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## The Comeback of Wood Construction

**B**uildings are heavy polluters. They account for about 40% of global greenhouse gas emissions. The construction phase alone represents 10%, and most of this is the result of the materials used.

While making cement and steel greener is a priority, another alternative exists. Wood construction is not only less harmful to the environment; it actually can generate a positive environmental impact. In fact, wood is the only truly renewable building material. Compared to steel and concrete, it has a positive carbon footprint from start to finish, across the design and construction phases, throughout its lifetime and at end-of-life. Concrete emits 0.3 tons of carbon dioxide per m<sup>3</sup>. Wood, by contrast, absorbs 1 ton. Plus, with new technologies, it can provide a better strength-to-weight ratio and requires less energy and water during construction.

At present, wood is not as economical as steel and

concrete. Other constraints include a patchwork regulatory environment and lingering consumer fears and prejudices. Nonetheless, particularly in a resource-strapped world with a growing environmental consciousness, wood construction is making a gradual comeback. Our analysis, obtained through discussions with materials experts and companies - in the absence of homogenous aggregate data - identifies three catalysts for growth in wood construction in developed countries.

The construction industry offers secular opportunities which may not correspond to the shorter time horizons of typical investors. But Ambienta was created to capitalize on long-term environmental trends, and this is the basis of our success. We are happy to share investment opportunities in segments that already deliver opportunities in the wood value chain for the asset classes we manage, from private equity to listed equities.



# Wood Usage: Where We Are and How We Got Here

**W**ood has always been used in construction. The first wooden buildings date back to 10,000 years ago. Wood remained largely unchallenged as one of the most popular and convenient ways to build houses in many parts of the world until about the 18th and 19th centuries, when innovations in cast iron and brick production in the UK spearheaded the popularity of these materials across the West and in China. At the same time, mass production of steel and concrete became widespread first in Europe and then in Asia, overtaking wood.

Technological advancement wasn't the only reason for the slowdown in the use of wood. Fire also played a part. The Great Fire of London of 1666 raged for five days, destroyed 13,000 buildings and left 80,000 people homeless. Coincidentally, on the same day in 1871, two catastrophic fires in America, one in Wisconsin and the other in Chicago, left 1,400 dead. Such widely publicized events helped fuel fears that led to restrictive construction codes – many of which still exist – as well as trepidation among consumers.

Post-World War II reconstruction catapulted the growth of cement and steel, providing strong and easy-to-scale materials required for the huge rebuilding of cities and major infrastructure. They were also ideal for the multi-storey buildings needed to fulfil the urbanization needs of a booming population.

The chart below shows how solid wood and cement are used in construction worldwide today. Most regions that have wood on their doorstep use it abundantly. In the U.S., thanks to ample supplies and widely available standard softwood produced at steam-powered sawmills already in the 1800's, wood was and remains the single dominant material for single-home construction. In fact, 90% of new single-family homes are built with wood. Not surprisingly, the U.S. uses twice as much wood per

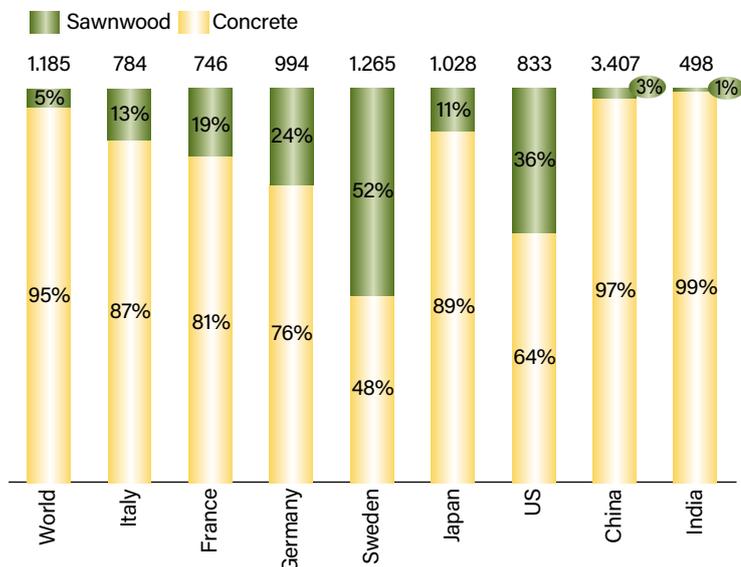


**Neolithic Wooden Longhouse**

unit of population than countries like France and Italy. The same is true in Northern Europe, where 73% and 50% of the surface of Finland and Sweden respectively is covered with forests (in Finland, 10% of the population actually owns forests) and wood construction is deeply embedded in the national cultural heritage. In Sweden, wood use is equivalent to concrete (which still remains the material of choice for civil infrastructure).

But in other regions, wood's penetration has been less marked. In China, where the population increased from 1.1 to 1.4 billion and urbanization grew from 26% to 64% since 1990, wood use in construction has remained very marginal. In Japan, despite extraordinary 90% urbanization rates, which favoured concrete in the past century, wood represents 11% of volumes, mostly found in more traditional rural homes. In Western and Southern Europe, only about 10% of all single-family houses are entirely made of wood, but total penetration is on average 20%, since about 40% of roofs are built with wood.

**Relative Use of Sawnwood and Concrete in Different Regions**  
m<sup>3</sup> of material used per thousand people



Source: Ambienta proprietary analysis on FAO and US Geological Survey data

# Environmental Benefits of Wood Construction

Wood is a natural carbon sink. Forests absorb more CO<sub>2</sub> per year than the total carbon emissions of the U.S. or the combined production of steel and cement.

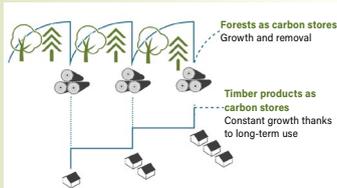
Forest management is a global issue. Today, 31% of the earth's land is covered by forests, down from 34% in 1990. This drop is mainly caused by illegal deforestation driven by pastoral farming and feedstock production. But in regions like Europe, where 96% of forests is actively

managed, they have increased by 10% since 1990.

Controlled wood harvesting has positive environmental benefits. Young trees grow most rapidly and are especially effective in storing carbon. When cut, trees stop absorbing CO<sub>2</sub>, which is only released when they are decomposed or burned. Therefore, the longer the lifespan of the wood end-product, the longer its carbon is stored. Moreover, wood products can be reused and recycled, further extending the benefit.

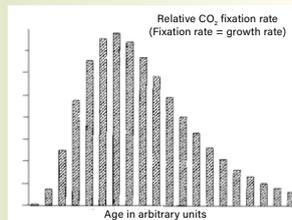
## Wood's Carbon Storage Benefit

### Long-Term Carbon Storage



- When trees are transformed into long-lasting wood products, decomposition and CO<sub>2</sub> release is delayed, and carbon is stored longer
- The use of wood products in construction and furniture substitutes highly polluting materials such as steel and cement

### Acceleration of Forest Renovation



- Old forests have a reduced ability to grow and store CO<sub>2</sub>
- Proper tree harvesting can increase the carbon storage potential of forests

### Prolonged Life through Reuse & Recycle



- At end-of-life, wood is easily downcycled to make panels, pulp for paper or is burned for energy
- Paper is easily recyclable and can be repurposed many times

However, the wood construction value chain is not entirely efficient. Wood needs to be cut, dried and treated with chemicals. Manufacturing is energy-intensive. Transportation is also expensive because wood usually entails large volumes.

Yet, wood can still boast an overall CO<sub>2</sub> footprint that is 10-30% lower than an alternative concrete equivalent application and up to 80% lower than steel construction. To assess the actual CO<sub>2</sub> footprint of various materials in an apples-to-apples manner, we weighted the mechanical strength of different materials for similar applications. This evaluative calculation is obviously simplified and not exhaustive but provides a baseline comparative approach that

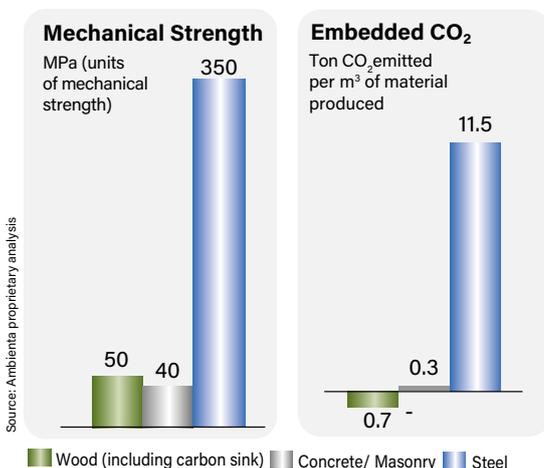
explains a real-world difference in environmental impacts.

For example, let's compare wood and concrete. As a general assumption, it is fair to say that wood is 25% stronger than concrete (50 MPa vs. 40 MPa<sup>1</sup>), although respective mechanical strengths can vary by up to 50%, according to individual concrete formulas and different types of wood.

Hence, you need 25% less wood. Using less material is not the only environmental advantage provided by wood. In fact, although both materials generate about 0.3 tons of CO<sub>2</sub> to make 1 m<sup>3</sup> of structural wood or concrete, wood additionally stores 1 ton of CO<sub>2</sub> during its growth phase. Therefore, it delivers a net CO<sub>2</sub> absorption of 0.7 ton per m<sup>3</sup>. Concrete, by comparison, does not provide an embedded carbon benefit.

Wood can boast an overall CO<sub>2</sub> footprint that is 10-30% lower than alternatives

## Comparison of Actual CO<sub>2</sub> Footprint of Materials in the Same Application (Structural Construction)



In addition, wood is also three times lighter than concrete, which helps to further save material in construction. In short, wood is the most environmentally sustainable construction material compared to its alternatives, and this factor has to ultimately drive its growth if we believe in a carbon neutral future. If all countries used as much wood as Sweden (where, as we have seen, wood construction accounts for 52% vs. 48% for cement), not only would concrete use be cut by half; the construction phase of all global buildings would also generate zero net emissions, since wood's carbon absorption would compensate for other materials emissions.

<sup>1</sup> Megapascal (MPa) units measure mechanical strength in structural applications.



# The Comeback of Wood Construction

**W**e believe wood construction is making a comeback. Regulation, technological advances and economic convenience are catalysts for growth in many regions. However, these catalysts are not fully developed yet. In fact, some present constraints which, in the short term, cause tensions and slow down the industry's growth. Consumer perception in particular acts as a regional limiting factor. Below we analyze wood construction's three growth catalysts and its main constraint.

## CATALYSTS FOR GROWTH

### 1. Regulation:

As briefly mentioned above, over the past century regulations have deterred wood construction, mostly because of fire hazards. Over the past 20 years, things have changed. Regulation across different re-

gions of the world has started to embrace the environmental benefits and technological advancement delivered by wood. The benefits are, however, still mitigated by a patchwork of divergent regional rules that complicate and stifle the industry's full potential. In other cases, rules simply need time to yield benefits.

The most notable regulations favourable to wood are:

- **ETS: The EU Carbon Tax on Wood's CO<sub>2</sub>-Intensive Alternatives:** All recent EU policies are favourable to wood, which can be a major contributor to the EU's Green Deal. Of these, the most impactful will be the Emissions Trading Scheme (ETS), (previously covered by *Ambienta's Lens The EU's Revamped Carbon Pricing Policy*.) It will indirectly improve the economics of wood in Europe and the UK by taxing the CO<sub>2</sub> footprint of other more polluting construction materials. Carbon credits on cement and steel will be reduced in 2026 and will end altogether by 2030. Cement and steel will henceforth be priced according to the CO<sub>2</sub> used in their production. The specific economic impact of ETS is discussed below.
- **Lifting the Ban on Multistorey Buildings:** Historic caps on the height of wood buildings are being removed in many regions, following technological advances in wood construction. This inevitably but slowly opens development opportunities in new segments and uses. Sweden's pioneering 1995 law has only delivered a 20% share of Swedish multi-storey buildings in almost 30 years. Other countries are following, albeit at different speeds and permitting different heights. The U.S. is a case in point: the 2021 rule allowing buildings to reach from six to 18 storeys depends on the approval of individual cities, which have different rules and caps.
- **Mandating the Use of Wood in Public Buildings:** Countries establishing wood's prominence in public buildings are expected to increase. Two notable examples exist today. In France, by 2022 at least 50% of all new public buildings will have to be made of wood or renewable materials. In addition, buildings higher than eight storeys meant for the 2024 Paris Olympics

will require 100% wood. In Finland, the Ministry of the Environment has set incremental targets for the percentage of wood in public buildings. By 2025, the goal is 45%.

### Regulatory Challenges:

Unlike cement and steel, whose structural characteristics depend on chemical formulas established and certified hundreds of years ago, solid wood can vary in strength by over a hundred-fold according to its biological origin (species, natural cracks, knots, etc.). Plus, it undergoes varying technological processes, many of which have been recently developed. Hence, the structural certification of wood, which is required when it is used in construction, is complex. Also, different countries have different structural standards and requirements: CE in Europe, MTP in Australia, ANSI in the US. A wood builder wanting to operate internationally will spend considerable time and effort in meeting them. A mid-sized wood products company we spoke to has a team of seven people dedicated to regulatory work.

Finally, the European wood industry is highly fragmented and lacking a strong lobbying group in Brussels, unlike the cement and steel sectors. Individual national associations exist and are vocal. But the lack of the thrust of a strong, central voice advocating for the industry is a weakness and a source of frustration for many players. For example, while specific high-energy performance proxies (i.e. heating requirements) during a building's lifetime can be achieved and certified, this is not true when assessing the overall environmental footprint. This kind of certification would evaluate the materials used for construction; in the case of wood, this would clearly recognize its superior environmental performance. Although this cannot be certified today, it could become a standard if a strong wood lobbying group existed.

### 2. Technological Advances:

Significant technological advances since the 1990's have deeply transformed the way wood is used in construction. New treatments and assembly capabilities are creating market opportunities that were hitherto inaccessible to wood. They are also allowing wood to be the darling of world-class architects, who are using wood in innovative and beautiful buildings.

- **New Products and Uses:** Cross laminated timber, glulam and laminated veneer lumber, the result of gluing together multiple layers of timber, are 10 times stronger than solid wood and as strong as steel. Plus, they are lighter. Further, fire and moisture resistance have been greatly improved thanks to innovative chemical and thermal treatments.

These characteristics enable wood to be used in multi-storey buildings, both residential and commercial, and large projects like stadiums, concert halls and museums. They are also well-suited to the densification of urban planning, which favours adding storeys to existing structures and re-purposing old office buildings for residential use.

Wood can be a major contributor to the EU's Green Deal

- **Assembly and Prefabrication:** Assembly processes, driven by digitalization, are making leapfrog advances in wood construction. Timber is a great fit with Building Information Modelling design and Computer Numerally Controlled manufacturing in factories. Wood's texture, lightness and ease of assembly are ideal for splicing, lamination and modular volumetric prefabrication.

Benefits are especially strong compared to traditional construction, where ageing and lack of skilled workers are major issues. Comparatively, wood also delivers modular and adaptable design solutions, and prefabrication in factories. Avoiding on-site construction in densely-populated areas speeds up time (+55%), reduces disruptions (-80% truck deliveries) and pollution (-35% CO<sub>2</sub> emissions and up to -90% waste during production), and ensures higher quality. An in-depth analysis of these benefits is found in our Lens *Sustainable Construction – the Prefabrication Opportunity* published in 2020.

Finally, prefabrication has shed its reputation as the ugly duckling of construction. Famous architects have begun embracing prefabrication in part or in whole, turning wood into cutting edge and beautiful designs. Kengo Kuma, Shigeru Ban, Herzog & de Meuron and Frei Otto, all winners of the Pritzker Prize, are raising wood and prefabrication to new aesthetic and design heights.

**Technological Challenges:**

Adopting rapidly changing technologies in wood construction poses challenges: not all players are able to keep up. Architects and construction companies are often not up-to-date with the latest solutions available. Industry experts have told us that designs often over-estimate the amount of wood needed for a building by up to 20%.

**3. Economic Convenience:**

Today, building with wood generally does not deliver a strong economic benefit, but we believe that it will in the future. New technologies and greater know-how on the part of all players, favourable regulation and the need to optimize the skills shortages that penalize traditional



The Odunpazari Modern Museum in Turkey is built with wood and designed by Kengo Kuma

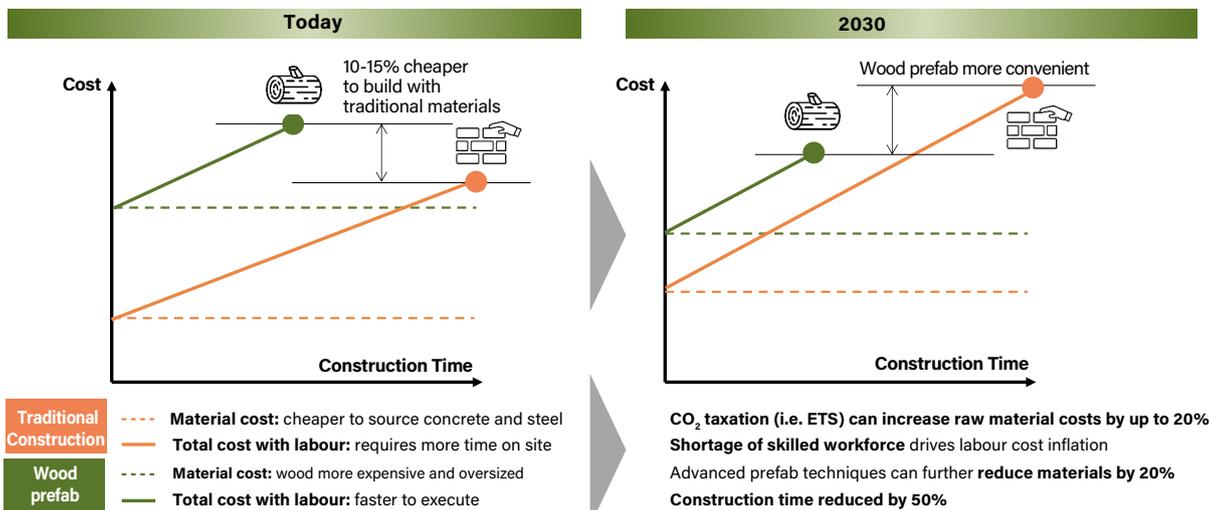
construction will trigger this shift.

Making a clear-cut assessment of wood's economic benefits compared to its alternatives is complicated, given the lack of available data and the many variables involved: different construction techniques, proximity to raw materials, design complexity, regional standards, personal choices and sensitivity to shorter/longer paybacks. Regional differences also apply: in markets where wood has reached a critical mass, prices are comparable or even cheaper than alternatives. Where less developed, prices are higher and require greater initial capital investments.

The following chart provides Ambianta's estimates for prefabricated wood's higher economic convenience compared to alternatives in the next decade. Currently, traditional construction delivers a 10-15% economic advantage over wood although it takes longer to complete. Lower traditional raw material prices help offset higher labour costs and longer site times. Instead, wood's faster execution cannot compensate for a raw material that is two to three times more expensive.

But, on the way to 2030, ETS benefits will kick in in Europe and the UK, penalizing CO<sub>2</sub>-intensive materials with a price spike of up to 20%, and a shortage of skilled workers will drive labour cost inflation in traditional construction. By contrast, continuously evolving prefabrication techniques may reduce materials needed by as much as 20% and halve construction time.

**Current and Projected Construction Costs for Traditional Cement Construction vs. Prefabricated Wood**



The ETS will help make wood more convenient in Europe, the UK and in countries where carbon credits will be accounted for. At a carbon price of € 50 per ton of CO<sub>2</sub> emitted material, the cost of armored concrete (which is reinforced with steel) could rise by 10%. But if carbon is priced at € 150 per ton, it could jump by 30%. And since structural materials can account for up to 15% of total construction costs, these increases can be decisive in shifting economic convenience in favour of wood.

Finally, as the different variables fall into place, ETS kicks in, and markets scale, we estimate that wood convenience will accelerate and further catalyze growth opportunities for wood construction.

### Consumer Perception

Consumer perception about wood construction varies by region. Not surprisingly, it is more negative in markets where wood buildings are less developed and is fuelled mostly by worries about durability and fire hazards, and environmental consciousness. These concerns inevitably restrain the development of the market today and present a chicken-and-egg dilemma which will be difficult to solve.

This point is made clearly in a 2022 European survey on consumer perception which shows that the most

important positive attribute associated with wooden buildings is environmental sustainability and the most negative is durability and fire risk. In Northern Europe, people have an excellent understanding of wood's sustainable benefits and real risks. In Western and Eastern Europe, respondents still claim that wood is less durable because of moisture and fire. In Southern Europe, 100% of respondents agree that fire is a major problem with wood buildings.

We know that these concerns are unfounded. Compared to steel, which buckles in extreme heat, wood generally behaves more predictably, providing people more time to evacuate. Today, wooden buildings comply with rigorous fire regulation and no statistical correlation between modern wood buildings and increased fire hazard exists.

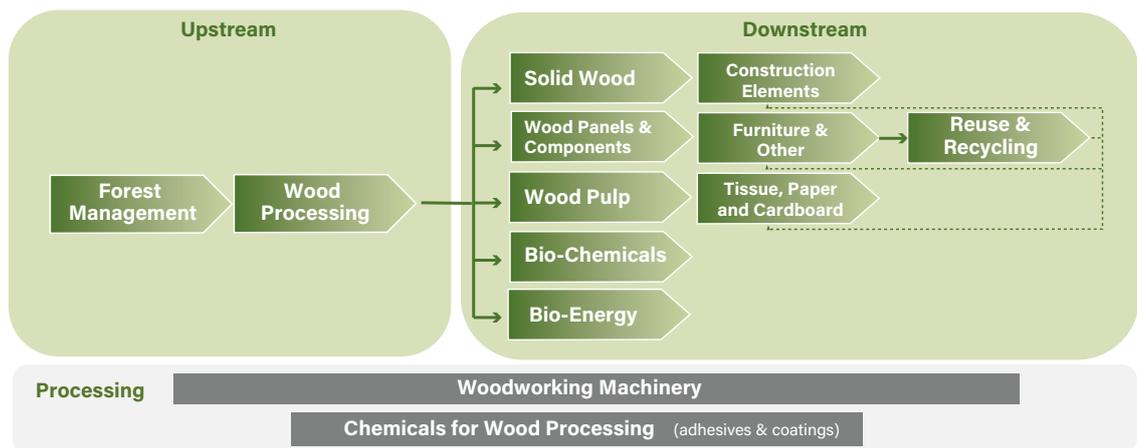
Consumer preferences take time to change. But, driven by environmental considerations, economic benefits and more aesthetically pleasing designs, people will become more favourable to wood. We notice this shift starting to occur in markets that have been slow to adopt wood construction. In Germany, heightened environmental sensitivity has steadily pushed the share of wood prefabricated single and double-family houses from 15% in 2011 to 23% in 2021. In Italy, wood-framed buildings have doubled over the last 10 years.

## Investment Opportunities

What follows is our analysis of investment opportunities in the wood value chain, where we identify segments that already deliver the most appropriate risk-return profiles for the asset classes we manage, from private equity to listed equities. The truly secular opportunities

in the construction industry may be difficult to seize through the short time horizons of typical investors. But Ambienta was created to capitalize on long-term environmental trends, and we continually monitor industries which deliver opportunities over time.

### Wood Value Chain and Related Services



#### 1. Upstream

Integrated forest managers have a natural competitive advantage. The wood biomass can be monetized either through rental agreements, direct harvesting or the sale of sawn wood. Since they are generally vertically integrated, they can provide forest-based products in different markets whose products have a growing added value.

The outlook for these players is positive because of the expected growth of: 1. wood in construction, 2. specially-treated paper used in packaging (i.e., wood-based foams that replace polystyrene and bio-based films that make paper water repellent), 3. applications that replace plastic. These three areas will not only offer growing market opportunities but also increase the value of forest assets.

Forestry companies used to be considered low-return investments. Historically, their return on invested capital (ROIC) was below 5% on average. Over the past 5 years, the average ROIC of the same companies doubled to 10% thanks to sustained wood pricing and their ability to produce higher value-added products vs simple wood trading.

Stora Enso, one of the largest forest owners globally, has reviewed upward the value of its forests by over 50% in 2019-2021 alone. It is also a great example of an integrated forest manager that is capturing increasing value from the wood it owns. In fact, this player is the global leading producer of cross laminated timber and is actively researching ways to further extract value from its wood, including a wood-based graphite anode to replace fossil-based graphite in batteries.

## 2. Woodworking Machinery

The growth of wood products will drive opportunities upward in the value chain. In fact, secondary processing for solid wood products, wood panels and paper requires additional processing steps: Computer Numeric Control machining, treatment with chemical, heat and pressure technologies, sophisticated assembly, quality control and varying degrees of factory automation, ranging from manual carpentry workshops to fully-automated production lines.

An especially interesting process is linked to the reduction of waste, which can reach 50% of the weight of a standing tree. X-ray technology in sawing operations maximizes cutting, reduces tree defects and waste while also certifying the actual strength of each piece of lumber.

Homag, a part of the Durr Group, has a 30% market share in wood processing machinery, which has historically served the furniture and fixtures markets. The company's new growth strategy focuses on doubling its revenue share of machinery for wooden construction from 10% to 20% in the medium term, representing a 20% CAGR versus a 3% CAGR for the rest of its business.

Some private players in the wood machinery space enjoy market leadership in their relative segments. Companies with distinctive positioning in inspection and Numeric Control machining as well as in presses for cross laminated timber have up to 20% EBIT margin and can achieve ROIC above 20%.

## 3. Downstream

The construction industry is the most interesting investment opportunity among the various end-uses of wood. The value of the cross laminated timber market is estimated to grow over 20% per year for the next decade, from €1 Bn in 2019 to €9 Bn in 2030 compared to total roundwood production volumes that have maintained a stable low single digit CAGR over the past decades. This is consistent with historical growth rates of cross laminated timber production capacity, which grew over 10 times, from 0.2 M m<sup>3</sup> in 2008 to 2.2 M m<sup>3</sup> in 2020.

Similarly, wood-based insulation products grew at 10% CAGR in the past decade compared to half that rate for general insulation despite having similar or lower thermal properties and being 10%-50% more expensive.

Ambienta believes that the business case for natural insulation materials has room to improve further for three reasons: first, wood fiber and cellulose insulation can be sourced from lower quality and more convenient wood; second, today wood insulation only accounts for 5% of all insulation materials, thus scale could still improve unit economics; third, traditional insulation made with oil derivatives and energy-intensive materials will also be affected by the EU's ETS policy penalizing high-carbon alternatives. Steico, with a 40% market share of Europe's natural fiber insulation market, has been constantly showing good operating leverage, with an EBITDA margin increasing from 16% to above 20% over the past 5 years. The company is expected to double its revenues in the next five years and has been adding additional capacity in anticipation of higher demand.

Many more investment opportunities can be generated from the need to make the wood value chain itself more environmentally sustainable. Challenges of the wood value chain are waste management, chemicals use, biodiversity loss, energy intensity. A dedicated Ambienta Lens would be required to address all these issues.

The construction industry is the most interesting investment opportunity among the various end-uses of wood

### BIOPHILIA: WOOD IMPROVES WELLBEING

Growing scientific evidence points to the health benefits provided by wood interiors. Seeing, touching and smelling wood generates a greater feeling of comfort while lowering stress and blood pressure. Creativity and focus also improve in spaces with wood surfaces compared to steel or cement. Further, wood's greater ability to regulate humidity and absorb volatile organic compounds helps improve air quality.



<sup>(9)</sup> Thomas Berg, LUNDS UNIVERSITET, Statistical analysis of firefighting and damage caused by fire in mid-rise timber-framed residential buildings compared to other construction types



## CAP VERT

In September 2021 Ambienta's Fund III portfolio acquired Cap Vert, a leading French player in green space management and environmental services, to help it expand geographically. Since then, it has made four acquisitions. These position it uniquely as a top provider of high value-added ecological engineering services for natural and sensitive habitats and as a leader in the creation and maintenance of green spaces.

Cap Vert's activities help increase CO<sub>2</sub> absorption by up to 70%, reduce urban heat island effects (thus reducing A/C needs), improve water flow management and support biodiversity preservation in cities.

Cap Vert activities in 2021 reduced 35,000 tons of CO<sub>2</sub> equivalent to the emissions of 16,500 passenger cars in Europe.



## Summary of Key Findings

**Upstream:** the increased demand for wood products (in construction and in applications to replace more polluting materials) will support the price for wood and increase the value of forests.

**Woodworking Machinery:** benefits will flow down the value chain and capitalize on opportunities in factory automation, waste reduction and the production of cross laminated panels, glued-laminated timber and paper. Investment opportunities exist in taking advan-

tage of the underlying market expansion and by making these processes more environmentally sustainable.

**Downstream:** architecture, engineering and construction firms specialized in wood-based buildings can differentiate themselves and achieve above-market growth. Plus, wood's ideal suitability to prefabrication will deliver new opportunities. Finally, fast-growing wood-based insulation will continue being a high performer.



## Conclusion

Wood construction is destined to make a comeback. It will be driven by its superior environmental performance compared to alternative materials and by the resolution of challenges and tensions in regulation, by technological advances and, thus, by economic convenience. A likely change in consumer perception in underdeveloped markets will further spark this growth.

Investment opportunities in this space abound across the entire value chain. As always in our Lens, we have identified the segments that offer the most appropriate risk-return profiles for the asset classes we manage, from private equity to listed equities.



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