#Wood

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Developing long-life wood uses: a look at the German, Romanian and Swedish industries

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SUMMARY

Achieving carbon neutrality will require the redirection of harvested wood towards long-life uses

To achieve carbon neutrality, France is relying on its carbon sink to balance residual emissions in 2050. A smaller carbon sink would require even greater emissions reductions from other sectors (transport, agriculture, industry, etc.), sectors in which France is already calling for drastic sixfold cuts between 1990 and 2050. In a context where the carbon sink in ecosystems is already falling sharply due to an increase in tree mortality, preserving this sink and developing carbon storage in wood products must be a major concern of the national climate policy.

One of the main drivers for maximising the carbon sink is to optimise the use of harvested wood, by redirecting more wood towards long-life products. This lever is the cornerstone of the "carbon sink" component of the French National Low-Carbon Strategy.[1] The targets for redirecting the use of wood are very ambitious, but while the final figures are still being debated, this lever will have to be activated in any case if we want to achieve our carbon sink targets.

To achieve this objective, three kinds of wood products require development, all within the construction sector: engineered wood, structural panels and insulation materials derived from pulpwood. These products are the key targets because they can be made from low quality or small-diameter wood, which is currently mainly used for short-life applications such as energy and paper pulp. The task that remains is to identify the political and industrial levers for developing these products: our analysis marks the start of this work.

Is the grass greener in neighbouring countries? In search of best practice in Germany, Romania and Sweden

Do some countries get more out of their wood, particularly by manufacturing long-life wood products? If so, how can this be explained? To answer these questions, we began by identifying European countries that dedicate a larger proportion of their wood harvest to long-life products in comparison to France. Germany, Romania and Sweden were chosen, each for different reasons. The main motive for selecting Germany was that, more so than France, its wood harvest is used more as a material than as an energy source (**Figure 1**), and it has a very high level of wood-based panel production (**Figure 3**). Romania was chosen because of the proportion of harvested wood used as a material (**Figure 1**) despite the high proportion of hardwood in its harvest[2] (**Figure 2**), unlike France where deciduous trees are abundant but fuelwood accounts for the majority share. As for Sweden, its ability to use almost all of its harvest for material uses rather than for energy, as well as the significance of timber-framed buildings further supports its selection (**Figure 1**).

For each country, the study is divided into two parts:

- An inventory of wood uses in the country concerned, with the aim of highlighting the segments of the industry that perform better than their French counterparts, by obtaining proportionally more long-life wood products from the resources available. The wood harvest is then analysed, with a focus on the uses of hardwoods, of low-quality and small-diameter wood, and of so-called "secondary" resources (wood processing by-products, recovered wood), likely to be redirected from short uses to long-life wood products.
- An analysis of the factors that may underlie the better performances identified in part one, and a discussion of their reproducibility in France. This analysis is based on over fifty published bibliographical references and on the opinions of around twenty experts from these countries.

1 I4CE. Grimault, J., Tronquet, C., Bellassen, V., Bonvillain, T., Foucherot, C., 2022. Carbon sinks: is France's ambition realistic?

2 As shown in **Figure 3**, Portugal also has a very high proportion of hardwoods. However, Romania was chosen because the species it harvests (mainly beech and oak) are similar to those harvested in France, while the main hardwoods harvested in Portugal are eucalyptus and cork oak.

Main lessons for France

From these comparisons, we have identified three main inspirational levers for France.

1. Subsidizing long-life uses

Firstly, key wood products can be made more competitive than other construction materials. Germany, for example, subsidizes bio-based insulation (including wood fibre insulation) to cover half of the additional cost of the original product. It obtained a derogation from the European Commission to grant this state aid, on the grounds that it was environmentally beneficial. In the twenty years since the subsidy was introduced, the volume of bio-based insulation products entering the German market has seen a fifty-fold increase. Moreover, the cost to the public purse has remained moderate: the economies of scale achieved by bio-based insulation manufacturers have enabled subsidies to be discontinued while maintaining production.

The average Swede uses 360% more sawn wood than their French counterpart. This difference is mainly due to the renovation and extension of buildings. New construction is also a major driver, due to the fairly widespread use of timber frames for single-family homes, as well as for 20% of multifamily homes. However, this striking feature does not offer any obvious lessons for France. Firstly, because the greater use of timber frames seems to be mainly cultural. Secondly, because this practice is based on an adapted and abundant coniferous resource, a factor that would be difficult to replicate in France in the short term (I4CE, 2022). For medium and high-rise buildings, fire regulations are slightly more favourable in Sweden than in France, and an ad hoc national strategy has been implemented to support the expansion of the market, which began in the 1990s. While this strategy seems to be paying off, given the current market share of wood in this type of building, we would point out that even in this favourable environment, the Swedish market has been slow to evolve.

2. Ensuring public policies prioritize wood use

Secondly, it is possible to reduce the pressure from other uses, such as energy or paper, that compete for the same resources. At a constant level of harvesting, growth in one of these sectors or in the panels sector will be detrimental to the others by creating tension in the wood supply. In Romania, there is no paper industry while the panels sector is important. In Sweden, the efficiency of heating networks reduces the energy use of harvested wood, although this actually benefits paper rather than panels. In Germany, energy companies use recovered wood and panel manufacturers use wood raw material, whereas in France it is the energy companies that can afford wood raw material, while panel manufacturers have turned to cheaper recovered wood. Beyond the type of resource used, this last case shows the impact of different policy choices, one directed towards industry which has encouraged the development of panel production, and the other geared towards energy. These three examples illustrate the just-in-time relationship between these uses that compete for the same resource: even partial monopolization of the resource by one of these uses has an impact on the others.

Supporting these three sectors is possible by increasing harvest while reducing the forest carbon sink. In France, the strategy is to increase the level of harvesting while reducing the proportion of wood dedicated to the shortest uses. However, France's policy of heavily subsidizing energy use, including from primary resources, undoubtedly places it in a less favourable situation than the three countries studied here, in terms of the availability of small-diameter and low-quality wood for long-term uses. While our study was unable to identify effective prioritisation policies, the three examples above illustrate the need to establish trade-offs and prioritise certain uses.

3. Developing the furniture sector to boost the supply of semi-finished products

Finally, the existence of outlets is clearly a structuring factor. As far as the panel industry is concerned, maintaining its production rate depends on the ability to sell its stock. The lack of outlets for panels can limit the smooth running of factories; securing suitable outlets is therefore imperative if we are to increase production significantly. For example, a lack of outlets for engineered hardwood products in Germany, proved to be a limiting factor for Pollmeier sawmill's development of this semi-finished product. Here again, our study was not able to identify any effective policies for creating such outlets, apart from the German subsidy (see lesson 1). However, we note that the furniture industry relies on panels in Germany and Romania, and on engineered wood in Romania. The French furniture industry also consumes panels, but some of the furniture and panels used in production are imported. Although furniture is a less sustainable use than construction and renovation, it can help to scale up the production of these products, which can also be used in construction.

This report describes these three main lessons, as well as analyses other positive observations. For example, the study of Germany and Romania revealed industrial models that differ from the French one. The vertical integration of sawyers and panel makers on the same sites in Germany is one factor that makes them competitive. Similarly, the development of engineered wood for furniture in Romania is a promising trend, with no equivalent movement in France at present.

Figure 1. Proportion of industrial wood and fuelwood in the largest European harvests in 2019

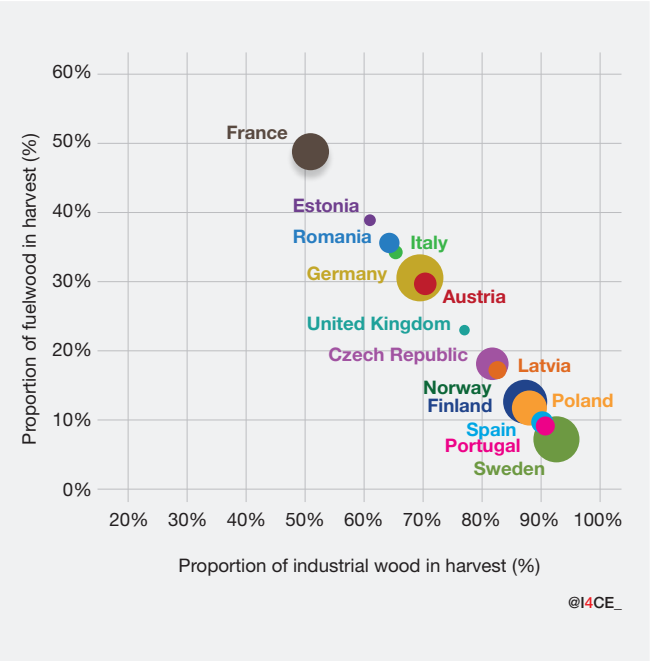
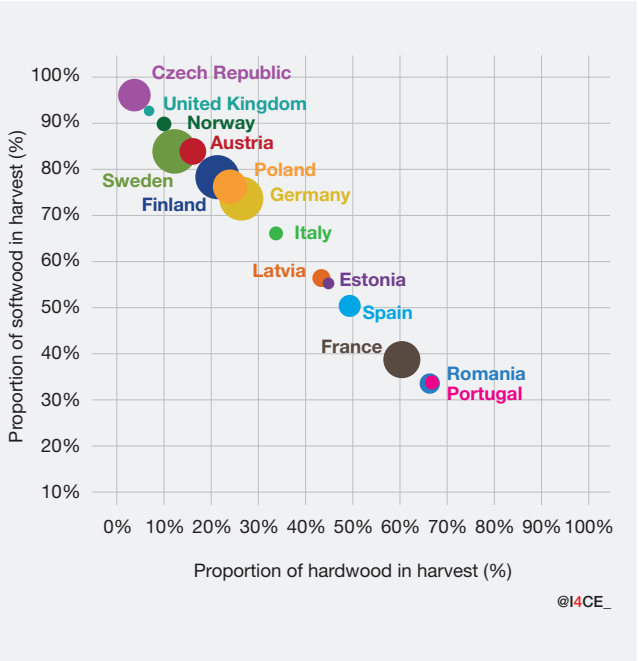


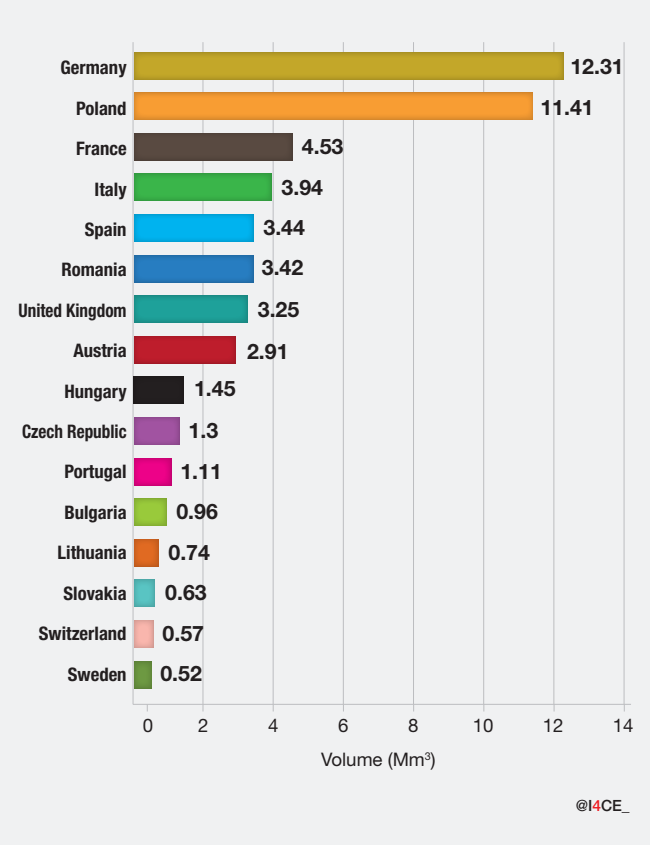
Figure 2. Species distribution in the 2019 harvest



NB: Only countries with a total timber harvest of over 10 Mm³ are shown. This figure is based on data supplied by countries to Eurostat. These data should be handled with caution: there may be discrepancies both in the volumes harvested and in their uses, with the result that fuelwood is frequently underestimated. Only Finland and France have updated their data to correct this, by accounting for the fuelwood self-consumed by households in the case of France.

Source: I4CE, based on (Eurostat, 2023)

Figure 3. European production of wood-based panels in 2019 (Mm³)



NB: only countries that produced over 0.5 Mm³ of panels are shown.

Source: I4CE, based on (Eurostat, 2023)

Some simplified definitions about wood and wood products

Deciduous / hardwood, coniferous / softwood: tree species are classified into two main families: deciduous (oak, beech, chestnut, etc.), and coniferous (fir, spruce, pine, etc.). The French forest is predominantly deciduous, but the wood industry mainly processes coniferous wood. As most of hardwoods are deciduous, and softwoods are coniferous, it is common to simply refer to them as hardwoods and softwoods.

Timber, pulpwood, fuelwood: these terms classify wood according to its quality and use. Timber corresponds to the best quality wood, most often found in the form of sawn wood used to make roof frames, pallets, furniture, staircases, etc. Pulpwood and fuelwood designate the same type of wood, i.e. wood of low quality and/or small diameter; it is the use that defines whether it is industrial wood used to produce pulp or panels, or wood used for energy production.

Engineered wood products: products made up of several sections of the same tree trunk or of several trunks, glued together. Many products fall into this category: glulam, cross-laminated timber (better known as CLT), plywood, particleboard and fiberboard, wood-based insulation...

Wood-based panels: in our report, it refers to particleboard (or chipboard), fiberboard and OSB. These panels are versatile: they can be used in furniture (except for OSB, which is mainly used for construction and interior fittings), in the structure of buildings (walls, floors, etc.), as interior cladding (walls, parquet flooring), and as joinery and interior fittings (doors, partitions).

For more information on wood types and their main uses in France, please consult our report Changing Wood Use to Improve Carbon Storage: Which Products Should Be the Short-Term Focus? (2022)

ACRONYMS AND ABBREVIATIONS

CLT	Cross-Laminated Timber
DE	Deutschland / Germany
EPR	Extended Producer Responsibility
FR	France
GDP	Gross Domestic Product
HDF	High-Density Fibreboard
MDF	Medium-Density Fibreboard
OSB	Oriented Strand Board
R&D	Research and Development

Units

Mha	Million hectares
Mm^3	Million cubic meters
Mt	Million tonnes
Mm^3 swe	Million cubic meters of solid wood equivalent
TWh	Terawatt-hour

CONTENTS

GERMANY

Germany was selected mainly due to the high proportion of wood harvested for material uses and its very high level of panel production, while its volume of harvested pulpwood is almost identical to that of France (**Table 1**).

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Table 1. Overview of forest-based industries in Germany and France in 2019

	Units	Germany	France
		Eurostat	
Total surface area	Mha	**11.5**	**17.3**
Net growth	Mm^3 over bark	**99.7**	**102.3**
Removal rate	%	**90%**	**67%**
Ownership type	%		
Public ownership	%	52%	25%
Private ownership	%	48%	75%
Surface area of production forests	Mha	**10.8**	**16.4**
Proportion of production forests out of total area	%	**94%**	**95%**
Standing volume	Mm^3 over bark	**3 539.7**	**3 065.3**

		National statistics	Eurostat		IGN-FCBA (2016)
Harvested volumes	Mm^3 over bark	**68.9**	**77.8**	**49.7**	**48.2**
Deciduous species	%	17%	26%	61%	58%
Oaks	%	*3%*	*NC*	*NC*	*22%*
Beech and other hardwoods	%	*14%*	*NC*	*NC*	*36%*
Coniferous species	%	83%	74%	39%	42%
*Spruce, fir, douglas fir, and other softwoods**	%	*69%*	*NC*	*NC*	*27%*
Pines (and Larch for Germany)*	%	*14%*	*NC*	*NC*	*15%*
Type of use		Eurostat			
Timber	%	*53%*		*34%*	
Pulpwood		*16%*		*17%*	
Fuelwood		*30%*		*49%*	
Sawnwood production	Mm^3	24.6		7.8	
Panel production (excluding plywood)		12.4		4.7	
Paper pulp production	Mt	2.3		1.6	

Sources: (Eurostat, 2023d, 2023e, 2023f, 2023g, 2023i; IGN and FCBA, 2016; Federal Statistical Office (Destatis), 2023). French removal rate based on (IGN, 2022).

*Larch harvested in France is included in the "other softwoods" category.

1. OVERVIEW OF WOOD USES IN GERMANY

With a view to identifying the segments of the German timber industry dedicated to long-life uses, we drew up an inventory of the resource types and volumes exploited, as well as their uses.

1.1. Overview of the German and French harvest

In 2019, 78 Mm³ and 50 Mm³ of roundwood was harvested in Germany and France, respectively (**Figure 1**). While the German harvest is now almost 60% higher than the French, this has not always been the case: Germany has only harvested more than France since 2003. The German harvest has risen sharply, by almost 140% since the early 1990s, while the French harvest has declined over the same period.

Historically, Germany has had a higher proportion of timber in its harvest: since 1992, timber has accounted for the majority of the German harvest, almost always at least half.

In France, timber accounts for only 34% of the roundwood harvest on average, and has changed little between 1992 and 2020. This fairly static situation is similar for the other harvest segments (pulpwood, fuelwood), while Germany has seen growth in fuelwood at the expense of pulpwood.

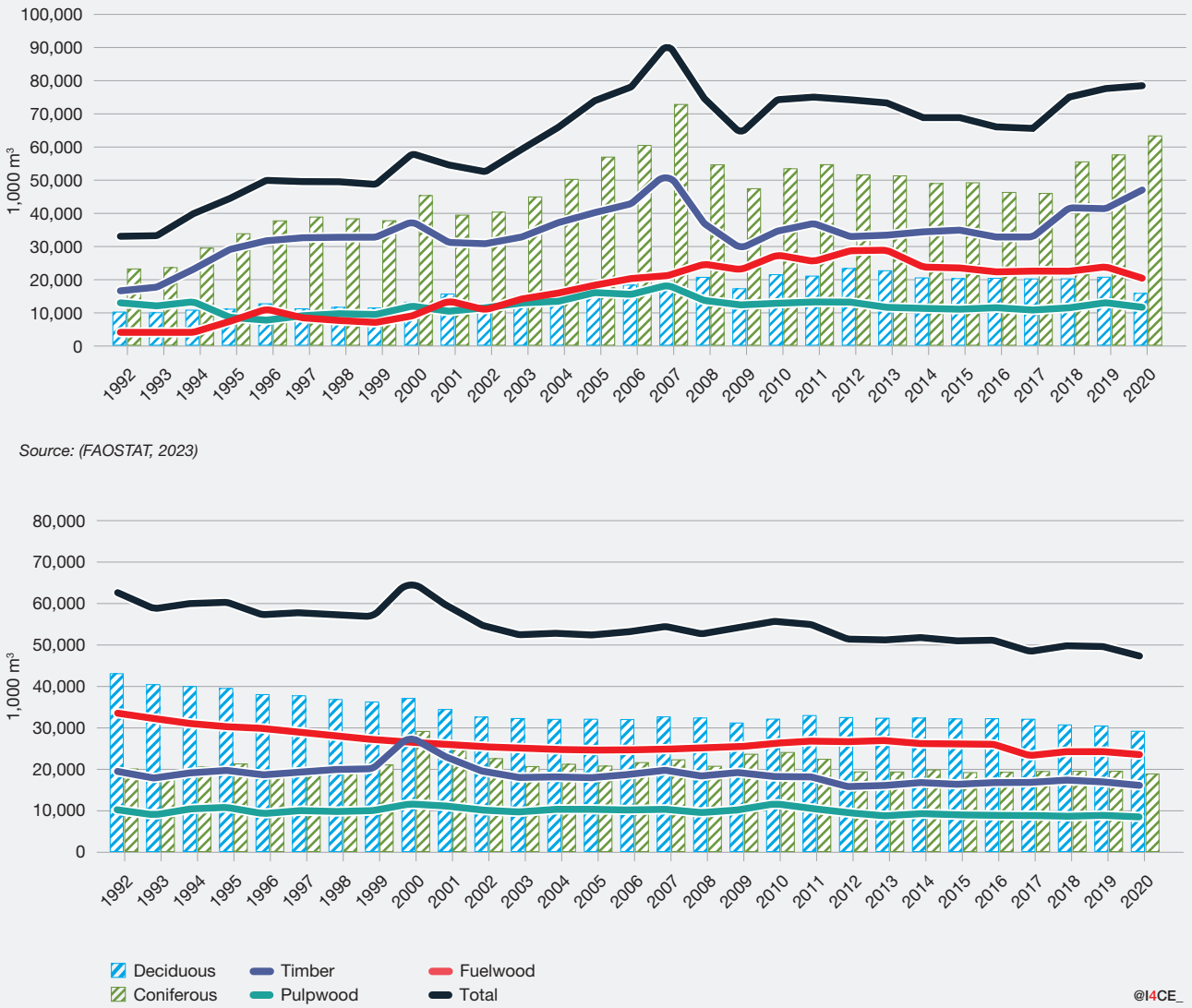
Taking trade into account, Germany has 60% more roundwood than France (**Table 2**). Most of the German trade concerns softwood, while in France, although softwood is the main import, the export of softwood is as high as that of hardwood.

Table 2. Production, imports, exports and apparent consumption of roundwood in France and Germany in 2019 (Mm³)

	France	Allemagne
Production	49.7	77.8
Import	1.4	7.6
Export	4.3	9.1
Apparent consumption	46.8	76.4

Source: I4CE, based on (Eurostat, 2023i; FAOSTAT, 2023)

Figure 1. Wood harvest in France and in Germany from 1992 to 2020 (1,000 m3)



Source: (FAOSTAT, 2023)

Source: (Eurostat, 2023h)

1.2. Timber

Valorization of hardwoods

In Germany, there is a great disparity between the uses of hardwood and softwood, which is similar to the situation in France: in 2018, two-thirds of the German hardwood harvest was destined for energy use, while at least three-quarters of the softwood harvest was destined for material uses (Purkus *et al.*, 2019b; Eurostat, 2023f).

Improving the valorization of hardwood is part of the current German national strategy (German Ministry of the Environment, 2016; German Ministry of Agriculture, 2018). There have been very few substantial positive developments in the material use of hardwoods over the past 20 years (Purkus *et al.*, 2019a). According to the experts interviewed, political decision-makers have only recently expressed a will to develop such usages.

The experts consulted considered engineered wood to be a sector of future growth for hardwoods because it would prepare the industry for a market shift towards greater hardwood availability compared to softwood. At present, although the subject of numerous research projects, there are few industrial applications. Regarding engineered products for the construction industry, only one sawmill (Pollmeier) is currently producing laminated veneer lumber (LVL) made from beech.

Wood chemistry has also been identified as a value-added sector for hardwoods (particularly beech) that is developing in Germany.

Valorization of small-diameter and low-quality wood

One expert reported that research projects are underway to enable the use of small-diameter wood in structural construction products[1]. However, as yet there is no industrial application for such a product.

To date, this wood is mainly used for the production of pulp, panels and energy.

Regarding low-quality wood, we distinguish between poor quality wood associated with disasters (storms, infestations, etc.) and poor quality in terms of the intrinsic qualities of the wood, linked to tree development in the forest (depending on species, soil, climate, silviculture, etc.) and the grading of the wood by the downstream sector.

Germany has suffered major disasters in recent years. Its harvesting of damaged wood has risen sharply, largely as a result of the bark beetle outbreak that affected some of Europe's softwood stands[2], and to a lesser extent due to storms (German Ministry of Agriculture, 2021b). The salvage harvest of damaged wood reached 46 Mm³ in 2019, which did not represent all of the damaged wood that could have been harvested (Jochem *et al.*, 2020). In response, the German industry did not need to increase the volumes of processed wood; by reducing the normal harvest and the usual volume of imports, a proportion of this 45 Mm³ was absorbed, but the industry still had to export part of its harvest, thus becoming a net exporter of softwood roundwood in 2019 (Jochem *et al.*, 2020; Weimar, 2020).

Not much information has been gathered on the mechanical grading of sawn timber in Germany. According to the experts interviewed, this job is increasingly performed by machines (rather than visual grading using a criteria grid), although certain technical obstacles remain, particularly for beech (the main hardwood species processed). However, researchers are working together with the manufacturers of grading machines to overcome these obstacles, and good communication between these actors could lead to rapid industrial deployment.

1 These products (glued-laminated timber, cross-laminated timber, etc.) are not usually produced from small-diameter timber. These woods correspond to the lower range of the "small wood" class defined by the IGN, with a diameter of between 7.5 cm and 22.5 cm (diameter at 1.30 m). To date, the preferred diameter for sawing and peeling is 15 to 25 cm for softwood, and 35 to 40 cm for hardwood (IGN and FCBA, 2019).

2 Insect damage was responsible for almost 75% of salvage logging in 2019 (German Ministry of Agriculture, 2021b).

1.3. Pulpwood, fuelwood, and secondary resources

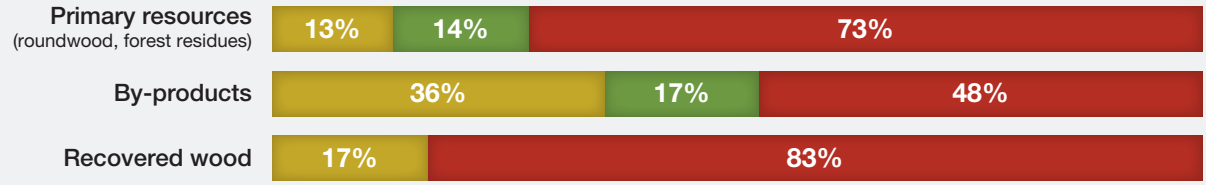
In both France and Germany, the energy sector dominates the use of pulpwood and fuelwood (**Figure 2**). However, the proportion for material uses (*i.e.* conversion into pulp and panels) is higher in Germany. Panel manufacturers in Germany process a higher proportion of roundwood (13%) compared to panel manufacturers in France (6%), but the biggest difference is in wood processing by-products: in Germany, a third of available by-products are used to produce panels and insulation, which is twice as much as in France (**Figure 3**, **Figure 4**).

Figure 2. Main uses of resources of pulpwood, fuelwood and secondary resources processed in Germany (2018-2020) and in France (2017), (%)

Sources: I4CE, based on (Ademe, Solagro, BVA, Biomasse Normandie, 2018; Ademe, 2021a; Döring et al., 2020, 2021a, 2021b, 2021c ; FCBA, 2018 ; Gieseking et al., 2021

NB: Resources of pulpwood and fuelwood quality include pulpwood and fuelwood-type roundwood, wood processing by-products and recycled wood.

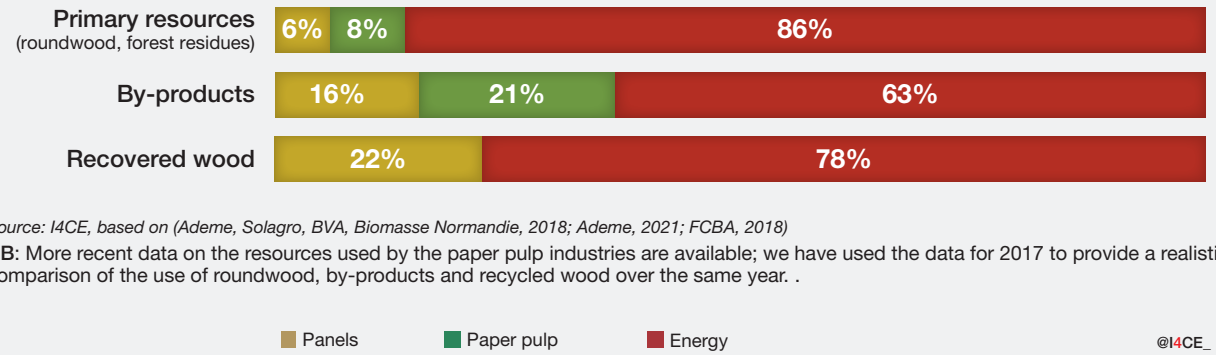
Figure 3. Distribution of pulpwood, fuelwood and secondary resources processed in Germany during 2018-2020 (%)



Source: I4CE, based on (Döring et al., 2020, 2021a, 2021b, 2021c; Gieseking et al., 2021)

NB: Data for the panels and insulation sector refer to 2020; data for the paper sector refer to 2019; data for domestic wood heating refer to 2018, while data for biomass power plants refer to 2019.

Figure 4. Distribution of pulpwood, fuelwood and secondary resources processed in France in 2017 (%)



Source: I4CE, based on (Ademe, Solagro, BVA, Biomasse Normandie, 2018; Ademe, 2021; FCBA, 2018)

NB: More recent data on the resources used by the paper pulp industries are available; we have used the data for 2017 to provide a realistic comparison of the use of roundwood, by-products and recycled wood over the same year. .

Material uses

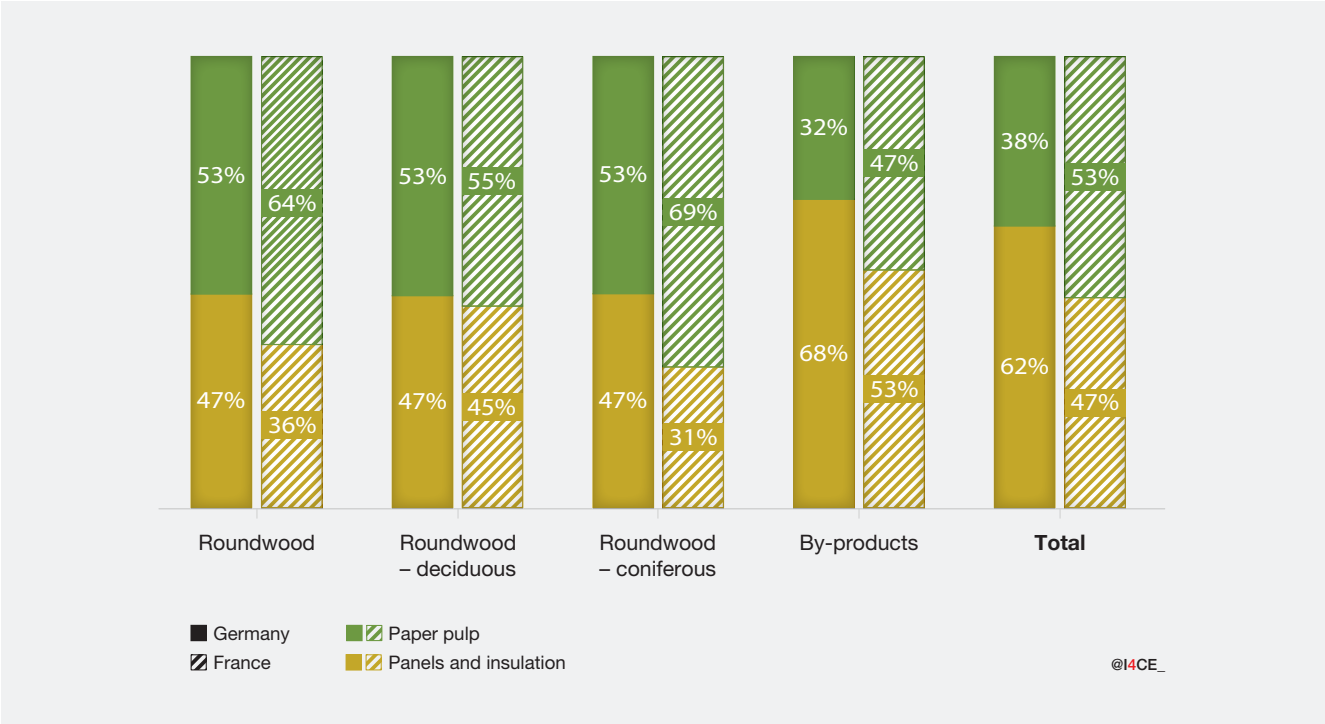
Allocation of resources between the production of paper pulp and of panels and wood-based insulation materials: Germany has a greater proportion dedicated to panels and insulation

Germany assigns a higher proportion of its wood resources to panel and insulation production in comparison to France (**Figure 2**).

While panels can have a short lifespan, for example when used on building sites or for packaging, they are mainly used in the furniture and construction sectors. We therefore conclude that the majority of resources intended for pulping in Germany are dedicated to long lifespan uses.

The differences between Germany and France in terms of the proportion of resources dedicated to panel production mainly concern the use of softwood roundwood (47% compared to 31%, respectively) and by-products (68% compared to 53%, respectively) (**Figure 5**). Recycled materials are always fully allocated to panel production, as used paper is not classed as a wood resource.

Figure 5. Distribution of raw materials for the production of panels, insulation and paper pulp in Germany (2020) and France (2019), (%)



Source: I4CE, based on (Döring et al., 2021a; Gieseking et al., 2021) for Germany; and based on (FCBA, 2020) data converted into cubic metres using the conversion rates for France (FAO, ITTO and United Nations 2020).

NB: Data represented in this graph can be found in Annex 1 **Table 5** and Annex 2 **Table 11**.

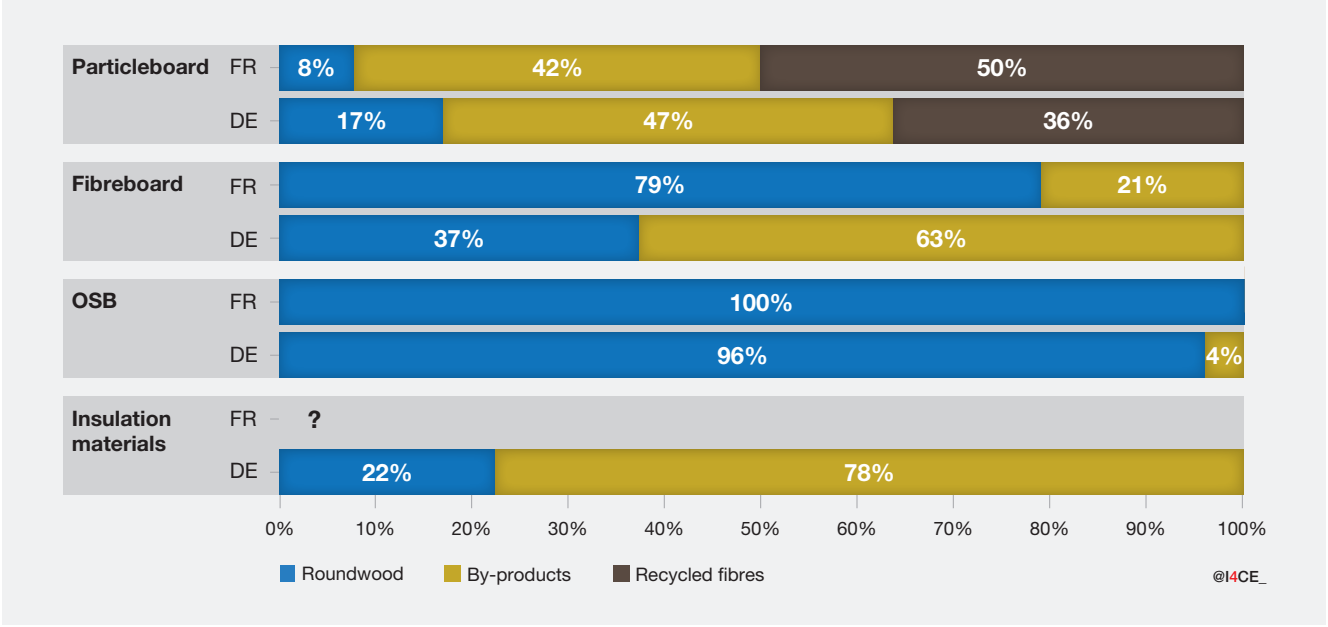
Resource types used in panel and insulation production: Germany uses more by-products

The materials used in the production of wood-based panels and insulation vary between the German and French sectors, depending on the product in question (**Figure 6**).

Particleboard uses a higher proportion of primary wood in Germany, particularly roundwood, the share of which (17%) is twice as high as in France, which compensates for this with a higher rate of recycled material incorporation. Regarding fibreboard, the German industry utilizes relatively little roundwood (37%), whereas French production relies mainly on this resource. For oriented strand board (OSB), the proportions are similar in both sectors. The comparison is less straightforward for insulation materials: there was limited data available on the proportions of raw materials used in the production of wood-based insulation in France. Only softwood roundwood is used for wood wool, and by-products may be used in the case of fibreboard insulation, although the proportions of roundwood and by-products in the total mix is not known (I4CE, 2022). In Germany, insulation production is mainly based on the processing of by-products, which account for almost 80% of the raw materials mix, compared to around 20% of softwood roundwood.

In Germany, bark and hardwoods are rarely used in panel and insulation production, as is also the case in France (I4CE, 2022).

Figure 6. Composition of pulpwood-based panels and insulation materials in France (2021) and in Germany (2020), (%)



Source France: (I4CE, 2022), based on a selection of manufacturer environmental product declarations (EPDs). Source Ger many: (Döring et al., 2021a).

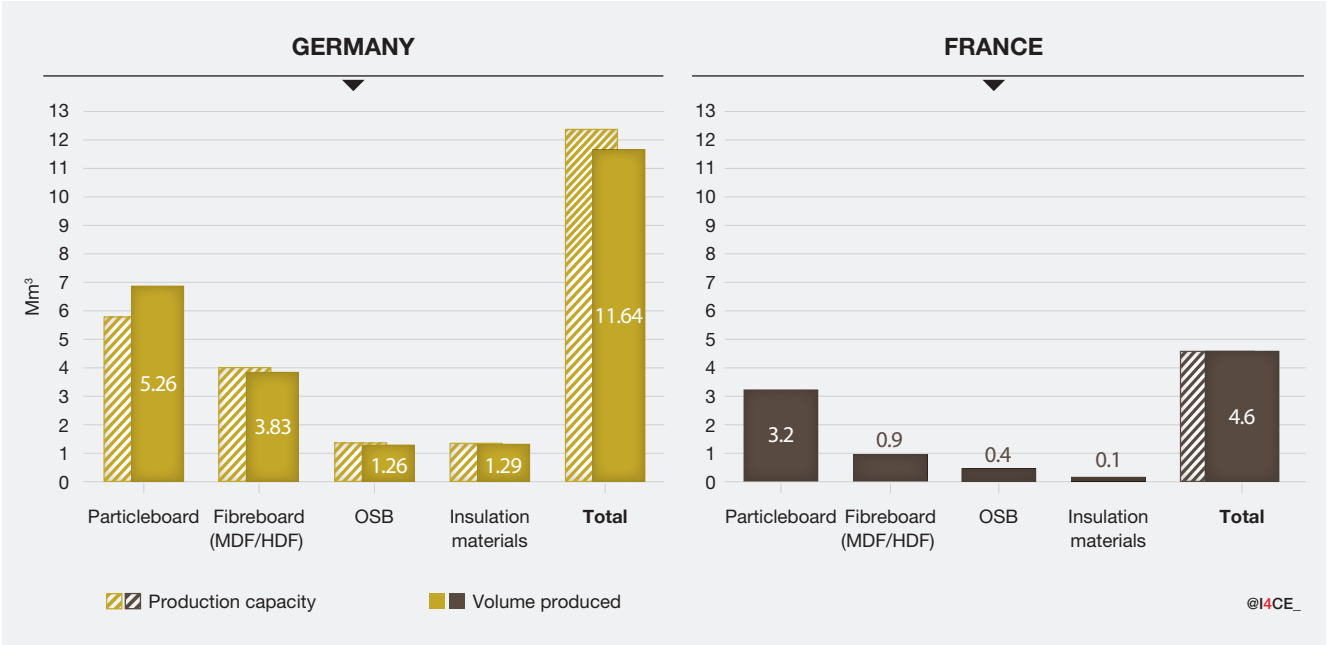
NB: More detailed data is available in Annex 1 **Table 6** and Annex 2 **Table 12**. Given that the respective data for each sector are not identical in nature, any comparison should be made with caution: the German data shown in **Table 6** correspond to the raw material flows used in the production of each product type, as declared by producers in a survey (Döring *et al.*, 2021a). As this level of detail is unavailable for France, the values given in **Table 12** are averages calculated from manufacturer declarations of the raw material mix used for their products.

Annual panel and insulation material production: twice as high in Germany

In 2020, German plants had the capacity to produce 12.3 Mm³, including 6 Mm³ of particleboard, 1.3 Mm³ of OSB, 4 Mm³ of medium density fibreboard (MDF) and high-density fibreboard (HDF), and 1.3 Mm³ of low-density fibreboard for insulation. In total, 94% of this production capacity was used (**Figure 7**).

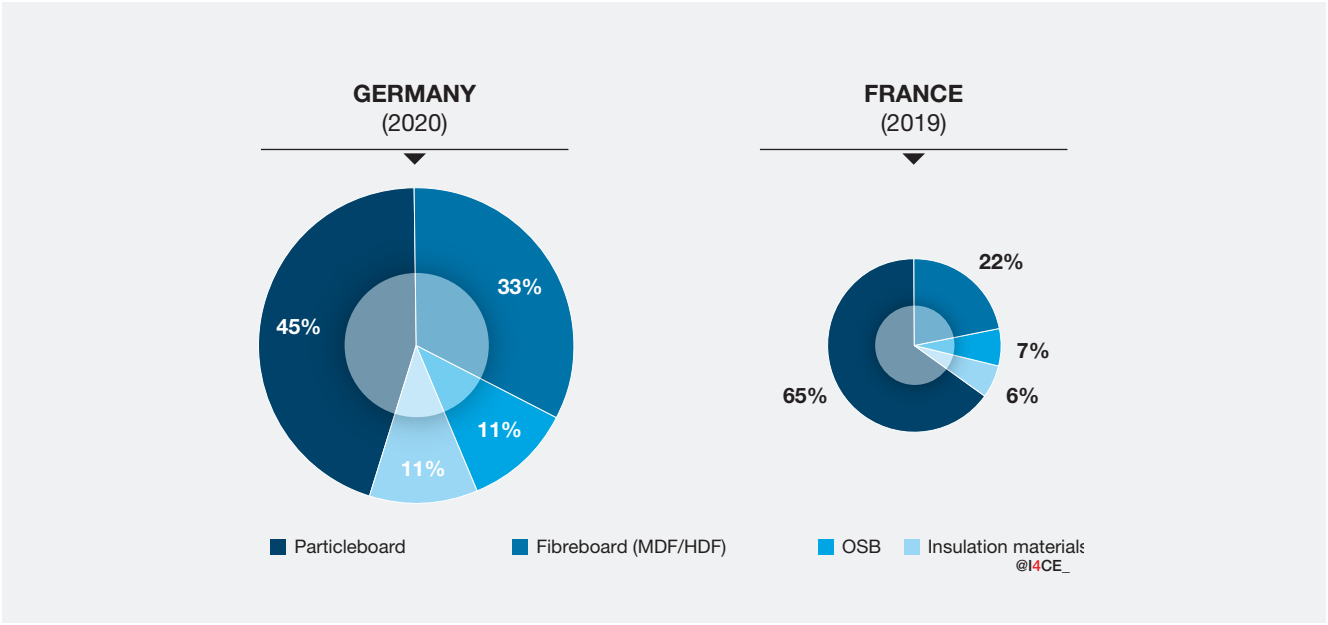
In 2019, France produced 4.6 Mm³ of panels and insulation materials, including 3.2 Mm³ of particleboard, 0.4 Mm³ of OSB, 0.9 Mm³ of MDF and HDF, and 0.1 Mm³ of insulation. According to the experts interviewed, the production capacity of the French panel industry (not including insulation producers) is also close to 100%; in the case of OSB in particular, production capacity should reach 0.5 Mm³ over the next few years.

Figure 7. Production volumes and capacity for panels and insulation materials in Germany (2020) and France (2019), (Mm³)



Sources: I4CE, based on (Döring et al., 2021a; FCBA, 2020)

Figure 8. Distribution of panel production in Germany (2020) and France (2019), (%)



Sources: I4CE, based on (Döring et al., 2021a; FCBA, 2020)

The German sector produces more than double the total volume of panels (including insulation materials) produced by the French sector. The difference is particularly marked in terms of insulation, for which Germany produces more than four times as much as France. Furthermore, the prices charged in France for certain insulating materials are 10 to 120% higher than those in Germany for comparable materials (**Table 3**). The greater production capacity of the German industry, and therefore its economies of scale, could at least partially explain the country's more competitive prices.

Table 3. Minimum and maximum prices (incl. VAT) for internal wall insulation (IWI) without additives, observed in Germany and in France in October 2022

	Thermal resistance	Average minimum price		Average maximum price	
GERMANY	m^2 K/W	€ TTC/m^2		€ TTC/m^2	
	1 ≤ R < 3	5.14		17.82	
	3 ≤ R ≤ 5	15.09		22.90	
	R > 5	17.19		25.18	
FRANCE	m^2 K/W	€ TTC/m^2	Δ Germany	€ TTC/m^2	Δ Germany
	1 ≤ R < 3	9.30	*+80%*	19.51	*+10%*
	3 ≤ R ≤ 5	17.45	*+20%*	32.30	*+40%*
	R > 5	30.66	*+80%*	54.43	*+120%*

Source: I4CE, based on observation of prices in October 2022 at selected German and French online stores specializing in building materials. Details on the calculation of this estimate can be found in **Annex 3**.

Finally, in terms of demand for these panels and insulation materials, Germany also outperforms France: on average, Germans use twice as many panels as the French population (**Table 4**). However, Germany exports almost half of its total panel production, mainly particleboard (32% of panel exports) and fibreboard (52%), over 70% of which is exported (Eurostat, 2023e). Panel imports by the German industry are also high, particularly particleboard (almost half of imported panels); the remaining imports are divided equally between OSB, fibreboard and insulation materials.

Table 4. Production, imports, exports and apparent consumption of panels and insulation materials in France and Germany in 2019 (Mm³)

	France	Germany
Production	4.5	12.3
Imports	0.6	4.2
Exports	0.9	5.6
Apparent consumption	4.3	10.9
Apparent consumption per capita (m³)	0.06	0.13

Source: I4CE, from (Eurostat, 2023e)

Energy use

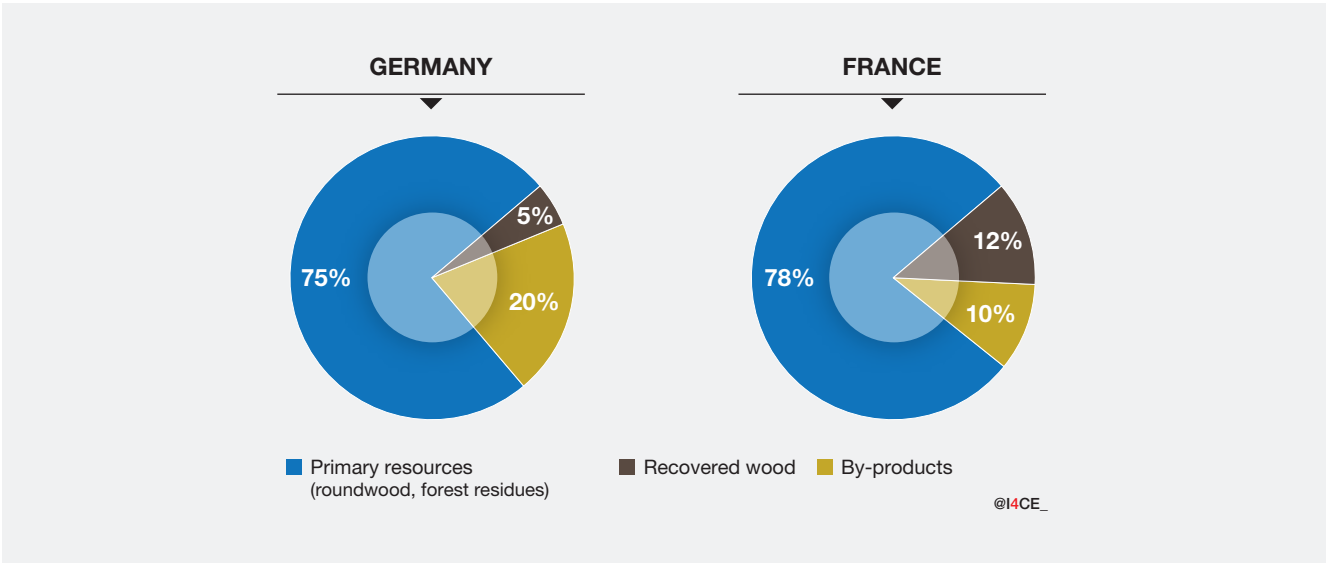
Residential sector

The German and French domestic wood heating markets are of the same order of magnitude, both in terms of the number of consumer households and the volumes of solid wood used: 6.6 million households used wood for heating in Germany in 2018, *i.e.* 18% of German households, which used 28.2 Mm³ swe (Döring *et al.*, 2020), compared with 6.8 million households in France in 2017, *i.e.* 24% of French households, which used 26 Mm³ swe (Ademe, Solagro, Biomasse Normandie, BVA, 2018).

The difference between the supply of wood to French and German households is small, particularly regarding the cascading use of wood principle. In both Germany and France, domestic wood heating is based mainly on roundwood logs (**Figure 9**). German households burn less hardwood than French households, in line with the abundance of softwood available; hardwood is nevertheless over-represented in the logs consumed in Germany (**Figure 10**). In France, it is difficult to influence the volumes harvested for domestic heating because the supply is dominated by self-supply (42% of logs, **Figure 11**). Self-supply is even more significant in Germany (62% of fuels) and, according to the experts interviewed, an added difficulty in Germany is trying to influence small forest owners, who are numerous and poorly organized.

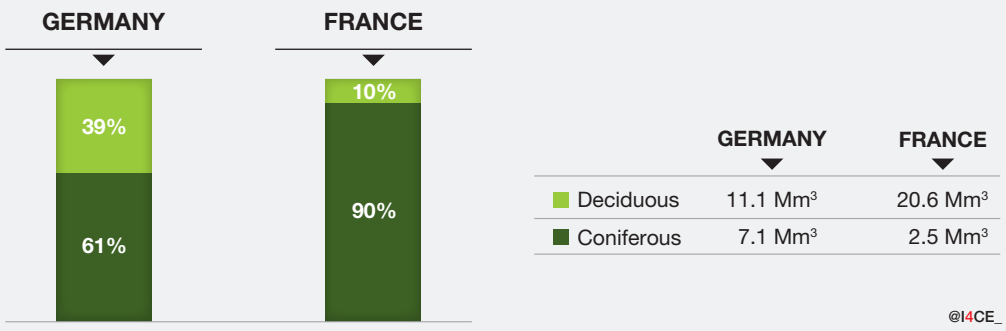
Given that we did not find any significant differences between German and French domestic heating sectors, we will not analyse this segment further.

Figure 9. Resource types used for domestic heating in Germany (2018) and France (2017), (%)



Sources – Germany: (Döring et al., 2020). France: (Ademe, Solagro, Biomasse Normandie, BVA, 2018)

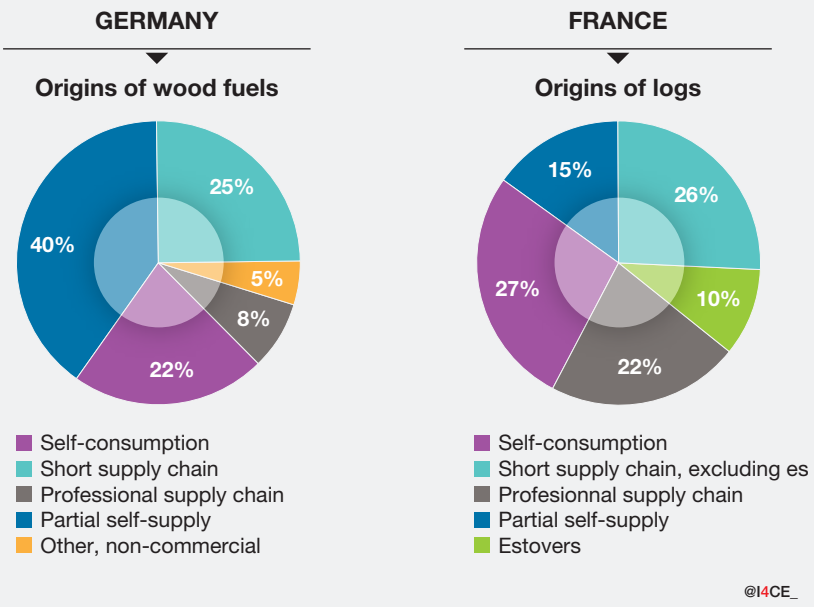
Figure 10. Species of logs used for domestic heating in Germany (2018) and France (2017), (Mm³, %)



Sources – Germany: (Döring et al., 2020). France: (Ademe, Solagro, Biomasse Normandie, BVA, 2018)

NB: German data relates only to forestry logs, while the data for France relates to logs regardless of origin (forestry, maintenance of green spaces, etc.).

Figure 11. Origins of logs in Germany (2018) and France (2017), (%)



*Sources – Germany: (Döring et al., 2020). France: (Ademe, Solagro, Biomasse Normandie, BVA, 2018). Definitions can be found in **Annex 3**.*

Non-residential sector

In Germany, the supply of materials for wood-based energy generation varies greatly depending on the size of the biomass plant. In the largest plants, recovered wood accounts for more than half of the supply, whereas it is a minority in the smallest plants (**Figure 12**). Large power plants are therefore not particularly dependent on roundwood or wood processing by-products, resources for which tensions can exist due to the requirements of the paper and wood panel industries. Smaller power stations are much more dependent on these resources: supplies are divided almost equally between roundwood, by-products, forest residue chips, and reconstituted fuels such as pellets and briquettes; given that the latter are in principle obtained from the processing of by-products, it can be assumed that the supply of power stations is particularly dependent on this resource.

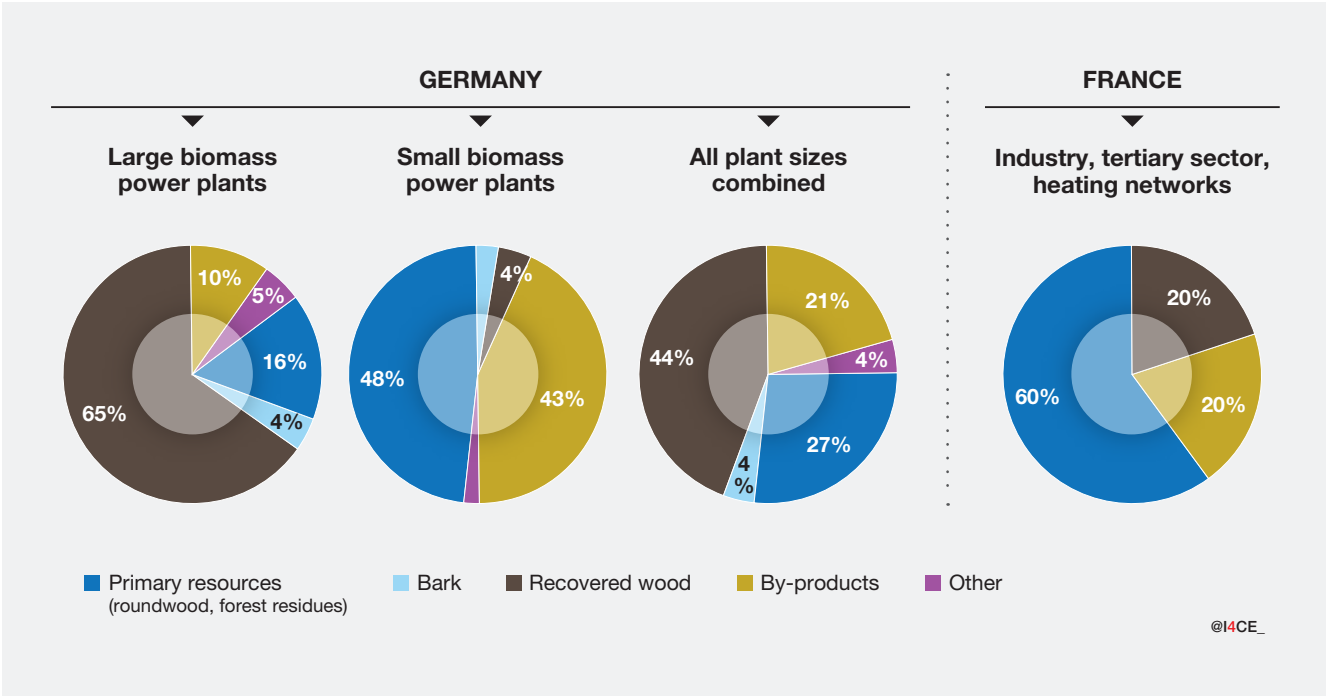
The available data on wood supplies to the non-residential sector are not as detailed for France. However, we can see that its composition is very different: forestry resources account for 60% of fuel in France, and the rest is equally divided between by-products and recycled wood.

Compared with the supply of total energy production for the German non-residential sector, French production seems less virtuous with regard to the principle of cascading resources, since the combustion of forest residue chips dominates, while the use of recycled wood is only at half this level. Some experts attribute this difference to the predominantly deciduous nature of forests in mainland France: small-diameter hardwood is harvested during forest maintenance and species such as oak can only be valorized for energy production. However, the experts interviewed also cited the boom in wood chips, which has come at the expense of their use by the panel industry, and has therefore been one of the factors behind the rise of the recycled wood incorporation rate for panels. Although more expensive to buy, fresh wood is still preferred by panel manufacturers because it is easier to work with and less expensive to process than recycled wood, the latter requiring a costly sorting procedure before use.

A third possible explanation could be the saturation of the recycled materials supply in France: at present, it seems difficult to increase the proportion of energy produced from recycled wood, since 80% of available wood waste is already recovered, half as energy and half as a material (Ademe, 2021b). It should be noted, however, that the forthcoming implementation of a new extended producer responsibility (EPR) scheme for construction products and materials in the building sector should increase the amount of recycled wood available.

The main explanation for the lower level of cascading in France is therefore difficult to determine, but is likely due either to the nature of the resource, the competition with energy production (wood chips), or saturation of the recycled materials supply.

Figure 12. Types of biomass consumed by the non-residential sector in Germany (2019) and France (2017), (%)



Sources (a, b, c): I4CE, based on (Döring et al., 2021b, 2021c).
Source (d): I4CE, based on estimates made by Ademe for its "Transition(s) 2050" scenarios.

2. FACTORS IN THE DEVELOPMENT OF THE GERMAN WOOD INDUSTRY

The review of wood uses in Germany identified two "best practices" that France could learn from to improve the proportion of the harvest dedicated to long-life wood products:

- in addition to the very large volumes of panels produced, the proportion of wood processing by-products used in their production is significant, particularly for fibreboard, which is currently produced from roundwood in France. The proportion of primary resources dedicated to panels is also higher. The German panel industry thus seems to have reached a sufficiently high level of development to be able to diversify its supply types and consequently to make greater use of a range of resources through panel production, enabling the avoidance of conflicts of use between panels, paper pulp and energy.
- the German wood-based insulation industry is more developed than its French counterpart: while volumes represent a relatively small proportion of total panel and insulation products, this total is more than ten times greater than in France.

The aim of this section is to determine how the German sector has reached its present configuration. To this end, we review the factors that may have contributed to its development: the historical and economic context, policies aimed at developing the sector and the industry, and the importance of the construction and furniture industries as outlets for the sector.

2.1. Factors in the development of the supply of wood products in the German sector

Suitable and abundant raw materials not only due to their resinous nature, but also to industrial and forest management decisions

Coniferous species predominate the German harvest (74 to 83% in 2019, see **Table 1**), with a very high volume (57 Mm³) which is almost three times greater than in France (Eurostat, 2023f). Softwood species are currently the most suitable for the market for a number of reasons, particularly given their ease of processing compared to hardwoods, and their compliance with international standards (I4CE, 2022). Most engineered products, both derived from timber (glued laminated timber, CLT, etc.) and from pulpwood (panels and insulation), are essentially produced from softwood resources (in the form of roundwood and by-products). The abundance of softwood logs is undeniably one of the strong points of the German industry.

This abundance also applies to wood processing by-products, and those of sawmilling in particular: given that the German industry produces large volumes of sawn wood, it follows that the volume of by-products is high, especially as canter saws are very common (CGAAER, 2014); these saws have a lower material yield than band saws, meaning that they generate more by-products, especially shavings (*i.e.* without the need for grinding to integrate them into the production chains of other industries). Furthermore, according to the experts questioned, some panel and paper manufacturers have secured their supplies of wood processing by-products by buying, or even building, sawmills close to their production sites.

Left to nature, German forests would consist mainly of beech. However, episodes of over-exploitation and very severe storms have resulted in several reforestations, which is why conifers now account for more than half of Germany's forest area. The reforestation after the Second World War was particularly influential in this regard, since it was dominated by the introduction of coniferous monocultures (German Ministry of Agriculture, 2015). According to the experts interviewed, subsequent reforestation in the wake of devastating storms was carried out using a mixture of species. A process of converting softwood stands has also been initiated more recently (German Ministry of Agriculture, 2015), while increasing the proportion of hardwoods in forests is part of Germany's long-term forestry strategy and receives public financial support (German Ministry of Agriculture, 2021a).

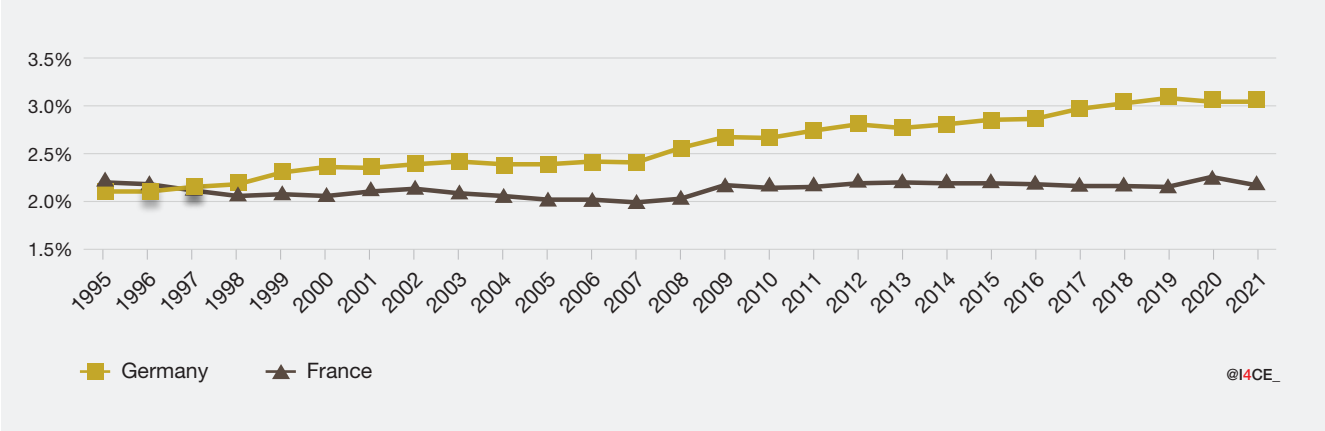
An industrial development context conducive to the wood industry

Strong industrial strategy

Compared with France, Germany has opted for an economic model - across all sectors - that relies much more on industry than it does on services. Industry has represented between 20 and 25% of German GDP on a stable basis since the 1990s, while it has fallen by 5 percentage points over the same period in France, stabilizing at around 12-13% of GDP since 2008 (Eurostat, 2023c). This divergence is the result of the political choices made by each country, which are resolutely focused on industrial development in Germany, notably with a higher proportion of R&D expenditure relative to GDP than France (**Figure 13**; Berger, 2012).

The German wood industry has therefore benefited from strong comprehensive industrial policies at the federal and regional levels, with objectives such as stepping up R&D, training (architects, bioenergy experts, etc.), discovery of new outlets (construction, chemicals, etc.), supply optimization, improving wood transport conditions, etc. (German Ministry of Agriculture, 2004, 2018). According to the experts interviewed, this policy has had a major impact on the industry, especially in states such as Bavaria that have been particularly supportive of this policy.

Figure 13. Gross domestic expenditure on R&D in Germany since 1995, as a percentage of GDP (%)



Source: (Eurostat, 2023b)

Reindustrialization of new states following German reunification

German reunification has had a major impact on economic activity in the five new states of former East Germany, including in the forestry and timber sector. Many wood processing companies in this region were closed down due to reasons of a lack of competitiveness, becoming obsolete, or a mismatch between supply and demand for certain products (Beer, 2004).

From the 1990s until the mid-2000s, to assist in this reindustrialization effort, federal and state governments and the European Union allocated substantial subsidies to support private sector investments. These subsidies were not confined to the wood industry, but nevertheless contributed to its development. In the state of Thuringia, for example, the combination of European subsidies[3] at a rate of 40% of the amounts invested, the state guarantee on bank loans, very low wages, and 10 or 15-year supply contracts, led to the installation of one of the largest hardwood sawmills in Germany today (CGAAER, 2014; Timber-Online, 2022).

Within just a few years, as a result of the massive investment of several billion euros, production in the sawn wood, panel and paper sectors has risen sharply. Regarding sawn wood, production was initially stimulated by demand from the construction sector, but this quickly shrank. Although sawn wood and panel production doubled over the period 1995-2002, this was mainly due to the strong growth in demand from the furniture industry for panels made from timber (plywood) and pulpwood (particleboard and fibreboard), which contributed to a sevenfold increase in production (Beer, 2004).

This renewal of the East German industrial landscape has left an impression on the sector's current structure. In terms of pulpwood panel production in particular, most plants currently operating in the former East German states were either constructed or purchased during this period by European companies (Portugal, Austria, Switzerland) and to a lesser extent by German companies from the former Federal Republic of West Germany. These plants now account for around 40% of Germany's panel and insulation production capacity.[4]

Vertical cooperation between wood industry actors

An essential factor to ensure continuous panel production is the security of supply, which can be undermined by conflicts over wood use. These conflicts have tended to increase in recent decades as a result of the rise in the use of wood for energy purposes, including in Germany (Hennenberg *et al.*, 2022). Compared with its French counterpart, the German sector stands out for having greater cooperation between the various sectoral actors, which enables the wood supply to be better aligned with the needs of manufacturers.

The German industry makes more use of supply contracts (CGAAER, 2014), which guarantee sufficient quality raw materials in the required quantities. In addition, the industry has so-called "integrated" production sites, where several levels of the value chain are combined on the same site (*e.g.* a sawmill and panel factory). This type of industrial organization is common: for example, sites that appeared during the period of strong industrial development in the

3 As part of the objectives adopted by the European Commission in 1988, aimed at the "development and structural adjustment of regions whose development is lagging behind" and the "development of rural areas" ("EU Cohesion Policy 1988–2008: Investing in Europe's future," 2008)
4 Authors' estimate based on (Döring *et al.*, 2021a).

former East German states were all organized along these lines, enabling savings on transaction and transport costs by combining roundwood orders and by-product recovery from sawmills directly by the associated panel factories (Bauer, 2006). Some operators also own forestry companies, which are responsible for managing their own roundwood supplies; this type of integrated production model also exists in France, but is perhaps less developed.

2.2. Factors in the development of wood product demand in the German sector

A national strategy to increase per capita wood consumption by 20% (2004)

In 2004, the German Ministry of Agriculture[5] published a strategic policy document, the Charter for Wood (Charta für Holz), with the aim of increasing wood production and consumption in Germany. It sets the target of increasing per capita wood consumption by 20%, including for energy purposes. According to the experts we interviewed, no specific policy measures were taken to achieve this target, but the Charter does contain a number of commitments aimed at encouraging consumers to opt for wood:

- redefining public procurement rules at all levels of the German administration to encourage the use of wood products in construction;
- eliminating regulatory obstacles to the use of wood in construction;
- organizing communication campaigns about wood and its applications.

Other strategic guidelines also target wood supply, particularly by strengthening cooperation between upstream and downstream parts of the sector (vertical cooperation), and between downstream actors at the same processing levels (horizontal cooperation).

While this objective and these measures are not exclusive to long-life uses of wood, it is likely that they have contributed to the growth dynamic of the German wood industry.

Building regulations and incentives for renewable energies: a possible springboard for both fuelwood and material use

Since the end of the 1990s, the German federal government has introduced a number of measures to reduce carbon emissions from the building and energy sectors, while aiming to phase out nuclear power.

A programme to encourage the production of heat from renewable energy[6] and, in particular, the German Renewable Energy Sources Act (EEG[7]), have strongly encouraged the use of renewables by subsidizing the replacement of fossil fuel heating systems with renewable energy heating systems (including wood biomass), as well as the kilowatt-hours produced by renewables. The EEG has especially contributed to the growth in wood use as an energy source for electricity production (Hennenberg *et al.*, 2022).

Furthermore, building regulations to encourage energy efficiency may have had a positive effect on wood consumption by the construction sector due to the thermal insulation properties of wood, which give it a market advantage. However, according to one expert consulted, regulatory hurdles remain a major obstacle in this regard.

Existence of a strong furniture industry, a factor in local panel sector development

As panel production is continuous (I4CE, 2022), the industry needs sufficient outlets to avoid stock bottlenecks, which would lead to production slowdowns or stoppages. In Germany, the furniture sector is one of the main panel outlets; in 2007, 70% of the particleboard produced (*i.e.* 6.5 Mm³) was used in furniture manufacture (Wenker and Rüter, 2015). According to the experts interviewed, the presence of a strong furniture industry in the German states to the north of Italy, in northern Italy itself, as well as in North Rhine-Westphalia, may explain the local development of the panel industry. Indeed, over the period 1995-2007, these German states had numbers of companies and employees in the furniture manufacturing sector that were around three times higher than the national average (Eurostat, 2015). Baden-Württemberg currently has only one particleboard factory, which has a relatively small production capacity (around 400,000 m³), while Bavaria and North Rhine-Westphalia in particular now account for the majority of German particleboard production: a production capacity that amounts to more than 4 Mm³ including MDF/HDF fibreboard (Döring *et al.*, 2021a).

In the former East German states especially, the panel industry (including veneer and plywood, which are produced from timber) has also shown a significant production increase, mainly supplying the furniture sector: its production increased sevenfold between 1995 and 2002 (Beer, 2004).

5 Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft: Federal Ministry of Consumer Protection, Food and Agriculture.
6 Marktanreizprogramm zur Förderung Erneuerbarer Energien (MAP). This programme ran from 1999 to 2021, before being replaced by the Federal Financing Fund for Efficient Buildings (Bundesförderung effiziente Gebaüde – BEG).
7 Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz – EEG).

Today, the German furniture industry is one of the largest in Europe. In 2019, the German wood furniture market[8,9] generated more than €11 billion, making it the European market leader (Eurostat, 2023a). This figure is four times greater than that of its French counterpart, and may at least partially explain why per capita panel consumption is lower in France.

Strong support for the bio-based insulation market (2003-2007)

In the early 2000s, the German federal government decided to support the development of the market for insulating materials made from renewable raw materials. In 2002, bio-based insulation was not particularly competitive compared to "traditional" options (*i.e.* insulation based on mineral and petrochemical products, such as glass wool, polystyrene, etc.): the extra cost per m3 could be as much as €55 to €88 depending on the product type;[10] bio-based insulation materials had a low market share (around 4% of the total volume of the insulation materials market); and only a limited volume was produced annually (65,000 m³).

Thus, between 2003 and 2007, the German Agency for Renewable Raw Materials (Fachagentur Nachwachsende Rohstoffe e.V., FNR) distributed between €24 and €27 million in public funds in the form of direct grants to final consumers (private individuals and companies that rent, own or develop buildings) to partially offset the extra cost of choosing bio-based materials (generally up to a maximum of 50% of the additional cost).[10,11,12] The aim was to support the industry in its efforts to produce and sell 200,000 m³ of bio-based insulation annually, thereby enabling "manufacturers to achieve economies of scale, [which] should help to reduce [their] costs in the long term [...] and thus improve their profitability".[10,13]

As this measure qualified as State aid,[14] it had to be submitted to the European Commission for approval. The Commission gave its approval, which was particularly based on the German government's arguments about the "environmental benefits" of an increased use of bio-based insulation materials, namely:

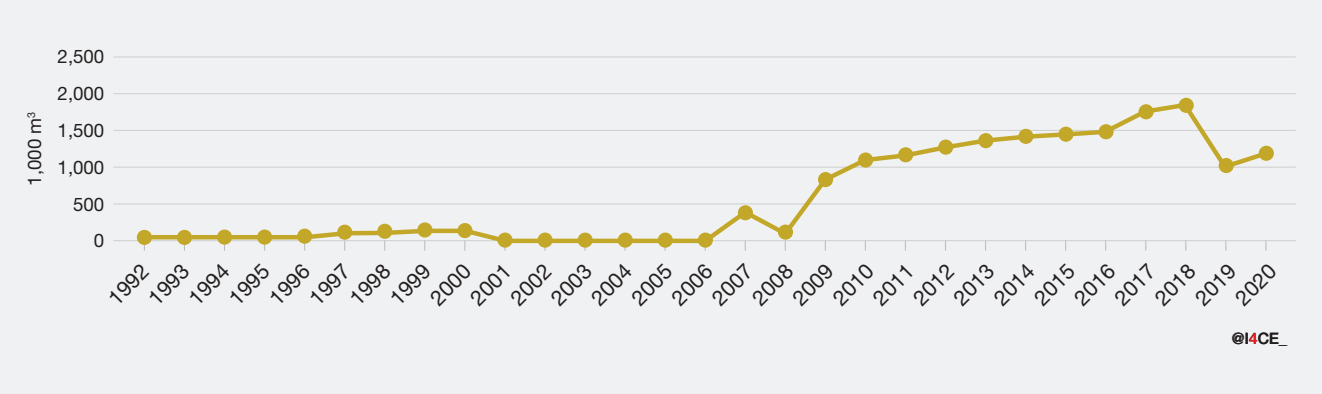
- conservation of non-renewable natural resources (*e.g.* sand, volcanic rock),
- climate protection, as bio-based materials have a much lower carbon footprint than mineral and petrochemical insulation materials.

Although wood was not mentioned as one of the renewable raw materials covered by the measure, the first version of the Wood Charter (2004) indicates that it was one of the raw materials targeted. There has also been a recovery in the production (**Figure 15**) and apparent domestic consumption (**Figure 14**) of wood-based insulation since 2006-2007.

In 2020 the market share of bio-based insulation reached 5% (FNR, 2021). This very modest growth from its 2002 level can be explained by the development of the insulation market: considering all types of insulation combined, the market volume has increased by 50% (FNR, 2021; Sprengard *et al.*, 2013). An analysis of the volumes consumed gives a more accurate picture of the progress achieved: in 2020, 3.5 Mm³ of bio-based insulation materials were sold on the German market (FNR, 2021). This represents a fifty-fold increase on the volume consumed in 2002.

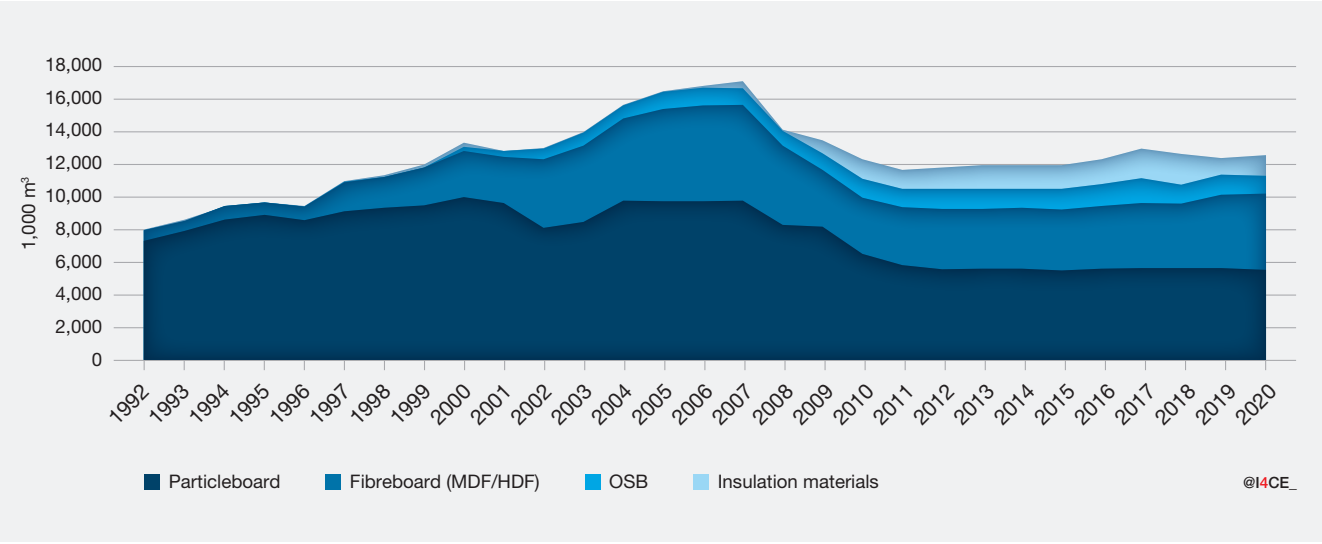
8 Excluding chairs.
9 All types of wood: sawn wood, plywood, particleboard …
10 Commission Decision C (2003) 1473 final, SA.14377 of 9 July 2003 concerning State aid (No 694/2002) paid by the German Federal Government to promote the use of insulating materials from renewable raw materials, OJEU C/197/2003, 21 August 2003, p11. Press release IP/03/970 of 9 July 2003.
11 Commission Decision C (2005) 379, SA.18716 of 12 January 2005 concerning the prolongation of the above-mentioned State aid, OJEU C/136/2005, 3 June 2005, p46.
12 Commission Decision K (2007) 447, SA.21864 of 7 February 2007 concerning the prolongation of the above-mentioned State aid, OJEU C/62/2007, 16 March 2003, p4.
13 Translation of an extract from the referenced decision, available in German only.
14 According to Article 107(1) TFEU (formerly Article 87 TEC): aid granted by a Member State of the European Union which affects Community trade and competition by favouring certain undertakings or the production of certain goods.

Figure 14. Apparent consumption of wood-based insulation in Germany from 199 to 2020 (1,000 m³)



Source: (Eurostat, 2023e)

Figure 15. Production of wood-based panels and insulation in Germany from 1992 to 2020 (1,000 m³)



Source: I4CE, based on (Eurostat, 2023e; FAOSTAT, 2023)

Example of a local initiative to develop wood construction: Bavaria (2022-2024)

German states have more powers than French administrative regions. In particular, a state can go beyond federal standards and implement measures that apply only within its own territory. This is the case for Bavaria, which established a programme to promote timber construction (BayFHolz), coming into force in June 2022 until the end of 2024 (Bavarian Ministerial Gazette, 2022).

The programme provides a limited amount of financial support[15] in the form of grants of €500 per tonne of carbon stored in wood products; €25,000 to €200,000 can be allocated per construction project. New buildings and extensions to local authority buildings (*e.g.* offices, schools, etc.) as well as residential buildings and extensions are eligible for support,[16] provided that some structural elements of the buildings are made of wood (solid or composite). Bio-based insulation materials are also eligible.

The calculation of tonnes of carbon stored is based on data from ÖKOBAUDAT, a similar system to the French INIES database, which lists life cycle analyses of a large number of construction materials, from the extraction of raw materials to a product's end of life, calculated in accordance with the same standard as used by the INIES database (EN 15804).

Since this measure has only recently been implemented, it is not yet possible to assess its effectiveness in terms of the development of timber construction in Bavaria. However, it is notable in that its eligibility is restricted to wood products, which makes them more competitive than substitutes (plaster, concrete, mineral insulation, etc.).

15 State aid of up to €200,000 does not require approval from the European Commission, in accordance with Community law.
16 Minimum surface areas must be met for the project to be eligible.

3. CONCLUSIONS AND LESSONS FOR FRANCE

The aim of this study of the German wood industry was to identify practices that optimize timber use and/or that lead to the allocation of low-quality and small-diameter roundwood, as well as secondary resources (by-products, recovered wood), primarily to the production of panels and insulation, both of which could increase the proportion of the wood harvest dedicated to products with a long lifespan (I4CE, 2022).

Regarding timber, the German industry mainly makes use of coniferous wood, and although deciduous trees are also harvested, they are mainly used for energy purposes. The French sector appears to be more advanced in terms of the possible uses of hardwoods, with several engineered hardwood products already being marketed. The extension of timber qualification criteria to smaller diameter, lower quality wood could become a reality if the research projects currently underway produce conclusive results. For the moment, however, the smallest diameters are used as pulpwood and fuelwood, or damaged wood is used as timber where possible, as in France.

In terms of pulpwood, the German wood sector has a number of positives compared to its French counterpart in several respects. The panel and insulation sectors are much more developed than in France, both in terms of supply and demand. Germany undeniably has an advantage, with a very large availability of coniferous resources, both in the form of roundwood and as by-products generated by German sawmills. However, the development of these sectors has also been achieved through the implementation of proactive policies and specific industrial organization.

Policies dating back to the 1990s and 2000s are partly responsible for Germany's current production levels. The most ambitious of these policies were focused on the use of wood as a raw material, with major subsidies to encourage industries to develop and improve the competitiveness of bio-based insulation materials by temporarily covering a proportion of the additional costs compared to traditional insulation materials. As a result, a large number of panel production sites have been established in the region, and wood insulation production and consumption has increased.

The development of the panel industry has also been facilitated by the large number of outlets in the German furniture sector, the presence of outlets being vital for panel factories because of their production method, which requires rapid sales of the volumes produced. Finally, by adopting a cooperative approach, some panel production sites and sawmills have been able to solve the conflicts of use issues that can occur over sawmill by-products. However, while this type of organization was possible in the former East Germany, at a time when the country was being restructured, it may be more difficult to replicate in an existing industrial fabric. This does not, however, reduce the benefit of searching for synergies between sawmills and panel factories. Such synergies could take a different form, that is potentially less capital-intensive and more easily attainable, for example by developing cooperation on roundwood orders and by-product recovery among existing sawmills and panel factories that are geographically close but belong to different entities.

Regarding energy production from wood, the domestic wood heating market in Germany is broadly similar to its French counterpart in terms of the number of households using wood and the volumes and types of wood consumed. However, when it comes to collective and non-residential use, the German energy sector stands out positively in terms of the hierarchy of uses, exploiting more secondary resources than forest resources. Conversely, in France, the panel industry has had to adapt to an energy sector that mainly draws on forest resources, by incorporating increasing amounts of recycled wood into its production. Transposing the supply structure of the German sector to the French sector would involve major industrial transformations, with the aim of increasing the proportion of by-products and recycled wood used for energy purposes. This would require substantial investment in the energy sector,[17] while the panel industry has already invested heavily in wood sorting systems. Another part of the solution would be to make the panel/insulation market relatively more attractive than the energy market. It should be noted, however, that the valorization of the additional volumes of recycled wood that will be generated by the new EPR for construction waste could also put the issue of these investments on the agenda to increase the proportion of recycled wood in the energy sector.

17 It would only be possible to redirect a proportion of wood waste towards the energy sector if investments were made in filtration systems adapted to the different classes of waste.

LIST OF GRAPHS AND TABLES

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ANNEX 1.
ADDITIONAL DATA ON GERMANY

Table 5. Consumption of wood raw materials in Germany for the production of paper pulp (2019) and panels and insulation (2020) in volume (Mm³ solid wood equivalent) and as a percentage by type of resource (%)

	Panels	Paper	Total	% Panels	% Paper
Roundwood	5.14	5.71	10.85	47%	53%
- Roundwood – hardwood	*0.59*	*0.67*	*1.26*	*47%*	*53%*
- Roundwood – softwood	*4.54*	*5.04*	*9.59*	*47%*	*53%*
Wood processing by-products	8.16	3.78	11.94	68%	32%
Recycled materials (excluding paper)	2.47	0	2.47	100%	0%
Total	**15.77**	**9.49**	**25.26**	**62%**	**38%**

Sources: (Döring et al., 2021a; Gieseking et al., 2021)

NB: the volumes shown include imports. The average import rate for resources used in the production of panels and insulation is around 7%.

Table 6. Consumption of raw materials for the production of wood-based panels and insulation (Mm³ solid wood equivalent) and proportion of each type of resource in the supply of each product (%), in Germany in 2020

	Particleboard		Fibreboard		OSB		Insulation		Total
	Mm³ swe	%	Mm³ swe	%	Mm³ swe	%	Mm³ swe	%	Mm³ swe
Roundwood	1.07	16 %	2.34	36 %	1.56	95 %	0.17	22 %	5.14
- hardwood	*0.21*	*3 %*	*0.32*	*5 %*	*0.06*	*4 %*	*0*	*0 %*	*0.59*
- softwood	*0.85*	*12 %*	*2.02*	*31 %*	*1.50*	*91 %*	*0.17*	*22 %*	*4.54*
Bark	0.09	1 %	0.09	1 %	0.02	1 %	0	0 %	0.21
By-products	3.20	47%	4.08	63%	0.06	4%	0.60	78%	7.95
- Wood processing by-products	*2.82*	*41%*	*4.05*	*62%*	*0.06*	*4%*	*0.57*	*74%*	*7.50*
- Other by-products	*0.39*	*6%*	*0.04*	*1%*	*0.00*	*0%*	*0.03*	*3%*	*0.45*
Recycled materials	2.47	36 %	0	0 %	0	0 %	0	0 %	2.47
Total	**6.84**	**100 %**	**6.51**	**100 %**	**1.64**	**100 %**	**0.77**	**100%**	**15.77**

Source: (Döring et al., 2021a)

Table 7. Production capacity of panels, utilization rate and actual production in Germany in 2020 (Mm³, %)

	Production capacity	Volume produced	Utilization rate
Particleboard	5.78	5.26	91 %
OSB	1.30	1.26	97.4 %
Fibreboard (MDF/HDF)	3.97	3.83	96.5 %
Insulation materials	1.29	1.29	100 %
Total	**12.34**	**11.64**	**94.4 %**

Source: (Döring et al., 2021a)

Table 8. Wood consumption per fuel for domestic heating in Germany in 2018 (Mm³, %)

Type of fuel	Mm³	%
Roundwood	20.9	74%
- From forests	*18.2*	*64%*
- From landscape maintenance and non-forest areas	*2.7*	*10%*
Forest residues	0.2	1%
Recycled wood	1.4	5%
By-products	2.2	8%
Pellets and briquettes	3.5	12%
Total	**28.2**	**100%**

Source: (Döring et al., 2020)

Table 9. Wood consumption per fuel by large-scale biomass power plants (output > 1 MW) in Germany in 2019 (Mm³, %)

Type of fuel	Mm³	%
Roundwood	1.7	10%
From fast-growing forests and plantations	*0.4*	*3%*
Material from landscape maintenance	*1.2*	*7%*
Forest residues	1.7	10%
- Including bark	*0.7*	*4%*
Recycled wood	10.7	64%
By-products	1.5	9%
Pellets and briquettes	0.2	1%
Other	0.8	5%
Total	**16.5**	**100%**

Source: (Döring et al., 2021c)

Table 10. Wood consumption per fuel by small biomass power plants (output < 1 MW) in Germany in 2019 (Mm³, %)

Type of fuel	Mm³	%
Roundwood	2.1	26%
- From fast-growing forests and plantations	*1.4*	*17%*
- Material from landscape maintenance	*0.7*	*9%*
Forest residues	2.1	25%
- Including bark	*0.3*	*3%*
Recycled wood	0.3	4%
By-products	1.8	22%
Pellets and briquettes	1.7	21%
Other	0.2	2%
Total	**8.2**	**100%**

Source: (Döring et al., 2021b)

ANNEX 2.
ADDITIONAL DATA ON FRANCE

Table 11. Consumption of wood raw materials in France for the production of paper pulp, and panels and insulation materials in 2019 in volume (Mm³ solid wood equivalent) and percentage by type of resource (%)

	Panels	Paper	Total	% Panels	% Paper
Roundwood	2.73	4.80	7.53	36%	64%
- Roundwood – hardwood	*1.15*	*1.42*	*2.57*	*45%*	*55%*
- Roundwood – softwood	*1.58*	*3.49*	*5.07*	*31%*	*69%*
Wood processing by-products	2.35	2.11	4.45	53%	47%
Recycled materials (excluding paper)	1.04	0	1.04	100%	0%
Total	**6.11**	**7.01**	**13.31**	**47%**	**53%**

Source: I4CE, based on data from (FCBA, 2020), converted into cubic metres using conversion rates for France (FAO, ITTO and United Nations, 2020).

Table 12. Estimate of the share of each type of resource in the supply of the production of wood-based panels and insulation materials in France in 2021 (%)

	Particleboard	Fibreboard	OSB	Insulation	
	%	%	%	Wood wool	Wood fibre
Roundwood	8%	79%	100%	100%	?
By-products	42%	21%	0%	0%	?
Recycled materials	50%	0%	0%	0%	?
Total	**100**	**100**	**100**	**100**	**?**

Source: (I4CE, 2022), based on a selection of environmental product declarations (EPDs) from manufacturers.

NB: In the coming years there could be a change in the incorporation rate of recycled materials in fibreboard and OSB production. Wood fibre insulation can incorporate all types of raw materials (I4CE, 2022), but the breakdown is not known. The exact consumption of raw materials, per product, is not available.

Table 13. Consumption of wood fuels for domestic heating in France in 2017 (Mm³, %)

Wood type	Mm³	%
Logs (from roundwood)	19.8	78%
- From forests	*14.8*	*58%*
- From maintenance of orchards, green spaces or hedges	*5*	*20%*
Recycled wood	3	12%
Forest residue chips	0.07	0%
Reconstituted wood fuels (pellets, logs, etc.)	2.6	10%
Total	**25.5**	**100%**

Source: (Ademe, Solagro, Biomasse Normandie, BVA, 2018)

Table 14. Origin of logs for domestic wood heating in France in 2017 (Mm³, %)

Origin	Mm³	%
Self-supply	9.7	42%
- Self-consumption	*6.3*	*27%*
- Partial self-supply	*3.4*	*15%*
Short supply chains	8.2	35%
- Short supply chains, excluding estovers	*6*	*26%*
- Estovers	*2.2*	*10%*
Professional supply chains	5.2	23%
Total	**23.1**	**100%**

Source: (Ademe, Solagro, Biomasse Normandie, BVA, 2018)

NB: The difference of around 3 Mm³ compared with the logs recorded in **Table 2** corresponds to logs obtained from recycled wood, which we have separated from other log types.

ANNEX 3.
DEFINITIONS AND METHODOLOGICAL DETAILS

Definitions of household firewood supply channels according to (Ademe, Solagro, Biomasse Normandie, BVA, 2018) :

- Self-supply:
  - self-consumption: the user does not pay for the wood and harvests it from their own property or that of an acquaintance (friend/neighbour) or the local authority.
  - partial self-supply: the user pays for some of the wood, which comes from their own property or that of an acquaintance (friend/neighbour) or the local authority.
- Short supply chain:
  - short supply chain excluding estovers: the wood comes from a private individual/forest owner or farmer.
  - estovers: the user obtains their supplies from communal or sectional forests covered by forestry regulations. […]
- Professional supply chains: the user relies on a specialized firewood merchant for fuel other than logs (pellets, chips, etc.).

Estimated prices for insulation materials in Table 1

This estimate was based on the products available on 13 October 2022 on the websites of DIY superstores in Germany (3 shortlisted, 2 selected) and building merchants in France (3 DIY superstores shortlisted, 2 selected; 4 building merchants shortlisted, 2 selected). In total, the prices of 12 products were used to calculate average German prices, and 30 products to calculate average French prices.

ROMANIA

Romania was selected because of the high proportion of hardwoods harvested, and the high level of valorization it achieves with this type of resources (**Table 1**).

CONTENTS

Table 1. Overview of forest-based industries in France and Romania in 2019

	Unité	Romania	France
		Eurostat	
Total surface area	Mha	**7.0**	**17.3**
Net increase	Mm^3 over bark	**51.5**	**102.3**
Removal rate	%	**32%**	**67%**
Ownership type	%		
Public ownership	%	66%	25%
Private ownership	%	34%	75%
Surface area of production forests	Mha	**5.3**	**16.4**
Proportion of production forests out of total area	%	**77%**	**95%**
Standing volume	Mm^3 over bark	**1,821.6**	**3,065.3**

		National statistics	Eurostat		IGN-FCBA (2016)
Harvested volumes	Mm^3 over bark	**15.9**	**15.8**	**49.7**	**48.2**
Deciduous species		60%	66%	61%	58%
Oaks	%	*10%*	*NC*	*NC*	*22%*
Beech	%	*32%*	*NC*	*NC*	*10%*
Other hardwoods	%	*18%*	*NC*	*NC*	*26%*
Coniferous species	%	40%	34%	39%	42%
Spruce, fir, douglas fir, and other softwoods	%	*NC*	*NC*	*NC*	*27%*
Pines	%	*NC*	*NC*	*NC*	*15%*
Type of use		Eurostat			
Timber	%	*52%*		*34%*	
Pulpwood	%	*13%*		*17%*	
Fuelwood	%	*36%*		*49%*	
Sawnwood production	Mm^3	**5.2**		**7.8**	
Panel production (excluding plywood)		**3.5**		**4.7**	
Paper pulp production	Mt	**0.0**		**1.6**	

Source: I4CE, based on (Eurostat, 2023a, 2023c, 2023e, 2023f, 2023g; IGN and FCBA, 2016; Romanian Ministry of the Environment, 2020). French removal rate based on (IGN, 2022).

1. OVERVIEW OF WOOD USES IN ROMANIA

With the aim of identifying which segments of the Romanian wood industry are allocated to long-life uses, we drew up an inventory of the types and volumes of resources exploited and their uses.

Analysing the Romanian forestry-timber sector is made more difficult by the limited availability of harvesting and processing data. While forest harvesting data does exist, there are discrepancies between the official harvest figures, recorded in the national statistics, and the harvest estimated by national forest inventories. As for the uses of harvested wood, it is possible to quantify the flow of wood materials to the main applications (timber, pulpwood, fuelwood), but too much data is missing to identify the flows to all processing sectors (*e.g.* flows of by-products to panel production), and thus to the final consumption sectors (*e.g.* construction, furniture).

To make up for this lack of data, interviews were conducted with stakeholders in the Romanian industry. Unless otherwise stated, the information provided below is based on the comments of these experts.

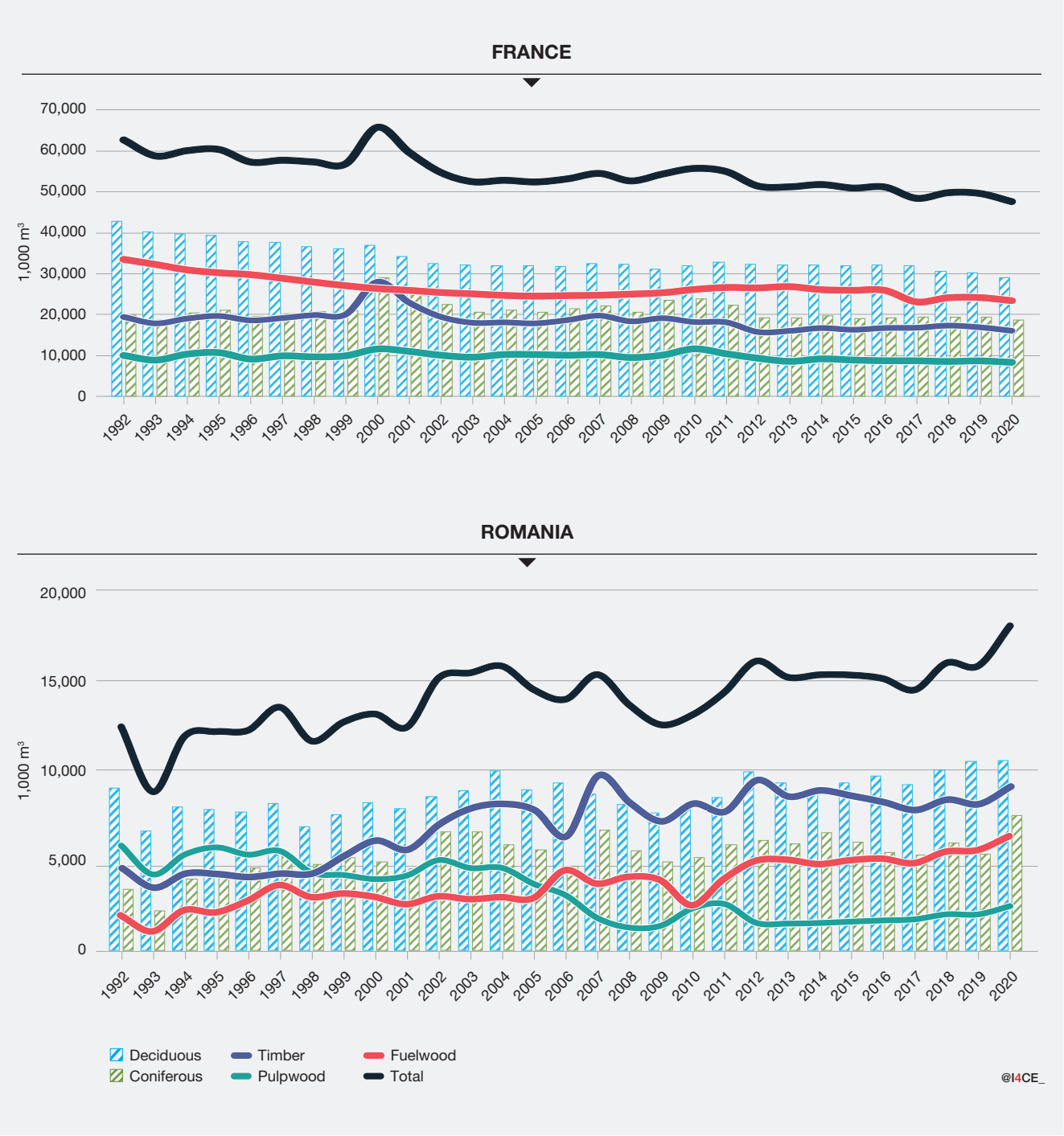
1.1. Overview of the French and Romanian harvests

France harvests much more wood than Romania: in 2019, according to Eurostat, it harvested three times more roundwood (50 Mm³; **Figure 1**) than Romania (16 Mm³). Therefore, while making comparisons between absolute harvest volumes is not particularly useful, it is much more interesting to analyse the changes in the distribution of harvests among the different uses.

Over the last thirty years, the proportions of timber, pulpwood and fuelwood have varied very little in France: fuelwood has always dominated material uses (timber and pulpwood), with the exception of the year 2000 when timber rose to the level of fuelwood due to the severe storms at the end of 1999. While in Romania, although the harvest distribution has often fluctuated, since 2005 the harvest has been dominated primarily by timber, followed by fuelwood, according to the Eurostat data.

In terms of species, the harvest is predominantly hardwood in both countries, although in France the harvest of hardwoods fell by 30% between 1992 and 2020 (43 Mm³ harvested in 1992 compared with 29 Mm³ in 2020).

Figure 1. Wood harvest in France and Romania from 1992 to 2020 (1,000 m³)



Source: (Eurostat, 2023c)

As shown in **Table 2**, neither country exports much roundwood: in 2019, 9% of the total French harvest was exported, compared with 1% for Romania.[18] Almost equal amounts of hardwood and softwood are exported from France, while Romania exports mainly hardwood. In both France and Romania, softwoods account for the bulk of imported volumes (Eurostat, 2023d).

18 Since 2020, Romania has banned the export of logs outside the European Union for at least ten years.

Table 2. Production, imports, exports and apparent consumption of roundwood in France and Romania in 2019 (Mm³)

	Romania	France
Production	15.8	49.7
Import	1.2	1.4
Export	0.2	4.3
Apparent consumption	16.8	46.8

Source: I4CE, based on (Eurostat, 2023d)

Unreported harvest and its likely uses

In Romania, a certain amount of harvested wood is not officially declared. According to the National Forest Inventory (NFI), average annual harvests over the period 2013-2018 amounted to 38.6 Mm³ – which would put Romania around ten million cubic metres behind France – while the volumes harvested according to forest utilization national statistics were only 19.5 Mm³ in 2018 (INS, 2021). Estimates of actual wood use in Romania also reveal a gap of around 20 Mm³ swe between the total available wood supply[19] and the needs of Romanian industry and households (JRC, 2021; Panaite and Bouriaud, 2020). A lack of data transparency means that it is impossible to make more accurate assessments of the actual apparent roundwood consumption or the amount of wood harvested illegally. Several experts interviewed believed that the discrepancy between the NFI and INS data does not reflect the actual amount of illegal felling, which they believe to be less; one expert estimated that between 10 to 15 Mm³ of wood is illegally felled each year. It is possible that a proportion of the identified 20 Mm³ gap could be due to methodological differences in the two datasets (Baban *et al.*, 2021; Popa *et al.*, 2020).

All experts questioned on this subject agreed that these undeclared volumes are mainly used to heat rural households. An estimate of fuelwood supply and demand is in line with this view, with supply estimated to be at least 20 to 30% lower than demand for fuelwood (Popa, *et al.*, 2020). According to the experts interviewed, a small percentage of the illegal supply of timber may also be going into industrial processing, but this proportion is limited due to administrative formalities designed to ensure timber product traceability, along with the national computerized timber tracking information system, SUMAL 2.0.

Similarly, not all wood harvested from French forests is declared. The gap between the harvest declared in the national statistics and NFI's forest harvest figures was around 10 Mm³ per year over the period 2011-2015 (IGN and FCBA, 2016). This discrepancy is mainly attributed to household firewood self-consumption, *i.e.* using free wood from one's own forest, or from a forest of an acquaintance (in the absence of an official commercial intermediary).

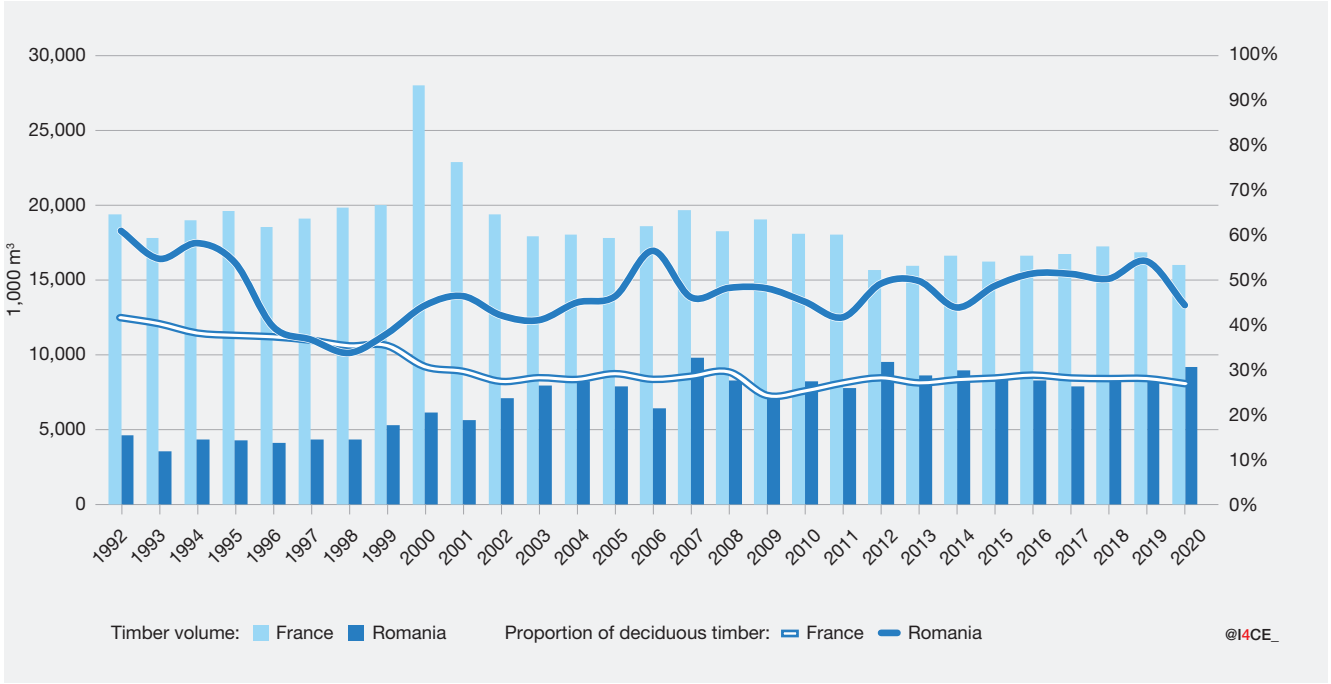
1.2. Timber

The French timber harvest was around 15 to 20 Mm³ per year over the period 1992-2020, and the trend is downwards: timber harvesting fell by 17% between 1992 and 2020. In contrast, in Romania, the timber harvest almost doubled over the same period (4.6 Mm³ in 1992 and 9.2 Mm³ in 2020).

The proportion of hardwood in the Romanian timber harvest fluctuates, but since the 2000s it has accounted for almost half. Beech occupies an important place, accounting for two-thirds of hardwood timber (**Table 3**). National statistics do not detail the softwood species harvested, but it is probably mainly Norway spruce, since this is the main coniferous species found in Romanian forests[20] (Romanian Ministry of the Environment, 2020). In France, the hardwood share of the timber harvest remains relatively similar from one year to the next, but it is dropping steadily, accounting for 27% in 2020 compared to 41% in 1992 (**Figure 2**).

19 This means taking import and export flows into account, as well as secondary resources such as wood processing by-products.
20 Norway spruce accounts for 19% of Romania's forest area. The second most common coniferous species is fir, but this only accounts for 4% of the forest area.

Figure 2. Volumes of timber harvested and corresponding share of hardwoods in France and Romania from 1992 to 2020 (1,000 m³;%)



Source: I4CE, based on (Eurostat, 2023c)

Table 3. Species of timber harvested in France and Romania in 2019 (%)

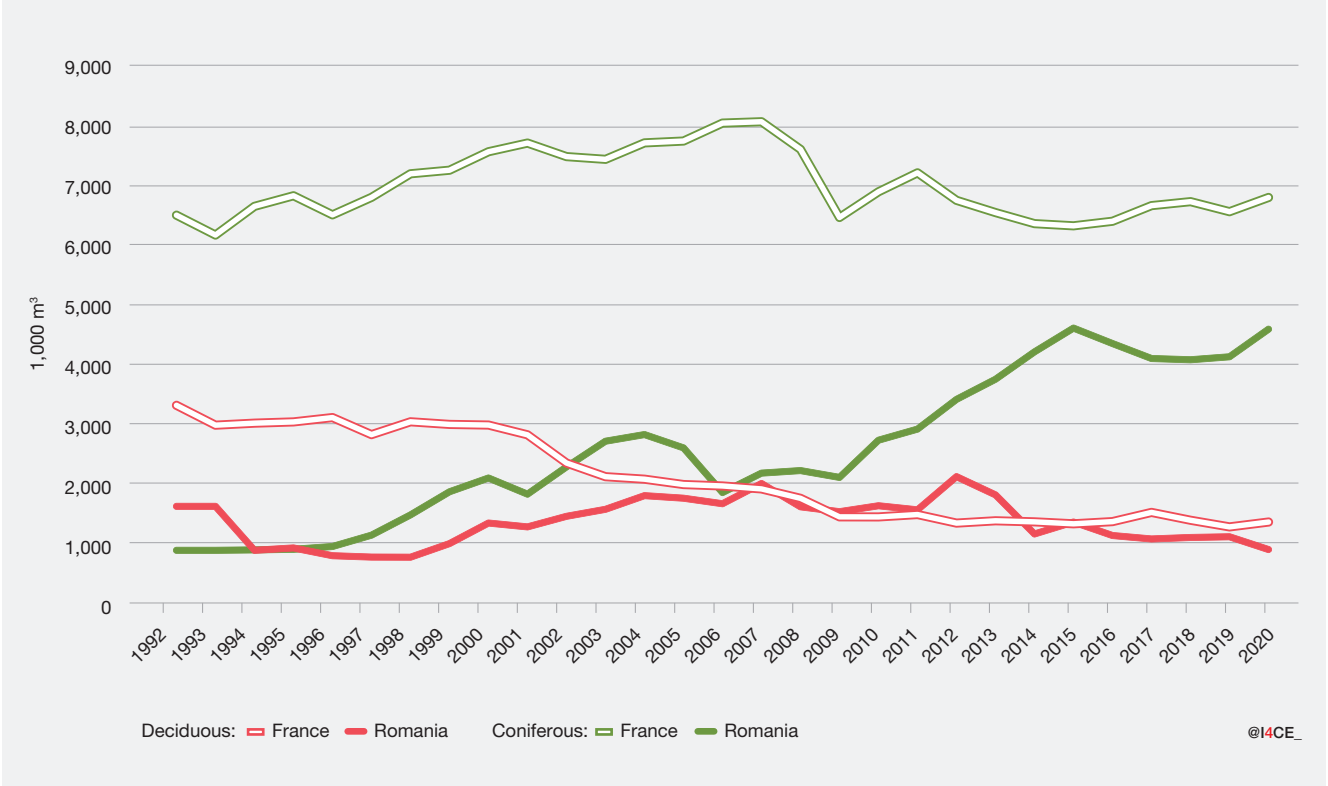
	France	Romania
Oak	**27%**	**46%**
Beech	12%	7%
Poplar	6%	29%
Other hardwoods (chestnut, valuable hardwoods, etc.) *(France)*	7%	NC
Other hard hardwoods *(Romania)*	2%	NA
Other soft hardwoods *(Romania)*	NA	5%
Autres feuillus tendres *(Romania)*	NA	5%
Softwood	**73%**	**54%**
Fir	17%	NC
Norway spruce	18%	NC
Douglas fir	15%	NC
Maritime pine	16%	NC
Other softwoods	7%	NC

Source: I4CE, from (Agreste, 2023; INS, 2022)

Valorization of hardwoods

In both countries, the volume of sawn softwood[21] now far exceeds that of sawn hardwood (**Figure 3**). Since the end of the 2000s, both countries have produced approximately the same volumes of sawn hardwood: in 2019, France produced 1.3 Mm³ of sawn hardwood and Romania 1.1 Mm³.

Figure 3. Sawnwood volumes by species in France and Romania from 1992 to 2020 (1,000 m³)



Source: (Eurostat, 2023e)

Almost half of Romanian sawn hardwood is exported (**Table 4**). The destination of exports is not known specifically for hardwoods, but most exported Romanian sawn wood (all species combined) goes to countries that are not European Union members; in 2019, this amounted to almost 90% of the 1.7 Mm³ of exported sawn wood (Eurostat, 2023e).

Table 4. Production, imports, exports and apparent consumption of sawn hardwood in France and Romania in 2019 (Mm³)

	France	Romania
Production	1.3	1.1
Imports	0.3	0.1
Exports	0.5	0.5
Apparent consumption	1	0.6

Source: I4CE, based on (Eurostat, 2023e)

According to the experts interviewed, Romanian hardwood timber is mainly used for furniture, particularly beech sawn wood. Oak veneers are also used for furniture; in 2019, 0.13 Mm³ of veneers were produced (0.16 Mm³ in France) but the proportion of oak, or more broadly hardwoods, is not known. Experts also mentioned very short-lived uses for beech wood, such as toothpicks, ice-cream sticks and kitchen utensils, although it is not known whether it is timber or pulpwood that is used in this way.

21 These volumes were produced from domestic resources and imported roundwood. However, the latter is a minority: 0.24 Mm of softwood timber was imported into France in 2019, and 0.75 Mm³ into Romania (Eurostat, 2023b). Assuming a sawn wood yield of 50%, 0.12 Mm³ and 0.38 Mm³ respectively would have been produced from imported wood. Information is not available for hardwood timber.

Wood is rarely used in buildings, apart from in tourist and traditional areas where solid wood buildings can be seen. Hardwoods in particular are not used in construction. Nor are hardwoods used in engineered wood products for the construction industry (*e.g.* glulam, CLT, LVL, etc.), but they are used in furniture. One company in particular (Aviva SRL) produces engineered wood products on a large scale from hardwoods (notably oak) in a variety of forms, such as tables and worktops. More detail on this company is provided in **Section 2.2**.

Valorization of small-diameter and low-quality wood

Forest management is strictly regulated by Romanian law, which requires long rotation cycles,[22] prohibits thinning once a stand has exceeded three quarters of the rotation duration, and sets a maximum harvest volume of around 20 Mm³ (Giurcă *et al.*, 2022). According to our experts, although such rotation lengths should favour timber production, they can be counterproductive and lead to timber depreciation in the standing forest. In addition to this potential depreciation, which is not currently documented and seems occasional rather than widespread, Bouriaud *et al.* (2016) demonstrate the lower productivity of Norway spruce and beech stands in the Romanian mountains due to the rules in force.

Our expert interviews did not reveal whether the Romanian industry is generally better at processing low-quality wood than the French industry. At least some of this wood is used in furniture and interior design products. This is particularly true of the Aviva factory, which processes wood of all qualities and does not always treat wood defects (see **section 2.2**). Apart from this example, small diameter and low-quality wood is mainly used for panel manufacture and energy production.

1.3. Pulpwood, fuelwood and secondary resources

Material uses

Three times less roundwood in Romania...

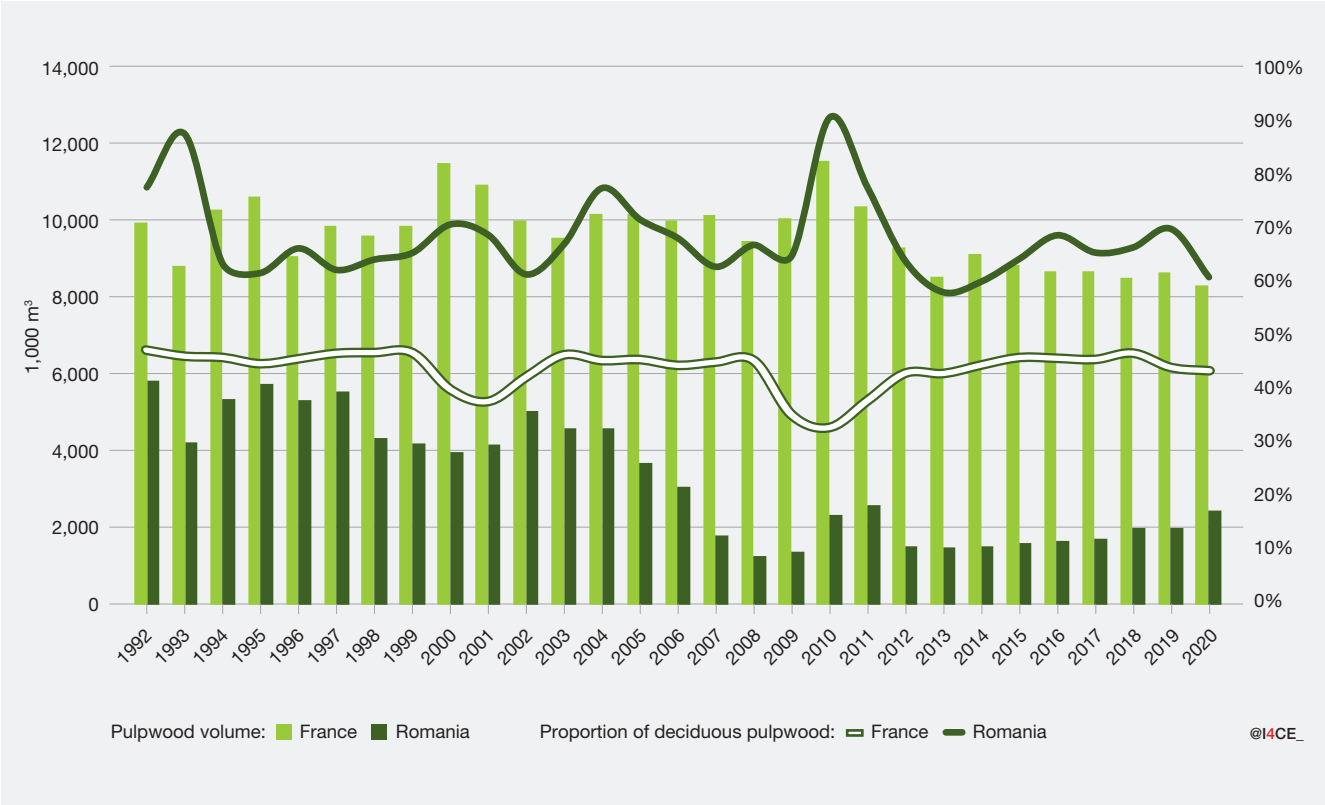
The volume of pulpwood harvested in Romania has fallen dramatically in recent decades: 2 Mm³ was harvested in 2019, which was only a third of the volume harvested in 1992 (5.8 Mm³) (**Figure 4**). In France, 8.3 Mm³ of pulpwood was harvested in 2019. The change between 1992 and 2019 is much smaller than in Romania, at just 13% (almost 10 Mm³ harvested in 1992).

The above-mentioned volumes encompass the categories "pulpwood [...]" and "other industrial roundwood" in the Joint Forest Sector Questionnaire (JFSQ). The latter category corresponds to "industrial roundwood (wood in the rough) other than sawlogs, veneer logs and/or pulpwood", *i.e.* poles, pitprops, match blocks, etc. (Eurostat, FAO, ITTO, UNECE, 2021). While they represent only small volumes in France (0.6 Mm³ in 2019), they account for more than half of Romania's pulpwood harvest. It is surprising that the pulpwood harvest is so low given the volumes of wood-based panels produced in Romania, an issue explored further in the next section. Here again, statistical reliability may be the cause of the problem. We also note that Panaite and Bouriaud (2020), in their estimate of Romanian wood flows, assumed that these volumes would result from wood sorting and that they would supply particleboard production. We also consider that a proportion of these "other industrial roundwoods" are likely to be used by the panel industry, and as we have no further information on their end uses, we did not distinguish them from the wood assigned to the "pulpwood" category.

In 2019, hardwoods accounted for 62-70% of Romania's declared pulpwood harvest (INS, 2022; **Figure 4**). In France, pulpwood tends to be softwood (56% of the pulpwood volume harvested n 2019).

22 From 100 to 200 years for most species, depending on whether the wood is for sawing or peeling (Romanian Ministry of Agriculture, 2000).

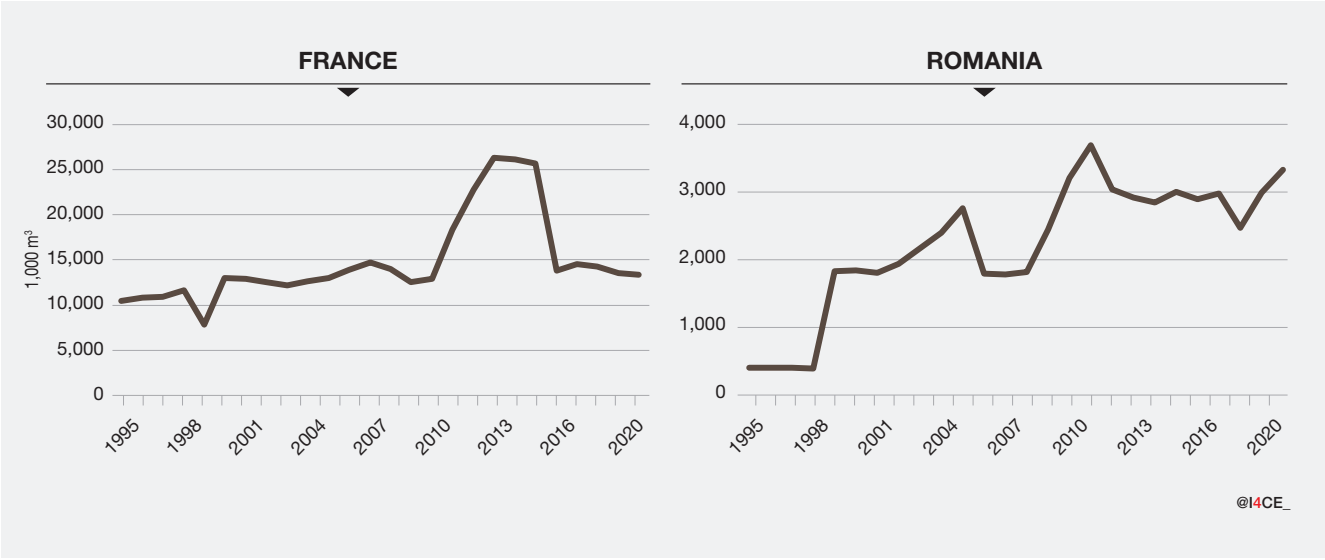
Figure 4. Volumes of pulpwood harvested and corresponding share of hardwoods in France and Romania from 1992 to 2020 (1,000 m3; %)



Source: (Eurostat, 2023e)

The quantities of wood processing by-products produced in France and Romania are of very different orders of magnitude, with around five times as much being produced in France in 2019 (**Figure 5**). The development of Romanian volumes since the 1990s is remarkable: this figure stood at around 0.4 Mm³ between 1995 and 1998, then increasing by more than 350% in 1999.

Figure 5. Wood processing by-product volumes generated in France and Romania from 1995 to 2020 (1,000 m³)

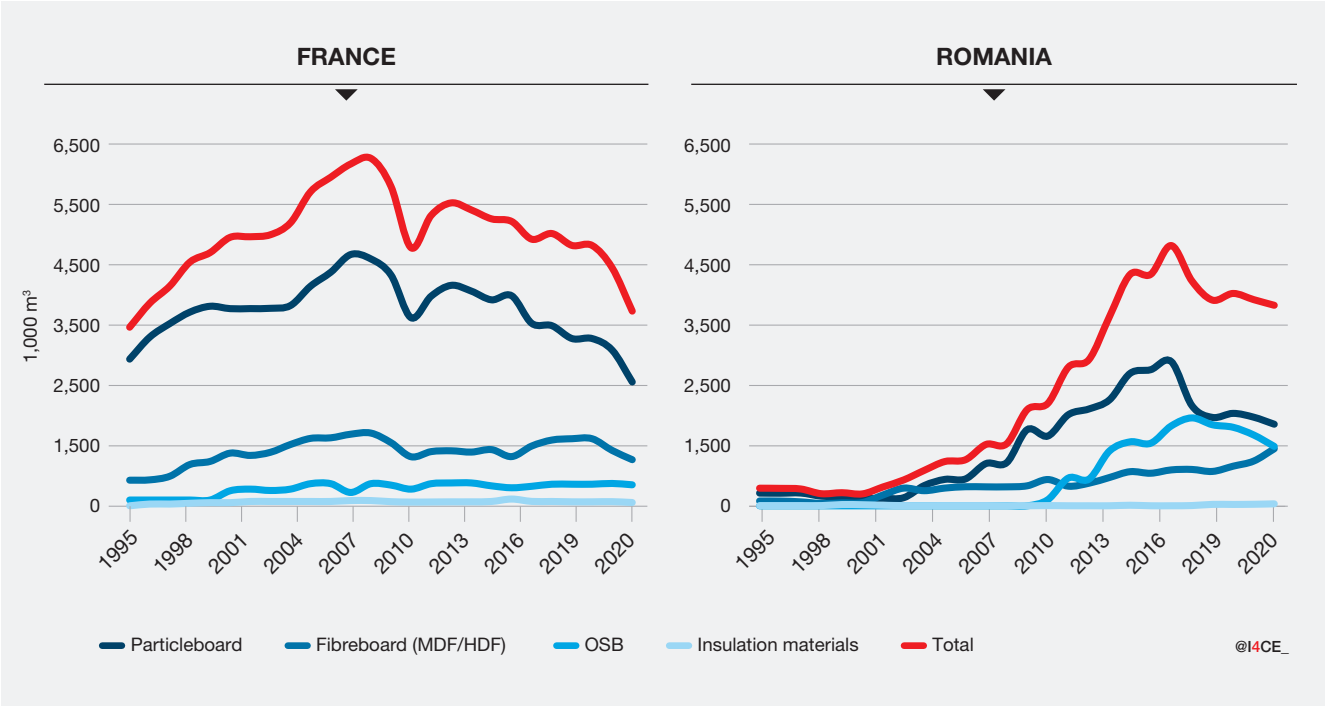


Source: (Eurostat, 2023d)

... yet panel production is almost at the same level as in France

This type of resource is mainly used to produce paper pulp and wood-based panels. In Romania, paper pulp was last produced in 2009 (Eurostat, 2023g). The wood-based panel industry, on the other hand, has developed considerably since the 1990s: from 0.3 Mm³ of panels produced in 1995, it has been producing around 4 Mm³ of panels since 2013, and produced 3.7 Mm³ in 2019 (**Figure 6**). The development of this industry concerns all panel types, apart from insulated panels. It is a very different story in France, where panel production exceeded 6 Mm³ in 2007 (**Figure 6**), but has declined since then. In 2019, 4.3 Mm³ of panels were produced (65% of which were particleboard and 23% MDF/HDF fibreboard), which is the same level as in the early 2000s, with little change in the proportions of each panel type produced.

Figure 6. Volumes of panels and insulation materials produced in France and Romania from 1995 to 2020 (1,000 m³)



Source: I4CE, based on (Eurostat, 2023e; FAOSTAT, 2023)

The experts interviewed said that Romanian panels are partly produced from hardwood resources, in different proportions depending on the manufacturer. It was not possible to be more specific on this point due to a lack of data, but as hardwood represents the majority of the pulpwood harvested, it is possible that panel production in Romania is more dependent on hardwood than in France.

Regarding the incorporation of recycled wood, at least one panel manufacturer has made significant efforts in this area by setting up used furniture collection points and arranging the collection logistics to supply its production. Compared to France, it seems that Romanian panels have a lower incorporation rate of recycled raw materials. For example, in 2019, 1 Mt of recycled wood was incorporated (Ademe, 2021) into the 2.3 Mm³ of particleboard produced in France, whereas the FAO estimated that Romania had collected 0.2 Mt of recycled wood in 2019 (FAOSTAT, 2023) and that the country produced 1.6 Mm³ of particleboard (**Figure 6**). Therefore, assuming that this estimate is accurate and that all of this recycled wood is used for particleboard production, the quantity of recycled wood used would be five times less in Romania, for particleboard production that is only 30% lower than in France.

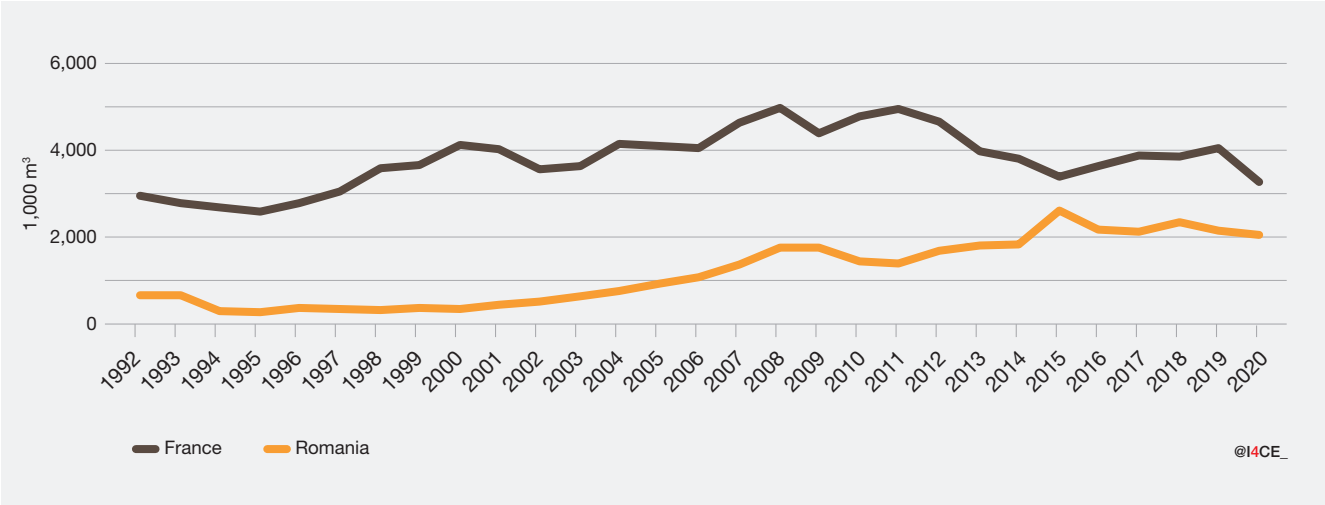
Apart from OSB, Romanian panels are intended only for furniture and interior fittings. They are largely sold on the external market: almost 60% of Romanian production was exported in 2019 (**Table 5**), half of which went to the European Union and the other half to the rest of the world. Since the early 2000s, there has been an increase in national apparent consumption (**Figure 7**).

Table 5. Production, imports, exports and apparent consumption of wood-based panels in France and Romania in 2019 (Mm³)

	France	Romania
Production	4.3	3.7
Imports	0.6	0.6
Exports	0.9	2.1
Apparent consumption	4.0	2.1

Sources: I4CE, based on (Eurostat, 2023e)

Figure 7. Apparent consumption of wood-based panels in France and Romania, 1992-2020 (1,000 m³)



Sources: I4CE, based on (Eurostat, 2023e; FAOSTAT, 2023)

Energy use

Figure 8 clearly shows the difference between the volumes of roundwood for energy production harvested in France and Romania: the French figure is much larger, with 24 Mm³ harvested in 2019 compared with 5.6 Mm³ in Romania. In both countries, fuelwood is mainly hard deciduous trees (beech, oak, chestnut, hornbeam, etc.).

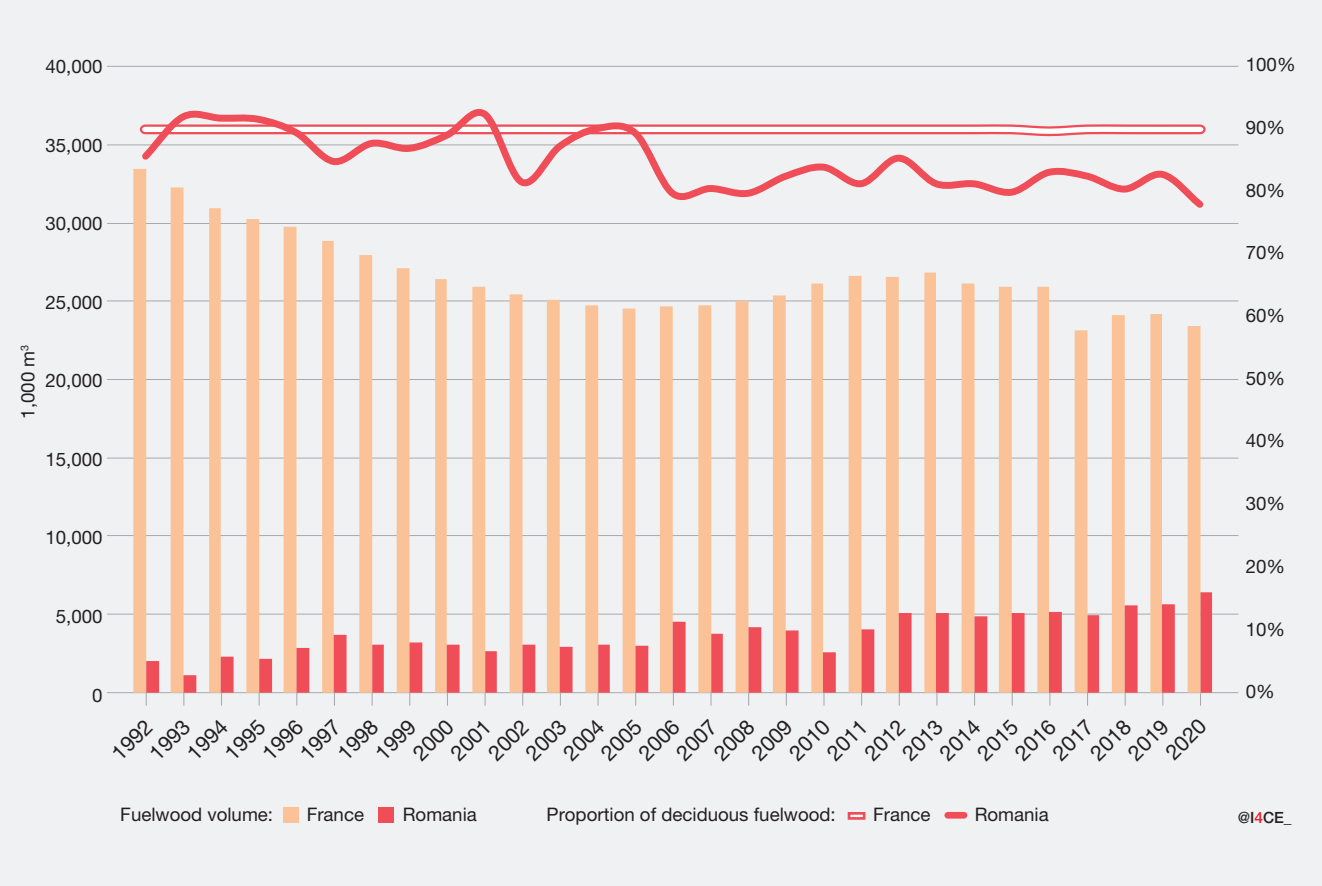
Demographics undoubtedly account for much of this difference: in both countries this fuelwood is mainly used by households in the form of logs, and France has more than three times as many households (29.8 million according to INSEE6) than Romania (8.3 million according to INSSE[23]). Furthermore, as mentioned in **section 1.3**, between 10 and 20 Mm³ are not included in Romanian public statistics and are mainly used for energy production.

The use of wood for energy production by companies is relatively low: while wood processing plants use some of their own by-products to fuel their dryers and boilers (which most of them have, according to the experts we interviewed, except for the smallest ones), biomass power plants are rare in Romania. Consequently, the use of wood as an energy source is mainly an issue relating to households, which seem to have a relatively high consumption compared to French households. A survey of more than 500 Romanian households indicates an average annual wood consumption of nearly 9 m³ per wood-using household, ranging from 5 to 14 m³/year depending on the locality (Bouriaud *et al.*, 2017), while in France the annual household wood consumption is estimated at around 4 m³ (Ademe, Solagro, Biomasse Normandie, BVA, 2018). Households in rural areas constitute the main consumers in Romania, who use wood for heating and some also for cooking, although the latter is becoming rarer. According to the experts, the combustion appliances used by these households are not very efficient. There is also reason to believe that the greater frequency of mixed systems in France (*e.g.* wood-burning stoves and electric radiators) is another contributing factor to the difference between the two countries.

Given that, in terms of fuelwood, the Romanian sector does not demonstrate any positives compared to French sector (*e.g.* cascading wood use, less use of wood for energy in general, etc.), we do not see any potential areas of good practice that could usefully be replicated in France.

23 INSEE and INSEE are the national statistics institutes in France and Romania respectively.

Figure 8. Volumes of fuelwood harvested and corresponding share of hardwood in France and Romania from 1992 to 2020 (1,000 m³; %)



Source: (Eurostat, 2023d)

2. FACTORS IN THE DEVELOPMENT OF THE ROMANIAN WOOD INDUSTRY

The considerable uncertainty and incompleteness of Romanian national statistics limit the robustness of the comparison with France. Nevertheless, the inventory of wood uses in Romania revealed three noteworthy features that could lead to "good practices" that France could draw on to improve the proportion of the harvest dedicated to long-life wood products:

- Sawn wood production in Romania is high relative to French production.
- Hardwoods and low-quality timber processed by the Romanian industry have short to medium lifespans. However, some industry actors seem to have extended the grading boundaries for hardwood valorization to include material that is lower quality but suitable for sawing.
- Romania's wood-based panel industry, which was in its infancy until the late 1990s, has developed strongly over the last twenty years, and its production level is now of the same order of magnitude as that of its French counterpart.

The aim of this section is to examine the factors driving the development of these sectors.

2.1. Possible explanations for Romania's sawnwood production level

In 2019 the French timber industry produced 6.6 Mm³ of sawn wood, while Romania produced about two thirds of this amount (5 Mm³). A comparison of the level of sawn wood production relative to the timber harvested in each country would not be very robust due to the uncertainties surrounding the Romanian statistics; the fact that there are three times fewer production forests in Romania than in France; that the standing volume is almost half the size; and that the proportion of hardwoods in the harvest is slightly higher (**Table 1**). All these characteristics are unfavourable to a level of sawn wood production that is almost equivalent to that of France. However, it should be emphasized that the long rotations imposed by Romanian legislation (despite the limitations mentioned in **section 2.2**), combined with the fact that the majority of Romania's forests are publicly owned24 and managed by a single operator, provide favourable conditions for timber production.

With regard to sawn wood production in particular, several factors could explain Romania's performance:

- France exports more of its harvest than Romania (see **Table 2**). According to Eurostat, up to 3.2 Mm³ of timber would have been exported in 2019; if it had been processed in France, sawn wood production would have exceeded 8 Mm³.
- The Romanian Forestry Code gives a pre-emption right to companies in the furniture industry for the purchase of wood from state-owned forests, so that they can produce sawn wood. Since state-owned forests account for half of Romania's forests, this provision should in principle support the production of sawn wood.
- Sawing in some Romanian plants is said to be more efficient than in France, although the lack of data on the subject makes it impossible to quantify the cubic metres gained. In the next section, we focus on a major furniture component producer, who is one of the main practitioners of sawing optimization in Romania.

2.2. An industrial model to valorize hardwoods that aims to minimize material losses

The Aviva factory manufactures kitchen furniture, worktops and engineered wood flooring. It is one of Ikea's main subcontractors.

Aviva has an "integrated" factory, which means that it centralizes several links in the value chain, managing all stages in primary and secondary processing (debarking, sawing, removal of defects, drying, assembly and gluing of strips, shaping of finished products, etc.) of hardwoods (mainly oak, but also beech, chestnut, ash and birch), from the log to the finished product. The only activities it does not carry out are:

- Wood collection from forests: logs are purchased locally according to available supply. Ikea's investment company owns and manages some Romanian forests (around

24 48% of forests belong to the State, 18% to other public entities and 34% to private actors (Romanian Ministry of the Environment, 2020). Public forests are managed by a single operator, ROMSILVA, the equivalent of the Office National des Forêts in France.

46,000 ha according to the experts interviewed), but does not use them specifically to supply its subcontractors;

- Distribution of finished products: Aviva is a subcontractor and does not sell its products under its own brand. Its products are marketed through long-term contracts with distributors.

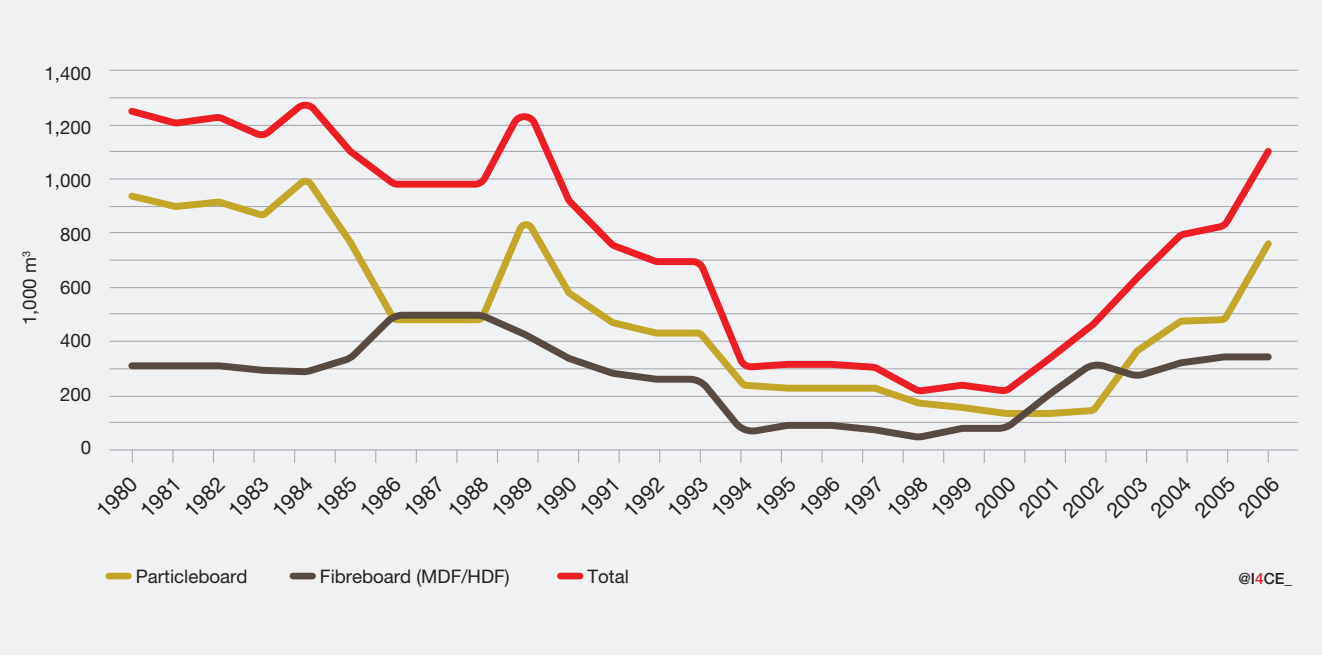
Although not the only plant of its kind in Romania, according to the experts interviewed, it stands out for the improvements and development of its production facilities. Between 2011 and 2012, significant resources were invested in production capacity enabling the company to launch a range of engineered products. According to the trade press and experts, this funding came from EU sources (Revista Mobila, 2018) and shareholders. This investment gave Aviva flexibility regarding the quality of the wood it processes: its engineered wood products offer greater freedom in terms of appearance, because it is possible to use less visually attractive strips inside a product while maintaining the appearance of the finished product. This type of product also enables the use of less raw materials, compared to a solid wood product (I4CE, 2022). Aviva is also working with the wood-based panel industry: some of its products contain particleboard covered with hardwood strips.

Technologies for optimizing throughput, coupled with those for optimizing the assembly of strips, limit material losses; in practical terms this means using all sections of wood, even those of variable and/or small dimensions. Resource management is optimized by an Enterprise Resource Planning (ERP) software package.[25]

2.3. High availability of raw materials and markets: success factors for the Romanian wood-based panel industry

Romania's communist regime came to an end in 1989, which had a major impact on the wood-based panel industry. While the average panel production between 1980 and 1989 was 1.1 Mm³, it represented only 24% of this volume over the period 1994-2000, with an average production of 0.3 Mm³ (**Figure 9**). The industry was becoming obsolete until major foreign investment helped it to modernize and diversify its product range (UNECE, 2000, 2002; Ioras, 2007).

Figure 9 . Particleboard and fibreboard volumes produced in Romania from 1980 to 2006 (1,000 m³)



Source: I4CE, based on (FAOSTAT, 2023)

25 (Forestry Club de France, Conseil & Stratégie Durables, CYME Innovations, FIVE Conseil, 2019)

According to the experts interviewed, a range of other factors also contributed to the upward trend in panel production from 2000 onwards. Firstly, panel production has faced little competition for raw materials in Romania, since the only other potential consumers are households using firewood. Even then, we use the word “potential” because panels are mostly produced from softwood, and households tend to use hardwood for heating. There are uncertainties regarding the mix of species used in panel production because of the quantity of hardwood pulpwood harvested, which has no other industrial use. The Romanian pulp industry gradually disappeared in the 2000s, which also explains the plentiful supply of wood for panel producers. Lastly, the panel industry was not the only sector to have suffered from political and economic upheaval following the end of the Communist regime: this was also true for the sawmill industry, although it recovered more quickly from the slowdown in its production. The experts we interviewed often mentioned the arrival of a large Austrian sawmill company, specializing in softwood, as having been beneficial to the panel industry due to the volumes of wood processing by-products generated.

Furthermore, Romania’s geographic location is ideal for maintaining important export markets (particularly Europe, North Africa, and the Middle East). And while production for external markets continues, domestic demand is also said to have increased as a result of a marketing strategy focused on customizing panel furniture.

CONCLUSIONS AND LESSONS FOR FRANCE

The aim of this study of the Romanian wood industry was to identify practices that support the valorization of wood materials, particularly in relation to hardwoods, and to study the way the wood-based panel industry has developed in a context where the national harvest is predominantly hardwood.

It seems that the material uses of the Romanian harvest are probably lower than the figure given in the Eurostat data. Nevertheless, sawn wood production in Romania remains high, possibly due to the favourable environment for timber and sawn wood production that results from the statutory long rotations and the centralized forest management. For hardwoods in particular, the Romanian sector has developed a variety of markets. As these products are short-lived, we have focused on the industrial model of Aviva, one of the largest Romanian companies specializing in the processing of hardwood and engineered wood-based furniture components, characterized by the concentration of the various processing stages within the company. The development of a range of engineered hardwood products has proved to be a winning strategy to diversify markets for lower-quality wood, confirming this approach as a useful lever for redirecting hardwood towards longer-lasting uses than for energy, as identified by I4CE (2022). A previous study found that Aviva's model was difficult to replicate in the French furniture industry, particularly because of the difference between French and Romanian labour costs, which made the model unprofitable in France.[26] However, the experts interviewed highlighted the high cost of raw materials in Romania. Furthermore, the production of higher value-added engineered products for the construction industry (such as glued laminated timber, CLT, LVL, etc.) could boost the profitability of a French equivalent, especially as there are already companies producing engineered wood in France. It is therefore possible to imagine the supply developing through greater cooperation among sawmills and engineered wood production units. In the short term, this would limit the need for investment in complete processing chains, while meeting national requirements that have so far been poorly covered by domestic production.[27] For these reasons, we believe that the replicability of the Aviva model in France should not be dismissed too easily.

Regarding the rapid growth of the Romanian wood-based panel industry, it is clear that key factors were raw material availability and the existence of major markets. The demise of the Romanian paper sector, which meant the disappearance of industrial competitors for the use of pulpwood and fuelwood resources, along with only very limited demand for energy use, effectively channelled these resources into panel production. Strengthening the relative competitiveness of long-life uses compared to paper, cardboard and energy therefore appears to be a clear driver for development. In France, a similar trend could be encouraged by subsidizing such uses or by exercising more caution when taking measures to stimulate demand for fuelwood. Finally, the growth in panel supply is constrained by its potential markets, given that overproduction would lead to bottlenecks in production units. In Romania there are major markets for panels, but only in the furniture sector, and half of these are for export. Recreating this situation in France would be difficult, given that the domestic furniture market is already saturated with wooden products, and because competition on the export markets would be necessary, despite transport costs. Furthermore, if the aim is to increase the carbon sink provided by long-lasting wood products by changing the way wood is used, then building sector markets would need to be massively expanded, which could be achieved by making panels more competitive than alternative products.

26 (Forestry Club de France, Conseil & Stratégie Durables, CYME Innovations, FIVE Conseil, 2019)

27 In 2016, around 15% and 30% of national demand for CLT and glulam, respectively, was met by French production. In the case of LVL, demand was only met by imports (BIPE and FCBA, 2019).

TABLE OF GRAPHS AND TABLES

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SWEDEN

Sweden was selected for its high level of material use of the harvest (**Table 1**), and for the importance it assigns to timber construction. The study is in two parts:

- the first reviews the uses of wood in Sweden, aiming to determine which segments of the sector are more efficient than their French counterparts;
- the second part analyses the factors that may underlie the current structure of these segments and their reproducibility in France, with a view to changing the way wood is used in France.

CONTENTS

1. OVERVIEW OF WOOD USES IN SWEDEN

Table 1. Overview of forest-based industries in France and Sweden in 2019

	Units	France	Sweden
		Eurostat	
Total surface area	Mha	**28.0**	**17.3**
Net increase	Mm^3 over bark	**123.7**	**102.3**
Removal rate	%	**69%**	**67%**
Ownership type	%		
Public ownership	%	21%	25%
Private ownership	%	79%	75%
Surface area of production forests	Mha	**23.5**	**16.4**
Proportion of production forests out of total area	%	**84%**	**95%**
Standing volume	Mm^3 over bark	**2,696.3**	**3,065.3**

		National statistics	Eurostat		IGN-FCBA (2016)
Harvested volumes	Mm^3 over bark	**89.1**	**74.4**	**49.1**	**48.2**
Deciduous species		11%	12%	61%	58%
Oaks	%		*NC*		*22%*
Beech, and other hardwoods	%		*NC*		*36%*
Coniferous species	%	89%	84%	39%	42%
Spruce, fir, douglas fir, and other softwoods	%	*56%*	*NC*		*27%*
Pines	%	*33%*	*NC*		*15%*
Type of use		Eurostat			
Timber	%	*50%*		*34%*	
Pulpwood	%	*42%*		*17%*	
Fuelwood	%	*7%*		*49%*	
Sawnwood production	Mm^3	**18.7**		**7.8**	
Panel production (excluding plywood)	Mm^3	**0.6**		**4.7**	
Paper pulp production	Mt	**12.1**		**1.6**	

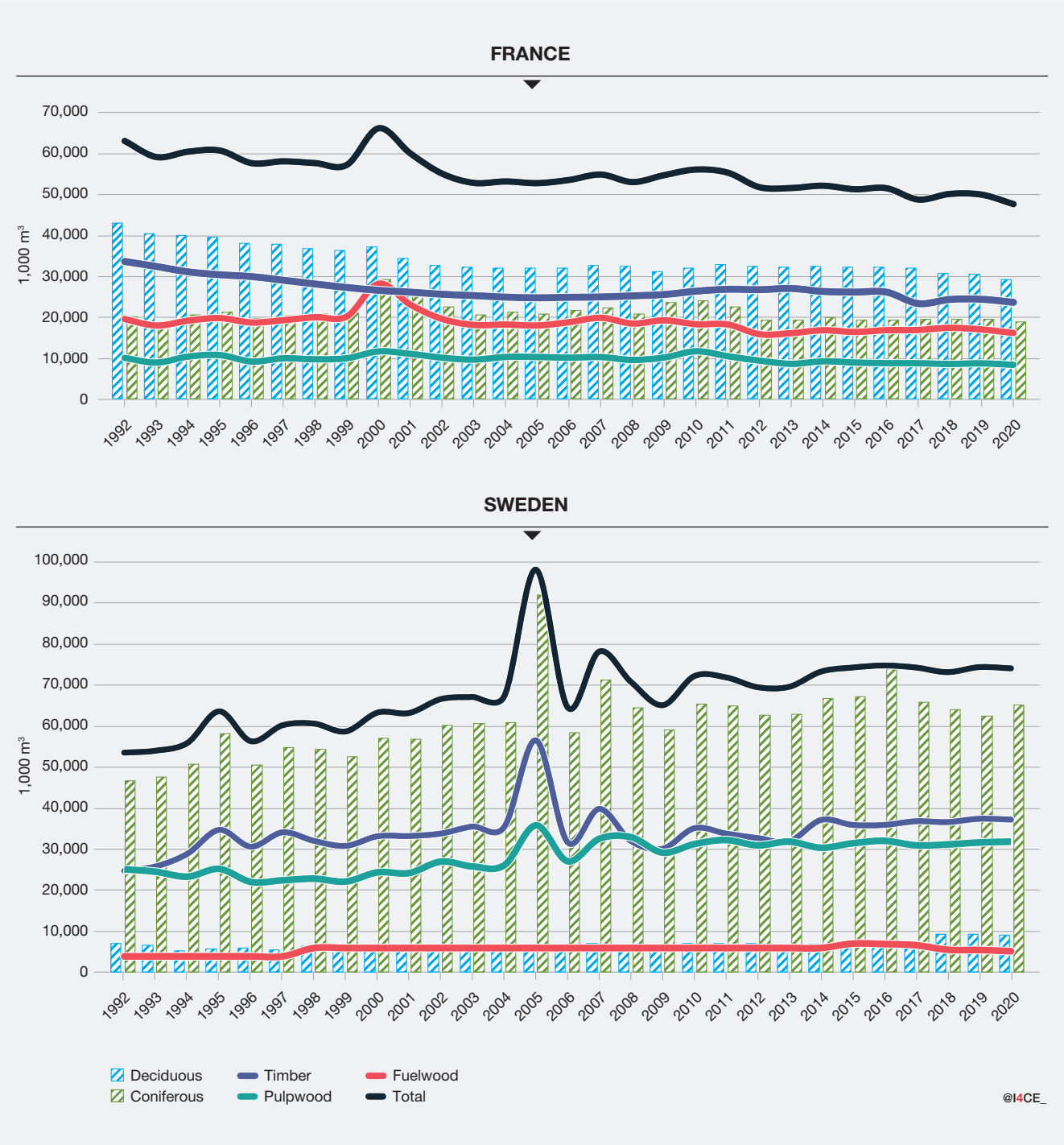
Source: I4CE, d'après (Eurostat, 2023a, 2023c, 2023e, 2023f, 2023g ; IGN et FCBA, 2016 ; SLU, 2022). Taux de prélèvement français d'après (IGN, 2022).

With the intention of identifying the segments of the Swedish timber industry dedicated to long-life uses, we drew up an inventory of the resource types and volumes exploited, as well as their uses.

1.1. Overview of the French and Swedish harvest

In 2019, according to Eurostat data, Sweden's roundwood harvest was almost 74 Mm³, while in France this figure was 50 Mm³ (**Figure 1**); but according to national statistics, the Swedish harvest is even higher at 89 Mm³. Thus Sweden's wood harvest is around 50% to 80% greater than that of France, and is following an upward trend, unlike the French harvest. The Swedish harvest is made up almost exclusively of coniferous wood (90% of the harvest), whereas they represent only 40% of the French harvest. In both countries, exceptional harvest peaks occur due to storms (1999 and 2009 for France, 2005 and 2007 for Sweden).

Figure 1. Wood harvest in France and in Sweden from 1992 to 2020 (1,000 m³)



Source: (Eurostat, 2023c)

Sweden has almost twice as much roundwood available as France (**Table 2**). It exports very little roundwood and imports six times as much as France, so in 2019, 82 Mm³ of roundwood was ready for consumption or processing in Sweden, compared with 47 Mm³ in France.

Table 2. Production, imports, exports and apparent consumption of roundwood in France and Sweden in 2019 (Mm³)

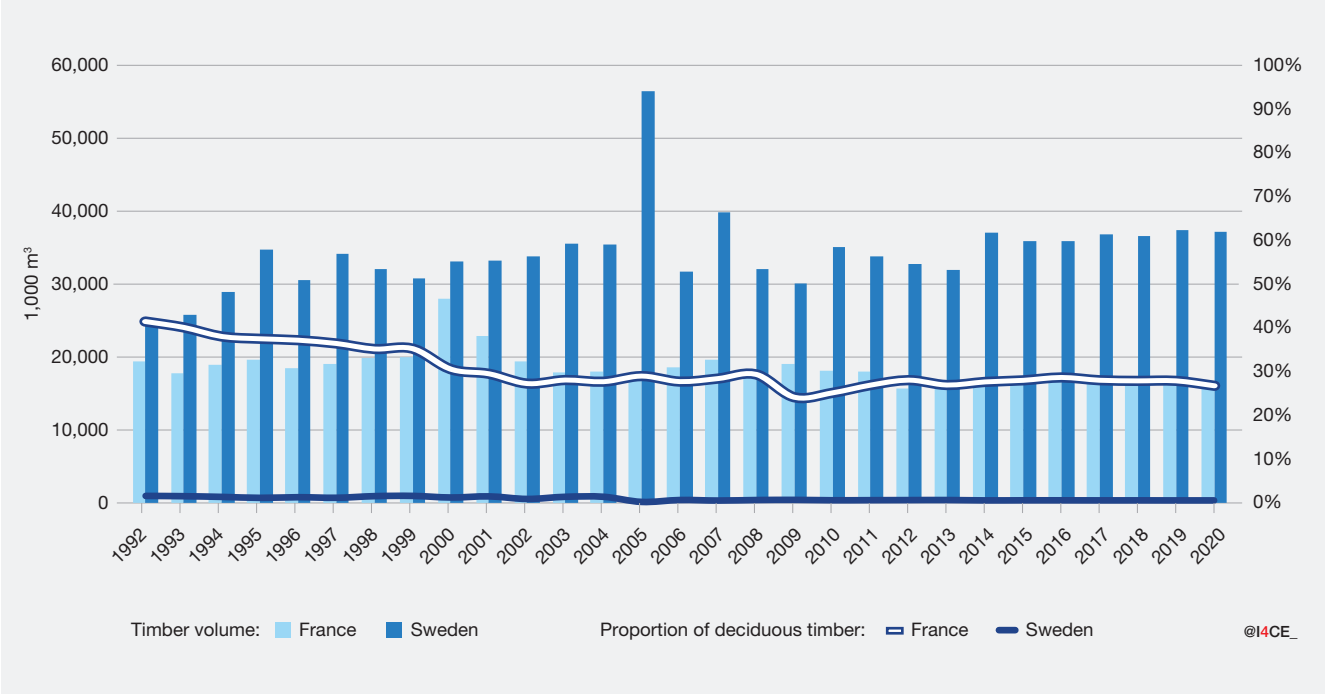
	France	Sweden
Production	49.7	74.4
Import	1.4	8.9
Export	4.3	0.9
Apparent consumption	46.8	82.4

Source: I4CE, based on (Eurostat, 2023b, 2023d)

1.2. Timber

The gap between the French and Swedish timber harvests widens every year. In the early 1990s, Swedish harvests were only around 30% higher, whereas they are now 130% higher than French harvests, at around 37 Mm³ compared with 16 Mm³ in France (**Figure 2**). This is a result of a decline in the French harvest of 17% between 1992 and 2020, while the Swedish harvest increased by 50% over the same period.

Figure 2. Volumes of timber harvested and corresponding share of hardwoods in France and Sweden from 1992 to 2020 (1,000 m³; %)



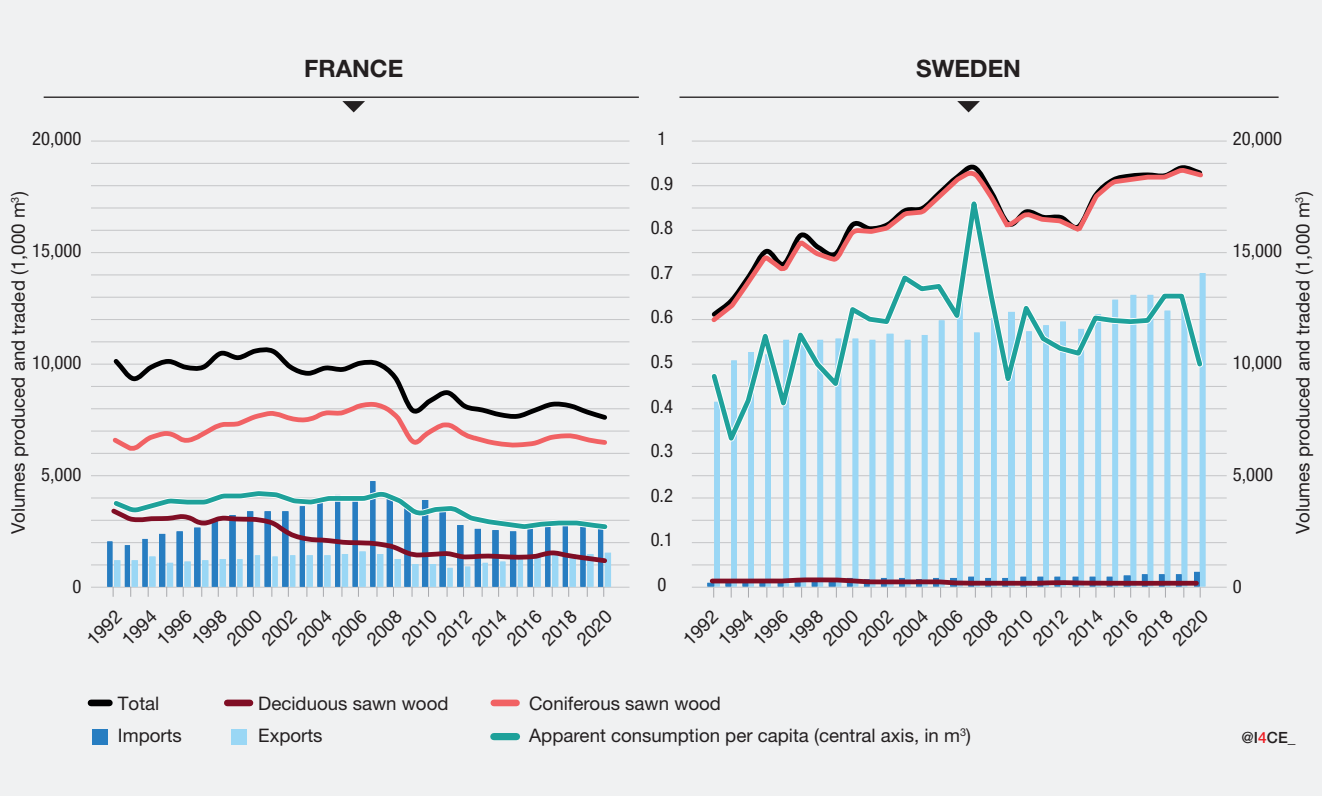
Source: I4CE, based on (Eurostat, 2023c)

Sawnwood production

In 2019, France produced 7.8 Mm³ of sawnwood, compared with 18.7 Mm³ in Sweden (**Figure 3**). In both countries, coniferous sawnwood accounts for a large majority: 84% of sawn wood in France (*i.e.* 6.6 Mm³), 99% in Sweden (*i.e.* 18.6 Mm³). In almost 30 years, Swedish production has increased by 54%. In France, the opposite trend has been observed: total sawn wood production has fallen by 25%, mainly due to the declining production of sawn hardwood (66% decrease). Swedish production of sawn hardwood is very limited, accounting for just 1% (or 0.1 Mm³) of total sawnwood production in 2019, suggesting that the processing industry is virtually non-existent.

The fall in French sawnwood production has not been reflected in an equivalent fall in apparent consumption: a 43% growth in sawn wood imports between 1992 and 2019 offset the fall in national production, despite a moderate rise in exports (23% increase).

Figure 3. Production, imports, exports and apparent consumption of sawnwood in France and Sweden in 2019 (Mm³)



Source: I4CE, based on (Eurostat, 2023c)

In Sweden, although exports have increased since 1992 (53% increase) and accounted for 70% (or 12.6 Mm³) of national production in 2019, the growth in production (54%) and imports (223%) was greater. As a result, the apparent per capita consumption of sawn wood in 2019 was almost five times higher than in France (**Table 3**).

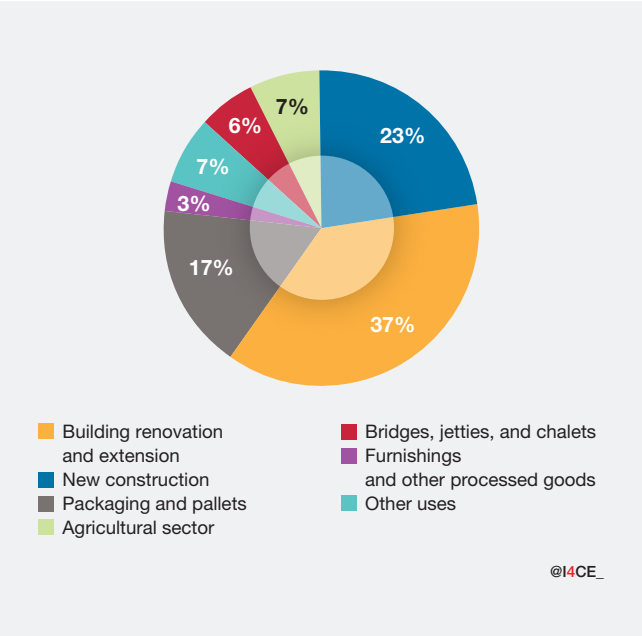
Table 3. Production, imports, exports and apparent consumption of sawnwood in France and Sweden in 2019 (Mm³)

	France	Sweden
Production	7.8	18.7
Imports	2.8	0.5
Exports	1.5	12.6
Apparent consumption	9.2	6.6
Apparent consumption per capita (m³)	0.14	0.65

Source: I4CE, based on (Eurostat, 2023e

More than half of the sawn wood consumed in Sweden is used in the construction sector (**Figure 4**). Renovation (non-energy) and building extensions account for the largest proportion of sawn wood (37%), followed by new construction (23%). The building sector is also the largest consumer of sawn wood in France (I4CE, 2022), accounting for almost half of the available wood products.

Figure 4. Distribution of uses of sawn softwood consumed in Sweden in 2018 (%)



Source: Skogsindustrierna, 2021

Valorization of small-diameter wood

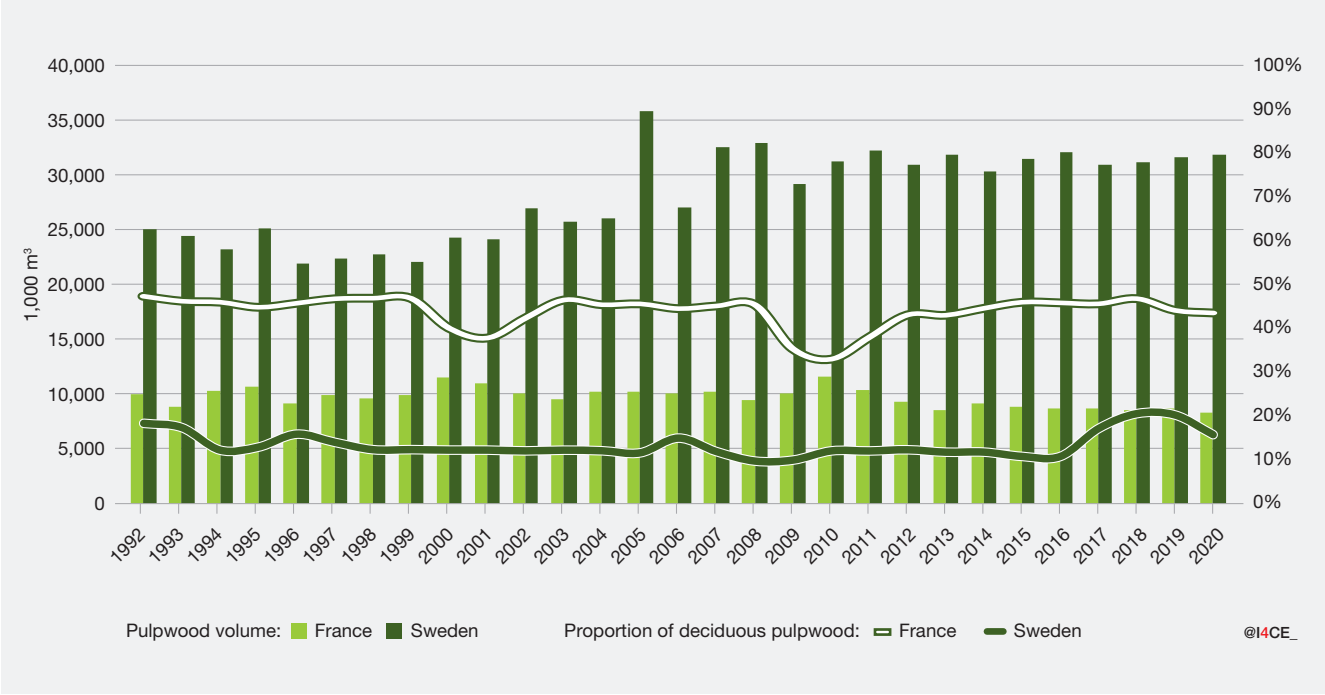
According to the experts interviewed, the diameters processed in Sweden are equivalent to those processed in France, generally with a small-end diameter of 14 to 20 cm (IGN and FCBA, 2019). Some sawmills have specialized in processing smaller diameters, but such practice is marginal.

1.3. Pulpwood, fuelwood and secondary resources

Material uses

Over the last thirty years, Sweden's pulpwood harvest has been two to four times higher than France's (**Figure 5**). Since 2010, it has exceeded 30 Mm³ harvested annually, whereas the average French harvest over the same period was just 9 Mm³. While proportionally hardwoods represent two to four times more of the French harvest than the Swedish one, in terms of volume Sweden harvests almost as much, or even more, depending on the year. Since 2017, Sweden has harvested around 5 to 6 Mm³ of hardwood pulpwood (birch), while France harvested around 4 Mm³.

Figure 5. Volumes of pulpwood harvested and corresponding share of hardwoods in France and Sweden from 1992 to 2020 (1,000 m³; %)



Source: I4CE, based on (Eurostat, 2023c)

Sweden has very large volumes of wood processing by-products, with 21 Mm³ of by-products generated in 2019, compared with 14 Mm³ in France (Eurostat, 2023c).[28] The material use of pulpwood and secondary resources in Sweden is limited to the production of paper pulp, since only 0.6 Mm³ of particleboard was produced in 2019 (FAO, 2023) despite roundwood harvest for pulping of more than 30 Mm³ (**Figure 5**). Sweden is also Europe's largest paper pulp producer, with 12 Mt produced in 2019, sharing second place with Finland in the top three largest paper and cardboard manufacturers, with almost 10 Mt produced. France ranks, respectively, sixth (1.6 Mt produced) and fifth (7.3 Mt of paper and cardboard produced) on the European market (Eurostat, 2023g).

As pulp production is a short-life wood use, we do not explore the material uses of pulpwood and secondary resources in Sweden in this report.

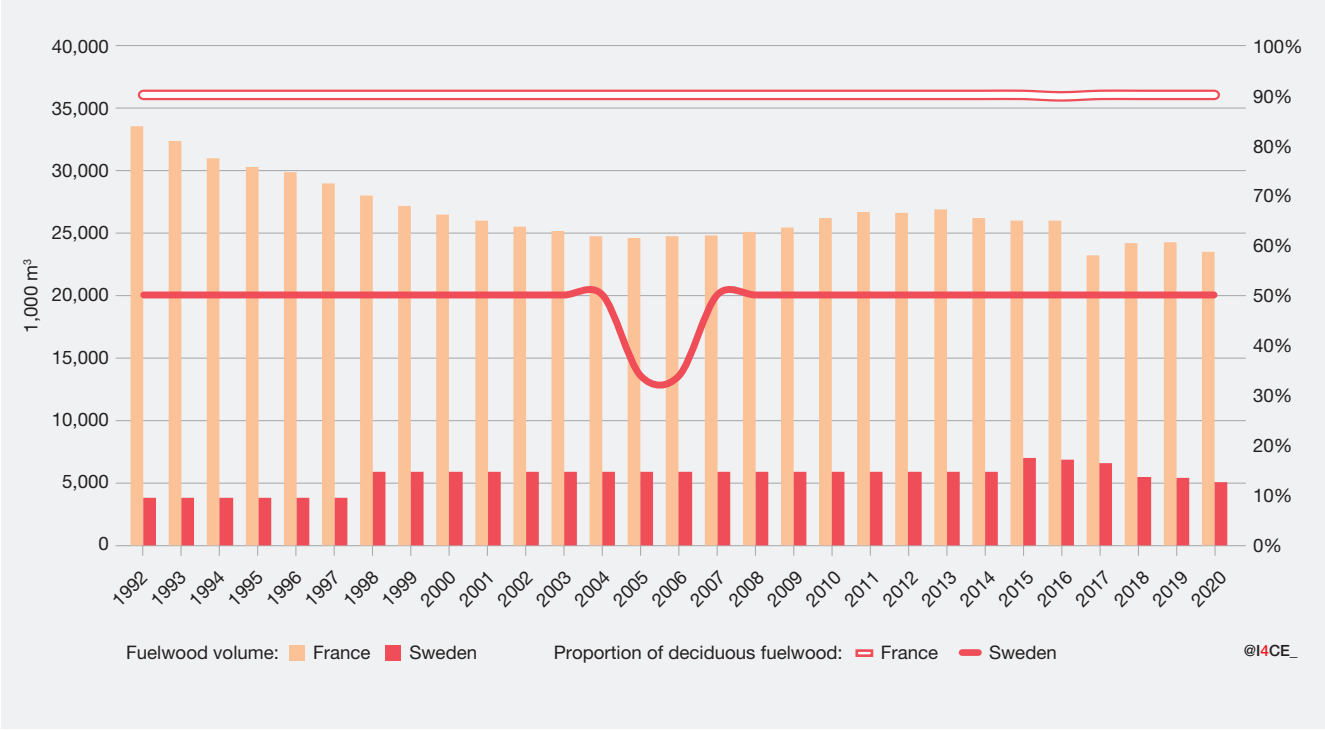
28 Since one of the main sources of wood processing by-products is sawing, and since Sweden saws much more wood than France, it is not surprising that the Swedish sector generates more by-products. However, the difference between the two countries seems relatively small given the difference in sawn wood production. This can be explained by the fact that the statistics on by-products include by-products from other forms of processing, in particular panel production, which is much more significant in France than in Sweden. Furthermore, Sweden only saws softwoods, which naturally have a higher sawing yield than hardwoods; in France, this yield is 55% for softwoods compared with 47% for hardwoods, and the yield for softwoods in Sweden is only 50% (FAO, ITTO and United Nations, 2020).

Energy use

The use of roundwood for energy is highly significant in France, accounting for 49% of the harvest in 2019 (**Table 1**), or 24 Mm³. The proportion of fuelwood in the Swedish harvest varies according to the source used: in 2019, according to Eurostat, 5 Mm³ of the 74 Mm³ of roundwood harvested was allocated to energy, *i.e.* 7% of the harvest (see **Table 1**). However, according to the JRC, this figure rose to 12% in 2017, with 11 Mm³ of fuelwood out of the 91 Mm³ harvested (Cazzaniga, 2021). In both cases, the use of roundwood for energy appears to be marginal in Sweden.

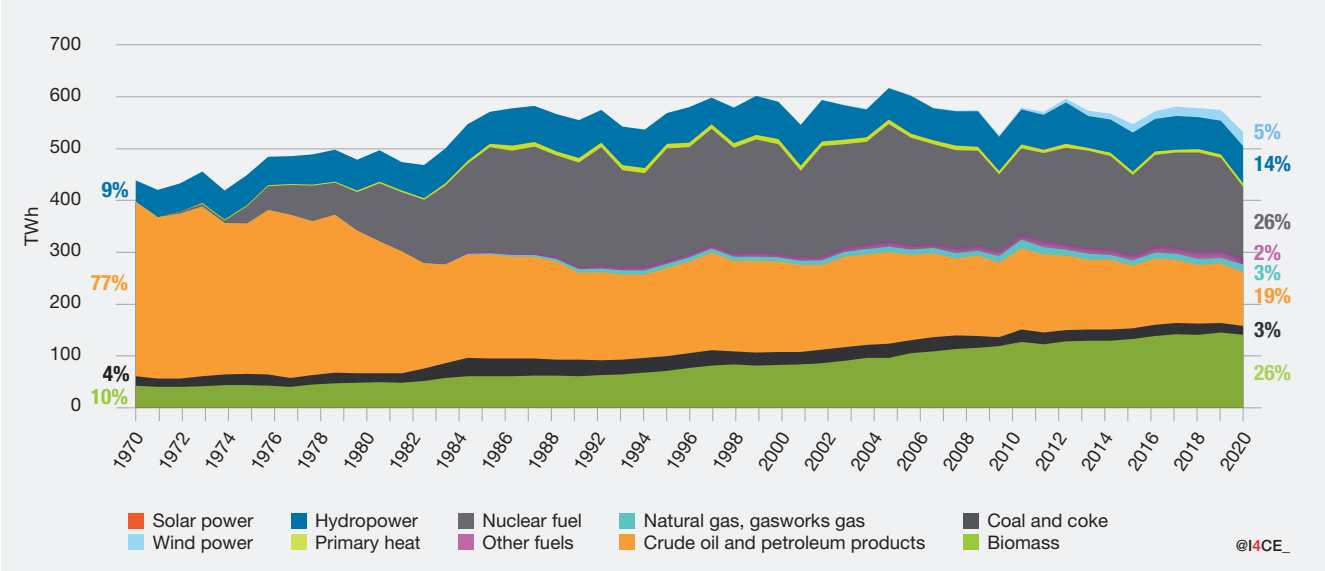
However, in 2020 biomass accounted for 26% of Sweden's total energy supply (**Figure 7**) and although this biomass was not solely comprised of wood and its processing by-products, these materials accounted for at least 73% (Swedish Energy Agency, 2022), the main components being black liquor29 (47%) and raw wood (46%). Densified wood (pellets, for example) was a minor constituent (6%). Industry is the largest biomass consumer (42%; **Figure 8**), with the paper pulp industry using the most (89%), followed by other wood processing industries (7%; excluding furniture production).

Figure 6. Volumes of fuelwood harvested and corresponding share of hardwoods in France and Sweden from 1992 to 2020 (1,000 m³; %)



Source : I4CE, based on (Eurostat, 2023d)

Figure 7. Total energy supply by type of energy in Sweden from 1970 to 2020 (TWh)



Source: (Swedish Energy Agency, 2022)

29 By-product of paper pulp production

2. FACTORS IN THE DEVELOPMENT OF THE SWEDISH WOOD INDUSTRY

The French and Swedish industries are very different in several respects, such as the level of sawn softwood production or the proportion of the harvest allocated to paper pulp production. As the aim of this study is to identify practices that are favourable to the development of long-life uses for hardwoods, and small-diameter or low-quality wood, only the factors that contribute to the development of valorization chains for these resources are examined.

The scope of the analysis of the Swedish sector is therefore limited to two issues, highlighted by the comparison of wood uses in France and Sweden:

- Even though they export a large proportion of sawn wood, the Swedes consume much more than the French, and use it mainly in the construction sector.
- The use of roundwood for energy purposes is marginal in Sweden, despite the fact that biomass plays an important role in Swedish energy policy.

The aim of this section is therefore to explain why Sweden's per capita sawn wood consumption is so much higher than France's, and how competing uses are structured in Sweden.

2.1. Swedish sawn wood consumption

The main areas of sawn wood consumption in Sweden are construction and building renovation and extension, which accounted for 23% and 37% respectively of the nearly 6 Mm³ of sawn timber consumed in 2018 (see **section 1.2**). Given that the market share of wood-based extensions is growing in France, and has already reached 30% (VEIA, 2021), the following section focuses on new construction, for which the French market has more room for development.

The success of wood construction for single-family homes

The use of wood in single-family homes is very common in Sweden: timber frames are used for 80-90% of these houses (Swedish Ministry of Industry, 2018). In France in 2020, the market share of wood used for the construction of single-family homes was only 10%.[30] According to the experts interviewed, the importance of wood in the single-family home construction market is mainly due to Swedish cultural habits. The experts noted that timber-frame construction in Sweden does not generate any additional costs compared with other construction methods.

Rule changes governing the construction of medium and high-rise buildings

The situation is very different for multifamily housing, and more generally for medium and high-rise buildings. Between 1874 and 1994 the use of wood in buildings of more than two storeys was forbidden, but since then the market share of timber-frame construction in multifamily housing has grown, reaching 20% by 2019 (Statistics Sweden, 2022). Current Swedish fire safety regulations for buildings stipulate certain precautions to be taken when wood is used in a building, although according to the experts interviewed, the level of safety guaranteed is relatively flexible: the regulations place the highest emphasis on performance engineering by favouring the obligation of results over the obligation of means, and thus allow project owners to adapt the rules if they carry out their own fire safety engineering study (ISI study) to prove that their solution provides the right level of safety. There are less restrictions for buildings of less than 8 metres in height, while taller buildings have very stringent regulations – the period of fire resistance is increased and encapsulation[31] of the wood becomes compulsory – but compliance can be waived by fitting sprinklers. According to the experts consulted, sprinklers are widely used in Sweden, so these regulations are rarely applied. Therefore, up to a height of 28 metres, there are few restrictions on the use of wood in buildings, even visible wood, provided that fire safety performance can be demonstrated.

Comparing fire regulations between Sweden and France is complicated by the forthcoming arrival of new building regulations in France. At present, French regulations are, in theory, more flexible on the use of wood than Swedish regulations because they do not include any wood-specific rules. In practice, however, a very safety conscious policy, drawn up by the Préfecture de Police of Paris and the Paris fire brigade in July 2021, is being applied beyond the borders of the Paris region, even though its legal nature does not make it binding. Although the Building Code allows an ISI study to be conducted to prove that fire safety requirements have been met by a "solution of equivalent effect" (French Construction and Housing Code, art. L141-3), according to our expert interviews, very few buildings take advantage of this option. A shortage of qualified personnel to carry out such studies and the costs involved means that they are only accessible to large-scale projects.

The new regulations could remove some barriers to the development of the wood construction sector by helping

30 Market share calculated by the authors on the basis of the national timber construction survey on activity in 2020 (VEIA, 2021) and the 2020 housing account report (SDES, 2021).

31 When encapsulated, the material is covered so that it is isolated from its environment.

to disseminate expertise about the material and, above all, by stabilizing the requirements to be met. The current lack of clarity may discourage building owners from choosing wood, but it may also hinder R&D in construction techniques due to a lack of visibility on the regulations to be considered. It should be noted, however, that this policy is a recent measure, and the very permissive regulations on wood use that have been in force until now have not led to growth in medium and high-rise timber construction in France.

Development of a national strategy to promote timber construction

At the beginning of the 2000s, after authorizing the construction of timber-framed buildings, the Swedish government made the same observation: the updating of building regulations alone was not sufficient to boost the medium and high-rise timber construction market. The government therefore worked on an ad hoc national strategy, which was active from 2004 to 2008 (Swedish Ministry of Industry, 2004). Its aim was to increase the competitiveness of timber construction, and more specifically that of off-site timber construction.[32] The decision to favour this type of construction stems from a desire to reduce construction costs without being limited to the cost of materials. The strategy is based on a quantification of building construction costs carried out by the Nordic Timber Council (2002), which revealed that materials and labour accounted for equivalent proportions of the total cost, and that timber frames represented only 3% of the total cost. The Swedish government therefore preferred to attempt to reduce the total cost of constructing a timber building, rather than simply to support the competitiveness of timber. The factory prefabrication of building parts enabled labour requirements to be reduced and a better control of material costs.

The strategy included a range of short and long-term measures to improve the competitiveness of the timber construction industry. These included updating the training on offer and disseminating knowledge about timber construction, investing in production capacity at factories and also in R&D to create new timber construction systems. Numerous timber construction investment programmes for medium and high-rise buildings have since been launched (some even before the national strategy was implemented). The industry has invested alongside the government, and universities have also been heavily involved in R&D projects that have helped to develop the market (Mahapatra *et al.*, 2012). The main aims of these programmes have been to create a network of actors involved in timber construction, to connect actors in the housing sector with those in timber construction, to develop timber construction training opportunities and research programmes, and to fund pilot projects. This collaboration between government, industry and research institutes was highlighted by some of the experts interviewed as an important factor in the successful launch of this new timber construction market.

Recent national-level developments

Today, while the market has evolved in the desired direction, the Swedish government is maintaining its efforts to build more housing with a low environmental and climate impact (Swedish Ministry of Industry, 2018). Not wishing to position itself in favour of any one material or construction solution, it promotes sustainable construction in general, not just timber construction. These efforts resulted in the introduction of subsidies totalling €23 million, allocated over the period 2018-2020 to support innovative sustainable construction projects (*e.g.* projects on life cycle analysis, off-site construction, etc.). In addition, it has been compulsory for buildings constructed since 2022 to provide life cycle analysis results, from raw materials extraction to the use of construction products in the building. This declaration does not yet include any limits on the CO_2 emissions generated (Steinmann *et al.*, 2022), as is the case with the new environmental regulations for new buildings in France (RE2020). According to the experts consulted, this action could eventually encourage demand for wood construction.[33]

The experts interviewed reported that building with wood today is not more expensive than any other material. It is difficult to say when wood reached this level of competitiveness: during the 2000s, there was no consensus in the literature as to whether or not there was a cost premium (Mahapatra *et al.*, 2012), with researchers reaching opposite conclusions on the subject. It is likely that the existence of extra costs varies between traditional and industrialized construction; the latest strategy paper published by the Swedish Ministry of Housing mentions that industrialized timber construction is still perceived as expensive.

Local initiatives

Finally, local authorities are not subject to the principle of technological neutrality, and some are particularly supportive of timber construction by implementing strategies to develop the sector within their boundaries. This is the case in the Växjö municipality for example, where only wooden buildings are permitted in one area of the city, and regulations require half of all public buildings to be timber-framed.

32 Off-site construction involves prefabricating building structure parts in a factory (*e.g.* prefabricating CLT walls) and assembling them on the construction site.
33 As the production of bio-based construction materials has low CO_2 emissions relative to materials of mineral or petrochemical origin, imposing limits on CO_2 emissions and comparing LCAs on this phase of the life cycle of materials encourages a preference for bio-based materials.

2.2. Managing conflicts of use

Growth of biomass in the Swedish energy mix, but not at the expense of wood material valorization

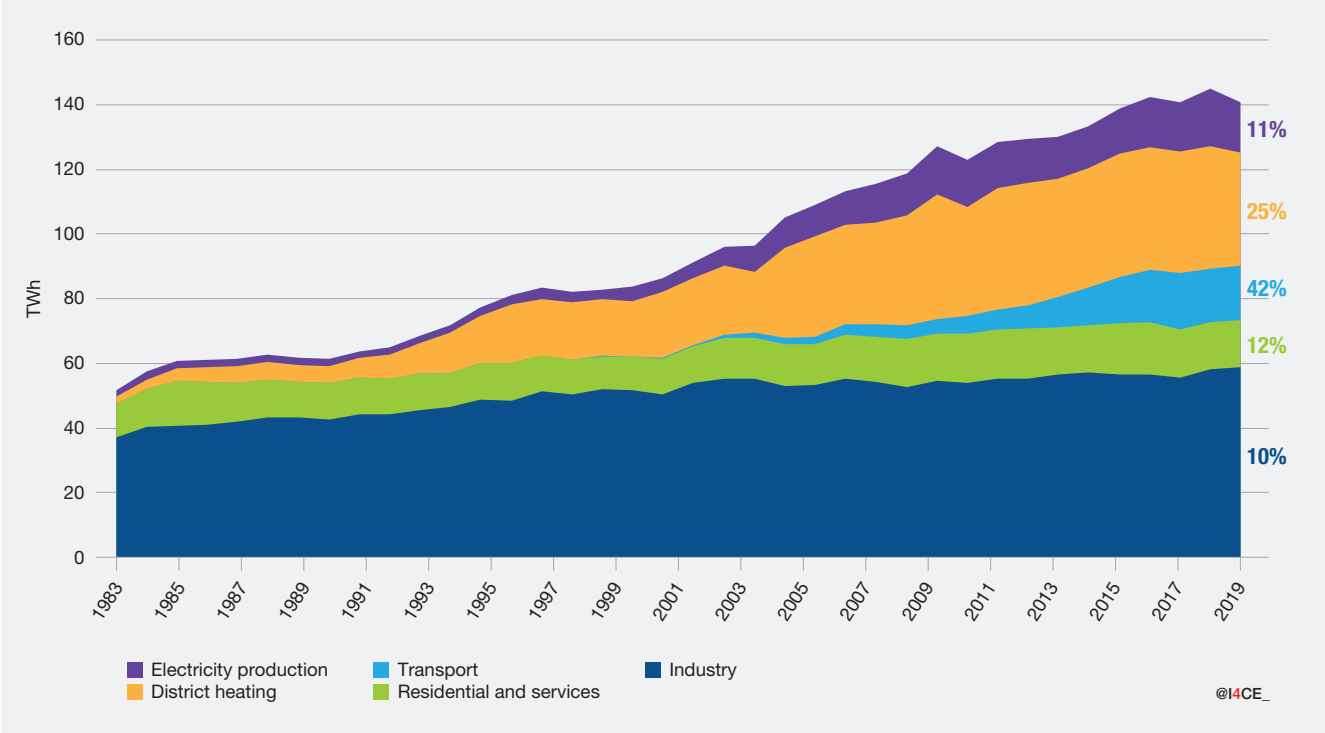
Despite the low proportion of fuelwood in Sweden's roundwood harvest (see **section 1.3**), biomass played a crucial role in its energy transition following the oil crises of the 1970s. Biomass accounted for 10% of the total energy supply in 1970, rising to 26% by 2020 (**Figure 7**), and is used in particular to supply heating networks, which account for a quarter of the available resource, compared with 10% for the residential sector (including individual homes but not heating networks) and services (**Figure 8**). Biomass is the main source of energy for these networks, with 60% of their energy coming from biomass (Swedish Energy Agency, 2022). According to experts, heating networks mainly use by-products of sawmilling, black liquor, forestry chips, and wood that has been too damaged by forest fires or pathogens to be used in industry.

Heating networks mainly supply the residential and service sectors, which account for 80% of their production (Swedish Energy Agency, 2022), with almost 75% of Swedish homes connected to them (High Council for the Climate, 2020). In relation to the total energy consumed for heating and hot water production, the proportion of energy from these networks varies according to the type of building: while it is 20% for individual dwellings, it rises to 80% for non-residential buildings, and even up to 90% for collective housing (Swedish Energy Agency, 2022).

Domestic heating is therefore very different from practices in France, particularly where wood is concerned, with the vast majority of householders still using logs in individual fireplaces (Ademe, Solagro, Biomasse Normandie, BVA, 2018). The widespread nature of heating networks in Sweden, which are more efficient[34] and use secondary or recycled biomass, are undoubtedly the reason for the relatively low proportion of wood energy coming from the country's primary harvest, which leaves more available for industrial wood uses.

Several relatively recent policies have contributed to the development of biomass use. In 1991, Sweden introduced a carbon tax from which biomass was exempt, making it more competitive with other energy sources (Nilsson *et al.*, 2004; Cruciani, 2016), particularly for heating networks (Nilsson *et al.*, 2004). Subsidies were also granted during the same period for the establishment of biomass power plants, as well as for local authorities that set up biomass-fuelled heating networks and for households willing to connect to these networks (Nilsson *et al.*, 2004; Cruciani, 2016). Despite these incentives, quality roundwood has not been included in this growth in the use of wood as an energy source; according to the experts interviewed, the main reason for this is cost, which is far too high compared with alternative resources that are available in abundance (by-products, forestry residues in particular) to be used by heating networks.

Figure 8. Biomass consumption by sector in Sweden since 1983 (TWh)



Source: (Swedish Energy Agency, 2022)

34 According to the emission factors in the Ademe's database (the French Ecological Transition Agency), energy production by heating networks emits 2.5 times less CO_2 equivalent than burning wood in an individual stove (all types of wood considered).

An attempt to provide a legislative framework for wood use in response to the growth in energy use

In 1987, the Swedish government enacted a law[35] the objectives of which were to protect the wood industry from the growth in the use of wood for energy purposes, and to prevent the industry from becoming too concentrated, by limiting the quantities of wood consumed by the largest wood-processing industries. Only the first objective, and the associated provisions, are presented here.

This law stipulated that biomass power plants and producers of pellet-type fuels that use roundwood with a diameter greater than 5 cm or wood processing by-products (excluding bark) would be required to apply for administrative authorization once their expected annual consumption exceeded 10,000 m³. Without this authorization, offenders would face fines or imprisonment. Under this law, the wood industries were to retain primacy of access to the resource, leaving only the surplus resource for the energy sector.

This law was quickly repealed for a number of reasons, some of which concerned the major industries also covered by the law. Regarding the section of the law concerning the use of wood for energy purposes, two points seem to have played a role in the law's repeal:

- difficulty of application: it has proved "impossible to determine on a case-by-case basis the quantity of raw materials that can be authorized for combustion without risking a future shortage of raw materials in the forestry industry" (Swedish Government, 1991);
- concerns over resource depletion in the industry had decreased: while demand for forest residues by the energy sector grew strongly in the first half of the 1980s, there was a subsequent slowdown. Moreover, in 1990, the supply of wood processing by-products exceeded demand, due to a cyclical downturn in paper pulp production and the low absorption capacity of the energy sector (which was still underdeveloped at the time) (Swedish government, 1991).

Given that the law's purpose was to guarantee a supply of wood to the industry to ensure it had sufficient resources to flourish, there was no longer a reason to keep it in force. However, the rapporteur, who evaluated the law at the request of the Swedish government, noted that simply repealing it, at the same time as the introduction of a carbon tax and the subsidies referred to in the previous section, would risk undermining the panel industry. Promoting the use of biomass for energy could have had the effect of increasing pressure on the supply of wood processing by-products, and therefore reducing its use by manufacturers. To address this side-effect of the energy policy without calling it into question, the rapporteur suggested introducing a reimbursement system for panel manufacturers to cover the increase in the price of wood processing by-products. He proposed that the wood processing by-products price index should be linked to that of wood materials (timber, pulpwood). Reimbursement would not be automatic: it would only happen in the event of an increase in the price of wood processing by-products linked to an increase in demand for energy use, and could also take account of price variations from one region to another. In the absence of a digital record of the legal follow-up to this proposal, it has not been possible to verify whether or not this system was implemented, at least temporarily. It is therefore discussed here only to illustrate how the law might be able to regulate the use of wood.

35 Lag (1987:588) om träfiberråvara [Wood Fibre Raw Materials Act], SFS 1987:588, 1 July 1987.

CONCLUSIONS AND LESSONS FOR FRANCE

A comparison of the French and Swedish timber industries reveals three main points: Sweden is a very high sawn wood consumer; biomass accounts for a significant proportion of the energy mix, even though only 7% of roundwood is used for energy; and lastly, that the panel industry is trying to protect its access to resources.

The average Swede uses 360% more sawn wood than their French counterpart. This difference is mainly due to the renovation and extension of buildings. New construction is also a major driver, due to the fairly widespread use of timber frames for single-family homes, as well as for 20% of multifamily homes. However, this striking feature does not offer any obvious lessons for France. Firstly, because the greater use of timber frames seems to be mainly cultural, even though fire regulations are slightly more favourable in Sweden than in France. Secondly, because this practice is based on an adapted and abundant coniferous resource, a factor that would be difficult to replicate in France in the short term (I4CE, 2022).

The energy use of primary forest biomass remains limited to 7%, even though biomass represents 26% of Sweden's primary energy mix. This virtuous circle in terms of limiting the short-term use of primary wood can probably be explained by the abundance of wood processing by-products and the importance of heating networks. These networks, which supply three quarters of homes, enable wood to be used more efficiently and facilitate the use of by-products and wood waste for energy purposes. This aspect, which limits competition with longer-term uses of primary biomass, is partially reproducible in France since it would be possible to promote heating networks. Regarding the abundance of by-products, I4CE (2019) estimates that relocating the sawing of the 3.5 Mm³ of roundwood exported annually[36] would generate around 1.8 Mm³ of by-products, in addition to avoiding 1 $MtCO_2$ of emissions linked to the transport of wood.

Finally, since 1987 Sweden has been concerned about competition between fuelwood and material wood, both for roundwood and by-products. The implementation of a law that sought to make consumption in excess of 10,000 m³ subject to administrative authorization proved ineffective and difficult to implement, and a proposal to compensate for the extra cost linked to energy demand did not seem successful. These failures, combined with the dynamics of the paper industry, undoubtedly explain the small proportion of panels and insulation materials in Swedish production. While this does not provide positive lessons for France, it does confirm the level of care required when implementing incentives to use primary resources for energy purposes, which are difficult to counterbalance with other public policies.

36 Average over the period 2010-2020, maximum estimate based on data available from Eurostat, which do not allow timber and pulpwood exports to be completely separated.

FIGURES & TABLES

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