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Analysis of wood resource balance gaps for the EU

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Contents

Abstract

Wood resource balance (WRB) sheets are most useful in providing an overview of sources and uses of woody biomass, highlighting data gaps and inconsistencies. This technical report provides an analysis, on aggregated EU level, of WRB sheets available at https://ec.europa.eu/knowledge4policy/publication/wood-resource-balances. Summing the WRBs of individual Member States, the amount of woody biomass used in manufacturing of wood-based products and for heat and power exceed the total reported amount of woody biomass sources for all available years. We analyse these gaps, or 'missing resources', by (i) comparing wood removals data from official statistics with our own estimates of wood removals based on the amount of reported uses of wood for material purposes and energy generation and (ii) comparing secondary sources of woody biomass with their uses for material and energy production. Our results confirm that removals and fellings in official statistics are often underestimated, which means that on the overall EU level forest management intensity is likewise underestimated. They further indicate that the gap between reported uses and sources of woody biomass can mainly be attributed to the energy sector. An effort to improve data quality will be a key factor for reliable analysis of the wood-based economy.

1 Introduction

Using official data from various sources, JRC has developed Wood Resource Balance (WRB) sheets for individual EU Member States (MS) as well as for the EU[1] from 2009 to 2015 [1], building on the pioneering work done by U. Mantau (see [2] and [3]). Data sources used include the 2017 release of the Joint Forest Sector Questionnaire (JFSQ)[2], Eurostat[3], the Joint Wood Energy Enquiry (JWEE)[4] and the National Renewable Energy Action Plans Progress Reports (NREAP)[5] (see details in [1]). In this report we focus only on the WRBs for the whole EU, that were obtained summing item by item the WRB results of the individual MS.

When studying these numbers, it is important to note that the forestry sector is highly circular, meaning that frequently woody biomass "passes through" different subsectors before reaching its final use. As an example sawmilling, using industrial roundwood, besides sawnwood results in solid by-products, namely wood chips and particles, which can be used again in material production, e.g. for chemical pulp. Black liquor, a by-product of chemical pulping, is used in the energy sector. Figure 2, illustrates all the pathways between the different sources and uses of woody biomass represented in the WRBs, but also in the Sankey diagrams [4] that were derived from them. This means that "the same biomass" is accounted for more than once in both sides of the WRBs, as a source and as a use. This double accounting impacts the total values of the sources and uses sides, but does not affect the difference between them (the so-called balance).

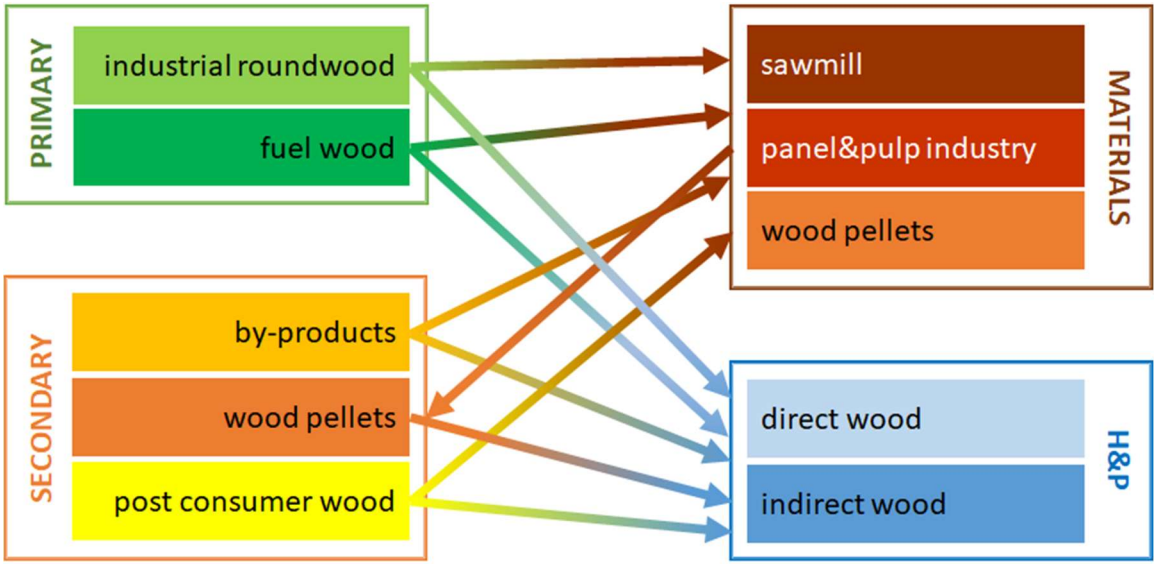

Figure 1. Flows of woody biomass among the different sectors of the WRBs. For simplicity, in this graph, post-consumer wood is aggregated together with secondary woody biomass, while in the WRB it is a stand-alone category. Detailed definitions of the WRB items can be found in [1].

The results show a growing overall use of woody biomass in the EU, and a growing share of the energy sector in total uses (see Figure 2). In a similar way, the reported sources increase steadily for both primary and secondary woody biomass (Table 1). The WRBs show that secondary woody biomass and post-consumer wood are an important source for both the energy sector and the material production, where they are used for wood pulp and some panels.

[1] Since the report is based on the data covering the period until 2015, when the UK was an EU member, unless specified otherwise the references to the EU include the UK.
[2] http://www.unece.org/forests/fpm/onlinedata.html
[3] https://ec.europa.eu/eurostat/data/database
[4] https://www.unece.org/forests/jwee.html
[5] https://ec.europa.eu/energy/topics/renewable-energy/progress-reports_en

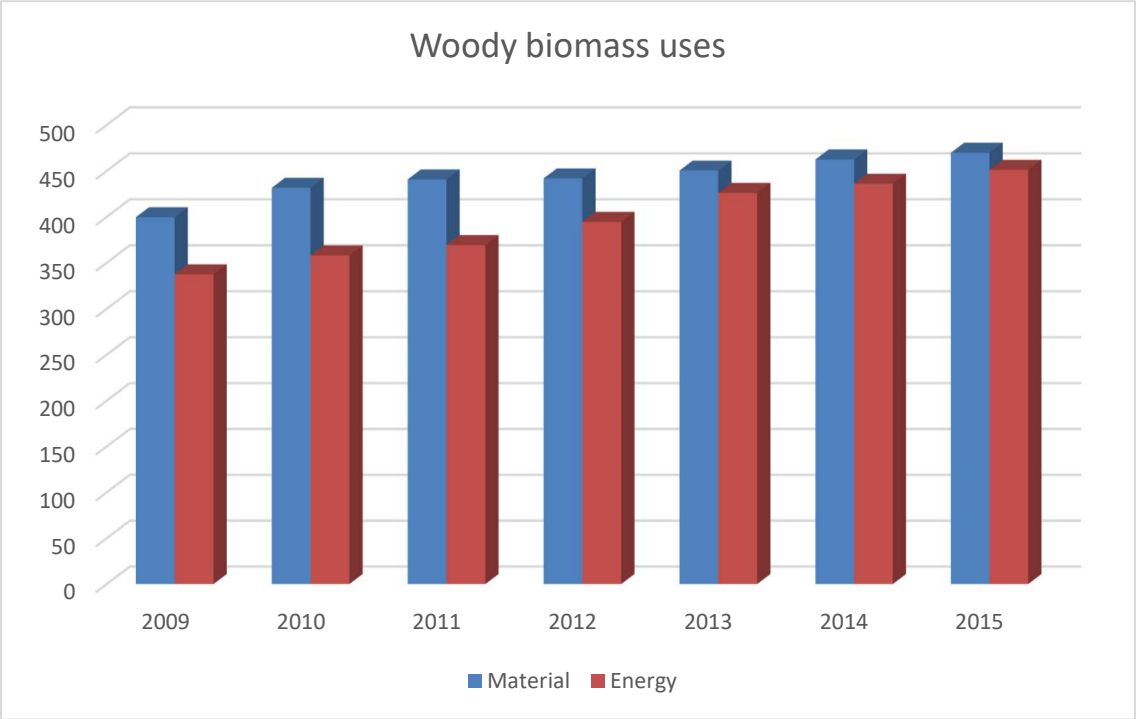

Figure 2. Woody biomass used in the EU (units: million m^3 SWE incl. bark)

At EU level, the amount of used woody biomass significantly exceeds the total reported amount of sources for all the available years (see *balance* in Table 1). This difference, which theoretically should be zero, is a red flag, meaning some relevant misreporting happened, mainly in the sources side. However, as some countries have a negative balance value (signalling missing reported uses), we could hypothesize that the balance figures in Table 1 are themselves underestimated. This gap persists over time. In 2015 there is a marked gap of 118 million m^3 solid wood equivalents (SWE).

Table 1. Summary of WRBs for the EU (units: million m^3 SWE incl. bark)

Mm^3 SWE	**Sources**			**Uses**		**Balance**
EU	**Primary**	**Secondary**	**Post-consumer wood**	**Material**	**Energy**	**(Uses - Sources)**
2009	453	168	30	400	338	87
2010	502	190	32	432	358	66
2011	507	194	33	441	369	76
2012	507	206	34	442	395	89
2013	516	213	36	450	426	112
2014	533	221	36	462	436	107
2015	541	226	37	470	451	118

A number of studies have indicated a strong tendency toward underestimation of removals and fellings in official statistics, see e.g., Pilli et al. [5] and Jochem et al. [6]. In this study we first assess the gap between sources and uses by comparing wood removals data from official statistics with estimates of wood removals based on the amount of wood used for material purposes and heat and power (H&P). We then compare secondary sources of woody biomass with material and energy uses thereof. Finally, we contextualize our results estimating their impact on the assessment of forest management intensity, an important aspect to consider in the framework of the updated Bioeconomy Strategy of the European Commission [7] and more in general of the European Green Deal [8].

2 Methods

We follow the approach of [5] in deriving wood removals based on the amount of roundwood used for material purposes and H&P production, accounting for net trade in roundwood, departing from the assumption that reported uses and trade are more reliable than reported removals. This hypothesis is required to constrain the degrees of freedom of the problem.

The amount of industrial roundwood needed for material purposes is estimated as:

$$IRW_{MS}^{m} = \sum_{p} Q_p \cdot f_p \cdot i_{IRW}^{p} \qquad \text{(eq. 1)}$$

where

IRW_{MS}^{m} is the amount of roundwood required for the material sector in the given Member State,

Q_p is the production quantity of the product *p*, provided by the JFSQ,

f_p is the roundwood equivalent conversion factor for the specific product *p*,

i_{IRW}^{p} is the input coefficient representing the industrial roundwood share in the input mix for product *p*.

All terms are country-specific.

Correcting for net trade in industrial roundwood obtained from the JFSQ (adding or subtracting net exports or net imports respectively), the amount of industrial roundwood that needs to have been domestically removed in the EU to satisfy material uses, IRW_{rem}, can be computed (see eq. 2).

$$IRW_{rem} = \sum_{MS} IRW_{MS}^{m} - IRW_{net\_trade} \qquad \text{(eq. 2)}$$

where IRW_{net_trade} is the difference between import and export of the IRW at global EU level.

In case IRW removals reported in JFSQ are larger than this amount, there is a 'surplus IRW' that is assumed to have been used for energy production.

The overall amount of woody biomass used for energy production is reported in the right column of the WRB, distinguishing between *direct wood* (wood entering energy production without further treatment, namely mostly removals from forests and trees outside forests) and *indirect wood* (processed wood fuel such as wood pellets, by-products from wood processing industry, post-consumer recovered wood). However, such a distinction between direct and indirect wood is not always reported by the MS, hence, from the available data, there is also some uncategorized woody biomass used for H&P, recorded in the WRB as '*unknown wood*'.

Wood removals for energy production can be estimated from the amount of *direct wood*, corrected for net trade in fuel wood (FW), but it is further likely that at least a portion of the 'unknown wood' consists of removals. The sum of the industrial roundwood removals derived from material uses as described above and removals derived from the *direct wood (d)* for energy, again corrected for the net-trade of fuel wood (FW_{net_trade}), represents the minimum amount of woody biomass that should have been removed in the EU (R_{min}) to satisfy declared uses for material production and H&P generation (eq. 3). We refer to it as minimum amount because it is the most conservative estimate, not yet accounting for the uncategorized woody biomass for energy that potentially could also count as contributing to removals.

$$R_{min} = IRW_{rem} + d - FW_{net\_trade} \qquad \text{(eq. 3)}$$

As maximum estimate of the removals, we consider the limit case where all 'unknown wood' (*u*) is completely made up of wood removals:

$$R_{max} = R_{min} + u^{*} \qquad \text{(eq. 4)}$$

As we describe in detail below, in some cases we can establish that a certain amount of the 'unknown wood' can be considered secondary woody biomass, accounting for some 'extra-sources' not required by the material sector. In these cases, the 'unknown wood' has been reduced accordingly in eq. 4. That is why it is represented with an asterisk. Both estimates clearly depend on the quality of the available trade data too.

These two use-derived estimates (lower and upper limit of a range of estimated removals) can be compared with removals data reported in the JFSQ. Further, by multiplying these EU-level removals, after correcting for bark, with the average ratio between fellings and removals for the period 2004-2013, i.e., 1.2545 (see [9]), assessments of fellings and ensuing forest management intensity based on reported uses can be made.

Similarly, we can analyse the differences between sources and uses focusing on secondary woody biomass[6] alone. Secondary woody biomass, estimated from the sources as reported in the left column of the WRB, is the sum of sawmill residues, other industrial residues, net-imports of wood chips and particles and other wood residues, bark, domestic black liquor, and post-consumer wood (PCW).

From the uses-side, the estimated amount of used secondary woody biomass for material production are derived as the product sum of production quantities, roundwood equivalent conversion factors of wood-based panels and wood pulp respectively, and the shares in the input mix for the product and the type of secondary wood source in question, again using country and sector-specific input coefficients:

$$SW_{MS}^{m} = \sum_{p,s} Q_p \cdot f_p \cdot i_s^p \qquad \text{(eq. 5)}$$

where

SW_{MS}^{m} is the amount of secondary woody biomass for the material sector in the Member State,

Q_p is the production quantity of the product *p*, provided by the JFSQ,

f_p is the roundwood equivalent conversion factor for the specific product *p*,

i_s^p is the input coefficient representing the share in the input mix of secondary biomass of type *s*, where $s \in \{\text{chips and particles, other industrial residues, bark, domestic black liquor, PCW}\}$.

All terms are country-specific.

When $\sum_{MS} SW_{MS}^{m}$ is smaller than the reported amounts in the EU WRB's source side, there is a 'surplus' of secondary woody biomass that is again assumed to be used for energy.

Uses of secondary woody biomass for energy can be straightforwardly estimated from the item *indirect wood* for energy production as reported in the WRBs. Also in this case, a portion of the uncategorized woody biomass used for energy (i.e., not specified whether direct or indirect) should be accounted as contributing to indirect wood, so we estimated minimum and maximum values as we did for removals.

$$SW_{min} = ind \qquad \text{(eq. 6)}$$

where *ind* means 'indirect wood' as reported in the WRBs, and

$$SW_{max} = SW_{min} + u \qquad \text{(eq. 7)}$$

where *u* is the 'unknown wood'.

At times the secondary woody biomass not used for manufacturing exceeds the reported indirect wood used for H&P. In this case, the difference can be subtracted from the quantity of 'unknown wood' obtaining u^*, since this amount actually qualifies as *indirect wood* for energy (eq. 8).

$$u^* = \begin{cases} u - \left(ind - \left(SW_{tot} - \sum_{MS} SW_{MS}^{m} \right) \right) & if \left(SW_{tot} - \sum_{MS} SW_{MS}^{m} \right) > ind \\ u & elsewhere \end{cases} \qquad \text{(eq. 8)}$$

where SW_{tot} is the total available secondary woody biomass.

[6] Following the accounting rules of the JFSQ, IRW and FW are reported under bark. Bark is entirely accounted as a secondary source of woody biomass, and therefore as indirect wood for energy.

3 Results

From eq. 1 and 5, it is possible to estimate the amount of primary and secondary woody biomass required to justify reported uses in the wood-based industry. Results are presented in Figure 3. In the 'sources' bars, the total reported IRW is represented (including net-import), the solid residues (the sum of sawmill residues, other industrial residues, net-imports of wood chips and particles and other wood residues) and PCW for material production, as evaluated by the given formulas. The results of our estimates for these three categories is shown in the 'uses' bars.

For all the years, the total reported sources are always larger than the uses. This means that the reported sources are enough to cover the declared uses. Aggregated EU IRW quantities from the JFSQ are larger than the IRW driven by material uses (accounting for the non-negligible amount of net-imports), resulting in 'surplus IRW' of some 5.8, 14, 12, and 18 million m^3 SWE for 2009, 2011, 2013, and 2015 respectively. Secondary sources (again accounting for the relevant net-import) likewise exceed material uses for all the years analysed. We assume that these 'surplus IRW' amounts, together with secondary sources not used for material purposes and estimated as described in the Methods section, are used for H&P.

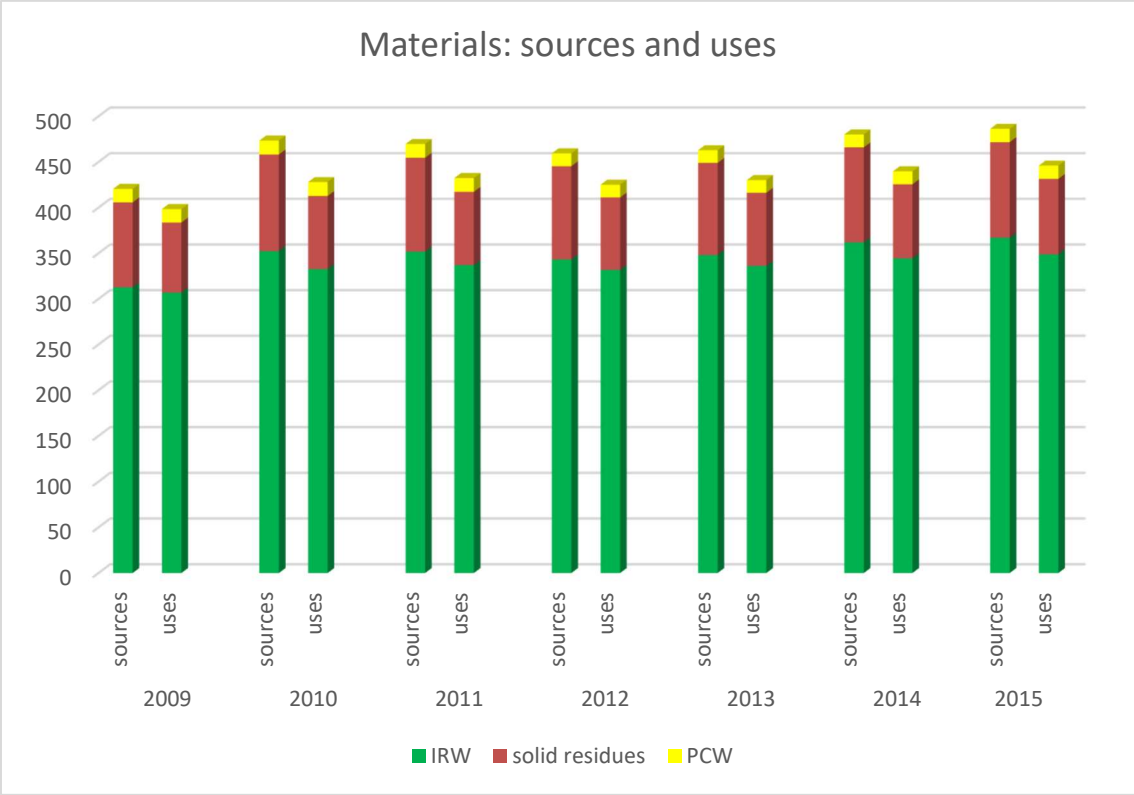

Figure 3. Sources and uses of woody biomass in the wood-based industry (units: million m^3 SWE, bark is included in the residues, but it is negligible). Solid residues include wood chips and particles, that are sawmill by-products, and other industrial solid residues by wood panel industry. The observed differences between sources and uses are the sums of the 'surplus IRW' and the secondary residues not used for manufacturing.

Subtracting the respective amount already "allocated" for material uses from each source, including also black liquor and imported wood pellets as sources, we analyse the H&P sector.

Overall in the H&P sector of the EU, the total uses of woody biomass exceeds the total sources by some 87, 76, 112 and 117 Mm^3 SWE for the years 2009, 2011, 2013, and 2015 respectively. Hence, the energy sector seemingly accounts for almost the whole gap (the 'unaccounted sources') between total uses and total sources of woody biomass, at the overall EU-level. It is worth mentioning that the amount of reported uncategorized wood (or "unknown wood") shows an overall increasing trend from 2009 to 2015 (see also [1]), accounting for 41, 45, 61, and 63 Mm^3 SWE in 2009, 2011, 2013, and 2015 respectively (Figure 4).

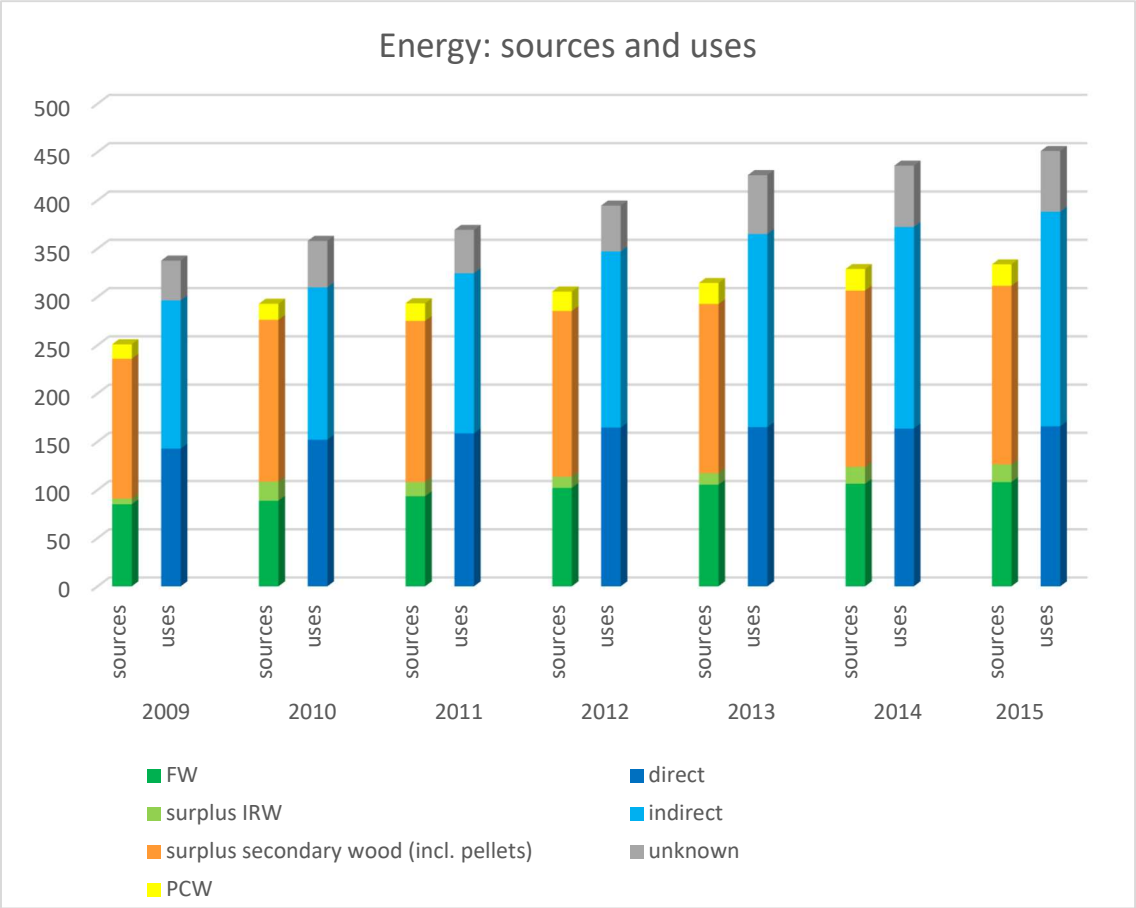

Figure 4. Sources (left bars) and uses (right bars) of woody biomass in the heat and power sector (units: million m^3 SWE)

Progressing in the analysis, we allocate the gaps and provide estimates of missing removals. Hence, considering all the sources and uses represented in Figure 3 and Figure 4, total primary wood sources and uses can be evaluated and are presented in Figure 5. The values include the net-imported roundwood in both sides and are reported under bark. "Energy sector" and "possible additional direct energy uses" corresponds respectively to the "direct wood" and the "residual unknown wood" (u^*), according to the logic presented in the Methods section.

For all the available years, results show a larger amount of estimated uses than reported sources, even when neglecting the "unknown wood" (Figure 5). If we do not include the "unknown wood", this gap irregularly reduces in time: in 2009 it is 51 million m^3 solid wood equivalent (Mm^3 SWE), while in 2015 it is 40 Mm^3 SWE. Elsewhere, if we add also u^*, after a short period of improvements, the gap between sources and uses increases: in 2009 the difference between all the possible uses and the total sources is 86 Mm^3 SWE, while in 2015 it is 103 Mm^3 SWE.

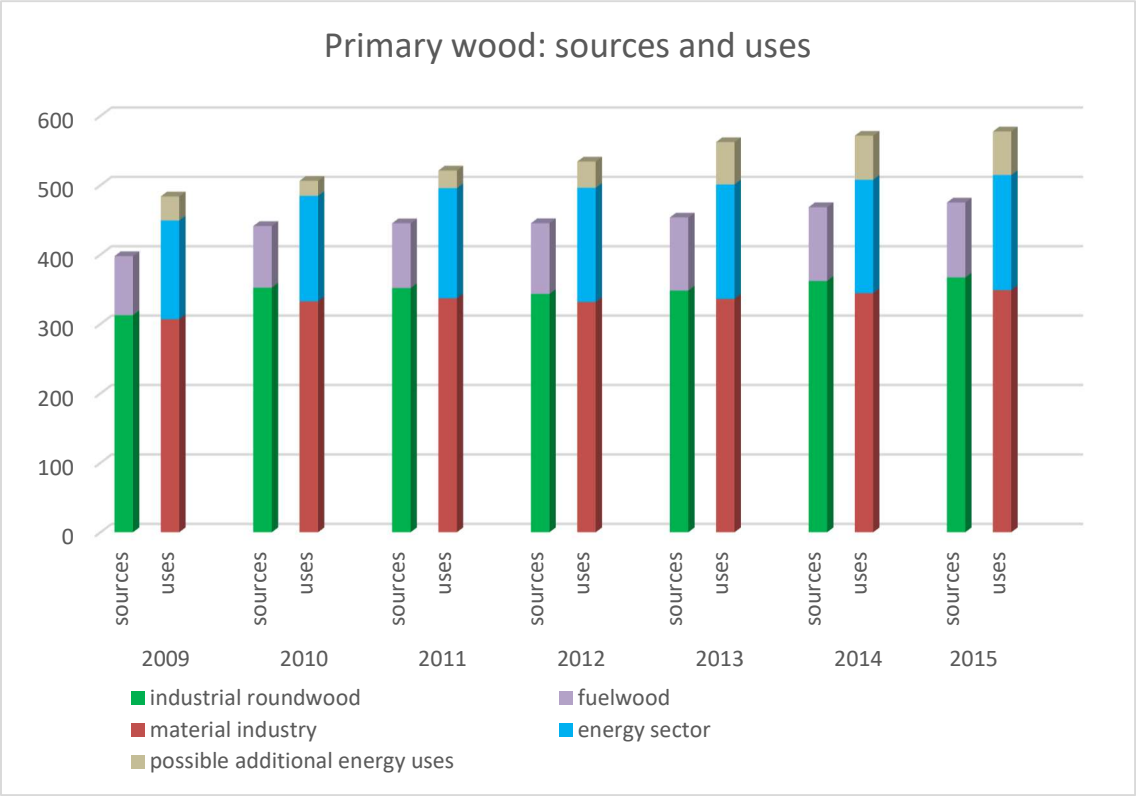

Figure 5. Sources (left bars) and uses (right bars) of primary wood in the EU (units: million m^3 SWE u.b.). "Possible additional direct energy uses" represent the possible additional direct energy uses that were estimated from the whole "unknown wood" as reported in the WRBs.

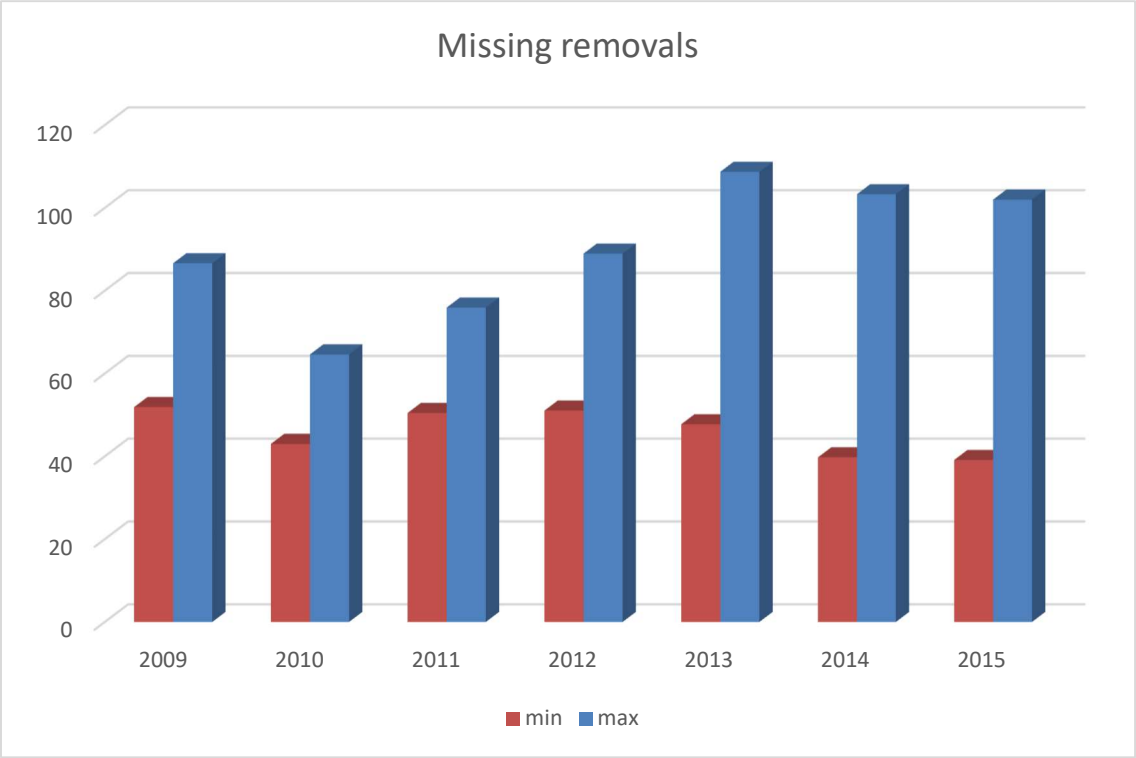

Figure 6. Differences between removals estimated from the uses and the JFSQ reported removals (units: million m³ SWE u.b.)

Reported removals of FW are always significantly smaller than the uses of primary wood in the energy sector, implying that EU reported fuelwood removals are under-estimated (fuelwood net-trade, though quite negligible in the EU, being always less than 1 Mm3 SWE, was considered in the calculus). Considering only the "direct wood", the difference ranges from 55 Mm³ SWE to 65 Mm³ SWE. Including also the corrected "unknown wood", the "deficit" ranges from more than 85 Mm³ SWE to 121 Mm³ SWE. These estimates indicate a gap much greater than the 'surplus IRW'.

Applying eq. 3 and 4 to the obtained results, it is possible to estimate the minimum (neglecting the "unknown wood") and maximum amounts (also accounting for "unknown wood") of total removals from the reported uses. Both estimates are, for all years, considerably larger than the quantities reported by JFSQ (see Figure 6).

Under-estimated EU removals translate to under-estimated fellings. This of course also entails higher harvest-to-increment (H/I) ratios than suggested by JFSQ removals data (Figure 7). Though still under the threshold of 100% (which would mean no increase of growing stocks) for the minimum as well as the maximum case, the harvest to increment ratios derived from reported uses are higher than the ones implied by reported removals — e.g., for 2015 fellings estimates derived from uses give H/I ratios in the range of 0.70 to 0.85 rather than the 0.60 to 0.71 based on fellings derived from JFSQ removals data, and the trend is an increasing one. Hence, while net annual increment (NAI)[7], is rather stable over the time period analysed, all the different estimates of fellings show an increasing trend.

[7] NAI is the annual forest growth minus losses due to the natural mortality. Here we have estimated NAI of total above ground biomass (including both stemwood and other wood components) in the forest area available for wood supply of the EU.

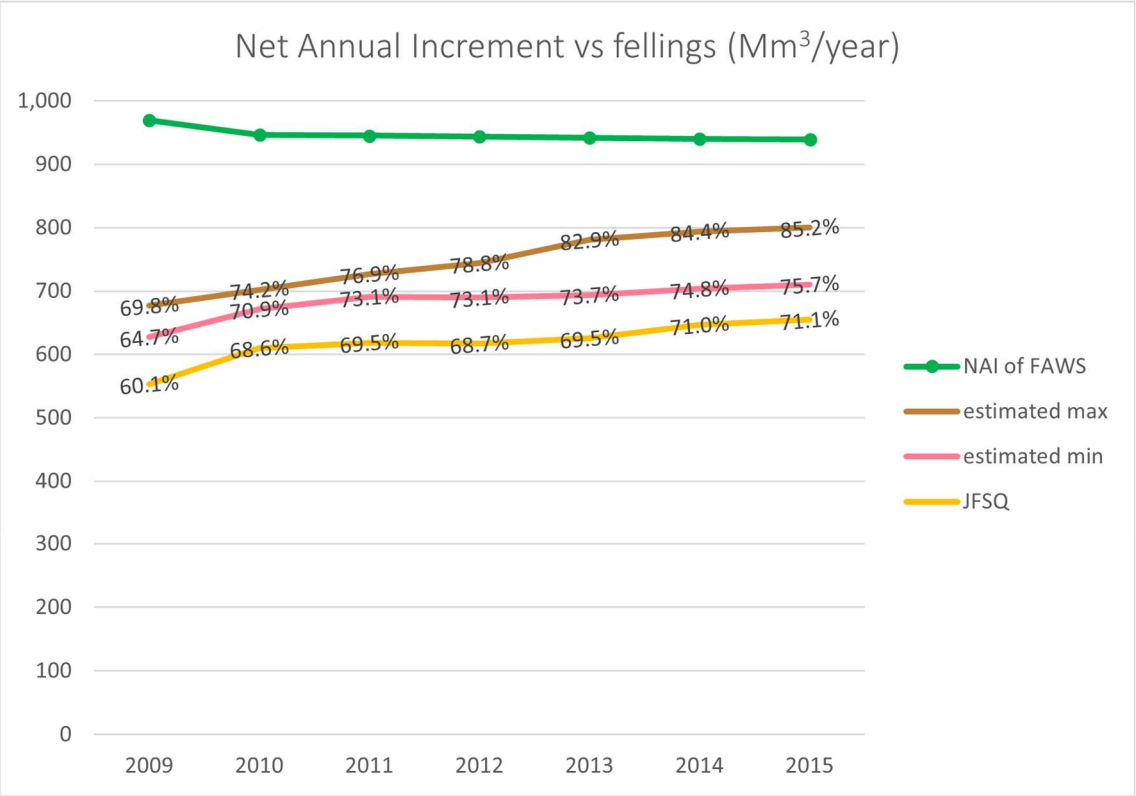

Figure 7. Fellings derived respectively from JFSQ removals and minimum and maximum fellings estimated from the uses, compared against the Net Annual Increment of Forest Available for Wood Supply from [1] (units: million m³ SWE o.b.). NAI includes both stemwood and other wood components.

Similarly to what was done for the primary woody biomass, it is possible to analyse the secondary woody biomass total sources and uses (Figure 8). The results obtained again show a discrepancy between sources and uses. It is worth noting that the differences are significantly smaller when neglecting "unknown wood" than when it is included. In the first case the differences (in absolute value) ranges between 3 Mm³ SWE in 2013 and 27 Mm³ SWE in 2010, while in the second case the minimum difference is 22 Mm³ SWE and the maximum is 78 Mm³ SWE in 2015. For most of the years analysed, the reported sources of secondary woody biomass are enough to cover the declared uses of "indirect wood".

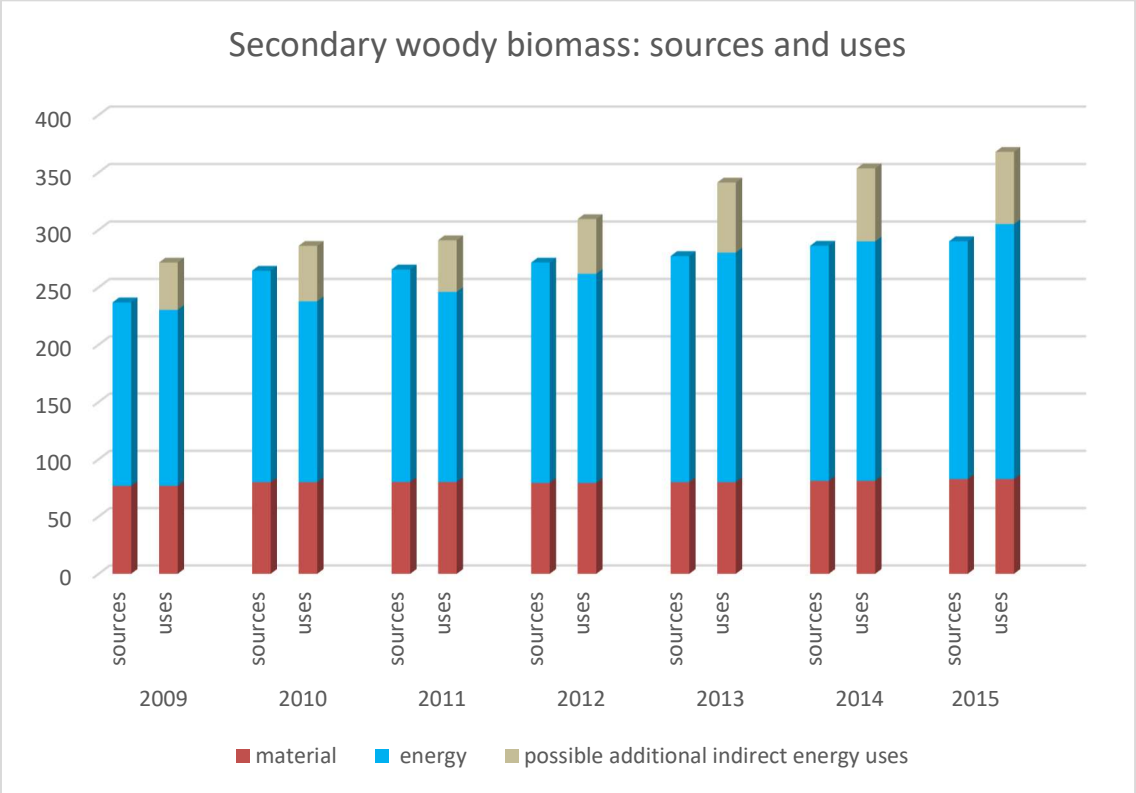

Figure 8. Sources (left bars) and uses (right bars) of secondary wood in the EU (units: million m^3 SWE incl. bark). "Possible additional energy uses" represent the possible additional indirect energy uses that were estimated from the whole "unknown wood" as reported in the WRBs.

4 Discussion and conclusions

The Wood Resource Balance (WRB) shows a growing overall use of woody biomass in the EU, and a growing share of the energy sector in total uses. For all the years analysed, the amount of woody biomass used in the manufacturing of wood-based products and for heat and power exceed the total amount of reported sources. This gap has been growing over time at EU-level.

Analysing these 'missing resources', we reaffirm that removals and fellings in official statistics are underestimated — implying that forest management intensity, in terms of harvest to increment ratio, is likewise underestimated. Furthermore, the amount of uncategorized woody biomass for energy generation has been growing steadily. It is reasonable to assume that part of this category is made up of removals from EU forests.

Our results indicate that the growing gap between reported uses and sources of woody biomass to a significant degree can be attributed to the energy sector, and to a considerable extent consist in underestimated roundwood removals. Not the least the growing trend of wood of unknown origin in energy uses is a matter of concern. It is thus of paramount importance to improve the availability and quality of data as regards energy use of wood, particularly considering the growing share of this sector in total uses of woody biomass. This to improve the analysis necessary to safeguard a sustainable and resilient resource use.

References and suggested further reading

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List of abbreviations and definitions

By-products: resulting from side-streams of forest-based industries, e.g., wood chips and black liquor.

Direct wood: removals from forests and trees outside forests, used directly for energy.

Fellings: roundwood (wood in the rough) that has been cut. Part of the fellings is not removed from the site, so fellings are larger than removals. They include bark.

FW: fuel wood

H&P: energy (heat and power) sector.

Indirect wood: processed woody biomass used as fuel, including post-consumer wood.

Industrial roundwood: roundwood (wood in the rough) that will is intended for material production. Generally, it measured under bark.

Fuel wood: roundwood (wood in the rough) that is intended for energy uses, includes wood which will be used for wood pellets. Generally, it is measured under bark.

Mm3: million cubic meters

MS: Member State of the EU

NREAP: National Renewable Energy Action Plans Progress Report

Post-consumer wood: recovered used wood.

Primary wood or primary woody biomass: roundwood (wood in the rough) removed from forest, other wooded land or other felling sites. Generally, in this report, like in the official statistics, it does not include bark.

JFSQ: Joint Forest Sector Questionnaire

JWEE: Joint Wood Energy Enquiry

Roundwood equivalent: amount of solid wood fibre required to produce a product, including the losses and the by-products.

Secondary woody biomass: all the woody biomass resulting from a previous processing in at least one industry. It includes solid residues, like chips and particles, other residues, like black liquor, bark and post-consumer wood.

Solid Wood Equivalent: amount of solid wood fibre contained in the product. When applied to roundwood, it is the same as “roundwood equivalent” and “solid volume”.

SWE: Solid Wood Equivalent

WRB: Wood Resource Balance

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