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THE LIFESPANS OF PRODUCTS MADE WITH MDF

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Abstract: *The Horizon Europe funded EcoReFibre project (www.ecorefibre.eu) is concerned with recycling fibreboards and, in particular, Medium Density Fibreboard. This paper covers our research on determining the typical lifespans of products containing fibreboard. Knowing the lifespan of a product is important as it is the main determining factor that influences the age when it becomes waste. This paper proposes that the average age at which a product containing MDF becomes waste is between 10.7 and 12.1 years.*

Key words: *fibreboard, MDF, lifespan, post-consumer waste, model.*

1. Introduction

Medium Density Fibreboard (MDF) is a phenomenal success story. In this paper, MDF will be used as a generic term for a wide range of wood fibre-based products, some of which are High Density Fibreboards (HDF). Large-scale, commercial production of dry process MDF really began in the 1980s and yet, less than 30 years later, it has become the second most produced wood-based panel in the world (Figure 1); number one is still plywood with a global production of nearly 129 million m^3 [3]. All this material will eventually become waste, but the question is when? This paper is concerned with determining how frequently products which contain MDF are replaced, in other words what is the typical lifespan of MDF-based products?

Information on the lifespan of MDF products is important for the EcoReFibre project [5], which is concerned with separating and reusing fibreboard waste. Like all materials, once an MDF panel is made, it will eventually become waste. First it is incorporated into a product, e.g. a piece of furniture, moulding, a toy etc., and each product type is likely to have a different lifespan. For example, a packaging product is likely to have a short lifespan of less than one year, whereas a door made from MDF will probably be used for several decades before being replaced. To calculate the average lifespan of MDF, one must ascertain the typical lifespans for a range of end uses and then calculate a weighted average. The European Panel Federation (EPF) collects information from their members, i.e. the MDF producers, on where their products are used and often this information is

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summarised in their Annual Reports, see for example [2]. The market is evolving continually and so the proportion of MDF used in one product category compared to another will change with time. The change in how MDF is used will impact how quickly it becomes waste.

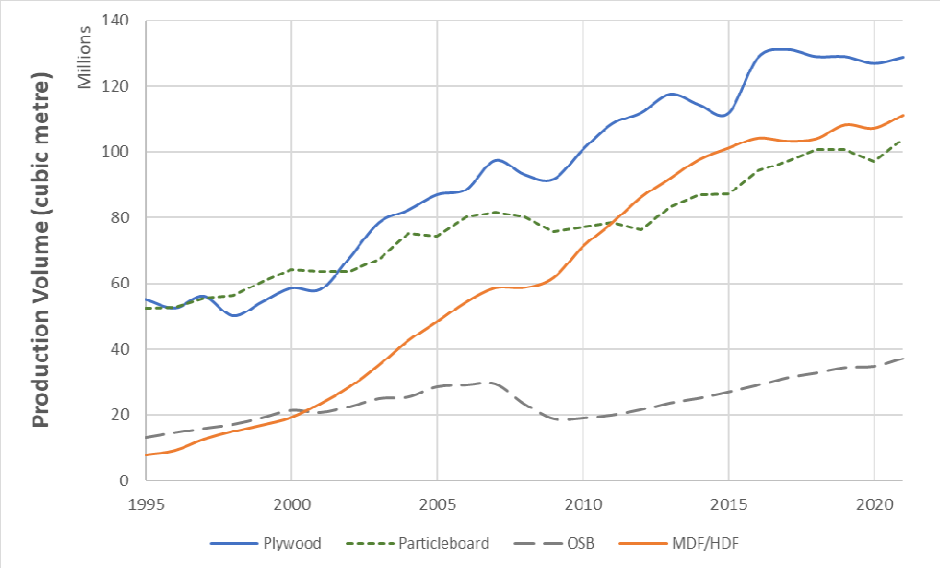

Fig. 1 . *Global wood-based panel production according to FAO [3]*

The approach taken to estimate lifespans is to use crowd wisdom. Francis Galton presented statistical evidence of the usefulness of the wisdom of the crowd in his paper entitled "*VOX POPULI*" (the voice of the people) [4]. He analysed 787 valid replies to a competition organized at a fair in Plymouth, to estimate the weight of an ox after it had been slaughtered and prepared [4]. He found that the median estimate (547.5 kg) was only 0.8% higher than the actual weight (543.4 kg) [4]. The EcoReFibre project will collect people's estimates for the length of time before a product is replaced by a new one via an online survey. Although a replaced product might be reused, the large quantities of wood waste generated in every European country indicate that the vast majority of fibreboard-based products enter the waste stream. Therefore, a time estimate for when a product is typically replaced is an accurate estimator of the lifespan of that product. It is hoped that more than a thousand responses to the survey can be collected during the lifetime of the EcoReFibre project.

If the consumption of fibreboard is known, this information and the data on where it is used and are combined with estimates of product lifespans, then the amount of waste fibreboard generated each year can be predicted.

2. Materials and Methods

The online survey is hosted by QuestionPro [7]. This site was chosen because it offers a numerical sliding scale as an answer to a question (Figure 2).

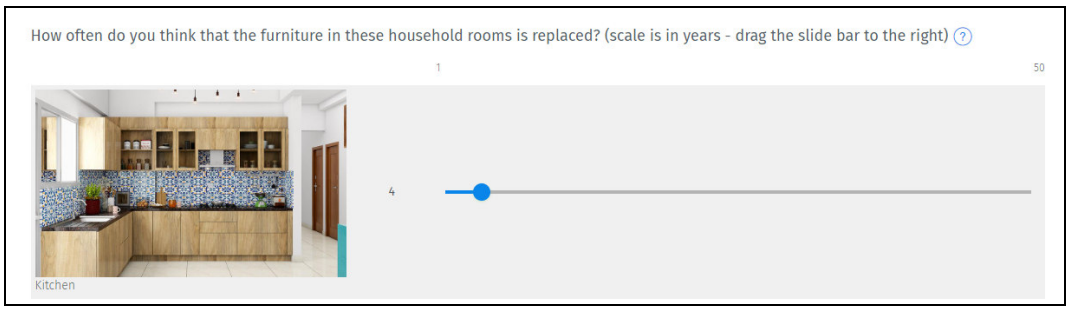

Fig. 2. *An example of a question in the survey with a sliding scale*

The questions in the survey are designed to be quick and easy to answer. No specialist knowledge is required and so anyone can answer based on their personal experiences. There are no questions about the responder and no personal information is collected. The only extra piece of information collected by the website is the country where the survey was completed. Consequently, it is not possible to analyse the data to see if, for example, women reply differently to men, but, this is not the objective of the survey. The country information might be useful later to see if there are geographical differences in the use of MDF.

There are two questions that ask responders to estimate their confidence in the correctness of their previous answers. This information has not, so far, been used to modify the values obtained; the wisdom of the crowd method relies on the fact that every answer is as valid as the others.

The survey contains two questions about losses of MDF before it is incorporated into a product. One question regards how much product might be lost due to transport, e.g. damaged edges, and storage losses, e.g. incorrect piling or storage conditions. A second question relates to the losses due to cutting and shaping a panel into components for products. Of course, the average person does not have firsthand experience of this and so their guesses might be wildly different to reality. Consequently, a parallel survey for manufacturers and end users will be conducted in the future.

English	French	German

Fig. 3. *QR codes that provide links to the different language versions of the survey, which will remain open until the end of 2025*

The survey data can be downloaded in the form of an Excel spreadsheet. All the data were analysed using Excel. Currently, there are three language versions of the survey: English, French, and German. The data from all three versions were combined into a single dataset.

This research is ongoing and so readers are kindly requested to complete the survey in whichever language they prefer, as shown in Figure 3.

3. Results

To date, there have been 132 replies to the survey (99 in English, 30 in French, and three in German). It is important to note that the English survey was published several months before the French version, followed by the German version. The mean and median lifespans for the different end-use categories are shown in Table 1.

In all but one case, the median is lower than the mean. This indicates that the replies are positively skewed. An example of this skewness is shown for Office Furniture in Figure 4.

Table 1. *The average and median lifespans of products containing MDF based on 132 replies to the online survey*

	Mean [years]	Median [years]
Kitchen	19.4	20.0
Bathroom	16.3	15.0
Bedroom	16.5	15.0
Living room	14.5	13.0
Dining room	15.9	15.0
Office	14.1	10.0
Mouldings	24.3	22.0
Toys	6.6	5.0
Doors	22.6	20.0
Art and craft	10.1	7.0
Shop interiors	6.7	5.0
Flooring	17.8	15.0
Packaging	3.1	1.0

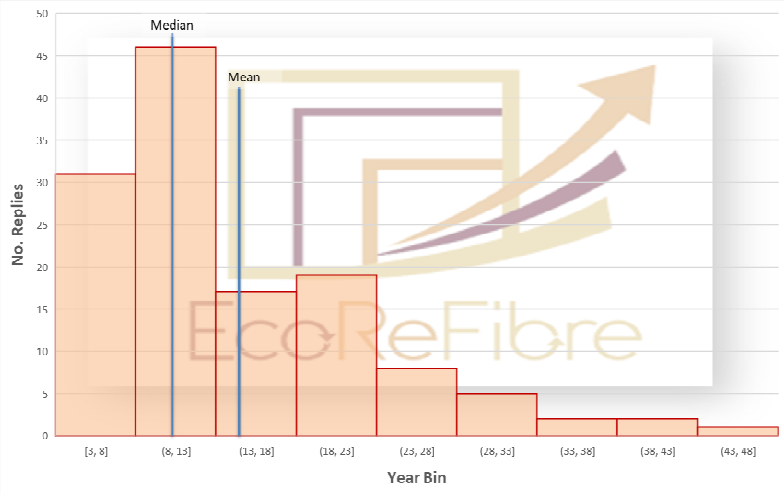

Fig. 4. *A histogram of the responses to the question of how often office furniture is replaced*

Table 2 summarises the estimates provided by the survey respondents to the question regarding the losses that are likely to occur in the first year after production, i.e. when the MDF panels are converted to components for products. Once again, the data are positively skewed. The average person has probably never considered such questions and so it is not surprising to learn that 72% of respondents indicated that their confidence in the accuracy of their estimate is very low or low; in other words, most people guessed.â

4. Discussion

The wisdom of the crowd technique uses the median value as a predictor of the correct answer. This is because the mean value can be strongly influenced by outlier values. If the distribution of the replies were truly binomial, then the median and mean values would be identical. This is not the case for any product category in Table 1. The positive skewness is to be expected when the only answers possible are positive integers; some will provide much higher estimates than others.

Table 2. *The estimated percentage losses of panel product from manufacture to end-use*

	Mean [%]	Median [%]
Transport and storage	5.4	5.0
Cutting and shaping	8.9	7.5
Combined losses	14.3	12.5

An average of all the median lifespans in Table 1 equals 13.8 years, but this is not an accurate lifespan for MDF because some uses, e.g. furniture manufacture, require a lot more MDF than others, such as mouldings. Consequently, a weighted average must be used. EPF publishes data in their annual reports on how much MDF is used in different markets. The data published in EPF's 2014 Annual Report [1] have been used for an initial estimation. These data are given in the first column of Table 3.

Table 3

The average lifespan of all MDF products using the distribution categories published in EPF in 2014 [1]

End-use	Proportion according to EPF [%]	Corrected proportion [%]	Typical lifespan [years]	Weighted average lifespan [years]
Furniture trade	36	32	14.7	10.7
Flooring	30	26	15.0	
Mouldings, panelling and other	10	9	11.0	
Shopfitting and joinery	24	21	5.0	
Processing & losses	-	12	1.0	

* *The highlighted cells have been calculated from the survey data*

Column 2 in Table 3 shows the same data after they have been modified to take into account the amount of product converted to waste in the first year as a result of machining and transport losses. An average of the median lifespan estimates for Kitchen, Bathroom, Bedroom, Living room, Dining room, and Office furniture is used to give a lifespan for the category "Furniture trade". Likewise, the lifespan for the "Mouldings, panelling and other" category is calculated using the data from Mouldings, Toys, Doors, Art and craft, and Packaging.

If it is assumed that 99% of all MDF will become waste within 45 years, then a curve can be derived so that 12% of MDF becomes waste by the end of year one and the average age at which all MDF becomes waste equals 10.7 years. Such a curve is shown in Figure 5. It is a Four-Parameter Logistic (4PL) model.

The curve can be used to estimate the proportion of MDF that has become waste at any given time after production. For example, just under 60% of the 2014 production should have become waste at the time this paper was written. Verifying this is unrealistic.

The equation for the Four-Parameter Logistic (4PL) model is given in Equation (1):

$$y = d + \frac{a - d}{1 + \left(\frac{x}{c}\right)^{b}} \quad (1)$$

where:

y is the percent of MDF that is now waste;
x – the year after production;
a = 6.77×10^{-15};
b = 1.00;
c = 8.87;
d = 118.5.

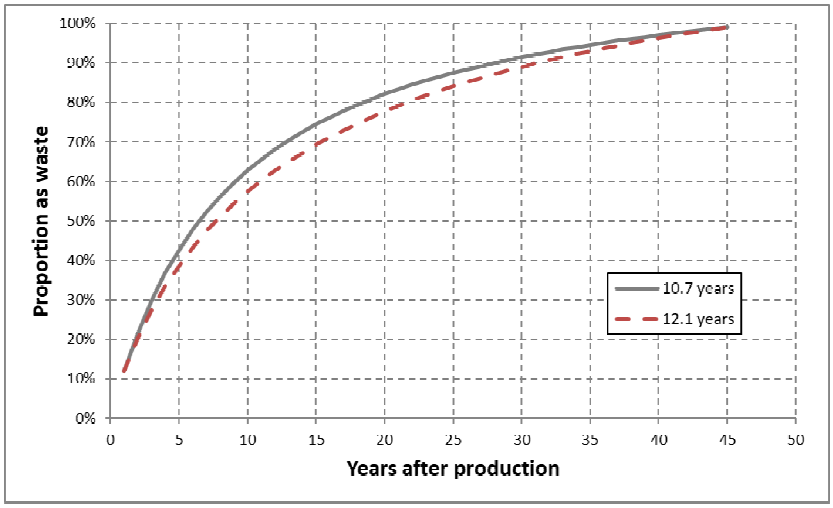

Fig. 5. *A Four-Parameter Logistic (4PL) curve that estimates the proportion of MDF that has become waste in any given year after its production*

As mentioned in the introduction, the market is evolving continually and so the proportion of MDF used for the various end-use changes with time, which will impact the weighted average lifespan for MDF. The changes might be small year on year, but there are obvious differences between decades, as can be seen in Table 4. EPF also adjusted the range of end-use in their 2022 Annual Report [2]. Much more MDF is now used for furniture, which tends to have a relatively long life, and so the weighted average life of a typical MDF has increased by 1.4 years. As a consequence, the MDF to waste conversion curve is modified slightly so that slightly less waste is generated in the early years and more later on as shown by the dashed curve in Figure 5. A methodology to integrate the changing end uses on an annual basis into the waste prediction model is being developed.

Table 4. *The average lifespan of all MDF products using the distribution categories published in EPF in 2022 [2]*

End-use	Proportion according to EPF [%]	Proportion [%]	Typical lifespan [years]	Weighted average lifespan [years]
Furniture trade	54	46	14.7	12.1
Flooring	15	13	15.0	
Construction	12	10	20.0	
Packaging	7	6	1.0	
Moulding	4	3	22.0	
Other	8	7	6.0	
Processing & losses	-	12	1.0	

* The highlighted cells have been calculated from the survey data

The work presented here will be used to update the existing model for global fibreboard waste generation published by Irle et al. [6]. The accuracy of these predictions is very dependent on the exactness of the lifespan values, and so publicity campaigns will be organized to encourage more responses to the survey. The existing data provide an interesting insight into the quantities of waste MDF generated on a global basis. If the storage and processing losses really are 12% of the total production, then this alone would generate approximately 15.5 million m^3, or about 11.1 million tonnes, in 2021. To this must be added the waste generated by the previous 44 years of production as predicted by the curves in Fig. **5.**, which brings the total MDF waste generated around the world in 2021 to around 76.4 million m^3, which is equivalent to 69% of the global production of MDF in the same year.

5. Conclusions

Given the large-scale production of MDF around the world, it is fairly obvious that

this will also result in similar large volumes of waste in the future. The analyses described in this paper should help to understand and predict the wave of waste MDF to come. In turn, this should give investors the confidence to invest in finding economically viable ways of converting these huge volumes into new products. The existing model provides reasonably accurate "ball park" figures for MDF waste generation on a global basis. What the model cannot do is provide the same accuracy to given regions like the European Union or a given country. The work conducted as part of the EcoReFibre project will hopefully result in a model that can offer predictions for specific regions.

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