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Mountain forest wood fuel supply chains: comparative studies between Norway and Italy

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ABSTRACT

Case studies of mountain forest wood fuel supply chains from Norway and Italy are presented and compared. Results from previous studies in which greenhouse gas emissions and costs were evaluated using life cycle assessment and cost analysis respectively, are compared. The supply chain is more mechanized in Norway than Italy. Steeper terrain and low road density partly explain the persistence of motor-manual felling in the Italian case. Mechanized forest harvesting can increase productivity and reduce costs, but generates more greenhouse gas (GHG) emissions than motor-manual harvesting. In both cases, the main sources of GHG emissions are truck transportation and chipping. The total emissions are 22.9 kg CO_2/m^3s.o.b. (Norway) and 13.2 kg CO_2/m^3s.o.b. (Italy). The Norwegian case has higher costs than the Italian one, 64 €/m^3s.o.b. and 41 €/m^3s.o.b. respectively, for the overall supply chain. The study shows that mountain forests constitute an interesting source for fuel biomass in both areas, but are a rather costly source, particularly in Norway. The study also exemplifies the care needed in transferring LCA results between regions and countries, particularly where forest biomass is involved.

1. Introduction

Climate change, due to higher concentrations of greenhouse gases (GHG) in the atmosphere, is becoming an increasingly significant issue. According to the Intergovernmental Panel on Climate Change (IPPC) [1], human activities are the main factor behind rising GHG emissions. The 2013 IPPC report stated emphatically that: "human influences on the climate system are clear" [2,3]. Underlying this conclusion is the utilization of fossil fuels, which results in an increasing GHG concentration in the atmosphere.

To reduce or at least stabilize the GHG concentration before 2020, emissions of GHGs and particularly CO_2 into the

Abbreviations: GHG, greenhouse gas; GWP, global warming potential; LCA, life cycle assessment; s.o.b., solid over bark.

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atmosphere need to be reduced. The use of renewable energy can contribute to this, for example by replacing fossil fuels with biomass. However, in the long run equal to forest rotation length, the CO_2 is captured during the tree growth making bioenergy favorable when produced sustainably, i.e. harvest does not exceed growth and soil condition is maintained. Although further knowledge of the role of soils is need, a sustainably managed forest operation system has great potential for climate change mitigation.

At the global level, the Kyoto protocol has been the key agreement for reducing GHG emissions to date [4]. The protocol ended in 2012 and a voluntary prolongation till 2020 is currently being followed by most, but not all, countries that ratified the original Kyoto protocol. International meetings continue, with the goal of having a new protocol in place by 2020 [5].

In Europe, the European Union (EU) has adopted an energy policy in accordance with international agreements based on a low carbon profile. The goal is to achieve three targets: a 20% reduction of GHG emissions to 1990 levels; an increase in the use of renewable energy to 20% of the total EU energy consumption; and a reduction in total energy consumption [6]. Within the EU, new actions for the period up to 2030 are being discussed. A mixture of all renewable i.e. naturally replenished, energy sources is crucial for achieving these targets. Biomass is one possible choice for the supply of energy which would also reduce GHG emissions, diversify energy supply and reduce pressure on limited resources [7]. Furthermore, it has the potential to be used as a fuel product in addition to producing power, unlike hydro power or wind energy. Woody biomass, agricultural products, slaughter waste, forest products and marine products such as algae are all example of accessible biomass. However, when harvesting biomass, one needs to maintain a balance between what the environment can tolerate, and what is socio-economically viable, i.e. it must be managed in a sustainable way.

Within this variety of renewable resources, woody biomass from forestry is an interesting energy source, already playing an important role in many parts of the world [8]. According to Smeets and Faij [9], biomass from conventional forestry will supply both the forest products industry and energy producers in the future. Woody biomass from mountain forests may be an additional resource for the future, simultaneously promoting socio-economic development. New opportunities of income and employment in both the forestry and bioenergy sectors may be generated for the local communities in mountain areas.

In Europe, one billion hectares of land, i.e. 36% of the total land surface, are forested, and the rate of forest biomass growth has increased in the last century [10]. Reforestation, i.e., reestablishment of forest cover, is occurring especially on sites once used for grazing and agriculture [11]. Over one quarter of all European forests are mountain forests [12]. Due to their altitude, mountain forests normally have a cooler climate than lower lying areas. Consequently they have a different species composition, slower forest dynamics, regeneration and growth, and a lower intensity of forest operations than lowland forests [13,14]. A rise in the global average temperature is predicted by the end of this century [15], most likely causing a shift in the tree line to higher altitudes and increase the availability of wood resources.

Around the world, the traditional concept of sustained-yield forestry had to be adapted to the specific conditions of mountain forests, in particular in Norway, to comply with environmental concerns.

The International Energy Agency [7] has predicted a 55% increase in energy demand by 2030, compared to 2000 levels. Currently only 60% of the total forest increment is harvested in Europe and this percentage is even lower in mountain areas [16]. Woody biomass could therefore be an important contributor to satisfying the increased energy demand, but at the same time there will be more and more pressure to find additional sources of wood fuels. Within this context, woody biomass from mountain forests could play a strategic role. Furthermore, in marginal areas, harvesting wood energy can promote rural development [17] and represents a new source of income for forestry companies.

In this study, we focus on two countries, Norway and Italy, with substantially different energy state. Norway is self-sufficient in energy, with domestic energy consumption being dominated by electricity, mainly derived from hydropower (99%). On the other hand, crude oil and natural gas account for almost 50% of the value of all Norwegian exports [18] so Norway is involved in fossil fuel businesses alongside the use of hydropower. Consequently, bioenergy holds a small share (6%) of domestic energy consumption of which domestic users use about 50% for heat production with small wood-burning stoves. In Norway, in 2010, about 53% of the domestic consumption of wood biofuels for heat production is used in households, 24% in the pulp and paper production, 11% as wood chips and bark in central district heating, 3% as briquettes and pellets and the remaining 9% in other industries including sawmilling. The market for wood pellets in residential areas is very small, close to zero [19]. At present the Norwegian wood chip market is in decline, partly because of shut downs in the pulp and paper industry and partly because subsidies for chipping of forest residues have disappeared. Productive forests occupy 40% of the Norwegian land area, and the annual increment is more than twice the annual harvest [20]. In 2002, about 30% of the forested area is located in the mountains [21], especially in Hedmark and Oppland counties. In Norway, 49% of forested land has an inclination greater than 20% and most of the potential for increased harvesting is in difficult terrain with low site quality, as is typical of mountain forests [22]. Norwegian mountain forests are managed according to specific rules, which forbid clear cutting and require the maintenance of the mature forest character to protect vital ecological functions. Selective cutting and small-scale clear cutting or group cutting, clear cutting of areas from 0.2 to 0.5 ha, are the conventional harvesting systems for mountain conditions, according to sustainable forest management criteria as specified in Levende Skog [23].

By contrast, Italy is not self-sufficient in energy, and in 2011, the energy dependence from abroad was of 81.3% [24]. In 2005, more than 30% of the Italian territory is covered with forests, of which 60% are mountain forests [25], generally located in steep terrain. Traditionally, mountain forests have very long cycles, hence we can assume that the forest situation hasn't changed in the last decade in both case studies.

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