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EUROPRUNING – A NEW DIRECTION FOR ENERGY PRODUCTION FROM BIOMASS

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ABSTRACT

One of the possibilities of biomass potential increase on the energy market is the utilisation of agricultural residues in the form of prunings coming from orchards and permanent plantations (fruit tree, vineyards and olive grove prunings and branches from up-rooted trees). The issue of such biomass acquisition for energy purposes in Europe is not fully developed and several aspects still require investigation and/or solutions. The result of that unsolved subject is EuroPruning project realised in the frame of FP7 which is focused on the development of new improved logistics for pruning residues. The paper presents the main goals and assumptions of the EuroPruning project. The methodology and the range of the research works related to harvesting, transport and storage of prunings is described, as well. Attention was paid as well to the environmental, economic and social aspects that are going to be analysed during the project realisation.

Introduction

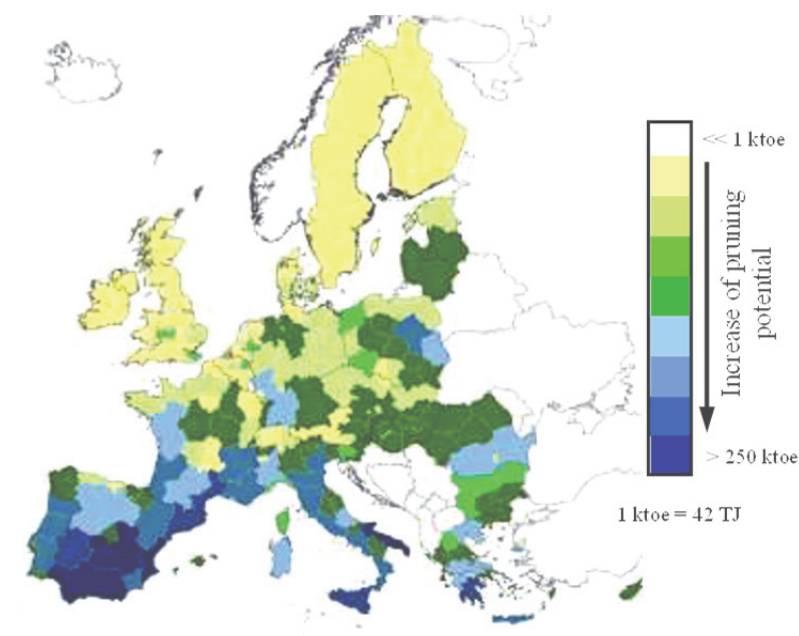
Many of the biomass fuels used today for energy production come from various sectors (agriculture, forestry, industry, waste etc.) and are in the form of e.g. wood products, dried vegetation, crop residues or aquatic plants. Biomass belongs to the one of the most commonly used renewable sources of energy in the last years. It is caused by its relatively low cost, high availability, indigenous nature and positive influence on the environment.

The most common biomass used in households for heating and cooking is wood from conifer and leafy trees. It leads to a considerable reduction in net carbon dioxide emissions that contribute to the greenhouse effect. However, the intensive use of fire wood as an alternative fuel may result in deforestation. The problems associated with denuding forests, and widespread clear cutting can lead to groundwater contamination and irreversible erosion patterns that could literally change the structure of the world ecology.

Therefore, other sources of wood for energetic purposes are searched that are abundant in a wide-scale yet non-disruptive manner, since they could be implemented at a local level by the society.

Moreover, it is crucial that biomass, during the whole chain of its route, could be converted to usable energy in ways that are more efficient, less polluting, and at least as economical as today's practices (EU White Paper, 1997).

One of the options, beside the straw residues, is the use of agricultural residues (prunings) coming from permanent plantations and orchards (Magagnotti et al., 2013; Spinelli and Picchi, 2010; Spinelli et al., 2010): olive trees, vineyards, fruit trees etc.. The European Union currently creates more than 25 million Mg of agricultural wood prunings each year (Nikolaou et al., 2003), but only a marginal percentage is used as solid biofuel. It should be mentioned, that in certain regions of the EU, the plantations with soft fruit, citrus, olives but also vineyards cover a significant surface delivering theoretically a large energetic potential. The energy potential from pruning and cuttings in permanent crops across a Europe is shown in figure 1.



Source: www.biomassfutures.eu

Figure 1. Energy potential from pruning

As the practical utilisation of pruning from permanent plantations and orchards for heat and/or electricity production is still not well recognised, an international Consortium (fig. 2) and finally European project EuroPruning has been created. The EuroPruning project aims to turn prunings into a valuable fuel source by developing solutions for their harvesting, transportation and storage that will create growth in the European biofuels market.

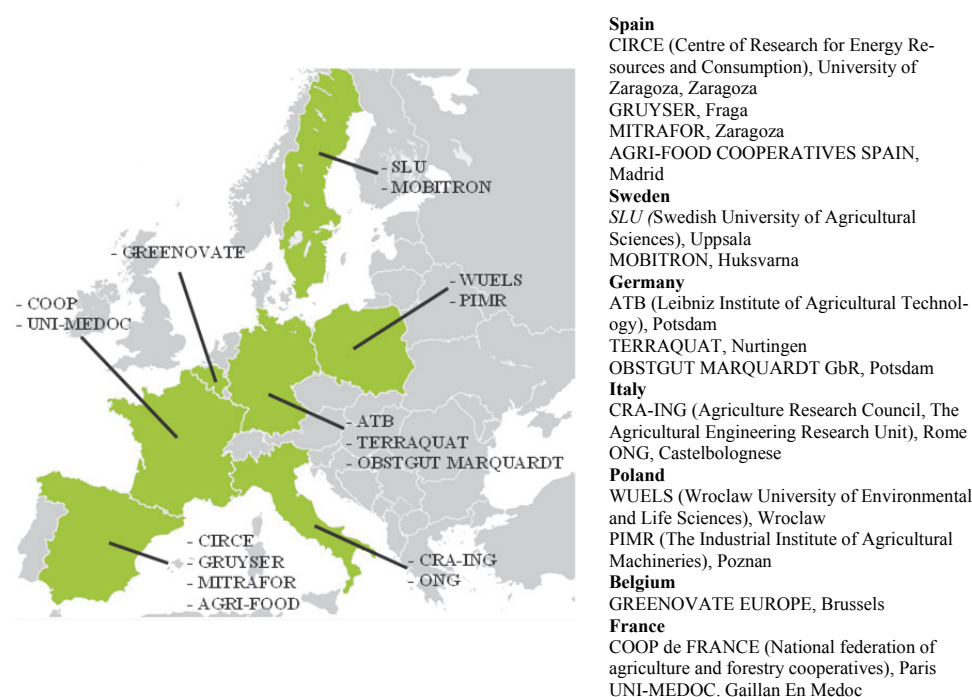


Figure 2. EuroPruning Consortium: (17 partners from 7 EU-countries: 6 research institutes, 8 small and medium enterprises, 3 other institutions, total budget: 4.6 million Euros, duration: 38 months).

The objective of this paper is to present the strategy of the EuroPruning project focusing on the main assumptions, the methodology to be applied and final targets which should lead to the increase of knowledge about the possible ways of pruning treatment in terms of environmental, economic and social aspects.

Motivation and the main objective of EuroPruning project

Agricultural residues are a potential source of renewable energy. There is already an implemented and developed logistic chain for straw residues from annual crops (Hahn and Herrmann, 2009; Sambra et al., 2008). Currently, in many countries, straw is a widely used biofuel for households heating as well as for heat/electricity generation in commercial plants. The straw market is well recognised and reached a level of stabilisation and acceptance in power engineering.

A high potential is also to be found in pruning residues from fruit tree / plant branches and twigs. The pruning yield depends on the kind of a fruit tree, geographical location and many other factors, but may reach even 7-8 Mg·ha⁻¹ of dry biomass having lower caloric value of ca. 17-18 MJ·kg⁻¹ (Velazquez-Marti et al., 2012; Bilandzija et al., 2012; Boschiero et al., 2013). Unfortunately, prunings are still an almost unexploited biomass resource. Usually, farmers along Europe chop the branches to incorporate them to soil as organic

supplement (which involves significant costs) or pile the branches and burn them on an open field (to avoid costs and get rid of the biomass). There are also other constraints limiting the utilisation of biomass for energy purposes. As compared to herbaceous crops, fields are more scattered in the territory and the size of plantations is smaller (imply more complicated logistics), harvesting of prunings from the soil in very dense plantations (distance between trees less than 1.7 m) is also complex and machinery cannot adapt to differential crop layouts. Finally, there is no procedure or proven technology of prunings treatment in terms of their use as a primary source of bioenergy.

As a result, EuroPruning project aims to take-off for an extensive utilisation of the agricultural prunings for energy in Europe. The main objective of EuroPruning, therefore, is to develop a new logistic chain including harvesting, transport and storage for woody residues from the fruit tree cuttings (fig. 3).

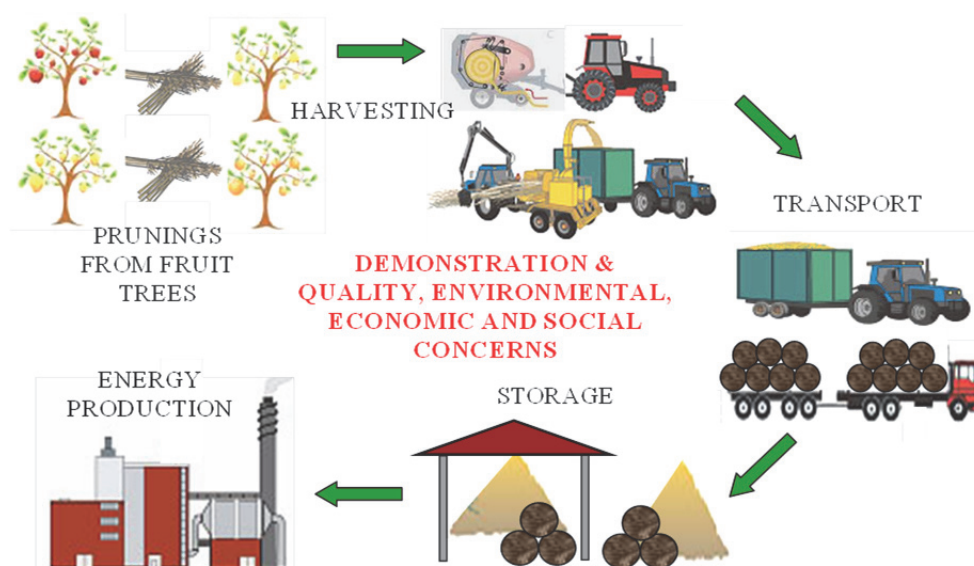


Figure 3. EuroPruning concept

To fulfil the EU requirements (European Commission, 2010) and insure the sustainable use of prunings, the economic, environmental and social aspects will be analysed, as well. Additionally, the project will develop new machinery for harvesting and on-site treatment of the prunings which will fill a technology gap in the market: a modular prototype (to be mounted on regular agricultural tractors) adaptable to different crop layouts able to pick-up the branches, chip and store them into a trailer or to wrap them; and a baler capable to produce large bales, similar to hay and straw bales. Machinery will be able to reduce costs and pre-treat the biomass so that the product is compatible with standard transport means. Furthermore, the achieved results and findings will be supported by the demonstrations performed on the permanent plantations in three different regions in Europe: Spain (Zaragoza

region), France (Médoc) and Germany (Brandenburg region), where newly developed machines for automated pruning collection (baling) and chopping will be tested.

Research methodology and work packages in EuroPruning project

To obtain the expected targets, the project has been divided into nine work packages (fig. 4). In addition, due to the complexity of the project there have been assessed two modules including several related work packages (WPs).

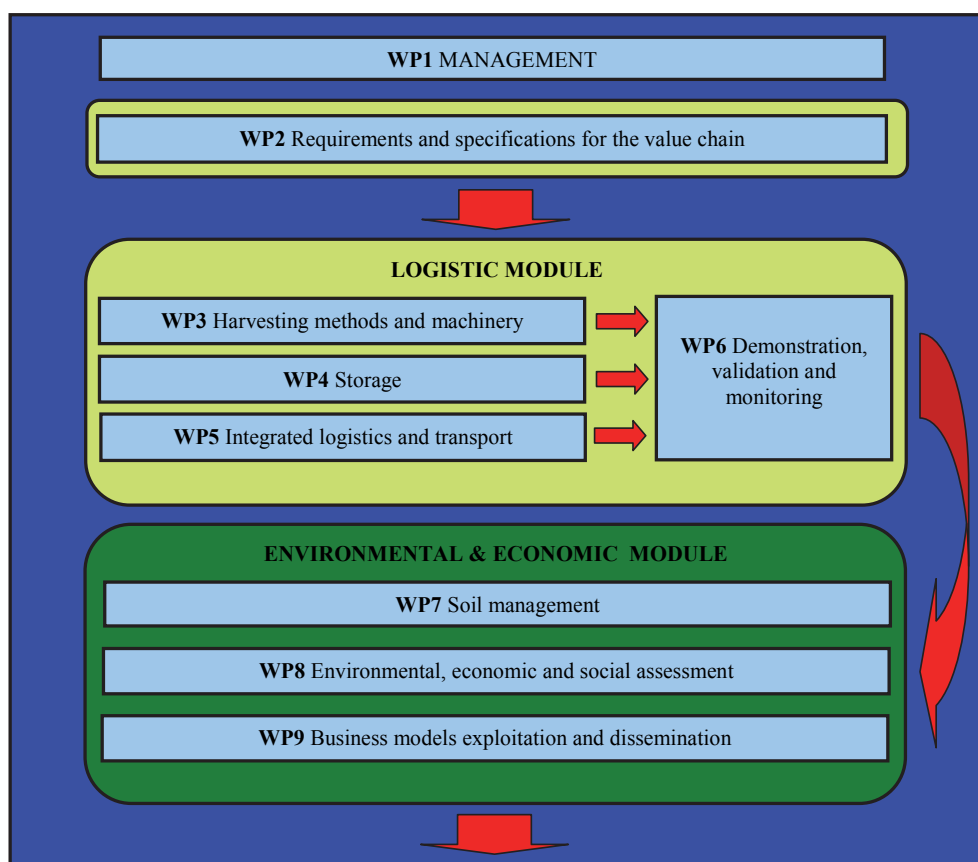


Figure 4. Distribution of the work packages in the EuroPruning project

The management issues are defined and developed in WP1 (Management) in order to ensure the project runs in the most efficient way.

Within the WP2 the analysis is focused on the assessment of the quality of agricultural pruning residues as feedstock for energy production at each step of the supply chain using defined criteria, like: physical-chemical properties including particles size, proximate and ultimate analysis, ash composition, impurities content etc. (fig. 5). Quality criteria, together

with other specifications (for example, consumer expectations) will be employed to evaluate the biomass across the demonstration activities of the supply chain: harvesting, pre-treatment, storage and transport.

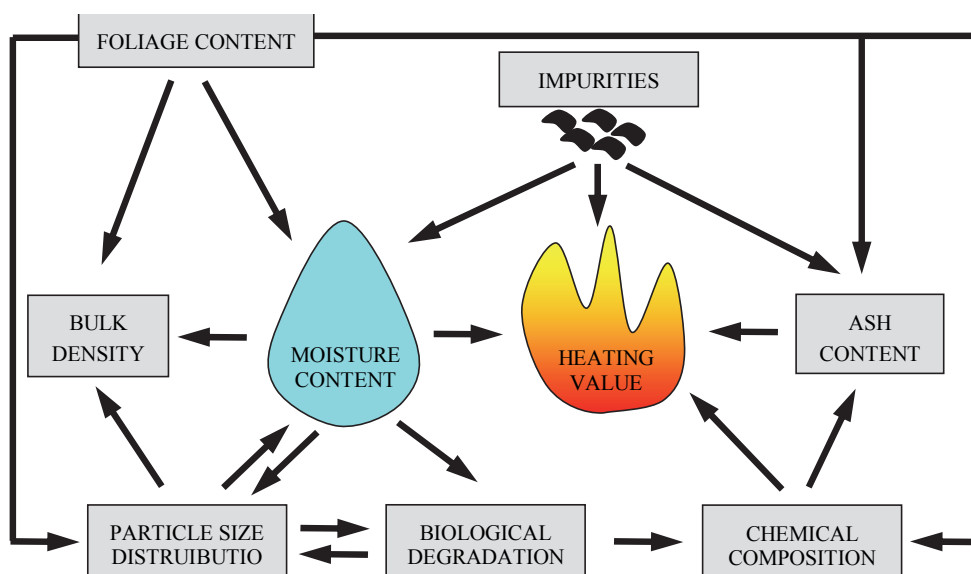


Figure 5. The quality criteria and the relations between the exemplified parameters of biomass

The procedure of the prunings quality control will be also applied during the demonstrations activities. Finally, the data will be implemented in the logistics module considered in the following WPs.

Next three work packages (WP3, WP4 and WP5) are the RTD type (Research and Technology Development) investigating different steps of the logistic chain: harvesting, storage and integrated logistic focused on the prunings' transport.

WP3 seeks to design, develop and build new prototypes for a sustainable and feasible large or small scale wood pruning logistics. In this task, particular attention is paid on the wide range of the requirements which should be fulfilled by the innovative machineries working in the fruit trees plantations.

WP4 contains the assessment of proper management of agricultural prunings storage and proposition of best practices regarding length of windrowing and adequate particle size under certain climate conditions. This data will encourage possible market players of the logistic chain to enter the bioenergy market with a product of high quality.

Based partially on the results obtained during the earlier steps of the investigated process, in WP5 the development and implementation of innovative logistics tools in order to optimise environmentally and economically efficient and effective handling of prunings along the whole value chain will be elaborated. It should be marked that the organisation, management, handlings, storage, packaging, transport, and other associated information

will flow in both directions (from producer to consumer and the other way). In addition, the financial flow will be implemented in that phase of the project. The traceability for monitoring from the fruit tree orchard (or other permanent plantation) to the final consumer will be performed to control and guarantee the quality of the prunings.

A substantial part of the project is WP6 including the demonstration phase. The role of this practical demonstration is to validate and monitor the processes of prunings harvesting, treatment as well as prototype machineries operation in real conditions. Moreover, in order to measure the different impacts of the new logistic, an economic and environmental module will be implemented (see fig. 4). The demonstration will take place in three areas across the Europe which are distinguished by varying local climates: Oceanic, Continental and Mediterranean (fig. 6).

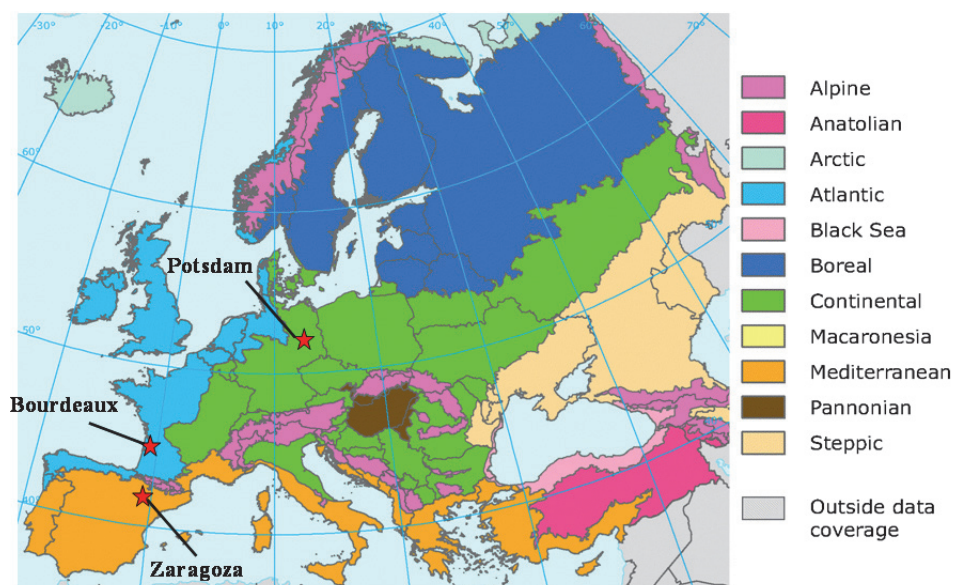


Figure 6. Biogeographic regions in Europe (EEA, 2011)

The selected site is the area of Médoc, near Bordeaux, in South-West France is an Oceanic climate. The area of Postdam, in North-East Germany, represents the continental climate prevailing in countries of Central Europe (Czech Republic, Poland, Hungary, etc.). The third location (Zaragoza in North-East Spain) represents the Mediterranean dry climate (typical of inlands in Spain). The practical results, the pilot-scale real operation demonstrations of EuroPruning are intended to show to farmers, logistic operators and companies of the energy sector along Europe that the use of the agricultural prunings is feasible, economic viable and profitable for large scale (Spanish demo site) and small scale (French and German demo sites) supply chains.

WP7 concerns soil management. The research to be performed in the demonstration areas are focused on the analysis of the influence of wood prunings on the composition of soil organic matter. It is important to determine, how much pruning should be left on the soil as

a source of mineral matter. It helps to avoid the need of extra fertilisation and to maintain the mineral balance in the agricultural system. If there is an excess of the prunings, they may be collected and allocated for energy purposes.

The results obtained in previous work packages will be subsequently analysed in terms of the environmental, economic and social aspects (WP8). It enables to evaluate the potential of the whole logistic chains investigated in the project and their application in Europe. The positive and negative effects or implications of the logistic chain will be identified in WP8. Moreover, the best logistic chains in terms of economics and environmental issues will be proposed, as well as their adaptability to different social contexts. Finally, the capacity of prunings to promote sustainable practices and development in rural areas will be discussed. By using different tools, LCA (Life Cycle Assessment), LCC (Life Cycle Costing) and SROI (Social Return of Investment) analysis will be performed.

Finally WP9 is oriented to dissemination actions towards the key players of the value chain and the general public as well as development of business plans for all major typical logistics supply chains. At the end, WP9 will provide recommendations for market uptake for each stakeholder as part of the exploitation plan.

Expected results and specific outcomes

The project outcomes (grouped into certain issues) are expected to be:

- a) prunings properties as a fuel:
 - identification and assessment of the specifications and properties of biomass from agricultural pruning residues,
 - selection of the appropriate methodology for sampling and testing of quality parameters, and its implementation on the demo sites,
 - assessment of the quality of pruning residues as feedstock for energy production at each step of the supply chain,
 - identification and definition of the specifications of the final users at each demonstration site,
 - elaboration of the guidelines and best practices for evaluating pruning residues along the whole value chain, taking into consideration geographical variations and end user demands.
- b) harvesting methods and machinery:
 - costs reduction for prunings harvesting up to 50% without affecting the quality and life cycle of the plant,
 - analysis and evaluation of the current harvesting methods according to the guidelines and specifications for the biomass quality for harvesting,
 - mapping of the EU27 pruning potential,
 - improvement of the current harvesting methods regarding environmental impacts, prunings quality and economics,
 - design and construction of a tested prototype of a complete new baler machine for branches from pruning residues,
- c) transport and integrated logistics:
 - reduction of prunings transport costs up to 30% by providing decision making tools to logistic operators,

- design and implementation of logistics tools in order to optimise environmentally and economically the transport of the pruning among the whole value chain,
- definition and development of the traceability systems on the pruning logistic to assure the quality,
- development and testing of a new Smart Box tool under real conditions for optimising logistics,
- d) storage of biomass from prunings:
 - testing and monitoring of the storage of prunings under real conditions in large piles,
 - definition of best practices for open air storage regarding to environmental, economic, safety and biomass quality concerns,
- e) soil management:
 - definition, depending on the soil conditions and crop requirements, the amount of pruning to be left on the field as amendment,
 - development and definition of a protocol and methodology for soil management analysis,
 - monitor the impact on the soil of the demo-sites,
- f) demonstration on the field and validation:
 - testing under real conditions the developments and results of the project,
 - analysis of samples obtained during the test on field to validate and optimise the developments of the project,
- g) impacts assessment:
 - definition of a methodology and measurements of the economic impact of the implementation of the results in the market,
 - determination of logistics cost in the whole value chain of biomass,
 - definition of a methodology and measurement of the environmental impact of the implementation of the results,
 - assessment of the social impact of the results of the project,
- h) business models and exploitation:
 - review of the current market trends on biomass,
 - development of the exploitation plan including: valorisation, SWOT analysis, exploitation roadmaps and value innovation analysis of individual projects results,
 - definition of business models for market take-up and safeguard the value of the project results,
- i) dissemination:
 - assurance of the effective branding of EuroPruning and dissemination of key results targeting farmers, policy makers, authorities, non-governmental organisations (NGOs), investors, professionals, land owners and researchers,
 - dissemination of results including advices for policy makers, focusing on measures to implement the improved new logistic chain of prunings,
 - dissemination of results of an environmental, social and economic analysis among stakeholders and users,
 - creation of the possibility for EuroPruning continuity beyond the end of the project, in order to attain the full potential impact.

Final conclusions

The increase of biomass potential allocated for decentralised and local energy production, especially amongst the agricultural residues, is still a very important task and challenge for European Countries in the coming years. Therefore, more and more attention is paid to the agricultural sectors that have not been yet investigated in respect of their utilisation as a source of solid biofuels. The prunings coming from orchards and permanent plantation are good example of this strategy. It led to the creation of the EuroPruning project supported by the European Commission.

The overall objective of the EuroPruning project is to develop and demonstrate a non-existent, new logistic chain for the biomass from pruning residues. The logistic chain includes the harvesting methods, the transport and the storage of the biomass. Furthermore, the quality of the biomass, the cost effectiveness of the processes as well as the environmental and social impacts will be taken into account.

To achieve this global objective, the following main specific targets were defined:

- assessment of fuel quality properties for pruning biomass related to the final consumer expectations and energy production,
- improvement of the harvesting methods and machinery development,
- transport and integrated logistics development,
- determination of optimal storage conditions of prunings,
- soil management analysis to define the optimal amount of prunings for energy purposes,
- demonstration and validation of the prunings-to-energy strategy under real conditions,
- impacts analysis of the whole logistic chains in terms of environmental, economic and social aspects,
- structure and definition of business models and other supporting tools introducing prunings to the biomass energy market.

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EUROPRUNING – NOWY KIERUNEK WYTWARZANIA ENERGII Z BIOMASY

Streszczenie. Jedną z możliwości zwiększenia potencjału biomasy na rynku energetycznym jest wykorzystanie odpadów rolniczych w postaci gałęzi ze ściniek drzew sadowniczych (drzew owocowych, winnic, drzew oliwnych i innych roślin korzennych). Zagadnienie pozyskiwania tego typu biomasy dla celów energetycznych w Europie nie jest w pełni rozwinięte i wiele aspektów wymaga nadal zbadania i/lub rozwiązania. Efektem tego jest projekt EuroPruning realizowany w ramach 7 Programu Ramowego ukierunkowany na rozwój nowej i ulepszonej metody logistycznej dla tego typu biomasy. W artykule przedstawiono główne cele i założenia projektu EuroPruning. Omówiono metodologię oraz zakres prac badawczych związanych z pozyskiwaniem, transportem i magazynowaniem takich odpadów rolniczych i uwzględniających aspekty środowiskowe, ekonomiczne i społeczne.

Słowa kluczowe: biomasa, ścinki gałęzi, sad, produkcja energii