

Material Flows Analysis of Timber and Wood-Residue Streams in Bulgaria: Evidence from MFA and Sankey Modelling

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CONTEXT

Why trace the flows of wood?

A renewable resource

Wood stores carbon and can substitute more carbon-intensive materials such as concrete, steel and plastics.

Circular bioeconomy

Cascading use extends the life of the resource: product → reuse → recycling → energy.

Evidence-based policy

Without a quantified picture of the flows, resource-efficiency policies are made in the dark.

Material Flow Analysis (MFA) quantifies flows and stocks within a clearly defined system — from harvesting to products and residues (Brunner & Rechberger, 2016).

Aim and research questions

To build a **mass-balanced flow model** of industrial roundwood and wood-residue streams in Bulgaria for **2014 and 2022**.

01

How is industrial roundwood allocated among the major wood-processing activities?

02

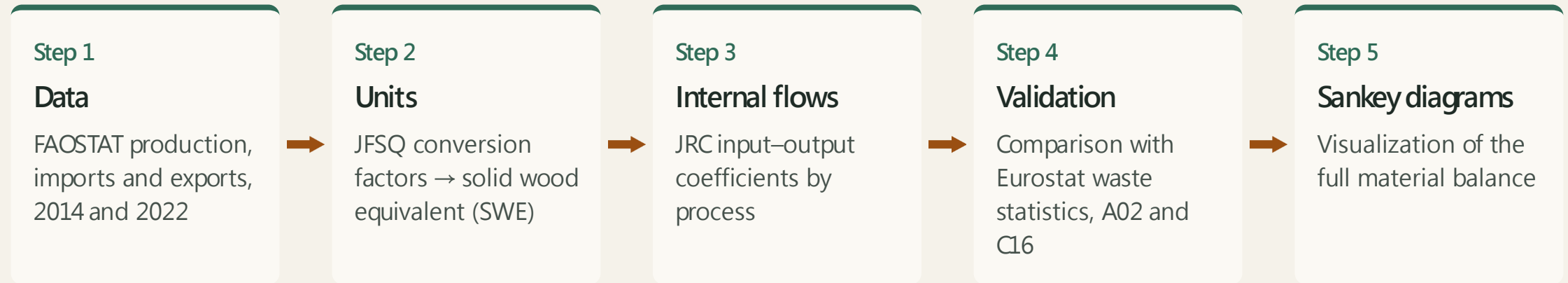
How much residue is generated: bark, sawmill by-products, forest and industrial residues, black liquor?

03

How much returns as secondary raw material, and where lies the potential for circularity?

METHODOLOGY

How the model was built



Novelty: internal residue streams are reconstructed at process level — information not directly available from official statistics.

SCOPE

System boundaries

Processes (primary flows)

Sawmilling (sawnwood)

Plywood and veneer sheets

Fibreboard

Particleboard

Chemical wood pulp

Residues (secondary flows)

Bark

Sawmill by-products (chips, sawdust, slabs)

Forest residues

Other industrial residues

Black liquor (from pulp production)

Years: 2014 and 2022 · **Unit:** m³ solid wood equivalent (SWE) · **Input:** harvest + imports – exports

Structural change, 2014–2022 (% change)

Product	Production	Import	Export
Industrial roundwood	+ 9.5	+ 94.0	−96.0
Sawnwood	−16.4	+ 367.0	−79.0
Plywood	−30.6	+ 46.3	−20.5
Veneer sheets	−19.2	−20.5	−47.6
Particleboard	+ 62.9	+ 92.5	+ 29.4
Fibreboard	+ 642.4	+ 64.5	+ 296.0
Chemical wood pulp	+ 55.6	−86.8	−18.8

Raw material stays at home

Exports of industrial roundwood fell by 96%.

Wood-based panels boom

Fibreboard + 642%, particleboard + 63%: more value-added processing.

Primary processing declines

Sawnwood, plywood and veneer fell despite rising imports.

Key flows, million m³ SWE: 2014 → 2022

5.57 → 5.98

Industrial roundwood harvest

+7% over the period; imports remain marginal (0.03 → 0.06)

1.16 → 0.08

Industrial roundwood exports

from 21% to about 1% of available supply

4.03 → 4.66

Roundwood entering the analysed processes

primary input into the five processes

0.42 → 1.30

Other wood uses¹ outside the system

energy, other products, stock changes (residual)

Material flows in 2014

5.60 million m³ supply

of which 1.16 million m³ (21%) left the country as exports

Sawmilling dominated

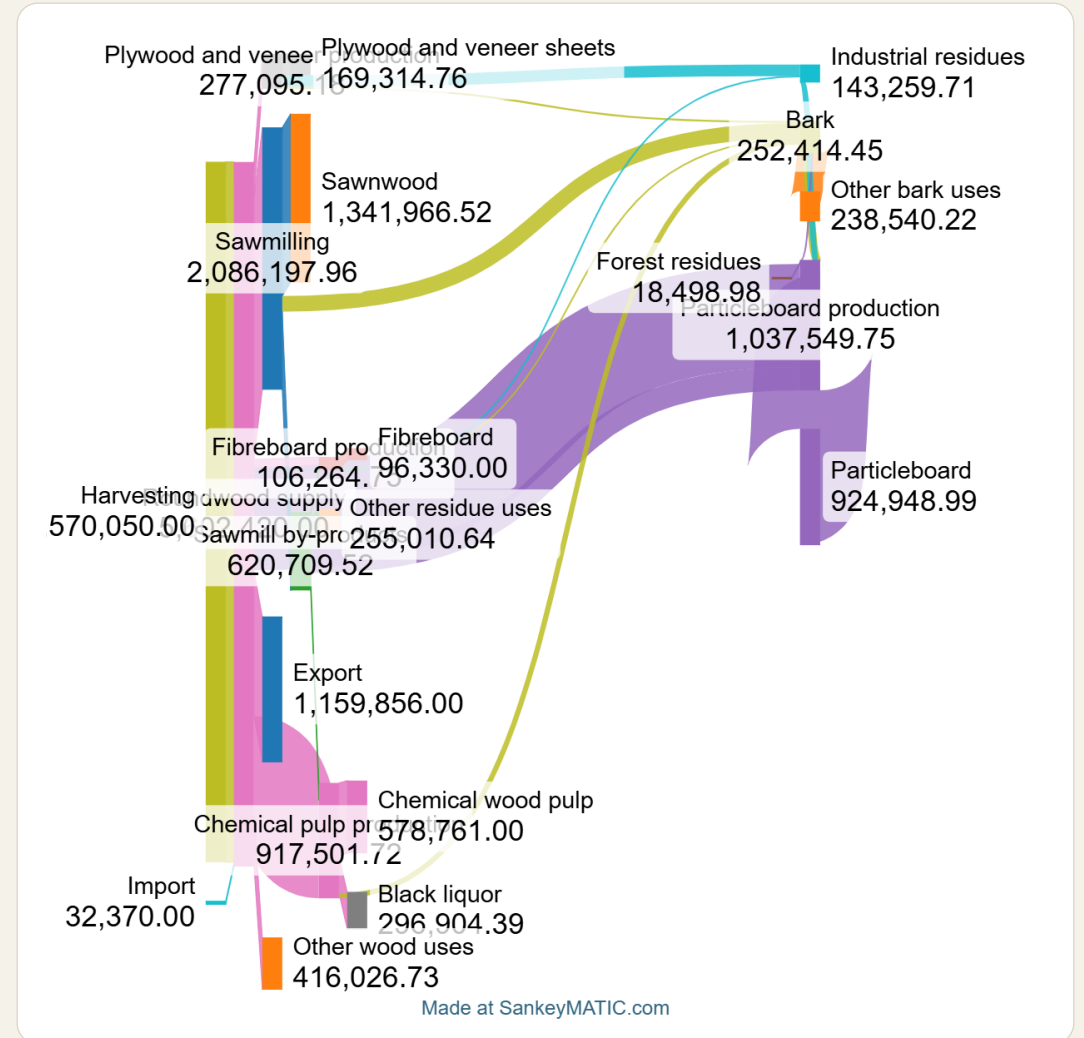
2.09 million m³, 47% of input to the analysed processes

Followed by particleboard and pulp

1.04 and 0.92 million m³ of raw material

Bark was hardly used

0.25 million m³ of bark, about 95% of it leaving the system



exports only 0.08 million m³ ($\approx 1\%$)

sawmilling 1.73 and particleboard 1.69 million m³ (32% each), pulp 1.43

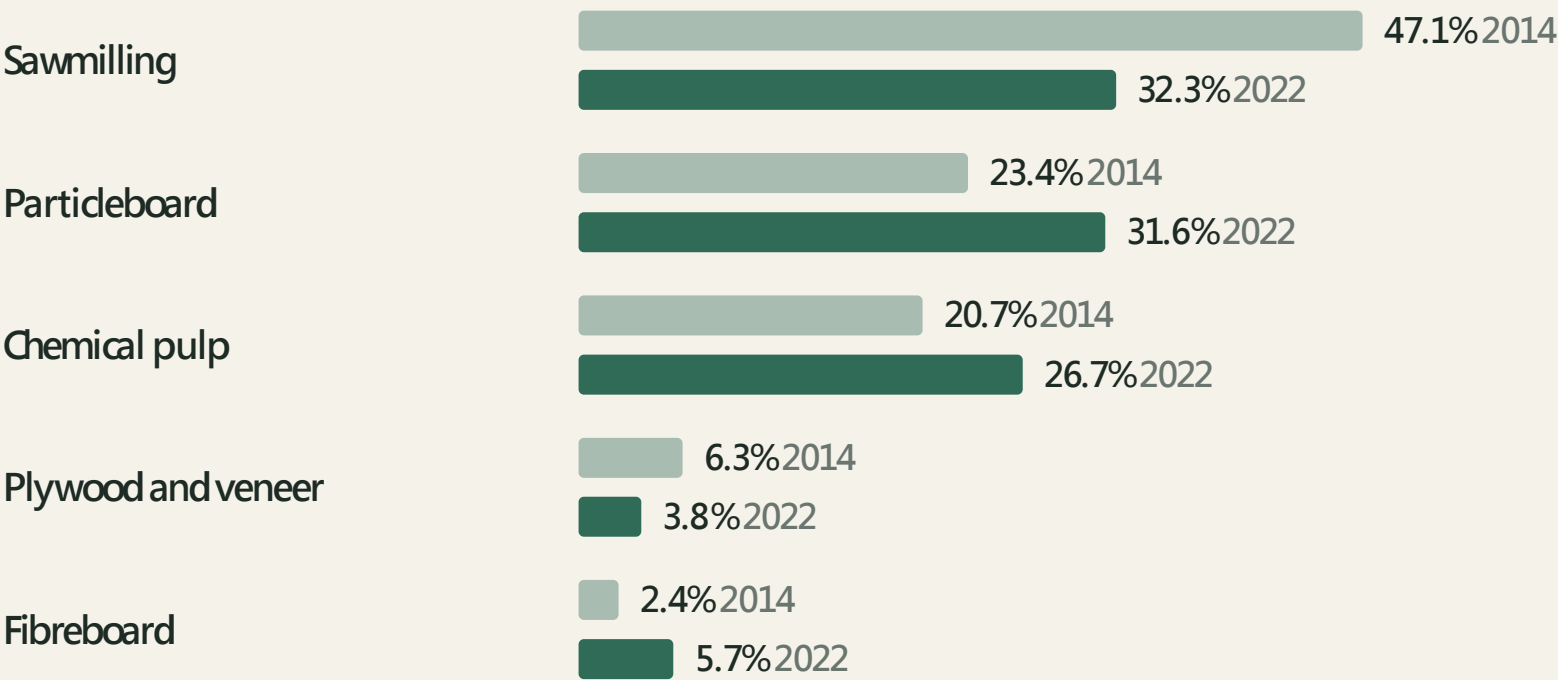
21% of particleboard input and 40% of fibreboard input are secondary

1.30 million m³ go to “other wood uses”



How the processing structure changed

Share of total material input to the analysed processes, % (light — 2014, dark — 2022)



Particleboard drives cascading use

21%

of particleboard input is secondary (2022): 301 k m³ sawmill by-products, 30 k m³ forest residues, 23 k m³ bark

40%

of fibreboard input comes from sawmill by-products (123 k m³, 2022)

0.40 → 0.69

million m³ of secondary raw materials used in the analysed processes (+ 74%)

5% → 7%

share of bark reused as raw material within the system — still very low

Untapped potential, 2022

Secondary flows leaving the analysed system:

Black liquor



Bark to other uses



Other industrial residues



Total ≈ 0.90 million m³ per year

DEPENDENCY

$\approx 20\%$

of sawmill by-products used in the system (125 of 639 k m³) must come from outside the modelled sawmills.

In 2014 sawmills produced a surplus; by 2022 panels and pulp need more by-products than sawmills generate.

CONCLUSIONS

Five conclusions

- 1 Structural shift**
From exporting raw material to domestic processing: roundwood exports almost disappeared.
- 2 Panels drive circularity**
Particleboard reaches sawmilling (32% of input each) and is the largest user of secondary raw materials.
- 3 Primary processing is weakening**
Sawnwood -17%, plywood and veneer -27%; domestic by-products no longer cover demand (≈20% external).
- 4 Residues still untapped**
Black liquor, bark and industrial residues: about 0.90 million m³ outside the system in 2022.
- 5 A blind spot in the data**
“Other wood uses” tripled to 1.30 million m³, without transparent reporting by destination.

IMPLICATIONS

What follows for policy and industry

Improved residue recovery

Bark and industrial residues as feedstock for panels, insulation and bio-based products, not only as fuel.

The cascading principle

Material use before energy use; higher recycling quotas for post-consumer wood.

Integrated value chains

Linking wood processing with bioenergy and bio-based industries, e.g. black liquor → energy and chemicals.

Better statistics

Reporting energy wood, stocks and residues in comparable units (SWE) and by destination.

Contribution, limitations and next steps

Contribution

- First process-based MFA of industrial roundwood and wood-residue streams in Bulgaria
- Internal flows reconstructed with JRC coefficients — not available in official statistics
- A reproducible framework for monitoring the circular bioeconomy

Limitations and future research

- Two snapshots — a full annual series 2014–2022 is next
- Average EU coefficients rather than national technology data
- Energy use and post-consumer wood are outside the boundary
- Next: carbon storage in products and links to firm-level efficiency

Thank you for your attention!

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