Title: Increasing reliance on energy wood? A case study on policy-practice interface in selected European countries

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Abstract: European Union's policies emanated during the last decade in the energy, climate and rural development sectors foster an increased reliance on energy wood as a contribution to the achievement of a low carbon economy. This study analyzed the degree of correspondence between European Union's policy ambitions with respect to energy wood and perspectives of national stakeholders about possibilities to increase reliance on this energy source. In particular, we collected stakeholders' opinions about current and future roles of energy wood and about chances of implementing three concrete options for increasing energy wood production. To carry out our study, we chose three European Union Member States with different characteristics (Germany, Slovenia and Spain) and we selected five stakeholder groups that covered as much as possible the actors of the energy wood contexts. While we detected that stakeholders were often uncertain about the feasibility of achieving European Union's policy goals, especially due to the environmental trade-offs that they associated to increasing reliance on this energy source, we found out that they supported European Union's discourses regarding the role of energy wood in boosting the competitiveness of the forest sector, contributing to climate change reduction and maintaining different forest functions. We suggest that, in order to achieve an increased reliance on energy wood, European policy makers use these positive considerations of the energy wood role to underpin their strategies and at the same time work to reduce the effect of environmental trade-offs by prioritizing at supranational level the policy objectives that affect the environment.

Points for practitioners: This study offers insights about the application of international policies in national and local realms, and the role of stakeholders in this implementation. It is useful for supporting policy decisions and designing viable policy instruments aimed at increasing reliance on energy wood, as well as for improving convergence between supranational policy goals and practical outcomes in the European Union.

Key words: European policy, forest biomass, bioenergy, stakeholders' perspectives

1 Introduction

In order to build a long-term energy strategy that strives for a low-carbon economy, the European Union (EU) has set policy goals for 2020, 2030 and 2050 that aim at increasing the use of renewables (European Commission, 2009, 2014, 2018). Energy wood, here defined as woody biomass harvested directly from forests[1] and used for energy purposes, is one of the strongholds of this strategy (Ferranti, 2014). This is evident in the 45% contribution of energy wood to the 2016 EU's gross consumption of renewables (Eurostat, 2018) and also in the climate, energy, forestry and rural development policy developments taking place from the early 2000s onwards. In the last two decades, different policy documents (see for example European Commission, 2013; European Commission, 2014; European Parliament and Council, 2013) and legislations (as prominent examples see Directive 2009/28/EC, named Renewable Energy Directive or RED, and the more recent Directive 2018/200 or RED II) were produced, which point at the need to increase reliance on energy wood. Based on the idea that European forests encompass a currently unexploited reservoir of wood (Asikainen et al., 2008) and that energy wood is characterized by

[1] In line with other studies (e.g. Mantau et al., 2010), this article excludes wood from plantations because in the European context these are often referred to as agricultural products.

"carbon-neutrality"[2] (Bright et al., 2012; Ferranti, 2014), EU legislations and policy documents praise energy wood's role in constituting a valuable substitute to fossil fuels and an important element in the solution of the climate change problem. In particular, they exalt its contribution to the security of domestic supply, the diversification of the EU's energy mix, the generation of income in rural areas and the maintenance of important environmental and social forest functions thanks to the promotion of an active form of forest management (European Commission, 2004; European Commission, 2005; European Commission, 2009; Faivre et al., 2018; Ferranti, 2014).

However, in literature, the enthusiasm expressed by policy documents is counterbalanced by the awareness that increasing reliance on energy wood can pose concrete risks for the environment (Beiträge und Standpunkte aus dem Öko-Institut, 2018; Searchinger et al., 2018; Schyns and Vanham, 2019). These risks include a depletion of the carbon stocks that are present in EU's forests and a reduction of forest capacity to contribute to climate change mitigation with the emission of CO_2 with the burning of woody biomass that would worsen the global warming problem (Schulze et al., 2012; Ferranti, 2014; WWF European policy Office, 2018; Searchinger et al., 2018). The awareness about these risks has played a growing role also in EU policies, which took increasingly into account the possible negative consequences of using energy wood without applying the necessary sustainability measures (IEA Bioenergy, 2018; ICCT, 2018). To give an example, compared to the RED (European Union, 2009), the RED II (European Union, 2018) addresses the use of energy wood by introducing new sustainability criteria for biofuels and bioenergy obtained from raw materials originating from forests (European Union, 2018; IEA Bioenergy, 2018). The recognition of these risks is strong also among stakeholders of the forest and energy sectors. Different representatives of the scientific arena and of civil society expressed their worries with respect to the possible negative consequences and limited feasibility of satisfying EU's policy objectives related to energy wood (Searchinger et al., 2018; WWF European policy Office, 2018; FERN, 2018; Beiträge und Standpunkte aus dem Öko-Institut, 2018; Matthews et al., 2018; Euractiv, 2018a). These stakeholders considered the sustainability precautions taken by EU policies as inadequate (e.g. FERN, 2018). They also claimed that, as other framework policies emanated in the EU (Jordan, 2000), EU legislation dealing with energy wood expresses common goals for EU Member States (MSs) and point at a general principle of integration among competing forest functions like wood production and nature conservation. Doing so, they do not indicate concrete solutions neither for increasing energy wood production nor for the environmental trade-offs associated to this production (FERN, 2011; Schulze et al., 2012). The solution of these trade-offs is left to the leeway of MSs (Jordan, 2000), which must transpose and apply EU policies sometimes facing a low acceptance by stakeholders and related implementation problems (Majone, 1999). Next to the stakeholders that blame the EU's approach to energy wood for being unsustainable, other actors, and especially forest owners and representatives of the economic sectors linked to bioenergy, criticize the approach of current EU policies for completely opposite reasons. They are concerned that, in the name of sustainability, the RED II imposes too many restrictions to the use of energy wood (CEPF, 2017a) and it undermines the economic viability of sustainable forest management (CEPF, 2017b).

The struggle between different stakeholders' perspectives about the suitability of the EU's approach towards energy wood highlights the complex policy and practical drawbacks of dealing with this energy source (Berndes et al., 2016). In light of this complexity, this paper aims at contributing to define the details characterizing the different stands stakeholders take about the

[2]The assumption of the "carbon neutrality" of wood holds that the biomass extracted from the forest and burned in the energy generation process is in the long run replaced by new biomass growth in the forest, which re-absorbs the carbon emitted by the process of energy generation (Czeskleba-Dupont 2012). In this sense, the carbon emitted when generating energy from wood is perceived as staying in the atmosphere for a rather short time frame and is set against the emissions generated by fossil fuels, which have a much slower recovery time and are supposed to stay in the atmosphere for a very long time (Bright et al. 2012).

concrete possibilities to implement EU's goals of increasing reliance on energy wood. The rationale behind this article developed from the idea that the correspondence between policy goals and stakeholders' perspectives about a policy issue are a key element in the successful implementation of policies (Julien et al., 2000; Irvin and Stansbury, 2004). By carrying out an analysis of stakeholders' perspectives about feasibility to achieve EU's goals of increasing reliance on energy wood, it contributes to the study of the policy-practice interface related to renewable energy that has been addressed by other authors (Stupak et al. 2007; Peters et al., 2015; Wolfslehner et al., 2009) and it offers evidence about the level of compatibility between supranational policy objectives and lower contexts. Doing so, it feeds in policy implementation literature that focuses on understanding the application of international policies in national and local realms, and the role of stakeholders in this implementation (Ferranti et al., 2014; Lindstad et al., 2015; Peters et al., 2015; Santopuoli et al., 2015; Bohlin and Roos, 2002). In this light, this study is useful for supporting policy decisions and designing viable policy instruments aimed at increasing reliance on energy wood, as well as for improving convergence between supranational policy goals and practical outcomes in the EU (Jordan, 1999; Dimitrova and Steunenberg, 2000; Boerzel, 2001).

2 Analytical Framework

This study is rooted in the idea that successful national and local implementation of international policies does not only depend on the legal transposition in national systems (Yanow, 1996), but also on society acceptance of the rationale behind (and scope of) policy requirements (Fischer, 2000; Alphandery and Fortier, 2001). This is particularly true in decentralized contexts like the EU, where national transposition of supranational framework is supposed to steer local outcomes towards common goals (Jordan, 2000). In the analysis of stakeholders' perspectives about EU's goals of increasing reliance on energy wood, we considered these perspectives as a litmus paper that gives an indication of the level of compatibility between policy ambitions and the reality of the energy wood context (Fischer, 2000; Posavec et al., 2015; Pezdevšek Malovrh et al., 2016). We collected and scrutinized stakeholders' opinions between November 2012 and September 2013, period in which the implementation of the RED was in its initial stage and much perplexity was expressed in the international arena about the practicability of EU's goals (Czeskleba-Dupont, 2012; Hesselink, 2010; Verkerk et al., 2011a, 2011b). At that time, energy wood was a side-stream from roundwood production in many European countries (Díaz-Yáñez et al., 2013). Some of the studies we used as reference for our research made clear that, for achieving an increased energy wood production, early 2000s' wood exploitation patterns needed to be changed by taking society acceptance of eventual changes into account (European Environmental Agency, 2007; Mantau et al., 2010).

The RED (European Union, 2009) and other EU policies and documents emanated in that period did not provide practical indications on how to increase energy wood production. Therefore, in order to build the framework for our analysis we drew on scientific literature that proposed scenarios of future energy wood production in the EU (e.g European Environmental Agency, 2007; Mantau et al., 2010; Verkerk et al., 2011b). These scenarios suggested changes in ongoing wood exploitation patterns like expanding the forest area available for wood supply and/or increasing the wood supply from existing sources. Based on these scenarios, we concentrated on three concrete options for increasing energy wood production, which were of inspiration for our enquiry of stakeholders' perspectives: 1) increasing the area where energy wood is harvested; 2) changing existing forest management practices to obtain energy wood and 3) exploiting tree components not traditionally harvested for energy production.

3 Methodology

In order to provide a varied picture of the energy wood contexts characterizing different areas of the EU while limiting the retrieval of information about stakeholders' perspectives to an easily displayable quantity of data, we selected three case study countries (Germany, Slovenia and Spain). These MSs were chosen because they were characterized by different historical, social and economic conditions, by different traditions linked to the use and import-export of (energy) wood and by varying national approaches towards the future role of wood (see for example Lindstad et al., 2015). The differences among the three countries made the collection of results suitable to support cross-country comparisons. For each country, we enquired opinions expressed by five stakeholder groups, chosen to cover as much as possible the different categories of actors that played a role in the energy wood context, and in particular:

- Conservation group (nature-conservation bodies e.g. associations and state agencies);
- Economy group (industries and associations representing end-users of timber and energy wood);
- Policy group (representatives of national Ministries and especially of forest administrations);
- Practitioners group (forest-owners' associations, forest enterprises and foresters); and
- Science group (scientific institutions, researchers and experts).

For selecting the 70 interviewees that joined our study (see Table 1), we used a purposive sampling strategy (Oliver, 2006) designed to capture their affiliation, their role within the institution they worked for and their expertise. The number of interviewees varied for each stakeholder group due to different availability of interviewees. Interviews were carried out face-to-face, by phone or Skype in the respondents' native languages and using in-depth methods (Miles et al., 2004; Ritchie et al., 2013). We posed general questions regarding stakeholders' opinions on the role played by energy wood at the time of the study and in the future (e.g. on current national forest management priorities and on opinions about increasing energy wood production), as well as specific questions on possibilities to apply the three concrete options for increasing energy wood production listed in Section 2. Interviews were voice-recorded, transcribed and analyzed with MAXQDA (Verbi Software, v.10), a software that facilitated retrieving and coding portions of text under labels that reflected different aspects of stakeholders' perspectives.

Table 1. Number of interviews carried out in the various countries for each stakeholder group.

	Germany	Slovenia	Spain	TOTAL
Conservation	3	4	2	9
Economy	13	4	2	19
Policy	4	4	1	9
Practitioners	12	7	3	22
Science	4	5	2	11
TOTAL	36	24	10	70

4 Results

This section displays first the information provided by stakeholders about the role of energy wood at the time of the study, forecasts for the future and general perceptions about increasing reliance on energy wood (Section 4.1) and secondly the specific perspectives of stakeholders about the application of the three concrete options for increasing energy wood production (Section 4.3). For drafting both sections 4.1 and 4.2, we used direct quotes from the interviews. Finally, Section 4.3 reflects over stakeholders' opinions in light of the overall national contexts characterizing the production of energy wood.

4.1 Stakeholders' perspectives about the role of energy wood at the time of the study and in the future

Interviewees from the three countries perceived that, at the time of the study, energy wood was a by-product of standard forest management, produced mainly from full trees harvested during thinnings and residues of final fellings. In Germany, full tree harvesting during thinning was allowed on stands with sufficient nutrient supply to prevent dangerous depletion of soil fertility. In Slovenia, energy wood was also derived from low-quality stems from final fellings, because of low demand in the domestic wood-processing industry. In Spain, interviewees mentioned that in some cases primary products of full tree harvesting were used to produce energy wood and that timber from burned forests was used for energy, as was wood generated in understorey clearing actions aimed at fire prevention. In Germany and Slovenia, interviewees mostly believed that the role of energy wood was going to receive more attention in the future, but in their eyes this energy source was not destined to gain market dominance over roundwood. In Slovenia, interviewees hoped for a future upturn of the wood-processing industry, and they foresaw that more energy wood as a by-product would be available for energy production. However, they frequently expressed a preference for increasing material rather than energy uses of wood. In Spain, as a consequence of the decline of the building-sector and of the particleboard industry, stakeholders expected a reassignment of wood resources to the production of chips and pellets and energy wood to become the main forest product in the near future.

Representatives of all three countries agreed that the increment of growing stock was larger than removals, and this made the goal of increasing such production realistic to their eyes:

"*For years overstocks have been established, now it's possible to fell above increment, without compromising sustainable use.*" Economy group (Germany).

However, some Spanish and German stakeholders talked of the need to establish limits to energy wood production. Especially in Germany, stakeholders from different groups perceived forest management sustainability as a limitation. Concerns regarded soil nutrient balance, biodiversity and forest overexploitation, which brought some interviewees to conclude that little or no extra energy wood mobilization was possible in Germany. Some German stakeholders mentioned the need to implement expensive compensation measures for nutrient supply if more wood was to be harvested:

"We have used 70% of sustainability of forests so far. And for sure we could use till 90% without serious consequences. However this will cause conflicts regarding biodiversity and on the long run possibly also regarding nutrient sustainability. Nutrient sustainability could be partially compensated by ash recycling and liming – from a natural science point of view that would be possible but it's a question whether this would be accepted by society […]*."* Science group (Germany).

4.2 Stakeholders' perspectives about possibilities to apply three concrete options for increasing energy wood production

4.2.1 Stakeholders' perspectives about the option of increasing the forest area managed for energy wood

Interviewees reported various means of implementing this option. Representatives of most Slovenian groups and from all Spanish groups referred to harvesting wood from currently unmanaged stands. Slovenian interviewees mainly agreed that future measures should focus on

unmanaged privately owned forest areas. Spanish stakeholders mentioned that unmanaged stands were often prone to fire risk stemming from uncontrolled biomass increase:

"Extracting biomass for energy is an opportunity […] *to apply preventive management for forest fires* […]. *Forestry treatments are very often included in fire prevention plans and later are not applied due to lack of budget. Then energy wood, if it results profitable, can be a chance to activate that."* Conservation group (Spain).

Harvesting more energy wood from low-profitability forests was mentioned as another possibility by representatives of most German groups. They referred to 1) forests characterized by timber stocks with low value and by steep slopes and 2) small private forests as labelled not-profitable because of the considerable efforts necessary to harvest, and mobilize the wood:

"*Many nature conservationists are against mobilizing* [wood from] *private forests because these are forests which are abandoned. But these forests are oftentimes spruce stands of 60 to 80 years and* [have] *absolutely high stocking levels and they are actually rather uninteresting with respect to nature conservation."* Conservation group (Germany).

Also in Spain harvesting low-profitability forests (e.g. extensive pine reforestation areas from the 1960s and '70s where minimal forestry treatments had been undertaken) was considered by some stakeholders as a relevant possibility to achieve the option of increasing the forest area managed for energy wood. Some Spanish interviewees stressed the opportunities related to fire prevention, but they highlighted the need for maintaining forest cover and avoiding energy wood harvesting in protected areas. In both Slovenia and Spain, weak cooperation among and organization of private forest owners was seen as an obstacle for implementing this option, as managing several individual small forest properties was considered to be expensive and not in line with the needs of the energy industry. Interviewees from the two MSs concluded that the establishment of forest owners' associations could have been a solution, though important difficulties existed for motivating associations to work smoothly:

"Forest associationism in Spain is limited and practiced with low interest, because [forestry activities] […] *in many cases are secondary activities, residuals for family economies, so they are not attributed much importance".* Economy group (Spain).

4.2.2 Stakeholders' perspectives about the option of applying changes in forest management practices

In Germany, we recorded contrasting opinions about the application of this option. Some German interviewees suggested to plant rapidly growing trees at the edges of forests (on their perimeter, along forest roads, etc.) and mentioned possible synergies between planting native species (e.g. hazel, European chestnut and poplar) and nature conservation, especially in areas hit by natural disasters:

"A possible chance for nature conservation could be increasing reintroduction of coppice forests […]. *If* […] *such a forest will be cleared in sections and not all at once, then species like hazel grouse can profit".* Conservation group (Germany).

Other stakeholders held that increasing the proportion of non-native species was a way to adapt to climate change, but some interviewees who feared that species like Douglas fir could change forest structures by negatively affecting nature conservation contrasted this positive attitude. Representatives of most German stakeholder groups cited intensification approaches like

denser forests or shorter rotation periods, but these were not perceived as important means to achieve this option. In Slovenia, an interviewee suggested to increase the share of young trees and the intensity of silvicultural works. This would benefit both energy wood production and biodiversity conservation:

"[…] *In lowland forests – which are also a habitat for smaller game, rabbits, pheasants and other birds – many young trees are an advantage. And if regularly performed, silvicultural works can produce a lot of energy wood".* Conservation group (Slovenia).

Thinnings in young and middle-aged forests were mentioned by stakeholders in all countries as means to apply this option. We recorded varied perspectives among German stakeholders. Representatives of all stakeholder groups mentioned that this practice had become profitable thanks to the development of the energy wood market. Profitability was foreseen to increase with further rising of energy wood demand. Interviewees reported also improved qualities of forest stands as positive effects of this trend:

"Many measures, like thinning, cost a lot. A few years ago we either had to spend money with losses, or many forest owners could not conduct thinnings, which led to unstable stands. […] *For us it's really important that stands get more stable now.* […] *Now we can conduct forest management by covering costs or we can even reinvest money derived from those interventions."* Practitioners group (Germany).

However, other German stakeholders discussed possible conflicts associated with this practice, like damages to soil structure due to excessive compaction by machineries, problems with nutrient supply and changes in forest structures. Interviewees from most stakeholder groups in Slovenia and from all Spanish groups expressed positive or partially positive opinions about thinnings in young and middle-aged forests. Slovenian stakeholders related such practice to increased stability of forest stands and they claimed the need for governmental support for this silvicultural measure. In Spain, interviewees reported that broad reforested areas required thinning to improve wood quality and biodiversity functions. They also highlighted that the products of thinning would have no market, hence representing only costs for managers. Energy wood was therefore perceived as an opportunity to cover costs and achieve improvement of forest stands.

4.2.3 Stakeholders' perspectives about the option of exploiting tree components not traditionally harvested for energy production

German and Spanish interviewees from all stakeholder groups as well as some interviewees from Slovenia mentioned increased harvesting of logging residues as applicable means for this option. In Germany, most stakeholders expressed positive opinions about this means, which were associated to reduced regeneration costs after logging, increasing revenues and satisfaction of silvicultural needs like preparation of natural regeneration areas. However, some German interviewees had concerns regarding negative effects on nutrient balance:

"At the time of my grandfather wood thinner than one's wrist remained in the forest in order to maintain soil nutrition. Nowadays […] *this does no longer correspond to my grandparents' idea of forest use".* Economy group (Germany).

Several Slovenian interviewees advocated that extracting more logging residues would not cause any negative effects on soil nutrients, but also that this might not be financially viable, for example because of possible negative effects on forest fauna. Also Spanish interviewees from

most groups expressed concerns on soil nutrients, but in their view benefits of harvesting logging residues compensated problems, especially when the type of soil was taken into account:

"*There is a big difference between acid and basic soils* [...] *because in a siliceous soil the nutrient loss is likely to occur and the organic layer is degraded easily and there is nothing to accumulate nutrients. Whereas in the basic* [soils] *biomass extraction can be a bit more intensive* [...]". Science group (Spain).

Among the means to achieve this option, interviewees from most stakeholder groups in Germany and Slovenia and from all Spanish groups mentioned the possibility that wood assortments traditionally serving material uses could be destined to the energy industry. In all three countries, it was expected that some of the wood that was used by the pulp and paper or particleboard industries would be used for energy in the future, especially if the predicted decrease in the capacity of industries using pulpwood would materialize, as it was already happening in Spain. In Germany, interviewees expressed negative feelings about this trend, which mainly stemmed from the importance attributed to the wood-processing industry in the national economy. In Spain, some interviewees reported (and agreed with) an initial opposition of the particleboard industry based on the need to apply the cascade principle for the use of wood, to which they opposed a quick adaptation of the paper industry to the growing energy wood market. This resulted in a fierce competition for the particleboard industry and in a new revenue source for the paper industry:

"*What we said was: well, let's use only what the particleboard industry doesn't want […] the effect we found is that who was more favored […] was the paper sector through the production of electricity, coming from Eucalyptus plantations, poplar, Pawlonia, etc.".* Conservation group (Spain)

Representatives of all German groups and of some Slovenian and Spanish groups mentioned increased use of low-quality trees as another possibility for implementing the option of exploiting tree components not traditionally harvested for energy production. In Germany, this was regarded as an only moderately relevant solution, as interviewees preferred that low-quality trees would stay in the forest to strengthen biodiversity conservation functions. In Slovenia, stakeholders reported more positive opinions about this means:

"The main aim is to have close-to-nature forests. […] *And this might demand more intensive interventions* […]. *As a result, we obtain a lot low-quality wood which is perfectly usable for energy purposes."* Practitioners group (Slovenia).

The solution of using deadwood to implement this option was mentioned by representatives of all German groups and of one Spanish group. While few German interviewees pointed out that the importance of conserving deadwood was a solid concept in the country and producing energy wood would not represent an obstacle to habitat conservation, most German stakeholders thought that this would contrast current nature conservation efforts with consequent negative effects on birds and animals. They expressed the need of more precise limits concerning quality and quantity of deadwood extracted, as well as concerns regarding intensification of deadwood use that was seen as possibly leading to segregation approaches with areas dedicated to deadwood maintenance and others to intensified depletion of deadwood.

In Spain, opinions on using deadwood were negative due to the importance of deadwood for biodiversity conservation:

"[…] *A percentage of deadwood, which should stay on the ground to ensure the function of different habitats of species*". Conservation group (Spain)

Full tree harvesting was mentioned by representatives of most German groups and of two Spanish groups as a further means to implement this option. In Germany, some interviewees reported the occurrence of an increased utilization of full trees derived from thinning operations already at the time of the study, which was not only put in relation with increasing energy wood demand, but also with a general trend to mechanization and growing wood prices. These interviewees felt negatively about this trend because they considered this practice as conflicting with carbon and soil nutrient sustainability. They feared a further increase of full tree harvesting in the future and thought more legal limitations were needed as well as effective compensations for soil nutrients. Some interviewees mentioned the possibility to plant tree species particularly suitable to full tree harvesting, though this possibility was considered realistic only for small-scale forest areas where ecological values did not represent an obstacle. Some Spanish interviewees were critical towards the extraction of branches and bark, as these wood assortments had high transport costs. Whole tree harvesting and stumps' removal were mentioned by representatives of some stakeholder groups in Germany and Spain, but most interviewees reported national legal limitations and expressed negative opinions. In Germany, removing stumps was not perceived as a realistic future solution. Only one Spanish interviewee regarded stump removal positively because it allowed obtaining more revenues from trees, but solely if this practice was carried out in plane areas. Other Spanish stakeholders gave negative opinions mostly related to soil erosion:

4.3 *Reflections on stakeholders' perspectives in light of the three national contexts under study*

The cross-country comparison we carried out highlighted that energy wood had different roles in the three case study countries, but that two important similarities among the countries existed. The first was a strict relation between the productivity of the wood-processing industry and the role played by energy wood in the national economies and in the imaginary of stakeholders. The more important the role of material uses, the less significant the role of energy wood. The second similarity was a correlation between the perceived (or hoped) future vitality of the wood-processing industry and the confidence of national stakeholders in the increased future reliance on energy wood. When stakeholders foresaw or hoped for a vital future role of the wood-processing industry, they also considered less realistic an increased reliance on energy wood. Germany offers a straightforward example of the functioning of these two rationales. The country had a more productive forest sector compared to the other two MSs, as reported also by Lindstad et al. (2015), and German interviewees perceived that energy wood was produced exclusively from low-quality wood assortments that were not used for material uses. The activeness of the forest sector, which was mainly orientated towards material uses, brought German interviewees to believe that energy uses were not destined to gain dominance on material uses in the future. When asked about the possibility that wood assortments currently used for material uses could be used for energy, most German interviewees expressed negative opinions due to their wish to keep up the economic importance of the wood-processing industry. Next to the influence exercised by the role of material wood in the country, a strong awareness about environmental trade-offs played a role in shaping the perspectives of German interviewees'. Many respondents believed that increasing energy wood production was not realizable especially due to concerns regarding soil nutrient balance, biodiversity and forest overexploitation, and that the limit for sustainability of forest management had already been reached at the time of the study. For example, German interviewees attributed limited contradictions to the option of producing more energy wood by increasing the forest area managed for energy wood and extracting this wood from low-profitability forests. They preferred this option to that of changing forest management practices by introducing species like Douglas fir and intensifying full tree harvesting. These two means

were indeed associated respectively to concerns regarding changing forest structures that limit biodiversity conservation functions, and to reduction of soil nutrients. Especially with respect to intensification of full tree harvesting, German stakeholders pointed out that legal limitations were needed to avoid intensification of such practice, as well as effective nutrient compensations in case the intensification would actually occur. With respect to the option of changing tree components destined to the energy industry, the majority of German stakeholders saw positively the possibility to increase harvesting of logging residues, because of possible benefits linked to reduced costs of and increased revenues from forest management. However, also with respect to this means they raised concerns regarding soil nutrient balance. Especially due to this attitude towards the recognition of the important environmental drawbacks of increasing reliance on energy wood, this study allows inferring that Germany might make of energy sources others than energy wood the strongholds for its strive towards a low carbon economy. This result is in line with what reported the German government in a document published right before interviews had been performed (Federal Republic of Germany, 2010).

Also the results we obtained for the Slovenian case resonate well with the two rationales presented in the previous paragraphs. Slovenia was characterized by a very limited production of roundwood compared to Spain and especially to Germany, and Lindstad et al. (2015) showed that the share of energy wood was half the roundwood. Slovenian stakeholders described the weakness of the roundwood industry and a depressed forestry economy, This explained why, at the time of the study, some of the Slovenian wood which could have been used for material uses was instead destined to the energy industry. However, the strong hopes for the rising of the national demand for material wood brought Slovenian interviewees to perceive an upcoming dominance of energy wood as unlikely, especially in the near future. The low level of associationism among private forest owners was depicted as a major obstacle. Perception about environmental trade-offs associated to an increased production of energy wood was more limited among Slovenian stakeholders respect to German ones. However, some actors did express their worries about impact of extracting more energy wood on the forest environment. For example, Slovenian stakeholders were divided among those who felt increasing harvesting of logging residues would have negative effects on fauna, and those who believed negative effects were unlikely to occur. This picture allows foreseeing that the country might continue its consistent reliance on energy wood in the future, but that due to the much endeavor required to increase roundwood (and consequently energy wood) production, it is realistic to think that it might put more efforts in increasing the role of other renewables. As last, in Spain, roundwood production at the time of the study was about one third than the German one (Lindstad et al., 2015). Our interviews made clear that in Spain material uses of wood were gradually decreasing their importance, hand in hand with the crisis of the building sector which affected especially the production of particleboards. This influenced the destination of a relevant amount of the wood produced to the energy industry. Moreover, in Spain forest fires represented a constant threat exacerbated by the presence of large amounts of unmanaged woody biomass in forests. For example, for implementing the option of increasing the forest area managed for energy wood, Spanish interviewees positively valued the possibility to turn to unmanaged stands, which could also contribute to reducing wildfire risk reduction. Energy wood was positively perceived by stakeholders as an opportunity to make fire prevention interventions profitable. Spanish stakeholders believed that the energy industry would further increase the use of wood in the future and foresaw a gradual reallocation of wood assortments from the material to the energy industry. This result is in line with statements made by the Spanish government before this study was carried out (Government of Spain, 2010). The low competition between energy and particleboard industries in Spain allowed forecasting a non-controversial contribution of energy wood to the future use of renewables in the country. This forecast is backed up also by the result that Spanish stakeholders had a weaker consideration of environmental trade-offs associated to energy wood compared to stakeholders from the other countries. For example, they expressed

concerns regarding increased harvesting of logging residues similar to those we recorded in Germany, but they felt that benefits of this practice compensated drawbacks. In the same way, differently from most German stakeholders, Spanish interviewees did not express their worries about negative consequences of increasing the use of low-quality trees to apply the option of changing forest management practices. They rather associated an improved wood quality to this means.

5 Discussion and conclusions

Despite energy wood played different roles in the three MSs under study, we found out that the relations between roundwood and energy wood production were strong in all three cases. By detecting that energy wood production played mainly a side-stream role to the production of roundwood, our study confirms results of other studies carried out in the period in which our interviews were performed (see for example Díaz-Yáñez et al., 2013). According to our interviewees, energy wood was most of all obtained from full trees or stemwood from thinnings and from residues of final fellings. However, in Slovenia and Spain we detected that, in some instances, energy wood was produced also from primary products of final felling operations. This data shows that the picture of energy wood production was slightly different from that depicted by Díaz-Yáñez et al. (2013), especially in the countries where the material wood industry was not very vital. In the picture we were able to draw thanks to our research, producing energy wood in some cases represented the main goal of forestry operations and somehow it got loose from the strict linkages that traditionally tied it to the production of roundwood. We detected that the growing economic relevance of energy wood was triggering a progressive strengthening of its role in determining the final goals of forest management activities.

This result unveils the early signs of a tendency that some stakeholders of the forest sector nowadays fear (Euractiv, 2018b; FERN, 2018), namely a growing intensification of forestry activities with the goal of producing more energy wood. Today, this tendency is seen by some stakeholders (especially nature conservationists and scientists) as a misinterpretation of the positive contribution that energy wood can play in low carbon economies (Euractiv, 2018b), if compared to the traditional use for energy purposes of the sole wood components that had no value as material. In light of these negative opinions, these stakeholders currently express also negative feelings about EU legislations like RED and RED II, which in their eyes promote the use of energy wood without considering the environmental dangers associated to an increased reliance on this energy source (Beiträge und Standpunkte aus dem Öko-Institut, 2018; FERN 2011, 2018). The categories of stakeholders that nowadays put forward their perplexities about the weak level of sustainability characterizing EU policy ambitions are the same that in our study expressed the most negative opinions about the feasibility of an increased reliance on energy wood. Our analysis made clear that, at the time of the study and in all the three countries under analysis, energy wood was attributed also a positive connotation and it was depicted as a chance to diversify rural economy, revitalize national forest sectors, support environmental forest functions like fire prevention and contribute to climate change reduction. Stakeholders who held these positions relied often on the idea that no real obstacles were in the way of increasing production of energy wood due to the existing reservoir of wood hosted in European forests. These enthusiastic views were expressed mainly by representatives of the Practitioners and Economy groups, but also from some exponents of the Policy group. This mirrors opinions put forward in recent years by forest owners and managers regarding the role of energy wood in light of the upcoming emanation of the RED II (CEPF, 2017a).

Enquiring stakeholders' opinions on the feasibility of three concrete options for increasing energy wood production allowed us carrying out an in-depth analysis of the policy-practice interface regarding the increase of such production. None of the three options we explored was univocally perceived by interviewees, who expressed both positive and negative

opinions on possibilities to implement them. As a result, in some instances, stakeholders' perspectives coincided with EU's policy ambitions, while in others they were discordant. For example, stakeholders' perspectives resonated well with the view expressed by EU policy documents on the role of energy wood in achieving economic competitiveness of the forest sector (European Parliament and Council, 2013). Forest operations like thinning young and middle-aged forests as a means to apply the option of changing existing forest management practices, and the different means related to the option of changing tree components destined to the energy industry were attributed positive externalities like increasing revenues in rural areas and diversification of rural economy. However, several stakeholders raised the sustainability dilemma regarding these options. Also EU policy's discourse on positive mutual influences between climate and energy goals (European Commission, 2014) found a correspondence in stakeholders' perspectives. With respect to applying the option of changing forest management practices, some stakeholders referred to the possibility of using native rapidly growing species and perceived this as an opportunity to foster forest adaptation to climate change. As a last example, whole tree harvesting and stump removal were characterized by legal limitations in all countries and not perceived as concrete solutions for applying the option of changing forest management practices. This view coincided with EU policy goals of opting for the integration of different forest functions and avoiding to overlook forest sustainability limits (European Commission, 2013).

Similar results allow concluding that, on the one hand, European discourses on the economic role of energy wood as booster for the competitiveness of the forest sector did find a fertile ground in national implementation contexts, as did the discourses on climate change reduction. We suggest that policy makers interested in fostering an increased reliance on energy wood base their policy strategies on these positive properties attributed to energy wood. On the other hand, we suggest that policy makers both at EU and national levels better address policy weaknesses regarding environmental trade-offs associated to energy wood production. This could be done for example by clearly setting at supranational level the priorities between energy wood and environmental policy goals and exploring concrete options for increasing energy wood production without harming the environment. This prioritization of policy goals at EU level would reduce criticism by stakeholders about the fact that, in the EU, the solution of trade-offs associated with energy wood production is left at the national levels to solve. It would also reduce divergence between policy ambitions and stakeholders' perspectives on the possibilities to increase energy wood production, as well as reducing obstacles to the achievement of EU policy goals (Majone, 1999).

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