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Wood Preservation Practices and Future Outlook: Perspectives of Experts from Finland

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Abstract: This paper examined wood preservation practices and outlook considering climate change from the perspective of Finnish experts through interviews. Key findings highlighted that: (1) pressure impregnated wood will continually evolve and secure its market, and it seems worthy of developing modified wood products, especially with the increasing attention to recyclability and lifecycle concepts; (2) demand for highly processed surface treatment products is high; (3) opportunities for more sustainable and environmentally friendly wood preservation methods, and thus production volume will increase in the future; (4) increasing mold problems in Finland due to climate change make surface treatment more important than ever; (5) demands for fire protection treatments are increasing, but fire testing fees and processes have slowed product development; (6) although the possibility of the spread of termites triggered by global warming to Finland seems to be a future scenario, this issue needs to be considered in products exported to hot countries; and (7) preservatives have become more critical to protect untreated wood from the adverse effects of climate change. It is believed that this study will help accelerate the transition of innovative and environmentally friendly wood treatments on the Finnish market, thereby promoting the use of wood in the building construction industry.

Keywords: wood/timber; preservation; thermal modification; impregnation; surface treatment; climate change; experts; Finland

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1. Introduction

As one of the major producers of greenhouse gas emissions, the construction industry contributes to around 40% of energy-related CO_2 emissions globally [1–5]. Moreover, building construction in the European Union (EU) consumes 40% of materials and 40% of primary energy and produces 40% of annual waste [6]. Thus, changes and regulations for the construction industry can play a critical role in reducing CO_2 emissions and in the fight against climate change [7]. Today, there are two basic approaches applied in the construction industry to reduce environmental impacts: (i) the use of environmentally friendly materials; and (ii) optimizing energy consumption throughout the building's service life [8].

In this sense, wood as an environmentally friendly material is associated with lower carbon construction and lower embodied energy consumption compared to non-wood buildings [9–11]. Timber buildings offer significant benefits in the fight against climate change, as wood can be used as a substitute for other construction materials to minimize greenhouse gas emissions, but also has distinctive properties, e.g., storing enormous amounts of carbon in the structure [12–15]. Besides being used as a construction material, timber can be reused as a raw material for other buildings after its service life or incinerated as a last resort [16,17].

With the increasing environmental awareness and the use of low carbon footprint construction methods and materials that have become widespread recently, the position of wood products in the construction sector has been significantly strengthened [18–22]. For example, the Finnish Ministry of Economic Affairs and Employment is involved in Finland's national energy and climate strategy (2016) as part of the promotion of wood construction measures, which aims to promote the energy and climate targets adopted in the EU achievement by 2030 [23]. Regarding this, with the 2030 Climate Target Plan, the European Commission is proposing to raise the EU's target of reducing greenhouse gas emissions by at least 55% below 1990 levels by 2030 [24].

Today, the use of wood as a structural material is increasing relatively and developing with new applications including multi-story and tall building practices [25–29]. The increasing use of wood in construction is crucial as it is renewable, bio-based, can store large amounts of CO_2, and can replace traditional building materials, e.g., concrete and steel that are less environmentally friendly [30]. Moreover, for this reason, the use of wood in construction has been identified by the United Nations as a key tool in tackling climate change [31]. In this sense, the protection of wood is of critical importance for it to reach its full potential in the market and, accordingly, to fulfill its role in the fight against climate change [32].

Although one of the main problems of timber is its combustibility, which is an issue of high legislative prominence and a main concern for the public [33], timber may be subject to other sources of deterioration depending on its use (e.g., indoor, outdoor, exposure to precipitation, contact with the ground, marine environment) [34]. Wood exposed outdoors can be weathered by various abiotic elements including wind, dust, rain, and sunlight. Both moisture in the air and liquid water can be absorbed by the hygroscopic structure of timber and create dimensional changes, causing it to cup, warp, and crack [35]. If proper conditions are provided, living organisms, e.g., fungi, molds, and insects can be fed on nutrients found in their structural components or parenchyma [34]. All this will unavoidably change its chemical and physical features and appearance and, as a result, shorten its lifespan. This fact is of ecological and economic significance because the requirement to replace defective wooden parts makes it less competitive against other construction materials.

Additionally, wood's greatest weakness is its susceptibility to biological influences such as decay, which can become an issue that greatly limits its use as a building material given building regulations such as fire code [36,37]. The number of environmentally oriented studies and developments in wood products is increasing to improve the efficiency of wooden structures and thus their competitiveness against non-wood structures (e.g., [38,39]). Finland's climate is becoming progressively challenging for an increasing number of wooden structures. Continuing with the current model, climate change is expected through an increase in precipitation, flooding, and storms, among others, as well as other extreme weather events such as the intensification and generalization of severe heatwaves [40].

Good construction practices can prevent the wood from deteriorating by reducing its exposure to some sources of deterioration. Choosing naturally durable species or high-quality materials such as heartwood can also contribute to extending the service life of timber products. On the other hand, the cost and availability of hardy species and the ever-increasing importance of fast-growing, lower-quality timber call for other options [41]. Wood treatments become a very reliable solution to make the wood more resistant to deterioration. The most common method of wood preservation involves the application of preservative chemicals [42]. Numerous treatments such as thermal and chemical modifications (e.g., [43,44]) thermo-mechanical condensation (e.g., [45]), and impregnation (e.g., [46]) have been advanced in recent years. Wood can be impregnated with vacuum/pressure methods to deeply embed biocidal, hydrophobic, and fire-retardant materials into its structure [47]. Additionally, timber can be easily protected on its surface by various organic, mineral, or metallic coatings [48] or by various surface treatments.

The literature to date lacks a broad understanding of wood preservation practices and outlook in Finland. This study aims to provide an overview of the future of the wood preservation industry, as well as highlight the potential of wood preservation methods. It is important to know the woodworking methods that have potential in the future and to find out in which direction the currently used methods are developing. It is also critical to learn what challenges the changing world and environment may present, whether wood preservation can meet them, and how today's wood preservation methods adapt to the new requirements. By examining them, the study provides a proactive overview of the future of wood preservation methods. Overall, the aim is to gain a more comprehensive understanding of the current state of these practices and particularly climate change, from the perspective of industry professionals, mostly on the manufacturing side, through literature and interviews as comprehensively as possible. Since increasing the use of wood is key, reducing the environmental impact is crucial, especially in the methods and products used to preserve the wood on an industrial scale. Wood preservation methods, which can be produced industrially, cost effectively, and environmentally friendly, have the highest potential to affect the construction industry and environmental impacts.

In this study, timber or wood refers to engineered wood products [49,50], e.g., cross-laminated timber (CLT—a prefabricated multi-layer engineered wood product, manufactured from at least three layers of boards by gluing their surfaces together with an adhesive under pressure) (Figure 1), laminated veneer lumber (LVL—made by bonding together thin vertical softwood veneers with their grain parallel to the longitudinal axis of the section, under heat and pressure) (Figure 2), and glue-laminated timber (glulam) (GL—made by gluing together several graded timber laminations with their grain parallel to the longitudinal axis of the section) (Figure 3).

The remainder of this work is structured as follows: First, wood use in Finland is presented. This is followed by a description of the research methods used. After this section, the findings based on the interviews with Finnish experts in wood preservation and a comprehensive discussion section are provided. Finally, the conclusions and future prospects are given.

Figure 1. CLT (source: Wikipedia).

Figure 2. LVL (source: Wikipedia).

Figure 3. Glulam (source: Wikipedia).

2. Use of Wood in Finland

More than 75% of the land area in Finland is forest, where more than 20 million hectares are suitable for timber production. Annual forest growth in Finland is more than 100 million cubic meters, and annual log volume is about 60 to 75 million cubic meters, which means that the timber stock grows year after year. The total timber stock in Finnish forests today is about 2.5 billion cubic meters, 1.7 times the volume recorded in the 1920s, making Finland the country with the fifth-largest timber resource in Europe after Russia, France, Sweden, and Germany [51].

Finland has long traditions in the use of wood for printing and writing papers and packaging materials, construction and interior design, and energy production. Today, most of the round wood in Finland is consumed by pulp and sawmills, and the most important roundwood varieties are pine pulp wood and spruce logs (Figures 4 and 5) [52]. Wood is also used in the manufacturing of many other everyday products such as cosmetics, pharmaceuticals, and food. Modern technologies also allow the use of components derived from wood to produce clothing, plastics, asphalt, or animal feed. Increasing and disseminating the use of wood in diverse ways and for multiple purposes has been determined as a target in many strategies, including the National Forest Strategy 2025 and the Finnish Bioeconomy Strategy.

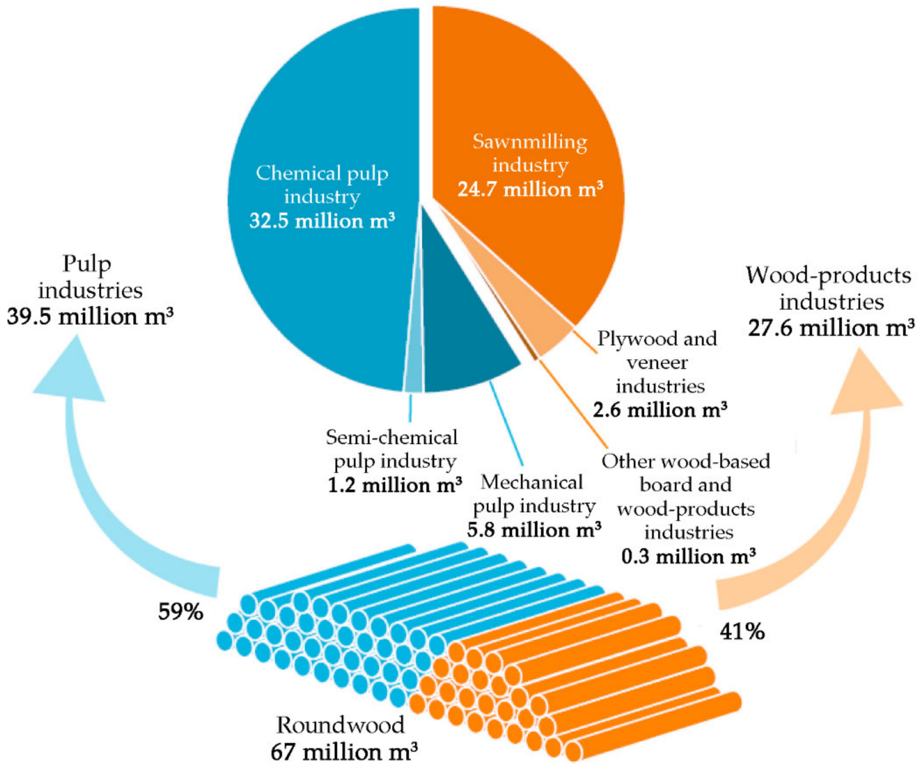

Figure 4. Use of wood in Finland.

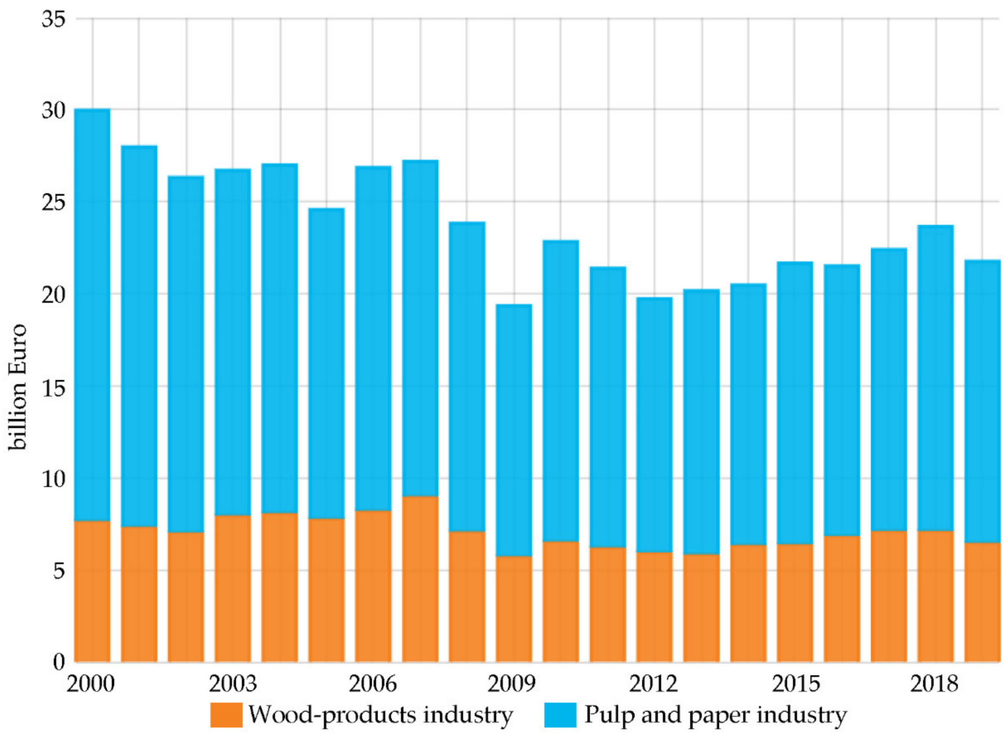

Figure 5. The gross value of Finnish forest industries (2000–2019).

Wood-based solutions have traditionally held a strong position in Finland's construction industry, accounting for around 40% of all building materials, of which around 80% of single-family homes have timber-framed solutions [53]. Wood is used on construction sites in structures, windows, doors, and finished surfaces, as well as in making formwork, among other uses. About 12 million cubic meters of sawn wood was produced in Finland in 2018. The industry has a significant impact on total sawn wood consumption, as around 80% of sawn wood is used for construction. Wood-based construction, which has been intensively developed in Finland since the early 1990s, has focused especially on large-scale wooden structures and increasing the energy efficiency of buildings mostly thanks to legislative support and government incentives.

As processed sawn timber, thermally modified wood is produced using the ThermoWood® process in two product classes in Finland, Thermo-S and Thermo-D, which determine the properties and uses of the final product [54]. In the ThermoWood® process, the quality of thermally modified wood is not controlled by the quality classification of untreated sawn timber, as the lumber to be thermally modified is graded according to its quality criteria before thermal modification. Figures 6 and 7 show ThermoWood® production statistics by years and wood species, respectively [55].

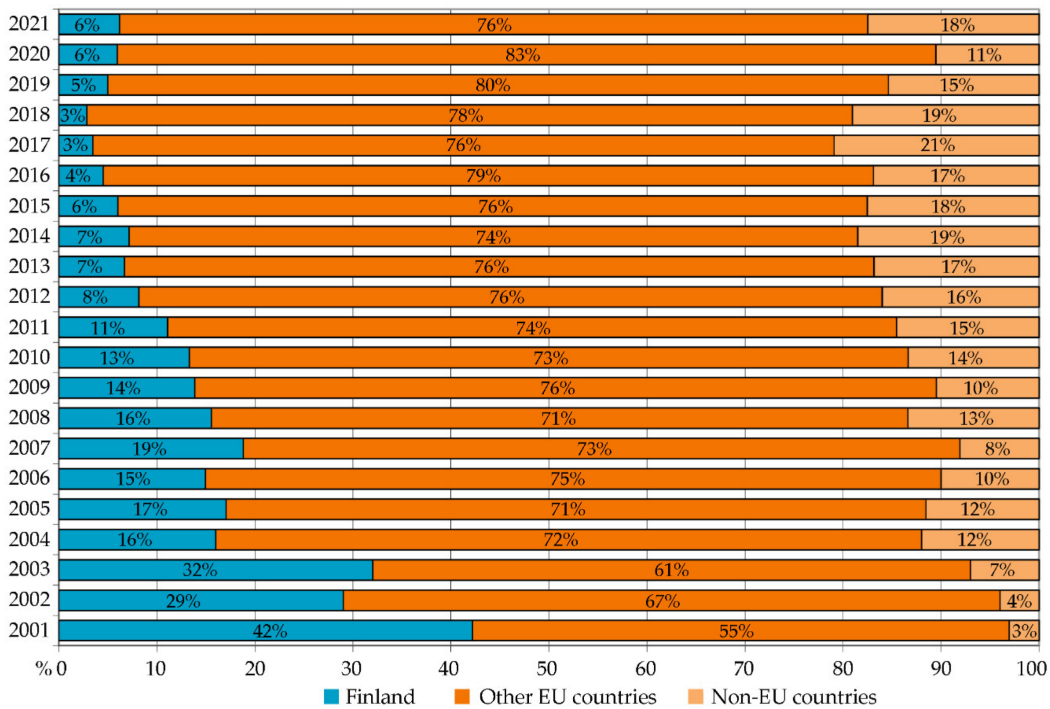

Figure 6. ThermoWood® production statistics by years.

In Finland, impregnated timber is pine timber impregnated with an impregnation agent containing copper compounds (C impregnation) of classes A and AB. While class A with a thickness of sawn timber ≥48 mm is used for structures in contact with the ground and water, class AB with a thickness of sawn timber ≤48 mm is used for structures above the surface of the ground. The most common lengths of impregnated timber range from 2.7 m to 5.4 m in 300 mm steps in Finland, and in terms of colors, besides traditional green, there is also brown, which is made by adding a colored pigment to the impregnation agent [56].

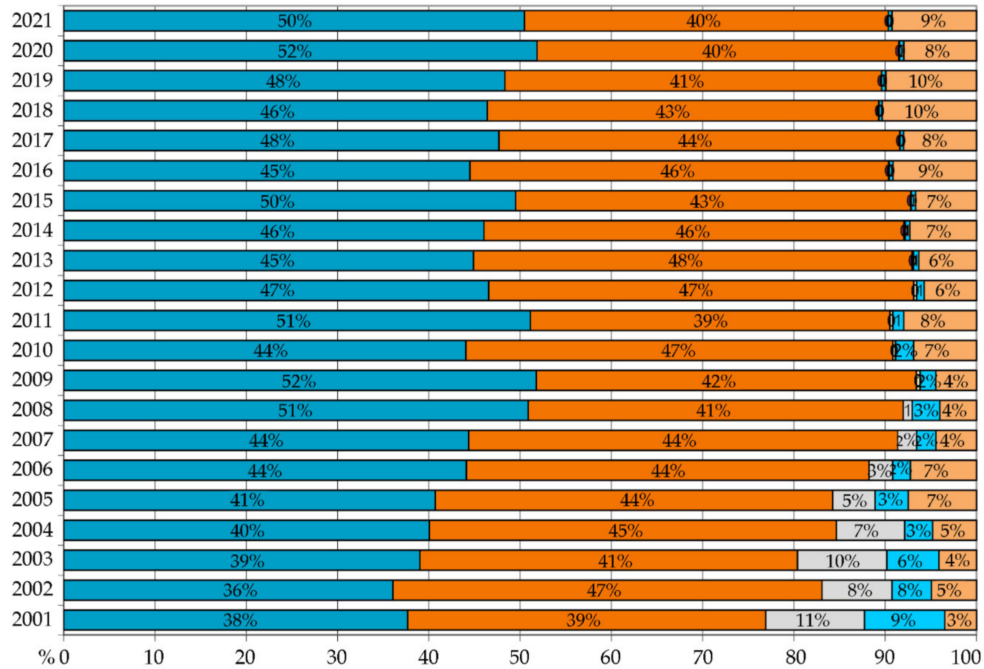

Figure 7. ThermoWood® production statistics by wood species.

There are currently 18 impregnation plants in Finland. In 2020, a total of almost 342,000 cubic meters of industrially impregnated wood was produced in Finland as seen in Figure 8 [57]. The share of impregnated sawn timber was about 280,000 m^3. The share of poles was 47,000 m^3 and crossties were 16,500 m^3. More than 90% of the impregnated lumber and about 30% of the poles were delivered to Finland. Lumber is impregnated in Finland with arsenic- and chromium-free copper impregnations. Crossties and poles delivered to the export market are mainly impregnated with creosote oil.

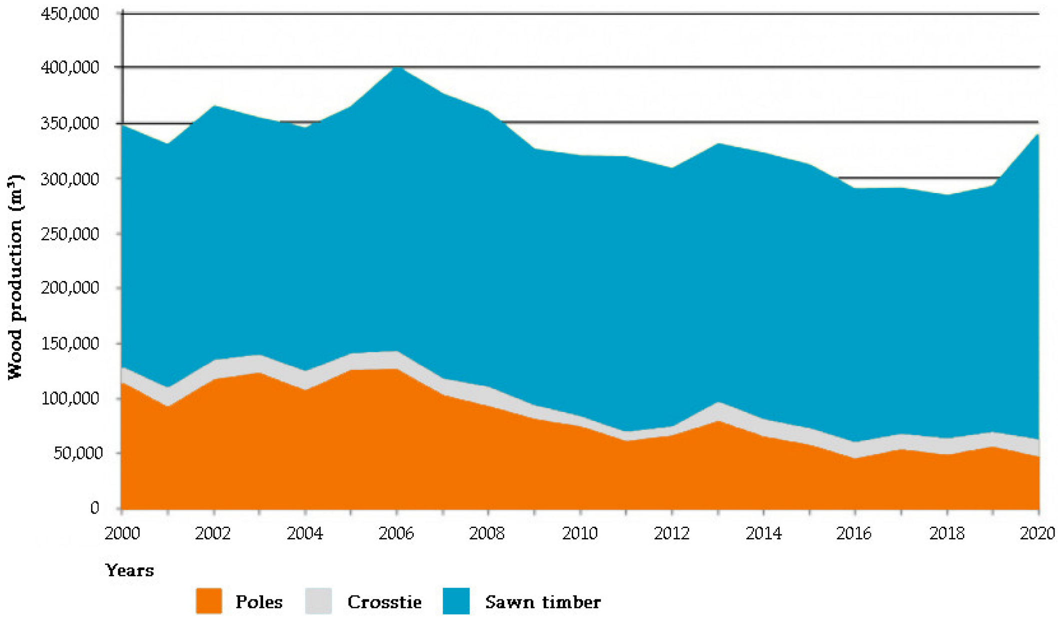

Figure 8. Industrially impregnated wood in Finland (2000–2020).

3. Research Methods

This research was carried out through a literature review and interviews [58] with experts to deepen the study (see Table 1). Representatives of various products were extensively selected for interviews to bring together as many different views as possible. The purpose of the interviews was to gather new information and new insights into wood preservation processes that have the potential to drive trends in wood construction and wood preservation products.

Table 1. Interviewees by their position/title, area of expertise, and organization type.

	Interviewee 1	**Interviewee 2**	**Interviewee 3**	**Interviewee 4**
Position/Title	Quality and environmental manager	Executive director	Managing director	Deputy director of the research team
Area of expertise	Thermal modification and impregnation	Thermal modification and impregnation	Thermal modification and impregnation	Thermal modification and impregnation
Organization type	Timber product company	Timber product company	Timber product company	University
	Interviewee 5	Interviewee 6	Interviewee 7	
Position/Title	Key account manager	Sales manager	RDI-manager	
Area of expertise	Surface treatment products	Surface treatment products	Surface treatment products	
Organization type	Surface treatment product manufacturer	Surface treatment product manufacturer	Surface treatment product manufacturer	

In this study, semi-structured interviews were employed as the ideal approach for data collection, as the practice allows for interactions of the interviewer and participant, and different perspectives inspire the creation of new topics beyond those originally explored [59,60]. The interview themes and questions were formed largely based on the trends observed in the literature review. Interview topics and questions are presented in Appendices A and B (see also Tables 2 and 3). Interview questions were prepared considering the interviewed experts' knowledge and experience in matters related to the wood preserving treatments. Interviewed firms and companies suggested the most appropriate of their staff to answer the questions sent to them in advance. Questions asked in Appendix B were used for surface treatment products when interviewing representatives. Otherwise, those in Appendix A were used as interview questions.

Interviews were organized via email and administered via online video conferencing. The program made it possible to record the interviews, which facilitated the analysis of the interview results. After the interviews, the video recordings were reviewed, and the results of the interviews were written clean and sent to the interviewees by e-mail for further review and completion. The improvements came from emails and one from a new Microsoft Teams conversation.

Table 2. The main themes, addressee, and main purpose of the interview questions (Appendix A).

<table>
<tr><th rowspan="2"></th><th colspan="2">Main Themes</th><th rowspan="2">Addressee</th><th rowspan="2">Main Purpose</th></tr>
<tr><th>Topics</th><th>Sub-Topics</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Pressure impregnation</td><td>Effective alternative method</td><td rowspan="13">Thermal modification and impregnation experts</td><td rowspan="13">Identifying experts' views and outlook</td></tr>
<tr><td>Future outlook</td></tr>
<tr><td>Modified wood products as substitutes</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Climate change and environmental concerns</td><td>Demand for the products</td></tr>
<tr><td>Wood construction trend</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Commercial modification methods</td><td>Heat-treated wood</td></tr>
<tr><td>Commercial success in modified wood products</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Fire protection</td><td>Upgrading the fire class of timber</td></tr>
<tr><td>Long-lasting surface treatment</td></tr>
<tr><td>5</td><td>Termite resistance</td><td>Effect of wood modification</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Untreated wood</td><td>Carbon footprint and building maintenance load</td></tr>
<tr><td>Finland's fight against climate change</td></tr>
</table>

In this paper, the authors analyzed the data. Due to the manageable number of the interviewed group, the analyzes were carried out manually, without using any numbering system for the responses, by going through the answers, highlighting the points emphasized by the interviewees, and classifying them. Categorization of the obtained data is an essential part of the analysis [61]. In assessing the reliability of the results, it should also be noted that the opinions are geared towards presenting a comprehensive picture of the future through fact-based forecasting. The responses were categorized under the identified recurring themes: (1) pressure impregnated and modified wood; (2) surface treatment products; (3) climate change and environmental concerns; (4) marketing of products; (5) fire resistance; (6) termite resistance; and (7) untreated wood. The results of the interviews and the identities of the interviewees were kept anonymous and confidential.

Table 3. The main themes, addressee, and main purpose of the interview questions (Appendix B).

	Main Themes		Addressee	Main Purpose
	Topics	Sub-Topics		
1	Wood surface treatment products	Popular products	Surface treatment product manufacturer	Identifying experts' views and outlook
		Demand for certain products		
		Main trends		
2	Climate change and environmental concerns	Demand for the products		
		Wood construction trend		
3	Fire protection	Upgrading the fire class of timber		
		Demand for the products		
4	Termite resistance	Effect of surface treatments		
5	Untreated wood	Carbon footprint and building maintenance load		
		Finland's fight against climate change		

4. Results

As noted in the previous section, the results of the interviews were divided into themes that provide a comprehensive picture of the current state of the wood preservation industry and its main developments. The themes occurred in more than one context in the interviews, regardless of whether the relevant question addressed a particular theme or who the interviewee was. Interview results were presented according to the following categories: (i) pressure impregnated and modified wood; (ii) surface treatment products; (iii) climate change and environmental concerns; (iv) marketing of products; (v) fire resistance; (vi) termite resistance; and (vii) untreated wood as shown in Tables 2 and 3.

4.1. Pressure Impregnated and Modified Wood

Responses from interviewees with industrial expertise highlighted that the currently used impregnations have succeeded in substituting the previously banned chromated copper arsenate impregnations, which have been replaced by copper-impregnated water-based impregnations that have been in use for nearly 20 years for wooden, telegraph and power poles, and game fences. It was pointed out that today's impregnations are functional even in the toughest conditions, function in terrace and courtyard constructions, and meet the service life expectations and needs of customers. Moreover, the interviewees' answers emphasized that a common Nordic NTR quality system [62] is being developed; product performance tested in field trials as well as safener concentrations are evaluated. Regarding this, product quality, i.e., durability, was considered essential for maintaining product competitiveness and reliability, and above all for good personal safety, responsible for the needs of the necessary user structures.

According to the sectoral experiences of the interviewees, it was foreseen that wood preservation methods will probably evolve into solutions that combine the properties of modification and pressure impregnation, such as copper oil impregnations, where the oil keeps the wood dry and preservatives such as copper prevent rot from progressing if the wood gets wet. However, it was thought that the number of approved biocides would decrease. It was also stated that copper oil impregnations are solutions that bring a longer service life to timber in industrial use.

Interviewees highlighted that although new regulations force the industry to develop new solutions and restrict the use of pressure-impregnated products, it is known that they are still safe to use, and their properties are constantly being improved. It was mentioned that the entry of new products into the impregnation market is a slow and long process, and the outcome is uncertain, the market supply of the products is regulated, and sufficient evidence is sought after to determine if wood preservatives are safe and effective. The interviewees' answers also emphasized that it should be ensured that the wood can be used in harsh outdoor conditions.

It was foreseen that since pressure-impregnated wood is a much cheaper alternative to modified wood products and that it will protect its market in the future. Moreover, interviews showed that although there are speculations that alternative solutions will replace the use of pressure-impregnated wood from time to time, it is not reflected in the production volume, on the contrary, the production volume of pressure-impregnated wood has increased in recent years. Finally, it was stated that the interest in modified wood products and various wood composites has increased and these products have some advantages that will replace the impregnation market. In this context, the necessity of processing wood for a better and longer life was underlined.

4.2. Surface Treatment Products

In the answers of the interviewees, it was emphasized that exterior cladding sheets and panels are the product group in which the most surface treatment is used in Finland, and paints are used in interior coatings and many waxes. Experts also noted that the trend is shifting towards priming and prefabrication of wood under controlled conditions, thus promising a maintenance painting interval of 10 to 15 years. It was stated that the handling of timber on construction sites is difficult to control and materials may be exposed to weather and moisture stresses and wet wood causes rotting problems under the surface of field painting. For this reason, interviewees underlined that pre-painting is an efficient way to avoid these damages, it reduces the amount of work carried out on-site and guarantees the longest possible maintenance paint intervals. Demand for highly processed products is also increasing because wood is used in larger buildings where maintenance painting is more challenging.

The answers of the experts pointed out that water-based products, which are much more durable, long-lasting, and flexible than old solvent-based products, are the most used surface treatment materials today. It was stated that the problem with alkyd oil paints is that they harden and lose their elasticity as they age and thus do not withstand the humidity changes in the wood at all, which means that the paint surface starts to crack, and they lose their gloss very quickly. Although opaque paints and topcoats that protect the wood are generally used, it was also mentioned that the popularity of transparent applications where the texture of the wood can be seen increases.

Interviewees highlighted that there are currently major differences in the binders used by manufacturers. For most product manufacturers, the products are currently based on alkyd, an alkyd resin, or plastic derivatives such as acrylate. It was also stated that bio-based binders will be increasingly used in surface treatment agents instead of raw fossil materials.

4.3. Climate Change and Environmental Concerns

Responses from interviewees with pressure impregnated and modified wood expertise highlighted that as a consequence of climate change, the demand and opportunities for sustainable wood products and therefore the production volume will increase in the future. In Finland, for example, it was noted that although pressure-impregnated wood is not currently used for exterior cladding, discussions on this issue may begin as climatic conditions become more challenging. These interviews pointed out that climate change and accompanying environmental concerns increasingly require the development of wood preservation methods. It was stated that smaller customers and individuals often find the use of wood as a construction material satisfactory, while larger customers make higher demands, such as carbon neutrality. It was also emphasized that the increasing demand for different certificates that show that products meet certain specifications today has led to more and more testing of the environmental impact of wood products.

The experts interviewed stated that modification can expand the uses of the wood, reduce the need to maintain the wood, and extend its lifecycle as important environmental objectives. It was highlighted that the non-toxicity of modified wood products is also a topical environmental goal; thus, all modified wood products aim to ensure that they reduce the environmental impact of the products. The answers of the experts showed that from an environmental point of view, more will be required of all materials in the future, as attention will be paid not only to the environmental impact during use but also to the overall environmental impact of the materials, which will increase the consideration of the carbon footprint of materials. When looking at lifecycle impacts, the need for maintenance also plays a significant role. However, it is not just about the materials, but also about their proper use. Structural solutions also aim to extend the lifecycle of products even further. Lifecycle issues and environmental impacts will be considered more comprehensively in the design of buildings. Attention was also paid to the recyclability of building materials at the end of their lifecycle. For materials, in the future, the requirements imposed can therefore be very diverse.

On the other hand, responses from interviewees with surface treatment product expertise highlighted that both the legislation and the customer require relevant certificates showing that all surface treatment agents are ecological. In addition, especially the young generation designers, as they want to use more environmentally friendly materials in their projects, define them very carefully in the material specification such as emission-free M1 class products. It was stated that many product manufacturers want to announce the bio-based percent of their products, which shows that the products are more environmentally friendly.

These interviews pointed out those lifecycle calculations and based on them the carbon footprint and GWP (global warming potential) are requested in the form of various certificates and documents. Especially on public construction sites, products may have limit values that determine whether the product can be used on that site. In these cases, a lifecycle calculation is often asked.

Climate change was strongly associated with non-plasticity, which will certainly be a megatrend in construction. The aim is to make the products such that they do not release microplastics into the environment. This could affect the popularity of acrylate paints, and on the other hand, they achieve the longest maintenance intervals.

Surface treatment product experts underlined that another trend, when environmental concerns are considered, is binders with different functions, which can dry faster or produce longer-lasting products. They stated that it is preferred to use products with long service intervals, especially in big buildings where wood maintenance is often more difficult, and in the long lifecycles of surface treatments, how the wood structures are made is also crucial. Improper structures such as water pockets and flat surfaces should be avoided to prevent water from affecting for long periods. Protecting the sawn surfaces of the timber from moisture also plays an important role on construction sites. Although the wood product naturally absorbs moisture from the sawn surfaces, the sawn surfaces of timber products are often left untreated. Dimensional instability caused by moisture causes timber surfaces to crack. Even if this is understood, sawn surfaces are often left unpainted as painting the surfaces will result in additional work on construction sites. Considering such matters, long maintenance painting intervals are obtained for today's surface treatments.

It was also pointed out in the interview that climate and environmental issues are at the heart of the product development of surface treatment agents, which in turn poses challenges when the various raw materials and biocides used in products are banned by the EU Chemicals Agency, where biocides regulation and chemical legislation control what types of biocides and raw materials can be used [63]. These regulations are constantly being tightened and biocides must always be replaced with something. Substitute products are usually toxins that often have poorer mold resistance and durability in general. It has been noted that the number of mold spores and therefore mold growth on wooden surfaces increased significantly in Finland's climatic conditions, which became more difficult with increasing temperature and air humidity. Therefore, there was a view that exterior cleaning of buildings, a common practice in Central Europe, would also become common in Finland. The need to develop bio-based solutions, which came to the fore with the prohibition of certain substances due to environmental concerns, was seen as one of the factors pushing the market.

In terms of untreated wood, based on the experts' response it was highlighted that with the loss of the ozone layer, the UV values are different than before, so the importance of painting as a protective treatment is also increasing. One of the most important functions of surface treatment agents is to protect wood against mechanical, chemical, and UV stress. Nowadays, water-based products achieve a 15-year maintenance interval. If considered that a wooden exterior cladding has a lifecycle of about 50 years, during which it is painted a few times, it will not have a significant effect on the growth of the carbon footprint of the exterior cladding. If the wood is left unpainted, it may affect the carbon footprint of the product to the extent of the paint surface, but this will increase the amount of maintenance work. If the lifecycle of the whole building is considered, the environmental impact of the untreated surface is higher than that of the untreated wood due to the increasing maintenance measures.

4.4. Marketing of Products

In the answers of the interviewees, it was emphasized that the success of commercial products can be explained by the ability to profitably produce large batches of products industrially. There may be many new potential wood preserving methods, but the threshold for their industrialization can be very high. Commercial success also requires that customers be assured of the product's functionality. It was also highlighted that the commercial success of pressure impregnated wood is due to good availability, affordability, and domestic production, but the basis of its existence is performance in weatherproof structures that are exposed directly to rain or rising moisture from the ground, repeatedly wetted and where moisture remains for a long time. In addition, it was stated that it can be offered in many different sizes and at very competitive prices and can be made cheaper compared to other products.

The success of the ThermoWood© (International ThermoWood Association, Helsinki, Finland) products was largely attributed to the relatively inexpensive production method using only heat and steam, and it was noted that other methods often involved certain chemicals that increased the price of the product significantly. It was also emphasized that the final price of the product and the required investment costs affect the process of starting the production.

The expert noted that since there are already affordable alternatives on the market for wood preservative products that are mainly aimed at increasing the resistance of wood to rot, it is difficult for new products that provide sufficient rot resistance to be successful unless they are at a competitive price. On the other hand, it was emphasized that the modified wood product market requires long-term studies and tests to ensure the durability of the materials, and it takes time for the consumer to trust the new products on the market.

4.5. Fire Resistance

According to the responses from interviewees, the increase in wood construction has increased the need for fire protection treatments for wood. Solutions can be found to increase fire resistance, but the extent to which they make it possible to increase the use of wood in construction depends on the prevailing fire regulations. It was noted that the criteria for fire protection of wood have also become somewhat lighter. Fire protection treatment is no longer needed as much as, for example, 5 years ago, when higher wooden apartment buildings had to be treated in their entirety with fire retardant paints. Today, it is often sufficient for the most important places for fire safety, such as emergency exits, to be treated with fire protection paints.

It was considered by the experts that fire protection paints came on the market about 10 years ago. During that time, there has been an annual increase in demand for fire protection products. Especially in recent years, when wood construction has been supported by the state, the demand for fire protection products has increased, and the demand will not decrease in the coming years. Finland is an exceptionally timber-built country and most buildings are already timber-framed. Today, however, the increase in wood construction is reflected in the design of public buildings of wood. With larger timber-framed and clad public buildings, the demand for fire-retardant painted wood products has increased. In part, fire protection painting makes it possible to build these larger buildings of wood.

It was also pointed out that modification can also improve the fire resistance of wood. For example, charring the surface of the wood has the effect of improving the fire resistance of the wood. Attention was drawn to the fact that fire testing and the resulting fees mainly slow down product development, especially for small businesses. Fire testing and standardization are challenging but will probably be easier as fire testing becomes more common and fire protection products are tested more purposefully.

4.6. Termite Resistance

In the answers of the interviewees, it was emphasized that in warm countries, such as in southern Europe and Asian countries, termites are a real problem and the wood material should be such that termites do not eat it. The problem is yet to be reported to have little to do with Finland, but thermite resistance may become more important in the future. In Finland and the Nordic countries, those manufacturers who have exported to warm countries already have to take this into account. There are registered wood preservatives that can affect termite resistance. The use and handling of these products are subject to permission. Registered wood preservatives require a long and expensive registration process that includes several different tests. To some extent, raw material suppliers have also protected their technologies with patents. It was also pointed out that certain impregnants also have good resistance to termites. Thus, solutions that increase the termite resistance of wood can be found, and in the future, their functionality is mainly a matter of regulation, which will be affected by which biocides will be banned. Modification methods can also provide solutions for better termite resistance of wood, but their success is largely a matter of cost.

4.7. Untreated Wood

Processing the wood to prevent it from cracking was defined as an important tool that contributes to the energy efficiency and impermeability of the houses and makes them more economical, and it was underlined that the importance of surface protection will increase in the future, especially with other adverse effects of climate change. On the other hand, the answers of the experts pointed out that some modified wood products can work well without surface treatment. A regulation set by the Finnish provincial council regulates that 70% of construction waste must be recyclable or directly reusable as materials, so it is worth developing construction solutions based on untreated or modified wood. Finally, while it was emphasized that the wooden structure is long lasting when planned correctly, the experts pointed out that it is important to develop a construction method to keep the wood dry so it can last for a while, even in high humidity conditions.

5. Discussion

Although the positions of the interviewees were representative of different products, their views expressed in the interviews were largely compatible and supportive of each other. Main highlights from the study of wood preservation practices in Finland include:

(i) The currently used impregnations have succeeded in replacing the previously banned chromated copper arsenate impregnations with their functional applications, and as a much cheaper alternative to modified wood products, pressure-impregnated wood will continuously develop and secure its market in the future. On the other hand, although the new wood preservation methods introduced are not economical and require long-term research and testing, modified wood products seem worthy of development and marketing, especially with the increasing interest in recyclability and lifecycle concepts.
(ii) Processing difficulties on construction sites due to the exposure to outdoor conditions have resulted in the demand for highly processed surface treatment products. In addition, water-based products, which are much more durable, long lasting, and flexible than old solvent-based products, are the most used surface treatment materials today. Bio-based binders will increasingly be used in surface treatment agents versus raw fossil materials.
(iii) The demand and opportunities for more sustainable and environmentally friendly wood preservation methods, and thus the volume of production, will increase in the future. This also increases the demand for different certificates on environmental impact and carbon footprint assessment of wood products. Moreover, increasing mold problems, changes in UV values, and relative air humidity in Finland because of climate change make surface treatment more important than ever.
(iv) The success of commercial products can be justified by the fact that a large volume of products, both industrial and domestic, can be produced profitably in very different sizes and at very competitive prices, and the threshold for industrialization may be too high for new potential methods.
(v) Fire protection strategies, such as fire-retardant paints, have paved the way for taller wooden buildings today. Demands for fire protection treatments are increasing, but fire test fees and processes have slowed product development, especially for smaller companies.
(vi) While global warming and the possibility of termites and other pests spreading to Finland are seen as a future scenario rather than a current threat, this issue should be considered for products exported to hot countries.
(vii) The use of wood preservatives is critical to protect from the harmful effects of climate change and to extend the maintenance intervals of wood.

The findings of this paper regarding the future of pressure-impregnated wood and modified wood, highly processed surface treatment products, bio-based binders, environmentally friendly methods of wood preservation, and fire protection strategies confirmed some of the findings reported in other studies, such as [64–68].

In the interviews, expert responses indicated that pressure-impregnated wood will continuously develop and secure its market in the future in Finland. Many innovative studies (e.g., [64,69]) on this subject in the literature support this finding. Additionally, expert opinions emphasized that the new wood preservation methods introduced are not economical and require long-term research and testing. This finding can be associated with the finding [70] that wood preservation is only beneficial if it is inexpensive, can be carried out on a large scale, and with minimal adverse environmental impacts, but all these criteria are difficult to meet.

On the other hand, it was pointed out that modified wood products seem worthy of development and marketing, especially with the growing interest in recyclability and lifecycle concepts. This finding can be associated with the findings of the study by Heräjärvi et al. Ref. [65] highlighted that the circular economy can play a key role in the future success of modified wood products. Similarly, the study on the environmental impact of wood modification through lifecycle analysis by Hill et al. [71] focused on the high carbon storage capacity of modified wood. Additionally, Jones et al. [72] concluded that the use of modified wood continues to gain more and more acclaim among architectural designers, specifiers, and users and demonstrates a sustained success across Europe, with three main wood modification processes including acetylation, thermal modification, furfurylation, and other alternative processes, as in the case of Finland.

According to the interviewees, it was identified that demand for highly processed surface treatment products is high due to both the cost advantage and the low workload at the construction site. Similarly, the increase in labor costs of woodworking and wood-based material producers in Central Europe forces manufacturers to use higher processed materials to reduce the share of these costs in the total production cost of the final product [66]. Our finding can also be associated with the finding of Sedliačiková et al. [73], the current demand for colored wood was considerably higher than the supply of such products in the Slovak market.

It was found that bio-based binders will increasingly be used in surface treatment agents compared to raw fossil materials in Finland. Similarly, this trend has been reflected in many studies of wood surface treatments, including bio-based materials, over the past five years [32]. Mostly belonging to the trends of organic coatings, these processes involved bio-based monomers for film-forming coatings (e.g., [74,75]), modified vegetal oils (e.g., [76,77]), biological polymers (chitosans, lignin, etc.) (e.g., [78,79]), and more (e.g., [80–83]).

Finnish industry experts predict that the demand and opportunities for more sustainable and environmentally friendly methods of wood preservation will increase in the future, and hence the volume of production. This finding is supported by increased worldwide research into bio-based wood preservatives such as mistletoe and lichen extracts [84], propolis extracts [85], and vegetable and fruit peel extracts [86] because of environmental concerns about toxic chemicals, stricter policy pressure, and efforts to mitigate climate change and other global sustainability topics [67].

Emphasizing the increasing mold problems due to climate change in Finland, it is among the findings that surface treatment has become more important than ever. Similar results were found in numerous studies [87–90]. One of these studies focused on the relationship between increased mold and climate change risk in two historic wooden buildings in Vestfold County, Norway [90]. The findings of the Norwegian study also showed a significant increase in the risk of mold on untreated wood surfaces due to climate change, but no risk of mold on treated surfaces. These results also justified our finding that the use of wood preservatives is critically important for protection from the harmful effects of climate change. In addition, the role of wood preservatives becomes even more critical when considering that indoor air quality problems caused by humidity and mold are among the most important problems in the Finnish building stock [91], especially in public buildings.

Interviewed experts underlined that the existence of fire protection strategies such as fire-retardant paints is critical for the realization of taller wooden buildings today. Similarly, many studies on tall wooden buildings in the literature have drawn attention to the vital importance of fire protection for these towers [68,92–96]. Furthermore, the increase in demands for fire protection applications in wood was among the key issues that the experts addressed. Recent research on new fire protection technologies and techniques confirms our findings (e.g., [97–99]).

The view that fire testing fees and processes slowed product development, especially for small companies, was common among experts. However, as research on fire protection treatments, such as fire-retardant paintings, increases (e.g., [100–102]), it can be predicted that these applications will become more widespread, and thus the cost will decrease.

During the interviews, it was reported that the termite spread will increase due to climate change, especially in wood products exported to hot countries, and that necessary measures should be taken accordingly. This finding can be associated with the finding underlined in the study by van Niekerk et al. [103] that those warmer climates are expected to increase the metabolic activities of all wood-threatening organisms such as termites, leading to an overall reduction in the service life of wooden structures.

6. Conclusions and Future Prospects

This paper studied wood preservation practices and future outlook considering climate change from the perspective of Finnish experts through interviews with industry professionals. In doing so, this study attempted to identify major themes, i.e., pressure impregnated and modified wood, surface treatment products, climate change and environmental concerns, marketing of products, fire resistance, termite resistance, and untreated wood. It is believed that the findings presented in this study will help step up the transition of innovative and environmentally friendly wood treatments in the market, thereby helping increase the use of wood in the construction industry in Finland.

Our findings have critical policy or regulatory implications for the market dynamics of wood preservatives in Finland. In particular, it will provide insight for key professionals such as architects, specifiers, manufacturers, suppliers, and other stakeholders in the timber construction industry, taking into account today's market needs and the regulatory and legal mandates required by relevant decision-makers.

Climate change and sustainable development are two of the most important factors shaping the development of the wood industry today. In this sense, regulations of the European Chemicals Agency, which controls whether the products used in the construction industry are environmentally friendly, will direct product manufacturers to develop products with low toxicity in terms of both the environment and human health, and it is thought that the accompanying testing and certifying process will become easier as the market share of these products increases.

It can be expected that regulatory and cost pressures on traditional wood preservation approaches using synthetic biocides will increase by local and European level bodies, and wood preservation methods that are environmentally friendly and better able to combat the consequences of climate change will become widespread, or we will begin to see the development of trees growing in fields that naturally produce durable wood. Reinforcing this trend will generate many opportunities to explore the properties and applications of innovative and durable wood products.

More research is needed on environmentally friendly wood preservation methods and bio-based wood preservatives. Additionally, the use of lignin, a wood industry by-product, and the effect of lignin treatment on the production chain can be further investigated. Comprehensive lifecycle effects of various wood preservation methods can also be examined in the long term and comparatively.

It is worth noting that increasing risks due to climate change, which Finland's wooden cultural heritage are also facing, threaten human health and building aesthetics. These should be considered an important problem and necessary wood preservative applications and interventions should be made. The 'more wood into life' approach is still active and therefore the life of wood products needs to be extended.

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Appendix A. Interview Questions to the Experts on Thermal Modification and Impregnation

Theme 1: Pressure impregnation.

- Impregnation treatment agents such as those containing arsenic have been banned CCA impregnations, has an effective replacement been found for these?
- What does the future of traditional pressure impregnated wood look like?
- Will modified wood products displace pressure impregnated wood?

Theme 2: Climate change.

- Climate and environmental concerns have increased the demand for modified wood products, are the concerns reflected in the development of modified wood products today?
- Wood construction has been and will continue to be increased as part of Finland's climate strategy. Will more be required of wood as wood construction increases?

Theme 3: Commercial modification methods.

- Heat-treated wood has been the most commercially successful of the modified products, are there any others coming?
- Why are only a few modified wood products commercially successful?

Theme 4: Fire resistance.

- With current fire protection treatments, the fire class of wood can be raised from class D up to categories C and B, does this allow for increased use of wood in construction?
- Fire protection surface treatments require regular maintenance treatment outdoors; can the modification achieve a more lasting effect on the fire resistance of the wood?

Theme 5: Termite resistance.

- Due to climate change, the distribution ranges of termites will increase, can modifications improve the termite resistance of wood?

Theme 6. What if the wood was left untreated?

- Possibility to reduce the product's carbon footprint and maintenance work and costs?
- How widely untreated wood could be used in Finland's challenge in the climate?

Appendix B. Interview Questions to the Experts on Surface Treatment

Theme 1: Development of wood surface treatment products.

- What are the most popular wood surface treatment products today?
- Are there clear differences in demand and changes in demand for different wood surface treatment products?
- What are the main trends in wood surface treatment and what is the focus of today's product development?

Theme 2: Climate change.

- Wood construction has increased and will continue to increase as part of Finland's climate strategy. With the increase in wood construction, will more be required of wood and wood surface treatment products?
- Is there a view of climate and environmental concerns and an increase in wood construction of wood in the product development of surface treatment agents today?

Theme 3: Fire resistance.

- With current fire protection treatments, the fire class of wood can be raised from class D up to categories C and B, does this allow for increased use of wood in construction?
- Has there been a change in the demand for fire protection products as wood construction is increasing?

Theme 4: Termite resistance.

- With climate change, the distribution ranges of termites are increasing, could wood surface treatments improve the termite resistance of wood?

Theme 5. What if the wood was left untreated?

- Possibility to reduce the product's carbon footprint and maintenance work and costs?
- How could widely untreated wood be used in Finland's challenge against the climate?

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