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CHARACTERIZATION OF GLUED-LAMINATED TIMBER SUPPLY IN CHILE

Janina Gysling[1], Carlos Kahler [2], Daniel Soto[3], Wilson Mejías[4], Pamela Poblete[5]

ABSTRACT: The rise of construction with wood in the world has its presence at local level, where there is great activity on this matter. The forestry institute (INFOR) actively participates in research projects carried out for the purpose of generate, and transfer economic, and technical information, which allow actors to make informed decisions to improve the development, and consolidation of construction with wood in Chile. In terms of economic information, for the first time the industry of wood engineering products is addressed, which is represented mainly by glulam (Glued laminated timber), whose supply is characterized in the present research. Thus, this study contributes to the decision-making process of private, and public actors involved in construction with wood; delivering an informed, and detailed analysis of the glulam in Chile; at the same time, the presentation of glulam industry profile aims to share this reality with the international interested community, and experts to gather opinions, and experiences about this industry's contribution in wood construction.

KEYWORDS: Engineered Wood Products, Glued laminated timber, Supply, Statistics.

1 INTRODUCTION

The Engineered Wood Products (EWP) corresponds to a series of construction structural products, made from beams, veneers, and other wood fibers mixed with adhesives, obtaining a larger dimensional unit, with superior resistance features than wood. It has a predictable performance, therefore reliable, additionally, it uses forests resources more efficiently [1].

The importance of these wood engineered products in construction it is demonstrated by the great development this industry has had in many countries where wood is a predominant material in this activity. While its use started, and reach notoriety in the non-housing construction sector, in the las few years, the use of engineered wood products has significantly increase in the housing sector, with important innovations in products, and applications, along with innovations in the architectural design.

Currently, Nordic countries are leading in wood construction projects, where the wide use of CTL (Cross Laminated Lumber) in high-rise housing building construction should be highlighted. Other countries that should be mentioned in this regard are: Japan, Italy, and Canada, among others. A lot of these developments are related directly to the need of countries of reaching in 2030 the UN's Sustainable Development Goals, due to the fundamental role the wood construction has played in matters of reducing the emissions of greenhouse gases. [2]

The number of companies in this sector is relatively small: 15 glulam facilities, one of I-joist beams, and six of industrialized truss. In CTL production there are two big companies in the Chilean forestry sector: Arauco, and CMPC (Niuform), and some sporadic actors.

The evolution of this sector has been relatively slow, in line with the evolution of construction with this material. However, in the last few years, the construction with wood has generated much interest, where the engineered products industry is becoming part of. For this reason, INFOR has added to its Forestry Statistic Platform this important sector of wood products, carrying out annual cadasters since 2020, which has allowed to understand the main parameters, and features, and the way the industry is evolving [1].

The main EWP elaborated in Chile is Glulam (Glued laminated timber). There are around a dozen facilities producing glulam, while other types of EWP for structural use, as in case of I-joist beams, and reticulated beams, have a limited participation. It should be noted that the first trails of glulam use in Chile are from 1960, when the forestry institute, supported by CORFO, brought Finnish experts with whom projects were developed as in case of the Universidad del Biobío sawmill in 1964; the industrial warehouse of the Sociedad Agrícola Forestal Copihue also in 1964, and the former Forestry Institute headquarters in Santiago, built in 1969 [3]. As a prove of

[1] Janina Gysling, (INFOR), jgysling@infor.cl
[2] Carlos Kahler, (INFOR), ckahler@infor.cl
[3] Daniel Soto, (INFOR), dsoto@infor.cl
[4] Wilson Mejías, (INFOR), wmejias@infor.cl
[5] Pamela Poblete, (INFOR), ppoblete@infor.cl

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the job done in 1960 by the Finnish experts is the Forestry Institute's 18 Technical Report [4]. Regarding the CLT, there are a few Chilean companies with project to produce CLT in large volumes. For example, the case of the Niuform company, a joint venture between CMPC, and Cortelima companies, which have carried out several construction projects with CLT, and glulam.

In this context, this research aims to contribute in decision-making processes made by public, and private actors involved in the wood construction sector, delivering an informed, and detailed analysis of glulam supply in Chile, industry with history in the country, and with highly relevant products for the wood construction development perspectives.

The 2151 NCh norm defines the glulam as "a resulting product of the assemble of structural graded lumber using adhesives, through their faces, ends, and edges, to finally create elements not limited by squareness nor length in which fibers must remain longitudinally parallel with each other, working as whole structural unit". The pieces of wood are longitudinally assembled through finger joints.

INFOR has series of glulam statistical information generated in three consecutive years of measurement. From these it can be seen that glulam production in Chile revolves around the 23.000 m³, far behind from records from other countries with long history like Germany, and Austria, whose production figures are near to 2 million m³ [6].

At world level, the wood species generally used in glulam production are coniferous, and in Chile, it is mainly manufactured with one of these species: radiata pine. The main use of this engineered product in Chile is as structural beams in non-housing works [3], while in United States, it is used massively as columns, beams, and headers in residential construction [7].

The glulam allows to design structures with different structural, and aesthetic qualities. There are industrial quality pieces (for those without aesthetic requirements), normal visual quality (for pieces to be use in construction in general), or selection quality (for pieces with high aesthetic requirements), the latter being treated to erase knots, and details of the material [8]. Another glulam feature is that it allows to work with variable, and lower squareness, and lengths, so when bonded together, it reaches the required structural quality, providing the project with an image of lightness, especially in works with big lights. Another advantage of glulam in respect of sawn wood it that it has 80% more resistance, and up to 40% more stiffness, which also contributes to the construction of big lights buildings with slender pieces [3]. The variety of forms, and dimensions that glulam allows is certainly its main attraction, therefore it is a material that has been used in several architectural projects, for housing, and non- housing purposes.

The norm related to glulam, where the procedures for its manufacture, and use are established, is included in the following Chilean norms:

- NCh 2148: *Madera laminada encolada estructural – requisitos e inspección* [8]. (Glued-laminated structural lumber – requirements, and inspection)
- NCh 2149: *Madera – Madera aserrada – determinación del módulo de elasticidad en flexión – método de ensayo no destructivo* [9]. (Wood – sawn wood, bending modulus of elasticity determination – non-destructive testing method)
- NCh 2150: *Madera laminada encolada – Clasificación mecánica y visual de madera aserrada de pino radiata* [10]. (Glued-laminated timber – Radiata pine sawn wood visual, and mechanical grading)
- NCh 2165: Madera laminada encolada – Tensiones máximas admisibles para la madera laminada encolada estructural de pino radiata [11]. (Glued-laminated wood – tension grades for radiata pine structural glulam)

2 MATERIALS AND METHODS

The information on glulam presented in this research comes from three cadasters carried out by INFOR on this product's manufacturer companies.

The cadasters of the glulam industry, carried out in 2020, 2021, and 2022, is an activity that INFOR will continue to do annually in order to provide the country with statistical series of this secondary industry remarkable segment, whether for the definition of public policies, as well as for the development of investment that contributes to increase this product supply.

Following the methodology INFOR uses when generating forestry statistics for the country, a total of 15 glulam manufacturer companies were identified. These companies were surveyed by INFOR's professionals through a survey form design for this matter. The information collected was added to the Forestry Statistical Platform, this is a tool to generate series, and statistical reports, which are available for the interested public. The information processing in the present research was carried out using EXCEL database.

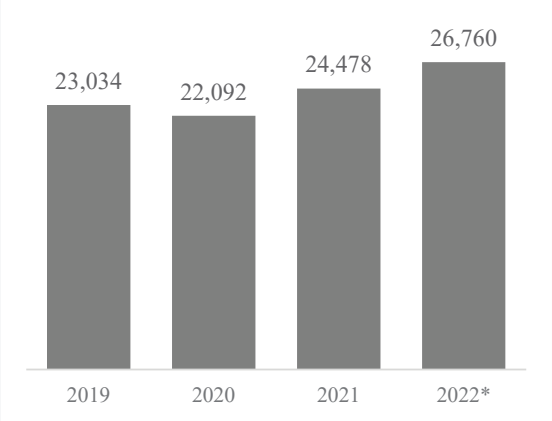
To know the problems, and goals the producers are facing, they were asked to choose from 10 options, the three most important by priority. Their responses were valued according to this prioritization, thus creating a value index for each option.

3 RESULTS

The glulam industry in Chile is constituted by 15 manufacturer companies, from which 12 were producing in 2021, and 3 were paralyzed, or without glulam projects. The glulam plants have presence in five regions around the country, but they are mainly concentrated in Metropolitan Region (7), and to a lesser extent, in Biobío region (4). Another 2 plants are located in La Araucanía Region, 1 in Ñuble Region, and 1 in Los Ríos Region.

3.1 PRODUCTION

In 2021, glulam production in Chile reached 24.478 m³ (Figure 1), which represented an increase of 10.8% in respect of the previous year. With these figures, the evolution of the 2019-2021 period shows an upward trend, in accordance with the forecast for the industry conducted in 2022, which indicates a growth of 9.3% in relation to 2021. The drop recorded in 2020 is attributed to the long periods where people could not go to work, with a consequent drop in the economic activity.



*: Industry estimation

Figure 1: *Evolution of glulam production in Chile*

The 2019 production was originated in 14 manufacturer plants, while in 2020 the number of plants dropped to 13, and in 2021 a new company was added, but three of the companies already added stop operations, therefore that year, the total of manufacturer companies was 12.

More than 90% of production is generated in regularly working plants, while some other plants only work occasionally or sporadically, this situation slightly increased due to the pandemic.

The glulam industry products are beams, and columns, impregnated or not (Figure 2). In the first two years of the analyzed period, beams, and then columns concentrated around 90% of production. However, in the last year of that period, the production of impregnated beams increased significantly, even exceeding non- impregnated beams, which is definitely in accordance with the requirements of specific projects where these products were used.

Production is determined mainly based on companies' orders. A proportion lower than 10% is made on the basis of last year production, and in 2021 also near 10% was produced to have a supply volume available. It should be noted that in the first two years, some companies did not provide information on this matter; however, the statistical procedure by itself, and the universal utility of the data it provides, contributes considerably to generate trust in all actors.

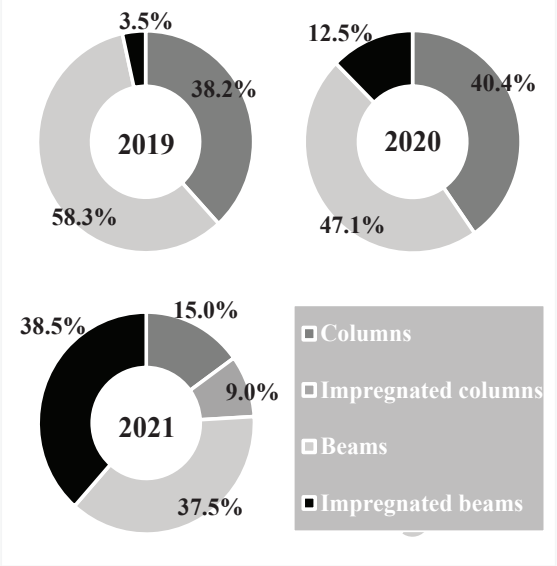


Figure 2: *Glulam production by type of product*

According to the information provided by the companies, approximately 83% of production was made based on orders (Figure 3). This means that it is a production generated in response to a known demand, through diverse construction projects in which the glulam industry participates as a structural elements provider.

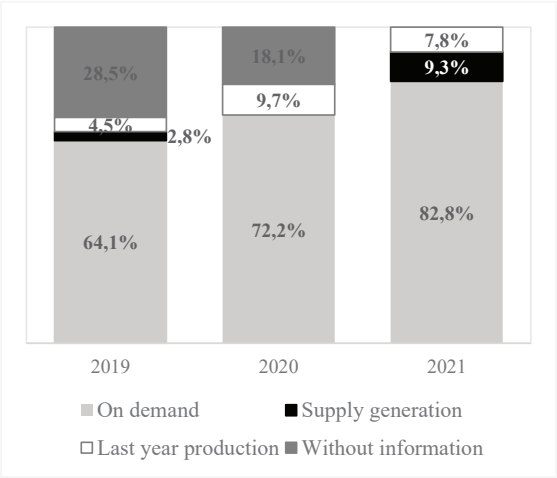


Figure 3: *How it determines the production of glulam in the*

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industry?

In glulam manufacturing, radiata pine is by far the most dominant species, as well as in the whole forestry, and wood industry. However, the Douglas fir is highlighted with a relatively significant participation, even though this experimented a strong fall in 2021, as a result of the sawn wood prices increase, and a lower relative availability of Douglas fir (Figure 4).

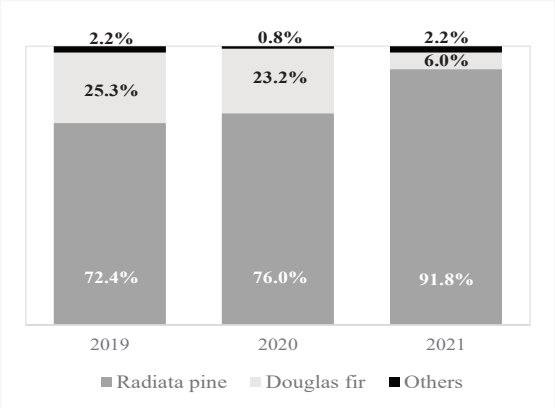

Figure 4: *Distribution of glulam production by species*

According to production volumes, there are three different groups of plants: with production >to 3.000 m³/year; with production between 1.000 – 3.000 m³/year, and plants with production < to 1.000 m³/year. It should be taken into account that, based on differencing according to annual production ranges, a plant can change of range from one year to another.

Glulam plants in superior ranges currently participate with more than 60% of production, while the ones in intermediate ranges produce 30%, and the one in inferior ranges participates with something more than 7%. Although proportions have varied between one and other ranges in the analyzed period, it can be affirmed that 2021 figures, with mitigated pandemic effects, are closer to the local industry reality (Figure 5).

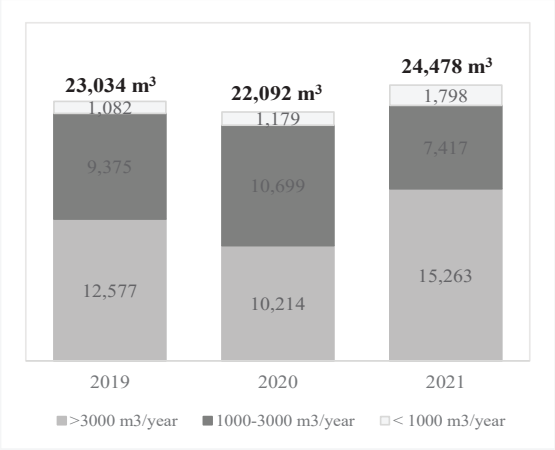

Figure 5: *Evolution of glulam production by annual production ranges*

On the other hand, the main variable cost of production is raw material, with a share of 42% in the first two years within the period, that grew in 53% in 2021. This growth reflects the significant increase in construction materials prices, like sawn wood, as a result of a demand activated by several state programs in support of families affected by the pandemic. Secondly, the workforce is included, that together with raw material represents more than two thirds of glulam's total production cost (Figure 6).

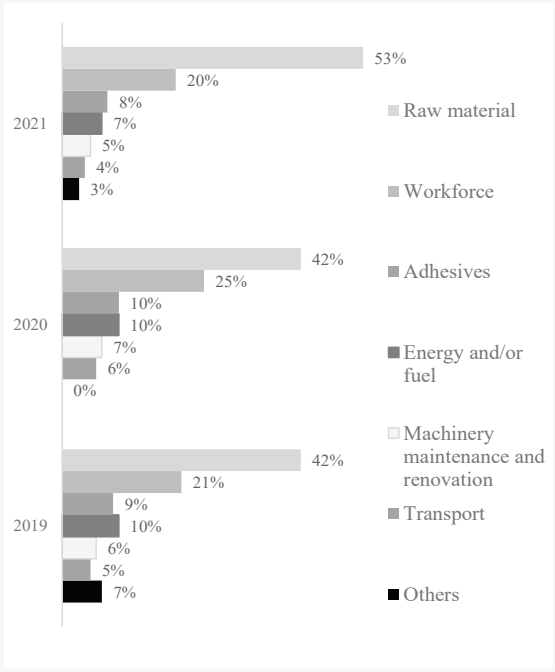

Figure 6: *Distribution of production variable cost by main items*

The occupation in glulam industry is relatively low, with 616 employed people in 2020, and 640 in 2021. Nearly 90% of occupation corresponds to permanent type of workers, mainly operators since the number of people working at the administration represent less than 10%. Moreover, more than 93% are men.

3.2 MARKETING

Glulam production is mainly destined to the internal market, but there is also a volume for exports, being Australia by far the main, and more stable market of destination.

During 2019 and 2020, the relation between the internal, and external market remained relatively stable, however, in 2021 exports increased until exceeding 40% of production (Figure 7). It could thus be supposed that the stimulus to increase production was the external market demand, more than the local market recovery.

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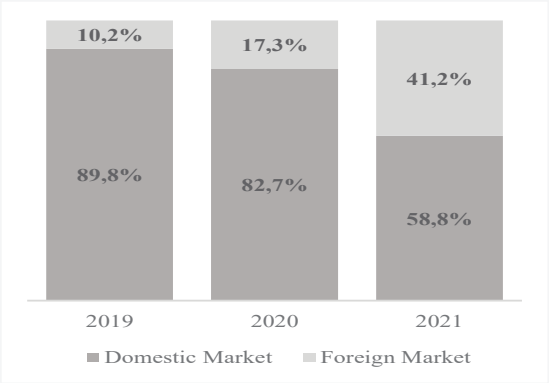

Figure 7: *Distribution of glulam production by market*

The main marketing channels for production that remain in the internal market are six, and their participation is relatively regular when compared with 2019, and 2021, however, in 2020, glulam producer sales in the internal market changed a lot in terms of destination, making marketing chains way more relevant, at expenses of the non-housing construction companies' participation (Figure 8).

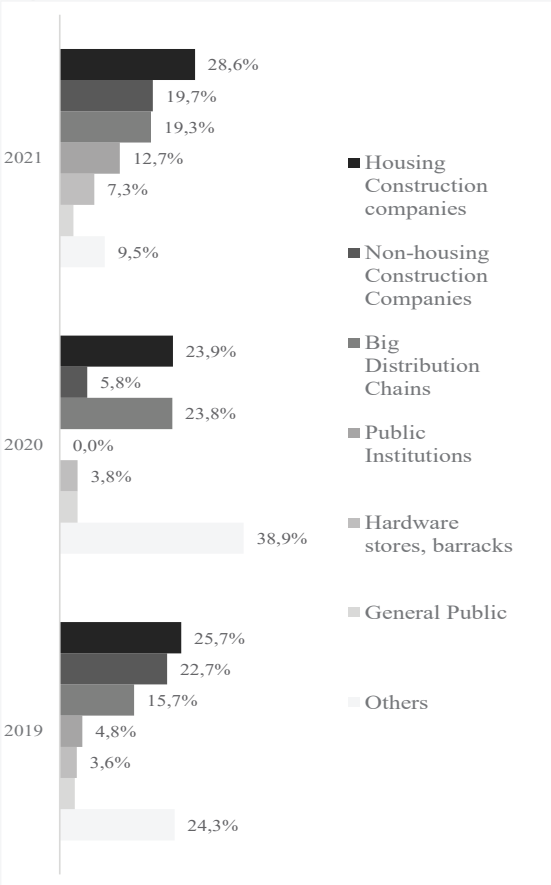

Figure 8: *Marketing channels in the domestic market*

In relation to the Chilean market perspectives in the next five years, glulam producers are solidly optimistic. In 3 annual consultations carried out, around 70% anticipates a growth in the market, while 10% thinks that the market will remain unchanged. The remaining 20% did not give a response, but none of the producers think that it will drop.

3.3 RAW MATERIAL

As mentioned before, the main raw material in glulam manufacturing is sawn wood, reaching in 2021 a total consumption of 34.010 m³, which reflects a decrease of 12.8% in respect of 2020. In Table 1, it can be seen that the most frequently way to obtain sawn wood is in dry state, although some plants purchase part of it in green state, and they dried it onsite. In other cases, sawn wood arrives impregnated or planned at the glulam plant. Only 9.4% of supply in 2020 was determined by the producers as structural sawn wood, meaning a classified wood with structural grade according to NCh 1198 norm, with moisture content lower than 20% according to NCh 1207 norm, dimensions, and tolerances according to NCh 2824, and preserved according to NCh 819 norm [12].

Table 1: *Sawn wood supply by state*

Type	2019	2020	2021
Green sawn wood	42	42	5,828
Impregnated sawn wood	313		104
Dry sawn wood	33,479	30,909	27,072
Impregnated sawn wood dried in chamber	1,116	1,519	509
Dry planned wood			497
Structural Sawn wood		3,682	
No information	3,469	2,867	
Total supply of sawn wood	38,419	39,019	34,010

On the other hand, glulam plants are supplied with sawn wood mainly from their own sawmills, this modality shows a growing tendency in the analyzed period, reaching a participation of 54% of supply in 2021 (Figure 9). On the contrary, the supply from sawmills with production lower than 1.000 m³/year is not significant, since in 2021 none of the glulam plant were provided from these productive units. The superior, and intermediate ranges participation does not show a clear tendency in the analyzed period, but they are very important when considering that together they provide something more than 40% of supply.

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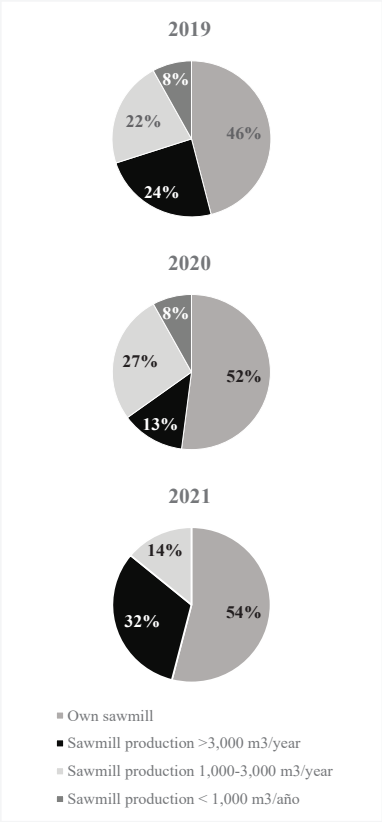

Figure 9: *Sawn wood supply distribution by type of sawmill of origin.*

3.4 PROBLEMS AND GOALS

The glulam producers were consulted about the main problems this activity faces, and the main goals they have planned. In respect of problems, the producer's prioritizations show differences year to year, but the one with higher valuation rate in the period is the low demand on glulam, and low availability of sawn wood for its manufacture. Way more behind is the lack of qualified workforce, sawn wood high cost, and its low quality. The valuation index for prioritized problems in 2021 are presented in Figure 10.

In the valuation of goals, the strong, and permanent disposition to increase production, and improve productivity is highlighted. In a second level, the produce's goals show the investment in technologic production, and diversification of products, and markets. It is worth to mention that even though one the biggest problems mentioned by the industry is the lack of trained workforce, there is no prioritization assigned in training the personnel in 3 years of consultation, which represents a contradiction. The valuation index for prioritized goals in 2021 are presented in Figure 11.

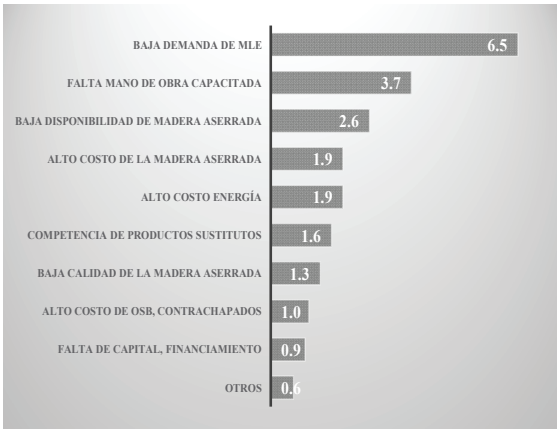

Figure 10: *Valuation index of problems in glulam industry, year 2021*

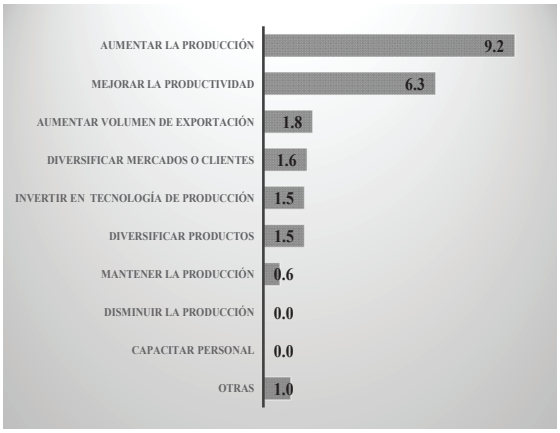

Figure 11: *Valuation index of glulam industry goals in 2021.*

3.5 PRODUCTION PROCESS

According to information collected through survey application, glulam plants are supplied almost entirely with dry sawn wood, but when they are supplied with green sawn wood, first it is dried, and then graded. Eventually, sawn wood is impregnated, depending on the component's requirements for it to be manufactured.

The first process in production of sawn wood laminations is obtaining this product with the allowed defects according to the structural grade required by the lamination (A, or B grades, according to NCh 2148). Then, the lumber is bounded together through finger joints to form laminations. When the length allows it, some companies are partially or totally supplied with laminations. After that, laminations are planed for they to reach desire dimensions. Subsequently, they are glued together and pressing to form laminated timber, before the curing of adhesives starts, whose thickness must remain as a thin layer. The most used adhesives in manufacture are melamine-urea-formaldehyde (MUF), and liquid polyurethane plastic (PUR). Lastly, the glued-laminated

timber piece is planed to reach its final dimension. Optionally, beams can include painting, or varnish finishings, which are applied depending on the client's requirements. The complete process of glulam production takes 4 days, being pressing the process that takes the longest time, between 4, and 12 hours, depending on the adhesive used.

Figure 12: *General Layout of glulam productive process*

Regarding the machinery used in the productive process, all consulted companies declare to have drying chambers, and impregnation to prepare the raw material. Then, in the lamination process, there are features to be highlighted, cutting tools like band saw blades, and sliding table saw, while two companies have CNC machines. The clamping process is carried out in a hydraulic, and mechanical press, and to a lesser extent, by hand press.

4 CONCLUSIONS

The most important EWP product in Chile, due to the number of companies involved, but overall due to its long history in the country, is glulam. However, the industry level of production is low, and has not been able to improve to superior levels of development, mainly due to limitation related to wood use, and its products in construction, resulting in, just as stated by producers, a low glulam demand.

Another limitation that producers have highlighted is the low availability of sawn wood, referring mainly to the structural sawn wood, which is the type of sawn wood that glulam requires to its production. This limitation comes from the sawmill industry, which produces low volumes of structural sawn wood, but this also originates from in the quality of lumber supply as a result of the predominant modalities in forest plantation management.

Even though the great activity existing in wood construction Chile has stimulated the interest, and expectations of wood products companies, the low production of structural elements allows to conclude that this is not enough to reach significant increases in the activity, in the short, and medium term, and what is probably needed is a more determined, and focalized boost from public policies.

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