Supplementary material: FutureForest2040

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Table 1a. Biodiversity and planned economy: Wood material output in the intermediate product group (tonnes)

The origin of the material entering into production process	Energy (heat&power)	Liquid biofuels	Biochemicals	Chemical & dissolving pulp	Mechanical and semi-chemical pulp	Sawnwood products	Wood-based panels (Plywood, particle- and fiberboard, EWPs)	Composites & Hybrids
Roundwood	0	0	1236195	5187604	1066218	5008135	2715214	0
Side-streams	2964999	3907502	1454704	836076	0	0	407568	1625690
End-of-life waste wood	1000873	0	0	0	0	0	410667	0

Table 1b. Circular economy: Wood material output in the intermediate product group (tonnes)

The origin of the material entering into production process	Energy (heat&power)	Liquid biofuels	Biochemicals	Chemical & dissolving pulp	Mechanical and semi-chemical pulp	Sawnwood products	Wood-based panels (Plywood, particle- and fiberboard, EWPs)	Composites & Hybrids
Roundwood	482908	0	0	3977768	2748095	2228180	1393961	0
Side-streams	1198471	2395280	1613133	766720	0	0	340684	480821
End-of-life waste wood	363708	0	0	0	0	0	0	267382

Table 1c. Era of social connection: Wood material output in the intermediate product group (tonnes)

The origin of the material entering into production process	Energy (heat&power)	Liquid biofuels	Biochemicals	Chemical & dissolving pulp	Mechanical and semi-chemical pulp	Sawnwood products	Wood-based panels (Plywood, particle- and fiberboard, EWPs)	Composites & Hybrids
Roundwood	0	0	0	3815882	2768066	4599307	1723117	2292395
Side-streams	603862	3420428	1613133	2114456	0	0	225242	310540
End-of-life waste wood	504969	0	0	0	0	0	0	267381

Table 1d. Era of social connection (increased energy): Wood material output in the intermediate product group (tonnes)

The origin of the material entering into production process	Energy (heat&power)	Liquid biofuels	Biochemicals	Chemical & dissolving pulp	Mechanical and semi-chemical pulp	Sawnwood products	Wood-based panels (Plywood, particle- and fiberboard, EWPs)	Composites & Hybrids
Roundwood	0	0	0	3815882	2768066	4599307	1723117	2292395
Side-streams	8604640	1039300	869378	639551	0	0	78594	95933
End-of-life waste wood	919939	0	0	0	0	0	0	551917

Table 1e. Biodiversity and planned economy (increased energy): Wood material output in the intermediate product group (tonnes)

The origin of the material entering into production process	Energy (heat&power)	Liquid biofuels	Biochemicals	Chemical & dissolving pulp	Mechanical and semi-chemical pulp	Sawnwood products	Wood-based panels (Plywood, particle- and fiberboard, EWPs)	Composites & Hybrids
Roundwood	8136812	0	706397	3683199	1066218	4701514	0	0
Side-streams	12602820	73514	79616	488401	0	0	65819	772658
End-of-life waste wood	764208	0	0	0	0	0	385524	0

Table 1f. Circular economy (increased energy): Wood material output in the intermediate product group (tonnes)

The origin of the material entering into production process	Energy (heat&power)	Liquid biofuels	Biochemicals	Chemical & dissolving pulp	Mechanical and semi-chemical pulp	Sawnwood products	Wood-based panels (Plywood, particle- and fiberboard, EWPs)	Composites & Hybrids
Roundwood	482908	0	0	3977768	2748095	2228180	1905080	1393961
Side-streams	7418344	484272	415363	754893	0	0	154304	225811
End-of-life waste wood	765628	0	0	0	0	0	0	267382

Table. 2 Extra scenarios: generation assumptions

Type of assumption	Explanation
Mill energy vs CHP/District heating energy shares of the production	In the baseline, it is assumed that 40% of the produced wood-based energy (excluding liquid biofuels) is used for mill energy. Respectively, 60% is assumed to be directed to CHP production.
The demand for wood-based energy in the production	With a simplified assumption based on mill energy needs in the baseline, the total energy demand per harvested ton on wood is assessed for each scenario. This is calculated by dividing wood material flows entering into mill energy by the total harvested wood.
Assumptions regarding CHP and district heating demand in the future, affected by general energy efficiency increment	In the reports of VTT and Pöyry it was assumed, that the total energy demand in CHP and district heating decreases on average to 83% from current level due to increased energy efficiency. Thus the demand for CHP and district heating was estimated by multiplying the baseline CHP material in the baseline by 83%.
Assumptions regarding general wood-based energy demand in the future	In some scenarios of VTT it was assumed that the need for wood-based energy decreases in general to 75% from current level due to increased utilizatuion of alternative energy sources. This assumption was utilized to create extra scanrios for Circular Economy and Era of social connection scenarios. On the contrary, in the scenarios of Pöyry, it was assumed that demand for wood-based energy increases to 1,5-fold from the current level. This assumption was utilized to create extra scenario for Biodiversity & planned economy

Table 3. Conversion efficiencies (from input to output intermediate product)

Product	Conversion efficiency (from input to output intermediate product)
Energy (heat&power)	97%
Liquid biofuels	40%
Biochemicals	35% *includes all usable output products
Chemical & dissolving pulp	24%
Mechanical and semi-chemical pulp	69% *Higher conversion efficiency, since recycled materials are included already here
Sawnwood products	46%
Wood-based panels (Plywood, particle- and fiberboard, EWPs)	41%
Composites & Hybrids	40% * Assumed similar to panels

Table 4. Conversion factors for material flow input-output processes and energy contents. The conversion factors for input material flows are from Hassan et al. (2018) and Vaahtera et al. (2021) if not indicated otherwise next to the value.

Production process	Output wood-based material content (t)	Input wood-based material content (t)	MJ/t	t/m3 input wood material
Energy (heat&power)	1	N/A	14906.6 *average taken from sidestreams (Alakangas 2000)	N/A
Liquid biofuels	1	N/A	3000 (Ben et al. 2019)	N/A
Biochemicals	1	221.7 An estimate based on own assumption of the extraction process and based on continuation process into succinic acid (E4tech (UK) ltd et al. 2015)	N/A	N/A
Chemical & dissolving pulp	1	4.3	N/A	0.4
Mechanical and semi-chemical pulp	1	1.4	N/A	0.4
Sawnwood products	1	2.2	N/A	0.4
Wood-based panels (Plywood, particle- and fiberboard, EWPs)	1	2.4	N/A	0.4
Composites & Hybrids	1	2.5	N/A	0.3

Table 5. Indicators for production: Value of production and employment

Product type	Value of product (excl. VAT)	Unit	Value of product REF	Employment	Unit	Emp REF	Energy demand in the production	Unit	energy demand REF
CHP/District heating (sold out)	62.75	EUR/MWh	(Tilastokeskus 2021)	5.8E-08	Jobs/MJ	(Montt & Maître 2018)	* included in the production efficiency	N/A	N/A
Mill energy	22.50	EUR/MWh	(Tilastokeskus 2021)	5.8E-08	Jobs/MJ	(Montt & Maître 2018)	* included in the production efficiency	N/A	N/A
Liquid fuel oils (pyrolysis oil heating value used as a reference)	58.44 *light fuel oil used as a reference	EUR/MWh	(Tilastokeskus 2021)	5.8E-08	Jobs/MJ	(Montt & Maître 2018)	4.9E-05	MWh/MJ	.(EurObserv'ER 2014)
Biochemicals	2648.65	EUR/t	(Alexandri et al. 2016)	3.2E-04	Jobs/t	(Vaahtera et al. 2021)	9.6E+00	MWh/t	(E4tech (UK) ltd et al. 2015)
Chemical- and dissolving pulp (dissolving assumed to be dominating)	619.45	EUR/t	(Viitanen et al. 2021)	1.5E-03	Jobs/t	(Vaahtera et al. 2021)	3.6E+00	MWh/t	(Göran et al. 2019)
Mechanical - and half-chemical pulp	302.60	EUR/t	(Viitanen et al. 2021)	1.5E-03	Jobs/t	(Vaahtera et al. 2021)	1.3E+00	MWh/t	(Göran et al. 2019)
Sawnwood	294.95	EUR/m3	(Natural Resources Institute Finland 2021)	1.5E-03	Jobs/m3	(Vaahtera et al. 2021)	5.7E-02	MWh/m3	(Göran et al. 2019)
Panels	573.38	EUR/m3	(Natural Resources Institute Finland 2021)	3.7E-03	Jobs/m3	(Vaahtera et al. 2021)	0.13 *average CLT, MDF	MWh/m3	(Murphy et al. 2015; Stora Enso 2020)
Composites and hybrids (assumed to have similar price to panels)	573.38	EUR/m3	(Natural Resources Institute Finland 2021)	3.7E-03	Jobs/m3	(Vaahtera et al. 2021)	5.40 *Assumed to be similar to OSB	MWh/m3	(Murphy et al. 2015; Stora Enso 2020)

Table 6. Roundwood prices

Type	Roundwood prices	Unit	REF
Sawlogs	22.98	EUR/t	(Metsälehti 2021)
Pulpwood	6.67	EUR/t	(Metsälehti 2021)
Energy wood	2.16	EUR/t	(Metsälehti 2021)

Table 7. Harvest operation costs

Type	Costs	Unit	COST REF	Employment	Unit	EMP REF
*Fellings in general (average of first- and second thinnings and final felling	5.48	EUR/t	(Tuomasjukka et al. 2019)	3.04E-05	FTE/t	(Tuomasjukka et al. 2019)

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