

# PREFABRICATED WOODEN HOUSING QUALIFICATION BASED ON REGULATORY COMPLIANCE, COMPLEXITY, AND SUSTAINABILITY IN CENTRAL CHILE

## CALIFICACIÓN DE VIVIENDAS PREFABRICADAS EN MADERA BASADA EN ATRIBUTOS DE CUMPLIMIENTO NORMATIVO, COMPLEJIDAD Y SUSTENTABILIDAD EN CHILE CENTRAL

## CLASSIFICAÇÃO DE MORADIAS PRÉ- FABRICADAS DE MADEIRA COM BASE EM ATRIBUTOS DE CONFORMIDADE REGULATÓRIA, COMPLEXIDADE E SUSTENTABILIDADE NA REGIÃO CENTRAL DO CHILE

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## RESUMEN

El estudio revisa los antecedentes publicados por fabricantes de viviendas prefabricadas en madera en Chile central. La metodología indaga en medios digitales de venta y servicio de impuestos internos. Utiliza los atributos de cumplimiento normativo-técnico, complejidad y sustentabilidad para calificar las viviendas prefabricadas en las regiones de Valparaíso, O'Higgins y Metropolitana. Un 83% de empresas son "constructoras-fabricantes", 83% están legalmente constituidas. La complejidad revela que, para proyectos de mayor envergadura, 54% tienen nivel bajo, 35% nivel medio y 11% nivel alto. Hay debilidades en cumplimientos normativos y en información técnica para los potenciales clientes, siendo la sustentabilidad el atributo menos destacado, ya que pocas explicitan datos como huella de carbono, reciclaje de materiales o certificaciones voluntarias para diferenciarse en el mercado. Por tanto, se concluye que faltan acciones para potenciar a este sector productivo, con potencial de industrialización, incorporando gestión y reglamentación, con lo que disminuiría la inseguridad territorial por autoconstrucción.

### Palabras clave

viviendas de madera, ventas por internet, seguridad, sustentabilidad

## ABSTRACT

This study reviews the background information published by manufacturers of prefabricated wooden housing in central Chile. The methodology carries out the investigation using digital sales and internal tax service media. It uses regulatory-technical compliance, complexity, and sustainability to rate prefabricated homes in Chile's Valparaíso, O'Higgins, and Metropolitan regions. 83% of the companies are "construction-manufacturers", while 83% are legally constituted. As for complexity, it is revealed that, for larger projects, 54% have a low level, 35% have a medium level, and 11% have a high level. There are weaknesses in regulatory compliance and in technical information for potential clients, with sustainability being the least prominent attribute, as few explain data such as carbon footprint, recycling of materials, or voluntary certifications to differentiate themselves in the market. It is concluded that there is a lack of actions to strengthen this productive sector, which has industrialization potential, by incorporating management and regulation, which would reduce the territorial insecurity for self-construction.

### Keywords

wooden homes, online sales, safety, sustainability

## RESUMO

O estudo analisa as informações publicadas pelos fabricantes de casas de madeira pré-fabricadas na região central do Chile. A metodologia explora os meios de vendas digitais e o sistema tributário nacional. Ela usa os atributos de conformidade técnico-regulatória, complexidade e sustentabilidade para classificar as casas pré-fabricadas nas regiões de Valparaíso, O'Higgins e Metropolitana. 83% das empresas são "construtoras-fabricantes" e 83% são legalmente constituídas. A análise revela que, no caso dos projetos maiores, 54% têm um nível baixo, 35% um nível médio e 11% um nível alto. Há deficiências na conformidade regulatória e nas informações técnicas para clientes potenciais, sendo a sustentabilidade o atributo de menor destaque, pois poucas empresas fornecem dados como pegada de carbono, reciclagem de materiais ou certificações voluntárias para se diferenciar no mercado. Conclui-se, portanto, que faltam ações para aprimorar esse setor produtivo, com potencial de industrialização, incorporando gestão e regulamentação, o que reduziria a insegurança territorial decorrente da autoconstrução.

### Palavras-chave:

casas de madeira, vendas pela internet, segurança, sustentabilidade.

## INTRODUCTION

### VULNERABILITY FACTORS THAT INTERACT IN THE FACE OF DISASTERS

The housing deficit caused by market problems, the lack of supply caused by disasters, and the proliferation of constructive solutions with different levels of quality are closely linked. While the State tries to solve housing needs, new needs are continuously generated in an endless cycle, and only some solutions are being regulated to ensure habitability that provides a lasting solution.

Actions are required throughout the risk cycle, ideally before an event, to prevent extreme natural events from becoming disasters (UNDRR, 2015). This entails allocating time to plan and provide resources for actions that reduce or avoid increased risks (Lacambra *et al.*, 2015) and contribute to mitigation, preparedness, response, or recovery. In this sense, having clarity about who the population at risk is and where it is located helps to make decisions to reduce the impact of future events and generate more resilient communities. In Chile, this has been institutionalized in Law No. 21,364 of 2021, which establishes the National Disaster Prevention and Response System, creating the National Disaster Prevention and Response Service (SENAPRED, in Spanish). This regulation focuses on prevention. However, among the pending needs, the management of housing supply to achieve timely and effective responses still needs to be implemented operationally. For example, this entity's responsibility is to ensure the supply of emergency housing as regulated by Exempt Res. 1448 (BCN, 2023c), which, albeit provisional, has direct implications for definitive solutions that do reduce the housing deficit. In this sense, the prefabricated wood construction industry, presented in the following article, offers an alternative.

Given how some of the prefabricated houses in Chile are installed and used, it is vital to have

territorial planning instruments that include risk areas. Nevertheless, in municipalities that do not have the resources to implement more overarching plans, the lives of people who must be preventively evacuated from risk areas are usually affected. An example of this is the urban sprawl in areas exposed to the threat of forest fires, which is not explicitly considered in the Urban Planning and Construction Ordinance (OGUC, 2017 in Spanish), according to the article that defines "non-buildable zones" and "risk areas" (Article 2.1.17). To look for comprehensive solutions, some Communal Regulatory Plans (PRC, in Spanish) and ordinances include forest fires and implement measures such as distancing, firebreaks, water networks, the removal of fuels and flammable materials, and changing to fire-resistant finishes of no less than an F-180 classification (González-Mathiesen & March, 2023). Meanwhile, the Draft Law that the National Forest Service prepared, in Article N°3, defines forest urban interface areas. It establishes that these must be identified in Regional Land Use Planning and Intercommunal and Communal Regulatory Plans, although it is still weak in preventive measures for existing buildings. The purpose of noting this issue in this article is because these areas are where prefabricated housing is commonplace, and it is urgent to reflect on changes in public policy with a global and systemic view on how to adapt living to climate change, which not only depends on each municipality in its territory but must be promoted nationwide.

### HOUSING SHORTAGE

Analyzing each region (Table 1) provides greater clarity about the situation. If this is linked to the research results on the different opportunities the market offers to meet the needs, a virtuous circle could be generated instead of a vicious one.

The quantitative deficit calculated with the 2022 Casen Survey, conducted by Chile's Ministry of Social Development and Family (MDSF, 2024), amounts to 552,046 new homes left to be built. The regions with the highest number of households with affordability

Table 1. Housing situation by region. Source: Prepared by the authors with data obtained from the 2023 Regional Report (BCN, 2023d)

O'Higgins	Metropolitan	Valparaiso
1.03 million inhabitants (projected to 2024), surface area 16,387 km <sup>2</sup>	8,420,729 inhabitants (projected to 2024), surface area 15,403.2 km <sup>2</sup>	2,025,693 inhabitants (projected to 2024), surface area* 16,396.1 km <sup>2</sup>
Total n° of dwellings 354,324 (99,909 rural). Housing deficit. 21,980 housing units	Total N° of dwellings 2,378,490 (92,339 rural). Housing deficit 504,770 homes	Total N° of Dwellings 788,830 (79,618 rural). The housing deficit without encampments is 102,000 dwellings; with encampments (255), there are 136,000 dwellings. Dwellings affected by the recent fire of January 2024: 8,188

\* Surface Area of Continental Chile: 756 770 km<sup>2</sup>

problems in 2022 are the country's most populous regions: Metropolitan (504,770 households) and Valparaíso (90,043). While the regional distribution of households in encampments, according to the 2022 List made by the Ministry of Housing and Urbanism, MINVU (2023) in Spanish, shows that the most significant number is located in the Valparaíso (25.6%) and Metropolitan (18.6%) Regions.

## WOOD CONSTRUCTION PRODUCTION CAPACITY

Although there is no survey of prefabricated wooden housing construction capacities, since no Chilean public or private body is responsible for doing so, it is a matter of observing the materiality with which emergency, temporary, cabin-type second homes, and modular homes are implemented to perceive that the demand exists and, therefore, the supply is increasing.

The analysis of used dwellings addressed by INFOR (2021) for 68,466 of them located in all regions of the country, using data from the 2017 Casen survey (Ministerio de Desarrollo Social y familiar, 2018), indicates that 38.1% are built mainly using wood, albeit always as a lower quality option throughout the size ranges, and worse still in segments under than 40 m<sup>2</sup>; since for every 100 wooden houses in the country, 23 have less than 40 m<sup>2</sup>. At the same time, there are 12 and 13 units in brick and concrete, respectively. The data shows that materiality is related to families' poverty level and the house's size.

Wood is the most commonly used material for homes of different socio-economic strata (Harju, 2022; Hidalgo et al., 2022), for being "the sustainable solution of the future in buildings in the world" (Green & Taggart, 2020; Bascuñán, 2021; Pacini, 2021; Garay et al., 2022), and more affordable in rural areas due to availability and poor access to state subsidies (González Méndez, 2022). Mistakenly, costs are reduced by supplying the market with homes that do not have sustainability attributes, such as energy efficiency and a low carbon footprint, from their manufacturing. In this sense, the thermal insulation of dwellings is mandatory.

Self-builds and housing assembly on the same site generate overcrowding (Hidalgo et al., 2022; González Méndez, 2022; Martínez Gamboa, 2022). The private market offers diverse construction typologies, qualities, and delivery times, from assembly kits to complete turnkey installation services. The question is who controls and supervises their correct installation, while the final reception of the work does not always occur.

Among the suppliers are consolidated architectural offices and/or construction companies, which comply with regulated technical specifications (TS) and even cover the final reception of the work. In other cases, only substandard habitability is accessed, where sustainability and safety indicators rarely exist or are

valued (Garay et al., 2021a). Since construction using materials such as brick and concrete generates 35% of waste globally, consumes 20% of water, and emits almost 40% of greenhouse gases, sustainability should not be optional since wood construction is being faced efficiently worldwide. To encourage this process of adopting sustainable construction in Chile, the work of the International Living Future Institute has been taken as an example. In 2006, the Institute launched the world's most rigorous and sustainable green construction program: the Living Building Challenge. Thus, 20 buildings globally aspire to achieve a "Net Zero Energy Building" (NZEB) certification (ILFI, 2024; Madera 21, 2023). Until now, structural construction in wood has not had access to high-rise buildings, except for some buildings created with a demonstrative effect or corporate buildings, having an excellent possibility for growth. (Ugarte et al, 2018; Wenzel & Guindos, 2024).

The study investigates the attributes of regulatory-technical compliance, complexity, and sustainability that prefabricated housing manufacturers offer through digital media. This allows understanding how potential customers receive information and suggesting improvements.

## METHODOLOGY

Bibliographic material of a scientific-technical nature, available in digital format, was obtained from the databases of books and journals subscribed to by the University of Chile, such as Web of Science, Scopus, ScienceDirect, and Springer. Literature and information resources from the Google Scholar search engine were also obtained, which provided context to the importance of the study and the state of the art. These bibliographic documents were stored in the Mendeley bibliographic manager. To create a list of the products, a search with Spanish keywords was conducted using Instagram, Facebook, LinkedIn, Instagram, and Google. The next step was to verify the company's formal existence in the Internal Revenue Service (SII), georeferencing their location, verifying their taxpayer identification number, and checking that the contact details were authentic. This generated a registry that included 88 companies, eliminating only those that did not have formal information.

Exhaustively reviewing digital sources for bibliometrics and descriptively analyzing the national market products classified as houses, prefabricated, or modular wooden houses was relevant. These were entered into the database search engines accompanied by Boolean operators to generate different combinations. This database generated a record in the Microsoft Excel software, where information on prefabricated housing

Table 2. Attributes (Complexity, Regulatory Compliance, Sustainability) and Likert scale. Source: Preparation by the authors.

Attribute	Variables	Level of the variable	Scale
I: Complexity	A: Experience of the manufacturer or construction company	Not mentioned	1
		<5 years	2
		5-15 years	3
		16-25 years	4
		<25 years	5
	B: Diversity of the offer: N°, design, and sophistication of the models	Not mentioned	1
		<5	2
		5-10	3
		11-15	4
	C: Diversity of housing sizes	Not mentioned	1
		<40m²	2
		40-72m²	3
		73-120m²	4
	D: Formality, initiation of activities, and registration with the Internal Revenue Service	>15	5
		Informal	1
		Formal	5
	E: Possibility of sale with State-granted housing subsidy	No	1
		Yes	5
	F: Participation in framework agreements, public tenders, and/or integration into real estate management	No	1
		Yes	5
II: Compliance with current regulations (CNV)	A: Seismic resistance	No	1
		Yes	5
	B: Fire-resistance	No	1
		Yes	5
	C: Thermal comfort	No	1
		Yes	5
	D: Acoustic comfort	No	1
		Yes	5
	E: Minimum dimensions	No	1
		Yes	5
	F: Water tightness	No	1
		Yes	5
	G: Airtightness	No	1
		Yes	5
I: Protection of materials for their durability	No	1	
	Yes	5	
III: Sustainability	A: Structural materiality of the building	Not mentioned	1
		Hybrid	3
		Wood	5
	B: Risk Reduction - forest fires, earthquakes, climate change.	Not mentioned	1
		At least one	3
		Two or more	5
	C: Bioeconomy - Reduce-Reuse-Recycle (RRR)	Not mentioned	1
		At least one	3
		Two or more	5
	D: Energy efficiency, water, self-generation, reuse	Not mentioned	1
At least one		3	
Two or more		5	
E: Others of the voluntary sustainable construction code (MINVU, 2023)	No	1	
	Yes	5	

manufacturers was compiled for the three regions analyzed.

After identifying the companies, the products offered were analyzed using the attributes and variables indicated in Table 2 as a guide. The study characterized “prefabricated housing” of 88 legally constituted manufacturing companies operating in Chile’s O’Higgins, Valparaíso, and Metropolitan regions. The analysis is based on their explicit descriptions of their products and the observation of images they show as unequivocal evidence of some attributes. This strategy allowed identifying the wooden housing products available in the national market and described the variables to be observed for the complexity, regulatory-technical compliance, and sustainability attributes.

With the information collected, a digital directory of the companies was created, and the housing models offered were selected and rated considering the attributes and variables detailed in Table 2; there was a range of more than three models; the three most representative ones were chosen to narrow down the list and the rating calculation. In this way, a rating score is a number acquired jointly for all the products in a company, considering the number of attributes observed (unweighted), presented on a Likert scale of 1 to 5, 1 being the lowest and 5 the highest. These levels are described in Table 3.

The rating is based on three criteria: (1) Complexity (C); (2) Compliance with current regulations (CNV); and (3) sustainability (S). The complexity attribute, C, involves the manufacturer’s experience and the diversity of its products

Table 3. Indicator guidelines based on attributes, according to quantity and quality, expressed on a Likert scale. Source: Preparation by the authors.

Quality of attributes (based on Table 1)	Description and number of attributes for each product (minimum one, maximum three per company, selected from the models offered)	Scale.
Not mentioned	It does not mention information about the characteristics despite being a formal company. It does not mention CNV in its products. Without sustainability information. Products without images in digital media. Low complexity: no experience or not indicated, no sales through tenders or subsidy, no description of technology and/or certification	1
Attributes without differentiating	Mentions only one of these characteristics: dimensions and number of available models. States CNV in thermal and/or acoustic comfort, seismic, or fire resistance. Provides some sustainability information. It is possible to determine the complexity level through the published models and projects. Belongs to this level only if it reaches average complexity. Formal company, evidence of the use of technology in its products, displays images and describes technically available models. It does not indicate subsidized sales or having certifications	2
Clearly identifiable attributes	Mentions two to four characteristics: dimensions and number of available models. States CNV in thermal and acoustic comfort, seismic, or fire resistance. Provides some sustainability information. It is possible to determine the complexity level through the published models and projects. Belongs to this level only if it reaches average complexity. Formal company, uses technology, displays images and description of available models. It does not indicate subsidized sales or having certifications.	3
Attributes with relevant technical explanation	Mentions three to five characteristics: dimensions and number of available models: States CNV in thermal and acoustic comfort, seismic, or fire resistance. It stands out through the sustainability information. It describes the products in suitable technical detail and presents plans and construction material sheets. It is possible to differentiate the ability to develop projects and products of greater complexity and flexibility that are adjustable to customer needs. It includes sustainability issues connecting with current needs. This group belongs to those that DITEC has registered as Industrializers.	4
Significantly outstanding attributes	Mentions more than five of these characteristics: dimensions and several available models. States CNV in thermal and acoustic comfort, seismic, or fire resistance. It stands out through the sustainability information. Formal company, uses the highest technology available in the country, displays images and description of available models. Indicates sales with subsidies, has some certification, and has an outstanding level in international sustainability indicators	5

in terms of types, models, sizes, product presentation, and company experience. It also involves formality, acceptance of subsidies, participation in a framework agreement, and after-sales services of the product. The CNV is based on the products explicitly demonstrating compliance with relevant technical standards, such as the variables detailed in Table 2, which are linked to aspects related to durability, particularly behavior for earthquakes and fires, as included in the OGUC. Finally, the Sustainability attribute, S, refers to variables that stand out regarding the standards and certifications adopted, such as the carbon footprint measurement, life cycle analysis, bioeconomy, process quality, efficiency and innovation, and improved acoustic and thermal characteristics of dwellings beyond the CNV.

The information register incorporates and describes the presence or absence of this information for the dwellings offered, as well as their details and relevant explanations.

The rating process was simplified by averaging the three attributes equally. This aspect is clarified because the indicator model published by Garay *et al.* (2022) was considered, where a greater or lesser weighting of one attribute compared to the others was taken into account, considering a complex multicriteria matrix.

Table 3 presents the indicator guidelines, grouping the variables of each attribute considered in Table 1 (complexity, regulatory compliance, sustainability) on a Likert scale from 1 to 5.

Table 4: Evaluated prefabricated houses and Likert scale level by region. Source: Preparation by the authors.

Region	Qualified companies*	Number of companies by Likert scale level	Score.
Valparaiso	16	1	1
		7	2
		8	3
Metropolitan	61	5	1
		29	2
		23	3
		4	4
O'Higgins	10	2	1
		4	2
		4	3

\*The number of rated products was between 1 and 3

## RESULTS AND DISCUSSION

Table 4 shows the units evaluated by the types of prefabricated houses located on each Likert scale achieved for each region.

According to what has been observed, the prefabricated housing industry is characterized by an average level of complexity; i.e., most companies can produce dwellings

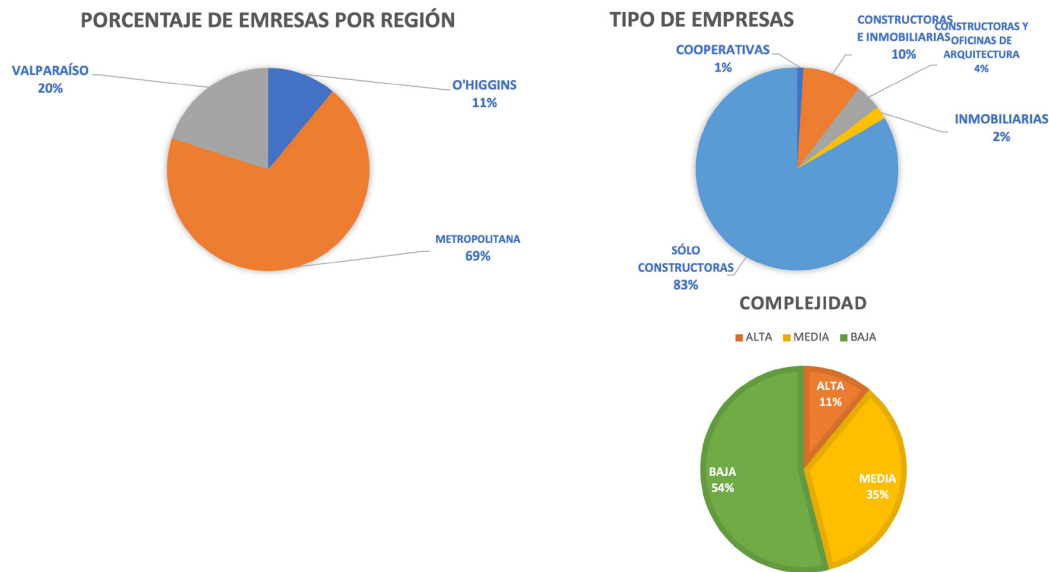


Figure 1. Evaluation of "Prefabricated Houses" Products for the three regions. Source: Preparation by the authors.

with standards that fit the requirements. However, this offer is not privileged since there is only sometimes an obligation to demonstrate technical compliance. This is ignored under the buyer's agreement, possibly to reduce costs and difficulties associated with the installation. In addition, the study shows that there is a sale of an assembly kit or the assembled house, but without installation, so that users can take it. In this way, the house manufacturer is dedicated to manufacturing and does not always assume responsibility for the installation. Therefore, it is the buyer's responsibility if rules are transgressed or mistakes are made. It must be considered that the work's final reception might be made or not, as municipal work directions use only the documents presented and not onsite inspections for approval (Garay *et al.*, 2021b; INE, 2023; Quinzacara, 2021; BCN, 2023b).

There is a significant group of companies that obtain a low rating, which is worrisome when the current housing deficit scenario leads people to look for urgent and low-cost solutions, finding in this market an option to temporarily and precariously solve housing needs, forming a vicious circle of dissatisfaction and demand for definitive solutions, where temporary housing becomes the "normality." The result is larger encampments or overcrowding by installing additional housing in a space initially intended for a single house. In this regard, it should be noted that, since November 2023, through Exempt Resolution 1448, those who provide emergency housing are obliged to comply with minimum standards (BCN, 2023c). Consequently, it is expected that homes built in the country will soon meet the standards for their location and that the setting is suitable for their habitability, mainly regarding accessibility and reduction of exposure to threats.

Only four companies obtained high-level products with a score of "4" because they have industrialization and

digitalization capacity and use BIM technology to plan individual solutions such as housing complexes. It is very likely that, through adaptations, some of the companies that scored level "3" can contribute to establishing articulations, requirements, and inspections of processes and products since, according to the evaluation carried out, it is seen that these actions are necessary.

Figure 1 presents the distribution percentage of companies by region and the types of companies, formality, and complexity observed.

69% of the companies are located in the Metropolitan Region, 20% in Valparaíso, and 11% in Libertador Bernardo O'Higgins. Construction companies predominate, with 83% of the studied sample. As for formality, 83% of companies are formal, and 17% are informal (this condition was verified for companies evaluated in the SII registry). On the other hand, the most frequent level of complexity is low, at 54%. 35% of them are at a medium level, and only 11% of these companies are of high complexity. This is according to information from the products' sales and the search in official sources such as the State's public market and tenders.

Table 5 describes the aspects considered to establish the sales prices of prefabricated houses. The Likert scale was assigned according to attributes delivered after online quotes, which was carried out to know details of how they usually break down the values, starting from a basic kit, including insulation as a compliment, extra costs for transportation, installation with or without sanitary connections up to complete turnkey service. This information considers the marketing used and added value for each order. This was used to check that companies are explicitly considering compliance with current regulations regarding, for example, thermal insulation of houses, a

Table 5. Aspects considered in the add-ons of prefabricated houses based on additional technical criteria and/or services. Source: Preparation by the authors.

Description of the level assigned	Level.
Minimum characterization of the product: materiality, surface area, price, and only offers KIT to assemble. Offers freight with an additional cost per km traveled	1
Suitable characterization of the product. Adds blueprints and constructive details of the KIT. There is clarity of what is included and what is not; offers freight with additional cost for transfer of the kit or turnkey houses but does not indicate thermal insulation	2
Offers all of the above and a service with separate installation charges or outsources the installation (workers to contact), freeing itself from responsibilities. Offers thermal insulation on request	3
Offers all of the above, possesses and demonstrates experience and clarity of an installed product. Includes thermal insulation	4
It offers all of the above, and it is the most reliable option, although its price is higher. It can be verified that it is a housing solution that meets the OGUC criteria, including thermal insulation and more sustainable building codes (CCS)	5

mandatory technical criterion according to the OGUC since 2007 for all new dwellings. The results show that most companies in the sample offer this and other services with separate charges in addition to the basic kit, which is quoted independently, so buyers can choose not to include it.

The purpose of this study was to apply a simpler version of indicators than the IISS previously published by Garay *et al.* (2022) after reflecting on the vulnerability and lack of sustainability of living by not taking into account territorial conditions, installing housing in areas of risk, exposure to earthquakes, volcanoes, and forest fires, among other threats, without understanding their importance. This research aims to draw attention to the supply of prefabricated wooden houses for three regions of central Chile: Valparaíso, Metropolitan, and O'Higgins. The results could be extrapolated to most of Latin America. Therefore, it is appropriate to look closer at the opportunity this productive sector has to manage processes that demonstrate sustainability, preparedness, and preventive actions associated with the new way of life that climate change is causing.

Overall, it was found that most companies use wooden elements of varying sizes. However, they do not comply with treated wood use per NCh 819 (INN, 2019), included in the OGUC. This was confirmed after visually checking the products and realizing there was no evidence of wood treated with preservatives or modified woods. There are also marked differences in the companies analyzed regarding technological capacity and incorporation of digitization using BIM, aspects that were not examined further. However, it was seen through the types of products and solutions that only a few explicitly state the use of technologies, digitization, computer design, or similar options. According to the figures in Table 3, 23 companies in the Metropolitan region, 8 in Valparaíso, and 4 in O'Higgins, were rated at level 3 of the Likert scale. This implies that they can potentially manufacture and supply houses with some additional requirements.

The Ministry of Housing and Urban Planning's Technical Division (DITEC, in Spanish) has announced the legal framework to regulate the industrialization companies it will use to reduce the housing deficit (BCN, 2023a). Four companies from the wood construction sector have been authorized, with projects for social housing and medium-rise buildings. These have made progress in regulatory compliance, using technology and BIM in production processes, coordinating industrialization in the factory, and making it possible to link up with other suppliers. In this way, Chile's wooden housing market could grow and develop even as an export product for Latin America.

As part of comprehensive solutions, the interaction between energy, seismic design, and other relevant technical criteria, such as fire resistance, is expected. Thus, it is vital to remember that this research shows that compliance with technical regulations is not being monitored when these houses are purchased on the private market. Martínez Gamboa (2022) found a similar result in his evaluation regarding the thermal subsidies of the Family Heritage Protection program and their effects on overcoming energy poverty in Chile and pointed out that "the most vulnerable households have not been focused on. This results from deficient handling by the program's leaders and the allocation of thermal subsidies with non-conforming goals considering the resources delivered, which has been done indirectly, sectorized, and without suitable monitoring and supervision" (p. 2). He also states that this is added to the problems caused by decentralizing public institutions, the lack of characterization and targeting of beneficiaries with territorial relevance, and transversal energy poverty. (Martínez Gamboa, 2022)

Under the life cycle analysis logic, by building with wood and protecting it, fewer forests would need to be cut down to build and/or heat, there would be less need for transportation, the useful life would be extended, and the need to recycle, replenish, and reuse would decrease up to three or four times more if the wood is treated correctly.



Presenting and describing this industry aims to highlight the existing productive capacity, make the adjustments to comply with the rules, strengthen the users, and do whatever is necessary to make this productive sector a more integrated, prosperous, and beneficial player for society.

So far, international research has been limited to identifying the actual behavior, construction technology, and design factors influencing thermal comfort and fuel consumption in dwellings. Location aspects, accessibility, and other factors that affect access to housing have been left aside, even though there is an increasing asynchrony between the needs and rhythms of the State (Penalty et al., 2022; Mendia, 2022; Felmer, 2018).

Finally, it is worrisome that safety in the region, regarding exposure to threats, has yet to be included in the regulations. Even though changes are perceived, actions are lacking, such as showing the advantages from a life cycle analysis regarding the final destination of construction materials, where wood tends to be better. However, this must be highlighted as an attribute in the still unsophisticated market of prefabricated houses. Thus, the three Reduce - Reuse- Recycle (R-R-R) elements must also be promoted.

## CONCLUSION

This industry is characterized by providing housing with kit-to-assemble, assembled, and, to a lesser extent, turnkey modalities. It is circumscribed mainly to construction factories, 83% of them, more than to real estate ones. However, both participate in the supply of housing solutions and, therefore, should be regulated by the State through actions to empower the productive sector, especially remanufacturing, which is currently focused on offering products and has not managed to become part of a larger ecosystem that impacts sustainable construction, since it has industrialization capacities.

The largest group of companies among those studied is located in the Metropolitan Region, with 69%, followed by the Valparaíso region with 20%, and finally, the O'Higgins region with 11%. As for formality, 83% are formal companies, and 17% are informal.

54% have low complexity, 35% medium complexity, and 11% high complexity, which shows the companies' level of preparation to face markets with higher demands for compliance with technical criteria, deadlines, and costs.

The overall evaluation of the 88 companies showed that 2.7% obtained level 1, 37.5% obtained level 2, 58.6% level 3, and only 1.1% were placed in level 4; none obtained level 5.

This information is relevant to fostering interest in these companies and providing more technical information to customers regarding their products, especially concerning current regulatory compliance. In addition to highlighting environmental aspects, some may exist and are not highlighted. In other cases, adjustments should be made to satisfy the demand according to requirements that are increasing annually.

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