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Mobilising woody residues to produce biomethane

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Summary

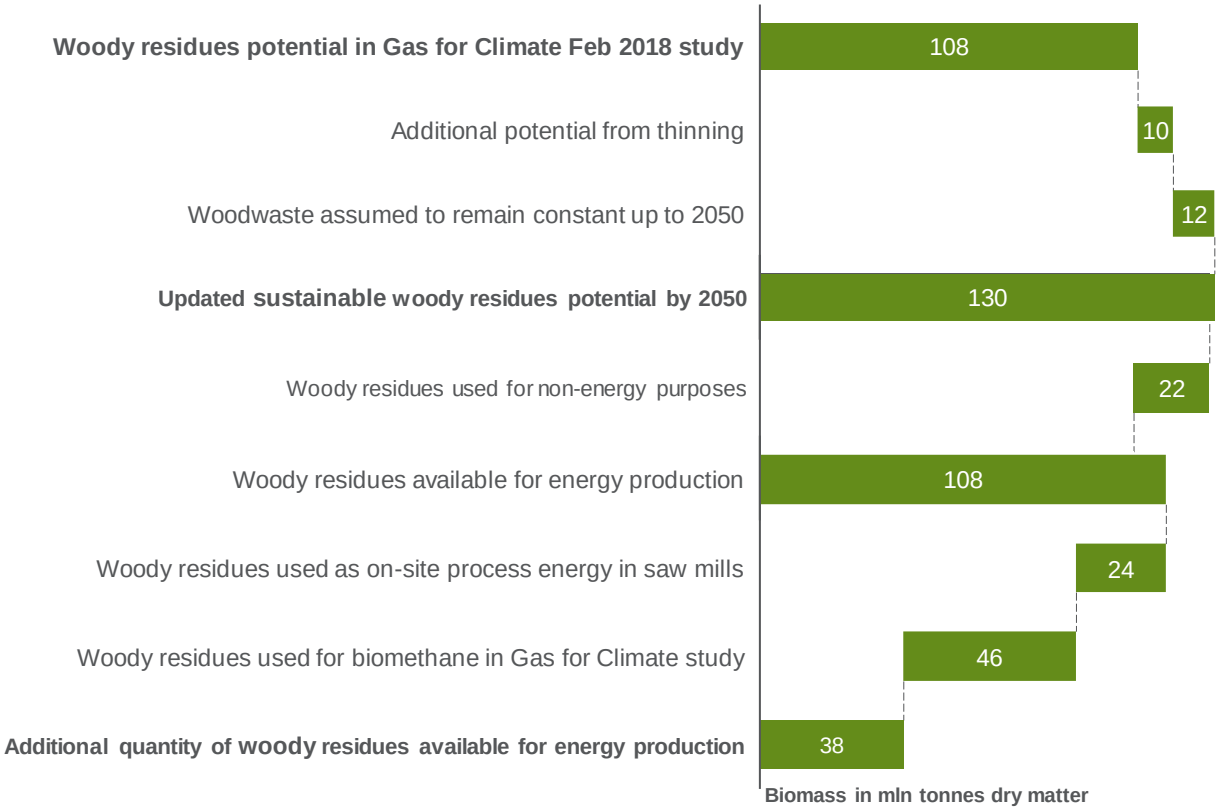
To achieve the Paris Agreement target of limiting global temperature increase to well below two degrees, a major redesign of the energy system is required. In the study Ecofys, a Navigant company, did for the Gas for Climate consortium, published in February 2018, the role of gas in a fully decarbonised EU energy system by 2050 was explored. The study concluded that EU-produced renewable gas production can be scaled up to at least 122 billion cubic metres (bcm) by 2050, including 98 bcm biomethane produced from 277 mln tonnes of biomass collected in the EU. This provides enough renewable gas to decarbonise the electricity production, heating of buildings and industry sectors in a smart combination with increasing quantities of renewable electricity from wind and solar.

Next to electricity production, heating of buildings and heavy industry, the EU transport sector is a large energy user. Deep decarbonisation of transport requires large quantities of renewable and low carbon fuels including electricity, hydrogen, biofuels, biomethane and synthetic fuels. While electricity and hydrogen may play an important role in passenger cars, it can be expected that dispatchable fuels will be important in heavy duty transport, shipping and aviation, including biofuels and renewable gas. The Gas for Climate study allocated a limited amount of 5 bcm biomethane to transport, or about 6% of estimated 2050 energy demand in heavy duty transport. This because from a societal cost perspective it makes more sense to use biomethane in the power and building sectors. Cost savings are important, but even more crucial is to achieve the objective of a fully decarbonised energy system. Thus, if additional biomass would be available this could be used to produce energy to decarbonise transport, especially in transport sectors where electrification is unlikely to be able to achieve full decarbonisation.

This memo assesses if it would be possible to increase EU supply of woody biomass residues to produce additional biomethane that could be allocated to transport. It concludes that by 2050 a total quantity of about 130 million tonnes of woody biomass residues can be made available, which is more than the potential as included in the Gas for Climate study. This increase results from an updated analysis of available early or primary thinning wood and the expectation that wood waste availability will remain stable up to 2050, different to municipal solid waste which we assume will decrease by 30% due to increased recycling. Some woody residues are needed to produce wood panels and for animal bedding and composting. Yet most material, about 108 million tonnes, is available for energy production. From this quantity, 24 million tonnes of bark will be used on-site as process energy at saw mills, leaving 84 million tonnes to produce dispatchable energy, either in the form of industrial heat from wood chips, biofuel or biomethane. This is 38 million tonnes more than was assumed to be used for biomethane production in the Gas for Climate study. If used entirely for biomethane, an additional 18 billion cubic metres of biomethane could be produced.

If all allocated to transport, biomethane in transport could increase from 5 to 23 bcm. This memo will be followed in early 2019 by a more comprehensive analysis of the fuel mix in decarbonised transport and of the allocation of available renewable and low carbon gases by 2050 to various demand sectors including transport on a societal cost basis.

The figure below visualises the analysis performed and resulting updated potential of woody residues for energy.



2. Availability and uses of woody residues

This section describes the potential of woody residues and explores current uses as well as expected developments

2.1 Estimated sustainable collectable potential of woody residues by 2050

In the Gas for Climate study we assume that only woody biomass waste and residues are used to produce biomethane. We avoid using roundwood, which has other uses such as pulp and paper and manufacturing of timber products and can have long carbon cycles.[1] We identified four categories of woody residues that can be used for biomethane without negative sustainability impacts: wood waste, landscape care wood, thinning, branches and tops and bark.

The Gas for Climate study estimated that the total annual sustainable collectable potential from the four woody residue types could be 108 million tonnes of dry biomass by 2050, with a break-down as described below.

Bark is the skin of stemwood that is shaven off after the harvest of roundwood. The February 2018 Gas for Climate study assumed that 34 million tonnes of bark (dry biomass) could be sustainably collected, assuming 80% of bark remains on the forest floor to ensure soil health.[2]

Branches and tops are parts of whole trees that are cut off the stemwood shortly after harvesting of roundwood. The Gas for Climate study assumed that 15.7 million tonnes of branches and tops could be sustainable collected.[2]

Thinning are young whole trees. Most of the biomass harvested during the 40–140 years of rotation of a stand results from thinning. Thinning can improve the growth rate and increase structural diversity. Increasing the canopy complexity by selecting trees with different heights promotes more efficient use of light and nutrients and improves the overall yield and wood quality as well as health and resilience of the stand. Regular thinning controlled by tree height (thinning measures in Europe are site dependent and usually conducted every 5–10 years) combined with the selection and facilitation of potential crop trees mainly from the target species. The number of thinning depends on the rotation cycle, Short rotation trees have only thinned few times, whereas long rotation tress are thinned several times. The Gas for Climate study assumed that 6.5 million tonnes of thinning, based on the conservative assumption that 2% of EU wood harvest would be early thinning, available for energy production.

Landscape care wood is collected during the maintenance operations of certain urban areas and treated as waste. It includes tree cutting and pruning activities in horticulture, arboricultural activity in parks and cemeteries, and tree management operations performed along roadsides, railways, water ways, orchards, etc. to keep plantations in the desired state as well as wood collection from private gardens. Road side verge grass is also included in this category. The Gas for Climate study assumed that 32 tonnes of biomass 'as received' or 24 million tonnes of dry biomass is available.[3]

Wood waste is a source of secondary woody biomass in the EU that include waste wood from wood processing, wood from paper and pulp production, construction and demolition waste as well as waste collected from households and industries. The Gas for Climate study assumed that 35 million tonnes of wood waste 'as received' or 28 million tonnes of dry biomass would be available.[4]

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[1] It may well be the world needs short-cycle roundwood for bioenergy in order to produce sufficient quantities of renewable energy to meet the well below 2 degrees climate change target.

[2] Eurostat data, 20% average sustainable removal rate was analysed in the 2013 Ecofys study 'Low ILUC potential of waste and residues for biofuels'. Furthermore, we assume that by 2050 the forestry wood harvests in the EU will have increased by 10% compared to today.

[3] (Elbersen, 2014): "Outlook of spatial biomass value chains in EU28"

[4] Based on Eurostat data

We revisited the analysis and assumptions and believe that there is scope to increase the sustainable woody residue potential estimate to 130 million tonnes, mainly because based on expert interviews our share of wood thinning of 2% (6.5 million tonnes) of total wood harvest is considered to be very low and should be at least 5% (16.5 million tonnes). Also, the Gas for Climate study assumed that wood waste quantities would reduce by 30%, while most literature sources do not consider wood waste to reduce between today and 2050.[5] This will be further explained below, as will be the allocation of available woody residues to energy and non-energy uses.

Table 1: Overview of different woody residue potentials (all units in million tonnes of dry biomass)

Feedstock	2050 potential GfC study	Updated 2050 potential
Barks	34.1	34.1
Branches and tops	15.7	15.7
Thinning for energy production	6.5	16.5
Landscape care wood	23.9[1]	23.9
Wood waste	28.1[1]	40.2
Total (mln tonnes)	**108.3**	**130.4**

1. We converted tonnes of biomass 'as received' as reported in Eurostat into dry biomass assuming 25% moisture content in landscape care wood and 20% in wood waste

2.1 Woody residues used for non-energy purposes and availability for energy

The total harvestable potential of woody biomass residues is currently used for both energy production as well as a number of other purposes. Below we evaluate the main end uses and explored to what extent we can assume an increase in woody residue demand from non-energy sectors in the period up to 2050. We conclude that pulp and paper production mainly uses roundwood and where it doesn't, it uses cutter shavings which are not part of our woody residue categories. Therefore, demand for wood for pulp and paper does not compete with wood which the Gas for Climate study assumes to be available to produce biomethane. We don't expect the chemical sector to become a large user of woody residues. The main non-energy uses of the woody residues categories considered in the Gas for Climate study will remain the wood panel industry and animal bedding. We conclude that from the total 2050 potential of 130 million tonnes, 108 million tonnes should be available for energy production.

Below we describe the main non-energy sector uses of woody residues,[6] following which we describe the allocation to energy and non-energy uses per category of woody residues.

[5] Population growth and increased GDP will increase the use of wood in construction etc. which is likely to increase wood waste. On the other hand, increased wood recycling will have a reducing effect. No clear view exists on the trend towards 2050. Elbersen et al (2016): "Outlook of spatial biomass value chains in EU28" and NL Agency (2013): "Competition in wood waste: Inventory of policies and markets" assume that wood waste will increase. We can assume that wood waste quantities will remain constant across the EU.

[6] We do not include the chemical sector in this overview. The chemical sector does not use woody biomass as feedstock today. In principle it is possible, through thermo-chemical conversion, to produce ammonia, methanol and other chemicals from woody biomass. However, the chemical sector looks into biochemicals

Pulp and paper
The pulp and paper industry mainly use roundwood, which is excluded from the biomethane potential in the Gas for Climate study. The sector uses some cutter shavings which are not considered to be used to produce biomethane in the Gas for Climate study. Also, a small quantity of branches and tops is used for paper production. Based on historical trends Ecofys expects that the virgin wood consumption for pulp and paper will remain constant, but there will be shift towards higher value products. Growth in production of paper packaging can be based on increased paper recycling, from the current 46% to well above 50%. [7] Based on this we do not foresee pressure from the EU pulp and paper sector towards using woody biomass residue categories assessed in this memo.

Wood panel industry
The wood-based panel industry does use wood residues from forestry operations including recycled wood. The sector currently uses 54 million m3 (~27 million tonnes) of woody biomass in the EU, 5 mln tonnes of which is recovered or recycled wood[8], 33% from industrial by-products such as sawdust whereas about half of all wood used to produce panels is roundwood. Wood based panels are widely used in furniture and construction and we can expect demand for panels is to grow by 3% annually up to 2050,[9] which would mean that nearly 13 million tonnes of recycled wood would be required by the EU wood panel industry in 2050.

Animal bedding
Wood shavings are used for animal bedding. We estimate that currently around 11 million tonnes of wood waste is used for animal bedding is within the EU. We assume that the development up to 2050 correlates with trends in livestock units in the EU farms. The EU Agricultural Outlook[10] estimates that cow herds remain stable towards 2030, sheep and goat herds slightly increase, and pig and poultry production is expected to increase marginally. EU livestock production is thus not expected to grow substantially up to 2030. The OECD-FAO agricultural outlook also expect EU meat consumption to remain stable. Extrapolating this we assume no significant growth by 2050 and, as a result, wood residues for animal bedding to remain constant.

Composting
Some 4 million tonnes of landscaping care wood is used for composting today. We foresee this wood use to decrease up to 2050 as other sources including animal manure, agricultural residues and sewage sludge are preferred feedstocks for compost. While quantities of available manure and agricultural residues may not change significantly, it is foreseen that the amount of treated sewage sludge will increase due to stricter EU regulation on landfilling[11] and thus more will become available for composting, reducing the need to use landscape care wood. A share of landscape care wood will continue to be used for composting, including a fraction of

mainly from sugar and starch rich biomass types, which are less costly to convert.6 We assume that no woody residues will be used by the EU chemical sector in the future.

[7] Between 2000 – 2017 the wood consumption for pulp and paper in the EU has been quite stable with a demand of around 150 million m³ of fresh roundwood. The main feedstock is roundwood with a share of 75% in 2017, whereas wood chips only have a share of 25%. The Confederation of European Paper industries (CEPI) has the ambition to add 50% more value in 2050 compared to 2010 resulting in € 25 billion added value in Europe. CEPI foresees a growth in established pulp and paper products of € 5 billion. Another additional € 3.5 billion are expected to come from new bio-based products. Increased paper recycling rates can be expected resulting from the EU Waste Framework Directive.

[8] https://www.wki.fraunhofer.de/content/dam/wki/en/documents/events/ligna2015-recycling-workshop/LIGNA-Workshop_13052015_EPF_Wijnendaele.pdf

[9] Growth of 5% in terms of revenue is expected towards 2025 based on https://www.grandviewresearch.com/press-release/europe-wood-based-panel-market-analysis. No estimates were identified for 2050 but it is anticipated that the industry will continue to grow steadily due to an expected increase in consumer disposable income, and a long-term annual growth figure of 3% within the EU up to 2050 seems appropriate.

[10] https://ec.europa.eu/agriculture/sites/agriculture/files/markets-and-prices/medium-term-outlook/2017/2017-fullrep_en.pdf

[11] http://ec.europa.eu/environment/waste/sludge/index.htm. Around 11% of the processed sludge in the EU is used for composting whereas 8% (~1 mln tonnes) goes to landfill. Due to the progressive implementation of the EU Urban Waste Water Treatment Directive 91/271/EEC. Sewage sludge production and disposal (Eurostat, 2018): http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ww_spd&lang=en. Around 11% of the processed sludge in the EU is used for composting whereas 8% (~1 mln tonnes) goes to landfill

wood available from private gardens used as compost by households. Yet based on the considerations above, we can assume that 2 mln tonnes of landscape care wood that is used for composing could become available for energy production.

Table 2 Overview of different woody residue potentials and their allocation to energy (all units in million tonnes of dry biomass)

Feedstock	2050 potential GfC study	Updated 2050 potential	Allocation to energy
Barks	34.1	34.1	34.1
Branches and tops	15.7	15.7	15.7
Thinnings for energy production	6.5	16.5	16.5
Landscape care wood	23.9	23.9	21.5
Wood waste	28.1[1]	40.2	20.1
Total (mln tonnes)	**108.2**	**130.4**	**107.9**

Below we explain our assumptions on the availability of biomass per type of woody residues for energy production.

barks, branches and tops

Managed forests in Europe are harvested primarily for the timber or pulp and paper industries. Tree trunks and larger branches are used for timber, while off-cuts, smaller diameter branches or lower quality timber are chipped and used by the pulp and paper or panel industries. Other parts of the tree like bark, branches and tops, stumps are typically not used by these industries and often bark, branches and tops are largely left in the forest as the cost of collection is not justified by market demand. However, there could be an incentive to increase collection for bioenergy purposes. We assume that the entire quantity of available bark, branches and tops will be used to produce energy, since the main uses of currently collected material are heat and power. Bark is used as a cheap renewable fuel for heat and power at saw mills. Branches and tops are either converted into wood chips or directly burned in an CHP plant. [12]

Thinning

The share of thinning in yearly roundwood removal in the EU can be up to 34%.[13] Often, multiple thinnings occur before a roundwood harvest takes place. The closer the thinning is towards the final felling the larger the harvested thinning trees are and the higher the chance that thinned trees will be used as saw wood in the timber sector. Early thinned very young trees have no other use but energy production. 'In between' thinnings are used for pulp and paper as well for panel production. It is difficult to divide the 34% share of wood thinnings over early, final and 'in between' thinnings. What is clear is that the 2% share of early thinnings in the total wood harvest available for energy as assumed in the Gas for Climate study seems very conservative. Based on additional expert interviews we can

[12] https://www.ecofys.com/files/files/ecofys-2013-low-iluc-potential-of-wastes-and-residues.pdf
[1313] Interview with forestry expert and based on the European Forest Information SCENario Model (EFISCEN).

conservatively assume that 5% of yearly roundwood removal in the EU are early thinnings with wood being available for energy production. This results in 16.5 million tonnes per year by 2050 of thinnings being available for energy.

Landscape care wood

Landscape care wood is mainly used as fuel wood (11 million tonnes) and to a lesser extent for composting (4 million tonnes) [14] . As explained above, some 2 million tonnes that is currently used for composting could become available for energy. We also expect that about 10 mln tonnes of currently uncollected potential of landscape care wood could be collected by 2050 and used for energy purposes. This means that in total over 90%, or 21 million tonnes of landscape care wood is assumed to be available for energy sector, which is still conservative when compared with other studies which assume 100% allocation to energy sector[15]. See also Table 4 in the Annex.

Wood waste

The current waste wood potential in the EU is around 40 million tonnes. The largest share of about 18 million tonnes is being incinerated with energy recovery. [16] Another 5 million tonnes is used in panelling board production and 11 mln tonnes for animal bedding. About 1 mln tonnes goes to landfill, and 5 million tonnes remains unused. See also Table 5 in the Annex. The use of wood waste for animal bedding is assumed to remain constant. Demand from the wood panel industry will increase. Total sectoral demand could increase from 5 to 13 million tonnes. Half of additional demand could be met by wood waste and the other half from increased thinning volumes, meaning that 9 mln tonnes of wood waste would be used to produce wood panels by 2050. We expect that the environmental issues associated with treating low grade or Grade C wood waste, will not be the same in the future, which would mean that by 2050 the 18 million tonnes of currently incinerated wood waste could by 2050 be used for other types of energy production including biomethane. We furthermore expect that the management of wood waste will be more effective by 2050, meaning the 5 million tonnes potential that currently 'unused' potential could become available by 2050. Also, no wood waste will be landfilled. In total this means that 20 million tonnes of wood waste could be available for energy production by 2050.

[14] Real potential for changes in growth and use of EU forests (EU wood, 2010): https://www.egger.com/downloads/bildarchiv/187000/1_187099_DV_Real-potential-changes-growth_EN.pdf

[15] The study Elbersen et al, (2016), "Outlook of spatial biomass value chains in EU28" assumes 100% availability for energy purposes

[16] Wood waste can be hazardous as well when containing substances like mercury or tar-based wood preservatives which make it only suitable for incineration, yet the share of hazardous waste in total wood waste is very small, around 3.5% and could potentially be used for biomethane production.

3 Woody residues for energy: renewable gas or biofuel

This section explores to what extent woody residues available for energy could be used to produce biomethane.

Based on our assessment of non-energy sectors and different end uses of the listed woody feedstocks in chapter 2, we estimate that 108 million tonnes of woody residues out of a total of 130 million tonnes will be available for energy sector. All available woody residues for energy sector are currently used for either electricity or heat generation. However, this current situation does not take into account a fully decarbonised energy system from a societal cost perspective. From a societal cost perspective, it makes sense to produce biomethane instead of directly combusting the woody biomass to produce electricity and heat[17].

A part of the woody residue potential will not reach the market and will continue to be directly used for electricity and heat production on-site at saw mills. Electricity consumption of EU saw mills is around 40 TWh at present[18]. If all of this electricity is produced using dedicated bio-CHPs then around 24 million tonnes of locally available woody feedstock is required. We assume that the process energy needs of the EU saw mill industry remain stable towards 2050 and this woody residue potential cannot become available for energy market. We don't assume a large on-site energy consumption from paper mills by 2050.[19]

Therefore, out of a total 108 million tonnes, only 24 million tonnes will continue to be used for electricity and heat production (in saw mills) and the remaining 84 million tonnes could then be used to produce biomethane and then make electricity, heat or use as industrial feedstock or transport fuel or to produce advanced renewable diesel/HVO as transport fuel

In the February 2018 Gas for Climate study, we assumed that 46 million tonnes is used for biomethane production (22 bcm). With re-assessment of non-energy sectors and various end uses of these woody feedstocks we have an additional 38 million tonnes (84 minus 46 million tonnes) that can be used to make either 18 bcm of biomethane, or other dispatchable energy such as advanced HVO transport fuel.[20]

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[17] This is assessed in our Gas for Climate report. For details please check the link: https://www.gasforclimate2050.eu/files/files/Ecofys_Gas_for_Climate_Feb2018.pdf

[18] http://www.ecoinflow.com/Portals/0/PROR_final_26_06_final-compressed_web.pdf

19 The Confederation of European Paper industries (CEPI) aims to reduce CO2 emissions by 80% before 2050. Currently, around 14 EU paper producers together with TU Eindhoven are developing an innovative technology that allows the separation of lignin and cellulose using a solvent that is biodegradable19. This innovation would drastically reduce the process energy that is currently needed to separate lignocellulosic materials into different components. Large scale application is expected in 15 years, well before 2050. With this technology maturity, we expect that the woody biomass that is used to meet process energy needs would be available in the market.

[20] Available woody residues for energy could also all be used as wood chips to produce (industrial) heat and power in a bio-CHP. The Gas for Climate study however assessed that biomethane power adds more value from a societal cost perspective than solid bioenergy. The societal value of renewable industrial heat (biomethane or solid bioenergy) need to be further assessed.

The advantage for producing biomethane from this additional woody residue is that it can be used in the power, buildings and industry sector, and therefore, can generate more societal cost savings. But at the same time, decarbonisation of aviation and shipping would need renewable liquid fuels where advanced renewable diesel/HVO can play an important role. Cost savings are important but even more crucial is to achieve the long-term objective of a fully decarbonised energy system. This means that it may make sense to use a large part of available woody residues to produce energy that can help to fully decarbonise EU transport, being it in the form of biomethane or liquid fuel.[21] If used entirely for biomethane, an additional 18 billion cubic metres of biomethane could be produced. If all allocated to transport, biomethane in transport would increase from 5 to 23 bcm.

The table below sums up the current potential and 2050 potential for each assessed feedstock as well as the allocation to the energy sector, as on output of the assessment in chapter 2.

Table 3: Overview of different woody residue potentials (all units in million tonnes of dry biomass)

Feedstock	2050 potential GfC study	Updated 2050 potential	Allocation to energy	Available for biomethane or biofuel	Allocation to biomethane in GfC study
Barks	34.1	34.1	34.1	10.1 *	10.2
Branches and tops	15.7	15.7	15.7	15.7	4.7
Thinnings for energy production	6.5	16.5	16.5	16.5	6.5
Landscape care wood	23.9	23.9	21.5	21.5	19.1
Wood waste	28.1[1]	40.2	20.1	20.1	5.6
Total (mln tonnes)	**108.2**	**130.4**	**107.9**	**83.9**	**46.1**

** After deducting process energy needs of the EU saw mills. It is assumed that mostly bark that is sawed at mills with round wood is used to meet process energy needs.*

21 Our estimates show that the amount of advanced HVO that can be made with waste oils collected in the EU is around 50 TWh. This is a small quantity compared to the total required quantity of 870TWh of renewable and low carbon energy required in decarbonised EU heavy duty road transport by 2050, let alone to decarbonise aviation and shipping. We expect that liquid fuels will be necessary in large quantities for aviation and other applications. This can be either biofuel or synthetic liquid fuel.

Annex – background tables

Table 1: Existing uses of landscape care wood

Feedstock	End uses	Potential 2015 (mln tonnes)[22]	Percentage share	Potential 2050 (mln tonnes)	Percentage share
Landscape care wood	Fuel wood (energy)	10.5	44%	22.25	93%
	Composting	3.75	16%	1.75	7%
	Unused (includes road side verge grass)	9.75	41%	0	0%
Total		**23.9**	**100%**	**23.9**	**100%**

Table 2: Existing uses of wood waste

Feedstock	End uses	Potential 2015 (mln tonnes)[23][24]	Percentage share	Potential 2050 (mln tonnes)	Percentage share
Wood waste	Incineration with energy recovery	18.1	45%	20.1	50%
	Recovery other than energy recovery	16.1	40%	20.1	50%
	-Panel industry	-4.8	-30%	-8.8	-44%
	-Animal bedding	-11.3	-70%	-11.3	-56%
	-Mulching	-0	-0%	-0	-0%
	Landfill/disposal	0.37	~1%	0	0%
	Incineration/disposal	0.31	~1%	0	0%
	Difference in treatment and production	5.3	13%	0	
Total		**40.2**	**100%**	**40.2**	**100%**

[22] Current uses obtained from EU wood (2010): https://www.egger.com/downloads/bildarchiv/187000/1_187099_DV_Real-potential-changes-growth_EN.pdf

[23] Obtained from Eurostat (2018)," Treatment of waste by waste category, hazardousness and waste management operations": http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wastrt&lang=en

[24] The further breakdown of potential use in "Recovery other than energy recovery" category is based on Ecofys estimates.

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