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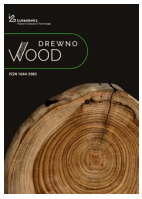

Comparative Analysis of Requirements for Recycled Wood Oversight in Wood-Based Panel Production

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This article presents a comparative analysis of the requirements for overseeing recycled wood used as raw material in the production of wood-based panels. It covers three key normative documents: the German AltholzV regulation (2002/2022), Italian national standard UNI 11951 (2024), and IKEA corporate specification IOS-MAT-0010 (2025). Distinctions were observed in the regulatory status and functional scope of these documents. AltholzV constitutes a legally mandated regulatory instrument, whereas UNI 11951 represents a voluntary industry standard, and IOS-MAT-0010 functions as a corporation-specific supply chain specification. The AltholzV framework establishes a classification system for waste wood based on contaminant profiles, thereby determining appropriate recovery pathways—specifically distinguishing between material recycling and energy recovery applications. In contrast, UNI 11951 outlines the technical requirements and operational procedures governing the use of pre-consumer and post-consumer recovered wood in the manufacture of wood-based panel products. IOS-MAT-0010 is designed to ensure chemical safety and regulatory compliance by controlling potentially hazardous substances, including heavy metals, biocides, flame retardants, and formaldehyde emissions in finished products. These regulations are not harmonized. The results indicate that to operate effectively in diverse markets, manufacturers must implement an integrated oversight system that combines the most stringent requirements of legal regulations (AltholzV), industry standards (UNI 11951), and corporate specifications (IOS-MAT-0010). This approach helps avoid sanctions, customer loss, and additional costs. The study's conclusions also highlight the need to harmonize AltholzV, UNI 11951, and IOS-MAT-0010 to simplify the procedures and reduce the administrative burden for manufacturers.

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Introduction

The growing pressure for a circular economy means that recycling regulations and standards must simultaneously protect the environment while enabling the safe use of recovered materials (Leone et al., 2025). This aims to increase the material efficiency in production and reduce waste (Spear et al., 2025). Scientific research indicates that reducing the demand for virgin wood and greenhouse gas emissions yields significant environmental benefits (Dahlbo et al., 2015; Jimenez-Gonzalez & Ayres, 2020). However, effective material recycling requires quality control of recycled raw materials, particularly regarding chemical safety, including heavy metal content, pesticides, and other hazardous substances (Reinprecht & Iždinský, 2022). In this context, it is

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essential to identify supply chain pathways and potential points of operator exposure to hazardous compounds, acknowledging that material properties may vary across production stages (Butlewski et al., 2016; Butlewski & Sławińska, 2014).

In industry and normative literature, several documents address the recycling requirements for producing wood-based panels. These include the "German regulation on the requirements for the recycling and disposal of wood waste" – AltholzV (version dated 2002, last amendment 2020); the Italian technical standard UNI 11951 "Management of recycled wood in the production of wood-based panels" (version dated 2024); the IKEA retail chain specification "IOS-MAT-0010 – Chemical Requirements" (version AA-10911-17 dated 2025). The so-called BAT reference documents are also important (Commission Implementing Decision (EU) 2015/2119 of November 20, 2015, establishing guidelines on best available techniques for producing wood-based panels under Directive 2010/75/EU of the European Parliament and of the Council).

In the US market, waste management, including by-products from the wood industry, is regulated by the Resource Conservation and Recovery Act (RCRA). The RCRA addresses waste management, but does not specifically address its use in panel production. However, it classifies chemically treated wood as hazardous. In 2018, the US Environmental Protection Agency (EPA) introduced the TSCA Title VI regulation, which focuses on reducing formaldehyde emissions from wood-based panels. The RCRA and TSCA impose strict requirements on manufacturers and processors regarding product testing, recordkeeping, and labeling. Under TSCA Title VI, manufacturers must have their products inspected by an independent, approved certification body (TPC) to obtain the certification.

Previous studies demonstrate that adherence to standards enhances board quality and fosters greater acceptance within European markets (Nguyen et al., 2023). At he same time, the need for harmonization of standards and requirements on an international scale is highlighted, which should translate into increased free movement of goods and services – thus fulfilling one of the main objectives of the European Union (the free movement of goods and services within the EU is guaranteed by the Treaties on the Functioning of the European Union (TFEU), Articles 26, 49–55 (right of establishment) and 56–62 (freedom to provide services) concerning the internal market, as well as Articles 34 – 36 TFEU relating to the free movement of goods).

This study compares three representative documents – AltholzV, UNI11951, and IOS-MAT-0010 – regarding the supervision of wood recycling to identify differences and formulate guidelines for their application by panel producers using recycled raw materials. These three documents governing the use of recycled wood – Regulation AltholzV, Standard UNI 11951, and specification IOS-MAT-0010 – originate from different sources and serve distinct yet overlapping purposes in regulating the wood recycling supply chain. The German AltholzV (2002/2020) is a mandatory national regulation primarily focused on environmental protection, enforcing strict classification (A1 to B) and hazardous substance limits to determine which waste wood is safe for industrial use (such as panel production) versus energy recovery. The Italian UNI 11951 (2024) is a voluntary national industry standard that provides a consensus-based technical framework for wood classification and quality requirements, aiming to standardize and build confidence in the domestic recycled wood supply chain. Finally, IOS-MAT-0010 (2025) is a mandatory corporate specification from IKEA that sets globally applied internal thresholds for quality, sustainability, and hazardous substances, often exceeding national legal minimums to ensure that all recycled wood used in its products meets its proprietary standards.

The primary aim of this study was to perform a comparative analysis of the requirements for overseeing recycled wood used as a raw material in the production of wood-based panels, focusing on the German AltholzV regulation, the Italian standard UNI 11951, and the IKEA corporate specification IOS-MAT-0010, highlighting the significant differences and determining the practical implications for manufacturers operating in diverse markets.

Materials and methods

This study presents a comparative analysis of three documents (AltholzV, IKEA IOS-MAT-0010, and UNI11951) of varying nature, aimed at overseeing the recycling of wood used in the production of wood-based panels. The selected documents are representative examples of legal regulations, industry standards, and corporate specifications that are key for European producers in the industry discussed. The criterion for selecting the issues compared in the analysed documents was the entity's perspective on using recycled wood in the production of wood-based panels and its efforts to demonstrate compliance with the relevant requirements.

The criteria were derived through a preliminary thematic and content analysis of the full texts of three reference documents: the German AltholzV regulation, the Italian standard UNI 11951, and the IKEA specification IOS-MAT-0010. This analysis involved two key steps:

1. Based on the research objectives, the key criteria for comparison were defined as follows:

- Legal status and scope of application (national, voluntary, contractual).
- Classification of recycled raw materials (e.g., division into categories).
- Requirements regarding the frequency and scope of laboratory testing (e.g., for raw materials and finished products).
- List of monitored contaminants (e.g., heavy metals, PAHs, and PCP) along with limit values.
- Required mechanisms for supervision and compliance enforcement (internal audits and external certification).
- Documentation and data-archiving requirements.

2. The data collected from each document were summarized in a standardized tabular format, enabling direct comparison and visualization of the differences.

The interpretation of differences and similarities was based on a comparative analysis of results, which necessitated a structured data standardization procedure to ensure consistency across the normative documents. This procedure was performed in the defined stages.

Initially, critical content, including core objectives, underlying assumptions, material categories, and key definitions, was systematically extracted from the relevant sections of each document. Subsequently, a set of common analytical categories applicable to all three sources was identified and defined inductively. This stage culminated in the development of a standardized coding sheet, in which each analytical category was assigned fixed labels, operational definitions, and explicit criteria for content inclusion and exclusion.

The content from individual documents was then transferred to tables as standardized entries. Where documents used different terms to describe similar concepts, the vocabulary was standardized using the most common or theoretically justified form. If certain information was missing from the document, it was recorded as "missing data" to avoid overinterpretation. The final set of criteria was organized into three primary categories for comparative analysis (Table 1).

This systematic procedure ensured that the comparison effectively highlighted the functional harmonization gaps between the three regulatory documents.

1. Characteristics of reference documents

The AltholzV (2002), "Ordinance on the requirements for the recycling and disposal of wood waste" (2002, last amended 2020)", was enacted as Article I, Section 3302, by the Federal Government on August 15, 2002, following consultation with stakeholders, while preserving the rights of the Bundestag, and with the consent of the Bundestag. It came into force on March 1, 2003, and was last updated on June 27, 2020. The AltholzV addresses material recycling, energy recovery, and disposal of used wood. The second paragraph defines key terms, including the categories of wood materials subject to recycling:

- AI – natural waste wood or wood that has only been mechanically processed and that has not been contaminated with non-wood substances to a greater or lesser extent during use,
- AII – glued, painted, coated, varnished, or otherwise treated waste wood, without halogenated organic compounds in the coating and without wood preservatives,
- AIII – wood waste containing halogenated organic compounds in the coating without wood preservatives
- AIV – wood waste impregnated with preservatives, such as railway sleepers, electricity poles, hop poles, vineyard appliqués, and other wood waste that cannot be classified in categories AI-AIII, except for PCB waste (as defined in the Regulation on PCB/PCT waste, which must be disposed of in accordance with its provisions – e.g., insulation boards containing polychlorinated biphenyls). It may not be used for the production of wood-based panels.

Table 1. The final set of criteria analyzed in the German AltholzV regulation, Italian standard UNI 11951, and IKEA specification IOS-MAT-0010

Category	Description	Examples of specific criteria
Material quality and classification	Requirements defining the physical properties and grade of the recycled wood permitted for high-quality applications	Wood classification quality categories
Hazardous substance control	Parameters specifying limits for substances that may pose environmental or health risks upon reuse	Maximum allowable concentrations (in mg/kg or ppm) for heavy metals (e.g., lead, cadmium) and halogenated organic compounds
Oversight and compliance framework	Criteria governing the nature of the document, its application scope, and the required control/monitoring procedures in the supply chain	Legal status (mandatory vs. voluntary), scope of application (national vs. corporate), and mandated monitoring frequency

Table 2. Limits for elements and compounds in raw materials

Elements/compounds	Permissible content (mg/kg)
Arsenic	2
Lead	30
Cadmium	2
Chrome	30
Copper	20
Mercury	0.4
Chlorine	600
Fluorine	100
Pentachlorophenol	3
Polychlorinated biphenyls	5

Source: own study based on AltholzV.

For the AI-AIV categories, appropriate waste codes have been assigned and presented in Annex III of the Regulation.

Pursuant to the recycling requirements in §3, §4 mandates high-quality recycling processes. Additionally, §5 establishes wood waste categories and prohibits contaminants such as PCBs from the input stream. This requires visual inspection and sorting deliveries into four predefined categories (AI-AIV). This process must only be carried out by experienced and trained personnel. Sorted recycling must be stored separately, and the waste must be disposed of.

Pre-sorted recycled material should be inspected in batches of no more than 500 tons for each recycling route (§6). Samples are visually assessed by color to detect the presence of tar oils and then tested to determine compliance with limit values. Detailed sampling and sample preparation procedures are specified in Annex IV of the Regulation. The manufacturer should conduct batch control tests quarterly at an authorized, accredited testing laboratory. Limit values are presented in Annex II of the Regulation, as shown in Table 2. Notably, the Regulation does not address requirements for finished products made from recycled materials.

UNI 11951 (2024), "Management of Recycled Wood in the Production of Wood-Based Panels", is an Italian technical standard specifying requirements for the use of pre- and post-consumer recycled wood materials suitable for the production of particleboard and fiberboard. The standard applies to all plants producing these panels.

The introduction to the UNI 11951 standard emphasizes that a product manufactured in accordance with its requirements is safe for consumers (including children, the elderly, and the infirm); it is also environmentally friendly, respecting the waste hierarchy characteristic of the circular economy, contributing to reducing deforestation, and sequestering significant amounts of carbon dioxide. The first chapter describes the purpose and scope of the standard. The second is devoted to reference documents and the standards cited. The third chapter contains terms and definitions, including what constitutes recovered wood, i.e., pre-consumer and post-consumer. The fourth chapter outlines the requirements for recycled wood, noting that it can be supplied in various sizes and from different sources, which ultimately determines its quality. It emphasizes that contaminants should be removed from wood materials at the early stages of panel production through a series of operations, including magnetic attraction (for ferromagnetic elements), electromagnetic induction (for paramagnetic and diamagnetic elements), and weight separation (for stones, glass, etc.).

Chapter five describes supply chain control methods, emphasizing the key role of supplier quality control audits, which are designed to assess supplier compliance with the standard's requirements. The supplier is required to comply with the acceptance criteria and provide documentation confirming the analysis. This document is intended to demonstrate that the recycled material is non-hazardous. The standard includes a template form (Annex A) for material compliance with the criteria of an organization using recycled material for board production. During supplier audits, the material's compliance with the data declared in the template should be randomly checked.

The supplier must perform analyses before contract signing, and then every two years thereafter, or whenever there is a change in the production or collection cycle of recycled wood. The analyses must also include test results for the content and occurrence of substances, compounds, and elements such as: Arsenic (As), Lead (Pb), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Zinc (Zn), Chlorine (Cl),

Table 3. Frequency of raw material analyses

Annual quantity delivered (tons)	Minimum analysis frequency
from 250 to 15000	Once a year
> 15,000 tons to 30,000	Twice a year
Every additional 15,000	One additional analysis/year

Source: own study based on UNI 11951.

Table 4. Limits of impurities in finished products

Elements/compounds	Limit values in mg/kg dry matter
Arsenic (As)	25
Cadmium (Cd)	50
Chromium (Cr)	25
Copper (Cu)	40
Lead (Pb)	90
Mercury (Hg)	25
Fluorine (F)	100
Organic chlorine (Cl)	1000
Pentachlorophenol (PCP)	5
Benzo(a)pyrene (a component of coal creosote)	0.5

Source: own study based on UNI 11951.

Fluorine (F), Pentachlorophenol (PCP), and Benzo(a) pyrene (creosote).

Limits and threshold values are not included directly in the standard. However, it is indicated that the tested recycling should meet the requirements of the so-called BAT (Best Available Techniques) provisions – Commission Implementing Decision (EU) 2015/2119 of November 20, 2015, establishing best available techniques conclusions for wood-based products, pursuant to Directive 2010/75/EU of the European Parliament and of the Council. The indicated document does not specify limits for the content of the listed substances and elements in recycled wood raw material. It only states (point 1.1.2 Good housekeeping) that to minimize the environmental impact of the production process, it is necessary, among other things, to: apply a quality control program for recovered wood used as raw material or fuel, in particular to control contaminants such as arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), fluorine (F), chlorine (Cl), organochlorines and polycyclic aromatic hydrocarbons (PAHs).

The following sections of the fifth chapter outline the requirements for delivery inspection activities, including verification of waste codes, visual assessment, typology, verification of foreign material content, and storage of accepted and questionable materials. All activities and their results should be recorded on forms, along with data identifying the delivery and supplier (manufacturer, carrier, origin, type, and quantity), mode of transport, travel date and route, recipient identification, and destination facility.

The document also specifies the frequency of delivery inspections, which depends on the amount of recycled material delivered (Table 3).

One supplier is randomly selected annually from among suppliers that supply less than 250 tons per year.

The standard also specifies methods for monitoring recycled raw material while producing wood-based panels, including sampling from the process mix. This is intended to identify any anomalies and verify the effectiveness of the control process for removing contaminants from the raw material.

The final analysis step specified in the standard is the inspection of the finished product. The frequency of inspections, which include chemical tests, is set at once per month. Contaminant limits are specified in Table 4.

The annexes to UNI 11951 specify the sampling method (Annex B), indicating their representativeness, and specify the methods for testing samples (Annex D). It also presents the waste codes permitted for recycling in the production of wood-based panels (Annex I).

Table 5. Categories of recycled raw materials

Waste category	Requirement	Documentation
AI. Natural, untreated wood waste that has not been chemically treated or contaminated	Quality assurance program – recycling supervision, developed by the manufacturer in accordance with the requirements of IOS MAT0010. (Annex 1)	– Manufacturer's declaration only. – Documentation of the management system, including recycling supervision, is available upon request
AII. Glued, painted, coated, varnished, or otherwise treated wood, without traces of halogenated organic compounds in the coatings and without preservatives AIII. Wood waste with coatings containing halogenated organic compounds, such as PVC, but without preservatives	Quality assurance program – recycling supervision, approved and controlled by an independent quality control organization	– Self-declaration – An independent inspection organization issues a quality assurance certificate
AIV. Preservative-treated wood waste and any waste falling outside of categories AI–AIII	Must not be used	Not applicable

Source: own study based on IKEA IOS MAT0010.

Table 6. Limits of impurities in the finished product

Pollution	Limit (mg/kg)	Frequency of tests
Lead	90	Research report: – AI once per year. – AII every 3 months, with a possible reduction to every 6 months following 4 consecutive compliant tests. – AIII no less frequently than every 3 months.
Cadmium	40	
Chrome	25	
Copper	40	
Arsenic	25	
Boric acid	25	
Fluorine	100	
Chlorine	1000	
Phthalates	250	
Lindane	1	
Pentachlorophenol (PCP)	3	
Creosote	0.5	

Source: own study based on IOS MAT 0010.

IOS MAT 0010 (2025), "IKEA Specification. Chemical Requirements", describes the principles and restrictions for specific chemical substances, resulting from national and international regulations, as well as IKEA's regulations regarding health and environmental hazards. The main objective of IOS MAT 0010 is to minimize the harmful effects of products on customer health and the environment, and to ensure product compliance with health and environmental regulations in all markets where IKEA operates. Notably, the document also indicates that it applies not only to the materials contained in products but also requires the avoidance of contamination during manufacturing, storage, and transport.

The IOS MAT 0010 specification contains a history of changes and outlines directions for further work, addressing planned future changes. The first chapter describes requirements for all materials used in IKEA

products, which are beyond the scope of this article. The second chapter contains requirements for wood, wood-based materials, and other materials (straw, leaves, linoleum). This section outlines the requirements and guidelines for utilizing pre- and post-consumer recycled wood in the production of furniture. These requirements depend on the category and type of waste used (Table 5). Requirements for the recycling supervision program are described in Annex 1 of the IOS MAT-0010 specification.

Limits on the content of pollutants, test methods, and the frequency of testing for finished products, including wood-based panels containing recycled materials, are presented in Table 6.

Annex 1 of the IOS-MAT-0010 specification provides guidelines for a quality assurance system, a program designed to control chemical risks in recycled wood materials. Section 1.3 outlines the requirements for documentation processes and associated responsibilities. The manufacturer should identify internal and external factors that may influence chemical risks to the finished product. At a minimum, the required inspections, tests, and records should be described to confirm compliance with the control plan's requirements, customer requirements, and other applicable requirements, standards, and codes. Specifications for inspecting and monitoring control and measurement equipment, as well as internal and external responsibilities for individual process activities, should also be included. These may also address the assessment of suppliers' management systems and their ability to supply recycled materials that meet the standard's requirements.

Risk assessment is another requirement. The standard emphasizes the need to prevent chemical non-compliance, which should be based on "risk-based thinking". In practical terms, potential hazards and failures must be identified, their probability and impact estimated, and a process for implementing corrective and preventive actions must be considered. The risk assessment must be documented and provided to IKEA upon request. The analysis should categorize and classify the types of wood waste used in the production process. The assessment should include supply sources, segregation processes, and recycling treatment. IKEA guidelines on chemical risks should be expanded to include other chemical hazards. Recycling is required to be tested for identified chemical and toxicological hazards—i.e., for elements, substances, and compounds that, in the risk assessment, reach a level requiring action. The initial frequency recommended by the standard for testing recycled raw materials is every 500 tons.

IOS-MAT-0010 also sets requirements for the quality control process while receiving recycled raw materials. The company should establish procedures for assessing raw materials before and after unloading, including visual inspection and criteria for accepting and rejecting batches of raw materials. It is also recommended that sampling and testing instructions be included. Appropriate equipment, control, and measurement devices, as well as sampling tools, are required, along with a designated area for conducting quality control processes.

The next section of the standard addresses the segregation process, which should be appropriate for its intended purpose, considering the results of the conducted risk assessment. Segregation should be monitored and effective.

The document outlines the requirements for the final inspection of the finished product, which must meet the test results specified in Table 6 of the article, ensuring that they do not exceed the limits for recycled materials. Test results should be monitored, and the monitoring program should be adjusted based on these results. A counter-sample collected for testing should be retained for three months from the date of collection, in case testing is necessary.

The organization should have a non-conformity management process in place, including the identification and resolution of non-conformities, as well as the implementation of corrective and preventive actions.

Records of activities must be maintained, and tasks must be performed by trained personnel. Training and competencies should include the correct interpretation of received data, the ability to characterize suspicious material, identify contaminants, segregate and separate materials, visually recognize and categorize raw materials (classes A1-AIV), the batch acceptance and rejection process, identifying content conformity, and reporting nonconformities.

The recycling oversight program should be subject to internal audits at a frequency dependent on the risk assessment results.

Interestingly, the IKEA IOS MAT 0010 standard (in Annex No. 1) contains a provision that, as an alternative to applying the requirements of this standard, one can use the requirements presented in the UNI11951 document or in the German AltholtzV regulation.

Results

Comparison of AltholzV, IOS-MAT-0010, and UNI 11951 requirements.

The analysis of the documents regarding the use of recycled wood in the production of wood-based panels clearly indicates that some of the requirements described in the documents are similar, but there are also significant differences. Key differences and similarities are presented in Table 7.

Table 7. Comparison of the requirements in reference documents

Criterion	AltholzV	IOS-MAT-0010	UNI 11951
Range	Legal regulation in force in a specific area (Germany)	Corporate specification in the IKEA supply chain	Voluntary industry standard
Material classification	Various recycling approvals. AI-AIV categories	Chemical substance limits, supplier declarations, and AI-AIV category	Quality criteria for recovered wood according to waste codes
Material testing	Mandatory on raw material (per batch)	Recommended on raw material (per 500 t)	Required on finished product (monthly)
Documentation	Obligation to record and control by the authorities	Supplier declarations, research reports, and the supervision system. Documentation retained for five years	Registration of internal control results
Research procedures	The annexes indicate chemical analyses and limits for recycled raw materials	Requirements and research methods, as well as limits for the finished product	Wood quality and purity control. Finished product limits
Enforcement	Legal sanctions / State inspection	Contractual compliance in the supply chain – customer to supplier requirement	No legal sanctions, possible contractual consequences

Source: own study based on AltholzV, IOS-MAT-0010, UN 11951.

Table 8. Summary of limits for the finished product

Name	Pollution limit in mg/kg	
	IOS-MAT-0010	UNI 11951
Lead	90	90
Cadmium	**40**	**50**
Chrome	25	25
Copper	40	40
Arsenic	25	25
Boric acid	**25**	**n/a**
Fluorine	100	100
Chlorine	1000	1000
Phthalates	**250**	**n/a**
Lindane	**1**	**n/a**
PCP	**3**	**5**
Creosote	0.5	0.5
Mercury	25	25

Source: own study based on IOS-MAT-0010, UNI 11951

Another significant difference lies in the requirements for finished products – wood-based panels containing recycled wood raw materials. Two of the three documents discussed – the UNI 11951 standard and the IOS-MAT-0010 specification – contain limits for finished products – wood-based panels manufactured using recycled wood. A comparison of these limits is presented in Table 8.

As shown in the analysis results above, there are differences between standards regarding the content

of elements and compounds, as well as their respective limits. The IOS-MAT-0010 standard is more restrictive. Differences occur in the values for cadmium (Cd) and pentachlorophenol (PCP). The UNI 11951 standard does not include phthalates, lindane, or boric acid.

Discussion

The governance of recycled wood-based materials operates through a multi-layered structure combining mandatory regulations, voluntary standards, and customer specifications, each with distinct legal status, enforcement mechanisms, and practical implications. The German AltholzV is a legally binding national regulation embedded in waste management and circular economy legislation; compliance is mandatory for any operator supplying the German market (Ludwig et al., 2016). In contrast, the Italian UNI 11951 is a voluntary standard that, in the absence of EU-wide or international equivalents, serves as the primary technical reference for the Italian market (Martins et al., 2023). IKEA's IOS-MAT-0010 specification represents a contractual requirement imposed on suppliers; although not legally binding in itself, it becomes a de facto obligation for any manufacturer wishing to supply the IKEA chain (Martins et al., 2023).

From a manufacturer's perspective, the optimal strategy is to integrate requirements from all three documents into a single, unified compliance system rather than treating them as separate silos. None of the instruments is comprehensive on its own; each addresses different aspects of material quality, contaminant limits, traceability, and testing protocols. Adopting the most stringent limits and procedures across the three ensures simultaneous compliance with AltholzV (mandatory in Germany), UNI 11951 (market reference for Italy), and IOS-MAT-0010 (contractual condition for IKEA), while identifying and implementing only the truly additive differences. Successful implementation requires:

1. Ensuring continuous, large-scale deliveries of recycled wood, characterized by material consistency (within the appropriate waste categories and codes).
2. Investing in effective and low-cost testing systems to manage the complexity of supply chains for recycled materials, combined with the non-harmonized criteria found in standards such as AltholzV, UNI 11951, and IOS-MAT-0010, necessitates the investment in effective and low-cost testing systems to achieve competitive productivity. This investment supports a comprehensive internal control system that covers the entire process—from raw material reception, through production monitoring, to finished product testing and evaluation.
3. Regular auditing, review, and updating of the recycling supervision program (with third-party certification where required by IOS-MAT-0010).
4. Archiving of all records for at least 5 years to support both internal audits and potential administrative inspections under AltholzV.
5. In-house or outsourced laboratory capabilities for monitoring hazardous substances (formaldehyde, phenol, heavy metals, PCP, etc.) and quality parameters in both incoming material (AltholzV focus) and finished panels (UNI 11951 and IOS-MAT-0010 focus).

Robust chain-of-custody systems supported by anatomical, genetic, and chemical wood identification methods are essential for due diligence across all frameworks (van Brusselen et al., 2023). However, FSC or equivalent Chain-of-Custody certification, while often demanded by customers, imposes high costs that represent a significant barrier—especially for smaller suppliers (Klarić et al., 2016; Gejdoš & Hitka, 2024). Contaminant risks remain critical: recent studies confirm exceedances of formaldehyde and phenol in recycled wood composites, underscoring the need for systematic testing to prevent hazardous substances from re-entering material cycles (Prodanchuk et al., 2023).

Manufacturers must manage a dual risk profile: legal sanctions for AltholzV non-compliance and commercial consequences (loss of key customers) for failing IKEA or other buyer specifications. Supply chain complexity in recycled materials inevitably increases quality control overheads, requiring investment in testing protocols, supplier qualification, and sustainability benchmarking to achieve competitive differentiation (Atik et al., 2020; Tasdemir & Gazo, 2019).

For wood-based panel producers—who primarily manufacture particleboard for furniture—the challenge is amplified when furniture manufacturers for IKEA or other international chains pass IOS-MAT-0010 requirements down the supply chain. In practice, organizations should prioritize compliance according to their target markets (e.g., AltholzV for Germany, UNI 11951 as a reference for Italy, and IOS-MAT-0010 for IKEA contracts), while recognizing that an integrated system satisfying the most demanding criteria will cover all relevant obligations. Manufacturers must therefore consult the primary regulatory texts and engage specialist technical consultants to fully operationalize compliance (Spear et al., 2025).

Future research should focus on empirical studies of compliance costs, a comparative effectiveness analysis of the three governance modes, and the feasibility of harmonized EU-wide quality standards for recycled wood.

Conclusions

The study has scrutinized the diverse regulatory and normative landscape governing the use of recycled wood in wood-based panel production, specifically comparing the mandatory German Regulation (AltholzV), the voluntary Italian standard (UNI 11951:2024), and the corporate specification (IOS-MAT-0010). The results highlight that while these documents originate from different spheres of influence—legal, industrial, and contractual—they collectively reveal the essential components for a robust, circular, and chemically safe supply chain. The key findings, summarized below, highlight the need for a shift from fragmented compliance to a harmonized management strategy. The results of the comparative analysis indicate that:

1. The documents have different natures and legal forces. The German AltholzV regulation is a mandatory legal requirement in Germany. The Italian UNI 11951 standard is voluntary. The IKEA IOS-MAT-0010 specification, on the other hand, is a contractual requirement, binding on suppliers of a given corporation.
2. Despite their differences, these documents fulfill complementary roles. AltholzV provides a legal framework, UNI 11951 provides quality management tools, and IOS-MAT-0010 imposes standards in the supply chain.
3. To operate in different markets, manufacturers must utilize an integrated management system that combines the most stringent requirements from each relevant document. This approach is essential to avoid legal sanctions, customer loss, and the costs of adapting the recycling management system. Therefore, it can be concluded that the best monitoring system combines legal regulations (AltholzV), industry standards (UNI 11951), and the corporate specification (IOS-MAT-0010).
4. There is a need for harmonization. Inconsistencies and differences in requirements can lead to increased administrative burdens and costs. Harmonizing criteria across legislative documents can reduce administrative burdens and operational costs, thereby streamlining the process of adapting to complex regulations and market requirements. Therefore, it would be worthwhile to submit the proposals indicated in the article to the technical committees dealing with standardization in the said scope – e.g. European committee CEN/TC 112 – responsible for the preparation of standards for wood-based panels and panels of other lignocellulosic materials covering: terminology, classification, requirements, product specifications, methods of testing or committee on the international level – ISO/TC 89 responsible for standardization in the field of panels such as fibreboards, particle boards and plywood based on lignocellulosic materials (derived from wood or other materials) including terminology, classification, dimensions, test methods and quality requirements.

Conflict of interest

The author(s) declare(s) that there is no conflict of interest concerning the publication of this article.

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