de St. Llorenç de Morunys, km 2. E-25280 Solsona, Spain

Website: *www.ctfc.cat*

Legal representative: Denis Boglio (denis.boglio@ctfc.cat)

Contact person: Isart Gaspà (isart.gaspa@ctfc.es), Pere Josep Navarro (pere.navarro@ctfc.es)

3.3.2. Description of the partner's activities/skills relating to biomass

The Forest Science Centre of Catalonia (CTFC) is a public consortium, the purpose of which is to contribute to improving the competitiveness of the forest sector; to development of the forest sector; and to rural development through research, technology transfer and training.

The Department of Forest Harvesting, Wood Mobilisation and Biomass is a department of the CTFC and has two branches: one focused on deepening knowledge of forest and wood harvests (technical optimisation, costs and the wood market) and one dedicated to the study of forest biomass (territorial diagnoses, material quality and supply chain logistics).

The fields of knowledge are:

- Logging techniques
- Skyline logging
- Forest road networks
- Wood market
- Chipping
- Storage and supply of forest biomass
- Financial plans of forestry companies
- Wood chip quality
- Woody energy crops
- Biomass composting

3.3.3. Carbon and energy balance of cogeneration in the local area of Moianès.

3.3.3.1. Description of the action

This report presents the results of the study developed within the framework of WP6 WG3, to investigate the carbon and energy balance of cogeneration, also known as distributed generation or combined heat and power (CHP), in the county of El Moianès in the Autonomous Community of Catalonia. The county is comprised of ten municipalities, occupies an area of 338 km^2 and has a population of 13,000.

3.3.3.2. Methodology

There are necessarily some assumptions made in order to conduct this study, which are standard to all PROFORBIOMED projects. Firstly, the characteristics of the biomass production chains are provided by the Punt Forestal study, with the inventories information and digital data from Catalonia; this information is then crossed with local harvesting characteristics, according to companies and stakeholders. The assumptions are as follows:

- Standard felling site of 8 ha, with a felling intensity of 13.1 odt/ha (rotation period of 22 years), resulting in a standardised harvest of 191 fresh tonnes (M 45%-w).
- No restrictions due to forest ownership; biomass harvests are collected when needed.
- Motor-manual felling.
- Extraction by skidder under full-tree harvesting system.
- Chipping at intermediate forest storage and delivery at M 35%-w.
- No opening of roads or special transport of machines is needed.

The net calorific value has been taken from the CTFC laboratory; the assumption is a net calorific value of 3.4 MWh/t30.

Two more assumptions are made, regarding energy efficiency and the emission conversion factors. With regard to the former, the CHP (Combined heat and power) facilities considered in this study, without regard to any technology (turbine with rankine or organic rankine cycle, engine after gasification, etc.), for an input of 100 energy units of biomass (net calorific value), are capable of producing 20 units of electricity and 40 units of thermal energy, equivalent to 20% electrical efficiency and 40% thermal efficiency, and overall energy efficiency of 60%. Actual heat conversion units in the surveyed companies and municipal facilities are assumed to have thermal efficiency of 85%.

The fuel emissions were taken from the Catalan Office on Climate Change, "Instituto para la Diversificación y el Ahorro de Energía (Madrid)" and "Pla de l'Energia I Canvi Climàtic de Catalunya 2012-2020, Generalitat de Catalunya".

3.3.3.3. Stakeholders involved

The study has been developed by CTFC in collaboration with the University of Western Macedonia, the Slovenian Forestry Institute (partners of PROFORBIOMED), the Catalan Energy Agency (ICAEN), the forest consultancy Punt Forestal SL and the Co-operation and Human Development Research Group of the Universitat Politècnica de Catalunya.

3.3.3.4. Outputs

The levels of technically available forest feedstocks for energy generation have been assessed within WP4 PA1.2 (GIS Tools). This pilot action has generated a layer of accessible forest areas and the numerical data associated with forest biomass yield (see Figure 6, page 40).

A survey has been developed by the company Punt Forestal SL within the framework of PROFORBIOMED, with the aim of developing a geodatabase of all the consumption points with an input of more than 600 MWhth per year.

To date, only 65% of the relevant industries have been surveyed. However, these companies represent more than 70% of the county's electrical industrial consumption. The information gathering process has benefitted from close collaboration with the Catalan Energy Agency (ICAEN). The electricity consumption of the ten municipalities was provided by ICAEN and processed by Punt Forestal SL (Table no. 7). The original data includes the details of consumption by sector.

Municipality	Average electricity consumption, MWh/year (2004-2008)	Share relative to the whole county (%)
Calders	3,449	5 %
L'Estany	2,177	3 %
Moià	40,582	55.5 %
Monistrol de Calders	3,697	5 %
Santa Maria d'Oló	7,375	10 %
Collsuspina	1,226	2 %
Castellcir	2,107	3 %
Castellterçol	8,802	12 %
Granera	280	0.5 %
Sant Quirze Safaja	3,089	4 %
	72,784	100 %

Table no. 7 Electricity consumption of the municipalities of Moianès. Average 2004-2008. Sources: ICAEN, Punt Forestal SL

A total of 5 CHP facilities have been proposed for this study (Table no. 8).

CHP facility	Heat production MWhth	Electricity production MWhe	Required supply (t30)	Electrical power (kWe) for 7.500 h	Municipality
Company 1	621	310	456	42.6	S.C.
Moià town	718	426	528	49.3	MOIÀ
El Vapor IP	5,000	2,500	3,676	343.1	CASTELLTERÇOL
Prat & Pla Romaní IPs	9,000	4,500	6,617	617.6	MOIÀ
Sta Maria Oló	5,000	2,500	3,676	343.1	SANTA MARIA D'OLÓ

Table no. 8 Proposed CHP facilities

For *Company* 1 and *Moià town*, the CHPs have been dimensioned according to the current heat needs. The other CHP facilities, have been dimensioned on the basis of intentionally overestimated needs, due to a lack of information from some of the companies in the area of the CHP locations. Therefore, current heat facilities in Moià town and in Company 1 are assumed to have a heat conversion efficiency of 85%, while this assumption is not needed for the other sites.

Therefore, for the energy and CO_2 balance, two scenarios are to be compared:

- Scenario 1: before the installation of CHP facilities.
- Scenario 2: after the installation of CHP facilities.

For assessing the balance, all electricity consumption for the region will be considered, but only the heat consumption of the buildings and industries affected by the CHP facilities.

Figure 6 shows the location of four of the five facilities and the technically available forest biomass for energy. Company 1 is not shown in the figure for the sake of confidentiality.

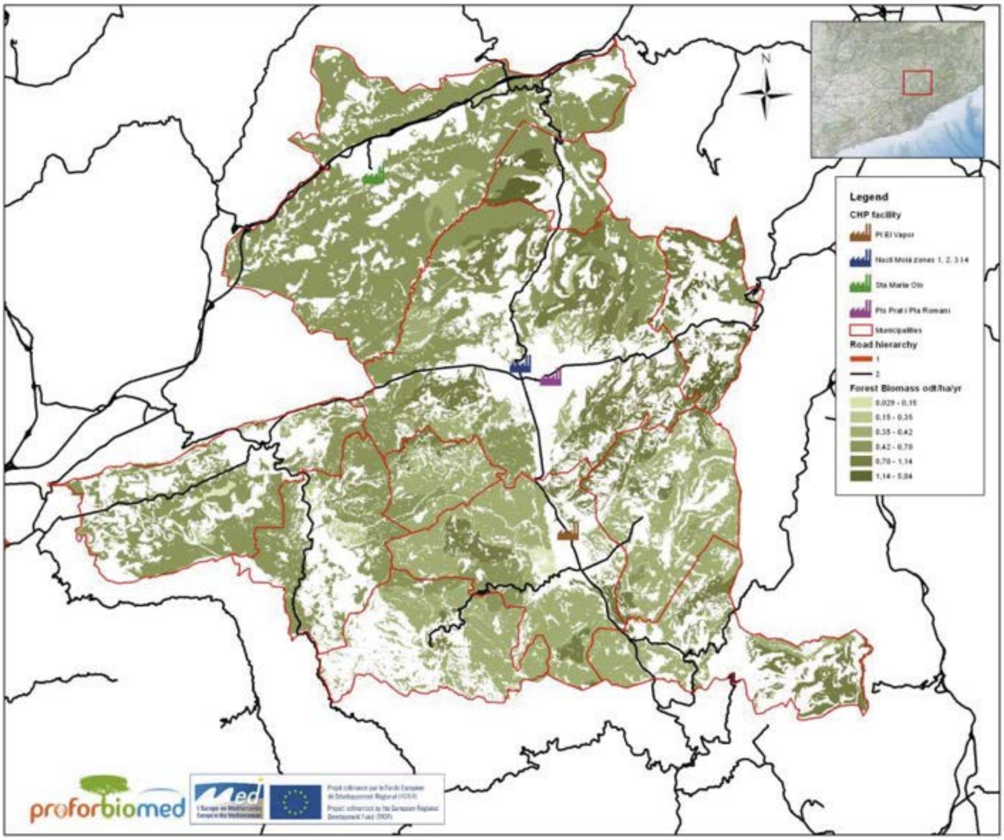

Figure 6. Location of four of the proposed CHP facilities and the technically available yield (odt/ha/yr) of forest biomass for energy. Company 1 is not shown due to confidentiality issues

The GIS tool provided by the University of Western Macedonia has been used and the ArcGIS location-allocation solver has produced the following results and generated Figure 7, Figure 8, Figure 9, and Figure 10.

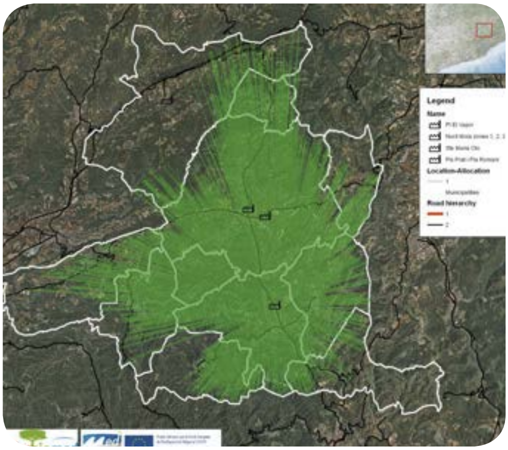

Figure 7. Solution for the supply of the facility IP El Vapor

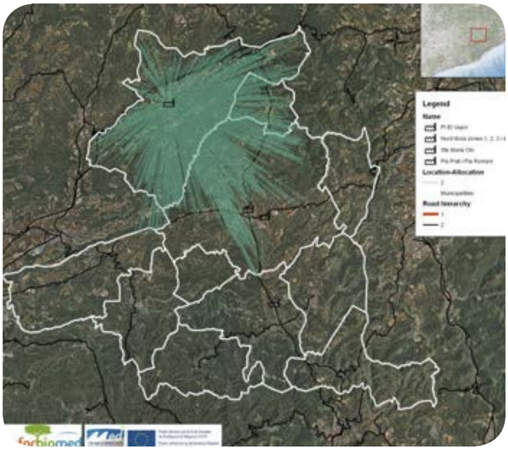

Figure 8. Solution for the supply of the facility in Santa María d'Oló

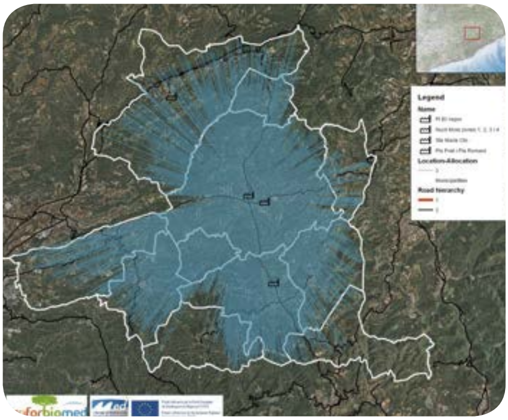

Figure 9. Solution for the supply to the facility in the town of Moià

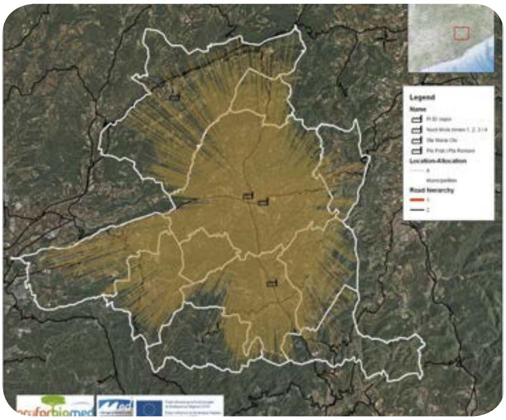

Figure 10. Solution for the supply to the facility of the IPs of Prat and Pla Romaní

In these figures, generated by the logistical model, it is possible to identify which regions are able to supply biomass to these facilities.

3.3.3.5. Impacts

The results obtained from the location-allocation solver are shown in Table no. 9 . The table includes the required supply, the available supply, which in some cases is not sufficient (as assessed by the software), the average supply distance, which is taken as the transport distance for the CO_2 tool, and the average assessed slope for the supply forest areas. The distances are very similar from one CHP to another, between 10 and 12 km.

CHP facility	Biomass consumption, odt/yr	Available for supply, odt/yr	Average supply distance, km	Average forest slope, %
Company 1	320	495	11.35	15.32
Moià town	370	502	10.98	15.88
IP El Vapor	2,573	2,369	10.24	15.71
IPs Prat & Pla Romaní	4,632	4,594	11.34	15.83
Sta Maria Oló	2,573	2,258	11.96	16.59

Table no. 9 Supply chain characteristics obtained from the location allocation analyses

Regarding the supply chain emissions and after running the online tool *http://co2.ctfc.cat*, the results for the standardised harvests are shown in Table no. 10 . The results show how important it is to optimise transport logistics, when trucks of differing capacity are available for chip delivery, given, at least in this case, the same consumption ratio per km for both types of truck. When using 90 m^3 trailers, delivery emissions per site lie between 270 and 320 kg of CO_2. When using smaller trailers of 30 m^3, the delivery emissions rise to 490 kg.

CHP facility	Personnel transport	Felling	Extraction	Chipping	Delivery	Notes
	Emissions per harvest area of 8 ha, with a felling volume of 191 t45 kg CO_2					
Company 1	78.08	86.26	482.26	1251.49	491.92	Delivery with 30 m^3 truck
Moià town	78.08	86.26	482.26	1251.49	491.92	
IP El Vapor	78.08	86.26	482.26	1251.49	268.32	Delivery with 90 m^3 truck
IPs Prat & Pla Romaní	78.08	86.26	482.26	1251.49	295.15	
Sta Maria Oló	78.08	86.26	482.26	1251.49	321.98	

Table no. 10 Unit emissions per harvesting site and supply chain for each of the CHP facilities

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For assessing supply chain emissions for each of the CHP facilities, the number of standardised harvesting sites needed for the supply of each facility was assessed. This value was then multiplied by the total number of tonnes of CO_2 emitted per harvesting site. The results are shown in Table no. 11

The energy balance, or the comparison between the primary energy use for both scenarios, is an important indicator of how the proposed solutions contribute to improved use of energy resources.

First, Table no. 12 shows how electricity production with the proposed CHP facilities would contribute to satisfying the county's electricity needs. Simply by co-generating with all the technically available biomass, 14% of the overall electricity consumption of *Moianès* would be covered.

CHP facility	8-ha harvesting sites, n	Total CO2 emitted for production and supply, t/year
Company 1	3	7.27
Moià town	4	8.41
IP El Vapor	24	53.07
IPs Prat & Pla Romaní	44	96.72
Sta Maria Oló	24	54.38

Table no. 11 Harvesting sites and total CO_2 emissions, per CHP proposed facilit

Municipality	Average electricity consumption, MWh*	CHP electricity production, MWh	CHP production / consumption, %
CALDERS	3,449	0	0.0
CASTELLCIR	2,107	310	14.7
CASTELLTERÇOL	8,802	2,500	28.4
COLLSUSPINA	1,226	0	0.0
L'ESTANY	2,177	0	0.0
GRANERA	281	0	0.0
MONISTROL DE CALDERS	3,697	0	0.0
MOIÀ	40,582	4,861	12.0
SANT QUIRZE SAFAJA	3,089	0	0.0
SANTA MARIA D'OLÓ	7,375	2,500	33.9
MOIANÈS	72,784	10,172	14.0

Table no. 12 Electricity coverage with the proposed CHP facilities, assuming no transport losses

*annual average for the period 2004-2008

By contrast, if one takes into account heating oil consumption (both for heating and industry uses), as assessed by the study performed by Punt Forestal SL in the framework of PROFORBIOMED, then coverage, if using all the technically available biomass for heating purposes, could reach up to 75% (Table no. 12).

Municipality	County	Technically available biomass, MWh/yr	Estimated heating oil consumption, MWh/yr	% coverage
Calders	Bages	3,910	5,384	73%
L'Estany	Bages	2,492	2,481	100%
Moià	Bages	10,399	26,156	40%
Monistrol de Calders	Bages	2,880	3,981	72%
Santa Maria d'Oló	Bages	11,045	5,147	215%
Collsuspina	Osona	2,671	2,003	133%
Castellcir	Vallès Oriental	5,051	3,813	132%
Castellterçol	Vallès Oriental	4,527	10,759	42%
Granera	Vallès Oriental	2,127	645	330%
Sant Quirze Safaja	Vallès Oriental	3,011	3,677	82%
	Total	**48,115**	**64,045**	**75%**

Table no. 13 Technically available biomass and estimated heating oil consumption. Source: Punt Forestal SL and authors

Two final balances of the proposed CHP facilities are presented in Table no. 14 and Table no. 15 In Table no. 14 the values for primary energy correspond to all sources of primary energy, including renewable sources. Table no. 15 displays only non-renewable primary sources. Both tables show the energy balance corresponding to:

Electricity consumption of the whole region of Moianès:

- Before CHP: using the conversion factors 2.55 (Table no. 14) or 2.35 (Table no. 15) to final electricity consumption for assessing the primary energy needs.
- After CHP:

- Electricity from CHP units: allocating one third of the primary energy associated with the final consumption of fossil fuels in the forest biomass supply chain (using conversion factors.

- Electricity from outside Moianès (remaining final electricity needs): using the conversion factors 2.55 (Table no. 14) or 2.35 (Table no. 15) (for assessing the primary energy needs).

Heat consumption of the installations affected by the CHP facilities:

- Before CHP: from the inventoried final fossil fuel consumption of industries and municipal installations, primary energy consumption is calculated using the conversion factors.

- After CHP: allocating two thirds of the primary energy associated with the final consumption of fossil fuels in the forest biomass supply chain.

Biomass consumption: primary energy as biomass is considered only in Table no. 14 .

The energy balance results in Table no. 14 , considering the scenarios created under the hypotheses of CHP installations, show that, although the supply chains for the proposed CHP facilities are short (see S), the overall energy balance is better before than after the CHP proposals, increasing from 206 GWh/yr to 212 GWh/yr. This reveals just how necessary it is to reach maximal efficiency in energy conversion, just after the supply chain, within the conversion facilities. This unbalanced result comes from the efficiency associated with heat production in CHPs, with a proposed value of 40%. Heat conversion efficiency of 20%, which is the same level as in electric energy generation, would allow less consumption of forest biomass as primary energy, although would result in less renewable electricity. Table no. 15 shows the results from another point of view, considering the use of non-renewable primary sources for energy generation. The results show that there is a substantial reduction in the use of primary energy from non-renewable sources after the installation of CHP facilities, from 190 GWh/yr to 148 GWh/yr.

Municipality		SCENARIO 1 – BEFORE CHP			SCENARIO 2 – AFTER CHP			
		PERE	FPER	BER	PERE	APFEFCE	APFEFCH	BERCHP
COLLSUSPINA		3,131			3,131			
S.C.		5,558			5,558			
CASTELLTERÇOL		22,472	5,257		16,089	75	150	12,500
GRANERA		716			716			
MONISTROL DE CALDERS		9,438			9,438			
MOIÀ	Moià town	103,614	946.4		91,203	12	24	1.806
	IPs Prat & Pla Romaní		8,063			137	273	22.500
S.C.		5,379		743	4,587	10	21	1,551
SANT QUIRZE SAFAJA		7,888			7,888			
CALDERS		8,805			8,805			
SANTA MARIA D'OLÓ		18,830	4,907		12,447	77	154	12,500
TOTAL MOIANÈS		**185,832**	**19,173**	**743**	**159,862**	**311**	**621**	**50.858**
		205,748 MWh/yr			**211,651 MWh/yr**			

Table no. 14 Energy balance for the scenarios before and after installing 5 CHP facilities, considering all primary energy sources

Where PERE is Primary energy required for electricity generation, MWh/yr; FPER is Fossil primary energy required for heat generation in CHP-affected facilities, MWh/yr, BER is Biomass energy required for heat generation + forest chain, MWh/yr, APFEFCE is Allocated primary fossil energy from forest chain for electricity generation, MWh/yr (1/3), APFEFCH is Allocated primary fossil energy from forest chain for heat generation, MWh/yr (2/3) and BERCHP is Biomass energy required for CHP, MWh/yr

<table>
<tr><th colspan="2" rowspan="2">Municipality</th><th colspan="3">SCENARIO 1 – BEFORE CHP</th><th colspan="3">SCENARIO 2 – AFTER CHP</th></tr>
<tr><th>PERE</th><th>FPERHCHP</th><th>NPFEH</th><th>PERE</th><th>APFEFCE</th><th>APFEFCHG</th></tr>
<tr><td colspan="2">COLLSUSPINA</td><td>2,878</td><td></td><td></td><td>2.878</td><td></td><td></td></tr>
<tr><td colspan="2">S.C.</td><td>5,110</td><td></td><td></td><td>5.110</td><td></td><td></td></tr>
<tr><td colspan="2">CASTELLTERÇOL</td><td>20,663</td><td>5,257</td><td></td><td>14.794</td><td>75</td><td>150</td></tr>
<tr><td colspan="2">GRANERA</td><td>659</td><td></td><td></td><td>659</td><td></td><td></td></tr>
<tr><td colspan="2">MONISTROL DE CALDERS</td><td>8,678</td><td></td><td></td><td>8.678</td><td></td><td></td></tr>
<tr><td rowspan="2">MOIÀ</td><td>Moià town</td><td rowspan="2">95,272</td><td>946.4</td><td rowspan="2"></td><td rowspan="2">83.860</td><td>12</td><td>24</td></tr>
<tr><td>IPs Prat & Pla Romaní</td><td>8.063</td><td>137</td><td>273</td></tr>
<tr><td colspan="2">S.C.</td><td>4,946</td><td></td><td>13</td><td>4.218</td><td>10</td><td>21</td></tr>
<tr><td colspan="2">SANT QUIRZE SAFAJA</td><td>7,253</td><td></td><td></td><td>7.253</td><td></td><td></td></tr>
<tr><td colspan="2">CALDERS</td><td>8,097</td><td></td><td></td><td>8.097</td><td></td><td></td></tr>
<tr><td colspan="2">SANTA MARIA D'OLÓ</td><td>17,314</td><td>4,907</td><td></td><td>11.445</td><td>77</td><td>154</td></tr>
<tr><td colspan="2">TOTAL MOIANÈS</td><td>170,870</td><td>19,173</td><td>13</td><td>146.991</td><td>311</td><td>621</td></tr>
<tr><td colspan="2"></td><td colspan="3">190,057 MWh/yr</td><td colspan="3">147,923 MWh/yr</td></tr>
</table>

Table no. 15 Energy balance for the scenarios before installing 5 CHP facilities and after, excluding renewable primary energy sources

Where PERE is Needed primary energy for electricity generation, MWh/yr, FPERHCHP is Needed fossil primary energy for heat generation in CHP-affected facilities, MWh/yr, NPFEH is Needed primary fossil energy in biomass chain for heat generation, MWh/yr, APFEFCE is Allocated primary fossil energy from forest chain for electricity generation, MWh/yr (1/3), APFEFCHG is Allocated primary fossil energy from forest chain for heat generation, MWh/yr (2/3)

The CO_2 balance of the two considered scenarios is presented in Table no. 16 . The values have been assessed considering the CO_2 emission factors and the emissions assessed for the supply chains of each facility. In this case, the carbon balance is significantly improved, given that biomass combustion accounts for zero emissions of CO_2, if compared to the combustion of fossil fuels.

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Municipality		SCENARIO 1 – BEFORE CHP		SCENARIO 2 – AFTER CHP	
		CO_2 emitted for electricity generation, t	CO_2 emitted in CHP-affected facilities for heat generation, t	CO_2 emitted for electricity generation, t	CO_2 emitted for CHP (supply chain only), t
COLLSUSPINA		405		405	
S.C.		718		718	
CASTELLTERÇOL		2,905	1,190	2,080	53
GRANERA		93		93	
MONISTROL DE CALDERS		1,220		1,220	
MOIÀ	Moià town	13,392	222	11.788	8
	IPs Prat & Pla Romaní		1,892		97
S.C.		695	3	593	7
SANT QUIRZE SAFAJA		1,019		1,019	
CALDERS		1,138		1,138	
SANTA MARIA D'OLÓ		2,434	921	1,609	54
TOTAL MOIANÈS		**24,019**	**4,228**	**20,662**	**220**
		28,247 t CO_2		**20,882 t CO_2**	

Table no. 16 CO_2 balance of the scenarios before and after the installation of 5 CHP facilities

3.3.3.6. Added value of transnational cooperation

During this study, knowledge transfers among three PROFORBIOMED partners have been successful: carbon tool from CTFC to Slovenian Forestry Institute (SFI), GIS-tool from University of Western Macedonia to CTFC and SFI, and GIS management from SFI to CTFC. This transfer has contributed to the final analysis.

3.3.3.7. Conclusions and lessons learned

The following conclusions may be drawn from this work:

Energy balance: the results show that, even proposing a CHP generation solution with short production chains, the energy balance, all primary energy sources considered, is worse after than before the CHP proposals. It has been suggested that the main reason for this negative result is due to inefficient heat conversion in the CHP facilities, in contrast to pure heating units with much greater efficiency. However, the proposed solution is better in terms of use of non-renewable primary energy sources.

CO_2 balance: the CO_2 balance, as assessed following the proposed methodology, is better with the proposal of CHP based on the use of biomass. The proposal thus contributes to reducing the rate of climate change due to the accumulation of CO_2 in the atmosphere.

No renewable energy can by itself cover the total energy demand of our societies. An appropriate renewable energy mix must be envisaged, for meeting the heating and the electricity needs for current and future generations.

Energy efficiency seems to be one of the most important drivers for sustainability in the use of resources, and significant efforts are to be devoted to this subject in the coming years. However, these efforts should be particularly focused on efficiency through insulation in buildings, as well as efficiency of energy conversion with renewable energies (biomass), which will indeed be the energy sources of the future. Efforts may also be devoted to efficiency in forest fuel supply chains.

Further studies should also consider the economic balance of the proposed solutions. At present, most of the micro-CHP technologies (in this study, the power ranges from 43 to 618 kWe) are in the demonstration and pre-commercial stages, meaning that the investment and operation costs are not clearly defined.

A comprehensive study for the whole region, and even further afield, should be performed in order to determine the ideal sizes and technologies for CHP units and hence allocate R+D funds accordingly.

3.3.4. Extraction of forest primary biomass with different harvesting systems in Catalan forests

3.3.4.1. Description of the action

In the context of Pilot Action 1.3, *Assessment of forest biomass production in WP4*, CTFC presents this study of forest primary biomass extraction with different harvesting systems in some typical Mediterranean forests in Catalonia. These trials had been accorded to meetings with stakeholders from the Provincial Council of Barcelona (DIBA, Diputació de Barcelona) and the Catalan Federation of Forest Owners' Associations (BOSCAT); one of the bottlenecks of the harvesting of forest primary biomass (understood as whole trees and full stems of wood-industry-unmerchantable products) is extraction by cable.

It also seemed important to compare predicted or modelled yield with the real quantities obtained in the harvest. For this reason, we are about to sign an agreement with the Forest Ownership Centre of Catalonia (CPF), which is the entity in charge of promoting a new management system known as OrGest. OrGest is now in the testing phase, and in these tests PROFORBIOMED and CTFC are willing to collaborate in order to better estimate productivity/yields related to *Pinus halepensis* (and also *Quercus ilex*).

An agreement has been reached with a forestry company to test a feller-buncher in Catalan young stands of *Pinus halepensis*, in order to trial a type of technology that is new to Catalonia, and a new way of organising the work.

3.3.4.2. Methodology

Firstly, in consultation with stakeholders, the areas where the tests were to be conducted were decided; the aim was to choose areas representative of the typical forests of the region, where different management strategies had been applied. Inventories were carried out to determine species and species distribution. A variety of tests were conducted during the project.

3.3.4.3. Stakeholders involved

The work involved different stakeholders: DIBA technicians and team-leaders, the head of BOSCAT, CPF technicians, forest workers (chainsaw operators, tractor drivers, truck drivers), companies exploiting forest primary biomass, and technicians employed locally by the forest administration.

3.3.4.4. Outputs

A summary of results is shown in Table no. 17 and Table no. 18 for a total of nine different areas (in area 1.3.7, four plots were tested); inventories and data were taken from all the chains.

	1.3.1		1.3.2		1.3.3		1.3.4		1.3.5	
	Whole plot area		Whole plot area		Whole plot area		Whole plot area		Whole plot area	
Name	PNIN Poblet		Mas Gomis		Cal Garrigó		Fusimanya		Vilarmau	
Objective	Yield estimate according to OrGest		Reduction of forest risk		Test different fire-prevention structures		Improve forest stand		Used as a reference for standard full-stem felling	
Elevation (m.a.s.l.)	920	460	415	415	430		72%			
Felling area (ha)	0.8	2	0.5	6		2.6	4.2	23.75		2.8
Average slope gradient (%)	50%	35%	10%	20% -	55%		133%			
Age (years)	40 and 20-30	Est. 40		46	Unknown	40-50	132%			
Growing stock (m³/ha)	115	85		110	82.8	148.7		120		
Intensity of thinning (%) (in terms of basal area)	32.5	65%			58%	19%	15%		17%	
Removal (No. trees/ha)	1000	Ca 1200			925	200	230		300	
Total removal (t/ha)*1	41	>45				11.7			20.2	
Remaining in ground (t/ha)							7.4			4.8
Share of green wood chips in total removal (%)	0 (all firewood)		86.60%		100		ca. 50%		0	
Average DBH of removed trees (cm) *2	10		15	15	15		20	10		20
Removal of roundwood (m³, over bark)	0			28.0	5.02	62.3 m³/ha	21.1 m³/ha			22.7 m³/ha
Amount of green wood chips bulk m³	0			981 m³bv						
Water content (w %) for wood chips *3	33% **		35%.***		44% *		46.8%*			49.1%*

Table no. 17 Description of the test sites

*roundwood ** for firewood two weeks after cutting *** ca. 45% just after cutting

proforbiomed
Promotion of residual forestry biomass in the Mediterranean basin

L'Europe en Méditerranée
Europe in the Mediterranean
Projet cofinancé par le Fonds Européen de Développement Régional (FEDER)
Project cofinanced by the European Regional Development Fund (ERDF)

	1.3.6		1.3.7				1.3.8		1.3.9	
	Whole plot area		Whole plot area				Whole plot area		Whole plot area	
Name	Vila - Bacardit		La Vila				Regenerat d'Avinyó		La Sentiu de Sió	
Objective	Improve forest structure and obtain data about full-stem harvesting		Removal of burned wood. Improve felling in the remaining area.				Test felling bunching in a young stand		Thinning of an afforestation from the 70s	
Elevation (m.a.s.l.)	855	460	470		415		470		330	
Felling area (ha)	3.2	46.1	1.8	1.8	1.8	1		2.3		9.4
Average slope gradient (%)	40%	35%	15%	10%	15%	15%		30%		10%
Age (years)	Unknown	Est. 40	40 - 50		46		20-30	40-50	40 - 50	
Growing stock (m^3/ha)		56.2			150	83.9		101.2		81.2
Intensity of thinning (%) (in terms of basal area)		9%			47%	45%		68%		37%
Removal (No. trees/ha)	330	330			800	600		4300		640
Total removal (t/ha)*1	5	12.8			68.9	31.5		67.5		39.5
Remaining in ground (t/ha)	3.4				0.1	0.3		0.9		0
Share of green wood chips in total removal (%)		73%			100	100		100		100
Average DBH of removed trees (cm) *2	15				15	10		5		10
Removal of roundwood (m^3, over bark)	9.7									
Amount of green wood chips bulk m^3										
Water content (w %) for wood chips *3		52.4%*			46.4	45.4		48%		44%

Table no. 18 Description of the test sites continuation

*roundwood ** for firewood two weeks after cutting *** ca. 45% just after cutting

3.3.4.5. Impact

Logging, skidding and chipping yields were taken in the majority of tests. This study's most useful contribution is the opportunity it has provided to test different methodologies and machinery; the results are the lessons learned for the partners and stakeholders.

3.3.4.6. Added value of transnational cooperation

The possibility of sharing field work methodologies with the PROFORBIOMED partners provided the opportunity to focus on obtaining value data from the tests.

3.3.4.7. Conclusions and lessons learned

The following is a summary of the conclusions and lessons learned during the tests:

Good organisation of the forest work may determine whether or not the harvest will indeed need to make use of the subsidies.

The performance of the felling-bunching machine is not as expected. It seems that it may perform better in roadside clearings, in combination with a forwarder.

The use of a tractor with grapple may help in increasing productivity (thus lowering the cost) when stacking is required in the forest. Stacking may be better performed with another type of head other than the Naarva EH28.

Chipping is no longer a bottleneck, because forest operators always find the best place for chipping, as long the forest administration also collaborates in facilitating the location of temporary sites for storage/chipping.

Losses of moisture content should be taken into account when evaluating economic balances, when public money is to subsidise operations.

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Impacts: Logging, skidding and chipping yields were taken in the majority of tests

3.4. Regional Development Agency. Region of Murcia. Spain.

3.4.1. Legal name / Contact details

Name of the Organisation: INSTITUTO DE FOMENTO DE LA REGIÓN DE MURCIA

Acronym: INFO

Official address, country and region: Avda. de la Fama nº 3, 30003 Murcia. Spain

Website: *www.institutodefomento.es*

Legal representative: Ms. Reyes Samper, Director

Contact person: José Pablo Delgado josep.delgadom@coiirm.es

3.4.2. Experiences in Energy Crops for Drylands

3.4.2.1. Description of the action

The experience is related to Pilot Action 1.6 of Work Package 4, and it sought the following objectives:

- Improving knowledge of *Robinia pseudoacacia* cultivation in arid Mediterranean environments, such as the Region of Murcia.
- Study of tree growth parameters (trunk diameter, crown diameter and height of the species).
- Determination of *Robinia pseudoacacia* production (t/ha) as a short rotation species.
- Analysis of applied irrigation volumes and ifluence on annual production.
- Most appropriate equipment for cultivation of this species.
- Economic analysis of *Robinia pseudoacacia* plantation, harvesting, transport and sale of biomass in short rotation.

Four plots were implemented, with the following characteristics:

Location (name) of pilot area: El Jinete, Cieza, Region of Murcia, Spain.

Size of pilot area: 4.335 m^2. Four 25 x 20 m plots (500 m^2)

Species: *Robinia pseudoacacia*, “Energy” clone

Vigour and precocity: This species offers good rooting of plants. As a result, these species have high growth rates, yielding high biomass production in short rotations. Due to the vigour and precocity in the early stages, it is suitable for use in short rotations of 2 to 5 years.

Hardiness: This species does not require high soil quality and survives in all types of terrain, but avoid soils with water stagnation, as it can develop iron chlorosis in soils with carbonate accumulation. *Robinia pseudoacacia* presents no particular cultivation difficulties. The strengths of this species are: drought resistance, has no specific pests and grows on poor soils.

Selective breeding: The only known selective breeding for this species is that performed by the company Biopoplar, producing a *Robinia pseudoacacia* clone called “Energy”.

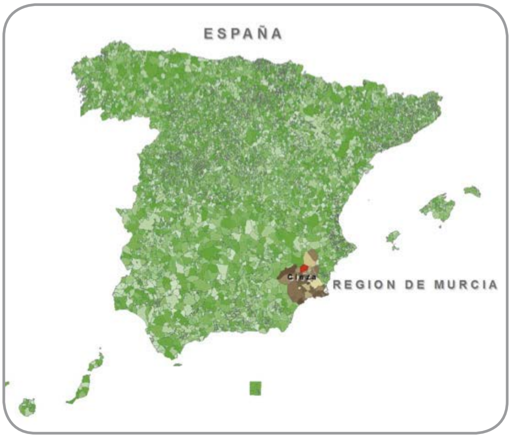

Figure 11. Plot location

Figure 12. Plot location

Figure 13. Plot location

Figure 14. Plot layout

The trial consisted in harvesting the produced biomass twice: once one year after planting and again two years after planting.

3.4.2.2. Methodology

The methodology used in this trial consisted in the following steps:

3.4.2.2.1. Soil preparation

The soil was prepared with a mouldboard plough in the first phase, then in the second phase, a rotovator was used to improve the planting area, resulting in more homogeneous, aerated soil.

- **Type of soil:** The soil type is alluvial, typical of river valleys. In this case, it is the plain of the River Segura in Cieza.

- **Physiography:** The physiography of the area is classified as flat terrain. Specifically, the experience will be developed on a plot located near the River Segura.

- **Subsequent machining requirements:** The machinery for soil preparation was a tractor (120 CV), equipped with mouldboard plough in the first phase and a rotovator in second phase.

3.4.2.2.2. Planting Density Framework

- **Dendrometry:** It has provided a framework of planting a double row, with a distance of 1,0 m between double rows with plants. The distance between plants within each row is 0,7 m. The double rows of plants, streets were separated using 3,0 m wide. This implies a surface of 1,.5 m^2 per plant, obtaining a final density of 6,667 plants/ha.

- **Technology:** Planting was done manually, due to the low volume of plants used in this experiment; this work was conducted manually by paid labourers with specialised equipment when necessary.

- **Cost:** To implement this pilot experience in *Robinia pseudoacacia* cultivation, investment in land preparation and plant purchase is necessary. Below is a summary of the economic costs by plant that will be required by each of these stages, assuming a total of 1,333 plants will be needed:

- Advance preparation of the land: €0.21/plant

- Acquisition, transport and planting: €1.27/plant

- Total cost: €1.48/plant.

- **Site quality:** The site is characterised by a high depth of soil for growing on the banks of the River Segura. As mentioned previously, these are alluvial soils.

Figure 15A. Pictures of the plantation process

Figure 15B. Pictures of the plantation process

3.4.2.2.3. Fertilisation

No fertiliser was applied.

3.4.2.2.4. Irrigation

As for irrigation, four levels of irrigation will be used. Below is a figure showing the different characteristics of the selected pilot areas:

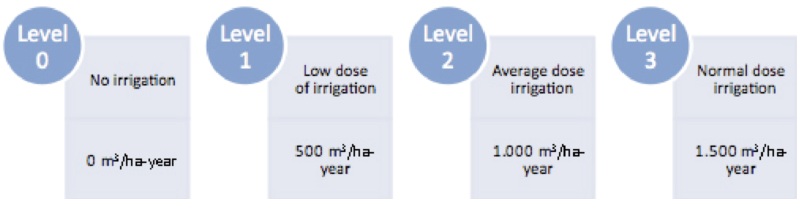

Figure 16. Different levels of irrigation used in the experiment


Figure 17. Pictures of the irrigation system

3.4.2.2.5. Weed control and pests

During the first two years, weed control will be used to facilitate the growth of *Robinia pseudoacacia* and prevent competition for water resources. Pest control has not initially been planned, because there are no known pests of this species.

3.4.2.2.6. Harvest

- **Rotation**: This research project will study short rotations, of two years. There is the possibility of extending the study for a further year, to study the performance of the plantation with rotations of three years.

- **Machinery:** In the area there is a biomass harvesting head, which places the chips onto a tractor trailer. A harvesting machine shall be considered for planting, providing mechanised support for the planting process.

Selection of transport systems is affected by the quality and structure of the forest road network and by conditions at the 'landings', which usually must be done with trucks (moving floor system).

3.4.2.2.7. Storage

The working system employed in Murcia, is that open meadows are commonly available close to the area of the crop. In these meadows, the biomass moisture content decreases to values of 25-30%. The condition to be met is that these meadows be accessible to large trucks.

Once the moisture content decreases, the biomass is transported in large trucks, which generally operate with a moving floor system.

3.4.2.2.8. Transport

Transport is by large trucks. It is best to use 90 m^3 flatbeds, as due to the low density of the wood chips, transporting large volumes decreases the cost of transportation.

3.4.2.3. Stakeholders involved

The study was implemented thanks to the Biomass Company Ingeniería del Entorno Natural, which carried out all the works needed, as well as the farmers of the municipality of Cieza, who provided the workforce.

3.4.2.4. Outputs

Figure 18. Pictures of the plots after two years

The final results two years after planting revealed that the diameter measured at the trees' base was greater in the irrigated plots. In fact, trees in these plots have diameters between 5.35 and 6.16 cm, while the non-irrigated plot produced trees with a base diameter of 3.50 cm.

Plot	Irrigation level	Diameter at base (cm)	Typical deviation	No. of trees
1	No irrigation	3.50	0.88	89
2	Low dose	5.35	1.10	101
3	Average dose	6.04	1.45	100
4	Normal dose	6.16	1.45	102
	Total	5.26	1.22	392
	Total	**48,115**	**64,045**	**75%**

Table no. 19 Statistics of the tree diameter at its base after two years

The study results were similar for tree height as for tree diameter, that is, the growth in height was greater in the plots that were irrigated. While non-irrigated trees grew 2.62 m high on average, the irrigated trees obtained heights between 4.07 and 4.89 m.

Plot	Irrigation level	Height (m)	Typical deviation	No. of trees
1	No irrigation	2.62	0.45	89
2	Low dose	4.07	0.48	101
3	Average dose	4.73	0.61	100
4	Normal dose	4.89	0.72	102
	Total	4.08	0.57	392
	Total	**48,115**	**64,045**	**75%**

Table no. 20 Statistics of tree height after two years

Regarding biomass collected after the experiment, as shown in Figure 12, two different qualities can be distinguished: aerial biomass, corresponding to the trunks and branches, and root biomass. The study offers the following results:

- Irrigation is very important for this species in semi-arid lands.
- An average irrigation dose is sufficient to produce a representative amount of biomass.
- The biomass produced in the second harvest is much bigger than in the first one.

Plot	Irrigation level	Aerial Biomass (t/ha)		Root Biomass (t/ha)		Total Biomass (t/ha)	
Plot	Irrigation level	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
1	No irrigation	11.3	11.4	6.6	6.7	17.9	18.1
2	Low dose	17.4	31.8	10.2	18.7	27.6	50.5
3	Average dose	18.0	44.2	10.6	26.0	28.6	70.2
4	Normal dose	16.8	46.4	9.9	27.3	26.7	73.7

Table no. 21 Mass of biomass collected in the harvests (average humidity 38%)

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Due to the high humidity detected in the harvested wood, and bearing in mind that the biomass energy content depends only on the dry mass, production from the aerial part of the plants is over 27 dry tonnes per hectare after two years (average dose of irrigation). In this case, the raw biomass cost is €58.33 per dry tonne.

Plot	Irrigation level	Aerial Biomass (DMT/ha)		Biomass Cost (€/DMT)
		Year 1	Year 2	
1	No irrigation	7.0	7.1	90.25
2	Low dose	10.8	19.7	59.68
3	Average dose	11.2	27.4	58.33
4	Normal dose	10.4	28.8	64.84

Table no. 22 Dry mass of aerial biomass collected in the harvests and its cost

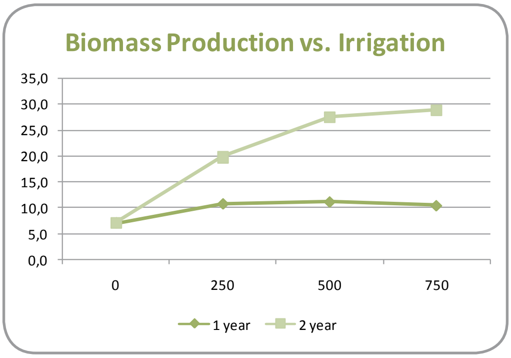

Figure 19. Dry mass of aerial biomass collected in the harvests

3.4.2.5. Impacts

The use of *Robinia pseudoacacia* as a short-rotation species represents a good solution for putting some abandoned lands into production. This practice not only produces biomass for energy purposes in rural areas, but is also an important strategy for fixing CO_2 from the atmosphere (Figure 19). It is, indeed, a good way of revitalising rural areas, specifically when there has been reason to abandon farming lands. A farmers' organisation to produce, collect and process this biomass to transform it into a useful fuel would also be suitable for this purpose.

3.4.2.6. Added value of transnational cooperation

The transnational cooperation has been important in terms of sharing similar experiences and spreading existing knowledge to other regions and countries, but mainly, in encouraging partners to work together towards the same target. The close contact between partners participating in this Pilot Action has been vital for its success.

3.4.2.7. Conclusions and lessons learned

The conclusions from this experience are the following:

- *Robinia pseudoacacia* is a species relatively well adapted to drylands, but in this particular area, an average dose of irrigation was required.
- Biomass production increases exponentially with the years. The bibliography shows that the most profitable option is harvesting every three years. At that point, the biomass produced should be over 50 dry tonnes per hectare at a price below €50 per dry tonne.
- Short-rotation plantations represent new activity for rural areas, mainly those affected

by abandoned lands.

- It also offers a new opportunity for farmers, to switch from food production to producing biomass energy, while protecting the land and fixing carbon from the atmosphere.

- This practice helps to retain the soil in drylands, thus reducing the impact of desertification in Mediterranean zones.

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Robinia pseudoacacia is a species relatively well adapted to drylands

3.5. Municipality of Enguera, Valencia Region. Spain.

3.5.1. Legal name / Contact details

Name of the Organisation: Ayuntamiento de Enguera

Official address, country and region: Doctor Albiñana Strret, 1. 46810, Enguera, Valencia, Spain.

Website: *www.enguera.es*

Legal representative: Santiago Arévalo Llácer; Telephone: +34 96 40 33 Fax: +34 96 222 53 19 E-mail: enguera_ofi@gva.es

Contact person: Fernando Pradells Monzó; Telephone: +34 962 22 52 28; E-mail: fernando.enguera@gmail.com

3.5.2.Description of the partner's activities/skills relating to biomasss

Due to the large area of common land owned by the town of Enguera, they were looking to use these resources to enable local development, as well as improve conservation of their forests. Forest Management projects in public lands in public lands were designed to this end, with the main use being biomass, to support forest fire prevention.

3.5.3. Creation of the Valencian Forestry Platform

3.5.3.1. Description of the action

The main result of the participation of the Municipality of Enguera in the PROFORBIOMED project that has long-term potential has been the launch of the Valencian Forestry Platform (VFP). The constitution of the VFP on Friday 31st May 2013 in Enguera undoubtedly represented a milestone in the history of forests in the Autonomous Region of Valencia and a starting point for sustainable forestry development in this territory. The main challenge of the VFP is the preservation and improvement of Mediterranean forest ecosystems and the natural landscape, harmonising environmental conservation on the one hand, and sustainable forest management on the other. On this basis, all organisations that constitute the VFP are fully committed to sustainable forest management being the best guarantee for forest preservation, as well as for the provision of environmental and socio-economic services to the entire Valencian society, both rural and urban.

At a time when civil society should take decisive steps forward, the VFP was born as a fully independent, non-profit partnership without any mandate or political allegiance, currently comprising more than 30 stakeholders representing the full spectrum of civil society in the region with an interest in forest management: associations of public and private owners, major agricultural unions, industrial federations of wood and forest products, professional associations, conservation NGOs, research institutes and public universities.

The VFP faces the ambitious challenge of balancing the responsibility of a generational mandate to maintain and preserve a rich and diverse environmental legacy, with that of opening opportunities for job and wealth creation, as well as serving as the cornerstone of the socio-economic and environmental structuring of the asymmetrical Valencian territory.

Weaknesses and threats of forestry in the Valencian Region:

After three decades of regional governance in forestry and rural development, the forestry sector continues to suffer from a number of historical problems that have led to the following weaknesses or threats:

1. Forest occupies more than half of the territory of Valencia, 65% of which is private property. Municipalities own 30% of the forest area. Neither municipal forests nor private forest ownership is fully recognised by the regional government or by society. This surface area is increasing annually at a significant pace, despite wildfires. However, subsidiary forest management has not accompanied this increase in forests and the consequent biomass overload. The final result is widespread neglect of these forests.

2. For over three decades, the forestry sector has no longer been an active generator of jobs and wealth. Throughout the history of Valencia, as today in other Mediterranean regions, forestry has helped to provide income for landowners, based on active on-site, sustainable management.

3. The regional government (Generalitat Valenciana) has recently developed active policies derived from a forestry strategy, which have resulted in a very low management rate, generating discouragement and neglect, thus promoting rural depopulation and exponentially increasing the spread of large wildfires, as unfortunately occurred in the summer of 2012.

4. Extensive and often contradictory forest legislation exists. This legislation is the result of a highly protective policy, which is not effective for ensuring the good condition of forest heritage. This legislative overload and its derivative administrative tangle hampers management and new entrepreneurial projects and, consequently, a sustainable knowledge-based bioeconomy linked to agroforestry, as prescribed by the European Commission through the Lisbon Strategy. In some Valencian forest areas, up to eight types of protection coexist on the same terrain, with their respective laws and various administrative processes. Several years since the introduction of large, Natura 2000 protected areas, these have still not helped to improve forest conservation or management.

5. A lack of management and the accumulation of biomass in Valencian forests usher in the greatest environmental catastrophe suffered by Mediterranean ecosystems: forest fires. For almost two decades no large bushfires occurred, despite extreme summer weather conditions. However, the serious risk derived from the accumulated forest biomass unfortunately became clear in the summer of 2012, with the large fires of Cortes de Pallas and Andilla, with a total of 50,000 ha burned. Unfortunately, the current forest situation does not rule out a return to large fires in the coming summers. Wild fires are the most significant environmental disaster in Mediterranean forests. Nevertheless, it is difficult to assess the socio-economic losses, due to an underestimation of the market value of the various products and services provided by Mediterranean forests. The CO_2 emissions caused by the fires in summer 2012 were higher than the total annual emissions from industry, transport and energy consumption in the region of Valencia. This accelerated carbon emission into the atmosphere contributes to climate change and the acceleration of desertification processes in this Mediterranean region. The loss of biodiversity negatively affects countless socio-economic activities (mushrooms, beekeeping,

hunting, mountain sports activities, rural tourism, etc.). The vegetation loss carries an increased risk of soil erosion and flooding. The drastic decrease in groundwater recharge leads to increased dependence on water transfers. Ultimately, wildfires annihilate all kinds of forest resources (wood, biomass, cork and other products and services) for over twenty years.

3.5.3.2. Metodology

Paradoxically, while it occupies more than half of the territory, the forest primary sector contributes to less than 1% of GDP for the Region of Valencia. However, the possibilities for growth and development are significant, as other European and Mediterranean regions have demonstrated. Sustainable and integral use of forest biomass for bioenergy at the local/regional level has been identified as a key opportunity for the socio-economic and environmental development of the forest sector in this region.

Thus, in order to generate greater environmental and socio-economic value and to improve the employment and living conditions in the rural areas, the VFP, by consensus among all its associated organisations, proposes the following priority actions:

1. Encourage and facilitate sustainable forest management among municipal and private forest owners, enabling employment and wealth generation in rural areas and promoting effective rural development, based on territorial and social cohesion. To do this, the Regional Government should decisively support the development of Mediterranean forest resource value chains (especially the exploitation of residual forest biomass for energy, but also short rotation coppices for biofuels or wood, mushrooms and truffles, aromatic and medicinal plants for pharmaceutical or nutritional uses, etc.) in the regional implementation of the new Common Agricultural Policy, in other words, in the Rural Development Plan 2014-2020.

2. Grant the role and responsibility of forest management to municipal and private forest owners, who should never be perceived as enemies of the environment. They have successfully preserved the territory to the present day. Therefore, no more protections or administrative limitations should be imposed, to avoid further discouraging entrepreneurial activity based on bioenergy projects.

3. Increase sustainable biomass-oriented forest management plans for the Valencian forests. Encourage and support the forest management plans to be developed in public-private cooperation under the control of the public administration, allowing the development of local forestry companies as the best system for generating employment in rural areas.

4. Promote decidedly forest-based bioenergy as a substitute for non-renewable fossil fuels, including project-based, comprehensive management and responsible use, efficient processing and consumption of biomass at local or regional scale. This future-oriented value chain has been evaluated by the VFP as a driver for reactivating sustainable forestry, as can be observed in other regions of the Mediterranean, constituting the best practice for active forest fire prevention.

5. Implement Payments for Environmental Services, from Mediterranean forests to society, which currently receive no financial compensation. Biodiversity conservation, carbon sequestration, groundwater recharge and improvement of water cycle quality should be the priority areas. The high value of these services should be reflected in market prices, generating economic flows and activity.

6. Support public and private research, technological development and innovation in all activities of the forest value chain, as well as the knowledge transfer of new technologies, especially for

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the management, harvesting and logistics of solid biofuels as well as thermal and electrical exploitation of forest biomass.

7. Intensify advanced and specialised training in forestry and bioenergy, as well as improving education and forest culture in Valencian society.

The strongly independent VFP, which was created out of a broad social consensus, in a constructive and ambitious spirit, is focused on giving form to a traditionally dispersed sector. In a time when civil society needs drivers and opportunities, forestry presents itself to all strata of Valencian society and to their political decision makers as a promising sector that is finally beginning to function in a cohesive way. The VFP, as a result of the PROFORBIOMED project, lays the foundation for many job and wealth creation opportunities, for current and future generations.

3.5.3.3. Stakeholders involved

Enguera City Council, as a project partner and in order to meet project objectives regarding bioenergy cluster creation, took the initiative of summoning the group responsible for public and private research institutions, agroforestry property and representation of collective professionals, the largest group of technicians in Valencia, to propose a unit of action in favour of bioenergy markets, the orderly and sustainable use of natural resources and the activation of agroforestry areas of the Valencian Community.

As a result of this process, this non-profit association was founded with the aim to activate the bioenergy market in this region.

3.5.3.4. Outputs

By bringing together all sectors, the VFP becomes a participatory space in which to share information and promote research. It also encourages synergies capable of building links in a traditionally dispersed sector, and promotes forest owner recognition as a strategy for boosting development of the sector, thus generating environmental and socio-economic added value, and contributing to improving the living conditions of those living in the country's interior.

3.5.3.5. Added value of transnational cooperation

It can be seen how in a short period of time this cluster managed to bring together a large number of entities, each engaged in different actions but all related to the world of forestry (thus providing coverage of the whole sector) and was able to stage two events at regional level, even having dealings with the General Administration.

Figure 20. On May 31, 2013, a total of 18 groups created the Forest Valencian Platform to conserve and enhance forests

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Figure 21. President of the Autonomous Community of Valencia, Mr. Alberto Fabra, with the members of VFP

Figure 22. Extensive media coverage in Enguera

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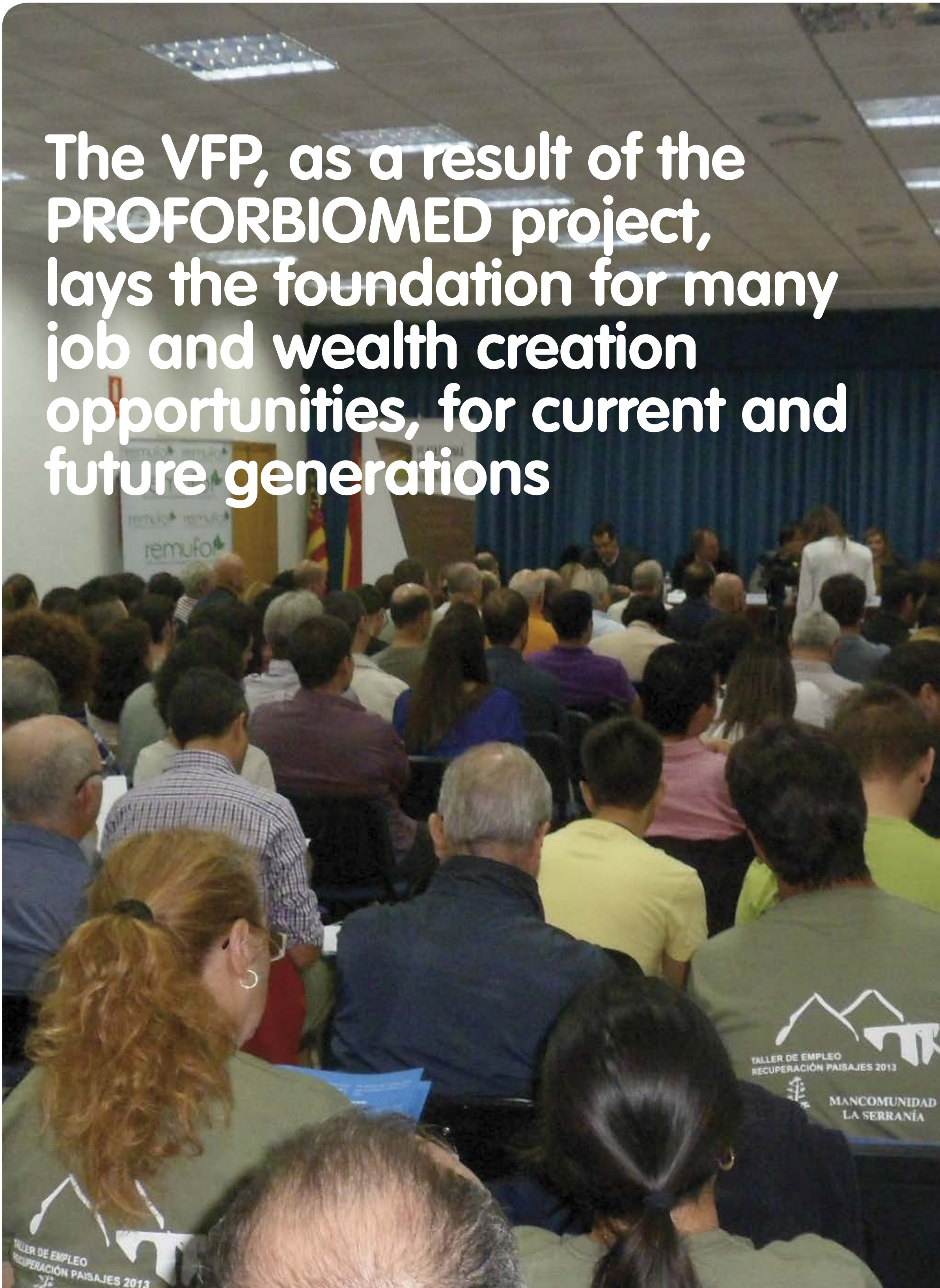
The VFP, as a result of the PROFORBIOMED project, lays the foundation for many job and wealth creation opportunities, for current and future generations



3.6. Institute for Environmental Protection and Research. Italy.

3.6.1. Legal name / Contact details

Name of the Organisation: Istituto Superiore per la Protezione e la Ricerca Ambientale

Acronym: ISPRA

Official address, country and region: Nature Conservation Department (NAT-SOS) .Via V. Brancati, 48 - 00148 Rome, Italy.

Website: *www.isprambiente.gov.it/it*

Legal representative: Dr. Stefano Laporta

Contact person: : Dr. Lorenzo Ciccarese - lorenzo.ciccarese@isprambiente.it

3.6.2. Description of the partner's activities/skills relating to biomass

The Italian National Institute for Environmental Protection and Research (ISPRA) is a national public organisation performing technical, scientific and research activities in: environmental assessments, metrology and controls; monitoring and prevention of atmospheric impacts; desertification, environmental data, information, indicators and reporting; protection of nature, soil, biodiversity, inland, marine and lagoon waters; control of nuclear safety, radiation protection and industrial risk, waste management, environmental education and certification, and coordination of the national system of the environment agencies of the Italian regions and autonomous provinces. The Institute also supports regulatory activities of the Ministry of Environment, Land and Sea at national, European and international level. Within the field of nature conservation, special interest is devoted to the exploitation of biomass as sustainable source of energy. In this regard ISPRA evaluates the potential contribution of various sources of biomass — from forest to agriculture residues and from dedicated plantations to industrial wood residues — to the national energy demand. In particular, activities are aimed at:

- increasing understanding of the greenhouse gas (GHG) outcomes, on a life-cycle basis, of bioenergy and carbon sequestration, especially for bioenergy technologies approaching a break-through, such as second generation biofuels;

- fostering international collaboration and common views of key technical and methodological issues;

- developing, improving, comparing and promoting methodologies for assessing GHG balances of bioenergy and carbon sequestration systems at project, activity and regional levels;

- supporting decision makers in selecting mitigation strategies that optimise GHG benefits, e.g. allocating biomass to energy vs. use as raw material; considering costs and benefits, as well as the practicalities of different mitigation strategies;

- assisting in the development and implementation of climate change policy, through methodological work for GHG accounting in the energy and LULUCF sectors.

3.6.3. Elaboration of a Report on the Impact of Short Rotation Forestry plantations on the Mediterranean Basin environment

Major EU directives, such as the Renewable Energy Directive, the Biofuels and Landfill Directives, along with the EU Emissions Trading Scheme and parts of the Common Agricultural Policy, are important drivers behind the growth of bioenergy, thus contributing to EU energy security and — as bioenergy has a substitution effect on fossil fuels — climate policy targets. In addition, EU member states have introduced a range of incentives, including research programmes, tax reduction and exemptions, investment subsidies and feed-in tariffs for bioenergy production.

Sustainable biomass production and the reliable supply of feedstocks is a critical factor for successful large-scale deployment of bioenergy. Biomass resources are a limiting factor for power-plant size, determining their collection radius and economics.

Short Rotation Forestry (SRF) and Short Rotation Coppice (SRC) systems can play a role as feedstock for bioenergy supply. Many countries in Europe have planned a substantial increase in the area dedicated to SRF and SRC. However, inappropriate and outsized expansion of SRF and SRC stands could negatively impact soil and water resources, biological diversity and future ecological services. In the pilot action described here, ISPRA focused on the potential impacts of bioenergy tree plantations on different features of the environment, including soil and water quality, cultural heritage, landscape, and biodiversity.

3.6.3.1. Description of the action

The action provides some insights into the effects of SRF and SRC on water, biodiversity, cultural heritage and landscape. The scope of this report is to review the potential impacts of Short Rotation Forestry (SRF) and Short Rotation Coppice (SRC) plantations on different features of the environment, including soil and water quality, cultural heritage, landscape and biodiversity. In this respect, SRF is a practice of cultivating fast-growing trees that reach their economically optimum size between few years, from 1 to 15 years, employing intensive cultural techniques such as fertilization, irrigation and weed control, and utilizing genetically superior planting material. Each plant produces a single stem that is harvested at around 15 cm diameter. SRC is an intensive practice of growing multi-stemmed woody material over short rotations, usually of less than five years, depending on plant material, growth conditions and management practices. SRC falls within SRF and it simply represents a specialized form of SRF more specifically oriented to meet energy requirements.

3.6.3.2. Methodology

The report is based mainly on findings taken from scientific and grey literature and from data archives belonging to ISPRA and Italy's Ministry of the Environment and Protection of Land and Sea. Personal communications from practitioners and scientists were also used for the preparation of the report.

3.6.3.3. Stakeholders involved

Public administrators (Regione Lazio), practitioners, researchers, industrialists and private owners were involved in carrying out the study.

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3.6.3.4. Outputs

The main output of the action is a report published by ISPRA, for which the reference is: Impacts of short rotation forestry plantations on environments and landscape in Mediterranean basin. Rapporti 196/14. ISPRA – Istituto Superiore per la Protezione e la Ricerca Ambientale, Roma, 115 p. - ISBN 978-88-448-0618-7.

This report presents the potential impacts that SRF and SRF plantations have on plant and animal biodiversity, soil sustainability, hydrology, landscape and cultural heritage, silvicultural and management operations, pests and pathogens, land use and land-use change. The report can be downloaded at

http://www.isprambiente.gov.it/it/pubblicazioni/rapporti/impacts-of-short-rotation-forestry-plantations-on-environment-and-landscape-in-mediterranean-basin

3.6.3.5. Impacts

The review provides information and advice to stakeholders and land administrators on the effects, both positive and negative, linked to the establishment and management of SRC and SRF stands of different species.

The establishment and management of short rotation forestry (SRF) and short rotation coppice (SRC) plantations pose a number of potential threats and benefits to the environment lato sensu and landscape. This review mentione above provides some insights, mainly based from findings taken from literature, on the effects on water, biodiversity, historical heritage, landscape. Potential threats to water quality mainly arise from soil preparations and harvesting operations. Both stages can be controlled by good practice. The overall quality impact of SRF and SRC is expected—mainly thanks to legislative constraints—to be largely beneficial compared to the alternative land uses currently practised in areas generally considered appropriate for conversion to SRF and SRC. In particular, SRF and SRC are expected to significantly improve water quality compared to arable cropping or other forms of land-use, and while conversion of only limited areas of more intensively farmed land may be appropriate, there are believed to be major opportunities for targeted planting of SRF and SRC to mitigate potential pollutant sources and interrupt delivery pathways to watercourses. Thus thoughtful establishment of SRF and SRC could help to deal with the major diffuse nutrient and sediment pollution pressures associated with agriculture and urban activities. Specifically, the analysis set evidence to a deficit of information on the effects on biodiversity of some of the species used in SRC and SRF and on their impact on soil quality and hydrology.

3.6.3.6. Added value of transnational cooperation

The work carried out under this pilot action, benefiting from the cooperation and the exchange of information and know-how among partners of the consortium, significantly enhanced the practical know-how for the implementation of SRC and SRF plantations in Mediterranean areas. It has also provided a basis for setting up sustainable forest management plans. In particular, for Italy, the results of the pilot action will be beneficial for drawing up and gaining approval of forest management plans according to the guidelines provided by the Environment Act (Decreto Legislativo 03/04/2006 no. 152). The survey lays a foundation for the selection of species likely to be used in different physiographic and climatic conditions, as well as providing information for entrepreneurs and contractors, for adequate planning of SRC and SRF plantations. Finally, the report contributes to the dissemination of environmental and biodiversity concepts linked to the implementation of SRF and SRC plantations. Other benefits are the recognition of gaps in knowledge and priorities for research and development; the identification of appropriate species to decontaminate polluted soils currently not suitable for agriculture; and the classification of appropriate species for building buffer zones to defend natural habitats, such as rivers and lakes, from the impacts of pesticides.

3.6.3.7. Lessons learned

The establishment and management of SRC and SRF plantations in Mediterranean arable cropland and other land-use systems may have both positive and negative effects on environmental features and landscape.

In order to maximise the positive effects and minimise potential negative effects from SRC cultivation, proper site selection and management adjustments are key factors. These factors should be implemented taking into account the research results related to each of the aspects affected by forest bioenergy cultivation.

Unfortunately, as SRF and, even more so, SRC cultivation are relatively new approaches, results of research on the effects on environmental features, cultural heritage and landscape are limited and cover neither a range of diverse environments, nor processes that change over time. On the contrary, they derive from specific field observations carried out in a limited number of plots that are mainly small in size.

The assessment of positive and negative environmental effects is a big challenge that all stakeholders involved in SRF and SRC cultivations must consider. Of course farmers need to be convinced to grow forest energy crops because they provide an economic profit greater than or equal to that of alternative farming crops. As demonstrated by the economic analysis carried out within the PROFORBIOMED project, the profit of such investments is not certain. Thus, decision makers might consider various direct or indirect incentives for farmers, to encourage shifts in land use from conventional farming to forest energy crops, if this would result in environmental benefits. For instance, a potential economic compensation could be a form of “reward” to farmers helping to fulfil set environmental goals (including carbon sequestration), while keeping agricultural land in production.

Some safety measures could be used to reduce negative impacts of SRF and SRC plantations on the environment:

- Avoid expansion of non-native species into natural habitats.
- Avoid the trivialisation of the landscape.
- Be cautious about changes to soil chemistry and water regime caused by the plantations.

The impact of SRF plantations can be positively enhanced by having mixed species/clones and diverse planting arrangements and in this vein, the following points should be considered:

- Plantation diversity: different rotation periods; different tree species; different ages.
- Diversity of structures between stands: balk structures; inner borders; conservation of glades or derelict land areas; special structures, e.g. stone or deadwood piles.
- Diversity of structures along the plantation borders and other areas: hedges, balk structures, solitary trees, special structures.

It is important to remember that SRF and SRC with appropriate species can contribute to water purification and decontamination of polluted soils.

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The reduced cultivation of soil associated with a change of land management from annual crops to SRC or SRF could reduce erosion and increase the organic matter content of soil. It is important, however, to take into consideration that growing SRF crops for biomass may potentially lead to significant soil nutrient depletion and acidification over time. Minimum tillage, in particular, can increase the organic carbon content in soils of SRF crop systems, especially in surface soil layers.

The long-term sustainability of soils in short-rotation biomass production depends on the balance between removal of nutrients by harvesting, and nutrients added by natural or induced fertilisation. Nutrients can leach from the soil or move with eroded soil particles, for which reason it is important to choose flat or low-gradient fields.

SRF may play an increasing role as a source of renewable energy and could be very important for both yield estimates and carbon sequestration. Conversion of agricultural land to SRF has potentially beneficial effects on soil carbon dynamics, with reported gains in soil carbon of up to 20%.

Regarding levels of biodiversity, there is a gradient of useful species which should be used in SRF, with willow at the top, followed by poplar, black locust and ailanthus. The biodiversity of SRF plantations of different species appears to be strongly correlated with the density of the canopy, which influences the light level reaching the ground and hence the abundance of the herbaceous layer, as well as the pace of litter breakdown.

For sustainable SRC practice, cultivation in fields located close to nitrogen sources (animal farms, wastewater treatment plants, etc.) is recommended, to decrease nitrogen outflow to adjacent water bodies.

Impact assessments and ecological evaluations of landscape functions need to carefully consider site-specific conditions (soil type, climatic parameters, etc.) as well as existing environmental goals. Furthermore, the land-use history and the vegetation in the surrounding landscape have considerable influence on species composition in SRC plantations.

3.6.4. Reforestation: grassland to short rotation coppice plantation in Lazio, Italy

3.6.4.1. Description of the action

This action was aimed at improving the possibilities of Short Rotation Coppice (SRC) producing a high quantity of woody biomass in a limited time (usually 2-3 years) through well-designed plantation management. In order to investigate this issue, the SRC methodology was applied in the Lazio Region. In particular, this PROFORBIOMED pilot action focused on converting abandoned cropland territory into a short rotation coppice plantation, using *Robinia pseudoacacia* L., which plays an important role in woody biomass production.

3.6.4.2. Methodology

Short rotation coppice (SRC) involves using a specialised woody crop, planned and managed to produce a relatively high quantity of woody biomass in few years (2-3). SRC plantations naturally aim for maximum biomass production and this varies considerably depending on the tree species and the influence of genetics, soil, climate and management on the survival, competition, and vigour of the stand. Harvestable yields in temperate and Mediterranean regions of Europe range between 17 and 26 m^3 ha^{-1} yr^{-1}, or about 10 and 15 tonnes of dry matter ha^{-1} yr^{-1}. After each harvest the new shoots re-grow from the coppice stools, starting a new rotation cycle. The rotation time varies from two to three years, in order to produce shoots of about 4 cm DBH, the dimension that best suits the machines typically used for harvesting. Rotations shorter than three years lead to reduced yields after several rotations, due to physiological problems including stump ageing and depletion of carbohydrate reserves, and maximum biomass productivity is expected with harvest cycles of three to eleven years.

The species typically used for SRC for biomass energy production in Europe are: *Betula pendula, Betula pubescens, Corylus avellana, Populus ssp., Salix ssp, Rhamnus frangula, Juglans regia,* the exotic *Acer negundo, Ailanthus altissima, Juglans nigra, Eucalyptus camaldulensis, Pawlonia tomentosa, Robinia pseudoacacia* and various clones of *Populus x euramericana.* However, most plantations consist of specific poplar clones.

The CO_2FIX model *(http://edepot.wur.nl/43524)* was used to assess carbon sequestration. The CO_2FIX model is a stand-level simulation tool for estimating the carbon sequestration potential of forest management, agroforestry and afforestation projects. It is a multi-ecosystem-level model on carbon accounting of forest stands, including forest biomass, soils and products. The model calculates the carbon balance with a time-step of one year. Basic input is current annual increment of stem volume and corresponding allocation patterns to the other tree pools: foliage, branches and roots. Carbon stocks in living biomass are calculated as the balance between growth (accumulation) on the one hand and turn-over, mortality, harvest and decomposition on the other. The model is divided into six major modules: biomass, soil (litter and humus), wood products, bioenergy, and both financial (which is not considered here) and carbon accounting. Figure 23 illustrates the modular structure of the model.

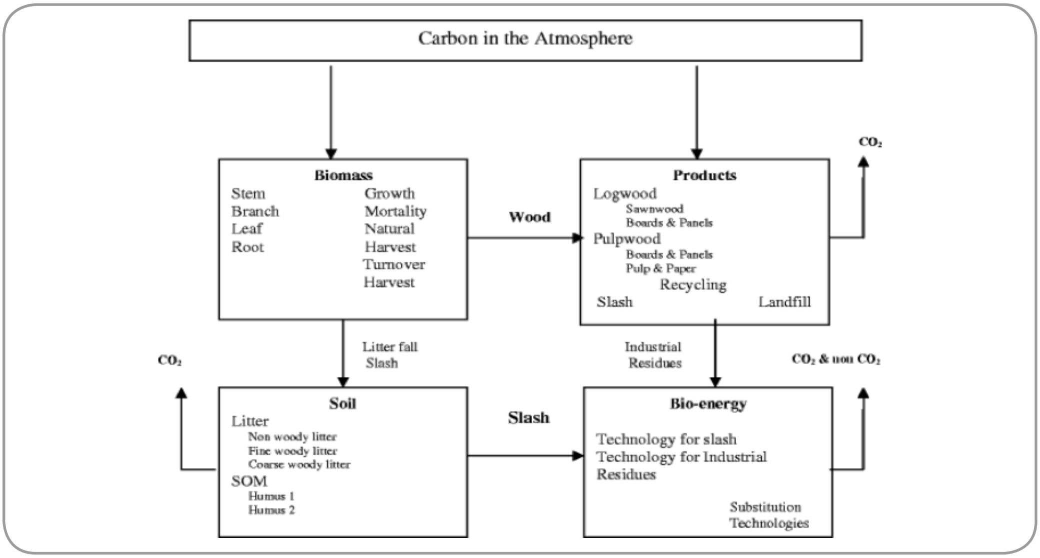

Figure 23. Structure of CO_2FIX V3 model, including major compartments used in each module, processes affecting the pools (right-hand side in the boxes), major flows between modules and CO_2 flows from modules to the atmosphere

For the soil carbon module, the litter is grouped as non-woody litter (foliage and fine roots), fine woody litter (branches and coarse roots) and coarse woody litter (stems and stumps). Litter is produced in the biomass module through biomass turnover, natural mortality (mortality due to senescence and competition), mortality due to logging and harvesting of trees, and logging slashes. Litter remaining from thinning and final harvest is distributed between the decomposition compartments of extractives, cellulose and lignin-like compounds according to chemical composition. The principle of the product module is that it tracks the carbon from harvesting to final decay. The harvested wood is allocated to different product groups depending upon the type of use of tree species, and taking into account the use of processing losses to other product groups.

Products are assumed to decay at a certain fraction per year depending upon the life-span estimates. Carbon is released to the atmosphere through combustion, as — in the case study presented in this report — products are used for fuel-wood. The product not used for bioenergy is allocated as slash (Table no. 23).

The model was parameterised for the simulations using published data on growth rate and biomass amounts (Table no. 24). The carbon content of dry matter was calculated assuming that the carbon fraction in live biomass is 50%. Wood density for the species considered was 0.58 Mg m-3. The litter production rate for the separate biomass compartments was derived by multiplying the biomass stock with corresponding turnover coefficients (per year).

The soil module of the CO FIX model uses climate data about precipitation, evapotranspiration and mean monthly temperatures.

	Logwood	Pulpwood	Slash
Robinia pseudoacacia L.			
Stem-harvesting	0.97	0	0.03
Branch	0.97	0	0.03
Foliage	0.00	0	1.00

Table no. 23 Product allocation for each harvesting cycle

Parameter								Value							
Basic wood density, (Mg m-3)								0.58							
Turn-over rates (1/yr)								0.97							
Foliage								0.95							
Branches								0.10							
Roots								0.04							
Ratio of dry weight increase relative to dry weight increase of stem (dimensionless)															
Stand age (years)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Foliage	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Branch	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Root	0.3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Fraction removed during thinning or harvest															
Age (years)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	0	0	0	0	0.97	0	0	0	0.97	0	0	0	0.97	0	0

Table no. 24 Summary of parameters used in simulating carbon dynamics in a SRF plantation of *Robinia pseudoacacia L.*

In order to estimate the carbon sequestration potential of a SRF plantation, this study considers a black locust (*Robinia pseudoacacia L.*) SRF plantation on abandoned cropland in central Italy, on a site approximately 50 km from the Tyrrhenian Sea coast, at 550 metres above sea level. The soil is of volcanic origin. The climate is Meso-Mediterranean with higher temperatures in July-August and low rainfall in summer (Figure 24).

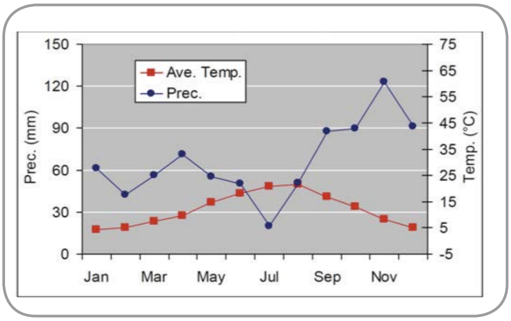

Figure 24. Graph of temperature and rainfall at the black locust plantation site

The plantation lasts 15 years and is harvested every three years. After five rotation cycles, the trees are removed and the soil re-generated. The planting density is 9,260 seedlings ha^{-1}, where distance between plants on the same row is 0.6 m and the distance between rows is 1.8 m. In this study we assume that the average yield of black locust SRF on first harvest is 10 cubic metres per hectare per year (m^3 ha^{-1} yr^{-1}), or 5.9 oven dry tonnes per hectare per year (odt ha^{-1} yr^{-1}) for the first three years after planting. After the first harvest, average yield increases to 20 m^3 ha^{-1} yr^{-1}, or 11.8 odt ha^{-1} yr^{-1}, for the next three rotation cycles and decreases to an average of 16.7 m^3 ha^{-1} yr^{-1}, or 9.7 odt ha^{-1} yr^{-1}, for the last cycle, before the plantation is removed (Figure 25). At each harvest we assume that whole foliage remains on site as litter and dead wood (Table no. 25). Roots do not die and enter the dead wood and litter pools. The main cultivation operations required for black locust SRF plantations are shown in Table no. 25 below.

Practices and operations per year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Planting operatWions																
Tillage	X															
Harrowing		X														
Transport and distribution of fertilisers (P, K)		X														
Planting out	X															
Cultivation practices																
Pest and disease control																
Mechanical weed control between rows		X			X			X			X			X		
Chemical weed control between rows		X			X			X			X			X		
Fertilisation (N)		X														
Irrigation		X														
Harvesting and transport				X			X			X			X			X
Soil re-generation (removal of SRF)																X

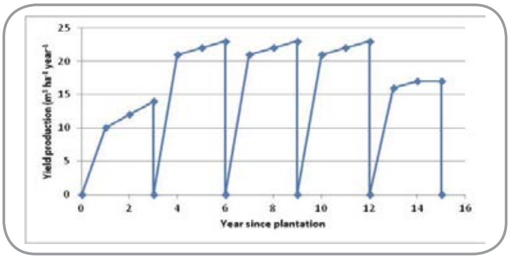

Figure 25. Changes in annual SRF crop yield (m^3 ha^{-1}) over five rotation cycles

3.6.4.3. Stakeholders involved

This case study was carried out in collaboration with both public and private institutions. In particular the Regione Lazio, as well as researchers, industrialists and other individuals, made important contributions to the achievement of the goal.

3.6.4.4. Outputs

Here we present the results from a case study of land-based activity relevant to the scope of this PROFORBIOMED pilot action: the establishment of a short rotation forestry plantation on former abandoned cropland using *Robinia pseudoacacia L.*.

The changes in carbon stocks in soil, litter and living biomass (roots, stems, branches and foliage) in a SRF plantation of *Robinia pseudoacacia* L. with a rotation span of 15 years, harvested every three years, is shown in Figure 26. The soil carbon pool, based on the Yasso model, highlights an increase in stock from 3.5 Mg C ha^{-1} in the initial year to 5.19 Mg C ha^{-1} by the end of the rotation cycle and before the final harvest; this is most likely due mainly to an accumulation of litter and dead wood on the ground. The stock in living biomass increased from 0.01 Mg C ha^{-1} to 15.08 Mg C ha^{-1} at year 15 (Table 4). Over the same period, the amount of carbon in the litter layer increased from 1.05 to 4.57 Mg C ha^{-1} after the last harvest.

The total amount of carbon accumulated before the last harvest is the sum of 12.53 Mg C ha^{-1} (living biomass) plus 1.32 Mg C ha^{-1} (litter layer) plus 13.67 Mg C ha^{-1} (harvested products).

For the same period, the carbon stock reached 25.99 Mg C ha^{-1} (10.42 Mg C ha^{-1} for the ecosystem carbon stock plus 15.57 Mg C ha^{-1} for the products).

At the end of the rotation cycle, bioenergy mitigation was estimated at 26 Mg C ha^{-1} (Figure 27). Total carbon sequestration was calculated at 52 Mg C ha^{-1} (10.42 Mg C ha^{-1} for ecosystem carbon stock, plus 15.57 Mg C ha^{-1} for the products (3rdharvest), plus 26.01 Mg C ha^{-1} from the bioenergy contribution to mitigation). At the final harvest the estimated balance for the atmosphere was -21.43 Mg C ha^{-1}.

Detailed data about biomass carbon partitioned between above- and below-ground pools are shown in 0

Finally, Table 28 displays the total carbon accumulated at the end of the rotation period (15 years), using the Tier 3 IPCCC Carbon Accounting Method, in the black locust stand for fuel-wood production.

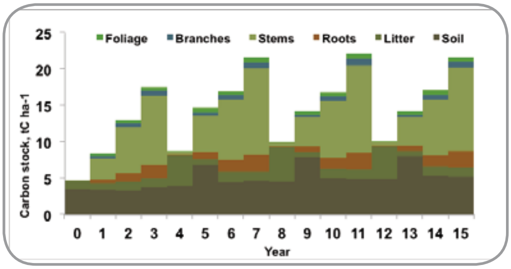

Figure 26. Changes in stand-based carbon stocks in a black locust SRC plantation

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Figure1.	Ecosystem pool			Total	Products	Bioenergy	Total	Atmosphere
	Biomass	Litter	Soil	ecosystem		mitigation		
Year	[Mg C ha⁻¹]							
0	0.01	1.05	3.5	4.56	0	0	4.56	0
1	4.18	0.82	3.43	8.43	0	0	8.43	-3.87
2	8.53	1.23	3.25	13.01	0	0	13.01	-8.44
3	12.53	1.32	3.67	17.52	0	0	17.52	-12.95
4	0.51	4.2	3.94	8.65	13.67	0	22.32	-17.74
5	7.14	0.77	6.79	14.7	0	7.86	22.56	-10.14
6	11.06	1.47	4.41	16.94	0	7.86	24.80	-12.37
7	15.69	1.29	4.58	21.56	0	7.86	29.42	-16.98
8	0.62	4.82	4.48	9.92	16.6	7.86	34.38	-21.97
9	5.58	0.77	7.86	14.21	0	17.39	31.60	-9.64
10	10.55	1.27	5.02	16.84	0	17.39	34.23	-12.28
11	15.88	1.37	4.86	22.11	0	17.39	39.50	-17.54
12	0.56	4.5	4.94	10	15.01	17.39	42.40	-20.44
13	5.52	0.74	7.96	14.22	0	26.01	40.23	-9.67
14	10.5	1.25	5.3	17.05	0	26.01	43.06	-12.49
15	15.08	1.34	5.19	21.61	0	26.01	47.62	-17.04
16	0.58	4.57	5.27	10.42	15.57	26.01	52.00	-21.43

Table no. 26 SRF plantation of *Robina pseudoacacia* L., from planting out (year 0) to planting removal (Year 16): carbon in ecosystem pools, bioenergy mitigation and removal from the atmosphere

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Year	Stems	Foliage	Branches	Roots	Total
[Mg C ha-1]					
0	0.01	0	0	0	0.01
1	2.91	0.46	0.23	0.58	4.18
2	6.26	0.56	0.48	1.23	8.53
3	9.48	0.54	0.69	1.82	12.53
4	0.39	0.02	0.03	0.07	0.51
5	5.01	0.74	0.39	1	7.14
6	8.27	0.56	0.62	1.61	11.06
7	11.94	0.62	0.85	2.28	15.69
8	0.48	0.02	0.03	0.09	0.62
9	3.94	0.55	0.31	0.78	5.58
10	7.8	0.65	0.58	1.52	10.55
11	12.01	0.71	0.86	2.3	15.88
12	0.44	0.01	0.03	0.08	0.56
13	3.9	0.55	0.3	0.77	5.52
14	7.76	0.65	0.58	1.51	10.5
15	11.45	0.62	0.82	2.19	15.08
16	0.45	0.02	0.03	0.08	0.58

Table no. 27 Biomass carbon in above- and below-ground pools in a SRF plantation of *Robina pseudoacacia* L., from planting out (year 0) to planting removal (Year 16)

Pool	t C ha^{-1}
Deadwood	0.99
Aboveground biomass, t C ha^{-1}	17.50 (stems: 14.31; branches: 1.02; foliage: 2.17)
Belowground biomass, t C ha^{-1}	5.47
Litter, t C ha^{-1}	3.20
Soil, t C ha^{-1}	12.05
Total, t C ha^{-1}	23.70

Table no. 28 New SRF *Robinia pseudoacacia* L. stand for fuel-wood: cumulative carbon at the end of the rotation period (15 years), using the Tier 3 IPCCC Carbon Accounting Method

The results of this research may contribute to describing and deepening the role that SRF energy plantations may have on reducing GHG emissions, to illustrating the concept that bioenergy is carbon-neutral and to highlighting existing methodologies for estimating GHG emissions linked to bioenergy systems and in particular, to the establishment and management of SRF plantations.

3.6.4.5. Impacts

The outcomes of this study may contribute to describing a variety of concepts, including the role that the that woody energy plantations may have on reducing GHG emissions and to highlighting existing methods for estimating GHG emissions linked to bioenergy systems and in particular, to the establishment and management of SRF plantations.

3.6.4.6. Added value of transnational cooperation

This pilot study, carried out under the PROFORBIOMED project, has benefited from important synergies among cooperating partners of the consortium, resulting in a large amount of information and know-how exchanged and additionally, consisting in practical experiences focused on the implementation of SRC and SRF plantations in the Mediterranean area. This context has given rise to significant support for the development of sustainable forest management plans and policies devoted to the abatement of GHG.

Another important goal achieved has been the dissemination of environmental and biodiversity-related concepts linked to the implementation of SRF and SRC plantations.

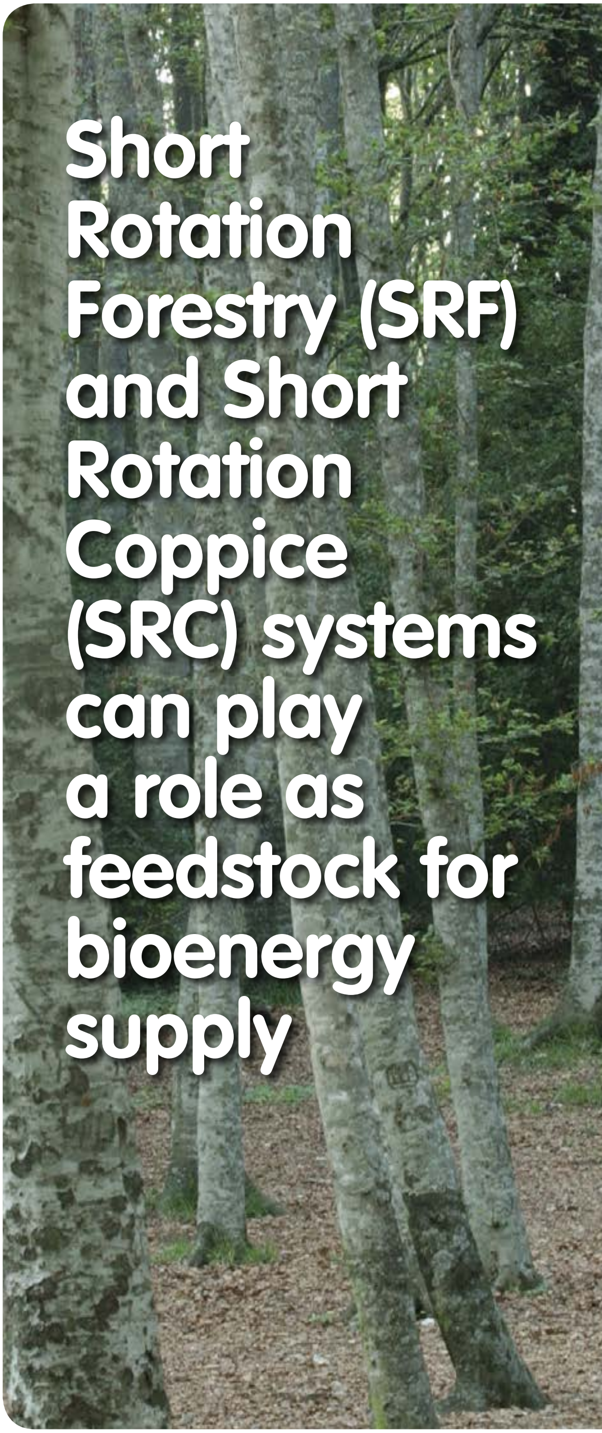
3.6.4.7. Conclusions and lessons learned

Forests are particularly important as carbon reservoirs because trees store much more carbon per unit area than other types of vegetation and they cover about 4 billion hectares, or 30 percent of the world's land area.

The methodology used here is taken from the IPCC Guidelines (*www.ipcc.ch*), which adopt a tiered approach: the lowest tier (Tier 1) uses a simplified methodology and default parameters for estimates; the middle tier (Tier 2) uses in general the same methodology but with national or regional data informing the estimates; and the highest tier (Tier 3) makes use of complicated carbon flow models that are parameterised with site-specific information. The present example used the Tier 3 method.

Estimates based on the direct extrapolation of yields from small experimental plots can also over-estimate the real productivity of the area. The yield levels derived from small-plot experiments could be up to 4–7 times higher than average yields from commercial plantations. It has to be emphasized that these estimates do not provide regional-scale figures, because productivity can vary broadly between different Mediterranean countries and different areas of the same country, depending on many bioclimatic factors, including temperature, elevation, precipitation, soil fertility, and frequency and intensity of biotic and abiotic disturbances.

This case study produced interesting results about the use of SRC and its high potential in fast-growth woody biomass production, thus providing concrete support for stakeholders making decisions related to sustainable forest management and environmental GHG control policies.



3.7. Lombardy Foundation for the Environment. Italy.

3.7.1. Legal name / Contact details

Name of the Organisation:
Fondazione Lombardia per l'Ambiente

Acronym: FLA

Official address, country and region: Largo 10 Luglio 1976, 1 20822 Seveso, Italy

Website: *www.flanet.org*

Legal representative:
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Contact person: : Mita Lapi; Telephone: +39 0280616112; Fax: +39 0280616180; E-mail: mita.lapi@flanet.org; Eleonora Fontanarosa; Telephone : +39 0280616113; Fax: +39 0280616180 ; E-mail: eleonora.fontanarosa@flanet.org

3.7.2. Description of the partner's activities/skills relating to biomass

FLA is a "non-profit scientific foundation", established by the Lombardy Regional Administration, aimed at promoting scientific research, training and public information on the most relevant environmental issues. Besides developing its own projects, education and dissemination activities, FLA is deeply committed to supporting local policymakers and institutional bodies in the definition, assessment and monitoring of environmental programmes and policies. To this end, FLA is working within a wide-ranging network of leading universities, scientific bodies and professional experts, at regional, national and European level. The projects' results are shared with national and local institutional and private stakeholders in order to strengthen environmental governance and raise more responsible awareness among the social and economic actors and the general public. One of FLA's main fields of activity is renewable energy sources, with a particular focus on biomass-derived fuels. The Foundation developed and coordinated the "Kyoto-Lombardy project", an integrated multidisciplinary research project aimed at assessing climatic trends, climate change impacts and GHG emissions at regional level as well as the related adaptation and mitigation strategies. Within this project, a specific study was assigned to the technological feasibility and economic evaluation of energy exploitation and plans based on the use of biomass in the Lombardy region, also assessing their environmental costs and benefits. FLA is presently also working on the ALPSTAR project (ALPINE SPACE programme) aimed at assessing and supporting good practices, local policies and energy strategies with a view to full carbon neutrality of the Alpine region by 2050. In the framework of this project, FLA is developing a pilot action in the Province of Sopndrio (Valtellina Valley) with the main objective of assessing in detail the current state of existing systems and plants from an energy, environmental and economic point of view. In particular FLA has focused its attention on the maximum attainable exploitation of the potential of the various biomass energy sources (forest wood, agricultural residues, biogas, organic waste, energy crops) throughout the whole province, in terms of their availability, environmental sustainability and economic competitiveness under different social, economic and technological scenarios.

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3.7.3. Development of a forest biomass traceability system

3.7.3.1. Description of the action

The FLA has led Pilot Action 1.5. "Development of a system of traceability of the forest biomass" (Work Package 4 -"Setting up of integrated strategies for the development of renewable energies"-). Pilot Action 1.5 aims to develop and test a new protocol establishing the principles and technical requirements for the traceability of forestry biomass along the entire supply chain, i.e. from the supply of raw materials to the final delivery point. By promoting traceability, the system intends to contribute to the promotion of responsible use of forest resources for energy purposes. For the purposes of the protocol, a forestry biomass supply chain consists of the following four main stages:

- Source of forest biomass, classified according to structure of origin and sources as defined by EN 14961-1.
- Biomass processing (chipping, milling, cutting, production of pellets).
- Intermediate transport and/or storage of the forestry biomass.
- Delivery point (e.g. thermal power plant).

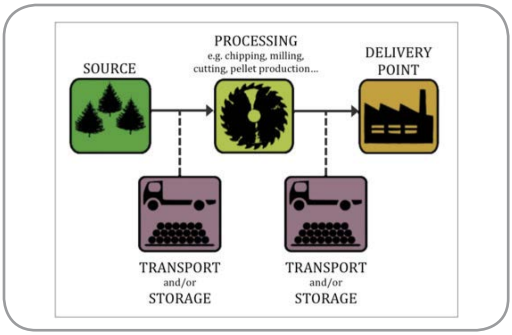

Figure 27. Simplified diagram of the biomass supply chain

The supply chain includes all involved parties (i.e. organisations), material flows and any services that may contribute to the production, storage and transport of forestry biomass.

3.7.3.2. Methodology

The general common methodology was developed by FLA with the support of its technical experts: ETIFOR and S.G.S. and has been discussed with the project partners involved in the pilot action. Once the methodology was agreed upon, background documents were collected and analysed, in order to build up a robust background for drafting the protocol. Background documents included:

- Normative references (e.g. Directive 2009/28/EC and Regulation (EU) 995/2010).
- Technical norms and standards (e.g. EN 14961-1:2010 and FSC-STD-40-004).
- Best practices from other experiences/ projects at European level.

Three different drafts of the protocol were then developed and distributed to project partners for discussion and comments. After each round, the protocol was revised and improved by including suggested comments and inputs. The consultation phase took place by means of both e-mail rounds and Skype meetings. This phase took about seven months, from December 2012 (1st draft) to September 2013 (6th draft). The protocol was tested in the field, by involving forest companies in Italy (Sicily), Slovenia and Spain (Catalonia). Results from field tests and additional comments from different stakeholders were then collected and used as inputs for a final wrap-up session to finalise the protocol.

The Protocol builds on existing experiences and initiatives in the biomass sector and aims to come into line with existing best practices, as far as possible. Particular reference is made to the following documents developed within Biomass Trade Centre 2 project *(http://www.biomasstradecentre2.eu/Biomass-Trade-CentreII/):*

- Quality assurance and quality control (QA/QC) system/procedures.
- Guidelines for sustainability assessment of short energy-wood supply chains.

3.7.3.3. Structure

The protocol is structured into three main sections:

- **Introduction**, which provides general information about the nature, aims, scope and structure of the document as well as key terms and definitions.
- **Part 1** - Requirements for organisations operating in the forestry biomass supply chain. Requirements include: 1. traceability requirements; and 2. additional requirements.
- **Part 2** - Auditing requirements and procedures, which includes rules to be followed by independent bodies in charge of monitoring implementation of the present protocol.

The document is then complemented by five Annexes: Annex 1 – Structure of wood biomass origin and sources according to EN 14961-1; Annex 2 – Summary of requirements for social/environmental sustainability; Annex 3 – Moisture estimation; Annex 4 – Tracking system; Annex 5 – Audit check-list (informative).

The protocol includes the following sets of requirements:

- Quality system requirements: these include typical system requirements, such as the existence and implementation of procedures, definition of roles and responsibilities within the organisation, and training and record-keeping.
- Technical requirements for traceability: these ensure traceability along the supply chain, with special reference to identification on receipt and delivery.
- Additional requirements: these include additional requirements defined according to different stages along the supply chain. In particular, additional requirements for biomass sources involve compliance with requirements defined by Regulation (EU) 995/2010. Additional requirements have also been envisaged for the storage and transport phases, when particular attention shall be paid to risks due to possible disease transmission, pests and fires during storage and biomass contamination during transport. Finally, further requirements have been defined for the delivery point, which should act as a repository for copies of all documents and information that are relevant for traceability along the entire supply chain and allow the monitoring of biomass flows.

Specific requirements for performing audits include: training and qualification needs for auditors, sampling guidelines, instructions on the definition of instances of non-compliance, and references for reporting.

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3.7.3.4. Stakeholders involved

The traceability protocol was tested in different pilot areas. The experience developed in the Sicani mountain range (Sicily region) is especially significant from the point of view of the involvement of local stakeholders. A demonstration event entitled **"Workshop for the start-up of the on-site activities"** was held in this pilot area of the Sicani mountains on 9th September 2013.

The main objective of this workshop was to explain to local stakeholders (technicians, forest enterprises and forest owners, public authorities, etc.) the specific methodology, and the tool developed by PROFORBIOMED to facilitate the traceability of the biomass and also to make stakeholders aware of the importance of ensuring high quality biomass through an efficient system and sustainable management procedures.

During the first part of the demonstration day, the protocol for traceability of wood biomass for energy was illustrated to the local stakeholders, together with the main results obtained. During the second part of the demonstration day, specific sustainable forest management interventions and modern technologies for wood biomass extraction using innovative working systems with low environmental impact were shown to the local stakeholders.

3.7.3.5. Outputs

The main output is the definition of a practical, useful methodology able to guarantee that the principles and technical requirements for the traceability of forestry biomass will be respected along the entire supply chain. The protocol defines procedures, working instructions and record-keeping measures to ensure traceability and identification of single biomass batches throughout the entire chain. The supply chain includes all the parties (i.e. organisations), material flows and services that contribute to the production, storage and transport of forestry biomass. By promoting traceability, the protocol aims to contribute to the promotion of responsible use of forest resources for energy purposes.

Implementation of the protocol will guarantee product quality to biomass consumers and users, as well as guaranteeing that good biomass management procedures have been respected throughout the biomass production chain. The document provides a common framework of requirements/rules and best practices that may be implemented by enterprises under the control of specific bodies that may vary depending on the particular case or region. The decision to avoid compulsory audits and certification derives arose from the need to take into consideration the characteristics and limiting factors (human, financial and technical resources) that may affect small and medium-sized enterprises (SMEs) as defined by EU Recommendation 2003/361. The final "Certificate of Inspection", produced by the audited organisation as evidence of compliance with the requirements laid down by the protocol, could be an important tool for companies to advertise and promote their business.

3.7.3.6 Impacts

While forest biomass could represent a valuable resource for promoting renewable energies and encouraging rural development, it might also raise some concerns with regard to the integrity of forest ecosystems and other associated production chain issues. In order to support appropriate, sound development of the biomass sector in Mediterranean Europe, good practices and appropriate guidance are needed. Many projects and initiatives have so far addressed the issue of biomass sustainability and traceability; coordination is now needed in order to provide clear guidelines to operators and robust evidence to consumers and markets.

A good traceability system, as proposed by ProforbioMed, could produce positive impacts, such as:

- Guarantee **the traceability of biomass** and solid biofuels throughout the entire supply chain.
- Give assurance to all stakeholders (suppliers, clients, consumers, etc.) on **the quality of biomass** and solid biofuels at every stage of the supply chain, by verifying quality, quantity and sustainability parameters (specific requirements for social/environmental sustainability have been defined).
- Promote and improve **transparency and legality** in the actions related to the management and production of biomass.
- **Provide instructions and information for local stakeholders** operating and trading in the bioenergy sector about the correct procedure for executing the quality, traceability and certification control system.

To respect the 14 "General principles to be applied in sustainable mobilisation of wood" (Good practice guidance on the sustainable mobilisation of wood in Europe, European Commission Agriculture and Rural Development, March 2010) and to improve the development of "short bioenergy supply chains", further development is needed to set up criteria and requirements defining the core aspects of good and appropriate management and production of biomass resources. The traceability protocol has been produced by PROFORBIOMED partners within this context and with these goals in mind.

3.7.3.7. Added value of transnational cooperation

Biomass traceability, as well as quality and control, can provide a robust background for improving the forest and energy sectors in Mediterranean countries, in terms of both sustainability performance and competitiveness. A great deal of attention has been paid in recent years to biomass quality requirements and a variety of projects have been developed on this issue. The cooperation between the PROFORBIOMED partners facilitated the building of stronger management capacity in this area and gave added value to the various studies and experiences that were implemented.

The Biomass Trade Centre 2 Project, *www.biomasstradecentre2.eu* led by the Slovenian Forestry Institute, (SFI) developed two specific tools that have been integrated into the PROFORBIOMED traceability protocol:

- **Quality control and quality assurance (QA/QC) system** that will help to guarantee the quality of solid biofuel throughout the whole supply chain,
- **Guidelines for sustainability assessment** of short energy-wood supply chains, that define a set of principles, criteria and requirements to promote and measure sustainability of the energy-wood supply chain, according to economic, environmental and social aspects.

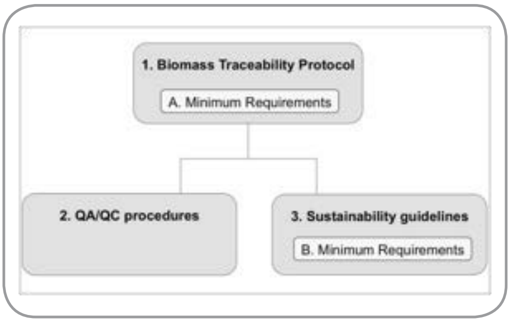

Figure 28. Traceability Protocol and links with existing initiatives

The Forest Technology Centre of Catalonia (CTFC) developed a new quality label for woodchips, DBOSQ *(http://afib.ctfc.cat/dbosq)*. It works to ensure quality and traceability of forest biomass, two fundamental aspects in order to build confidence in the product. The involvement of the CTFC in PROFORBIOMED and their cooperation in the traceability protocol pilot action provided a fundamental technical contribution to the development of the protocol, in particular their production of the "Guidelines for cost-effective moisture estimation".

The Business and Environmental Science Research Centre (CICAE), thanks to its experience and knowledge on the impact of biomass operations and harvesting on biodiversity and soils, produced specific "Guidelines to preserve biodiversity and soils".

The Sicily Regional Department of the Public Forests Agency (DRAFD) contributed by allowing the protocol to be tested in the field, in the pilot area of the Sicani Mountains, and by promoting and disseminating it to local stakeholders.

In conclusion, the transnational cooperation set up on this matter has allowed the different experiences and knowledge of the various participants involved in the pilot action to be shared and integrated. This, in turn, has made it possible to pool knowledge, optimise experiences, and exchange information to produce a more comprehensive instrument that is applicable at transnational level.

3.7.3.8. Conclusions and lessons learned

Biomass energy is expected to play a major role in the substitution of fossil fuels by renewable energy sources over the coming decades. With the EU Renewable Energy Directive (Directive 2009/28/EC) in place, there is a strong push towards sustainable use of solid biomass from

forests. Wood and wood waste in particular constitute the most important renewable energy source within the European Union, representing 47% of gross consumption of renewable energy and 67% of bioenergy use (Eurostat, 2011).

While the development of the forest biomass sector offers good opportunities for the mobilisation of wood products from Mediterranean forests, thus potentially contributing to active and more effective forest management, rural development and its related green economy run the risk of being insufficiently competitive compared to the traditional forest industry and of facing further challenges in terms of their environmental sustainability. The sustainability of the use of solid biomass is a key topic for the technical and policy agenda at both national and European level. The ongoing development of a 'Proposal for a Directive of the European Parliament and of the Council on sustainability criteria for solid and gaseous biomass used in electricity and/or heating and cooling and bio-methane injected into the natural gas network', together with other emerging issues, call for further attention to this issue and for joint, coordinated efforts by all the economic, social and institutional actors operating within the solid biomass arena. A technically sound and operationally reliable traceability system, as proposed by PROFORBIOMED, may provide valuable support for the development of sustainable bioenergy supply chains.

3.7.4. Biomass for Energy Pact

3.7.4.1. Description of the action

Biomass energy is expected to play a major role in the substitution of fossil fuels by renewable energy sources over the coming decades. With the EU Renewable Energy Directive (Directive 2009/28/EC) in place, there is a strong push towards sustainable use of solid biomass from forests. Wood and wood waste in particular constitute the most important renewable energy source within the European Union, representing 47% of gross consumption of renewable energy

The "Biomass for Energy Pact" is an international voluntary agreement developed within the framework of the project by all the partners, with the following main aims:

- To establish a permanent network of stakeholders (local authorities, enterprises, non-profit organisations, research institutions, etc.), aimed at stimulating and orienting the energy policies of the European Union on the basis of the real needs of local communities.

- To activate Technical Working Groups on specific issues, as a pro-active link between EU Institutions and local stakeholders.

- To promote **a**wareness and communication activities on the topics of bioenergy and energy efficiency.

- To maintain a permanent, strong network between the PROFORBIOMED partners for the implementation of future actions.

The Pact aims to be an example of agreement based on a bottom-up approach, capable of involving all the PROFORBIOMED partners and different local stakeholders interested in bioenergy topics, with the purpose of strengthening and disseminating the strategic theme of the production of energy from biomass.

The agreement aims to promote and to reinforce the EC objectives related to bioenergy development. In particular, it incorporates the key concepts defined in the "Europe 2020 Growth Strategy" and the "Roadmap on the EU's energy system until towards 2050". The agreement could be an innovative preliminary document to a more binding resolution (Energy Pact) that moves all the EU countries towards the realisation of the Energy Strategy for Europe.

3.7.4.2. Structure

The structure of the document has been shaped according to other international agreements. The structure of the Pact is made up of:

- Preamble: This includes the key points of EU policies (to ensure energy supply and security in Europe, to implement strategic common policies; to promote innovative technologies).
- Background: This includes a general description of the energy situation in Europe (deficiencies and targets); the basic information having been taken from the Energy and environment report 2008 (EEA).
- Objectives: These include some strategic goals related to the production and use of biomass as a strategic renewable energy source.
- Actions: These include some actions to be implemented in a coordinated way, to achieve shared objectives.
- Conclusions: These are focused on the effort to create a permanent network for promoting the launch of several initiatives aimed at supporting the use of biomass as a strategic resource.

3.7.4.3. Stakeholders involved

The main targets for the Pact are the local stakeholders involved in bioenergy topics (local authorities, enterprises and consortia, forest owners, non-profit organisations, research institutions, etc.). The Pact intends to be useful and effective tool for these local stakeholders and is expected to produce concrete effects in the MED territories.

A significant effort has been made by the project partners to involve local stakeholders in different countries. A "Letter of Support" has been drawn up, to be signed by the stakeholders that declare their agreement with the contents of the Pact. To date, 26 local stakeholders from the six MED countries (Italy, Spain, Greece, Slovenia, Portugal and France) have already signed the Pact.

The PROFORBIOMED partners have also prepared a special regulation that defines the procedure by which the signatories of the "Letter of Support", can activate specific Working Groups on specific issues (to be defined from time to time) to produce documents addressed to the EU/international institutions. This has been designed to be a valuable tool available to local stakeholders for better communication and dialogue with EU and international institutions.

In order to ensure a greater impact on the EU institutions, it is important to make sure that the "Biomass for Energy Pact" be well known among the local communities. The "Biomass for Energy Pact" should have wide participation at local level and the "Letter of Support" ought to be signed by a large number of local stakeholders. It is also crucial to explain to local stakeholders the advantages of subscribing to the Pact and the opportunity provided by the activation of specific Working Groups, to trigger a growing set of activities and attract new local organisations in supporting and sharing the Pact's objectives.

3.7.4.4. Outputs

This action, defined within the framework of the capitalisation actions, is aimed in the first instance, at maintaining and preserving a permanent relationship between the PROFORBIOMED partners, with the final goal of implementing future actions to improve the use of bioenergy. The main outputs linked with this action are:

- Definition of an international agreement named “Biomass for Energy Pact” to be signed by all the PROFORBIOMED partners.
- Establishment of a permanent network of stakeholders focused on stimulating and orienting the energy policies of the European Union on the basis of the real needs of local communities.
- Signing of the “Letter of Support” by 26 local stakeholders from different countries.
- Definition of a Working Group Regulation, a new tool able to put local stakeholders in contact with International/EU Institutions.
- Activation of technical Working Groups on specific issues as a pro-active link between EU Institutions and local stakeholders.
- Creation of a permanent “Steering Committee” formed by PROFORBIOMED partners to supervise the activities developed under the “Biomass for Energy Pact”.
- Promotion of awareness and communication on the topics of bioenergy and energy efficiency.

3.7.4.5. Impacts

PROFORBIOMED participants pay special attention to the **management and use of biomass as a strategic resource** for producing renewable energy. The actions provided in the agreement aim to produce strong impacts at local level, such as:

- To raise awareness and strengthen debate on the environmental priority of energy resources and their management.
- To limit the impact of heating and cooling systems, by suitable improvements in efficiency and reduction of energy consumption.
- To ensure better energy governance in Europe at different levels, with respect to energy management, mitigation and adaptation to climate change, with a special focus on forest management and forest biomass use for energy.
- To improve collaboration and knowledge transfer between stakeholders in order to facilitate the creation of clusters or other collaborative structures and activate investments in the field of biomass energy production.
- To promote development of new energy use policies and regulatory systems at regional, national and EU level and to obtain European and national support for the promotion of platforms, installations, facilities, etc.

3.7.4.6. Added value of transnational cooperation

The assessment of experiences carried out by organisations from different countries participating in PROFORBIOMED aims to open a permanent discussion channel on sustainable biomass energy use and production. This channel will help to achieve energy policy objectives that are able to harmonise the conflicting targets of ecological, economic and ethical sustainability.

The establishment of a permanent network that will focus on the strategic theme of production and use of energy from biomass, developed within the PROFORBIOMED project, will act as a tool to promote the launch of several initiatives, such as research and cooperation projects, technical documents, joint conferences, and networks of scientists and policy makers.

3.7.4.7 Conclusions and lessons learned

It is considered extremely important to develop initiatives, agreements, pacts, etc. capable of enhancing cooperation and actions towards common and shared objectives. It is also equally relevant to ensure that the actions provided in the documents have real impacts and produce real benefits at local level.

This is the ultimate objective of the "Biomass for Energy Pact", an international voluntary agreement intended to produce concrete and positive effects for local stakeholders.

The Working Group Regulation, defined in the framework of the Pact, aims at becoming an effective tool available to all the local actors that signed the "Biomass for Energy Pact", to communicate their needs, problems, strategies and interests to International/EU institutions.

The Pact is intended as a tool for creating a network at Mediterranean level between different local stakeholders (in different countries) linked by an interest in the bioenergy issue. The activation of Working Groups will provide the opportunity for cooperating and working together in strategic, common, cross-cutting topics in MED countries.

This mechanism will make it possible to launch joint actions targeted at EU institutional representatives that might be stronger and more effective than those carried out by individual players.

A fundamental appeal of this mechanism rests on the fact that EU/international institutions will themselves be beneficiaries of these actions by receiving a more direct response from local stakeholders. Furthermore, the EU authorities will be provided with more immediate feedback in relation to their needs and requirements, enabling them to better understand whether the present policies are moving in the right direction, or might be corrected in time without wasting further financial resources.

To ensure a greater impact on EU institutions, the agreement must be signed by a large number of stakeholders. For this reason it is crucial that all partners continue to look for new subscribers to the Pact and actively participate in future Steering Committee activities.

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Project cofinanced by the European Regional Development Fund (ERDF)

The Pact is a voluntary agreement that involves the PROFORBIOMED partners and local stakeholders in strengthening and disseminating effective strategies for biomass-based energy production

3.8. International Association for Mediterranean forests (AIFM)

3.8.1. Legal name / Contact details

Name of the Organisation: Association Internationale Forêts Méditerranéennes

Acronym: AIFM

Official address, country and region: 14 rue Louis Astouin, 13002 Marseille, FRANCE

Website: *www.aifm.org*

Legal representative: Abdelhamid KHALDI (President)

Contact person: : Marine Lovero, Project Manager (marine.lovero@aifm.org)

3.8.2. Description of the partner's activities/skills relating to biomass

The International Association for Mediterranean forests (AIFM) is an international NGO, based in Marseille, France, which is led by a board of directors from the entire Mediterranean area.

It was founded in 1996 to address the various issues facing Mediterranean forests through the exchange of knowledge, experiences or ideas, based on a cross-field, multidisciplinary and international approach.

AIFM topics cover every aspect of Mediterranean forests: fire and flood prevention, sustainable land management and planning, governance, preservation and promotion of biodiversity, adaptation to the effects of climate change, innovation and development of new markets, etc. Biomass fits among these as one of the upcoming challenges faced by Mediterranean rural areas.

3.8.3. Communication and dissemination activities

3.8.3.1. Description of the action

Within PROFORBIOMED, AIFM was responsible for Work package 2: "Communication, dissemination and awareness raising", i.e. all communication issues, both inside and outside of the project.

Inside the project, AIFM offered support to partners in their communication activities and contributed to sharing results and information within the partnership.

Outside the project, the main goal of WP2 was to disseminate the project results among all relevant public and private stakeholders, at regional, national and European level, through various tools and events.

3.8.3.2. Methodology

In order to be as efficient as possible, a communication plan was designed, with the objective of defining a common and efficient communication strategy.

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PROFORBIOMED

PROMOTION OF RESIDUAL FORESTRY BIOMASS IN THE MEDITERRANEAN BASIN

COMMUNICATION PLAN

(Updated version - 19/09/2013)

Work package 2 leader: Association Internationale Forêts Méditerranéennes (AIFM)

Figure 29. The project communication plan

The project communication strategy aimed to promote and share information about the project and its main areas of interest: forestry biomass, Mediterranean forests diversity and specificities, challenges for the local economy and the environment. It also aimed to influence identified target groups: forest, timber and energy professionals, policy-makers from local to European level and the general public.

The methodology was formed of three steps:

- Definition of the message;
- Identification of the different target groups;
- Development of specific communication tools.

The first two steps were conducted at the beginning of the project. The third one went on throughout the entire project lifespan.

As a complement to the communication plan and its identified tools, AIFM took advantage of its experience, knowledge and networks to coordinate and manage the project's communication action, as well as to disseminate key information on a wider scale.

Partners also developed their own communication campaigns, particularly at the end of the project, with the help of communication professionals, and in accordance with the adopted communication plan.

In addition, a database was created, bringing together relevant stakeholders at local, national and European level. This database was used for the dissemination of different tools, including the Biomass for Energy Pact.

3.8.3.3. Stakeholders involved

Within the partnership, every partner was involved in designing and implementing the different activities needed, with the support of AIFM and contractors for the specialised aspects.

The action did not directly involve stakeholders outside of the partnership, since communication was meant to come from the project. However, feedback was requested and given, in particular through social networks.

5 target groups were identified:

- Key stakeholders: forest managers, private owner associations, environmental

FRENCH STAKEHOLDERS	59			
Type / Name of the entity	Contact name	E-mail	Contact Tel	Address
Energy and environment agencies				
France Electricity (EDF, national energy group) - Direction régionale PACA		energieefficace@edf.fr		470 avenue du Prado - BP 177 13268 Marseille Cedex 08

Figure 30. Example of entry in the stakeholders database

associations, NGOs, energy agencies, environment agencies, chambers of industry, wood and energy production companies, community forest associations, forest cooperatives and inter-branch organisations,

- Decision and policy-makers: EU institutions (European Commission, European Parliament, Brussels regional offices, Committee of the Regions, Specialised EU networks), relevant ministries and other relevant national bodies (in charge of agriculture, forestry, environment) and regional and local authorities
- Members of the partnership
- General public: adults (biomass and forest users) or children (i.e. through environmental education at schools)
- Specialised public: universities, scientists, research institutes, architects and civil engineers.

3.8.3.4. Outputs

The outputs of the communication activities can be divided into three categories, each affecting the different target groups:

- Publications and printed material
- Online tools
- Events

Publications and printed material

In order to present the project in a quick and effective manner, printed materials were created.

Posters and leaflets in English or local languages were designed to present an overview of the project's main goals, actions and results. They were mainly dedicated to a broader audience, like the general public.

Figure 31A. Examples of printed material: leaflet and posters

Technical reports and specialised articles were prepared as well, in order to present specific aspects of the project, in particular for a specialised professional public, along with final reports, which summarise the actions conducted within the framework of the project.

Finally, with the aim of promoting capitalisation, a DVD bringing together all project deliverables will be issued and used even after the end of the project.

Online tools

To showcase the project to the widest audience possible, a website was designed, containing all relevant information on the projects, ongoing activities and events, and where all the deliverables

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Figure 31B. Examples of printed material: leaflet and posters

will be available. The website was supported by social media, with a dedicated LinkedIn group and multiple Facebook pages, all dedicated to fostering discussions on the project topics and sharing and relaying information on the website (nearly every Facebook publication and LinkedIn conversation included a link towards one of the website pages).

Figure 32. The project website

Six newsletters were also sent to a wide audience, in order to keep subscribers informed on completed and upcoming activities, as well as related publications. Finally, some partners used mass media in order to present their actions in a friendlier and more concrete way: promotional videos on YouTube or on local TV channels, radio or TV adverts.

Events

The third type of output was the organisation of various events, such as seminars and workshops, regional meetings and scientific conferences, and attending other events related to the project topics.

The main event organised in the framework of the project was the final international conference, held in Marseille, France in June 2014. During two days, around 100 people gathered to visit pilot sites, discuss ongoing biomass projects in the area and debate the challenges related to biomass. The conclusions of the conference will be available on the project website and on the AIFM website.

3.8.3.5. Impacts

The communication activities and dissemination campaigns contributed to spreading project information and results across a large scale.

At the end of August 2014, the website had been visited 17,100 times, the Facebook page had 273 likes and the LinkedIn group had 185 members.

The newsletter was sent to 540 direct subscribers, and more than 2000 people through the partners' own networks.

The final international conference brought together 90 people for the field trip and 70 people for the final day.

Overall, the communication activities and dissemination campaigns affected thousands of people in each of the six partnership countries.

Figure 33. The final international conference participants

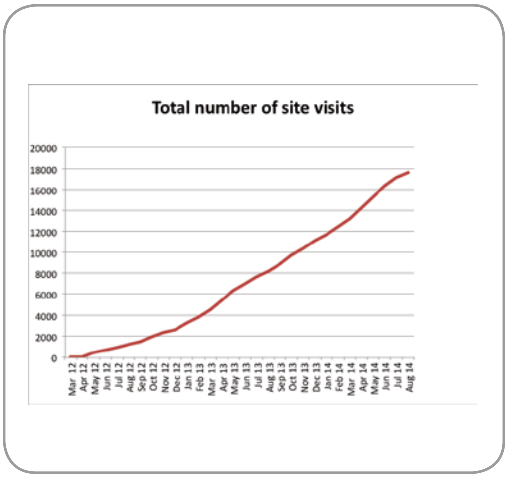

Figure 34. Change in the number of visits to the project website

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3.8.3.6. Added value of transnational cooperation

The transnational cooperation allowed for a wider audience for communication activities, in particular thanks to the stakeholder database established within the project.

Moreover, cooperation allowed each partner to take advantage of the diversity of partners as well as their previous experience in communication, along with a vast array of subcontractors, in order to create and put into action new methodologies and tools.

3.8.3.7. Conclusions and lessons learned

The communication activities and dissemination campaigns led during the PROFORBIOMED project helped spread information about the different activities led by the partnership, and their outcomes, both between partners and to stakeholders at a local, national and European level. Communication activities are crucial in order to share methodologies, tools and results, with a view to capitalisation and long lasting effects.

The transnational cooperation offered by the framework of the project was an asset to widen each partner's audience, as well as to share experience and networks.

AIFM offered support to partners in their communication activities and contributed to sharing results and information

3.9. Regional Forest Owners' Centre of Provence-Alpes-Côte d'Azur

3.9.1. Legal name / Contact details

Name of the Organisation: Centre Régional de la Propriété Forestière de Provence-Alpes-Côte d'Azur

Acronym: CRPF PACA

Official address, country and region:
7, impasse Ricard Digne, 13004 Marseille, FRANCE.

Website: *www.ofme.org/crpf*

Legal representative: Philippe Thévenet (Director), phone number: 00.34.4.95.04.59.04

Contact person: : LLouis-Michel Duhen louis-michel.duhen@crpf.fr or Nicolas Joly nicolas.joly@crpf.fr

3.9.2. Description of the partner's activities /skills relating to biomass

The CRPF is a public body dedicated to promoting the management of privately owned forests. The following are within the scope of its responsibilities:

- The awareness raising to private forest owners concerning forest management
- The validation of forest management plans
- The promotion of grouping management activities in small plots of privately owned forest

At a regional scale, 75% of forest is private. All studies show that there is ground for higher biomass mobilisation in the PACA region, especially in private forests. But because of harder woodcutting processes in private forests, the rate of exploitation is still low. The development of a biomass supply chain will need the biomass available in private forests, and the CRPF is the organisation that can help promote the sustainable management of these forests.

3.9.3. Development of a methodology for grouping private forest owners

3.9.3.1. Description of the action

In the WP4 PA 1.3, the CRPF PACA has led an action, which brought together private forest owners through the help of local elected representatives. The first step was a detailed analysis of the barriers for wood mobilisation in private forests in PACA. In the PACA region, this sector has surpassed the emergence stage after a strong government drive. However, our analysis is as follows: the focus is on studies into the availability of biomass resources, omitting the fact that most of it is privately owned. These studies indicate the presence of a resource but do not guarantee its availability. However, without owner consent, the resource will remain on site. There are a number of psychological, economic and land-based barriers to overcome, in order to achieve the consent of a large number of owners.

Psychological barriers

We shall begin with the psychological barriers because it is important to understand that "any decision to intervene in the forest comes from the owner of the forest" If owners do not want to do anything, there is no way of forcing them. It must therefore be clear that there are many reasons that can lead owners to be rather reluctant to allow logging.

Mediterranean private forest that has formed due to the abandonment of farmland can be considered young forest whose owners have not yet had the opportunity to acquire forest culture. They have therefore not understood that a forest is managed by the regular succession of cuts. In some key areas, where pine was exploited to harvest resin (turpentine production) and produce packaging timber, the interruption of this outlet for more than fifty years broke regular management.

Misunderstanding of timber

Public and private forest owners are bombarded with messages on the overexploitation of forests and may have been shocked that woodcutting is sometimes carried out without following forestry rules. In some forests, often in suburban areas, most of them have difficulty accepting logging, which seems to go against the protection of the environment. Reluctance from their family, neighbourhood or residents prevents a lot of these owners, who have not yet been convinced by forest managers, from accepting cutting. Others would be willing to do so, but have too many demands concerning the quality of third-party forest work, which they would associate with gardening in an area based on tourism (refusal of heavy equipment, problem of evergreens, etc.).

Heritage management misunderstood, the case of private forests

We should also take into account the reasons why homeowners keep family property or buy woodland. Behavioural surveys show that heritage is the primary reason. This often results in conservation being seen as a good way of passing woods onto the next generation in good condition; doing nothing seems to be good management, especially for a property that seems to grow on its own. Other reasons are divided among the various services offered by forest approval, such as the environment, hunting, landscape and picking. Timber production is almost always absent, apart from harvesting firewood for their own needs.

Irrational fears of the risk of forest fire

In a Mediterranean context, the threat of forest fires is an additional reason to refuse logging in plots. "Why cut trees when thousands disappeared during fires?" exclaimed a famous writer before the media widely reported this unjustified idea. In addition, logging leaves branches and needles (slash) in the cutting area, which can significantly reduce the desire for cutting because of the mass of fuel they represent.

A wall of regulations to cross

In the Mediterranean area, it is also necessary to take into account the weight of forestry and environmental legislation and also legislation related to urban problems. They all have their legitimacy, but also have the disadvantage of being superimposed (stacking of rules for the same area) and involve different people processing authorisation requests, which can become particularly laborious. Motivated private forest owners sometimes end up abandoning their plans because of this last obstacle.

Economic barriers

Low-income

Overcome if logging could be profitable or at least used to offset expenses (cost of drawing up legislative documents (e.g. PSG), regular up-keep, investments, maintenance access, etc.) and taxes. This is unfortunately not the case since total revenues currently stand at €6-8 per m^3, or income of €20 to 25 / ha / year.

Low value products

Some "trendy" owners also lament the lack of promotion of products, most of which end up at the pulp mill plant. The proportions of wood that could be used in packaging timber, often too small to justify sorting, the absence of a local chain and ignorance of the physical qualities of Aleppo pine are the reasons most regularly put forward to explain this fact. Of course, because of that, most owners prefer to wait.

Fear of exploitation

Moreover, the perception of managers, owners and other local players has somewhat "damaged" logging activity. They deplore the damage to roads and protected trees, but also payment problems and the difficulty of knowing exactly what is being sold.

The cost of peace prevails

In summary, many owners believe that the low income is not likely to balance the "peace cost" (which they save by doing nothing) and do not take the decision to engage in genuine management by approving the act of cutting.

Technical aspect

In our region, slopes and a lack of road networks are the main obstacles. Private forests are developed on former agricultural land, which is why they are better served by road networks than public forests. But the problem is present over large areas due to local public roads which are not suited to carrying logging trucks.

Sociological aspect

The direct target group will be private forest owners. They are the key target of the CRPF in its legal framework and they are the owners of the resource we want to mobilise.

But there are other groups that will be affected by our work. Since the beginning, our aim was to use the local influence of elected representatives to transfer the message of the CRPF: private forests play an important part in the development of wood energy. Moreover, a common vision of private and public plots is needed for better harmony in planning forest development. In this way, locally elected representatives, through their proximity with private forest owners, can be an important means of sharing information and raising awareness among this population. As well-known local people, they are more trusted by citizens. People will more likely adhere to a local dynamic than follow instructions by the CRPF or the wishes of recent industries requiring large amount of biomass.

Then, raising awareness among foresters was one of the actions implemented in the project, by trying to improve their skills. With PROFORBIOMED, they had the opportunity to have their work analysed, and the possibility to test new harvesting methodologies, as well as to take advantage of examples of best practice from other Mediterranean countries.

By organising several events in our pilot municipalities and by working with local councillors, we brought the debate into the sphere of all citizens of these municipalities, as they should feel involved in the development of their local environment.

Our work has been divided into two parts, operating simultaneously: First, working with local councillors and owners to complete the pilot scheme we presented to PROFORBIOMED partners Then, implementing a series of demonstration actions, in order to test or present new methodologies for silviculture or local events for private forest owners, policy-makers, and professionals in the chain.

3.9.3.2. Methodology

After making contact with the CPA, we decided to work with 4 towns in particular. The idea was to test these four municipalities with different methodologies for each phase of the pilot project:

- contact owners with the support of local elected representatives
- present PROFORBIOMED and the planned action in the area
- attempt to group private forest owners together

Indeed, it seems that the most important aspect for achieving the mobilisation of this resource in private forests is to obtain the consent of the owner. The economic attractiveness is low in our region (low-quality wood and fragmented plots), so we have to find another way to talk to them. The fight against fire was sometimes an important point, and nowadays, wood energy is another.

As indicated in the introduction, in order to gain local support to improve our approach, we have worked closely with local councillors. The aim was obviously to involve and educate owners upstream, explaining the work of each stakeholder (CRPF, service provider, etc.) as precisely as possible, in order to facilitate their compliance with the process.

The towns of Lambesc and Saint Cannat were the most active so we focused on conducting an initial trial on their land. In Rognes and La Roque d'Anthéron, we organised a meeting to introduce the project and the work that we wanted to achieve. These municipalities were interested in the issue of private forest management and the development of wood energy, but were generally less advanced in their thinking on the subject than in Lambesc and Saint Cannat, and were less attentive to our requests. We first implemented the pilot action in Lambesc.

Before driving action in private forests, we wanted to "take the pulse" of owners. We therefore decided to carry out a questionnaire to be sent by post in order to quickly reach a large number of people. The objective was to identify their expectations regarding their forest, any barriers, their plans and finally their opinions on wood energy. It also allowed us to see if private / public forest cooperation was relevant in this area. The answers were anonymous because we wanted to promote sincere answers and comments and increase response rates. Given the high fragmentation of private forest in this area, it was agreed with the municipality to send a questionnaire to all owners of more than 0.4 ha (approx. 300 people).

Once written in conjunction with the Mayor, the CPA and the Union of Forest Owners, the questionnaire was tested with three forest owners in the town as follows: we asked them to fill out the questionnaire in our presence, requesting that they inform us of any difficulties in understanding others and their comments. As the questionnaire was to be distributed by e-mail, it was important to be as clear and readable as possible.

After taking into account all comments made throughout the questionnaire development process, we published a final version. This was sent to all forest owners in Lambesc (over 0.4 ha)

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along with a letter signed by the CRPF, the Mayor of Lambesc and the President of the Bouches-du-Rhône Union of Forest Owners. The deadline for response to the questionnaire was 15 days, with the option to either return it to the CRPF headquarters or the Mayor's office. The first option was widely preferred by owners.

We analysed the results and presented them during a feedback meeting in Lambesc, to which all of the relevant owners were invited. We had ten participants and two articles in the local press. The main results were presented in a booklet distributed to participants and all owners.

Along with this, a call for tenders was launched to select a service provider who would perform the forestry work in the municipalities according to the specifications we had set. The service provider had to follow the protocols provided by the CRPF.

A letter was sent to owners to keep them informed of the next steps. A document was published on the Town Hall website to share our message with the largest possible number of people. Trying to keep everyone informed on our topic was a key point of our work. Sharing complementary knowledge at local level is one of the prime factors for pilot action success.

After completing the operation in Lambesc, we realised that a lot of people who answered the questionnaire and were motivated for woodcutting in their land didn't fit into the economical framework of our service provider. Their plots were too small or they didn't have enough wood and no way of grouping together with neighbours, making it economically impossible to act on their desire. So we decided to change our contact methodology for Saint-Cannat. We first went on the field to identify an area smaller than the whole municipality, with enough wood for exploitation. In this area, we contacted all private forest owners, regardless of the size of their plot. For economic reasons, exploitation couldn't take place on the initial site, so it was moved to a place nearby called Eguilles, where the woodcutting took place.

The rest of the methodology was exactly the same as for Lambesc.

3.9.3.3. Stakeholders involved

To determine an area that would be interested and of interest with regards wood energy, the CRPF organised a meeting to which the main communities of municipalities in the region and main actors in wood energy were invited.

Following this meeting, it appeared that the Communauté du Pays d'Aix (CPA) best met our expectations:

- Strong involvement in the development of wood energy by its elected representatives
- Strong forest presence on its land and high proportion of private forest (60%)
- Existence of storage platforms
- Existence of a first descriptive study of private forests (see next chapter)
- Locating eElected representatives willing to work with private forests.

Within the 36 municipalities in CPA, we contacted four of them (Lambesc, Rognes, Saint Cannat and La Roque d'Anthéron), and worked with two (Lambesc and Saint Cannat).

Then, during the process of contacting private forest owners, we worked with the Bouches-du-Rhône syndicate of private forest owners.

3.9.3.4. Outputs

The main output is a methodology to contact private forest owners that can be repeated in other municipalities.

We entered the project with ideas to test and doubts to overcome. The project allowed us to test our ideas, resolve the doubts we had, reveal new ones and improve our methodology. The project can be seen as a starter for the management of several forests that were abandoned until now. We can now proceed at a larger scale, following lessons learned during the project.

On In terms of the concrete output of the actions implemented by the CRPF during PROFORMIOMED, we have:

• An excel tool that gives the amount of biomass available in the Forest Management Plans of private forest owners for each municipality and each year, according to the type of forest plot and the kind of intervention.

• A tool to easily summarise and analyse the results of the questionnaire.

3.9.3.5. Impacts

Across the area, we contacted more than 600 private forest owners for a common action. Although all of them did not answer, all the activity across the area can have results for future activities, and they may be more receptive to a further requests. We then sent an invitation to awareness-raising activities to more than 1000 people, and a total of over 70 people attended our demonstration days.

The results of 3 grouping operations in the Aix-en-Provence region – exclusively *Pinus halepensis*, the region's main resource:

Location	Owners	Surface area	Volume
Lambesc	5	12.2 ha	640 m^3
Rognes	4	22.4 ha	1045 m^3
Eguilles	2	13.6 ha	700 m^3 (approx.)

Table no. 29 Results of 3 grouping operations in the Aix-en-Provence region

The communication actions were well designed, with several articles written in the CRPF paper, which were sent to more than 9000 private forest owners and main forest organisations. Three articles were then written in local newspapers concerning the awareness-raising actions we carried out, reaching more than 170,000 people.

3.9.3.6. Added value of transnational cooperation

PROFORBIOMED project, the CRPF was the only partner to deal with the extreme upstream part of the supply chain. Through our main actions, we promoted awareness-raising for the issue of privately owned forests amongst partners.

Then, by analysing the situation in other countries, we discovered how they dealt with the issue of private forests, and all the different ways to promote the management of these areas. We can say that we learnt from others' experience, and we also made them aware of some situations they may not have known about. This is the key purpose of transnational activities, to see what exists beyond our boundaries and to enlarge the scope of our work.

As the CRPF was in charge of reporting for the WP4 PA 1.3 actions, we had a good overview of the prices and sivicultural processes in other countries. We could compare prices, work completion deadlines, and the type of forest plots, promoting this through the companies with which we have been working in France. It gave us access to a lot of high quality data, in order to compare and adapt our woodland methodology.

Then, we can conclude that the presence of an international panel of experts at the final seminar helped local stakeholders to focus on the priorities for their needs, improve discussion between them and reduce tensions.

3.9.3.7. Conclusions and lessons learned

Some of the following points have been raised:

- The need of local elected representatives to receive training on forests. We wanted to work with them and realised that they needed more precise information on the topic. Because of their small interest in forests, they often spread wrong messages through citizens.

- The Wood energy is a great tool to involve private forest owners in the management of their forests. It is necessary to promote it in order to increase the value of woods of low value.

- We must bear in mind that wood energy must only be for very low quality woods. It is important to separate various wood qualities on each plot, in order to better optimise the value of nature.

3.9.4. Creating value from two *Quercus suber* products.

3.9.4.1. Description of the action

From a forestry point of view, many of our region's cork forests are in a poor state of health and should be regenerated for new cork oak forests that may produce cork with high added value. Thus, many cork trees (scrap) must be cut. This regeneration effort is not performed because it is not profitable for the owners. Therefore, we must find an economic opportunity for this large volume of wood and cork. Regional initiatives were developed to address this problem. In the Var, discussion on the topic of regeneration has been carried out by the community of municipalities of the Gulf of St. Tropez, the Maure Bois Energie association and ASL cork oak Var, supported by the CRPF PACA. To make these operations economically profitable, a new outlet was proposed, whereby any cork oaks felled were crushed. The resulting chips, composed of cork and wood particles, were sold to landscapers to use as mulch. This industry has developed but does not currently generate profit for the owners, operators and mulch producers. Depending on the operating conditions, the profit generated by the processed product barely or failed to offset the operating cost. Even if this is a real opportunity, in many cases, it must still be developed. On the other hand, cork aggregate is a product that is sold on the international market. Its value is approximately 10 times higher than granulated cork / timber. The value of the cork oak wood could be twice as high as the granulated cork / timber.

ALLGAIER holding based in Germany. This group is specialised in the design and development of tools capable of separating virtually all types of aggregate. Their applications are numerous: quarries, chemistry, compost, etc. Several separation methods exist within ALLGAIER and one developed by the Spanish company ALMO, a subsidiary of the ALLGAIER group, seems to meet our objectives. The company, which employs about thirty employees, has its headquarters in Avilés in Asturias.

3.9.4.2. Methodology

The product to be separated

The community of communes Saint Tropez and the surrounding municipalities chipped cork oak wood and cork during a thinning operation and sent two big bags to ALMO. The chipping took place on a rainy day and the mash was soaked. A big bag contained an unscreened product and the other container has been screened with a particle size diameter of 10 mm. We note that the whole tree was ground.

The test bed

The test bed consists of the following elements, assembled as shown in Figure 35:

A gravity table. It consists of a perforated grid which is placed over the granules and through which air is blown. The air can be blown perpendicular to the grid or in multiple directions.

- A fan which blows the air
- A cyclone that sucks fine particles
- A feed hopper
- A screen that can connect or disconnect the circuit
- An elevator for conveying the processed product to the hopper (closed circuit)
- The carpet feeders that link components to each other

The separation operation is based on the difference in mass between the particles. Air is blown into a stack of mixed aggregates. The particles are abundant and can be better separated. This principle works even better when the particles are dry. Thus, particle agglomeration can be avoided. Using vibration, the heavier particles climb up the slanted gravity table, whereas the lighter particles travel downwards. This operation is more effective when the particle size is uniform.

Several parameters may be adjusted:

- The volume of air injected into the densimetric table
- The size of the gravity table grid holes
- The time particles spend in the gravity table
- The flow direction (not considered in this case)
- The relationship between table width / material flow supply

The test bed operates in closed circuit in order to change settings continuously

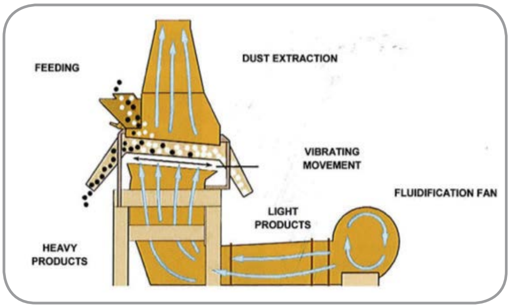

Figure 35. Slika 1: Diagram showing segregation

First, note that the scale used in the gravity table was perforated with 4 mm holes. The original mixed crush was dirty and soil and many twigs from the crown were present.

The big unscreened bag was tested first. After running the system a few times to help drain the mash and tweak the settings, the initial separation was not satisfactory. Indeed, at the gravity table output, we firstly obtained wood chips mixed with twigs and soil particles, and secondly, cork granules mixed with many soil particles, twigs and wood chips. This second fraction did, in no way, comply with the expected product.

Therefore, it was decided to screen the product with grids of 15 mm and 10 mm in order to homogenise the initial product. This solution did not lead to any improvement. To remove dirt and twigs, it was decided to change the gravity grid. The idea was to eliminate the circuit twigs that were falling through the holes in the grid. On the other hand, the power of the cyclone that sucks very light particles had been pushed to its maximum setting.

This adjustment did actually lead to better results. Four product fractions were identified:

- The "cork" (Figure 36 a) cork.) from which the twigs were removed. Some had been evacuated by the perforated densimetric grid table, but most by the cyclone suction. There are still dirt particles. Most of these particles were sucked into the cyclone. Many small wood chips still remain.

- The "wood" (Figure 36Cork; b) wood; c) waste. which contained only perfect wood chips.

- Figure 36, c) waste, which represents the elements that passed from the gravity table and through the gate. This product consists essentially of fine woodchips and small twigs. This product can be recovered as wood chips obtained in the preceding product fraction. The "wood" and "scrap" can be shuffled after separation.

- A "suction" fraction that corresponds to the elements drawn by the cyclone. It includes twigs and light soil particles.

Figure 36. a) Cork; b) wood; c) waste

3.9.4.3. Stakeholders involved

The free trade union association "Suberaie Varoise".

3.9.4.4. Outputs

The study's main output is a tonne of cork separated using the methodology presented. Additionally, a document has been published in French to promote the results of this study.

3.9.4.5. Impacts

Given the low quality of the pulp tested and the initial results obtained in the time we were allotted, outlook is positive. Indeed, it is expected that ALMO will continue its investigations. ALMO, given its significant experience in separation, has said that effective separation is possible (understood to be <5% of wood chip in the "cork" fraction without twigs or mud). Once their investigations have been made, another shipment of crushed products will be sent to confirm the settings.

Hopes are even higher as the separation affected the whole tree and therefore a large amount of material. This could reduce operating costs by less processing work.

For now, ALMO is set to produce a report on the detailed tests that they have been conducting.

After the validation step, if the separation is proven to be effective, ALMO will inform us about the engine performance and sizing of the equipment used, including for the gravity table, according to an equipment supply forecast. This will mean that an installation cost can be defined. It includes on-site installation and technician training. After-sales service (telephone and quick dispatch of a technician) is included in the cost because the company prefers to support its customers in the long term. In terms of maintenance, no major annual wear is reported in this industrial process. Regular engine lubrication is the only thing to take into account. Nevertheless, ALMO has given us a price range which ranges between €40,000 and 200,000.

3.9.4.6. Added value of transnational cooperation

As we have seen, the experiment was international in itself. The transnational aspects of PROFORBIOMED allowed us to spread the initiative through a better channel than the trade union could have done alone. As we have explained, separating the cork and wood from the *Quercus suber* tree is a very new technology. The topic of old *Quercus suber* forest is recurrent along the Mediterranean coast, so partners could have an insight into what has been done on our side. And for the operator, it is also interesting to promote its technology to expand into new markets.

3.9.4.7. Conclusions and lessons learned

A positive result of the separation is having obtained "wood" and "scrap" fractions, which have a direct value. The main disadvantage is in the "cork" fraction, which is not valuable in this state. Several parameters can explain the poor separation.

Some relate to the quality of the product:

Moisture

The high moisture content of the original product has smoothed densities and caused amalgam between the particles, which was helped by the wet earth. This implies that the initial product must have a suitable moisture content (> 30% to 50% maximum) .

In practical terms, it is necessary for the operator responsible for this operation to perform the grinding in dry conditions and store ground products in a waterproof area. For on-site grinding (in the forest), as was the case here, the whole tree is shredded. To reduce the rate of leaves and fine twigs, one idea might be to leave the trees for about a month after felling. This time allows the leaves to fall easily when hauling and would remove a large number of twigs, as they become brittle during the stay. In this way, the high carbon content in the leaves could stay on the forest floor.

On the other hand, for future installation, a

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storage place seems highly recommended. If there is too high humidity, one idea would be to let fermentation take place in the mash to dry it.

The homogeneity

As we mentioned above, the homogeneity of the particles in the initial homogenate is very important, both in terms of form and size. For the variety of forms (long and thin twigs, ball of cork, wood chips in a flat square, etc.), the final test showed fairly good results. According to ALMO, it still can be improved.
Given the market for "bulk insulation" for which the "cork" fraction is predestined, it would be interesting for the grinding to obtain particles of about 10 mm.
Other parameters concerning the test:

The cyclone

To optimise separation, ALMO proposes to increase the cyclone power. Indeed, the cyclone used did not present sufficient maximum power. ALMO therefore wishes to change this equipment and re-test separation. Thus, all the twigs and soil particles could be eliminated.

The usual settings

To get a better result for the "cork" fraction by eliminating a maximum of wood chips inside, ALMO has yet to conduct tests on the adjustment parameters mentioned above. Again, in view of the first tests, ALMO is very optimistic about this development.
For the coming months, the idea of the association is to find a way of obtaining the machine, in order to start wider use in this area.

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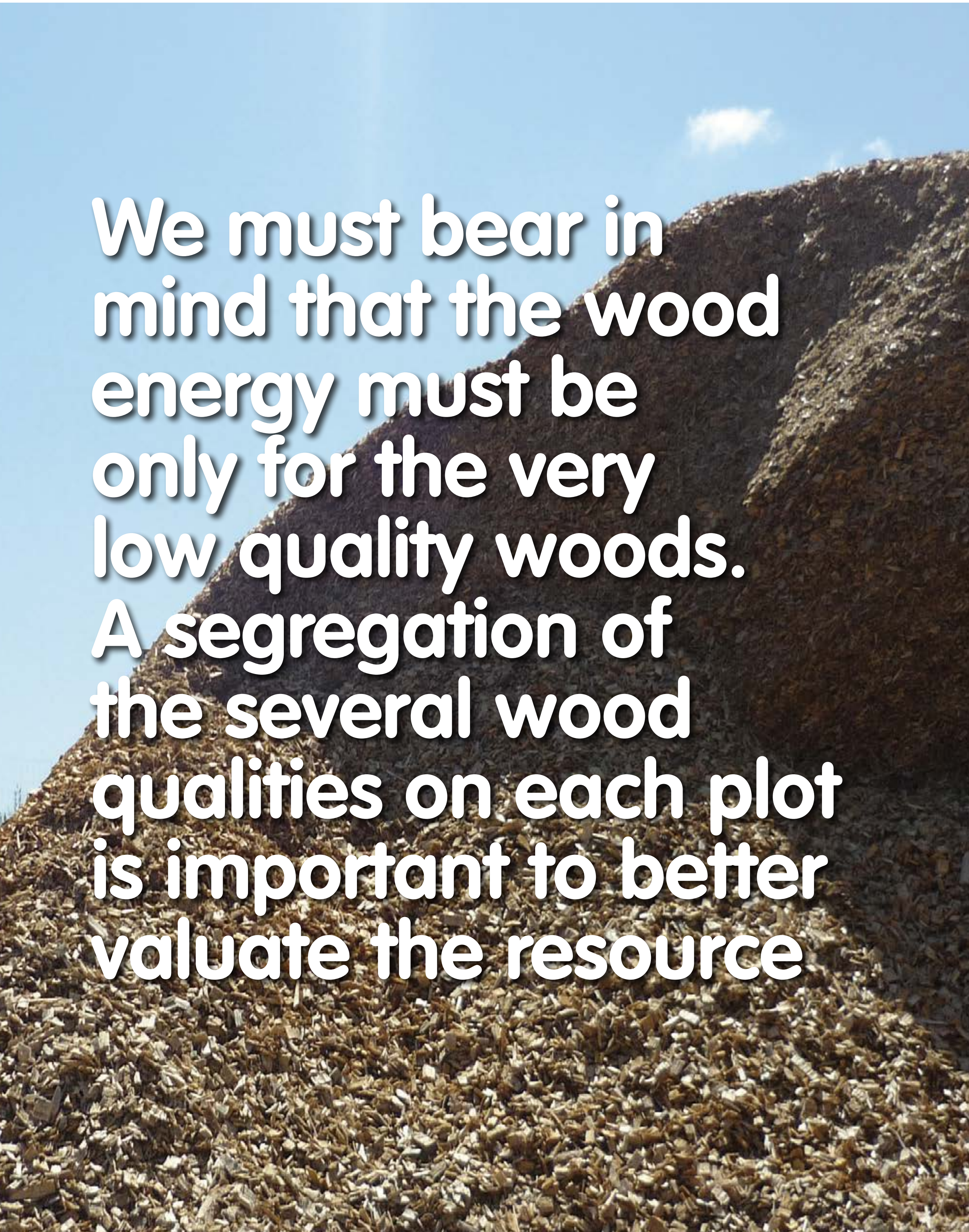

We must bear in mind that the wood energy must be only for the very low quality woods. A segregation of the several wood qualities on each plot is important to better valuate the resource

3.10. Slovenian Forestry Institute (SFI), Slovenia.

3.10.1. Legal name / Contact details

Name of the Organisation: Gozdarski inštitut Slovenije (Slovenian Forestry Institute)

Acronym: SFI

Official address, country and region: Gozdarski Inštitut Slovenije, Večna pot 2, 1000 Ljubljana, Slovenia

Website: *www.gozdis.si*

Legal representative: Dr. Primož Simončič; Telephone: +386 1 200 78 01; e-mail: primoz.simoncic@gozdis.si

Contact person: Dr. Nike Krajnc; Telephone: +386 1 200 78 17; e-mail: nike.krajnc@gozdis.si

3.10.2. Description of the partner's activities/skills relating to biomass

The Slovenian Forestry Institute (SFI) is a public institution of national importance, dedicated to research in the fields of forests, forest techniques and economics, game management and use of wood biomass for energy. It was founded by the Government of the Republic of Slovenia and operates - in line with modern environmental thinking - under the auspices of the Ministry of Higher Education, Science and Technology and the Ministry of Agriculture and the Environment. The SFI is multidisciplinary, dedicated to development, research and applications, and is running a wide variety of operational within particular research projects.

The Department of Forest Techniques and Economics monitors the development of modern forest techniques and efficient technologies appropriate to our geographical and socio-economic conditions. Its main activities include: development of modern technological maps; evaluation and standard-setting for particular phases of technological processes; economical evaluation of forest functions; effective use of wood biomass for energy; tree monitoring; soil damage caused by felling and skidding; wood flow analysis; roundwood balances and calculation of CO_2 sink from forests and harvested wood products.

The SFI's Department of Forest Techniques and Economics has been involved in R&D projects, dealing with the evaluation of the biomass and energy potential of Slovenian forests and with other wood sources for more than 20 years.

3.10.3. Production of green wood chips versus traditional harvesting of wood logs

3.10.3.1. Description of the action

The SFI has led Work Package 4, "Setting up of integrated strategies for the development of renewable energies." In the framework of pilot action 1.3 "Assessment of forest biomass production", SFI studied different aspects of forest residue extraction.

The use of fossil fuels for producing energy is increasingly becoming a luxury, due to its high cost. This is also the main reason that the use of wood is rising rapidly in Slovenia. In Slovenian forests, selective cutting and final cuttings with natural regeneration are mainly applied, with forest residues remaining in the forest unused. With the development of the wood biomass market and with increased demand for wood chips in Slovenia and also in neighbouring countries, an interest has arisen in green wood chips from forest residues. The interest in green wood chips comes mainly from the larger biomass users, since their technologies allow for the burning of low quality chips with higher water content (above 20%).

One of the first problems faced by the extraction of forest residues in Slovenia is that a cut-to-length harvesting system is mainly used. The whole tree system is used only with cable crane yarding in steep terrains. The predominant harvesting technology is chainsaw, followed by tractor (it is estimated that less than 10% of felling is fully mechanised, using a harvester followed by a forwarder). With cut-to-length systems, selective cutting and the predominating harvesting technology, the concentration of forest residues is rather small and the detailed economics of these operations has not yet been analysed in detail. The ecological concern regarding negative impacts on forest stands and soils has also become an issue raised by the Ministry of Agriculture and the Environment and by some environmental organisations.

To address this new issue, the SFI, in the framework of the PROFORBIOMED project (MED programme) set up a trail on selected test plots. The main aim was a detailed study of different aspects of forest residue extraction. Based on the collected data, we would like to prepare generic guidelines for forest residue extraction with a focus on thinning in stands with DBH between 10-19 cm, taking into account different technologies, stand and terrain characteristics as well as soil types.

3.10.3.2. Methodology

For the study four different locations in Slovenia (one in Nanos, two in Vremščica and one in Trnovo) were chosen for the study. In each location two 0.25 ha plots were selected in similar stand conditions, with the objective of comparing different felling systems, using the same methodology. Production of roundwood and green wood chips was planned for all eight plots. On the first plot in every location production of green wood chips was prioritised, and on the second plot in every location, traditional production of roundwood, including pieces of smaller diameter. For studying the technologies used for extraction of forest residues, time studies were set up and carried out.

In all locations, the forest owner selected the contractors to perform all the described activities and the SFI did not influence any decisions taken regarding the selected technology. Operators were selected according to a bidding process.

Not all forest operations were performed at the same time. Given the limited time and resources, it was decided that felling would not be studied in detail (studies for new Slovenian chainsaw felling norms were conducted in 2011 by the SFI), so the time consumption and cost calculations of this operation were estimated using the new Slovenian norms. All wood assortments were therefore measured after felling and cross-cutting (middle diameter and length).

For studying different technologies used for extraction of forest residues, time studies were set up and carried out. All operations were recorded using Trimble Nomad hand-held field computers with the time-study software UMT-Plus. We focused on the cycle level of measurements, because in cycle-level measurement, the observation unit is a single work cycle (e.g. the felling of a tree, the forwarding of a load, etc.). This kind of measurement offers more detailed information and can help to describe the work process with greater accuracy (Spinelli, Visser, 2009). Every single working process was included, but generally they are all divided into three categories (such as productive time or supporting time, with all remaining time considered a delay). Productive time includes only effective time that is comparable among the plots. The time taken up by forwarding (driving the full load from the site to the landing (Nurmi, 2007)) and driving unloaded (the time from the moment when the forwarder leaves the standstill position at the landing until it stops for loading (Nurmi, 2007)) was excluded from the comparison of productivity at both plots because of the different distances and different arrangements of the strip roads on each plot.

As part of the time study, we also measured all the outputs gained during the work process. Outputs are evaluated in terms of both quantity and quality, which are equally important to evaluating work method (Spinelli, Visser, 2009). This is why the product quality was evaluated by comparing actual product characteristics with market specifications - in our case its moisture content, particle size distribution and bulk density for wood chips, or quality and quantity classification for logs. With product output data, we were able to calculate the productivity of different technologies.

Most of our output data were gathered by gaining information about solid volume of logs collected at the forest road or loose volume for wood chips.

a) NANOS Location – Norway spruce

The first location was in the Slovenian Dinaric Alps, where Norway spruce *(Picea abies)* was previously used for afforestation. The area of 16.31 ha is a single forest compartment and is owned by the local agrarian community Ravnik - Orlovše. The whole area was afforested 50 years ago on pasture land. Two 0.25 ha plots in similar conditions were selected. Both plots were selected in the same felling area; distance between plots was 0.5 km. At the end of the year 2010, the trees were marked for cutting by a local forester. The aim of the study was to compare different systems of felling (bucking), using the same type of technology. On both plots, production of roundwood and green wood chips was planned. Basically, the ''two-pile cutting method" was used. In the first plot, production of green wood chips was prioritised, meaning that the forest worker took only the quality part of the log (last cross-cutting was done at a diameter of 10-15 cm), with the rest being ground up for wood chips. In the second plot, production of roundwood was prioritised, including with a smaller diameter (last cross-cutting was done at diameter 6-7 cm). Case study plots 1 and 2 differ in their minimum diameter of wood, 6-7 cm and 10 cm respectively. On both plots, trees were felled motor-manually with a chainsaw by two operators working at the same time. Roundwood was collected and transported to the landing site at a forest road using a Zetor Proxima Plus 105 41 farm tractor (79 KW) with Palms 82 trailer equipped with Palms 610T crane operated by a third operator. Roundwood production and production of green wood chips were separated and performed by two different contractors. Collection of forest residues (branches and tops) with a mini excavator (Yuchai YC35-8) followed the felling and transportation of roundwood. Forest residues were transported to a landing area with a smaller forwarder, Novotny LVS 5000, where they were chipped by a large-size chipping machine Starchl Mk 86 - 600 with a Palfinger crane powered by a FENDT Vario 930 tractor. The transport of logs or wood chips from landing site to final buyer was not part of the time study.

In the case of roundwood, the price agreed for felling and transporting amounted to €25/m^3. In the case of green wood chips, the selling price of wood chips at forest site (not at forest landing area) was negotiated and agreed on at €0.3/ loose m^3. According to Slovenian legislation, the branches and tops of spruce should be gathered in stacks if there is any danger of a bark beetle *(Ips typographus)* attack. Therefore the price for felling and transporting was lowered by €2/ m^3 to €23/m^3, while forest workers did not have to collect the branches and tops into stacks in the forest. These types of forests in Slovenia are particularly endangered by these beetles; with green wood chip production the risk of an attack was lowered, which can be considered as a positive side effect of wood chip production.

b) Vremščica Location – Black Pine

The second location was in Forest Management Unit Vrhe, where the majority of forests are private. The area where test plots were located, is owned by the local agrarian community Gabrče. The whole area was afforested with Black Pine. Two 0.25 ha plots in similar conditions were selected. Both plots were selected in the same felling area; distance between plots was 0.5 km. On the first plot, production of green wood chips was prioritised. On the second plot, production of roundwood was prioritised, including pieces of smaller diameter.

Figure 37. Test plot after cutting of trees (Vremščica – Black Pine)

On both plots, trees were felled motor-manually with a chainsaw by two operators working simultaneously. At the same time roundwood was collected and transported to the landing site at the forest road with a Woody 110 skidder. Extraction and production of green wood chips was separated and performed by a different contractor, specialised in the production of wood chips. Stacking of forest residues (branches and tops) into piles was done by mini excavator (Yuchai YC35-8) following felling and transportation of roundwood. Forest residues were transported to the landing area with a smaller size forwarder Novotny LVS 5000, where they were chipped by large-size chipping machine Starchl Mk 86 - 600 with Palfinger crane, powered by a FENDT Vario 930 tractor. The transport of logs or wood chips from landing site to final buyer was not part of the time study.

In the case of roundwood, the price agreed for felling and transporting amounted to €14/ m^3. Green wood chips were bought by a subcontractor who performed the extraction and production of wood chips. The selling price of forest residues in the forest stand was €0.6 per loose m^3 produced.

c) Location Vremščica - Hop Hornbeam

The third location was also in Forest Management Unit Vrhe, where the majority of forests are private. The area where test plots were, is owned by the Local Agrarian Community Gabrče. Two 0.25 ha plots in similar conditions (coppice stand) were selected.

On Plot 1, trees were cut according to the whole (full) tree method, harvested with a chainsaw and extracted with an adapted agricultural tractor (Massey Ferguson 4345). Wood chips were produced at the forest road from whole trees (with a large chipper - Albach Silvator 2000). In Plot 2, felling was carried out by the traditional assortment method with a chainsaw and extracted with an adapted agricultural tractor - Massey Ferguson 4345, while in this case the forest residues remained in the forest. In the case of roundwood, the price agreed for felling and skidding amounted to €16/t. Logs were sold for €36/t at the forest road, wood chips for €44/t to a local pellets producer. The cost of wood chip production with a wood chipper was €11/t. In case of roundwood, the price agreed for felling and skidding amounted to €16/t. Logs were sold at €36/t at the forest road, wood chips for €44/t to a local pellets producer. The cost of wood chip production with a wood chipper was €11/t.

d) TRNOVO Location

The fourth location was in the Slovenian Dinaric Alps, in Forest Management Unit Trnovo, where almost all forests (97%) are state owned. Forests are managed by the Agricultural Land and Forests Fund of the Republic of Slovenia. The average annual increment is 6.22 m^3/ha. Two 0.25 ha plots in similar conditions were selected. On the first plot, production of green wood chips was prioritised and on the second plot, roundwood production.

The aim of these test plots was to monitor fully mechanised cutting of tress and transporting of roundwood with a forwarder. Harvesting on both plots was done by the concessionaire, with a subcontractor hired for the production of wood chips. Felling of trees was performed with a John Deere 1470D harvester, with help, in some cases, from a forest worker with a chainsaw. Cutting was followed by transporting the roundwood and forest residues with a forwarder (John Deere 1410 Eco III). Due to some issues with subcontractors, after a wait period of almost one year, production of wood chips was performed with an Eschlböck Biber 80 large chipper.

3.10.3.3. Stakeholders involved

There were several different stakeholder groups involved, from the forest production players on the one side, to the decision makers on the other. The former comprised forest owners (Local agrarian community of Ravnik – Orlovše, Local agrarian community of Gabrče, Agricultural Land and Forests Fund of the Republic of Slovenia) and forest workers (subcontractors specialised in wood biomass production, forest workers performing cutting and skidding, concessionaire (harvesting and forwarding)), while the latter comprised players such as the Slovenian Forestry Service and local community representatives. The pilot action results were presented to the general public in several workshops, locally as well as internationally.

3.10.3.4. Outputs

a) NANOS Location

The comparison of productive times revealed time savings (31%) in the case of green wood chip production. This was mainly because of the time saved at logging (the final cross-section at a larger diameter and much less cutting branches on account of longer tops), roundwood transportation (collecting and transporting logs with large diameter has a major impact) and logging residue transportation (branches and tops concentrated in piles) to the forest road. This can also be explained by the difference in average DBH and not only by the choice of technology, given that the average diameter was greater on Plot 1. Average bulk density of wood chips (measured according to EN 15150: 2011) at both plots was very similar, with 263 kg/loose m^3 for Plot 1 and 262 kg/loose m^3 for Plot 2.

Productivity for all operations combined was

37.8 roundwood equivalent (RWE) per hour on Plot 1 and only 26.0 RWE/hour on Plot 2. The greatest difference in productivity occurs during the logging residue extraction process, which is 67% higher on Plot 1.

According to the results from Norway spruce forests of similar age, optimisation of green wood chips can lead to higher productivity of all operations, the only exception being collection of forest residues with a mini excavator. The use of a mini excavator can be justified for pile preparation in order to achieve higher productivity of forwarding. In the case of manual cutting, the piles of wood are usually small and scattered over a larger area, which is why a mini excavator is used for grasping the residues.

According to differences in plot structure in terms of DBH (arithmetic mean DBH), distribution per number and per volume of the subclass of trees with DBH between 10 and 19 cm was selected. On Plots 1 and 2 the percentage volumes of the selected DBH, out of the total felled volume, were 42% and 54% respectively. The percentage number of trees with the selected DBH ($10^{-1}9$ cm), out of all trees cut, amounted to 70% in both plots. The differences between the plots related to the DBH structure of felled trees were thus minimised. Additionally, this is in line with our assumption that the applied system might be most suitable for the first commercial thinning in coniferous even-aged stands with diameters between 10 and 19 cm. For trees in the DBH range from $10^{-1}9$ cm, significant differences related to the method of bucking were found, in RWE m^3 structure.

Due to different methods applied in selected plots, the assortment structures differ significantly. Analysing results from the mechanical pulping industry perspective, we could favour the method used on Plot 1, where production of green wood chips was prioritised. However, the production of wood chips represents 32% and 26% of total production, for Plots 1 and 2 respectively.

The total costs of wood chip production (at landing site) reported by the contractor were €10.56/loose m^3 or €34.22/green t; data from our test plots are only 6% lower (€9.88/loose m^3 or 37.54/green t). The selling price of wood chips delivered at plant site was €80/dry tonne (€45.5/green t). Including the transport costs (total costs of transport reported by contractor were €7140 or €18.37/green t on average), the contractor had losses of –€7.09/green t. The main factor in this case was the transport distance, which was 150 km one-way. With development of the local market, the transport distance and consequently transport costs would drop and in this case they should not exceed €8/green t.

Costs converted to the roundwood equivalent were higher on Plot 2, by more than 50%. The biggest contribution to this cost difference is the significantly greater time spent on extracting logging residues with the forwarder. Results showed that the majority of the total costs calculated on the roundwood equivalent represents costs for green chip production.

b) Vremščica Location – Black Pine

Comparison of productive time on both plots showed that on Plot 1, where production of green chips was prioritised, there were time savings of 10%. Time saved in logging is the result of final crosscutting at larger diameters (the last cross section at 10 cm or more) and a smaller share of debranching. Time saved at forwarding is the result of transporting roundwood of larger dimensions. Time saved at extraction of forest residues is the result of longer tree tops remaining after harvesting.

Average bulk density of wood chips (measured according to EN 15150: 2011) at both plots

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was similar, with 237 kg/loose m^3 on Plot 1 and 263 kg/loose m^3 on Plot 2. Productivity for all operations combined was 30.5 RWE/hour on Plot 1 and 29.2 RWE/hour on Plot 2. Productivity of all monitored operations was higher on Plot 1, with the only exception being the production of wood chips. Wood chip production was slightly higher (12.7%) on Plot 2, which can be explained by the fact that handling larger tree tops with thicker branches takes more time. The biggest difference is the difference in productivity of the forwarder, where productivity on Plot 1 was 27% higher than on Plot 2.The difference in the structure of forest wood products is seen between the classes of "Pulpwood" and "Green wood chips". On Plot 1 the percentage of pulpwood is smaller, as can be expected, because of the production of green wood chips from some of the roundwood and the lower top diameter of the last wood assortment

Figure 38. Production of wood chips at forest road (Vremščica - Black Pine)

for pulpwood. The impact of the used technology is logically reflected in the "FS factor", which indicates how many wood chips were obtained per unit of roundwood (results are presented in Table 30). In the case of plots on Vremščica, we do not have detailed information about costs and revenues of contractors, so we compared only the calculated direct costs of machinery. Analysis of the direct costs of machinery showed that costs per RWE were higher on Plot 2, by 13%. The greatest contribution to this cost difference is the longer amount of time spent for transport of forest residues with the forwarder.

Results showed that the majority of the total costs calculated on the roundwood equivalent represents green wood chip production costs (80%). Of the total costs for green wood chip production, extraction of forest residues with a forwarder represents 58% on the first plot and 66% on the second plot.

Calculated direct costs of machinery for the production of roundwood are €4.60/RWE on Plot 1 and €5.16/RWE on Plot 2. Calculated direct costs of machinery for the production of wood chips are higher, and amounted to €17.68/RWE on Plot 1 and €20.41/RWE on Plot 2. The ratio between the roundwood and green wood chip production costs is 20:80 on both plots.

c) Vremščica Location - Hop Hornbeam

The results of productive times for cutting, skidding and wood chip production are not directly comparable, since the technique and assortments on both plots were different. Comparison is possible for the cutting and skidding phase.

Comparison of productive times on both plots showed that time was saved on Plot 1 (43%), where the tree method was used in order to promote the production of green wood chips.

Productive time (converted to roundwood equivalent) of cutting as well skidding is almost half as low on Plot 1, where the tree method was used, compared to Plot 2, where the assortment method was used.

Comparison of productivity in the case of thermophilic deciduous stands is slightly different to the other locations, because two completely different systems are used. Plot 1 used the tree method with chipping of whole trees on the forest road, while Plot 2 used the assortments method with skidding of roundwood, without forest residue extraction. Both technologies are actually traditional to this area, so the comparison is justified.

Productivity on Plot 1 is 61.6% higher than on Plot 2. If we compare only the phase of cutting and skidding, we can see that the productivity of these two operations together is 48% higher on Plot 1 than on Plot 2. Productivity of cutting and skidding on Plot 1 is 9.73 RWE/hr and 5.05 RWE/hr on Plot 2. On Plot 1, where wood chips are produced, productivity of chipping whole trees is high, at 34.3 RWE/hr, which is the highest productivity of wood chip production at all comparative sample plots. The high-performance wood chipper partly contributes to this.

Average bulk density of wood chips (measured according to EN 15150: 2011) on Plot 1, where wood chips were produced, was 366 kg/loose m^3.

Produced wood products were wood chips on Plot 1 and on Plot 2, roundwood suitable for the pulpwood industry and for wood fuel. The "FS factor", which indicates how many wood chips were obtained per unit of roundwood, was determined based on roundwood analysis and weighing the branches. FS in this case was 1.29. Additionally, we performed laboratory analysis to determine the basic density of hornbeam and its humidity. Wood density was R = 600 kg/m^3.

There is no detailed information about contractors' costs and revenues for these plots, so we compared only the calculated direct costs of machinery. As mentioned above, the harvesting technology is markedly different on each plot. Therefore the direct costs of machinery are substantially different. Analysis of the direct costs of machinery showed that costs converted to RWE are higher on Plot 2, by 35%. The greatest contribution to this difference in costs is the longer time spent skidding roundwood with an adapted agricultural tractor. In the case of whole-tree skidding (Plot 1) the costs of harvesting were €6.6/RWE; for skidding of roundwood (Plot 2) costs were €11.7/RWE. On Plot 1 wood chip production costs are low, at €1.2/RWE. Calculated direct costs of machinery for the production of roundwood are €6.97/RWE on Plot 1 and €12.53/RWE on Plot 2; if the wood chip production costs are added in, the costs are €8.17/RWE (Plot 1) and €12.53/RWE (Plot 2). The ratio between the roundwood and green wood chip production costs on Plot 1 is 85:15.

d) TRNOVO Location

Comparison of productive times according to specific operations showed that even in the case of mixed forest and cutting with harvester, time savings can be expected for wood chip production (36%). In the case of mechanical harvesting and extraction with a forwarder, time savings on the first plot, especially in the phase of transporting forest residues with a forwarder, are 65%. This is a result of a higher concentration and larger quantities of logging residues.

Unlike other test plots (**Vremščica**, Nanos), where tree cutting was performed manually with a chainsaw, the case of mechanical harvesting showed that productivity increased when the production of roundwood was prioritised over green wood chip production. The productivity of mechanical harvesting was more than twice the productivity in Plot 2. The exact reason for this difference could be due to the tree structure of harvested trees. Forwarder productivity, in terms of logging residue transport, was higher when green wood chip production was optimised. Average bulk density of wood chips on Plot 1 was 382 kg/loose m^3 and on Plot 2,474 kg/loose m^3. This data is influenced by the fact that almost a year passed between harvesting and production of wood chips. Nevertheless, we can conclude that the productivity of the wood chipper and forwarder is higher when production of green wood chips is optimised. If we compare the roundwood equivalents, the difference in productivity is slightly higher. If we compare the productivity of machines per tonne of produced chips (fresh tonnes) then the differences are slightly lower. In our case, forwarder productivity was 11.7 t/h on Plot 1 and 4.9 t/h on Plot 2.

In uneven-aged forest stands of beech, fir and spruce, the amount of green wood chips produced is markedly higher on Plot 1. On Plot 1, where production of wood biomass was prioritised, the amount of green wood chips produced compared with roundwood quantity is relatively high, but this is not surprising, given the lesser number of assortments that are made from one tree.

Figure 39. Transporting forest residues with forwarder (Trnovo)

Because a harvester and forwarder are used in this location, the results cannot be compared with other test plots. Analysis of the direct costs of machinery showed that costs converted to RWE are higher on Plot 2, by 40%. The greatest contribution to this difference in costs is the longer time spent and consequently the increased costs of transporting forest residues with the forwarder. Costs of both harvesting and forwarding of roundwood are higher on Plot 1 (23%) than on Plot 2. Total costs of harvesting and forwarding amounted to €4.0/RWE on Plot 1 and €3.1/RWE on Plot 2, of which transporting roundwood with the forwarder represents more than 95%. On Plot 1, the cost of wood chip production was €6.58/RWE and 14.49/RWE on Plot 2. The cost for extraction of forest residues with the forwarder represented €4.06/RWE or 62% of total costs (Plot 1) and €11.49/RWE or 79% of total costs (Plot 2). The cost of chipping forest residues is relatively low and amounted to €2.52/RWE on Plot 1 and €3.01/RWE on Plot 2. Calculated direct costs of machinery for the production of roundwood and wood chips are €10.62/RWE on Plot 1 and €17.61/RWE on Plot 2. The ratio between the costs of roundwood and green wood chip production on Plot 1 is 38:61 and 18:82 on Plot 2.

e) Comparing the structure of productive time and direct material costs of machinery for all four test areas

Below we present a graphical comparison between all pilot cases. Through this comparison we aim to show that there are differences in both the structure of productive time as well as the total direct costs between different test areas and among areas. These differences arise from stand characteristics, natural resources, quantity and structure of felled trees, selection of machines, and experience of contractors as well as from the working methods used.

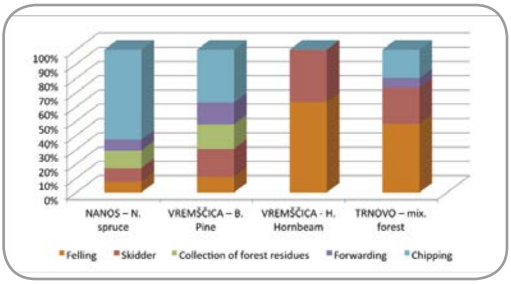

Figure 40. Structure of productive time for each test area - plots where roundwood production was prioritised

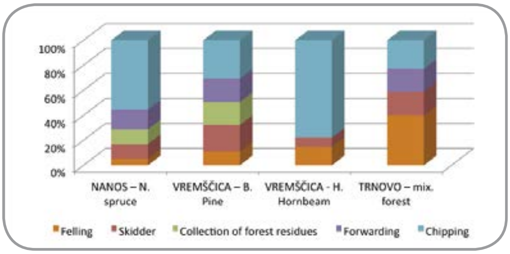

Figure 41. Structure of productive time for each test area - plots where wood chip production was prioritised

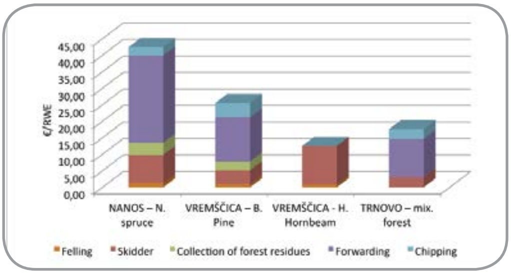

Figure 42. Comparison of costs for specific phase for each test area – (€/RWE) – roundwood

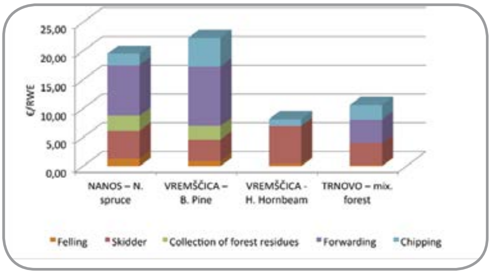

Figure 43. Comparison of costs for specific phase for each test area – (€/RWE) – roundwood

3.10.3.5. Conclusions and lessons learned

Utilisation of forest residues in Slovenia, where selective cutting and the cut-to-length system prevails, is not considered common forest practice. After felling with chainsaw and skidding with tractor, forest residues are commonly gathered in piles (to prevent beetle attack in coniferous stands) and left in the forest. The SFI set up several test plots to determine whether forest residue extraction in Slovenia is possible. The SFI then studied different aspects of forest residue extraction in detail. Different systems of felling and skidding were used. Production of both roundwood and green wood chips was planned on all test plots, with the difference that on some plots production of roundwood was prioritised and on the other plots, production of green wood chips.

The comparison of productive times revealed time savings in all cases where production of green wood chips was prioritised. According to results obtained from this research, we can conclude that the optimisation of green wood chips can lead to higher productivity of all operations. Analysis of the direct costs of machinery showed that costs per RWE were higher on all plots where production of green wood chips was prioritised.

There are differences in both the structure of productive time and in the total direct costs

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between different test areas and among areas. These differences arise from stand characteristics, natural resources, quantity and structure of felled trees, selection of machines, and experience of contractors, as well as from the selected working methods.

Results from plots suggest that the method of optimising the volume of roundwood and green wood chips might be an interesting and cost-efficient way of handling the first commercial thinning, especially in even-aged forest stands.

Taking into account the positive effect on bark beetle attack prevention, the mechanisation of manual work and the negative consequences of the procedures (damage to trees and soil and nutrients lost), it is hard to conclude whether or not forest residue utilisation should be recommended as a common practice in Slovenia.

Location	Main tree species	Plot number	Type of producction	Roundwood m³ss)	Pulpwood mechanical pulp cl.1	Pulpwood mechanical pulp cl.2	Pulpwood chemical pulp	Sum assortiment	Green wood	SUM	FD	FS
Nanos	Norway spruce	P1	WOOD CHIPS	6,27	6,95	6,85	0,24	20,31	13,7	34,1	1,6	0,6
Nanos	Norway spruce	P2	ROUND WOOD	3,4	4,79	5,43	2,64	16,3	5,1	21,4	1,32	0,31
Vremsica	Black pine	P1	WOOD CHIPS	4,34	NA	NA	9,4	13,7	8,05	21,79	1,59	0,59
Vremsica	Black pine	P2	ROUND WOOD	7,92	NA	NA	20,13	28,05	9,64	37,6	1,3	0,3
Gabrce	Hop hombeam	P1	WOOD CHIPS	NA	NA	NA	NA	0	55,7	55,7	1,2	1,2
Gabrce	Hop hombeam	P2	ROUND WOOD	NA	NA	NA	39,6	39,6	0	39,6	1	0
Timovo	European beech silver	P1	WOOD CHIPS	NA	NA	NA	NA	NA	32,2	NA	NA	0,55
Timovo	European beech silver	P2	ROUND WOOD	NA	NA	NA	NA	NA	12,4	NA	NA	0,15

Table no. 30 Produced assortiments and green chips on individual plots

Calculation based on the value of the tariff classes (SFS, E5)

NA – data not available
RWE m³ss – roundwood equivalent in m³ with bark
FD - constant for the available above ground biomass
FS – constant for production of green wood chips per unit of roundwood (m³ss)

3.10.3.6. Added value of the transnational cooperationAdded value of transnational cooperation

Work on the pilot action was coordinated jointly across the different areas. In the first phase, all involved partners cooperated in developing the common methodology. The methodology is completely transferable to all involved areas and is ready to be implemented in any MED area. Therefore all involved partners performed field tests, and results were consolidated by the lead partner and discussed among the working group. All the results were accompanied by technical guidelines for forest biomass production were published in a joint final report. The assessment of forest biomass production enables managers to choose management strategies and to set objectives and assess incomes and expenditures. It is also essential for setting potential energy production and planning power plants. One of the main outcomes of pilot action 1.3 is the knowledge that will be used for decision making and to inform the drafting of a biomass production plan. Another transnational outcome is the introduction of new technological approaches that are easily transferable within the MED area and are represented in various dissemination activities, such as examples of best practice. This best practice example was disseminated via several trade articles as well as in publicly available journals in Spain, France and Slovenia.

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Production of green wood chips versus traditional harvesting of wood logs

3.11. Local energy agency Spodnje Podravje (LEASP). Slovenia.

3.11.1. Legal name / Contact details

Name of the Organisation: : Local energy agency Spodnje Podravje

Acronym: LEASP

Official address, country and region: Prešernova ulica 18, 2250 Ptuj, Slovenia, Spodnje Podravje.

Website: *www.lea-ptuj.si*

Legal representative: Ass. Prof. Dr.Janez Petek; Telephone: +386 (0)41 981 463 ; Fax: +386 (0)5 99 78 002; E-mail: janez.petek@steng-nccp.si

Contact person: Ass. Prof. Dr.Janez Petek; Telephone: +386 (0)41 981 463 ; Fax: +386 (0)5 99 78 002; E-mail: janez.petek@steng-nccp.si

3.11.2. Description of the partner's activities/skills relating to biomass

Spodnje Podravje local energy agency (LEASP) is responsible for implementation of renewables in local energy systems within the municipalities of Spodnje Podravje. It is thus also responsible for accelerating the use of biomass within the Spodnje Podravje region.

The LEASP performs feasibility studies for the layout of the district heating systems based on wood biomass within the municipalities of the Spodnje Podravje region. It also performs technical analysis of the best available techniques, in order to determine the optimal technology for the use of biomass in the district heating (DH) systems based on wood biomass. The LEASP activities also focus on the set-up of the biomass cluster, covering the supply, technology and demand side of the biomass value chain as well as the establishment of biomass energy cooperatives.

3.11.3. Feasibility studies for the layout of the district heating systems based on wood biomass

3.11.3.1. Description of the action

The Local energy agency Spodnje Podravje has performed Pilot Action: Feasibility studies for the layout of district heating systems based on wood biomass.

The feasibility studies for the district heating (DH) system layout based on wood biomass are the preparatory documents before the final investment and implementation decisions are made. They are used as the document for the arrangements between authorities, decision makers, investors, banks and other relevant stakeholders. Feasibility studies for DH systems include the analysis of:

- existing heat consumption of public buildings;
- Installed capacities of existing heating system (boiler houses on the non-renewable energy sources);
- possible new users of district heat

(households, industries and services);

- possibilities of the possible locations for boiler houses and pipes;
- designing of the system design;
- availability of local biomass sources and prices;
- technical possibilities for the system (CHP technology, boilers);
- economic evaluation of the investment (investment costs, operating costs, payback period and internal rate of return);
- recommendation for the investors and public sector.

The main objective of this pilot action was to perform as many feasibility studies as possible for different municipalities. Therefore, activities needed to be carried out to make contact with a variety of municipalities. It was thus decided to establish a biomass consortium comprising various partners from the forestry sector as well as different municipalities. As a result, two biomass consortia were established in Slovenia. Through these consortia and through the presentation of their activities, it was easier to address municipalities. LEA SP has had positive responses from the municipalities, who see wider opportunities in the biomass industry. Besides maintenance of the renewable energy supply and consequently, environmental protection, they also see the potential for increased economic activity, creation of green jobs, employment for various sectors of the population and other additional interests.

A suitable methodology needed to be developed, in order to be able to perform the relevant feasibility studies on the DH system layout based on wood biomass. The feasibility studies needed to contain the following categories: basic description of the DH system, analysis of the potential heat consumers included within the DH system, technological analysis of the power plants and the DH system layout, process simulation of DH system operation, economic analysis of the investment and final conclusions. These categories are presented in more detail in the chapter on Methodology.

As the final outputs, feasibility studies for the DH system layout based on wood biomass were performed for the following municipalities: Cirkovce, Cirkulane, Dornava, Žetale, Ajdovscina, Bovec, Kobarid, Krajnska Gora, Miren, Most na Soci, Otlica, Pod Grcno, Tolmin, Makole, Podlehnik, Ormož, and Ptuj. In these municipalities there are ongoing activities for the actual installation of DH systems based on wood biomass. Implementation still depends, however, on the will of the decision makers and investors and the preparedness of end consumers. Interest has been roused in other municipalities, as a result of the example of good practice set by the above-mentioned municipalities. These pilot actions constituted the preliminary activities to accelerate sustainable use of local wood biomass.

3.11.3.2. Methodology

The methodology for feasibility study preparation designed by the Local energy agency Spodnje Podravje was established as result of research activities, on which components need to be included within the study to satisfy all the relevant stakeholders (investors, end users, installation team, and engineers).

The methodology has six main sections:

- Basic description of the DH system.
- The Analysis of the potential heat consumers within the DH system.

- Technology analysis of the power plants and the DH system layout.
- Process simulation of DH system operation.
- Economic analysis of the investment.
- Final conclusions.

In the following, each of the main sections of the feasibility study will be presented in-depth.

Section: Basic description of the DH system

Under this section, the basic information about the DH system needs to be presented, including the following information:

- The chosen geographical area (municipality) for DH system installation.
- Potential of the local wood biomass.
- Potential of the technical installation.
- Potential size of the DH system.

In this section only the basic data are stated, the explanation and the process of the calculations are described under other sections of the methodology.

Section: Analysis of the potential heat consumers within the DH system

The initial step in the DH system planning phase is to determine the size of the DH system and identify potential heat consumers. Firstly, when a specific geographic area is depicted, an analysis of the present energy supply in the municipality has to be performed. This is carried out in Local Energy Concepts documents, where an in-depth analysis of the energy issues within municipalities is conducted. After this, the potential heat consumers are identified and compared with the optimal layout standards for the DH system. After that, present heat consumption is listed, as presented in Table no. 31

Potential heat consumer
Heating area
Type of heat source
Power input of heat energy (kW)
Consumption of useful energy (kWh/a)

Table no. 31 Overview of present thermal energy consumption of potential heat consumers

Section: Technology analysis of the power plants and the DH system layout

In the section on the technological analysis of the power plants, various scenarios are analysed. The technologies are depicted in accordance with best available techniques. Different technologies are better suited to the specific requirements and needs of different DH systems. It depends on the size of the system, the type of energy that would be produced (heat, cool and/or electricity), temperature levels of the system, type of end consumers and other categories. At first the possible technologies are described, then the chosen technology is presented more in-depth. Table no. 32 presents the basic technical data for the case of the organic rankine cycle (ORC) power plant, by way of example.

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Heat source	Thermal oil in a closed circuit
Rated temperature of the thermal oil on the hot side (inlet/outlet)	310/250 °C
Thermal power of the thermal oil on the hot side	4,690 kW
Rated temperature of the thermal oil on the cold side (inlet/outlet)	250/130 °C
Thermal power of the thermal oil on the cold side	450 kW
Hot water temperature (inlet/outlet)	60/80 °C
Thermal power for the heat consumers	4,100 kW
Electrical power at the threshold of the electrical generator	1,001 kW
Own electricity consumption (power of own consumption)	51 kW
Output electric power (in electric grid)	950 kW
Dimensions of the cogenerating plant	15 x 4.5 x 3.3 m
Electrical generator	Asynchronous, 3 phase, low voltage, 400 V

Table no. 32 Basic data of the ORC plant

Section: Process simulation of DH system operation

The mass and heat balance of the system needs to be conducted under the process simulation section. When calculating these balances, the technical characteristics of the equipment manufacturer or provider were taken into account. The data required for the calculation are the following: power plant production time, operating support, bulk weight of chips, moisture content of wood chips, price of wood chips, calorific value, diversity factor of heat consumers, annual efficiency of the boiler house, capacity of generated electricity, capacity of heat energy, total power required, electricity sold to the grid (if electricity is also produced) and others. In Table no. 33 , the end results of the simulation process are presented as produced heat and electricity and identified heat energy needs.

HEAT AND POWER	Q / (MWh/a)	P /(MW)	Pfi /(MW)
Electricity produced			
Heat energy produced			
Loss of theBoiler loss (2 %)			
Useful heat/power available			
Heat sold			
Network losses (4.5 %-7 %)			
TOTAL required heat/power			

Table no. 33 Produced heat energy and electricity and heat energy needs

O heat energy flow (MWh/a)
P consumer input power (MW)
Pfi Consumed power regarding simultaneous consumptionconnecting (MW)

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In the process simulation section, once the potential end consumers, the size of the system and the most appropriate technology for the DH system layout have been defined, the layout of the DH system pipeline can be established. Due to the network losses and additional costs of pipeline installation, the optimal network for the DH system is determined, taking into consideration the distance between end consumers "and the boiler room". Figure 44 presents a map of the DH system pipeline, with the corresponding heat consumers.

Figure 44. Map of Ormož DH syste

1 Pfeifer Langen
2 Carrera Optyl
3 Households
4 Municipal building
5 Kindergarten
6 Stanka Vraza primary school
7 Ormož primary school
8 Secondary school
9 Retirement home
10 Health care centre
11 Castle farm
12 Castle
13 Police station
14 Hospital
15 Service sector

Section: Economic analysis of the investment

This section analyses different scenarios of teThis section analyses different scenarios of technology providers and the corresponding equipment. The end price of the sold heat is defined in different ways for different end consumers. For the industrial end consumers, the final price is calculated according to consumption and heating costs. For the private sector, the final price is established in line with regulations on the pricing of the production and distribution of steam and hot water for district heating purposes for tariff-paying customers. Afterwards, the revenues from the sold energy are calculated based on sales prices and volumes of produced electricity and heat. In the costs section, the investment costs need to be identified and respected. The specification of the investment costs includes the purchase of land, project documentation preparation, installation, insurance, engineering and construction work, project management, power plant and the corresponding equipment, pipelines and various others. The operating costs of the DH system then need to be defined, which include: wood chips, workers, consumables and servicing, auxiliaries, maintenance, electricity consumption, insurance, accounting, interest costs, amortisation and other unforeseen costs. Afterwards, once all the categories have been identified, a simulation of the economic projections for the depicted time period is performed.

Section: Final conclusions

The final conclusions section expresses an opinion on the eligibility of DH system installation. The core facts of the DH system installation are reviewed, including the real proposed implementation scenario for the system, with its acknowledged restrictions and possible threats.

3.11.3.3. Stakeholders involved

The Local energy agency Spodnje Podravje's intentions was to perform as many feasibility studies as possible for DH system installation based on wood biomass in order to accelerate the sustainable use of wood biomass. Accordingly, LEASP wanted to involve society at large. Two biomass consortia were therefore established, one in the Spodnje Podravje region and one in the North Goriška region. In the Spodnje Podravje biomass consortium, there was a drive to include the maximum number of municipalities and expert organisations, with the intention of addressing and including wood owners in subsequent activities in the second phase. The Spodnje Podravje biomass consortium includes following stakeholders: Local energy agency Spodnje Podravje, Slovenian Forestry Institute, Forestry and Agriculture cooperative Žetale, Forest management company Maribor, Goriška Local Energy Agency, Municipality of Ptuj, Municipality of Cirkulane, Municipality of Destrnik, Municipality of Dornava, Municipality of Gorišnica, Municipality of Hajdina, Municipality of Juršinci, Municipality of Kidricevo, Municipality of Majsperk, Municipality of Markovci, Municipality of Podlehnik, Municipality of Sveti Andraž, Municipality of Trnovska vas, Municipality of Videm, Municipality of Zavrc, Municipality of Zetale, Municipality of Makole, The structure of the Goriška biomass consortium is similar. The main objectives of establishing biomass consortia are:

- exploiting the potential of forests for development of wood processing and energy production;
- ensuring the sustained supply of wood without compromising the sustainability of forests;
- establishing plantations of fast-growing

tree and shrub species in degraded areas, with the aim of revitalising these areas and simultaneously producing wood destined mainly for energy purposes;

- facilitating the establishment of wood processing plants, based on local sources of wood;
- as far as possible, taking advantage of biomass for heating public buildings, where it is feasible and economically justified;
- facilitating the establishment of local biomass logistics centres for the production and storage of various wood fuels of guaranteed quality;
- ensuring a high degree of energy self-sufficiency at local level;
- providing new jobs at local level;
- encouraging the development of research activities in the fields of extraction, processing and wood usage;
- achieving national and European goals on climate change, energy efficiency and use of renewable energy sources, according to the requirements of 28/2009/CE.

In the case of DH system installation, it is important that local government representatives be involved, given that they are the decision makers for the space act in the future and the plans for future investments have to be provided in advance. To this end, the municipalities showed a great deal of interest in the biomass consortia and arrangements for future investments are in process.

Additionally, the PROFORBIOMED project was presented at various national and international conferences and seminars, as well as in direct meetings with possible investors and end users (Figure 45).

Figure 45. Stakeholders' meeting.

3.11.3.4. Outputs

The main outputs of the project are the various feaThe main outputs of the project are the various feasibility studies that were conducted for the layout of the district heating system based on wood biomass. The methodology for the feasibility studies was created and the final concept was used for the preparation of the above-mentioned studies.

- The following is a list of the main PROFORBIOMED outputs, comprising various feasibility studies for different municipalities:
- Feasibility study for the layout of the district heating system based on wood biomass for the Cirkovce municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for

the Cirkulane municipality.

- Feasibility study for the layout of the district heating system based on wood biomass for the Dornava municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Žetale municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Ajdovscina municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Bovec municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Kobarid municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Krajnska Gora municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Miren municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Most na Soci municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Otlica municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the PodGrcno municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Tolmin municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Makole municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Podlehnik municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Ormož municipality.
- Feasibility study for the layout of the district heating system based on wood biomass for the Ptuj municipality.

3.11.3.5. Impacts

Production of various feasibility studies for DH system layout based on wood biomass has a significant impact on the increased sustainability of local energy system development. Wood biomass is recognised as a renewable resource and therefore, with the local use of waste wood biomass, the renewable share of the energy balance could be increased. The feasibility studies are the basis for securing investments. As a result, various municipalities are engaged in discussions among municipalities and potential investors for DH system installation. Establishment of the biomass consortium had also a variety of impacts on establishing the biomass network to cover the entire biomass value chain (supply, technology and demand).

PROFORBIOMED project definitely provided a foundation of materials and initial activities for the successful implementation of biomass use in our country and especially, the region of Spodnje Podravje. Local energy agency Spodnje Podravje is planning the following activities as a result of the PROFORBIOMED project: establishment of the biomass technology logistics centre research projects from the field of wood biomass, establishment of a social enterprise for the production of simple wood products from waste wood parts and also support to start-ups from the wood sector.

3.11.3.6. Added value of transnational cooperation

The Mediterranean countries have similar problems and features regarding the structure of forest management, as well as some differences. However, many of the examples of good practices and advice from other partners made a significant contribution to the planning of biomass projects in Slovenia. The consortium comprised various partners, research organisations, biomass associations, professional forestry organisations, local energy agencies and others. This meant that transition of knowledge from the research field to the operative level was of high priority. The PROFORBIOMED project included research activities for the novel development of models for sustainable management use as well as development of smart grid concepts for the optimal supply of biomass. Various pilot activities were also being conducted, which implemented the research results as well as boosting interest and accelerating the final use of wood biomass in specific regions and countries.

The transnational cooperation made it possible to make comparisons between different situations in the field and provided opportunities to share experiences, knowledge and advice. In our opinion, these kinds of projects are beneficial, while greater work could be performed in terms of sharing of all the resources from the partners.

3.11.3.7. Conclusions and lessons learned

Through the activities of the PROFORBIOMED projects, the Local energy agency Spodnje Podravje accelerates the sustainable use of wood biomass. The implementation of various actions and novel models were intended, as well as connections being made with relevant stakeholders. It is committed to the real-life implementation of the new findings, in examples of good practice. The pilot actions were thus designed as suitable tools for these aims. The pilot actions covered the performance of feasibility studies for the DH system layout based on wood biomass for different municipalities in Slovenia.

Forests cover 67.3 % of Slovenia's land, making wood biomass the most suitable renewable resource for increasing the share of renewables in the energy balance. Its economic viability has also caused different stakeholders to decide for the use of biomass. There is especially strong interest among public authorities to provide green energy supply for public buildings. It thus made sense that the preparatory activities should initially include feasibility studies for DH system installation. The first step comprised the establishment of the optimal methodology for the feasibility study for DH system layout based on wood biomass. All suitable features needed to be included. The main outputs of the pilot actions were feasibility studies for DH systems in different municipalities in Slovenia. The feasibility studies provide the basis for subsequent activities by investors, decision makers and end users, in terms of organising the construction of the DH system.

The empowerment of the stakeholders in the Spodnje Podravje region in the biomass value chain was an interesting task. An analysis was performed, on which would be the most suitable way of addressing stakeholders and obtaining positive results. The decision was made to establish to biomass consortia, one in Spodnje Podravje and one in the Goriška region, to connect all the relevant stakeholders in order to increase the use of wood biomass.

PROFORBIOMED project activities also served as a catalyst for and supporter of the initial wood biomass activities in the region of Spodnje Podravje. As a result, various plans were laid for future activities. In the future, a biomass technology centre would be established, in order to: connect all the relevant stakeholders in the region; provide effective management of the entire biomass value chain; balance supply and demand of wood biomass; provide service activities and expert knowledge; and support research activities, among other functions. Research activities have also been planned, such as for example the establishment of the virtual local biomass cooperative, to balance the supply and demand of local wood biomass. In this research project, the technology and environmental segments would be included. The environmental segment would provide monitoring activities for different impacts on the environment. In the future, support is planned for the entire wood production industry and an agreement was made with the municipalities to jointly develop Spodnje Podravje's successful biomass strategy.

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Production of various feasibility studies for DH system layout based on wood biomass has a significant impact on the increased sustainability of local energy system development

3.12. University of West Macedonia (UoWM). Region of West Macedonia, Greece.

3.12.1. Legal name / Contact details

Name of the Organisation:
University of West Macedonia

Acronym: UoWM

Official address, country and region: Sialvera & Mpakola, GR 50100 KOZANI, Region of West Macedonia, Greece

Website: *www.uowm.gr/english/index.htm*

Legal representative: Prof. Petros Patias, President of the Research Committee of the University of West Macedonia

Contact person: Prof. Ananias Tomboulides, scientific supervisor, Dr. Ioannis Fallas, National Coordinator

3.12.2. Description of the partner's activities/skills relating to biomass

The University of West Macedonia (UoWM) leads research and academic activities in the field of energy in the Region of West Macedonia. The main focus of these activities has been on fossil fuels, due to the lignite thermal power stations situated in the region, which produce more than 50% of the total country's electric energy consumption. For this reason, thermodynamics, liquid flows, simulation of combustion, design of combustion chambers, etc., are among UoWM's areas of expertise.

On the other hand, an increased importance is, however, being attributed to renewable energies, among which biomass holds a privileged place, due to its importance, not only for CO_2 reduction and its potential for greening energy production, but also due to its many positive effects for the regional economy, in terms of GDP and employment creation, specifically in the region's more underdeveloped areas. In this context, in addition to expanding the fossil fuel R&D activities to the biomass field, UoWM also explores the socio-economic impact of biomass upon the region.

3.12.3. Support to PROFORBIOMED partners for the development of Bioenergy Clusters

3.12.3.1. Description of action

The action in favour of developing clusters in the framework of the WP3 of the Strategic MED PROFORBIOMED Project focuses upon facilitating the transfer of know-how and assistance from the more advanced to the less experienced partners, in order to help them proceed with their clustering efforts in their own territories.

Namely, the UoWM possesses knowledge acquired through research on clusters and the practical experience from the procedure of setting up the Cluster of Bioenergy and Environment in Western Macedonia, together with the Region of Western Macedonia. The University was thus able to provide support to the partners who were interested in proceeding with the development/ enhancement of a cluster in their regions.

3.12.3.2. Methodology

UoWM has made contact with all those partners that declared their interest in receiving support for their clustering procedures. Almost all partners confirmed their initial interest, while the preliminary discussions revealed the following, for each partner:

Italy

FLA: interest in establishing a new cluster in the Vartallina Valley, Lombardy.

ISPRA: potential interest in mobilising local actors to form a new biomass cluster, preferably on the topic of cascade use of wood.

Figure 46. Meeting at FLA premises

Portugal

CICAE, ALGAR: interest in establishing two small new clusters in the region, one in the east and one in the west, or establishing one new cluster, including all players.

Figure 47. Round table meeting in Loule

Figure 48. Signature of cluster establishment agreement in Algarve

France

AIFM, CRPF: interest in either being incorporated within an existing cluster (foresters), or forming a new one, with power stations.

Greece

ADEP: interest in establishing a network around the activities of ADEP and its biomass office.

Figure 49. Presentation on clusters to local stakeholders in ADEP / Patras

Spain

CTFC: interest in establishing a biomass cluster in Catalonia.

Figure 50. Presentation on clusters at Catalan Biomass Fair

GOV: interest in examining the potential of establishing a new cluster or being incorporated into an existing one.

Enguera: in further supporting and enriching the work of the existing cluster

Figure 51. Cluster support meeting at GOV premises, Valencia

Figure 52. Valencian Forest platform towards Cluster. Support meeting in Enguera premises

Thereafter, each partner was asked to provide UoWM with a short description of the status quo of their potential regional cluster, including information about key players, main stakeholders interested in participation, and potentially pre-existing networks and/or clusters, etc.

At the same time, UoWM collected information about specific features of each region that is hosting or will host the cluster.

Based upon this information, UoWM proceeded to arrange round tables with representatives of the receiver partners, in order to jointly discuss and analyse the individual situation of each partner.

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UoWM requested additional data for the local and regional status quo, if it was judged necessary for the evaluation of the existing situation.

Following this analysis, UoWM provided some recommendations and advice on the envisaged course of the clustering action in each partner's case. All this was gathered together in a final report detailing the existing situation in the region where the cluster is situated, and proposing general guidelines and a set of measures, policies, activities, etc., in order for the "receiving" partners to proceed with the development of their clusters.

3.12.3.3. Stakeholders involved

As mentioned above, UoWM is the main participant in this action, capitalising upon its knowledge on bioenergy clusters, as well as upon the experience acquired through the establishment of the Bioenergy and Environment Cluster in Western Macedonia. The "receiving" partners, who received experience transfers from UoWM for the development of their clusters, include the following:

In the course of the project, a significant number of local and regional stakeholders have been involved in this process, as each of the receiving partner regions has managed to mobilise many actors interested in developing synergies in the field of biomass exploitation. The list of these stakeholders is provided in the individual lists of stakeholders involved in these meetings.

3.12.3.4. Outputs

The main outputs of the project include the advancement of understanding among the project's partners on the topic and the functions of a cluster and the benefits for their region, as well as initiation of the procedures for the development of such clusters in most of the partners' territories. The signature of relevant agreements by many of the partners and the launch of cluster development in their regions will hopefully lead to the establishment of clusters as legal forms, according to the specific framework in each region. Moreover, the achievement of consensus among local stakeholders around the need to boost the development of residual forest biomass is in itself a success, as it paves the way for more integrated forms of cooperation in these territories.

Italy	France	Portugal	Greece	Spain
FLA	AIFM	CICAE	ADEP	CTFC
ISPRA	CRPF	ALGAR		GOV
				Enguera

Table no. 34 Partners involved

3.12.3.5. Impacts

As mentioned above, the activity had many positive impacts upon the participating partners: first of all, most of the partners involved acquired a better understanding of the concept of clusters and their potential positive influence on their regional economies. Following that, most managed to mobilise and meet many local stakeholders regarding the objective of developing biomass clusters and even sign some agreements, thus creating some proto-cluster formations. By doing so, they achieved a dual objective: on the one hand, they spread the benefits of using residual forestry biomass, both for the economy and for the forest itself. On the other, they introduced stakeholders to the clustering notion and, implicitly, to the spirit of cooperation. The latter may, in the long term, constitute one of the major impacts of the project, as it has the potential to significantly alter the "non-cooperation" mentality that is prevalent in the Mediterranean basin.

3.12.3.6. Added value of transnational cooperation

This activity has been a clear example of transnational cooperation, without which it would be impossible to implement it: UoWM possessed knowledge on clusters, but this had to be combined with partners' knowledge of the local situation in order to produce fruitful results.

Indeed, the UoWM expertise on clusters and namely on biomass/bioenergy clusters was important for the initial teaching seminars to local partners on the basic concepts of clusters. However, all the other stages of the activity were based on transnational cooperation and exchange of knowledge, which had to be shared in order to produce the desired added value: as each case of cluster development is unique, the partners contributed their knowledge of the local socio-economic fabric in discussions with UoWM, in order to achieve the optimum solution for each local situation. This also worked reciprocally, as the new examples enriched the knowledge of UoWM on examples of cluster development.

During this procedure, many findings and practicalities were also circulated among the various partners, such as potential core members of clusters, agreement models, etc. This was clearly boosted by the collaboration generated through the transnational cooperation promoted by PROFORBIOMED.

One other aspect that was influenced by the transnational cooperation was the fact that most of the previous experience was derived from Central, Eastern and Northern European countries. However, as mentioned earlier, the Mediterranean area has its own specific characteristics and therefore, many of the factors that affect the development of clusters in this territory are different from the above-mentioned European areas. While an isolated case of a cluster would give some useful feedback, the parallel work with many cluster formations provided a wider perspective for the Mediterranean Basin and made it easier to work with the partners, by learning from one another.

3.12.3.7. Conclusions and lessons learned

The cluster development activities have been quite successful because they succeeded, in a rather short time framework, to provide local partners with the essential tools to initiate the procedures for the development of their own clusters. Further to the provision of an adequate theoretical background, they were also quite fruitful in mobilising local stakeholders around the focal issue of exploitation of residual forestry biomass.

However, the actual time framework was in fact too short: as clustering involves the building and strengthening of relations among actors and, ultimately, among people, it is necessary to provide an adequate time framework for these activities that builds trust, through the cooperation involved. Therefore, a period such as the duration of a project seems to be more suitable for such a long process to evolve and mature at a satisfactory level.

Additionally, the development of common activities for the members of newly-built clusters within the time framework of a project, can further contribute to consolidating trust among them and provide the essential initial impetus for strengthening their ties.

Finally, it is easy to envisage that the work carried out within PROFORBIOMED on cluster development will continue in the field of biomass/ bioenergy, with new clusters being developed in the same or other regions of the eligible area, but it can also be adapted to other sectors of the economy: by maintaining the basic horizontal principles of the work carried out in this sector and adapting them to the specific needs of the new sector, the same methodology can be applied to other sectors of the economy.

Needless to say, this work can easily be transferred to potential clusters in the traditional sectors of the economy, but it can also be applied, with certain modifications, to sectors of the modern economy. Therefore, it holds very interesting perspectives for the development of regional economies around the Mediterranean Basin.

UoWM suppors Cluster development arround MED area

3.13. Patras Municipal Enterprise for Local Development (ADEP). Region of Western Greece

3.13.1. Legal name / Contact details

Name of the Organisation:
Patras Municipal Enterprise for Local Development (ADEP). Region of Western Greece.

Acronym: ADEP

Official address, country and region:
Eleutheriou Venizelou 38 & Solomou Str. 263 33 Patras. Greece.

Website: *www.adep.gr*

Legal representative: Panagiotis Xypolias; Telephone: +30 2610 361 744/7; Fax: +30 2610 361 749; E-mail: konstada@adep.gr

Contact person:
Ilias Karachalios; Telephone: +30 2610 361 744 / +30 6945656263; Fax: +30 2610 361 749 ; E-mail:ilias.karachalios@adep.gr / environmental.consulting.gr@gmail.comCoordinator

3.13.2. Description of the partner's activities/skills relating to biomass

ADEP is the municipal enterprise in Patras dealing with issues related to environmental protection and the promotion of biomass.

The Environment & Sustainable Development department of Patras Municipal Enterprise for Local Development is managing Western Greece Regional Office for Promoting Energy Recovery from Forestry Biomass.

3.13.3. Western Greece Regional Office for Promoting Energy Recovery from Forestry Biomass in Patras

Figure 53. Pictures and location of the Western Greece Regional Office for Promoting Energy Recovery from Forestry Biomass in Patras

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3.13.3.1. Description of the action

The Western Greece Regional Office for Promoting Energy Recovery from Forestry Biomass in Patras is a one-stop promotion point, able to provide information, advice and guidance to citizens and organisations – referring them to other specialised sources of advice as necessary - on a wide range of forest, wood biomass fuel and conversion technologies.

Figure 54. Wood biomass fuels shown in the office

3.13.3.2. Methodology

The methodology followed in this action was the following, step by step:

- Guidelines for planning the biomass office.
- Selection and allocation of the building for the biomass office (with an official decision from the municipality's consul), in an old reconstructed school in Monodendri.
- Planning construction of the interior and exterior of the biomass office.
- Planning the educational programme for the school visits.
- Call for tenders for the contractor to manufacture the thematic surfaces that will form the interior of the office.
- Selection of contractor.
- Construction of the interior and exterior of the office.
- Organisation of educational programme with schools.
- Inauguration.
- Operation of the office.

In order to operate in the best possible way, the Western Greece Regional Office for Promoting Energy Recovery from Forestry Biomass dissemination activities were necessary.

These were:

- Development of a Facebook page (*www.facebook.com/biomass.office*).
- Opening an email account (patras.biomass.office@gmail.com).
- Promotional videos.
- Articles on web portals.
- Participation in fairs (Environment Day, 2nd Energy Forum, Climatherm fair).

The benefit to the office of participation in these fairs was to provide information to the public on the operation of the office and the services provided there.

There is a complete training programme specifically for students at the Biomass Office (the training programme includes activities such as information about environmental issues; climate change and renewable energies; information on biomass; why and when biomass is a renewable energy; wood biomass and types; forest management; implemented best practices in the vicinity; videos related to these issues; biomass materials, such as wood pellet, briquettes and wood chips in order to familiarise the students with their use; use of electronic tablets with energy games; Biomass game with questions related to biomass use; Biomass crosswords; Energy snakes and ladders board game; Biomass Snakes & Ladders Giant board game). Students of all schools in the region were contacted upon initiation of the educational programme on biomass, through the primary and secondary education office.

Figure 55. Organised group visit in the office

The Office is operating during the morning hours and there is an option of organised group visits, through contacting the environmental department of ADEP.

3.13.3.3. Stakeholders involved

In addition to ADEP, operation of the Biomass office has also involved the Patras Municipality, who provided the building. The educational programme also takes place in this office, in collaboration with the Directorate of Primary and Secondary Education's department of environmental education of the Western Greece Region, with the aim of providing environmental education and raising awareness among students and teachers on issues related to biomass use and exploitation.

3.13.3.4. Outputs

The main outputs of these actions are:

1. Western Greece Regional Office for Promoting Energy Recovery from Forestry Biomass in Patras.

2. Educational Programme for students on use of biomass residues. The Biomass office, as a source of information, education, and technical consulting, offers specialised, objective information about wood biomass energy, technologies, and general fuel resources.

The following services are provided to stakeholders, technicians and end users:

1. Exchange of best practices concerning wood biomass technology, demonstration projects and management approaches, which will contribute to territorial cohesion. Direct support to regional stakeholders by turning know-how into show-how (workshops, project development, field trips).

2. Creation of a management tool consisting of a databank that will pool information on demonstration projects and best practice. It will help stakeholders to find tailor-made solutions for

investments in wood bioenergy plants, and for their operation.

3. Serving a regional client base, the Biomass Office works with universities, community housing projects, hospitals, businesses, utilities, government agencies and schools. Offering a wide range of technical services, assisting clients considering wood biomass systems in determining economic and site feasibility, design, vendors, funding sources, and project implementation and management.

The following services are provided to the public:

4. The Biomass Office offers extensive information about the various benefits and issues regarding the use of community-scale wood biomass energy. Its resource section covers information about the use of woody biomass and pelletisable "solid" fuels.

5. The publications section is a source for a variety of information, including an image library of downloadable pictures for use, free of charge, which includes sections on solid biomass fuel types, equipment, and combustion and storage facilities. For a comprehensive listing and explanation of the technical terms regarding all aspects of biomass technologies, see the Glossary of Biomass Heating Terms.

6. The Biomass Office can provide a list of links to related sites containing further information on wood biomass energy.

7. Organisation of events and promotional campaigns to the local community, farmers, suppliers and the technical community of the region.

8. Setting up an targeted stakeholder dialogue to promote energy use of wood biomass.

Collaborations:

9. Participation and collaboration with national and European networks related to energy from wood biomass.

Services to students and schools:

10. The aim is to become a reference point for training visits and environmental education programmes for the region's schools.

Figure 56. Educational games for schoolchildren

Operation

Between the inauguration of the Biomass office on 15th January, and 27th May of the same year, it received more than 1000 visitors. Most were students participating in the educational biomass programme that runs in the office.

3.13.3.5. Impacts

The Western Greece Region is a large area with limited use of biomass residues and unfortunately, no forest management is applied in the area. The Patras Office for Promoting Energy Recovery from Forestry Biomass is a great tool for informing citizens and educating students on related issues, disseminating biomass energy use and showing the importance of forest management and its relationship with sustainable development.

The Biomass Office was inaugurated on 15th January 2014. The inauguration started at 11 am with the sanctification, which was followed by a tour of the exhibition by the head of the ADEP's environmental department, Mr. Konstantakopoulos, initially to local stakeholders and then to school students. More than 1700 people visited the office in the first six months and over 1200 students took part in the educational programme.

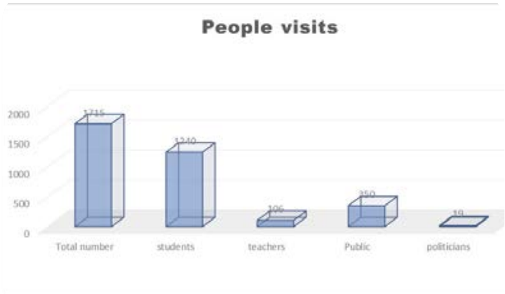

Figure 57. Number of visits

3.13.3.6. Added value of transnational cooperation

Offices for Promoting the Energy Recovery from Forestry Biomass are a great tool for informing and educating on issues related to biomass energy and forest management but also for promoting the use of residues in Mediterranean areas. Several constraints presented themselves, due to the lack of information and education on these issues. The possibility for citizens to be better informed, and so adopt new habits, by promoting the use of biomass energy residues from forestry management, is a very important issue related to the sustainable development of these areas.

Three offices for Promoting Energy Recovery from Forestry Biomass were developed within the project in the Mediterranean area. Two in Greece (Patras and Kozani) and one in Spain (Enguera). The methodology used by each partner for operating these offices has provided the partnership with extensive knowledge on the development of promoting strategies for biomass energy use and the different methodologies that can be used. This will have a positive impact on developing future promotion actions, information/educational offices and related projects in all the regions involved. At this point, the present action of the PROFORBIOMED project represents a great opportunity to test and compare the different methodologies used in these offices, in order to adopt the best information-dissemination model.

3.13.3.7. Conclusions and lessons learned

The Western Greece Office for Promoting Energy Recovery from Forestry Biomass officially started its operation the day of the inauguration. Many citizens and students have already visited. From now on, the plan is to promote it, at local, regional and also national level. For this reason, the Patras Municipal Enterprise for local development has set an ambitious schedule of organising events in Western Greece.

The Biomass office and biomass educational programme for schools is included in the Patras Municipality's Sustainable Energy Action Plan *(http://www.eumayors.eu/about/signatories_el.html?city_id=236&seap)*. The Biomass office is linked to two other successful environmental educational centres (Panachaiko Natura 2000 area centre and the Patras Water House) that ADEP is operating and it is also linked to the used oil recycling project for producing biodiesel for heating in schools.

The intention of ADEP is to continue its operation for very long time after the end of the project. In order to overcome the barriers that were previously mentioned, ADEP is planning on taking a grant from the Greek government, for which

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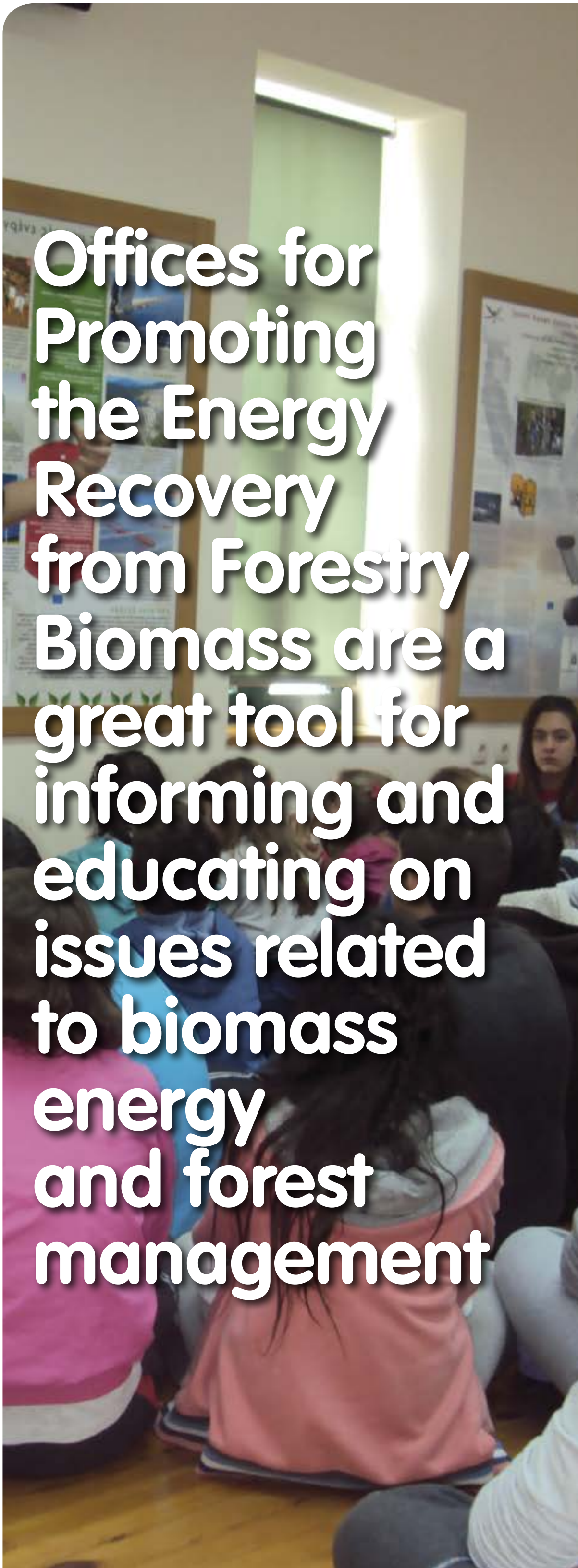
reason a meeting has been held at the Ministry of Environment and Climate Change.



Offices for Promoting the Energy Recovery from Forestry Biomass are a great tool for informing and educating on issues related to biomass energy and forest management

3.14. CEUPA/INUAF/CICAE - Business and Environmental Sciences Research Centre, D. Afonso III University, Portugal

3.14.1. Legal name/ Contact details

Name of the Organisation: : Centro de Investigação em Ciências do Ambiente e Empresariais, Instituto Superior Dom Afonso III.

Acronym: CEUPA/INUAF/CICAE

Official address, country and region: Instituto Superior Dom Afonso III, Convento Espírito Santo, 8100-641 Loulé, Portugal.

Website: *www.inuaf-studia.pt*

Legal representative: Manuel Rebelo Marques; Telephone: +351 289 420 480; Fax: +351 289 420 478; E-mail: inuaf@mail.telepac.pt

Contact person: Joana Pacheco; Ana Rita Bárbara; +351 289 420 480; Fax: +351 289 420 478; E-mail: cicae@inuaf-studia.pt; joanapacheco.pacheco@gmail.com; anabarbara@inuaf-studia.pt Coordinator

3.14.2. Description of the partner's activities/skills related to biomass

Centro de Investigação em Ciências do Ambiente e Empresariais (CICAE, the Business and Environmental Sciences Research Centre) is a private research centre, located in southern Portugal (Algarve). CICAE has skills in the fields of ecological restoration, conservation, environmental risk management, energy efficiency, quality and certification. It has cooperated in other EU-funded projects. CICAE provides consultation on scientific research activities through its academic background. It coordinates and supports research and development projects related to environmental protection and management.

3.14.3. Residual Forestry Biomass in the Algarve Region: (1) Availability of phenolic compounds and (2) Development of pellets

3.14.3.1. Description of the actions

The CICAE led Pilot Action 1.1. "Assessment of the structural diversity of forest habitats" (Work Package 4 -"Setting up of integrated strategies for the development of renewable energies"). One of the subtopics developed in this Pilot Action was the identification of possible uses for biomass, besides the currently known use for energy.

The Algarve region is located in southern Portugal and has a characteristic Mediterranean climate even though it is on the Atlantic coast. The diverse landscape contains forests with *Quercus suber, Pinus pinea, Eucalyptus globulus and Pinus pinaster* and scrublands with *Cistus ladanifer, Arbustus unedo, Erica sp.* and *Ulex sp.* The abundance of these main species, and the current need to economically develop forests, provides the opportunity to explore new markets and ideas. The characteristics of Mediterranean species with regard to flavour and specific properties are increasing their interest from the point of view of the pharmaceutical and cosmetics industries, providing the region with a new possible source of economic development and viability.

Besides the direct use of biomass for energy, two main uses with potential economic benefits were identified. (1) Availability of phenolic compounds and (2) Development of biofuels – pellets.

3.14.3.2. Methodology

Biomass was collected in the Algarve region, in forest environments corresponding to the Caldeirão and Monchique mountains (Figure 58). The biomass collected derives from species that make a large contribution to the forestry wastes mix in the sampling areas. During cleaning and maintenance operations of the forest environment in the Algarve, substantial quantities of branches from *Eucalyptus globulus* and *Pinus pinaster* are collected along with aerial parts from *Cistus ladanifer* and *Lavandula sp.* Besides these species, the forest areas of Algarve have been impaired by the proliferation of *Acacia dealbata* Link, an invasive species that thrives in fire damaged forests and may completely overwhelm the naturally occurring species.

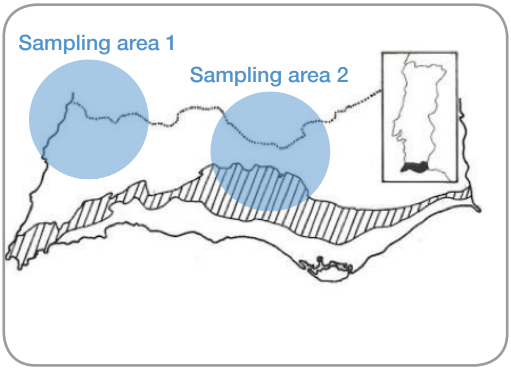


Figure 58. Schematic representation of the two locations selected for collection of residual forestry biomass.

With regard to the availability of phenolic compounds in typical flora from the Algarve, the study was conducted by CICECO, a research centre from the Chemistry Department of Aveiro University, represented here by Mara Freire and Ana Filipa Cláudio, with coordination of the activities provided by the CICAE team from Dom Afonso III University in Loulé: Domitilia Marques, Joana Pacheco, Inês Duarte, Erika Santos and Ana Bárbara.

1**- Availability of phenolic compounds:** Vegetal biomass generally has in its constitution a large quantity of valuable products that usually include phenolic compounds, phytosterols, triterpenoids, flavonoids and fatty acids (Freire, 2002). The interest of these compounds is often related to their antioxidant, anti-inflammatory and anti-microbial properties, among others (Du, 2009). These compounds are important in the cosmetics, pharmaceutical and food industries. The main components of *Eucalyptus globulus, Pinus pinea, Pinus pinaster, Cistus ladanifer* and *Acacia dealbata* samples were identified and characterised due to their high relevance and abundance in the south of Portugal. All biomass was collected in Sampling Area 1, except for *Acacia dealbata*, which was collected in Sampling Area 2 (Figure 58).

From the sampled biomass, branches and leaves were separated in order to differentiate the main compounds in each fraction. Two successive extractions were performed, an initial Soxhlet extraction using dichloromethane followed by a solid-liquid extraction with ethanol (Akkol, 2012; Freire, 2005). For each sample, moisture content and extract production were determined. Finally, GC-MS (Gas chromatography – mass spectrometry) was used to ascertain the quality and quantity of the main compounds present in each extract (Verdeguer, 2012). The total of phenolic compounds and polyphenolic antioxidants in the extracts was also determined using the Folin-Ciocalteu method (Singleton, 1965).

Besides characterisation of the various species, analyses of the same species but from different areas were performed to see if there were significant differences in composition depending on the area from which samples were collected.

Figure 59. Studied species: *a) Acacia dealbata; b) Eucalyptus globulus; c) Pinus pinaster; d) Pinus pinea; e) Cistus ladanifer*

The samples were dried for three weeks at room temperature using an experimental methodology. High temperatures can damage the samples and tend to degrade some compounds, like phenolics, and cause the loss of volatile ones.

Figure 60. Process of drying the samples; Top left - *Cistus ladanifer*; Top right - *Eucalyptus globulus*; Bottom left - *Pinus pinaster*; Bottom right - *Pinus pinea*

Once the samples were dried, branches and leaves were manually separated so that they could be analysed individually. Each part was milled with an electric mill and separated by size. The diameter selected was between 0.1 and 1 mm for all samples (branches and leaves).

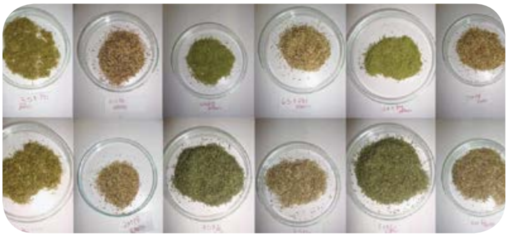


Figure 61. Dried and milled samples of biomass (*Cistus ladanifer, Eucalyptus globulus, Pinus pinaster* and *Pinus pinea*)

2.- Testing and development of various pellets from the Algarve region (Portugal). With regard to their potential use as solid biofuels, the study was conducted by Margarida Gonçalves and Benilde Mendes from UBiA, the department of Science and Technology of Biomass, from The Universidade Nova. The team also included Ulisses Fernandes, Mafalda Henriques and Mário Costa from the Mechanical Engineering Department, Instituto Superior Técnico, Technical University of Lisbon and, the CICAE team, from Dom Afonso III University, in Loulé, with Domitilia Marques, Joana Pacheco, Inês Duarte, Erika Santos and Ana Bárbara.

Biomass was partially dried in situ and then transported to a pellet production facility (Casal e Carreira Biomassa Lda) located in the Alcobaça region. The drying process was completed in covered warehouses with suitable ventilation until the biomass moisture content was below 12% (w/w).

Sub-samples of the dried biomass (1 kg) and of the biomass pellets (10 kg) were collected to perform pellet quality tests and for determination of chemical composition and calorific value at the Faculty of Science and Technology, Universidade Nova de Lisboa (Caparica, Portugal) and the Biomass Centre for Energy (Miranda do Corvo, Portugal). Representative samples of the pellets produced with forestry waste biomass (50 kg) were transported to the facilities of the Mechanical Engineering Department of the Technical University of Lisbon (Lisbon, Portugal).

Formulation and production of the biomass pellets: the materials were milled to a diameter below 3 mm and admitted to the press for densification. During pelletisation the biomass was heated to 90°C, and extruded through die orifices with a diameter of 6mm or 8mm. Generally, additives such as used vegetable oil or starch may be included in the pellets at concentrations below 2% (w/w) to improve their mechanical durability but were not used in the preparation of the pellets studied in this work, so that they would reflect only the behaviour of the various biomasses used.

Various forestry waste biomasses were densified alone (100%) or with various proportions (50% or 25%) of pine biomass, using pine biomass wastes from the furniture industry and end-of-life pine materials (known as CMC mix) and pine reference biomass, both supplied by Casal e Carreira Biomassa Lda. The formulations are given in Table no. 35.

		Pellet Formulation (% w/w)												
Biomass Description	**Pellet code**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**
Pine wood (Reference)		100				50	50	50	50					
Pine wood waste mix (CMC)										75	75	50	100	
A. dealbata wood					50				50			50		
A. dealbata branches						50								
E. globulus branches		100								25				
P. pinaster branches			100											
C. ladanifer (aerial part)				100							25			
Lavandula sp (aerial part)							50							
Mixed bushes (aerial part)								50						
Vitis vinifera (prunings)									50					

Table no. 35 Formulations of biomass pellets incorporating forestry wastes, reference pine wood and other wood wastes

Determination of pellet quality parameters: total moisture content was determined gravimetrically after drying the samples at 105°C as per EN 14774-1:2009; the ash content was evaluated gravimetrically after incineration of the samples at 550°C as per EN 14775:2009.

The bulk density of the pellets was determined by weighing a mass of pellets corresponding to a volume of 1.2 L (method adapted from EN 15103:2009).

The mechanical durability of the pellets and the quantity of fines passing through a 3.5 mm sieve were determined as per EN 15210-1:2009.

Determination of pellet composition and estimation of their calorific value: the elemental compositions (carbon, hydrogen, nitrogen and sulphur contents) of the pellets were determined at FCT-UNL, by elemental analysis (Thermo Finnigan-CE Instruments, Italy, model Flash EA 1112 CHNS series) using standard methods for characterisation of biomass and solid biofuels (CEN/TS 15104:2005; CEN/TS 15289:2006). Oxygen content was evaluated by difference and the high heating value (HHV) was estimated using an equation proposed by Bridgewater et al. that takes into account elemental composition and ash content (Bridgwater et al., 1986):

HHV MJ/kg) =
341C+1323H+68S-15.3A-120(O+N)

Eq 1

where C, H, S, O and N are the concentrations of carbon, hydrogen, sulphur, oxygen and nitrogen respectively and A is the ash content on a dry basis (db).

Combustion tests: combustion tests were performed at the laboratories of the Mechanical Engineering Department of the Technical University of Lisbon using a domestic wood-pellet fired boiler with a maximum thermal capacity of 22 kW, with forced draught and fitted with a probe for collecting flue gases. The probe was connected to a series of gas analysers for determination of hydrocarbon gases (HC), nitrogen oxides (NOx), oxygen (O_2), carbon monoxide (CO) and carbon dioxide (CO_2). Boiler performance and emissions profile were assessed and compared with a standard pine-wood pellet.

3.14.3.3. Partners involved

The following stakeholders were involved:

Associations: CBE - Biomass for energy Centre; Local Forest Owners Associations (APFSC - *Associação de Produtores Florestais da Serra do Caldeirão* and ASPAFLOBAL - *Associação de Produtores Florestais do Barlavento Algarvio*); Universities (1) *Departamento de Química*, CICECO, Universidade de Aveiro, (2) UBiA, *Departamento de Ciências e Tecnologia da Biomassa*, Faculdade de Ciências e Tecnologia, UNL and (3) Mechanical Engineering Department, Instituto Superior Técnico, Technical University of Lisbon)

3.14.3.4. Outputs

With regard to the (1) availability of phenolic compounds in typical flora from the Algarve, the Folin-Ciocalteu method was used to test for phenolic compounds. Phenolics are one of the most relevant families that appear in biomass and they react with the Folin–Ciocalteu reagent, turning blue. A second extraction is very important for their determination. *Cistus, Eucalyptus and Acacia* were found to be very rich in phenolic compounds. Both pine trees are the species with the least phenolic compounds, except for the branches of *Pinus pinea*.

Leaves of *Pinus pinea* and *Pinus pinaster* are more complex, showing a higher diversity of compounds compared to the branches.

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As expected, *Pinus pinaster* samples have a considerable quantity of resin acids. Their main function is to protect and conserve the tree. Resin acids compounds are used for making inks, lacquers and varnish. Fatty acids were also identified, which are useful in cosmetics: palmitic acid, linoleic acid and octadeonoic acid, the last being mainly in branches. Some steroids used in food industry, and with pleasant fragrances, appeared too (see the Appendix - Table no. 36).

In *Pinus pinea* samples, sugars were found alongside some identified alcohols plus glycerol, vanilic acid, fatty acids used for quickly drying products, and other compounds as described above for *Pinus pinaster*. *Pinus pinea* is also rich in steroids used in pharmaceutical industry. Some compounds were found that protect against some types of cancer and cardiovascular problems (see the Appendix -Table no. 37).

Acacia dealbata was found to have many steroids and considerable amounts of sugar. Branches have a larger amount of palmitic acid (for creams and cosmetics) and inositol, an important sugar in the prevention of some mental disorders. The most highlighted compounds were alcohols with medical and pharmaceutical uses in the prevention of diseases such as Parkinson's and skin problems. Despite this, for *Acacia dealbata*, use as wood would be of more interest than extraction of phenolics (see the Appendix - Table no. 38).

Cistus samples are rich in resin and consequently in essential oils, as for *Pinus pinaster and Pinus pinea*. *Cistus* leaves are rich in many fatty acids; its compounds are used in creams, suntan lotions and products for protecting skin. They are also used in the pharmaceutical industry, due to their anti-microbial properties, and to treat some mental problems due to their high sugar content (see the Appendix - Table no. 38).

Eucalyptus samples are rich in essential oils and non volatile extractables. Their compounds are used in creams, soaps and the cosmetics industry due to their pleasant fragrances. Some of them are alos used in the food industry as flavourings and in the tobacco and pharmaceutical industries. Due to their anti-microbial and anti-bacterial properties, they are also used in certain "elixirs" and toothpastes (see the Appendix - Table no. 39).

The main products are detailed in the Appendix (Table no. 36 to Table no. 40).

With regard to the (2) testing and development of various pellets, the quality of the pellets produced was assessed by determining moisture and ash content, bulk density, mechanical durability and quantity of fines. The results are summarised in the Appendix (Table no. 41).

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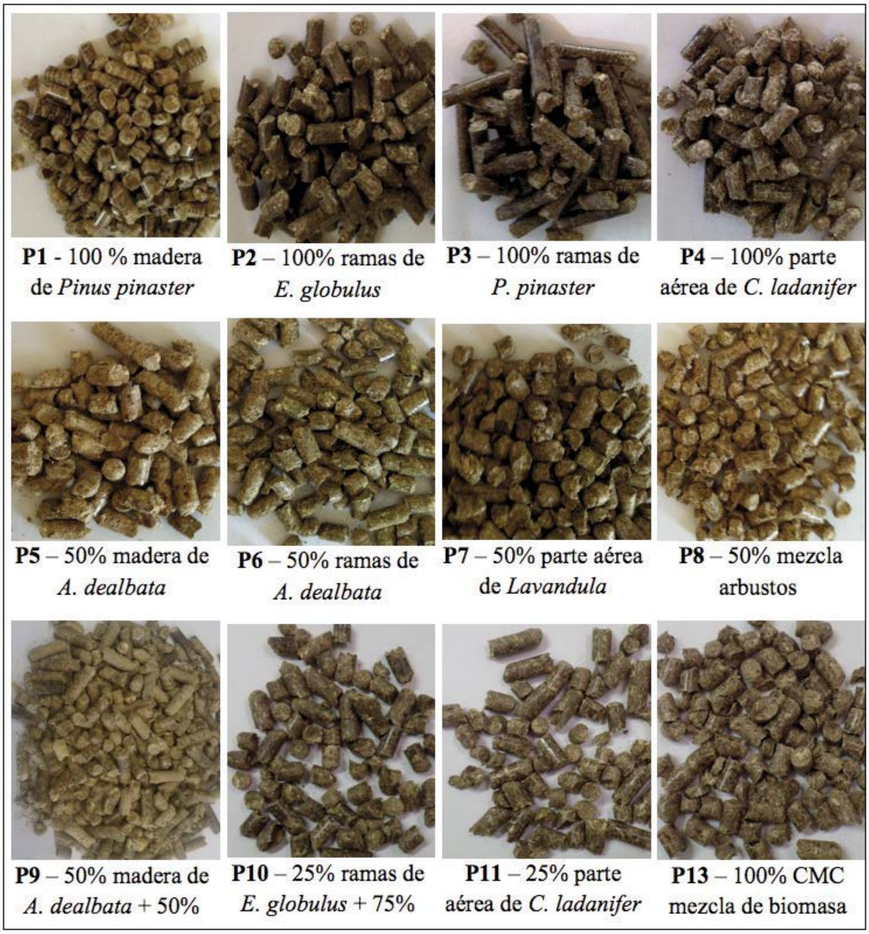

Figure 62. Pellets produced from residual forestry biomasses and their mixtures with pine wood and pine wood wastes

Pellets P2 (100% *E. globulus* branches) and P4 (100% *C. ladanifer* aerial part) presented a low HHV that resulted from their low carbon content and high ash content; the relative abundance of oils and resins in these two types of pellets is probably responsible for their good mechanical durability and low emission of fines with a diameter smaller than 0.5 mm;

Pellet P3 (100% *P. pinaster* branches) had a slightly better HHV but also presented a high ash content and poor mechanical durability;

Pellet P5 (50% *A. dealbata* wood) had the lowest ash content (0.9% w/w), good mechanical durability (94.2% w/w) and a reasonable HHV. Pellet P6 (50% *A. dealbata* branches) had a higher ash content but also a

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higher carbon content resulting in the highest HHV from the group of pellets tested. Therefore mixing these two biomasses (*A. dealbata* wood and *A. dealbata* branches), which is the logic approach if the whole plant is collected, will probably result in a biomass mix with good mechanical properties and also a good energy content;

Pellets P7 (50% *Lavandula* sp.) and P8 (50% Mixed bushes) showed acceptable HHVs but had poor durability and consequently a large quantity of fines. The quality of those pellets could be optimised by incorporation of an aggregating additive.

The combustion behaviour of pellets P5 to P8 revealed a different pattern of emissions for pellets containing non-wood biomass (P6, P7 and P8), probably because of different physical properties, such as particle size distribution, that may require adjustment of the boiler operating conditions.

The pellets of *A. dealbata* and *Vitis vinifera* prunings (P9) had the lowest ash content confirming the positive effect of *A. dealbata* biomass on this quality parameter.

The incorporation of 25% of *E. globulus* biomass or 25% of *C. ladanifer* biomass had a positive effect on the bulk density of the pellets but a negative impact on their mechanical durability. Nevertheless, although the mechanical durability of pellets P10 (25% *E. globulus* branches, 75% Pine wood waste mix) and P11 (25% *C. ladanifer,* 75% Pine wood waste mix) was significantly lower than that of Pellets P13 (100% pine biomass mix), it was still close to the durability of the pine reference pellets P1 (91.9% w/w). The high durability of pellets P13 may be explained by the presence of additives used in the furniture industry, and therefore present in these wastes, that may function as aggregating agents during pellet production.

One of the negative characteristics of the pellets produced with waste pine biomass (P13) is their high ash content that requires frequent ash removal operations from the boiler and may lead to the formation of incrustations. Incorporation of 25% of *C. ladanifer* biomass reduced the ash content of the pellets from 5.6% to 4.6%.

All pellets integrating forestry waste biomass (P9, P10 and P11) had higher carbon content and a higher HHV than the pellets with industrial biomass waste (P13), so the incorporation of forestry wastes had a positive effect on the calorific power of the pellets produced with pine biomass mix, a waste from the furniture production industry.

3.14.3.5. Impacts

The fact that biomass is not being used for energy or other purposes in the region, while simultaneously an economic crisis is affecting the region and severe forest fires occur periodically, proves that sometimes the potential is present yet nothing is done to take advantage of it. The economic exploitation of forest residual biomass for energy and for the other uses cited can improve social and economic development, such as improved forest management with direct and positive impacts on fire hazards.

These studies prove that local biomass, present in regional forest ecosystems and resulting from forest management, have potential as biofuel and have compounds with high interest to the chemical, pharmaceutical and food industries. It is now reasonable to expect Regional/National/European investment, mobilisation and profit.

3.14.3.6. Added value of transnational cooperation

Pellet P3 (100% *P. pinaster* branches) had a slightly better HHV but also presented a high ash content and poor mechanical durability;

Pellet P5 (50% *A. dealbata* wood) had the lowest ash content (0.9% w/w), good mechanical durability (94.2% w/w) and a reasonable HHV. Pellet P6 (50% *A. dealbata* branches) had a higher ash content but also a higher carbon

3.14.3.7. Conclusions and lessons learned

This study can provide guidelines for future work. The identification and quantification of compounds increases the real value and potentialities of biomass exploitation. Essential oils are high-value products that can be extracted from residual biomass. All the species studied were found to have interesting and valuable compounds for the cosmetics, pharmaceutical and food industries. The development of identification, extraction and purification techniques along with the recuperation ones, would clearly contribute to sustainable development before these fractions or biomass residues are burnt.

With regard to the availability of phenolic compounds in typical flora from the Algarve, the results show that:

As expected, *Pinus pinaster* samples have a considerable quantity of resin acids. Also identified were fatty acids: palmitic acid, linoleic acid and octadeonoic acid; the last being mainly in the branches.

In *Pinus pinea* samples, sugars were found alongside from some identified alcohols plus glycerol, vanilic acid, fatty acids used for quickly drying products, and other compounds

Acacia sp. were found to have many steroids and considerable amounts of sugar. Branches have a larger amount of palmitic acid.

Cistus samples are rich in resin and consequently in essential oils, as for *Pinus pinaster and Pinus pinea*. *Cistus* leaves are rich in many fatty acids;

Eucalyptus samples are rich in essential oils and non-volatile extractables. This study can provide guidelines for future work. The identification and quantification of compounds increase the real value and potential of biomass use. Essential oils are high-value products that can be extracted from residual biomass. All the species studied were found to have interesting and valuable compounds for the cosmetics, pharmaceutical and food industries. The development of identification, extraction and purification techniques along with the recuperation ones, would clearly contribute to sustainable development before these fractions or biomass residues are burnt.

With regard to the testing and development of various pellets:

Globally, the results indicate that forestry wastes from the Algarve region can be incorporated into pellets produced from pine biomass or from pine industrial wastes and thus contribute to reducing their carbon footprint while preserving pellet quality.

Pellet production and boiler operation parameters may require some adjustment when using different biomasses, in order to obtain pellets with good mechanical characteristics and to minimise flue gas emissions.

*Acacia dealbat*a biomass presented the best overall values for all parameters tested and resulted in pellets with a quality comparable to or even better than pine reference pellets.

Since the regular felling of young *Acacia* trees is the recommended procedure to control the expansion of this invasive species and allow the growth of

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autochthonous components of the ecosystem, an opportunity to couple forest management with sustainable pellet production has been identified. Furthermore, the incorporation of mixed bushes into biomass pellets, especially at mass ratios below 50%, is a strategy that may contribute to drawing economic value from such waste and act as an incentive for regular maintenance of forest areas.

3.14.3.8. Appendix

	Family of compounds	Compounds	Properties and applications
Pinus pinaster	Resin acids	Pima Pimaric acid ric acid	Properties related to protection, conservation and drying. Used in: inks, lacquers and varnishes.
		Abietic acid	
	Resin ac Fatty acids ids	Palmitic acid	Creams, soaps and cosmetics generally.
		Linolenic acid	Reduces cardiovascular risk and has a neuro-protective effect on living beings.
		Linoleic acid	Increases the production of testosterone.
		Stearic acid	Source of energy
	Alcohols	Glycerol	In the food industry (ice-cream, syrup) and cosmetics.
		Heptanol	Cardiac electrophysiology and also cosmetics due to its pleasant fragrance.
	Triterpenoids	Coprostanol	Biomarker
	Steroids	Avenasterol	Anticancer properties, to fight cholesterol level and in cosmetics in creams or lotions
		β-sitosterol	
	Terpenoids	α-ambrinol	Pleasant aroma mainly used in cosmetics.
	Carboxilic acid	Benzoic acid	One of its derivatives is acetylsalicylic acid (aspirin). Used as a food preservative.
	Phenolic compounds	Vanillic acid	Used as antioxidant and flavouring agent

Table no. 36 Main properties and applications of compounds and families of compounds present in the biomass of *Pinus pinaster*

	Family of compounds	Compounds	Properties and applications
Pinus pinea	Resin acids	Pima Pimaric acid ric acid	Properties related to protection, conservation and drying. Used in: inks, lacquers and varnishes
		Abietic acid	
	Resin ac Fatty acids ids	Palmitic acid	Creams, soaps and cosmetics generally.
		Oleic acid	Key role in the synthesis of hormones. Used in soaps, creams and suntan lotions. Protects and regenerates the skin
		Linolenic acid	Reduces cardiovascular risk and has a neuro-protective effect on living beings.
		Linoleic acid	Increases the production of testosterone.
		Stearic acid	Source of energy
	Alcohols	Glycerol	In food industry (ice-creams, syrup) and cosmetics
		Heptanol	Cardiac electrophysiology and also cosmetics due to its pleasant fragrance
	Steroids	Avenasterol	Anticancer properties, to fight cholesterol level and in cosmetics in creams or lotions
		β-sitosterol	
	Phenolic compounds	Vanillic acid	Used as antioxidant and flavouring agent
	Sugars	Inositol	Promising advances for people suffering from conditions such as bulimia, panic attacks, obsessive-compulsive disorder (OCD) and bipolar disorders.
	Plant lignan	Matairesinol	Precursors of the mammalian lignans that have the ability to decrease the risk of occurrence of certain cancers and cardiovascular diseases
	Terpene	Gurjenene	Used in fragrances

Table no. 37 Main properties and applications of compounds and families of compounds present in the biomass of *Pinus pinea*

	Family of compounds	Compounds	Properties and applications
Acacia dealbata	Fatty acids	Palmitic acid	Creams, soaps and cosmetics generally.
		Linolenic acid	Reduces cardiovascular risk and has a neuro-protective effect on living beings.
		Linoleic acid	Increases the production of testosterone.
		Oleic acid	Key role in the synthesis of hormones. Soaps, creams and suntan lotions. Protects and regenerates the skin.
		Stearic acid	Source of energy
	Terpenoid	α- ambrinol	Pleasant aroma mainly used in cosmetics.
		Cedrol	
	Alcohols	Glycerol	In the food industry (ice-cream, syrup) and cosmetics.
		Heptanol	
		Octacosanol	Cardiac electrophysiology and cosmetics.
			Combating herpes, skin diseases, Parkinson's disease, cholesterol and atherosclerosis
	Steroids	Esterol Δ7 Esterol Δ5 Δ7, espinasterol	Producer of sterols with therapeutic anticancer properties, cholesterol lowering, and used in the cosmetics industry in creams or lotions.
	Triterpenoids	Lupenona Amirina	Protective effect against myotoxic and neuromuscular block and has antioxidant activity. Cytoprotective, anti-inflammatory and antinociceptive properties.
	Sugars	Inositol	Promising advances for conditions such as bulimia, panic attacks, obsessive-compulsive disorder (OCD) and bipolar disorders
	Hydrocarbon	Squalene	Precursor of vitamin E and hormones with anticancer and antioxidant properties.

Table no. 38 Main properties and applications of compounds and families of compounds present in the biomass of *Acacia sp*

<table>
<tr><th></th><th>Family of compounds</th><th>Compounds</th><th>Properties and applications</th></tr>
<tr><td rowspan="14">Cistus ladanifer</td><td rowspan="4">Fatty acids</td><td>Linoleic acid</td><td>Increases the production of testosterone.</td></tr>
<tr><td>Oleic acid</td><td>Key role in the synthesis of hormones. Used in soaps, creams and suntan lotions. Protects and regenerates the skin.</td></tr>
<tr><td>Stearic acid</td><td>Source of energy</td></tr>
<tr><td>Eicosanoic acid / Arachi-dic acid</td><td>Used in the production of detergents, photographic materials and lubricants.</td></tr>
<tr><td rowspan="2">Terpenoid</td><td>α- ambrinol</td><td rowspan="2">In the food industry (ice-cream, syrup) and cosmetics.</td></tr>
<tr><td>Globulol</td></tr>
<tr><td rowspan="2">Alcohols</td><td>Glycerol</td><td>In the food industry (ice-cream, syrup) and cosmetics.</td></tr>
<tr><td>Heptanol</td><td>Cardiac electrophysiology and also cosmetics due to its pleasant fragrance.</td></tr>
<tr><td>Steroids</td><td>Esterol Δ7
Esterol Δ5
Δ7, espinasterol</td><td>Producer of sterols with therapeutic anticancer properties, lowers cholesterol and used in the cosmetics industry in creams or lotions</td></tr>
<tr><td>Triterpenoids</td><td>Lupenona
Amirina</td><td>Protective effect against myotoxic and neuromuscular block and has antioxidant activity. Cytoprotective, anti-inflammatory and antinociceptive properties.</td></tr>
<tr><td>Sugars</td><td>Inositol</td><td>Promising advances for people suffering from conditions such as bulimia, panic attacks, obsessive-compulsive disorder (OCD) and bipolar disorders.</td></tr>
<tr><td>Phenolic compounds</td><td>Timol</td><td>Antioxidant with pleasant fragrances. Strong antibacterial properties and fungicide. Used in “elixirs” and toothpastes as anesthetics and antiseptics. Anti-tumour and anti-mutagenic effects.</td></tr>
<tr><td>Lactones</td><td>allicol B, alliacolide, vernolipin or lactucin</td><td>Antimicrobial, anti-inflamatory and insecticide properties.</td></tr>
</table>

Table no. 39 Main properties and applications of compounds and families of compounds present in the biomass of *Cistus ladanifer*

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	Family of compounds	Compounds	Properties and applications
Eucaliptus globulus	Fatty acids	Palmitic acid	Creams, soaps and cosmetics generally.
	Terpenoid	α- ambrinol	Pleasant aroma mainly used in cosmetics.
	Terpene (mono and sesquiterpenes)	Eucaliptol	Toxic if ingested in high doses. Used as flavouring in the food and tobacco industries, and also in insect repellents and "elixirs".
		Globulol	Sesquiterpene with antimicrobial properties
		Aromadendrene	Used in fragrances. Antimicrobial properties
		Alo- aromadendrene	Used in fragrances. Antimicrobial properties
	Alcohols	Glycerol	In the food industry (ice-cream, syrup) and cosmetics.
		Heptanol	Cardiac electrophysiology and cosmetics
	Steroids	Δ5, β-sitosterol	Anticancer properties, lowers cholesterol, and used in the cosmetics industry in creams or lotions.
	Triterpenoids	Amirina	Cytoprotective, anti-inflammatory and antinociceptive properties.
		Betulonic acid	Antibacterial and against prostate cancer
		Oleanolic acid	Anti-viral and anti-tumour properties. Protects against liver diseases
		Betulinic acid	Anti-bacterial, anti-cancer and anti-fungal
		Ursolic acid	In cosmetics mainly but it also prevents the proliferation of cancer cells
		Acetiloleanolic acid	Antiangiogenic properties
		Betulinic acetyl acid	Cytotoxic activity in human cancer cells

Table no. 40 Main properties and applications of compounds and families of compounds present in the biomass of *Eucalyptus globulus*

Pellet Code	Moisture (% w/w)	Ash (% w/w, db)	Bulk Density (kg/m³)	Mechanical durability (% w/w)	Quantity of fines (% w/w)
P1 - 100 % *Pinus pinaster* wood	7.1	1.1	733.0	91.9	0.3
P2 - 100% *E. globulus* branches	9.1	7.8	692.0	96.1	1.3
P3 - 100% *P. pinaster* branches	10.0	6.3	659.0	88.5	6.0
P4 - 100% *C. ladanifer* aerial part	8.7	6.0	670.0	95.9	0.4
P5 - 50% *A. dealbata* wood	7.5	0.9	671.0	94.2	1.1
P6 - 50% *A. dealbata* branches	2.6	1.9	695.0	91.5	2.4
P7 - 50% *Lavandula* aerial part	6.9	2.8	668.0	89.7	2.7
P8 - 50% mixed bushes	6.8	1.8	658.0	90.1	2.0
P9 - 50% *A. dealbata* wood + 50% Vitis vinifera prunings	8.5	1.8	-	-	-
P10 - 25% *E. globulus* branches + 75% pine biomass mix	7.8	5.6	712.0	88.9	5.6
P11 - 25% *C. ladanifer* aerial part + 75% pine biomass mix	8.1	4.6	681.8	90.8	5.5
P12 - 50% *A. dealbata* wood + 50% pine biomass mix	-	-	-	-	-
P13 - 100% pine biomass mix	8.9	5.6	678.6	96.1	2.2

Table no. 41 Quality parameters for pellets – moisture content, ash content, bulk density, mechanical durability and quantity of fines passing through 3.15 mm sieve

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That local biomass have potential as biofuel and have compounds with high interest to the chemical, pharmaceutical and food industries

3.15. ALGAR, Valorização e Tratamento de Resíduos Sólidos, S.A. Portugal

3.15.1. Legal name/ Contact details

Name of the Organisation: ALGAR, Valorização e Tratamento de Resíduos Sólidos, S.A.

Acronym: ALGAR, S.A.

Official address, country and region:
Barros de São João da Venda, 8135-026 ALMANCIL, Algarve, Portugal

Website: *www.algar.com.pt*

Legal representative: José Macário Correia

Contact person: Miguel Nunes

3.15.2. Description of the partner's activities/skills related to biomass

The firm "ALGAR, Valorização e Tratamento de Resíduos Sólidos, S.A." was incorporated on the 20th of May 1995 under Decree-Law no. 109/95, which governs the creation of a Multi-municipal System for the Development, Design, Construction and Operation of a Process for the "Selective Collection, Sorting and Treatment of Solid Waste in the Algarve".

In order to meet these goals, a Concessionary Contract was drawn up between the Portuguese State and ALGAR. Likewise, contracts were drawn up with the Municipal Councils in the Algarve for the Delivery and Receipt of Solid Urban Waste and Selective Collection.

ALGAR is part of the firm "E.G.F. - Empresa Geral do Fomento, S.A.", which holds 56% of the Share Capital and is the majority shareholder. The remaining 44% is held by the Algarve's 16 Municipal Councils.

Algar has three Composting Units; green waste is delivered to our facilities and transformed into an organic fertilizer.

3.15.3. Development of a Geo-Information System for Potential Forestry Biomass Management.

3.15.3.1. Description of the action

Development of a set of common methodological steps that permit assessment of forest biomass production potential and logistical exploration capabilities, preferably to be used within the territories of the Mediterranean basin.

The methodological framework is mainly dependent on GIS tools and methods whose description and sequence was typified and simplified as far as possible.

Given significant differences between territories, the first stage of the work was dedicated to assessment of the present situation. In the subsequent stages, a set of methodological steps were developed to assess biomass productivity, normalise infrastructure information and develop logistical analysis.

All of the work was territorially based in the pilot areas defined by each of the participant partners of this pilot action.

3.15.3.2. Methodology

This chapter will present the methodology adopted and, therefore, its content represents the core of the present work. The main difficulties for this type of work are related to normalisation of the basic information (each country/region/partner has different cartographic/geographical approaches to this theme) and the definition of the geoprocessing stages to adopt. These two issues condition the adopted structure and therefore must be carefully addressed. Firstly, it is crucial to define the basic core data to use, balancing it between the need to gather the essential information to fulfil the objective stated above, and the existence of such information in a large proportion (preferably all) of the territories to which the methodology is directed. Secondly, the complexity of the solution may affect the choice of software to use and the number of potential users. To face these issues, two options were adopted: question every partner to better know their basic data and the methodologies adopted to gather it, and the development of a methodological approach capable of being executed in any GIS. That said, the core of the work was developed with ESRI ArcGIS 9 and also tested in Quantum GIS. This latter solution, which is open source, increases the possibilities for dissemination of the methodology.

The present chapter in therefore organised into three subchapters related to preparatory work (production, completion and analysis of a questionnaire for the partners), forest biomass potential assessment and logistical analysis.

Preparatory work

To assess the information available from each of the partners, a questionnaire were drawn up and mailed to each of them. This document was made up of a set of 34 questions, divided in 4 thematic sections: inventory data, road network, base cartography and other information. These sections were chosen in order to gather information on the main areas of the future work. The responses were then summarised and analysed to enable normalisation of the existing data.

Road network characteristics	PARTNER					
	LP DG MA	CTFC	CRPF	SFI	UOWM	ICNF
Road identification	yes	yes	yes	yes	yes	yes
Type of surface	yes	yes	yes	no	yes	yes
Width	yes	yes	no	no	yes	yes
Turning circle	no	no	no	no	no	no
Type of vehicle	no	yes	no	no	yes	yes
Exit points (information available)	no	no	yes	no	no	partial
Crossing points (information available)	partial	no	yes	no	partial	partial
Turning points (information available)	no	no	no	no	partial	partial
Signage(information available)	no	no	no	no	no	no
Maximum speed	yes	no	no	no	no	yes
Property	yes	no	no	yes	no	partial
Crossroads	no	no	no	no	no	no

Table no. 42 Road network characteristics (questionnaire answers)

Forest Biomass potential assessment

To assess the biomass potential, a methodological approach was adopted, based on inventory data and growth models.

The proposal includes the use of inventory data from the main productive species in each region, and the application of biomass equations. A set of equations for several species and regions can be found in Zianis et. al.

This methodology was applied to the Algarve region, with priority given to the three main wood production species of the region in applying the model: *Eucalyptus globulus, Pinus pinaster and Pinus pinea*. These species represent roughly half of the forested areas of the region.

To obtain the biomass production values, a set of equations from the National Forest Inventory (AFN, 2010) was used. These equations refer to various tree parts. In this way, it was possible to select the parts that compose what is usually referred as residues (excluding the timber parts, normally used by the main industries: wood and paper pulp).

Mathematical growth models were used to obtain biomass production values for each of these species. These tools were used to simulate various silvicultural prescriptions, and obtain biometric values to use in the biomass equations.

The territorial representation of these values was achieved using soil use data. The values of potential productivity were linked to the data, and converted to a raster format. This transformation was for later use of the data as well as for possible analysis of data in variable territorial zones.

Logistical analysis

Forest biomass exploitation is dependent on two main factors: biomass availability (treated in the previous point) and operating costs. In this chapter, a description is given of the proposed methodology for using a GIS to create a set of decision support tools for analysis of the second factor. A brief generic and sequential description of the set of geoprocessing operations will be made. These operations are meant to support managers dealing with exploitation operations and forest biomass management.

The cost analysis developed within the scope of this work is mainly based on secondary transport of forest biomass (transportation between exploitation locations and industrial processing sites). Costs related to processing forest material were not addressed in this work (cutting, processing and primary transport - within the forest to the loading sites). The financial values available to characterise these operations did not present any territorial variation (i.e. they were fixed and uniform) which is why they have been excluded from the present model. Their inclusion in later analysis is, of course, possible (and recommended) and, if they present territorial variability (for instance, variations related to slope or type of forest species), their integration into the present model is easily achievable.

Basic data (mandatory)

Use of the present model is dependent on the existence of the following set of mandatory data:

- Available forest biomass (raster format)

A file obtained from the set of operations developed in the first phase of the model (briefly described in the previous section). The information must represent biomass production potential on a territorial (preferably by hectare) and temporal basis. Whenever this type of cyclical information regarding productivity is not available, the utility of a logistical analysis is severely reduced.

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- Road network

A line vector file with a representation of the road network to be used for exploration and transport of forest biomass. It must be possible to assign each of the road segments an average speed value. In some cases, if necessary, 3D files may be obtained to include information on slopes in selection of the speed values.

- Consumption locations

A point vector file with the geographical location of the considered biomass consumption locations. These locations must be located on road network segments.

Geoprocessing operations

1. Travel time calculation, over the road network, to the consumption locations

For the calculation of the average travel time over the road network, a COST DISTANCE operation is used. This operation requires a raster file as input and, therefore, the line vector file of the road network must undergo format conversion. In this conversion, the cost values to consider must be used to produce the new raster file. The cost to consider in this case will be travel time (represented in minutes), which is clearly related to the average travel time considered for each road segment. To calculate these values, the spatial resolution of the output file must be taken in consideration. In the case of the Algarve example, all the raster files have a spatial resolution of 8 meters. This means that, the cost values to consider must be converted to an 8 meter distance. For a road segment with an average speed of 80 km/h, the cost value (in minutes) to cross each 8 meter pixel will be 0.006. For each of the locations considered (consumption locations), the COST DISTANCE operation will make a cumulative calculation of the cost (travel time) over the entire road network considered. Ultimately, a raster file (geographically equal to the one used as input) classified with travel times (in minutes) will be obtained. Each cell will be coded with the value of time necessary to reach the closest destination location considered.

2. Cost allocation to the entire territory

To be able to relate each of the cells in the pilot areas with the travel cost over the road network, as calculated above, an operation called EUCLIDEAN ALLOCATION was used. Using Euclidean distance calculations between cells in the raster, this operation transfers the cost values from each cell in the road network segments, to its neighbour cells. In this way, every cell will be coded with a cost value, directly related to the one coding the closest road segment.

3. Transportation cost

To calculate the transportation costs, using travel times, a formula adapted from (Cozzi, et al., 2013) was used. Its components are described below:

CT= ((tpx2)+tt)*Cmt/Pmt

where:

CT - transport costs in euros/ton
tp - travel time over the road network (in minutes)
tt - loading and unloading time (in minutes)
Cmt - transportation costs (euros/minute)
Pmt - Maximum load allowed

Each of these values must be adapted to the reality of each region. The application of this formula in the GIS is made through the adoption of a simple map algebra operation, using the output of step 2.

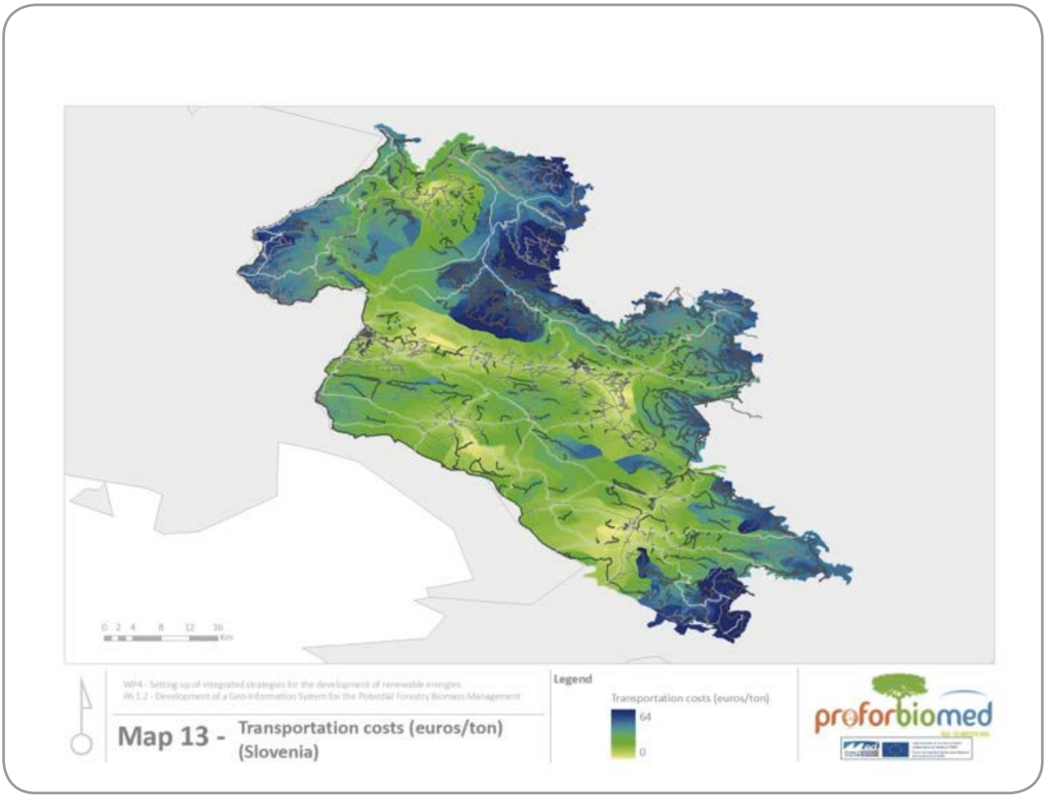

Figure 63. Transportation costs in Slovenia

4. Influence Zones calculation

Through the use of a COST ALLOCATION operation, it is possible to determine the influence zones for each of the consumption locations considered, using the cost values obtained in the previous step.

For the adopted example, the points used in step 1 were used again. At this point, it is possible to consider several analysis scenarios. The output of step 3 can be combined with various sets of consumption locations. It is also possible to establish a maximum value for the analysis (when this value is reached the remaining cells are coded as No DATA and excluded from the final result). This is particularly important if we need to define a financial threshold for a specific location to ensure its economic viability.

5. Biomass availability calculus

Using the cost zones obtained in step 3 and the influence zones calculated in step 4, combined with the available biomass values from the first phase of the model, ZONAL STATISTICS can be used to build demand curves for each of the consumption locations considered. These curves mean that the average transportation cost for each influence zone can be calculated, relating it to the amount of forest biomass available in each of these zones.

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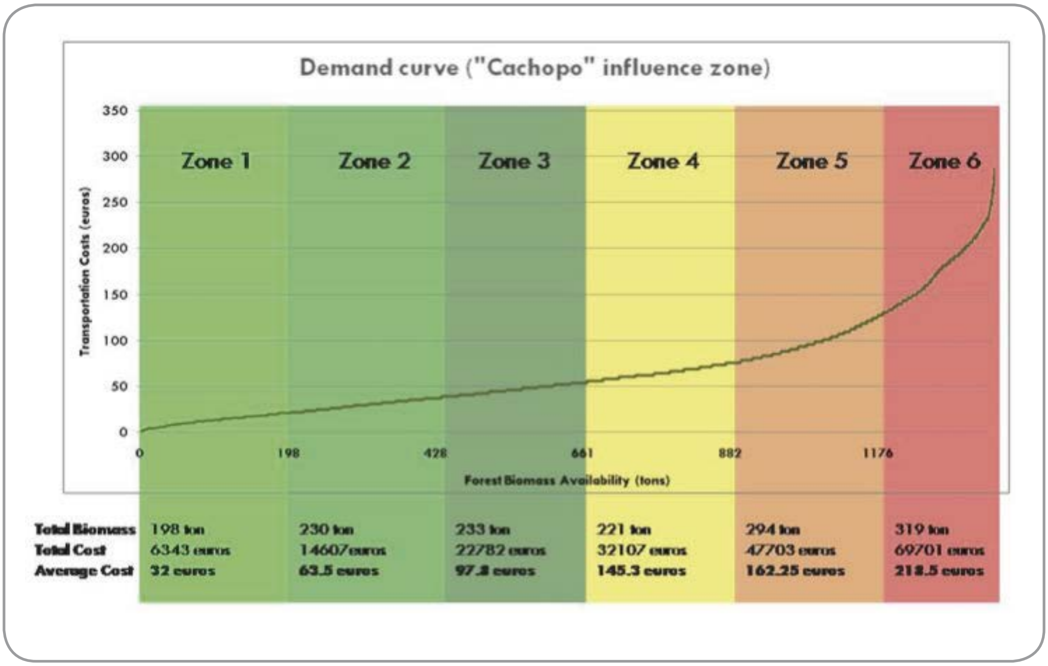

Figure 64. Demand curve for the "Cachopo" influence zone

3.15.3.3. Stakeholders involved

No stakeholders were involved in the development of this activity. The methodology was developed with the involvement of several project partners. At various phases of development, the work was presented to a regional (Algarve) group of stakeholders that included universities, businesses, forest producers, political boards and others. The questions and/or suggestions gathered in these meetings were useful in construction of the final solution.

3.15.3.4. Outputs

The main outputs of the activity, organised by the sub-sections cited above, were as follows:

The main outputs of the activity, organised by the sub-sections cited above, were as follows:

Preparatory work

A report summarising the answers given by the partners to the questionnaire. The report is structured as per the various sections of the questionnaire: pilot area, inventory data, road network data and other data available.

Forest Biomass potential evaluation

With regard to assessment of forest biomass potential, the outputs were of two kinds. For the Algarve region, once the entire methodology described above was applied, the output was a report with a set of tables describing the production potential of the region (and its main administrative zones) and the respective graphical representations.

For all other partners, the outputs of this chapter were exclusively the graphical representations, showing the forest biomass potential in their pilot areas. Using the biomass production potential data (mainly in tons/ha.year format) and soil use georeferenced data, a map was obtained for each of the partners' pilot areas with the forest biomass potential distribution.

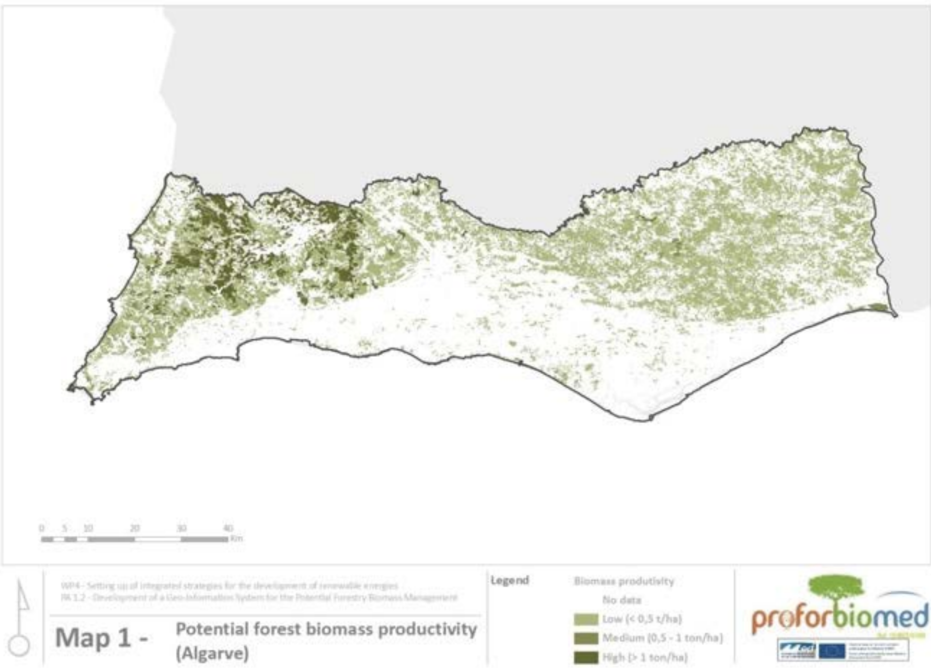

Figure 65. Potential forest biomass productivity in the Algarve Region

Logistical analysis

This section has described the production of a common methodological approach capable of being applied to the majority of partner regions and a set of geographical results from application of the method to partner data.

Road network normalisation

Transportation cost (euros/ton) maps for pilot areas

Influence zones maps for consumption locations within each of the pilot areas

A set of **demand curves f**or each of the consumption locations selected

3.15.3.5. Impacts

The impacts of this activity were mainly related to two situations: the production of forest biomass potential estimates and the development of a methodology to address logistical issues, mainly related to secondary transportation of the raw material.

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In the first case, the impact was mainly felt in regions (like the Algarve) where such studies had never been produced. This activity produced information regarding the existence (and potential for sustainable use) of forest biomass, providing various stakeholders with a starting point to address the forest biomass market. The geographical distribution information provides the greatest impact as it gives stakeholders a more realistic assessment of the potential in their region. This can also help address the logistical issues of biomass exploitation.

The impact produced by the development of a logistical analysis is related to the fact that, in most cases, secondary transport of the biomass (from the forest to the consumption location) represents the majority of operating costs. This fact highlights the importance of the outputs related to this theme. Now that the activity has produced a set of methodological steps, which should be relatively easily applicable to various territorial realities, its use can have a big impact on the decision making process associated with forest biomass exploitation.

3.15.3.6. Added value of transnational cooperation

From the preparatory work presented above, it was possible to establish the main characteristics of the various partners and their specifications and options regarding forest biomass exploitation. From this starting point, it was possible to obtain best practices from each of them, resulting in a set of common methodologies with global application, useful for a wider scope of situations.

The fact that the various transnational partners were at different stages of development of forest biomass exploitation also provided an effective way to reduce the learning curve for some of the partners.

3.15.3.7. Conclusions and learned lessons

- There are a lot of differences in the biomass production potential methodologies adopted by the various partners of the project. These differences are mainly due to distinct forest types, management strategies and final uses of the feedstock;

- This creates difficulties in the establishment of a common methodology for an extended group of partners, ensuring that each gets the information needed to address their own specifications;

- The decision to adopt a methodology based in inventory data and growth models is related to the fact that, according to the answers given by partners to the questionnaire, this type of data exists in most of the different contexts. The work of Zianis et. al., regarding growth models, can be used to apply such a methodology to a large group of European territories (partners or non-partners of the present project);

- Despite the differences in their classification and characteristics, normalisation of the road networks of the various partners is a process that, for the purpose of this work, can be achieved relatively easily. For the use recommended here, road sections must simply be classified by average speed. By its simplicity, this criteria can be widely and easily applied to all types of road (from highways to forest roads) despite the many differences between partner territories;

- The logistical analysis based on "cost-distance" formulations provides a cost estimate for biomass transport, for very large territorial areas;

- Aside from its clear dependency on road network average speed information (cost), this type of method lacks prior information on consumption points, located within the scope of the road network used in the analysis;

- This information must be integrated to create scenarios that support decision making between biomass consumption locations;
- Combination of the transport cost methodology with territorial information on biomass production availability means that information about biomass exploration and transport system profitability can be gathered relatively quickly;
- Geographical information systems are an essential tool for applying this type of option, and provide powerful support for forest managers and policy makers when installing forest biomass frameworks.

3.15.4. Evaluation of the economic, environmental and social returns from replacement of the diesel burner heating system with a biomass one at the São Brás de Alportel District Indoor Swimming Pool

3.15.4.1. Description of the action

This project applies to the "São Brás de Alportel District Indoor Swimming Pool" as a case study where currently the thermal needs are met by two diesel boilers with additional input from solar panels installed on the roof.

Motivated by constant increases in diesel prices, the swimming pool management decided to look for an alternative energy solution to reduce the high operating costs.

As a result, the new system will adopt a wood pellet boiler, which requires a check on inertia tank capacity and design of the wood pellet storage solution.

The viability study will consider the swimming pool energy demands via current diesel consumption compared with the same energy supplied by a wood pellet system, once investments and operational costs have been identified.

3.15.4.2. Methodology

The methodology applied to this study is based on comparison of current diesel consumption with biomass data as the alternate energy.

3.15.4.3. Stakeholders involved

Municipality of São Brás de Alportel

3.15.4.4. Outputs

Results analysis

Economic indicators

The technical / economic analysis was based on following assumptions:

- nterest rate (capital cost): 6%
- Equipment depreciation term: 10 years
- IRR and NPV term: 10 years
- Discount rate: 8%
- Inflation rate: 3%

The tables below give the economic indicators obtained for the various equipment items and scenarios considered (the range from green to red represents more to less attractive options).

Internal Rate of Return (IRR) @ 10 years

		Lowest wood pellets price	1 Frolling Turbomat 320 kW	2 Zantia Osaka 350 kW	3 Viessmann Pyrot 300 kW	4 Frolling Turbomat 250 kW + accumul	5 Zantia Osaka 180 kW + accumul	6 Viessmann Pyrot 220 kW + accumul	7 Herz Firematic 201 bio + accumul
IRR	Vertical metallic silo	215 €/ton	31,8%	24,9%	27,8%	28,4%	30,9%	25,5%	30,5%
	Vertical silo with elevator	178 €/ton	33,1%	27,7%	29,0%	29,8%	34,3%	28,7%	33,8%
	Brick / concrete silos	178 €/ton	30,2%	24,6%	27,1%	27,4%	30,0%	25,1%	29,5%
	Outdoor flexible silos	215 €/ton	29,3%	26,4%	25,0%	26,1%	30,4%	24,7%	29,5%

Net Present Value (NPV) @ 8%, 10 years

		Lowest wood pellets price	1 Frolling Turbomat 320 kW	2 Zantia Osaka 350 kW	3 Viessmann Pyrot 300 kW	4 Frolling Turbomat 250 kW + accumul	5 Zantia Osaka 180 kW + accumul	6 Viessmann Pyrot 220 kW + accumul	7 Herz Firematic 201 bio + accumul
VAL (€)	Vertical metallic silo	215 €/ton	171417	136198	152087	154971	167397	139311	165323
	Vertical silo with elevator	178 €/ton	193410	165530	172466	176964	198915	170827	196839
	Brick / concrete silos	178 €/ton	179249	146388	161794	163589	177851	149501	175513
	Outdoor flexible silos	215 €/ton	159468	144695	136340	143024	164973	134701	160715

Payback (ROI) @ 10 years

		Lowest wood pellets price	1 Frolling Turbomat 320 kW	2 Zantia Osaka 350 kW	3 Viessmann Pyrot 300 kW	4 Frolling Turbomat 250 kW + accumul	5 Zantia Osaka 180 kW + accumul	6 Viessmann Pyrot 220 kW + accumul	7 Herz Firematic 201 bio + accumul
Payback (€)	Vertical metallic silo	215 €/ton	4,2	4,9	4,6	4,5	4,3	4,9	4,3
	Vertical silo with elevator	178 €/ton	4,1	4,6	4,5	4,4	4,0	4,5	4,0
	Brick / concrete silos	178 €/ton	4,4	5,0	4,7	4,6	4,4	4,9	4,4
	Outdoor flexible silos	215 €/ton	4,4	4,7	4,9	4,8	4,3	5,0	4,4

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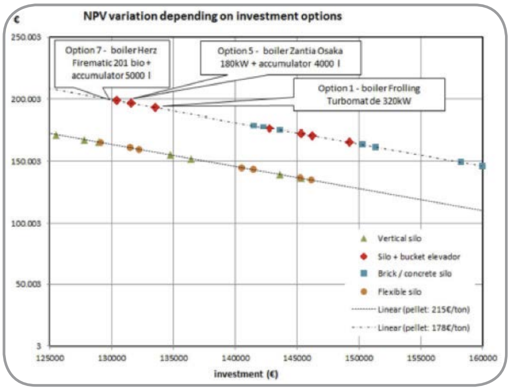
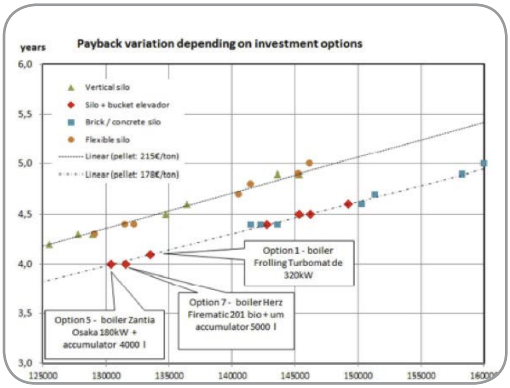
Promotion of residual forestry biomass in the Mediterranean basin

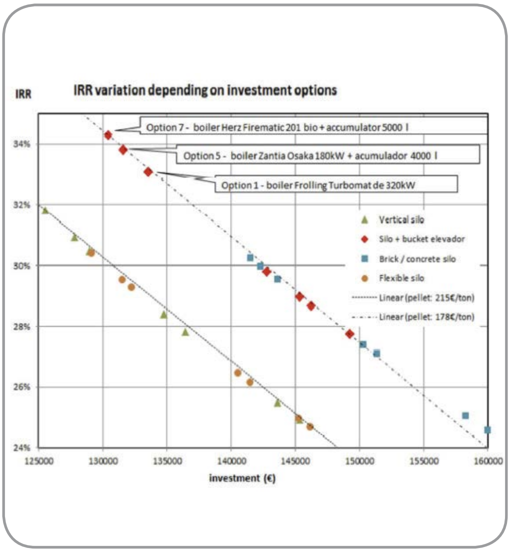
As the investment varies between €125,000 and €160,000, it will result in a Payback (ROI) from 4 to 5 years, an Internal Rate of Return (IRR) from 34% to 24% and a Net Present Value (NPV) from €130,000 to €200,000.

Technical Options 1, 5 and 7 have better economic returns and among these, Option 1 does not require an additional thermal accumulator.

The following charts show the effects on economic indicators for various solutions and investment amounts.







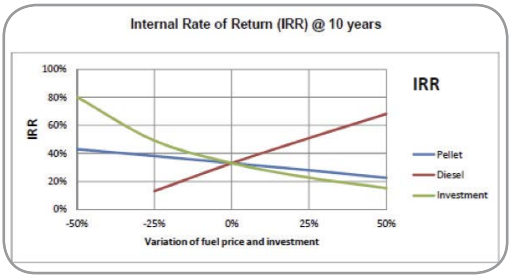
Considering that wood pellet boilers have an expected life time of about 20 years, this investment in a replacement boiler looks to be a very interesting and advisable choice.

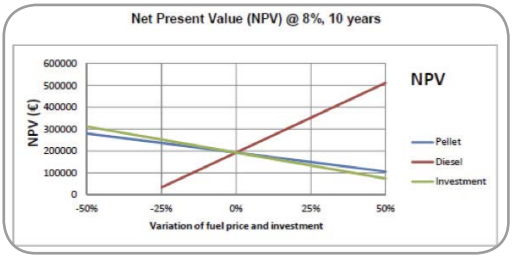
The "São Brás de Alportel District Indoor Swimming Pool" has an opportunity for a good return on investment that provides an NPV of over €100,000 and annual savings in fuel costs of more than 60%.

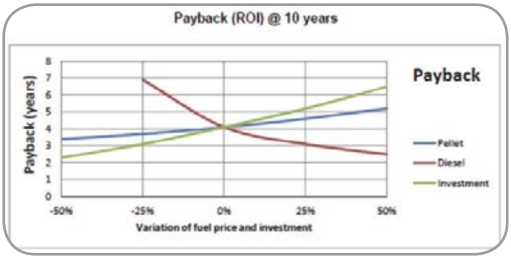
Beyond the very attractive economic indicators, installation of a wood pellet boiler provides important environmental benefits. Net CO_2 emissions associated with biomass combustion are considered as zero, as this CO_2 is the same amount absorbed by the trees that generated this biomass fuel during their growth.

Sensitivity analysis

For a sensitivity analysis, we considered a base scenario corresponding to the investment option of a 320 kW Fröling Turbomat boiler without inertia accumulator connected to a metal silo with bucket elevator. This equipment combination corresponds to a total investment cost of €133,518, with fuel costs taken as €178.00/ton for wood pellets and €1.40/litre for diesel fuel. The analysis method consisted of applying a variation from -50% to 50% on these three parameters to obtain the corresponding effects on IRR, NPV and ROI. The following graphs express the results.





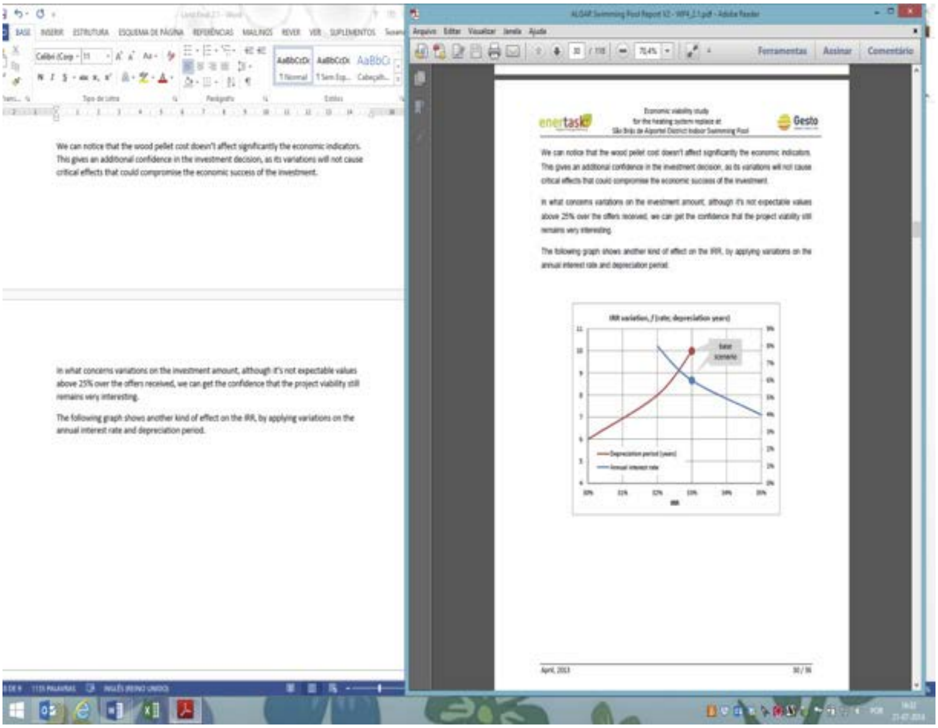


Diesel price is the parameter that produces the largest variation in the economic indicators. It is not expected that diesel prices will drop, in fact, they will probably rise with the result that the payback period will be shorter.

Note that wood pellet cost doesn't significantly affect the economic indicators. This gives additional confidence in the investment decision, as its variations will not cause critical effects that could compromise the economic success of the investment.

With regard to variations in the investment amount, although not expected to rise more than 25% over the offers received, we can be confident that the project still remains viable.

The following graph shows another kind of effect on the IRR, by applying variations on the annual interest rate and depreciation period.



Conclusions and recommendations

It is always advisable to choose a technical solution that allows the cheapest delivery method for wood pellet purchase.

The brick / concrete silo deals well with that, although the construction of these kinds of silos is more expensive, as there is the need to include a removable cover to prevent rainwater ingress and ensure safe access.

For this reason, Solution B is more advisable; this consists of a vertical metal silo usually connected to a pneumatic filling hose, which can also be associated with a bucket elevator allowing full drop deliveries from ordinary trucks.

The best equipment choices are options 1, 5 and 7, associated with storage solution B, as follows:

- Option 1 – one 320 kW Frolling Turbomat boiler

- Option 5 – one 180 kW Zantia Osaka boiler + one inertia accumulator with 4,000 litre capacity

- Option 7 – one Herz Firematic 201 bio boiler + one inertia accumulator with 5,000 litre capacity

From these choices the last two last involve lower power boilers which require an additional inertia accumulator. In fact, these two options have some drawbacks, such as the complexity of assembly to fit in with the existing installation, extra piping and electrical connections, and additional controls on the current management system.

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For Option 1, an offer was presented as a turn-key based agreement. This option is highly recommended because if any kind of malfunction or problem arises during construction or assembly, the supplier will have to ensure that the equipment and installation fulfil all requirements.

3.15.4.5. Impacts

Bearing in mind the assumptions used when conducting this study, it was found that consumption and annual costs related to the use of pellets, will be about 60% lower than current ones, which include purchase of fuel (diesel).

In addition to the economic advantage there are also environmental benefits, as the net CO_2 emissions associated with the combustion of biomass are considered as zero.

3.15.4.6. Added value of transnational cooperation

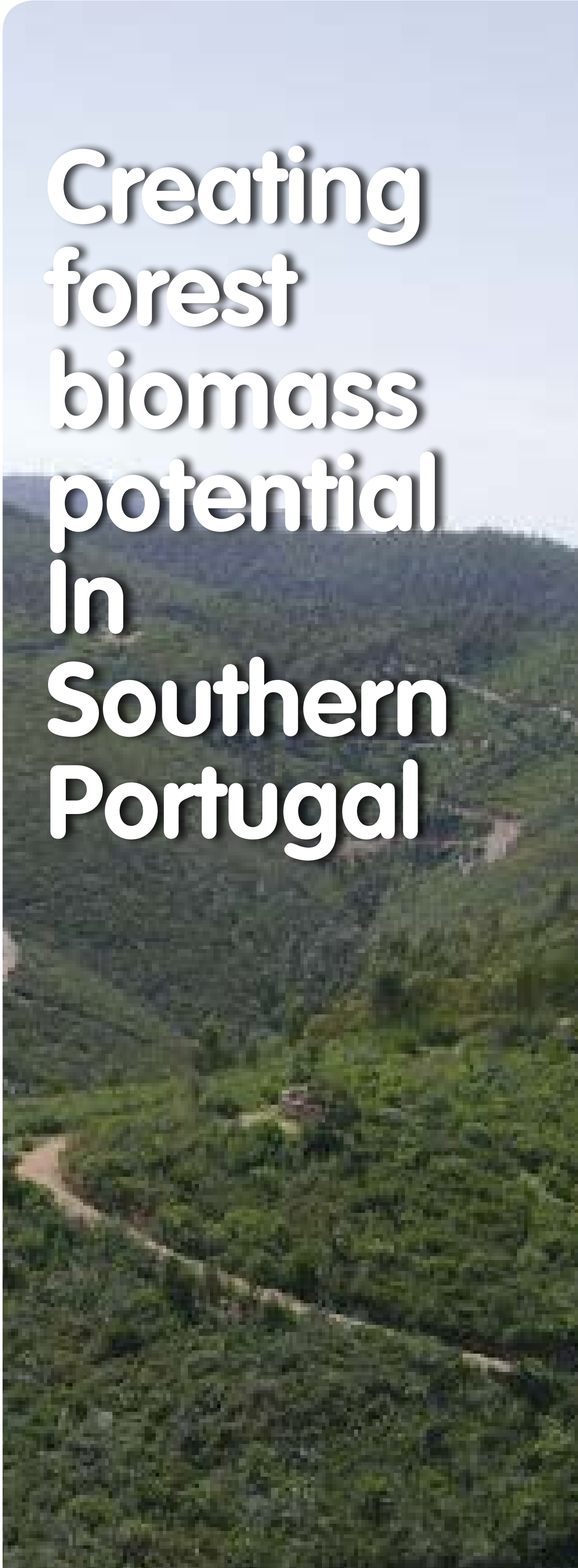
From this kind of project is possible to verify the various stages of development of each partner, some of whom are far ahead of others. So there is a great opportunity to obtain best practices for each action developed in the scope of this project and establish common methodologies.

3.15.4.7. Conclusions and learned lessons

As stated previously, the knowledge that we gain from each partner is added value for us to continue the pursuit of development in Biomass production, uses and systems.

Proforbiomed gave us the opportunity to study Biomass uses and compare its advantages as a fuel.

It was shown that it is relatively easy to adopt new technologies with more benefits, both economic and environmental.



3.16. Regional Department of Rural e Territorial Development (DRSRT), Sicily Region

3.16.1. Legal name/ Contact details

Name of the Organisation: : Dipartimento Regionale dello Sviluppo Rurale e Territoriale, Assessorato regionale dell'agricoltura, dello sviluppo rurale e della pesca mediterránea, Regione Siciliana

Acronym: DRSRT

Official address, country and region: via Regione Siciliana, 4600 – 90145 Palermo, Sicily, Italy.

Website: *https://pti.regione.sicilia.it/portal/page/portal/PIR_PORTALE/PIR_LaStrutturaRegionale/PIR_AssessoratoregionaledelleRisorseAgricoleeAlimentari/PIR_AzForesteDemaniali/PIR_2777669.2805205784*

Legal representative: Felice Bonanno, Telephone: +39 091 7077401; Fax: +39 091 9838994; E-mail: dirigente.aziendaforeste@regione.sicilia.it

Contact person: Massimo Pizzuto Antinoro Telephone: +39 091 7077157; Fax: +39 091 9838994; E-mail: mpizzuto@regione.sicilia.it

3.16.2. Description of the partner's activities/skills related to biomass

The Regional Department of Rural and Territorial development is the public authority which manages all state-owned forests of the Sicilian Region. The Authority has an institutional role that, due to the geographical, economical and social background in which it is carried out, foresees development of management policies as well as the enforcement of project choices and ideas, at times courageous and necessarily aiming at long terms results that are implemented according to planning logics. Its widespread and constant presence on the territory certainly guarantee the best efficiency in the promotion of biomass use as renewable energy font.

3.16.3. Assessment of forest biomass derivable from the sustainable management of Mediterranean plantations in the Sicani mountains (Sicily)

3.16.3.1. Description of the action

In view of an ecological and environmentally use of the biomass drew from forest operations, it is utterly important to well know the forest ecosystems characterizing the regional territory and in particular the pilot area of the Proforbiomed project. In this way it was possible to acquire specific information on the forest types in the area, its ecological and structural characteristics and the evolutionary dynamics. The information gathered have been fundamental in order to detect the most suitable forest management policies and interventions, able to put together the use of biomass and an increased of forest ecosystems stability.

The studies carried out in the pilot area of the Proforbiomed project can be considered representative of a fair part of the regional territory for what concerns the social, economic and environmental context (presence and distribution of reforestations and of the most widespread forest categories such as evergreen or deciduous oaks).

Overall, in the pilot area of the Proforbiomed project, reforestations of conifers and broadleaves cover a surface of 8,323 hectares, equal to 44% of the woods in the area defined for the establishment of the Regional Park of the Sicani Mountains; they make up 8% of the total reforestations present in Sicily and approximately 14% of reforestations of Mediterranean and mountain conifers.

This work has the purpose of providing an overview and a short description of the consistency of forests potentially available for biomass production within the pilot area of the Proforbiomed project in Sicily. The forest resources of this area are mainly characterized by artificial forests of conifers, most of them of Regional property. The area of the Sicani Mountains is one of the districts in which, from the second half of last century, the major extensions of reforestations of western Sicily have been realized, in the scope of a policy for territorial safeguard from hydrogeological instability started from the State and adopted by the Region.

More in detail, the survey mainly aims at:

- Detecting the forest types suitable for the use of biomasses providing specific information on the ecological and site characteristics, structure and evolution in order to identify the most appropriate forestry operations;
- Provide information on the potential in terms of biomass production for the different forest types and taking into account the rate of growth and the types of interventions expected;
- Provide a contribution to the knowledge of the Sicilian forest ecosystems and their potential in terms of biomass production in order to compare them with other region in the Mediterranean basin.

3.16.3.2. Methodololgy

A. General description of the project area

The Proforbiomed pilot area is placed in mid-western Sicily, between the provinces of Palermo and Agrigento (¡Error! No se encuentra el origen de la referencia.). It almost entirely falls inside of the territory candidate for the establishment of the Regional Natural Park of the Sicani Mountains, and is included in the territories of the municipalities of Bivona, Cammarata, Santo Stefano Quisquina, San Giovanni Gemini in the province of Agrigento, and Castronovo di Sicilia in the province of Palermo (Figure 66).

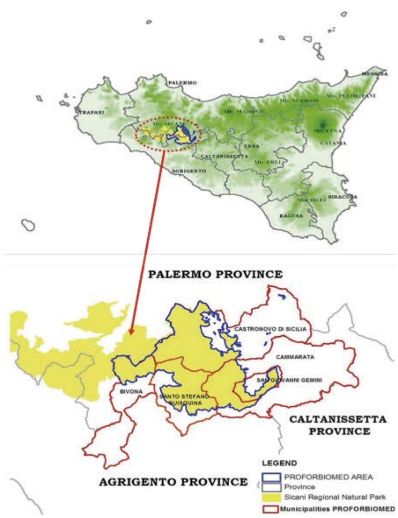


Figure 66. Framework of the Proforbiomed pilot area in Sicily

B. Forest types appropriate for the production of biomass

This chapter describes more in detail the woods potentially usable for biomass production purposes. In particular, the distribution and the physiognomic characteristics have been analyzed on the basis of several studies, mostly carried out by the Department of Agricultural and Forest Sciences of the University of Palermo

The most represented forest types in the area are mainly Mediterranean conifers (Aleppo pine, stone pine and common cypress), making up around 80% of the total (Figure 67). Among these, the most widespread forest type is the Aleppo pine forest that, with 2,097 ha, constitutes 43% of the total reforestations in the area; broadleaves reforestations, exclusively represented by *Eucalyptus* sp.pl., cover an overall surface of slightly more than 267 ha, i.e. 5% of the total reforestations.

Apart from being the most representative for the area, these forest types are also the most suitable for biomass production for energy purposes, both for the trees density and for the extension of the forest types affected by silvicultural operations (thinning cuts aimed at re-naturalisation), as well as for the low commercial value of the supplies obtainable by such actions.

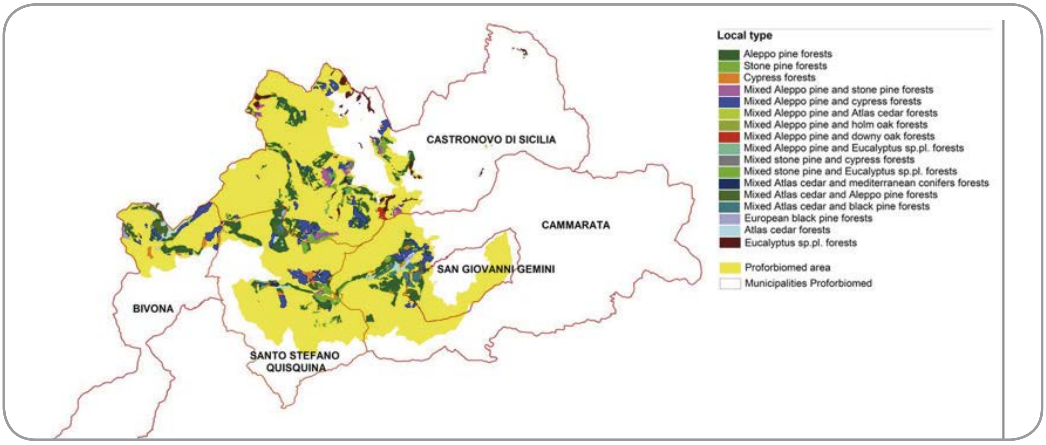


Figure 67. DIstribution of forest type plantations in the Proforbiomed area

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Forest types	Physiognomic characteristics			
	Surface	Cover degree (Average)	Specific composition	
			Species	%
Aleppo pine foresta	2097.5	70	Aleppo pine	74
			Common cypress	8
			Native broadleaves	14
Stone pine foresta	313.7	55	Stone pine	57
			Common cypress	37
			Aleppo pine	6
Cypress forests	258.7	62	Common cypress	77
			Aleppo pine	9
			Native broadleaves	8
Eucalyptus sp.pl. forests	267.1	57	*Eucalyptus* sp.pl	10
Atlas cedar forests	166.6	70	Atlas cedar	85
			European black pine	5
			Native broadleaves	8
European black pine forests	77.9	74	European black pine	72
			Native broadleaves	24
Mixed Aleppo pine and cypress forests	945.1	65	Aleppo pine	40
			Common cypress	36
			Montane coniferous	21
Mixed Aleppo pine and *Eucalyptus* sp.pl. forests	16.3	-	-	-
Mixed Aleppo pine and stone pine forests	160.4	-	-	-
Mixed Aleppo pine and Atlas cedar forests	10.0	-	-	-
Mixed Aleppo pine and holm oak forests	2.4	-	-	-
Mixed Aleppo pine and downy oak forests	34.2	-	-	-
Mixed stone pine and cypress forests	30.9	-	-	-
Mixed stone pine and *Eucalyptus* sp.pl. forests	5.0	-	-	-
Mixed Atlas cedar and Aleppo pine forests	243.9	60	Atlas cedar	48
			Aleppo pine	35
			other Medit. conifers	17
Mixed Atlas cedar and Medit. conifers forests	25.7	-	-	-
Mixed Atlas cedar and European black pine forests	116.8	74	Atlas cedar	41
			European black pine	30
			Native broadleaves	22

Table no. 43 Physiognomic characteristics for each forest types in the PROFORBIOMED area

C. Types of forest operations

The artificial forest stands need some silvicultural operations able to guarantee a more efficient and permanent coverage of soil, and a higher degree of stability, functionality and biodiversity. The aim of the management is, in the majority of cases, the gradual replacement of the exotic species currently present (Mediterranean and Mountain conifers) with native hardwoods.

In order to support the natural processes, it is important to plan the management choices respecting the successional trend and assessing the degree of evolution reached. In this framework find place the thinning cuts to be carried out on artificial stands, frequently showing some density conditions still similar to those of implantation phase.

More generically, the re-naturalization operations pursue the aims briefly summarized below:

- Promoting the progressive replacement of exotic species ecologically unsuitable;
- Directing stands towards a greater compositional and structural complexity and a higher environmental value;
- Favouring the restoration of natural processes, that is, of the mechanisms of self-regulation, self-perpetuation and an increase in the system's strength and resilience;
- Recreate an harmonious landscape.

D. Estimation of forest biomass for energy production

The estimate of the biomass collectable from a first thinning cut for the re-naturalization of reforested areas has been carried out through the following steps:

- Subdivision of forest types into Management Units (MU), depending on the cover degree and trees density;
- Calculation of the existing volume according to representative dendrometric data for each forest type identified on field;
- Identification of surfaces that may be involved by cuts depending on their ecological and site conditions (also taking into account accessibility, evaluated depending on slope class);
- Identification of thinning intensity in the MU;
- Calculation of stem volume collectable from thinning cuts;
- Calculation of the biomass obtainable from branches by means of the Biomass Expansion Factor (BEF) applied to the main species;
- Estimate of the average volume and average mass collectable with thinning cuts for each MU.

All forest types have been classified according to the degree of tree cover through photo interpretation of digital colour orthophotos (Flight 2007). During this phase the MU have been identified, i.e. some homogeneous areas per forest type and degree of cover. For the purposes of MU identification, the correlation between the degree of cover and trees density (Table no. 44) has been carried out. The MU with a density ranging from 600 to 900 Trees/ha (cover >50%) have been classified as dense; scarcely dense those with a density between 400 and 600 Trees/ha (cover 20-50%), sparse those with a density ranging from 200 and 400 Trees/ha (cover <20%).

In order to identify a balanced intensity of intervention, compatible with the needs of the forest stands analysed (structure regulation, start-up and/or support to the re-naturalisation processes), for each MU has been identified a thinning modality (degree and intensity) depending from their level of cover/density and slope class. Table no. 45 shows an example of the type of thinning for MU in the Atlas cedar forests type.

Forest type	Degree of cover	Trees Density (Trees/ha)	MU
Atlas cedar forests	> 50	600-900	Dense Atlas cedar forests
	20 – 50	400-600	Scarcely dense Atlas cedar forests
	< 20	200-400	Sparse Atlas cedar forests

Table no. 44 Example of correlation between Tree density and degree of cover for the identification of MU for the Atlas cedar forests type

Forest type	MU	Degree of cover	Slope	Thinning type	
		%	%	degree	intensity
Atlas cedar forest	10. Dense Atlas cedar forest (600-900 Trees/ha)	20 – 50	< 25	Strong	35%
			25 – 40	Moderate	25%
			> 40	Weak	15%
	11. Scarcely dense Atlas cedar forest (400-600 Trees/ha)	20 – 50	< 25	Moderate	25%
			25 – 40	Weak	15%
			> 40	-	-
	12. Sparse Atlas cedar forest (200-400 Trees/ha)	< 20	< 25	Weak	15%
			25 – 40	-	-
			> 40	-	-

Table no. 45 Example of different thinning intensity depending on the degree of cover and slope class

The stem volume has been calculated on the basis of dendrometric data collected in 88 sampling areas, SA), realized among different reforestations of the Sicani Mountains. In particular, 19 SA have been realized in the SCI “Bosco di S. Adriano (ITA020025), 27 in the SCI Monte Rose and Monte Pernice” (ITA020029) and 42 in the SCI “Monte Cammarata” (ITA040005). In each SA, for each tree have been registered the diameter (D) at 1.30 m and total height (H). By using the double entry volume tables, the total stem volume for each SA has been calculated from diameter and height. To the stem volumes of each SA, regrouped per MU, the Biomass Extension Factors have been applied obtaining the total aboveground biomass of trees (including trunk, branches and leaves) in volume, then subsequently transformed, through the basic density of each species, into the corresponding mass values expressed in tons. (Table no. 46).

Forest type	Tree species	Biomass Expansion Factor (BEF)	Relative Density
High forest	Atlas cedar	1.22	0.56
	Black pine	1.33	0.47
	Mediterranean pines (*Pinus halepensis, Pinus pinea, Pinus pinaster*)	1.53	0.53
	cypress (*Cupressus sempervirens, C. arizonica*)	1,70	0.31
Coppice	*Eucalyptus sp.pl.*	1.33	0.54

Table no. 46 Biomass expansion factor and basal density of species in forest types that can be used for the production of biomass for energy purpose

Once obtained the total wood mass, including branches, the average mass for each MU has been calculated depending on the degree of cover (Table no. 47).

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Forest type	Tree species	Biomass Expansion Factor (BEF)
Aleppo pine forests	Dense	217
	Scarcely dense	218
	Sparse	153
Stone pine forests	Dense	234
	Sparse	452
Common cypress and / or Arizona cypress forest	Dense	196
	Scarcely dense	57
	Sparse	52
Atlas cedar forests	Dense	107
	Scarcely dense	138
	Sparse	53
Black pine forests	Dense	97
	Scarcely dense	114
Mixed black pine and Atlas cedar forests	Dense	146
	Scarcely dense	83
	Sparse	18
Mixed Aleppo pine and cypress forests	Scarcely dense	159
	Sparse	67
Mixed Atlas cedar, black pine and Aleppo pine forests	Dense	116
	Scarcely dense	108
Mixed Atlas cedar, Aleppo pine and cypress forests	Dense	115
	Scarcely dense	102
Mixed Atlas cedar, downy oak and sycamore maple forests	Dense	104
Mixed Atlas cedar and Aleppo pine forests	Dense	185
Mixed Atlas cedar and Arizona cypress forests	Dense	99
Mixed Aleppo pine, Atlas cedar and common cypress forests	Scarcely dense	101
Mixed common cypress and Atlas cedar forests	Dense	261
Eucalyptus foresti	Dense	27
	Scarcely dense	69
	Sparse	45

Table no. 47 Average wood mass for each MU

These average values have been entered into GIS and the overall wood mass has been calculated as well as the mass to collect for each forest type with the first thinning cut.

E. Identification of exploitable biomass types

For the identification of exploitable biomass types in the pilot area we only considered the plantations of Mediterranean and Mountain conifers. Table no. 48 shows the average values of total aboveground and branches biomass obtainable for each forest type based on a first thinning cut. Table no. 49 finally shows the values of aboveground woody biomass extractable as a yearly average expressed in terms of fresh weight

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(50% moisture) and moisture expected at the entrance of the power plant (30%), considering once again a single thinning cut on a minimum period of use for a biomass power plant (15 years).

Forest type	Surface (ha)	Allowable cutting biomass (t)	Allowable cutting biomass per hectare (t/ha)	Allowable cutting biomass (t)	Allowable cutting branch wood biomass per hectare (t/ha)	% of branch wood on the total cutting biomass %
Mixed Atlas cedar and Mediterranean conifers forests	25.68	1047.78	40.80	288.42	11.23	27.53
Mixed Atlas cedar and Aleppo pine forests	243.93	7884.99	32.32	2165.98	8.88	27.47
Mixed Atlas cedar and black pine forests	185.69	1985.51	10.69	430.40	2.32	21.68
Mixed Aleppo pine and Atlas cedar forests	9.95	489.22	49.16	134.89	13.55	27.57
Mixed Aleppo pine and cypress forests	945.12	35080.08	37.12	13309.2	14.08	37.94
Mixed Aleppo pine and holm oak forests	2.36	93.19	39.50	32.44	13.75	34.81
Mixed Aleppo pine and stone pine forests	160.41	11045.00	68.85	3821.97	23.83	34.60
Mixed Aleppo pine and downy oak forests	34.21	339.69	9.93	119.76	3.50	35.26
Mixed Aleppo pine and *Eucalyptus* sp.pl. forests	16.28	993.68	61.04	343.89	21.12	34.61
Mixed stone pine and cypress forests	30.95	2558.86	82.69	886.70	28.65	34.65
Mixed stone pine and *Eucalyptus* sp.pl. forests	4.97	133.55	26.85	46.26	9.30	34.64
Atlas cedar forests	166.62	3382.81	20.30	599.99	3.60	17.74
Cypress Forests	258.73	9751.68	37.69	3998.38	15.45	41.00
Eucalyptus sp.pl. forests	267.10	2056.71	7.70	502.40	1.88	24.43
Aleppo pine forests	2101.57	129033.02	61.40	44597.82	21.22	34.56
Stone pine forests	313.72	27525.73	87.74	9531.49	30.38	34.63
European black pine forests	77.93	1781.69	22.86	443.41	5.69	24.89
Average	**-**	**-**	**40.98**	**-**	**13.44**	**31.06**
Total	**4845.24**	**235183.18**	**-**	**81253.43**	**-**	**-**

Table no. 48 Average values for total aboveground and branches biomass obtainable for each forest type, based on a first thinning cut

Forest type	Allowable cutting biomass (t)	Annual productivity of fresh biomass (50% of moisture content) (t/ha/year)	Annual productivity of fresh biomass (30% of moisture content) (t/ha/year)
Mixed Atlas cedar and Mediterranean conifers forests	25.68	2.61	2.18
Mixed Atlas cedar and Aleppo pine forests	243.93	2.07	1.72
Mixed Atlas cedar and black pine forests	185.69	0.68	0.57
Mixed Aleppo pine and Atlas cedar forests	9.95	3.15	2.62
Mixed Aleppo pine and cypress forests	945.12	2.38	1.98
Mixed Aleppo pine and holm oak forests	2.36	2.53	2.11
Mixed Aleppo pine and stone pine forests	160.41	4.41	3.67
Mixed Aleppo pine and downy oak forests	34.21	0.64	0.53
Mixed Aleppo pine and *Eucalyptus* sp.pl. forests	16.28	3.91	3.26
Mixed stone pine and cypress forests	30.95	5.29	4.41
Mixed stone pine and *Eucalyptus* sp.pl. forests	4.97	1.72	1.43
Atlas cedar forests	166.62	1.30	1.08
Cypress forests	258.73	2.41	2.01
Eucalyptus sp.pl. forests	267.10	0.49	0.41
Aleppo pine forests	2101.57	3.93	3.27
Stone pine forests	313.72	5.62	4.68
European black pine forests	77.93	1.46	1.22
Total	**4845.24**	**-**	**-**
Weighted average of annual productivity using surface of each forest type	**-**	**3.11**	**2.59**

Table no. 49 Average biomass annual productivity estimated both as fresh weight (about 50% moisture) and with a 30% moisture content

[1] The average values of extraction per hectare are estimated depending on the slope and average cover of the stands belonging to each forest type.

[2] The average values of extraction per hectare have been estimated depending on the slope and average cover of the stands belonging to each forest type.

[3] Woody biomass with a moisture content of approximately 30% has been considered as raw product, given that this is the one that is typically used at entrance of the power plant as starting material for the realization of other byproducts (wood chips, pellets etc. ...).

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3.16.3.3. Stakeholders involved

In order to bring to the attention of local communities and stakeholders the results of the activities aimed at estimating the forest biomass available for energy use in the forests of the area, some meetings were organized throughout the duration of the project.

On the 27th February 2013, Sicily Region organized a local meeting/workshop in order to present the activities of the Proforbiomed Project. The meeting was held at the boardroom of the municipality of Santo Stefano Quisquina (one of the municipalities that are included in the selected Pilot Area), in the province of Agrigento. The meeting/workshop was addressed to the local stakeholders. During the meeting, the project and the activities carried out so far were explained in order to show to local stakeholders the potential benefits and advantages that the territory of the Sicani mountains might get from the use of forest biomass.

During the first part of the Workshop for the start-up of on field activities in the pilot area of the Sicani mountains (Sicily) (9th September 2013), the main results obtained by the implementation of the Proforbiomed project were illustrated to the local stakeholders (Figure 68). The second part of the on field activities took place at the Pilot Area of Monte Katera (Portella Cicala). During the demonstration activities, following a preliminary and careful selection of plants to be removed with the aim of promoting the establishment and evolution of the re-naturalization processes, the activities of cutting, skidding and chipping of forest biomass were initiated, using innovative and low environmental impact working systems.

The main objectives intended for the stakeholders meetings have been:

- Promoting information on the possibility of combining the sustainable management of reforestations with the production of forest biomass for energy purposes, considering that for these types of forests this is the only activity that provides a cost-effective production;

Figure 68A. Workshop for the startup of on field activities in the pilot area (9th September 2013 - Santo Stefano Quisquina, AG)

Figure 68B. Demonstration activities at the Pilot Area of Monte Katera (Santo Stefano Quisquina, AG)

- Bringing to the knowledge of workers and professionals in the forest management field the sustainable silvicultural operations in order to also manage and improve those woods falling into protected areas and subject to regulatory constraints;

- Raising public awareness, private investors and municipalities on the appropriateness and cost-effectiveness of settling small biomass power plants for the heating of buildings and public utility infrastructure (offices, gyms, swimming pools, etc ...);

- Explaining the methodology for estimating forest biomass in order to provide public and private owners of forests and potential investors with a valuable tool for estimating and evaluating the production potential of the forests in the area as a function of the opportunity to settling small biomass plants;

3.16.3.4. Outputs

The information gained with the various actions of the Proforbiomed project allowed to develop an effective methodology of investigation in order to identify some suitable woods in the pilot area for the use of residual biomass for energy purposes. The investigation model developed can be considered replicable in other areas of the region and in other Mediterranean countries, characterized by the presence of similar socio-economic and environmental conditions. More in detail, the approach adopted allowed to:

- Identify the most suitable forest types in terms of suitability and affordability for the use of biomass for energy production;

- Develop a method of analysis of forest ecosystems able to provide information on the evolutionary dynamics and structural characteristics in order to identify, for each of them, the most appropriate silvicultural operations able to combine the use of biomass with a greater stability of forests ecosystems;

- Develop an approach aimed at informing the public and in particular stakeholders (local authorities, investors, government agencies or private companies in the forestry sector), for a greater involvement of local communities in the creation of a wood-energy chain.

The demonstration activity allowed to make a comparison between the production of biomass obtained from the silvicultural operation performed in the testing area and the one obtained through the estimation methodology performed in a GIS environment for the whole territory. From the results obtained, we can certainly state that, at least with regard to high density forests, a significant difference can be appreciated between the estimated values and those resulting from silvicultural operations carried out in the pilot area.

3.16.3.5. Added value of transnational cooperation

The Mediterranean forests are vegetal communities characterized by a strong biodiversity and a valuable landscape, but also by a considerable fragility linked to climate changes, fire risk and the human pressure.

In Sicily, the awareness of the importance of proper management of high value forest ecosystems has been gradually increasing, especially since the rise of new possibilities to combine the sustainable use of forest resources with the production of income and benefits for the local communities.

Because of the economic crisis that is going through the entire Eurozone and the increasing cost of energy from traditional sources, biomass from forestry operations drawn from low technologic value wood species is gaining an increasing commercial value both for domestic use and for its use as fuel to feed power plants for the production of energy and heat.

In this sense, the activities carried out in Sicily as partner of the Proforbiomed project have represented an important opportunity to test on field, in a specific area of the region, the strategies to be implemented and the problems to be solved for the establishment of an energy chain. What is more, the transnational character of the project made it possible to carry out a series of activities in collaboration with various partners in the countries bordering on the Mediterranean Sea, allowing each of them to make available their wealth of expertise that from time to time was required by the various pilot actions. In particular, the possibility of opening a common roundtable for discussion and comparison between them allowed implementing and strengthening their technical knowledge, especially in those contexts in which aspects related to the development of the energy sectors are the biggest obstacles to current events. In particular, it allowed to:

- Define some innovative sustainable forest management methodologies to promote the use of forest biomass for energy purposes;
- Define some operational methodologies aiming at the implementation of energy chains;
- Define new techniques of forest use, which could be tailored on the territorial and economic context of Mediterranean forests.

3.16.3.6. Conclusions and lessons learned

The work carried out under the Proforbiomed project in Sicily has highlighted a number of strengths related to the implementation of management plans in the woods with a prevalence of Mediterranean conifers and the consequent development of an alternative forestry activity compared to the traditional and exclusive market of firewood. In particular, the main strengths identified are:

- Sufficient forest roads to allow the cost-effective exploitation of woods;
- Possibility of accessing public incentives to support the implementation of supply chains in the forestry sector and the implementation of forest management plans;
- Biomass productivity level able to maintain sustainable the abatement and skidding costs.

On the other hand, several criticalities have been highlighted, on which attention must be paid in the future in order to develop efficient strategies able to overcome them. Among such critical aspects, it is worth mentioning:

- The lack of management plans;
- The lack of a chain for biomass usage;
- Low level of mechanization of forest exploitation;
- Lack of awareness and confidence of local communities, mainly due to the scarcity of roundtables and demo activities on field,
- Lack of certification in the biomass production process.

Promotion of residual forestry biomass in the Mediterranean basin

In the Sicani Mountains the most widespread forest type is the Aleppo pine forest

3.17. Region of Western Macedonia. Greece

3.17.1. Legal name/ Contact details

Name of the Organisation:
Region of Western Macedonia

Acronym: RWM

Official address, country and region: Z.E.P (Zone of Active Urbanisation). Area Kozani, 50100 Kozani, Greece, Region of Western Macedonia

Website: *www.pdm.gov.gr*

Legal representative: Theodoros Karipides, Prefecture of Western Macedonia Region, http://www.pdm.gov.gr/ +30 24610 52610

Contact person: Dimitris Kouras, dkouras@gmail.com (RWM); Nikolaos Margaritis, margaritis@lignite.gr (CERTH); Panagiotis Grammmelis, grammelis@certh.gr (CERTH). Phone: +30 24610 53970 & +30 24630 55300 & +30 211 1069504

3.17.2. Description of the partner's activities/skills related to biomass

The region of Western Macedonia (RWM), the energy centre of Greece, could ensure complete energy independence for centuries via its energy reserves. The benefits that exploitation of lignite coal has thus far offered to the RWM and the whole country are unquestionable, but at the same time serious economic and environmental problems have occurred.

Although not an advanced partner for the development of bio-energy and the exploitation of forest biomass for energy purposes, RWM urgently needs rapid drastic changes in order to move towards a low carbon economy and the introduction of small-scale biomass plants. The Region has extensive experience in the implementation of similar actions in cooperation with local scientific organisations, namely the University of Western Macedonia (UOWM), the Technological Education Institute of W. Macedonia and the Chemical Process and Energy Resources Institute (CERTH).

Co-firing pilot experiments combining lignite with biomass have recently been performed in order to examine energy yield, quality of combustion and content of exhaust gases. The idea is to make broad use of biomass resources, as a fuel to ultimately replace lignite, to reduce GHG emissions and meet national targets. Furthermore, pre-feasibility studies are being performed regarding the implementation of small biomass plants that can provide heat and power to small communities. A representative study that will be funded by the Joint European Support for Sustainable Investment in City Areas (JESSICA) mechanism is described in the following sections.

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3.17.3. Techno-economic evaluation of a biomass pellet plant combined with a biogas CHP unit in the Municipality of Servia-Velventos

The Region of Western Macedonia, within the framework of Pilot Action 2.1 **"Preparation of pre-feasibility projects for a small or medium size biomass plant or district heating/cooling system – a case of energy contracting"**

(WP4 "Setting up of integrated strategies for the development of renewable energies"), carried out a pre-feasibility study of a biomass pellet plant combined with a biogas combined heat and power (CHP) unit. The study examines an investment project that includes the construction of a biomass pelletisation unit, in combination with an anaerobic digestion unit, in the municipality of Servia-Velventos. The proposed investment is a model of a sustainable small-scale project, as it combines two new technologies that are synergistic to each other.

1. An organic waste and agricultural residues processing unit

2. A forest residue pellet production unit

A schematic image of suggested installation is shown in Figure 69.

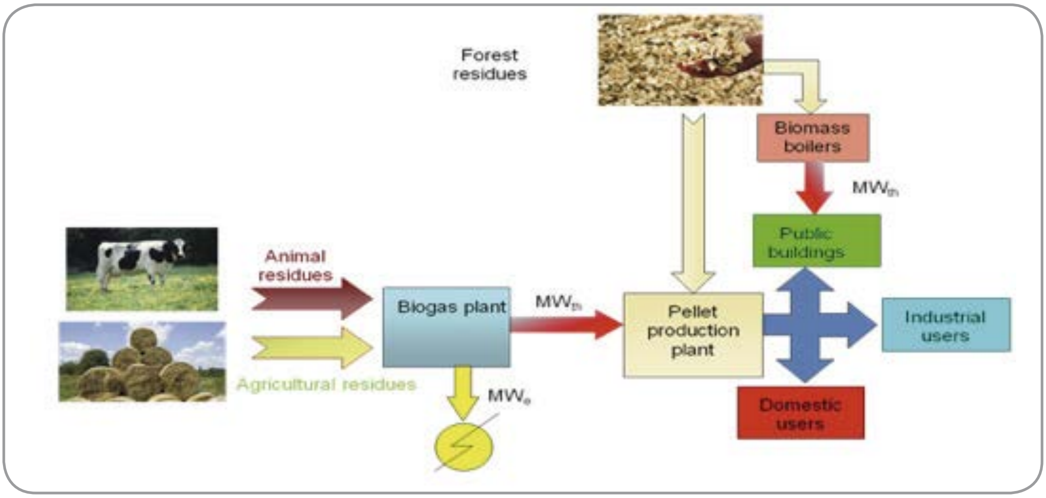

Figure 69. Installation that couples units for anaerobic digestion and pellet production

Anaerobic processing is suggested as the most environmentally and financially accepted method of animal waste processing. Animal waste is the raw material for the production of useful and financially important products (biogas, electricity, thermal energy, fertilizers etc). Meanwhile, the use of pellet biomass as an alternative fuel in heating and cooling applications is rapidly developing, due to efforts made to reduce the environmental footprint of energy production, mainly by reducing CO_2 emissions, and also due to the exponential rise in oil price.

3.17.3.1. Description of the action

The main parts of the installation are the following:

- Anaerobic digestion and a CHP unit
- Pellet production unit

The anaerobic digestion unit uses animal waste and agricultural residues, producing biogas that is then used for the generation of electricity and heat. The pellet production unit uses forest (ligneous) biomass for the production of pellets that can be marketed to household or industrial users. The heat produced by the CHP unit is used to cover the heat load for forest biomass drying in the pellet production unit. In addition, one or more biomass boilers can be used to cover the area's heating needs, using forest biomass or pellets as fuel.

1) Biogas Unit Description

- The biogas unit consists of the following parts
- Reinforced concrete animal waste feed tank
- 5 metal mesophilic bioreactors
- Biogas storage tank
- Two 600 kW CHP Units for energy and heat generation
- 3 liquid-solid separators
- One composting unit
- One sulphur extraction unit
- One processed waste collection tank
- One water collection tank

As regards the CHP unit, the following are suggested: Two units of model HET–GBC 600 (HAASE Energietechnik AG). The performance of those CHP units is 40.4% electric power, 22.35% heat output (cooling system with water) and 21.67% heat output (removal from the hot combustion flue gas). The nominal power of each unit is Pnom=600 kW(e) and the Maximum Power Point Voltage Vmpp is 400 V. The container in each of those units is fully equipped, totally autonomous and ready to operate. The CHP unit is connected to the Public Power Corporation (PPC) distribution network at the installation point. All the functions of the animal biomass production subsidiary parts will be controlled by PLCs and the necessary hydraulic flows will be achieved by installation of silt pumps.

2) Pellet production unit

Indicatively, a pellet production unit consists of the following parts:

1. Raw material storage

2. Raw material feed

3. Raw material cutting: The raw materials are taken to a cutter (grinder), aiming for an output size of 3cm. At this stage of cutting we have three possibilities: raw material as uncut wood (tree trunks), raw material as branches and raw material directly as sawdust.

4. Separator (sieve): Material less than 3 cm long goes through the sieve and goes out through the bottom, to the next stage of the production line. The pieces larger than 3 cm remain in the silo and are ultimately returned to to the grinder.

5. Dryer (in cases where raw material humidity is over 15%).

6. Silo

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7. Fine cutting: There is one more stage of cutting before inserting the material in the production machine, called fine cutting or chipping. We reduce the size of the sawdust to approximately 0.5-2.5 cm. That is about the desired size for the production machine to perform compression and pelletising.

8. Pellet machine: At this stage, sawdust is fed into the machine, where with the help of a drum or in some cases of a revolving cylinder, it is compressed and placed in suitable cases (cells) in order to take its cylindrical form, the final form of the pellets. Pressures of 20-300 atm are developed and so the aforementioned material gets a diameter of 6-8mm, a length of 10-50mm and a shiny, smooth surface.

9. Desiccator (cooling of the final product): Due to friction during the production in the machine – pellet mill – the pellets reach a high temperature of approximately 100°C. This temperature should be reduced before the pellets are packed. This can be achieved, at this stage, in the desiccators, with ambient air. The temperature of the final product should then be 5-10 degrees above ambient temperature. The humidity of pellets is also important. The humidity level should be under 8%.

10 & 11. Sieve and Scaling machine-packaging

3.17.3.2. Methodology

The following steps were followed in order to perform the technoeconomic analysis:

- Identification of biomass availability in the area considered
- Sizing of the biomass plant and estimation of costs
- Calculation of critical economic indices for different investment scenarios

1) Forest biomass

Availability of forest residues

The existence of steep slopes and lack of forest mechanisation in Greece, and also the overall system of exploitation of forests by logging cooperatives, based on the cost of raw wood produced per unit (m^3) do not encourage the removal of wood chips from forests. So far, there have been extensive studies to determine the quantity of biomass residues. Residue timber amounts to 1.7 million tons per year (CRES). However, as the harvesting of wood chips can cause depletion of nutrients and affect long-term productivity of forest land, the real potential is much smaller.

The potential of forest residues for the Municipality of Servia–Velventos was calculated using data for forest cover produced by Regional Development Company of Western Macedonia (ANKO). There are two main forest blocks. The first block is located in the former Municipality of Velventos where the most prevalent species is pine and the second one is located in the former municipality of Kamvounia where the prevalent species are beech, fir and oak, covering a total area of approximately 171,194 acres. According to F. Pedretti (2009), biomass is produced by broadleaf forests and coniferous stands at 2-4 tons per 10 acres. Within this study, the annual biomass production is about 2 tons per 10 acres. Consequently, the total forest biomass potential of Municipality of Servia-Velventos is roughly 34,000 tons. Bearing in mind that the moisture content is around 45%, the available potential of forest biomass is approximately 18,700 dry tones. Regarding the cost of woody biomass, as in the case of agricultural residues, it depends on the morphological and soil conditions of each region, which determine the total cost of logging and shifting of feedstock. Based on the data and information for the area, the cost of woody biomass is around €40-45 per ton.

<u>Wood pellets production</u>

The pellet market in Greece is growing slowly despite significant developments since 2006, when the first pellet plant began to operate. A total of five companies are engaged in the production of pellets mainly using coniferous and broadleaves residues. Mixed pellets (woody and herbaceous biomass) are produced by one manufacturer, although two more companies produce such pellets on a pilot scale. The pellet market is dominated by small scale manufacturers, due to the small market size and high risk of large scale investments. The previous legislative framework hindered the spread of high-tech central heating boilers using pellets as fuel, as it offered no incentive to replace conventional oil boilers with pellet boilers, while the operation of solid fuel boilers in Athens and Thessaloniki was forbidden. However, after the lifting of the ban on biomass combustion in residential boilers in the two major urban centres, it seems that the market landscape and marketing of biomass boilers is now changing. Prices for wood pellets are now at €150-200/ton for domestic use.

2) Agricultural residues

<u>Availability of agricultural residues</u>

Several surveys indicate that agricultural residues are the main source of biomass in our country. Agricultural residues are separated into two main categories: a) herbaceous annual crop residues (e.g. straw, maize, cotton, etc.) b) prunings from perennial crops, especially trees. The Communities in which there is greater availability of agricultural residues are shown in Figure 70. The annual crops that are established in the region include mainly wheat and maize. Perennial crops include olive, plum, peach, chestnut, almond, walnut and pistachio. The calculation of agricultural residues availability was performed using data from the National Information System for Energy.

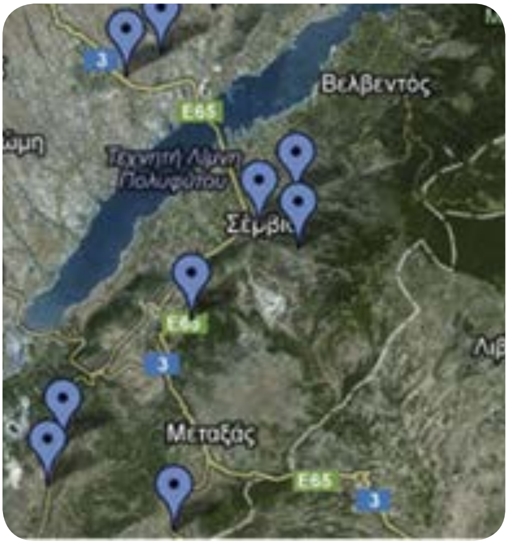

Figure 70. Communities with high biomass potential

In comparison with the rest of Greece, the availability of residues that are abundant in Greece are absent from the Municipality of Servia-Velventos. Examples are cotton, olive trees and citrus trees, and their absence is mainly attributed to climatic factors. Cereals (bread wheat, durum wheat, corn, barley) are the most important source of crop residues, accounting for 89.5%. It is also noteworthy that, in the region of Western Macedonia, there is very little year-to-year variation in the total production of cereals and the corresponding total amounts of these residues. Cereal residues, such as from wheat and oats,

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are mainly used for feeding and bedding animals and for mushroom production. Certain quantities are also used for paper production, although we have no precise information about this. However, the vast majority of herbaceous biomass residue is burned in the fields or is used as organic fertilizer. The prunings of small trees are burned. Exploitation of agricultural residues to produce electricity is not currently practiced.

Since most residues do not yet have market prices, there are no efforts to establish mechanised harvesting systems and an extended supply system. Wheat and corn residues are a notable exception. After harvesting, a linear straw pile is created which is transformed into straw bales using balers. Straw bales are loaded onto tractors and transported to neighbouring farms. Any excess is sold at average market prices. Table no. 50 summarises the available data on biomass prices.

Crops	Prices (€/tone)
Wheat bales (35-40kg)	80-90
Com	130-150
Cotton	110-140
Alfalfa	100-110
Tree large branches	100-120

Table no. 50 Prices for biomass as feed and for large branches, source: National Statistic Service of Greece, (2006)

3) Animal Wastes

A large part of the area (mainly highland) is traditionally rural and farming. Livestock is the backbone of the economy. Figure 71 shows the areas that are most relevant for animal biomass. Spots with blue and red represent the quantities of waste from cattle. Red spots represent communities with a greater number of animals. The yellow point represents a poultry farm (with 30,000 chickens) and the green spot represents a pig farm (5,000 pigs).

Figure 71. Spatial distribution of animal waste

The collection and transport of animal waste from farms to the final processing unit will also contribute to preventing pollution of soils, surface water and groundwater by nitrates. The pollution caused by nitrates comes from human activities. The main sources of nitrate pollution are various agricultural and livestock activities. Excessive use of nitrogen fertilizers to improve production has resulted in high nitrate concentrations in the subsoil. High concentrations of nitrogen compounds are observed not only in areas of intense agricultural activity, but also in areas where there is a high concentration of animal waste due to uncontrolled disposal. Examples of uncontrolled disposal, or persistence of animal waste on agricultural land for a long time with the risk of nitrate leaching and transport in groundwater, are presented in the following figures. Additionally, apart from the impact on soil and water, GHG emitted into the atmosphere affect public health and the environment.

Figure 72. Animal waste remaining in the field

Figure 73. Waste disposal example

Animal	waste t/head/year
Cattle	18.3
Pigs	1.89
Poultry	0.034

Table no. 51 Animal waste production per kind of animal, source: ASE D384.1, F. Pedretti 2009, Siemons R. 2004

In the event that the biomass quantity produced by cattle, pigs and poultry does not meet needs of the biogas plant, about 60,000 sheep are also raised in the area producing nearly 0.64 tons of waste per animal. The animal waste cost is determined by its quality and whether or not it can be used in other applications (e.g. composting for fertilizer production). The selling price may be determined by the owner's desire to offset the loss of alternative uses. Although there are no concrete sales prices for animal biomass in Greece, an indicative price is €10-25 per ton.

Anaerobic digestion biogas depends on the methane concentration. Biochemical composition of feedstock varies, and this is important for methane production. The available biomass types in the Municipality of Servia-Velventos are the following: animal waste (poultry manure, cow dung and swine sewage), agricultural waste (barley, maize, wheat) and forest residues in small quantities. Calculations are based on the data provided in the previous chapter. It must be noted that, in the current study, the heating value is assumed to be equal to 21 MJ/m^3. According to the literature, heating value ranges from 21 MJ/m^3 to 25 MJ/m^3. The available amount of animal waste is given in Table no. 52 .

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Type of animal waste	Number of animals	Annual production per animal (t/y)	Waste quantity per year (t)
Pigs	5,000	1.89	9450
Cattle	30,000	18.89	81,794
Poultry	4330	0.034	1020

Table no. 52 Quantity of animal waste in the municipality of Servia-Velventos

Based on the biomass energy content for the Municipality of Servia-Velventos and assuming that the unit uses animal waste (70%) and agricultural waste (30%), the anaerobic digestion unit would use the whole quantity of agricultural and animal waste and, for 8,000 hours of operation, the power of the unit would range from 0.7 to 1 MWe, plus 1.25 MWth. The type of biomass for pelleting is forest residues. The available dry matter is around 18,700 t/year with an initial moisture content of 45%. Pellet production potential is 10,000 t/year with a capacity of 1.5t/h (moisture 10%). Total hours of operation would be 6,500 h/year, with electric and thermal efficiency of 36% and 45% respectively. As mentioned above, the CHP unit's maximum output is 1.25 MWth, while the pellet production unit demands 650 kWth. The remaining 500-600 kWth could be used for the heating needs of the area. 17,636 tons of biomass are available for combustion. Biomass boilers can be installed for extra thermal output, in order to meet the thermal needs of the area.

Figure 74. Recommended location for installation of the unit and points where municipal buildings are located

4) Cost of capital

Cost of capital refers to the cost of debt and the cost of equity. The capital cost of the specific investment includes costs for construction of pellet plant and biogas unit respectively. Unit construction costs are listed in the following tables:

Description	Cost (€)
Bioreactor	560,000
A feeding tank of waste constructed by reinforced concrete	56,000
Biogas storage tank	126,000
CHP units producing power and heat	1,016,400
Solid-liquid separator	70,000
Composting unit	105,000
Pipes	42,000
Pumps	84,000
A building (laboratory, office, warehouse, workshop)	154,000
PLCs	105,000
Desulphurisation unit	56,000
Collection tank for processed waste	35,000
Water collection tank	98,000
Transfer and installation of equipment	315,000
Landscaping costs	140,000
Other equipment	87,000
Outside expertise	21,000
Studies and consulting fees	56,000
Total	**3,126,400**

Table no. 53 Costs for construction of the biogas unit

Description	Cost (€)
Grinding equipment	82,745
Drying equipment	188,090
Pelleting equipment	164,304
Packaging	40,349
Electrical equipment and other costs	101,102
Control system	28,860
Building facilities	387,860
Total	**993,310**

Table no. 54 Pellet plant capital costs

Total investment capital is equal to €4,119,710.

5) Funding

Investment capital will be provided through various sources. The most advantageous funding scenario has yet to be selected. The fixed rate period of the loan will be 10 years and the interest rate will be 8%. Annual installments will be paid at the end of each year. Funding scenarios are listed in the table below:

Scenario	Equity	Loan	Grant
1	30	40	30
2	20	40	40
3	10	40	50
4	30	70	0
5	12	88	0

Table no. 55 Funding sources

If there are no government grants, the cost of electricity will be €253 per MWh (220*1.15).

6) Annual expenditure

Operating expenditure, cost of biomass and working capital have to be taken into account to calculate the annual expenditure. Operating expenses are taken as equal to 8% of the capital investment. Table no. 56 provides data on cost of biomass, while the working capital is 30% of annual revenue.

Description	Cost (€/t)
Animal biomass	12
Agricultural biomass	40
Forest biomass	25

Table no. 56 Biomass cost

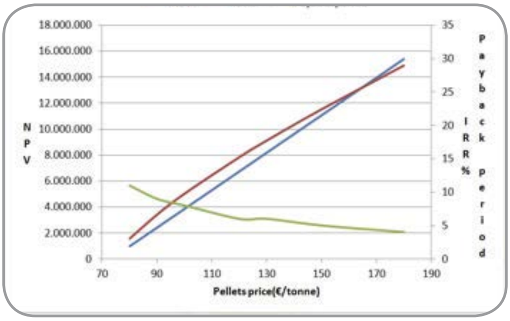
7) Annual revenues

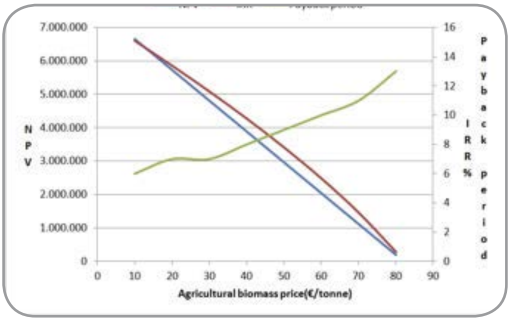
Company revenues will come from: the sale of electricity produced by biogas unit and the sale of pellets. Biomass feedstock will be dried by the thermal energy produced by the biogas unit.

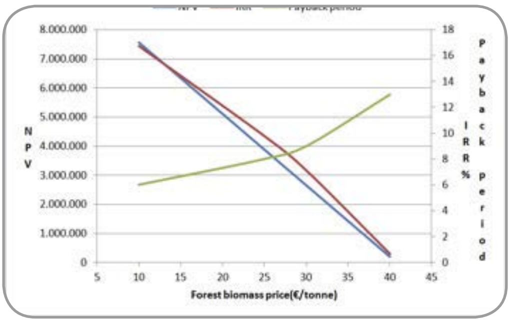
Sources of revenue	Cost
Sale of electricity	€220/MWh
Sale of pellets	€100/ton

Table no. 57 Sources of revenue

The payback period for the specific investment is 7 years, so this investment looks very attractive. The investment has a net present value of €9,745,863. with an IRR of 16.61%. Notice that current interest rates range from 10 to 12%. With regard to the specific investment, the effect of pellet prices, forest biomass prices, agricultural biomass prices and animal biomass prices on NPV, IRR and payback period has been determined. The following charts depict how independent values impact project assessment indicators.







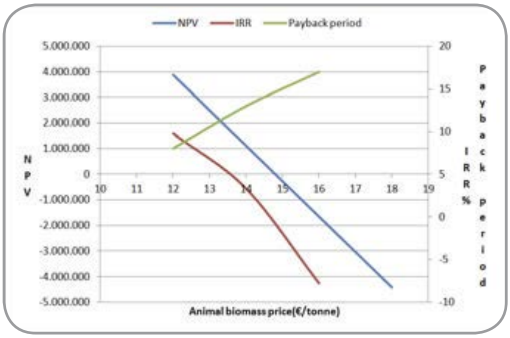


Figure 75. Effect of pellet and biomass price on NPV, IRR and payback period

As expected, biomass price severely affects the sustainability of the investment. With increasing price, the payback period increases, while the IRR and the Net Present Value decrease.

- Equity

The equity valuation is based on the following parameters:

Parameter	Value
Loan duration (years)	10
Interest rate (%)	8
Grace period (years)	0
Tax rate (%)	25
Depreciation rate (%)	10
Market interest rate (%)	8

Table no. 58 Financial parameters

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Using the aforementioned funding scenarios, investment criteria have been calculated regarding equity. The results are given in the graph below: It is assumed that loan's interest rate is equal to 8%. However, how a potential change in this specific financial parameter would impact investment criteria was also examined. Therefore, Net Present Value was calculated for various interest rates. The shortest payback period corresponds to scenario 3, where the funding sources are as follows: equity 30%, loan 40% and grant 50%. Obviously, an interest rate of 7% would result in the highest Net Present Value.

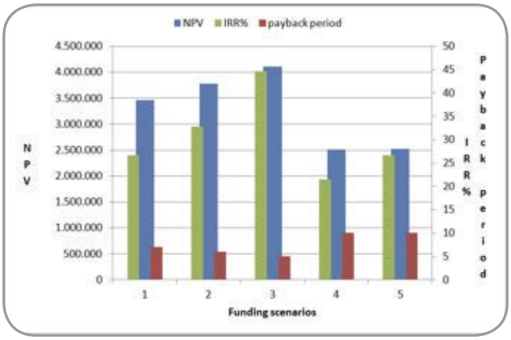

Figure 76. Equity valuation

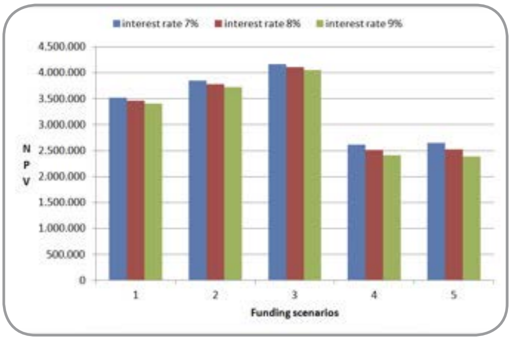

Figure 77. Present Value sensitivity analysis

3.17.3.3. Stakeholders involved

Four workshops are to be held during the autumn of 2014 to inform the stakeholders about the profitability of this kind of investment in the Region of Western Macedonia. Meetings will take place in rural, mountainous areas of the Region, where regional stakeholders are encouraged to take part.

3.17.3.4. Outputs

The outputs of this study are the following

- Biomass potential determination
- Biogas yield
- Technical characteristics of the pellet production unit and the CHP plant
- Sensitivity analysis
- Pre-feasibility project datasheet

3.17.3.5. Impacts

The project's implementation, namely the coupling of the biogas and pellet production units in the Municipality of Servia-Velventos has the following advantages:

- The geographical position of Western Macedonia in Climatic Zone D, according to KENAK (Energy Demand Management Rule) and increasing heating costs, due to poor climatic conditions, favour the development of a market based on cheap renewable energy sources.
- The important forest and agricultural potential of the Region ensures access to cheap raw materials for pellet production.

- The interest of Public Power Corporation (PPC) in biomass co-combustion in the lignite units as well as the interest of PPC in the installation of an exclusive combustion unit in Western Macedonia, provides great perspectives for major industrial clients.

Contribution of the investment to regional development and environmental protection
The investment is expected to play an important developmental role as:

- It creates new, immediate jobs, as well as indirect jobs in the supply chain of raw materials and final products.

- It saves funds that are now spent on imported fuels.

- It supports the environmental role of the Region and creates links for the developing renewable energy source (RES) technologies. Meanwhile, it creates favorable conditions for extra similar investments (power plants, decentralized production systems, etc.).

- It creates added value chains for by-products that currently either remain unused or pollute the environment.

The investment also significantly contributes to environmental protection, as:

- It deters uncontrolled animal waste disposal and residue firing that burdens the environment with particle emissions and dangerous air pollutants.

- It promotes high-efficiency biomass heating technologies with better environmental performance compared with current heating systems (fireplaces, wood stoves).

- It contributes to the national goals of greenhouse gas emission reduction.

3.17.3.6. Added value of transnational cooperation

The use of biomass for energy purposes represents a great challenge for Mediterranean regions in order to cover their energy demands and to meet climate change targets. Such an investment would contribute to environmental protection and regional development. Through transnational cooperation and dissemination actions, new technologies, innovative techniques and good practices will be transferred between partners, so that the decision makers of the region can choose the best solutions and select the appropriate methodology that enhances their business plan. In conclusion, this pilot action, and the transfer of pre-feasibility studies for small or medium biomass plants or CHP plants, enable partners to promote the development of their regions and encourage entrepreneurs to invest in biomass management for energy production.

3.17.3.7. Conclusions and lessons learned

An assessment of biomass availability and energy potential in the Municipality of Western Macedonia was perfomed in this study. Through this assessment, it is clear that the biomass potential of the region is sufficient to meet the needs of a 1 MWe biogas unit and a 10,000 t/year pellet unit. Such an investment would contribute to environmental protection and regional development. New, immediate jobs, as well as indirect jobs in the supply chain of raw materials and final products would be created and the uncontrolled animal waste disposal and residue firing that burdens the environment with particle emissions and dangerous air pollutants would be deterred. The capital cost of the investment is very high, but the expected profits are even higher. The fact that the investment criteria are positive for the various possible funding scenarios is really promising.

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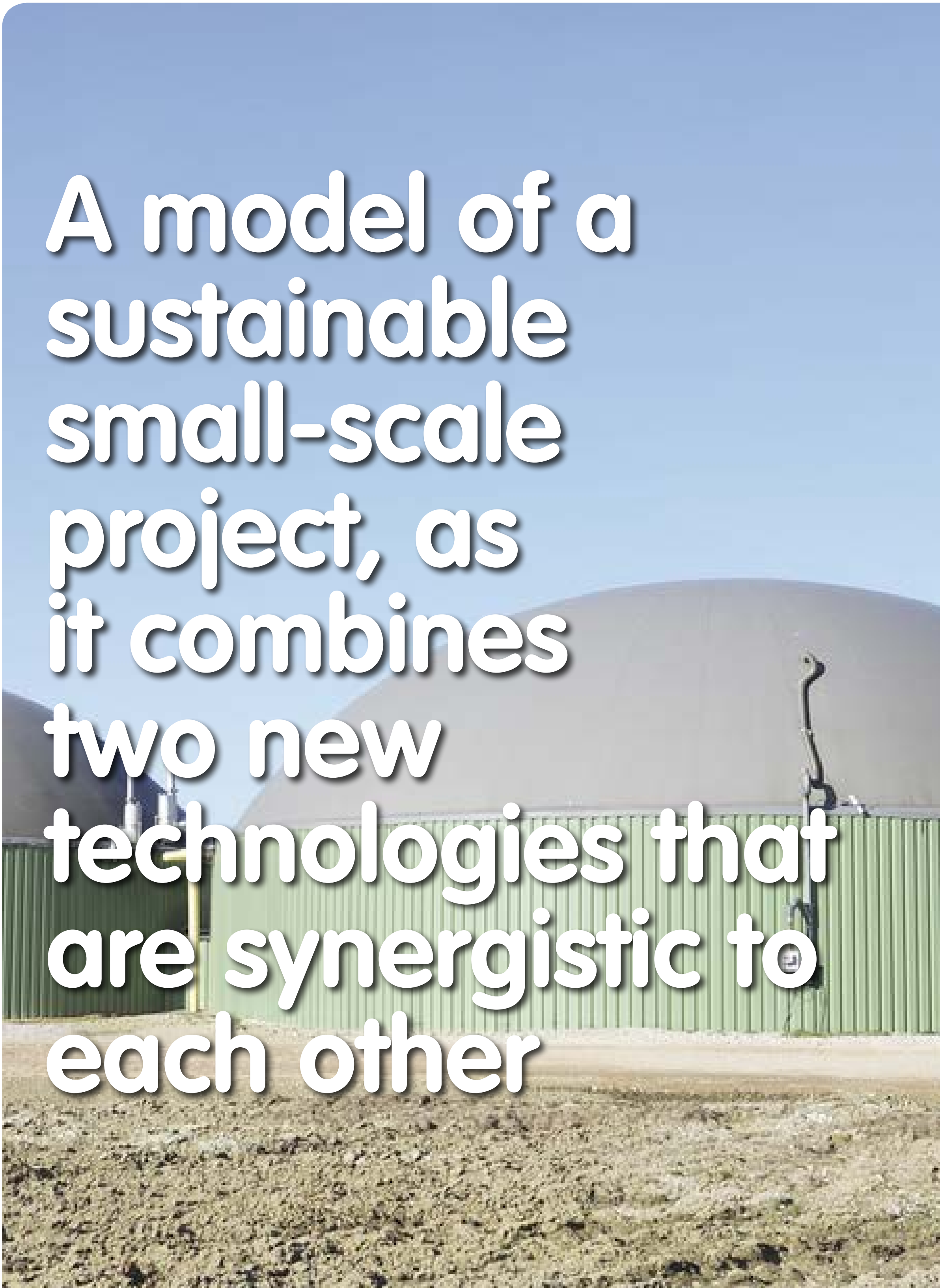
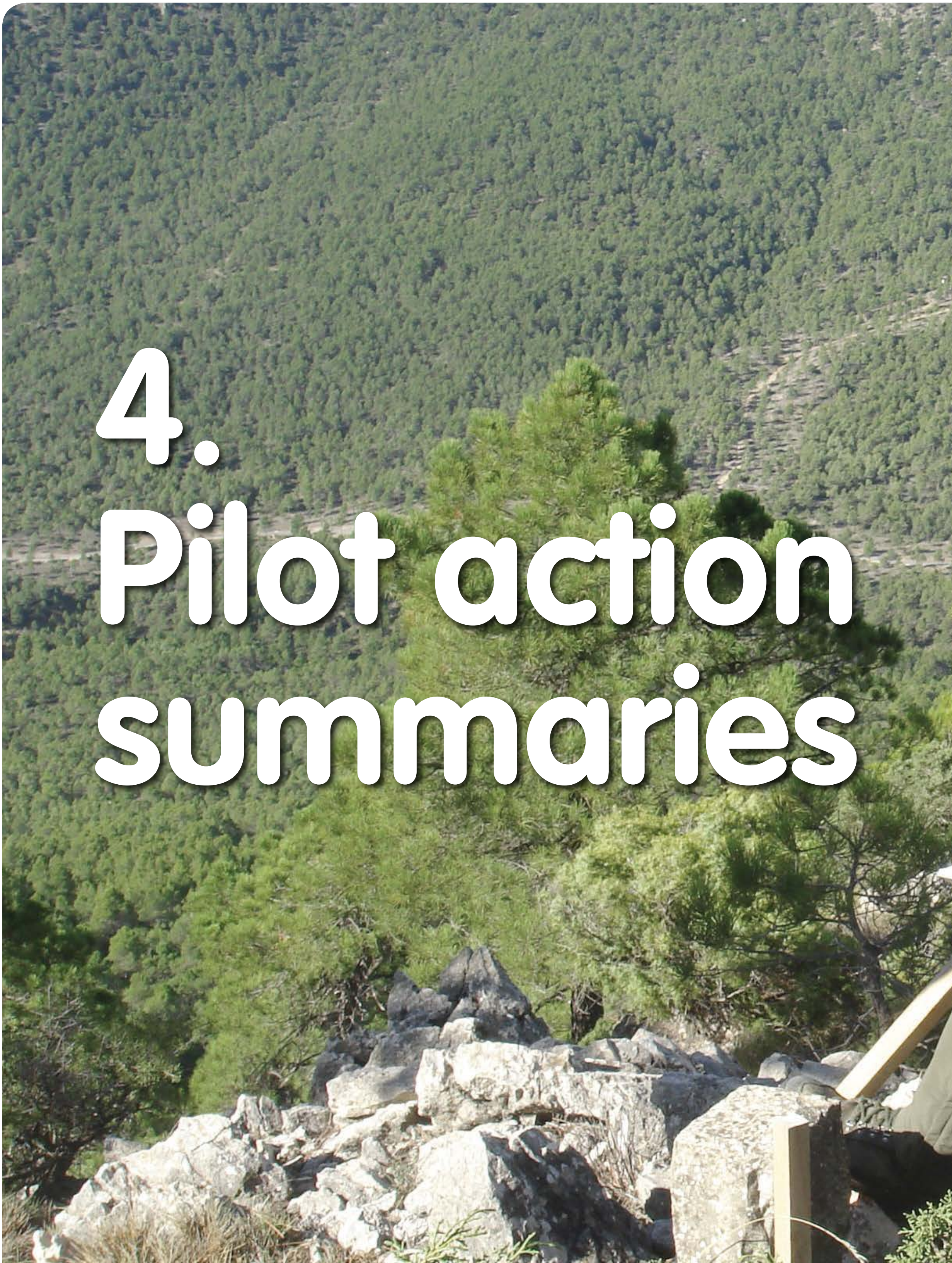

A model of a sustainable small-scale project, as it combines two new technologies that are synergistic to each other

4. Pilot action summaries



proforbiomed
Promotion of residual forestry biomass in the Mediterranean basin

Assessment of the structural diversity of forest habitats

MAIN OBJECTIVES:

Setting the know-how on structural diversity of forest habitats regarding a perspective of sustainable exploitation of forest biomass and providing it to the stakeholders.

STANDARD METHODOLOGY:

- Identification of the main forest types
- Inventory of forest plans main specifications
- Identification of the exploitable biomass types in the region
- Inventory of usual forestry practices, locally
- Identification of possible biomass uses (destinations)
- Field survey in pilot areas to measure forest habitats structural diversity
- Assess diversity in forests

MAIN RESULTS

- Vertical analysis of the forest typologies will allow the establishment of specific strategies for the use of the material present in each of them (and each of their height stratums). The quantity and spatial organization of the vegetal material will allow the design of more efficient exploitation methodologies and strategies;
- Will be critical to developing an approach aimed to inform the public and in particular the stakeholders;
- The traditional uses of the forestry resources are decreasing.

MAIN CONCLUSIONS OR RECOMMENDATIONS

- Evaluation of the exploitation potential and the establishment of logistical chains and systems; promotion of the knowledge on the forested areas for the biomass production potential
- Provide the regional and local policymakers with the essential information and data to develop clear national-level policy goals for forests and energy.
- An excellent tool to help introducing management into abandoned or non-managed forests
- Provide information on the evolutionary dynamics, structural characteristics and dendrometric parameters in order to identify, for each of them, the most appropriate silvicultural interventions able to combine the use of forest biomass with a greater ecosystem stability of forests.
- New strategies for the valorization of the residual forestry biomass: vegetable compounds (phenolic compounds and extraction of essential oils) and pellets testing.

PILOT AREAS:

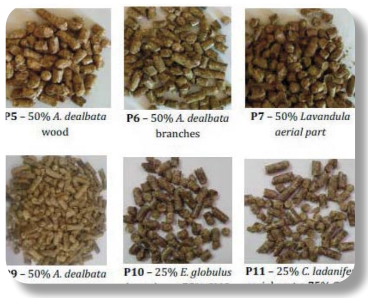
Portugal: Algarve region: Monchique and Aljezur municipalities

Italy: Lazio region

France: Lambesc Municipality

Slovenia: Area Vrhe, Nanos-Podkraj; Trnovo

RegSicily: Municipality of Cammarata



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Development of a Geo-Information System for the Potential Forestry Biomass Management

MAIN OBJECTIVES:

Development of decision support tools related to forestry biomass management: Principal components:

- Mapping of the potential forestry biomass;
- Mapping of the road infrastructure system;
- Development of cost/distance maps for biomass logistic.

COMMON METHODOLOGY:

Forest biomass potential evaluation

- Adoption of a methodological approach based on inventory data and growth models. Possibility to obtain biomass values by tree part.

Logistical analysis

- Adoption of a cost-distance based methodology;
- Calculation of the average travel time, over the road network, using cost distance;
- Relate each of the cells of the pilot areas with the travel costs, over the road network, using the Euclidean allocation;
- Calculation of the transportation costs, using travel times (adapted from Cozzi et al., 2013);
- Transportation costs (euro/ton)= ((travel time x 2) + loading and unloading time)* Transportation costs (euro/minute) / Maximum load allowed;
- Determine the influence zones of each consumption location using Cost allocation;
- Build demand curves, by consumption location, using influence zones and Zonal statistics.

MAIN RESULTS:

- Big differences in the partners' biomass evaluation methodologies;
- The normalization of the road networks using average speed values allows a broad and easy usage on different road typologies;
- The logistical analysis based on cost-distance allows the cost estimation of biomass transport, for large territorial areas in a short period, allowing a multi-scenario approach;
- The GIS are necessary tools to support forest managers and policy makers while installing forest biomass frameworks.

MAIN CONCLUSIONS

Normalize the methodologies for the forest biomass production potential evaluation, adopting methods based on inventory data, growth models and biomass equations; Define a set of standard classification items for the road network; Deepen the knowledge on transportation costs to best fit the models of the real conditions of each territory;

Increase the complexity of the GIS model, integrating ecological restrictions, the primary transport, processing locations and storage.

PILOT AREAS:

Spain: Alzira; Requena; La Yesa; Enguera (Valencia)

Castell de Mur; Mollerusa; Vila-Sana; La Fuliola; Bellpuig (Catalonia)

Cieza (Murcia)

Slovenia: Velenje

Portugal: Algarve Region

Assessment of forest biomass production

MAIN OBJECTIVES:

The main objective was to develop a methodology to acquire concrete and adapted data that helps define the characteristics and needs of the process of designing sustainable forest biomass production.

COMMON METHODOLOGY:

At the beginning of the project, the partners agreed on a series of ecological and environmental parameters they would compile in order to clearly present their pilot sites and compare them.
They then agreed on a group of variables to characterize their exploitation system.

MAIN RESULTS

- Great variability of extraction conditions: from very easy (low slope, no rocks, mechanization possible) to very difficult (slope close to 40%, rocks, very dense stand...).
- High variety of the studied stands: hard and softwoods, between 10 and 80 years old, with standing volumes of 85 to 340 m^3/ha.
- Volume extracted from 9 m^3/ha to 140 m^3/ha.
- Data on the costs of exploitation are difficult to compare, but they are between 21 and 45 €/ton.
- Selling price of the wood chips ranges between 35 to 70 €/ton.

MAIN CONCLUSIONS OR RECOMMENDATIONS

- The techniques and machinery used from one country to another are very different. Some transfer of techniques is applicable and could be useful.
- The skills of the team workers are very different from one country/region to another: some workers are not used to the chipping process after the felling of the trees.
- The state of the market varies considerably from one country/region to another: in some countries, the local market for wood chips is not really developed, while in others, there is a strong demand and pressure on the resources.
- The selling price of the wood chips is often very close to the costs of production and the wood is often not reimbursed. In order to improve the mobilized quantity, we recommend to remunerate the owner when possible.
- Due to the problems of unit conversion, the entire supply chain should think in terms of energy units and not weight or volume.

PILOT AREAS:

Slovenia: Kras region

Spain: Catalunya and Valencia region.

Italy: Sicily region

France: Bouche du Rhône.

Portugal: Algarve region

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Assessment of the environmental impact of forest biomass harvesting or extraction

MAIN OBJECTIVES:
To demonstrate forest managers;
To assess the environmental impact of the biomass harvesting or extraction.

COMMON METHODOLOGY:
To assess the environmental impact on biodiversity, soil and fire risk of the biomass harvesting or extraction

MAIN RESULTS:
- Fuel load reduction through shrub removal, significantly contributed to decreasing wildfire hazard;
- Passerine community: a useful indicator of the presence of disturbance in the forest environment;
- The effects of silvicultural practices on soil fauna found substantial impacts on soil forest fertility/productivity;
- To mitigate indirect losses after the harvest (erosion, leaching): is encouraged that acertain percentage of harvested biomass is left in the forest.

MAIN CONCLUSIONS

FIRE RISK:
Implementation of the power plant decreases the area burned; shrub removal decreases significantly for decreasing wildfire hazard; operations of wood biomass extraction are recommended.
SOIL:
The complete removal of the biomass is not advisable in areas used for *eucalyptus* production or areas with bushes; total removal of vegetation should be avoided, particularly in more sloping areas; the use of heavy machinery should be done with caution, particularly in the fine texture soils.
BIODIVERSITY:
Caution with endemics and species with high conservation value; extracting residual forest biomass does not lead, in general, significant impacts on fauna, but it is crucial to minimize the cutting phase and extraction of thee residual forest biomass. It is an important alert to forest ecosystems as complex biological systems characterized by the inherent and unpredictable environmental changing.

PILOT AREAS:

Portugal: Algarve region

Italy: Latium; Tuscany and Campania

Slovenia: all over Slovenia

RegSicily: Portella Cicala; Katera;Galluzzo

Spain (CTFC): Stand La Guardiola; Stand Mas Gomis; Stand Bosc del Ferrer/La Closa (municipality of Garrigoles); Stand Bosc del Ferrer/La Closa (municipality of Jafre)

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Promotion of residual forestry biomass in the Mediterranean basin

Development of a system of traceability of the forest biomass

MAIN OBJECTIVES:

Developing and testing a new protocol to asses and improve quality in the biomass value chain. The system intends to contribute to the promotion of the responsible use of forest resources for energy purposes

COMMON METHODOLOGY:

The main steps are: 1. Collection of normative references; 2. Collection of standards references; 3. Collection of experiences in the production and management of wood biomass; 4. Development of the protocol, based on information collected at the past points; 5. Identification of pilot areas; 6. Protocol presentation to local stakeholders; 7. Tests in the pilot plots in cooperation with local companies; 9. Revision and finalization of the protocol.

MAIN RESULTS

The definition of a practical and useful methodology able to respect the principles and technical requirements for the traceability of forestry biomass along the entire supply chain. The application of the protocol should ensure:

- The traceability of biomass at the source;
- The fulfillment of legislative requirements;
- The observance of good practices of wood management;
- The compliance with the quality and quantitative requirements of the final product.

MAIN CONCLUSIONS OR RECOMMENDATIONS

Biomass energy is expected to play a major role in the substitution of fossil fuels over the next decades. With the EU Renewable Energy Directive, there is a strong push towards a sustainable use of biomass from forests. While the growth of the biomass sector offers a good chance to mobilize biomass from Mediterranean forests, thus contributing to a more effective forest management, rural development and its related green-economy run the risk of being insufficiently competitive compared to the traditional forest industry. The Mediterranean regions must work closely to increase the good use of their resources in order to make the energy system as efficient as possible. A technically sound and operationally reliable traceability system may provide valuable support for the development of sustainable bio-energy supply chains.

PILOT AREAS:

Italy: Santo Stefano Quisquina (AG)

Slovenia: Central part of Slovenia near Ljubljana

Spain: Catalunia

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Demonstration plots with short rotation energy plantations

MAIN OBJECTIVES:

The primary objective of this pilot action is to test the short rotation energy plantations as an additional resource for biomass with energy purposes and their suitability in different MED areas.

STANDARD METHODOLOGY:

A technical data sheet has been drawn to gather the information related to the field work. This sheet includes fundamental data such as species and clones used as well as density, framework and harvest turn considered, and location (mean rainfall and temperature). Besides the aforementioned information, silvicultural management in relation to the soil preparation, irrigation, fertilization and control of weeds and pests has also been taken into account.

MAIN RESULTS:

- High variability in biomass production, depending on the location and species used.
- Higher yields in places with deep soils and high irrigation levels or high annual mean rainfall.
- One of the issues that may decrease biomass production is weed presence, so it has to be under control.
- First economic estimations show that the profit is very dependent on the biomass price, but with good production, this kind of crop is feasible.

MAIN CONCLUSIONS

- These crops can be considered as a potential biomass resource.
- Energy crops have to be taken into account jointly with Forest Management Plans in order to know potential biomass production in each area.
- It is interesting to use them on forest areas where they can give discontinuity, favoring forest fire prevention. Short rotation plantations are advisable to be used as green filters with the consequent environmental improvement.
- Further studies have to be done in order to know the real potential of the carbon sequestration in this kind of crops as well as the carbon footprint.
- Another option for additional biomass resources is the use of existing invasive species, decreasing their control costs.

PILOT AREAS:

Spain: Alzira; Requena; La Yesa; Enguera (Valencia)

Castell de Mur; Mollerusa; Vila- Sana; La Fuliola; Bellpuig (Catalonia)

Cieza (Murcia)

Slovenia: Velenje

Portugal: Algarve Region

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Promotion of residual forestry biomass in the Mediterranean basin

Development of forest biomass management plans

MAIN OBJECTIVES:

The primary objective was to apply previous pilot actions and integrate them in sustainable forest management plans in public and private forests, based on the knowledge and the work developed in the work package 4.

STANDARD METHODOLOGY:

A standard methodology was designed for the drafting of forest biomass management plans. Standard steps were defined, and a Technical Guide of contents and structure has been written.
However, for the inventory and data processing, each partner followed their own procedure (a particular software tool, LIDAR technologies, GIS technologies, etc.). Those specific methodologies have been reported so they could be transferred and applied in other regions.

MAIN RESULTS

- 8 forest biomass management plans (FBMP) with different approaches, in order to make them transferable in the whole MED area.
- Technical Guide of contents and structure of an FBMP.
- General Methodology: summary of typical steps for drafting an FBMP.
- Basic legislative ordinance: description of the most important legal aspects used by each partner.

These outputs can be consulted on the Proforbiomed website:
http://proforbiomed.eu/publications/project-deliverables/deliverables-workpackage-4/pilot-action-17

MAIN CONCLUSIONS OR RECOMMENDATIONS

- Given the growing demand of forest biomass for energy purposes, forest management is an essential tool to ensure the protection of the Mediterranean forests.
- However, forest planning is not a common practice in these regions due to low profitability of forests, expensive costs of inventory, fragmentation of forest ownership, etc.
- The different approaches developed in PROFORBIOMED have resulted in a decrease of the costs, an increase in the number of managed forests (public & private) and increasing interest by private owners.
- Public administrations should continue fostering forest management, especially on private ownerships. For this, raising awareness campaigns, and training programs should continue after the conclusion of the project.
- Furthermore, tools like Forest Certification should be promoted trough forest management plans in order to support and publicize that biomass is harvested in a sustainable way.
- their resources in order to make the energy system as efficient as possible. A technically sound and operationally reliable traceability system may provide valuable support for the development of sustainable bio-energy supply chains.

PILOT AREAS:

Spain: Public Forest "Sierra de Burete". Cehegín, Murcia; Public forest "Sierra del Negrete". Utiel, Valencia.

France: Communauté de Communes du Pays d'Aix. PACA Region.

Slovenia: Agrarna skupnost Čezsoča. Bovec.

Greece: Krania-Monaxiti-Kipourio Forest. Prefecture of Grevena

Italy: Valsassina area, Municipalities: Casargo, Margno and Parlasco. Lombardy; Public forests in the Municipaliity of Bivona.

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Preparation of pre-feasibility projects of a small/ medium size biomass plant or district heating system

MAIN OBJECTIVES:

The objective of this pilot action was to provide support to local and regional authorities for the implementation of the strategies for the development of renewable energy, taking into account environmental, social and economic constraints. The participating project partners selected local communities with an already developed supply side and prepared a pre-feasibility study for a small or medium size biomass plant or district heating system. The pre-feasibility study covered economic, environmental and technical aspects. It has been developed in different areas, in a coordinated or joint way depending on current data available in the different partner areas. Local stakeholders took part in this action

STANDARD METHODOLOGY:

Each pre-feasibility study followed the standard methodology based on the issues presented below.

1. General information about the project
2. Selection of potential location for the biomass plant
3. Heat consumption in the selected area (DH system)
4. Biomass fuel availability
5. Sizing of unit and DH system
6. Type of forest biomass available
7. Other resources of available biomass
8. Biomass fuel characteristics
9. Storage of biomass
10. Fuel feeding and handling
11. Type of combustion technology
12. CHP equipment
13. Other equipment
14. Costs
15. Policies and current legislation
16. Energy contracting
17. Environmental aspects of biomass combustion
18. Social aspects
19. General conclusions

MAIN RESULTS:

- Small/medium size biomass plants & District heating systems: The high NPV and relatively high payback period characterize these projects that can be profitable under proper and careful design
- Co-firing in thermal power stations: It can lead to overall profitability, but the big biomass quantities needed, changes in the yard of PPC, absent biomass supply chain, and transformation costs for units, make this project difficult to succeed and be sustainable. Sustainability of such an investment should be further examined in a more in-depth technical and financial analysis.
- Boiler replacement to biomass fired: Low cost of capital and relatively high biomass potential make these projects economically viable presenting a short payback period.

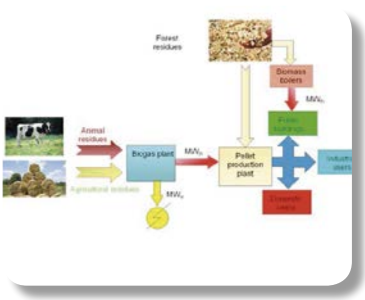
PILOT AREAS:

Greece: Four municipalites (Grevena, Amyntaio, Servia- Velvendos, Kozani) in the Region of Western Macedonia

Spain: Municipality of Yecla, Municipality of Enguera (Valencia), Municipalities of Mula and Bullas (Northwest region of Murcia)

Italy: Municipality of Bivona, Sicily region

Slovenia: Municipalities of Makole and Cirkulane in Spodnje Podravje region
Portugal: Algarve Region



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Presentation of existing good practice examples of forest biomass use

MAIN OBJECTIVES:

Transfer of existing good practices in forest biomass use to all project partner countries or regions.

COMMON METHODOLOGY:

For this activity field, the partnership agreed on the specifications of the actions that could be presented. In this process, they had to keep in mind the target public they wanted to inform. Then, a template was redacted and validated by the partnership. Each partner had to propose two best practice examples, and the most interesting ones were selected.

MAIN RESULTS

- Good energy practices allow economic efficiency as well as improved visibility in the national media.
- Short and local supply chains facilitate active forest management at the local level.
- Contracting can provide additional income opportunities for biomass producers as well as cost savings for final consumers.
- The MED flora offers many uses: for example traditional local uses or the production of pellets from invasive species.
- The main results should be presented in bullet points – the main partner should select some of the most significant results (most interesting from their point of view) and present them here.

MAIN CONCLUSIONS OR RECOMMENDATIONS

- Biomass can be a great tool for the fostering of forest management, and some specific new methodologies are already being developed: for example entire tree harvesting, which is suitable for young forest stands with a max diameter of 20cm. If there are bigger trees, manual felling must be employed.
- For local decision makers, the choice of installing a forest biomass boiler is largely based on the availability of the resource within their territory or in its immediate vicinity. The task of the global supply chain is to provide them with the appropriate info so they can make their decision with the most relevant data.
- Many new uses of biomass exist: pellets and handcraft are, for example, detailed in our document. These could be a good valuation for the biomass of our region.

PILOT AREAS:

Slovenia: different locations in Slovenia

France: Bouches-du-Rhône

Italy: Sicily

Greece: Region of Western Macedonia

Portugal: Algarve

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Development of economic and social Network

MAIN OBJECTIVES:

The aim of the pilot action was to provide tools for project partners to strengthen the biomass network in their regions. The work was done with the stakeholders in order to look for barriers and constraints in the sector and search for the appropriate formulas to improve the biomass chain with either technical, educational, legal or administrative issues.

MAIN RESULTS:

Three reports were delivered; a compilation of forest bioenergy data and barriers for each partner involved in the pilot action, a report about the Main characteristics of forest biomass and the influence of the final users profile and a final summary where each partner explained their work in the way of Dynamizations of the socioeconomic network.

The achievements done by each partner are:

- Algarve: implementation of a strategy at regional level
- Catalonia: increasing the biomass market
- Murcia: including biomass in a cluster of renewable energy
- Lombardy: regional and provincial perspectives – Sondrio and Valtellina Valley
- Slovenia: a biomass consortium
- Western Greece: education and awareness raising perspectives
- Western Macedonia: networking and clustering

MAIN CONCLUSIONS OR RECOMMENDATIONS

The successful results obtained during Proforbiomed came after a long time of work, which in some cases it was years. Proforbiomed has facilitated a framework for the continuation of some previous efforts. It provided the opportunity for new initiatives to come from the exchange of information. It is necessary to create interchange points in order to have a place for discussion of ideas on some topics and forums and host meetings of high importance with stakeholders. Regarding the educational program, the recommendation is to involve students on the design of the program. Finally, about the trust and personal skills: these two features seem to be extremely relevant when dynamizing and setting up a cluster, although - according to the stakeholders - in some areas a consortium is an interesting.

PILOT AREAS:

Portugal: Algarve

Spain: Catalonia (Lleida,

Girona and Tarragona),

Murcia (Yecla, Cieza, Cartagena)

Slovenia: Podlehnik,

Slovenska Bistrica and Videm

Italy: Lomabrdy

Greece: Patras. Western Macedonia Region

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Office for Promoting the Energy Recovery from Forestry Biomass

MAIN OBJECTIVES:

The development of specific tools to promote communication, dissemination awareness and training activities that support the building up of the forestry biomass exploitation in the MED area.

COMMON METHODOLOGY:

The common methodology was designed by Patras Municipal Enterprise for Local Development for the creation and operation of these biomass offices.
Common steps were defined in a Technical Guide that was outlining the general structure.
However in each area there were specific methodologies followed according to each of the different approaches.

MAIN RESULTS:

- 3 Regional Offices for Promoting the Energy Recovery from Forestry Biomass (BOs) with different approaches, in order to make greater impact in each area.
- Technical Guide on methodology followed by the creation of the BOs
- Technical Document collection of regional reports from Proforbiomed Partners on their experience in developing regional offices into promoting energy recovery from forestry biomass
- Educational Project held in Western Greece Office for Promoting the Energy Recovery from Forestry Biomass, were 1270 students already participated in.

MAIN CONCLUSIONS OR RECOMMENDATIONS:

- Offices for Promoting the energy recovery from Forestry Biomass are playing enormous role within the promotion of forest management and the use of forestry biomass residues for energy.
- These offices allow the communication between local authorities, stakeholders, enterprises, biomass producers and end users.
- Without fully operating Biomass Offices, it would be impossible for any type of stakeholder or individual to cooperate in order to achieve the best way of forestry biomass exploitation.
- These three Offices for Promoting the energy recovery from Forestry Biomass, in Patras (Greece), in Kozani (Greece) and in Valencia (Spain), are playing a major role as information/education/communication centres in promoting the forestry biomass residues use in the Mediterranean region.

PILOT AREAS:

Greece: Greece Office in Patras Ioannou Stavropoulou 36, Monodendri

Greece: Western Macedonia Regional Office, Kozani

Spain: Valencia Regional Office, Enguera

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Creation of a web portal to support cluster and networking activities

MAIN OBJECTIVES:

The Main objective was to create and test a web tool aiming at:
Connecting biomass users and producers; easing the market through a system of buying and selling; giving visibility to the EU best practices; creating an archive of articles, news, events.

COMMON METHODOLOGY:

The Web portal intends to enhance the consolidation, development and productivity on biomass management by easing the contact and the communication between the market's stakeholders. The web portal organises, in a logical model, the information published into the portal in order to ease its browsing and accessibility. The portal is realised by taking into account the major well established design patterns about the usability and ease of browsing.
The achievements done by each partner are:

MAIN RESULTS

- Creation of a new Local Web Portal available to project's partners
- Activation of three similar portals in Italy, Slovenia and Greece *(www.medbiomass.gr; www.medbiomass.sl; www.medbiomass.it)*
- Presentation and sharing of the Local Web Portal to local stakeholders
- Provision of opportunities for new actions and new projects related to the use of the new tool with the involvement of local stakeholders

MAIN CONCLUSIONS OR RECOMMENDATIONS

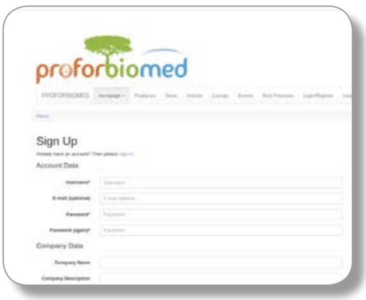
In order to ensure that renewable energies could be a real opportunity for local and regional economies, it is very important to develop initiatives with a real impact on local stakeholders that are able to produce concrete benefits for local bioenergy markets. The creation of a new and easy tool that helps users and producers to create new links and improve commercial activities, may provide a valuable support to develop sustainable bio-energy supply chains. Furthermore, it will be useful to raise awareness about the best practices at EU level and to provide regular updates on events related to bioenergy.

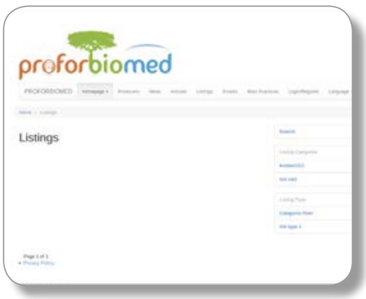
PILOT AREAS:

Greece:
www.medbiomass.gr

Slovenia:
www.medbiomass.sl

Italy:
www.medbiomass.it





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Application on field of Best Practices of sustainable forest management

MAIN OBJECTIVES:

The main objective was to support the circulation of specific technical information and the results that came from the project activities on sustainable forest management, through the on-field testing of demonstrative actions.

COMMON METHODOLOGY:

The P.A. was implemented, according to the "Guidelines" that were drawn up by the DRAFD, throughout the three phases: the diagnostic phase - collection of "Best Practices" in the field of sustainable forest management; the demonstration phase - on field application of specific operations; the communication phase - organization of dissemination activities addressed to local stakeholders and aimed at the diffusion of the P.A. results.

MAIN RESULTS:

- Increased knowledge of "Best Practices" on the forest management adopted at a European, national and local level;
- The support to the development of sustainable forest management strategies
- The dissemination of "Best Practices" among the local target groups, in order to favour the adoption of strategies capable of guaranteeing a sustainable management of forest areas, ensuring greater efficiency and profitability.

MAIN CONCLUSIONS OR RECOMMENDATIONS

The analysis of the "Best Practices" permitted to highlight the tools, strategies and actions, led to successful experiences which represent concrete reference examples for future activities concerning forest management in other territories with similar characteristics.
The on-field applications carried out in the permitted demonstration areas to test efficient systems of cutting, harvesting, transport and chipping the forest biomass, increasing technical knowledge of local operators.
The selected best practices and results of the activities that were carried out in the demonstration areas were presented to several public and private local actors, aiming to show the main tools which were able to improve the current forest management systems and optimize the operations of the forest biomass chain.

PILOT AREAS:

Italy: area of Portella Cicala on Monte Katera, Municipality of Santo Stefano Quisquina (Sicily Region)

Slovenia: area of Agrarian Common Gabrče, Municipality of Divača (Karst Region)

Greece: area of Platani, Municipality of Patras

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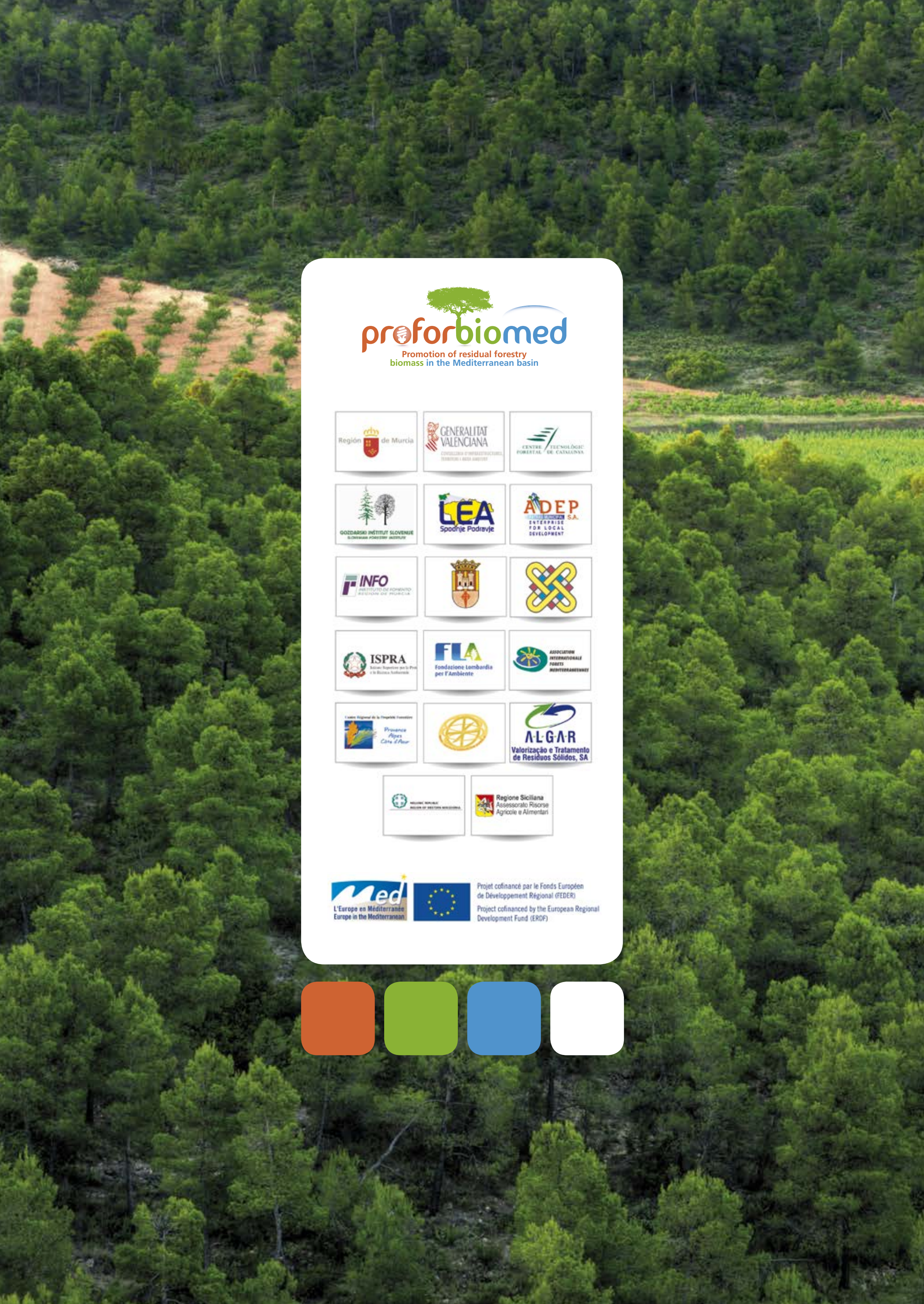

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