STSM Report

"Environmental impacts and energy balances in coppices: LCA on processes and products"

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Figure 1. An oak coppice under traditional management after felling and processing operations.

1. Introduction

In the last years identifying and quantifying the environmental burdens related to the products and the services have become an interesting and important activity in many research fields. An important contribute to the emissions is related to the energy supply, and the use of fossil fuels has an important role in this context. For these reasons in the last years the use of bioenergy has been promoted in order to reduce fossil fuels consumptions and to improve the renewable energy use (Guo et al., 2015). Woody biomass has a key-role in the renewable energy context because of the good potential in terms of material and technological availability. The European Union (EU) focused the attention on biomasses in the Renewable Energy Directive (RED) 2009/28/EC, where, in order to reach the 20% of energy from renewable sources by 2020, is expected that the 42% of this energy will be obtained by biomasses. The role of forests in this plan is fundamental and coppice management is an interesting way for producing wood for energy use. As well as wood is a renewable and a "zero emission" material, the extraction of wood through forest operations involves different machines and processes with a proper set of emissions. Life Cycle Assessment is a world-recognized methodology that permits to calculate the potential environmental impacts related to the entire life cycle of products and processes, including all the inputs and all the outputs related to the life cycle of the item analysed (International Organization for Standardization, 2006). In the last years LCA has been introduced also in forest sector (Heinimann, 2012). Regarding LCA on coppices there are some researches on Short Rotation Forestry (SRF) (González-García et al., 2014; Morales et al., 2015; Roedl, 2010) while there is a lack of knowledge on traditional coppice management (Pierobon et al., 2015).

2. Purpose

The purpose of this STSM was to improve the applicant's knowledge on LCA and to develop a real analysis based on a previously collected set of data.

The main aim of this STSM is to develop a LCA on forest operations in traditional coppices and on related products in Tuscany region. This is an Italian area with an important tradition and a developed forest sector, especially in traditional coppice management. Different types of forest operations in coppices were analysed, as showed below:

-Standard harvesting in traditional coppices: Short Wood System (SWS), manual felling and processing with chainsaw, manual loading of firewood up the bins, extraction by tractor with beans, loading of firewood on trucks and transport to the supplier;

-Aerial: Full Tree System (FTS), manual felling with chainsaw, extraction of the trees by cable yarder, processing at the roadside with processor, loading of firewood on trucks, chipping of wood residues, transport of firewood and chips to the supplier.

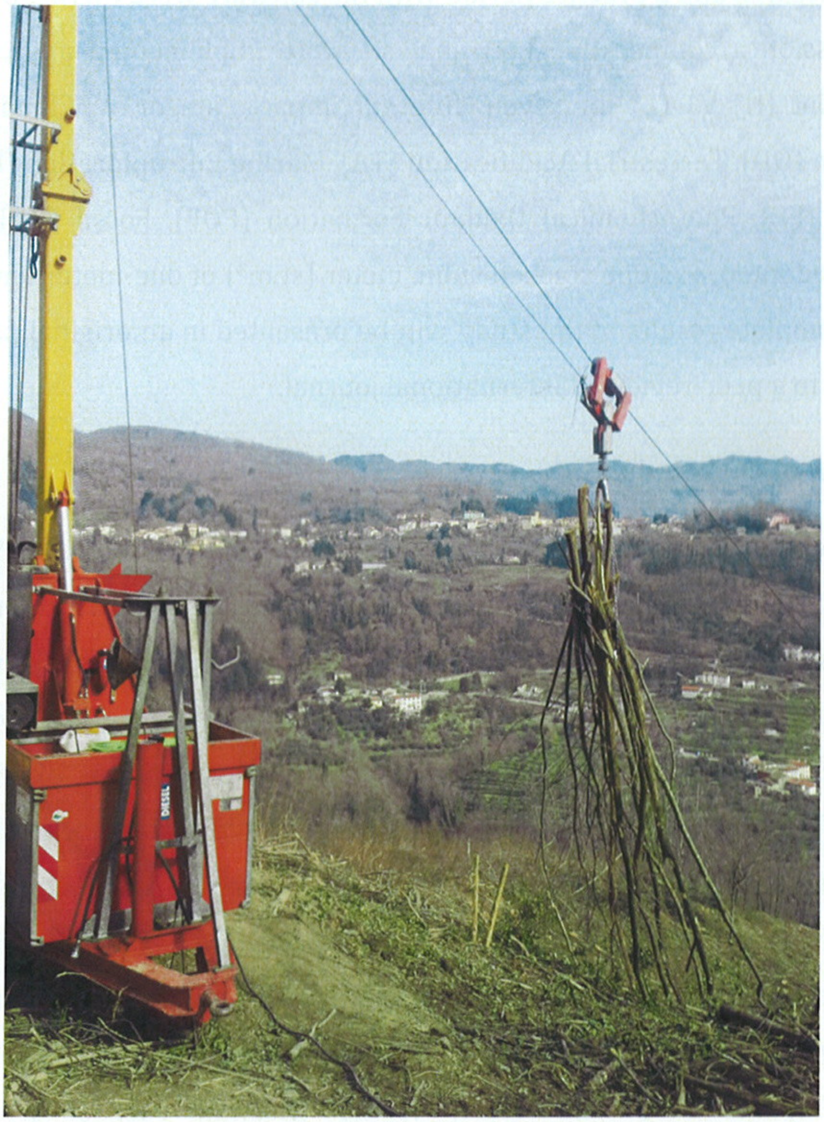

Figure 2. Extraction with cable yarder (Full Tree System).

Also a mechanized system was planned to be investigated but unfortunately, due to the uncommon bad weather in Italy during the first months of 2015 and the continuous changes of planning in forest activities by the selected enterprises, it was not possible to collect a reliable set of data for this kind of operation.

3. Methods, circumstances and locations

The period has been spent analysing the set of data previously collected in Italy; both a specific software for LCA (SimaPro 8) and a database (Ecoinvent 3) was used to manage and analyse the collected data.

During the first part of the mission, in order to improve the applicant's knowledge on LCA, a bibliographic research and a practise period with the software were carried out. In the second part of the mission a comparative LCA analysis were implemented applying the method "ReCiPe Midpoint (H) V1.12" for seven different impact categories: Climate Change (CC), Ozone Depletion (OD), Terrestrial Acidification (TA), Marine Eutrophication (ME), Freshwater Eutrophication (FE), Photochemical Oxidant Formation (POF), Fossil Depletion (FD). The functional unit adopted was one stacked cubic meter (st.m^3) of one-meter length firewood, at supplier. The complete results of the study will be presented in an original paper that will be soon submitted to a peer-reviewed international journal.

4. Overview of collected data

In order to collect a representative and reliable set of data for both the SWS and the FTS in forest operations in traditional coppice management, different operations in different work sites were investigated. In particular a time study (12 working days survey) were carried out in order to calculate the productivity of workers in all the different phases involved. Moreover the technical characteristics, the gasoline and diesel consumption for all the machines involved in the work were collected. The number of work days and workers were registered and used for analysing the impacts related to the workers transport (Berg, 1997). The characteristics of the forests were analysed before the beginning of logging operations by plot sampling in order to estimate the wood volume available in the area. The global coppice surface investigated was about 4 hectares. The main specie harvested were oak (*Quercus pubescens* Willd) in SWS and black locust (*Robinia pseudoacacia* L.) in FTS.

5. Results

In SWS, considering that the thin branches were left on forest surface, firewood is the only product obtained; in FTS the full tree were extracted and the thin wood residues were chipped. An average of 178 st.m^3/ha (all firewood) and 182 st.m^3/ha (140 firewood and 42 chips) of wood harvested were calculated respectively for SWS and for FTS. In table 1 the results related to the production of firewood by Short Wood System are reported.

Table 1. Results referred to the production of 1 st.m3 of firewood in SWS

Impact category	Unit	Total	Felling and processing	Extraction	Loading	Transport
Climate change	kg CO2 eq	6,82	13%	47%	16%	24%
Ozone depletion	kg CFC-11 eq	$1{,}15 \cdot 10^{-6}$	13%	43%	12%	31%
Terrestrial acidification	kg SO2 eq	$3{,}60 \cdot 10^{-2}$	8%	54%	18%	20%
Freshwater eutrophication	kg P eq	$1{,}27 \cdot 10^{-3}$	4%	52%	36%	7%
Marine eutrophication	kg N eq	$4{,}10 \cdot 10^{-3}$	21%	59%	11%	8%
Photochemical oxidant formation	kg NMVOC	$8{,}38 \cdot 10^{-2}$	46%	32%	10%	12%
Fossil depletion	kg oil eq	2,33	11%	45%	15%	29%

The emissions for the production of 1 st.m^3 of firewood are in general really low in all the impact categories considered, i.e. 8,9 and 6,8 kg of CO_2 eq, 3 and 2,3 kg oil eq respectively for FTS and SWS. The differences between the two systems analysed and the different products obtained are shown in figure 3. FTS permits to obtain chips as secondary product chipping the wood residues unsuitable as firewood. Regarding chips the environmental burdens are higher than firewood considering the different processes and machines involved in the production. In particular in FTS there is an increment in emissions between firewood and chips production in a range from 5% (in Marine Eutrophication) to 8% (in Ozone Depletion).

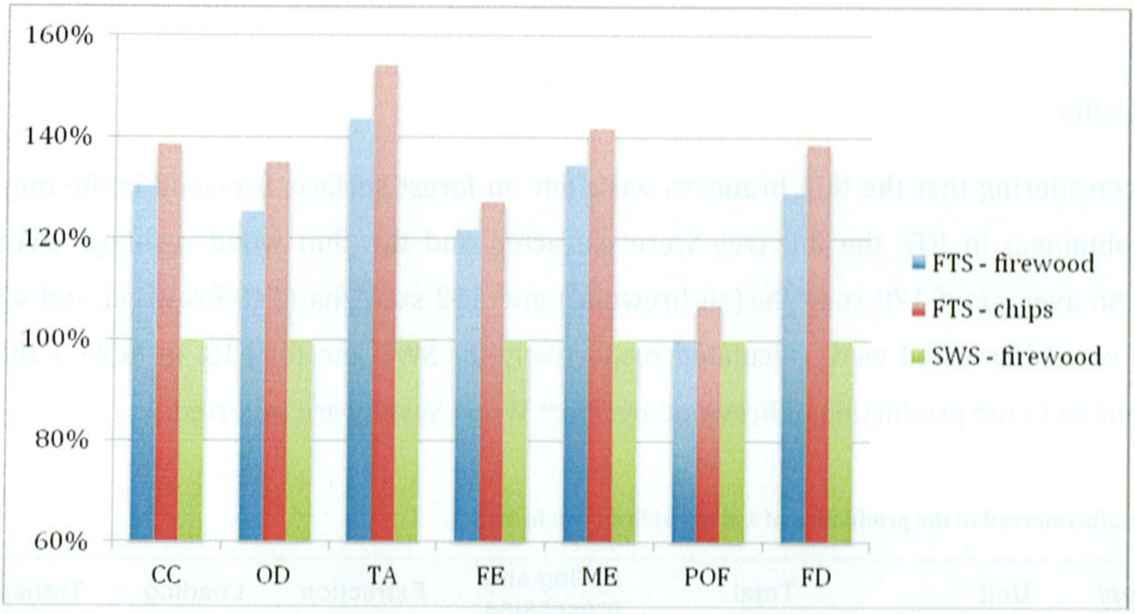

Figure 3. Percentage variation of emissions referred to "SWS-firewood" values (represented with the value 100% in the graph) between the different products analysed for all the examined categories: Climate Change (CC), Ozone Depletion (OD), Terrestrial Acidification (TA), Marine Eutrophication (ME), Freshwater Eutrophication (FE), Photochemical Oxidant Formation (POF), Fossil Depletion (FD).

The most important impact related processes are the production and use of diesel; the extraction phase generally has the highest ratio of environmental burdens in all the life cycle of firewood in SWS. Also in FTS the extraction phase is the one with the highest rate of emissions in almost all the impact categories considered (from 34% of total emissions in POF to 59% in ME).

6. Conclusions

The results of LCA showed that the environmental burdens related to forest operations in traditional coppice management (TCM) in general are really low. TCM, without the agronomic procedures like fertilising and weeding, generally has a lower impact than Short Rotation Coppice (SRC) (Roedl, 2010) where these practices could be really intense for maximizing the annual production. SWS showed a better profile than FTS in all the categories examined, due to the lower use of heavy machines and the huge amount of manual work hours. The chipping phase, considering the high power requirements and consequently the use of a machine with a huge consumption of diesel, explains why the environmental burdens related to chips are higher than firewood in FTS.

7. Literature

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