Technology Profile

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Lightweight Panels: One of the Paths Leading to Product Innovation

What are lightweight panels and what do they offer?

The aerospace and automobile sectors have a long history of successfully integrating lightweight materials in the construction of complex structures that require a high reliability rating. For many, there is a noticeable growing trend in the use of lightweight materials in the wood products industry, especially in the furniture manufacturing sector.

Lightweight panels can be as resistant and durable as solid wood panels (while weighing 70% less), and in some cases, have greater bending and tensile strength. Technological advances have recently made it possible to improve the performance of this new generation of panels. For example, thermofusible polyurethane adhesives have improved product flatness and moisture resistance as well as product mechanical performance and heat resistance.

On the basis of their density, “lightweight” panels can be grouped in four categories:

- heavy or traditional materials
- lightweight materials
- extra-light materials
- ultra-light materials.

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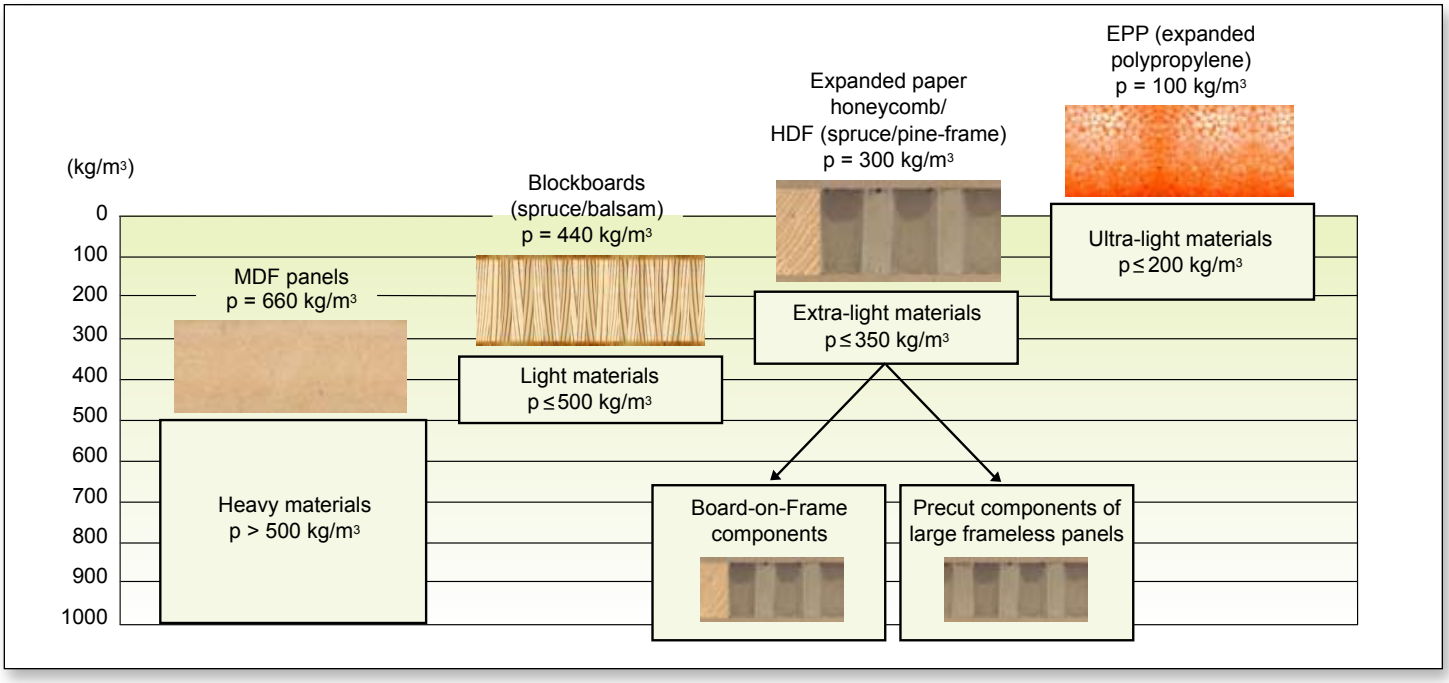


Figure 1: Classification of materials used in furniture manufacturing by density (*Think Light – Innovative Lightweight Panels*, 2008).

For manufacturers, designers and consumers, the use of lightweight panels offers:

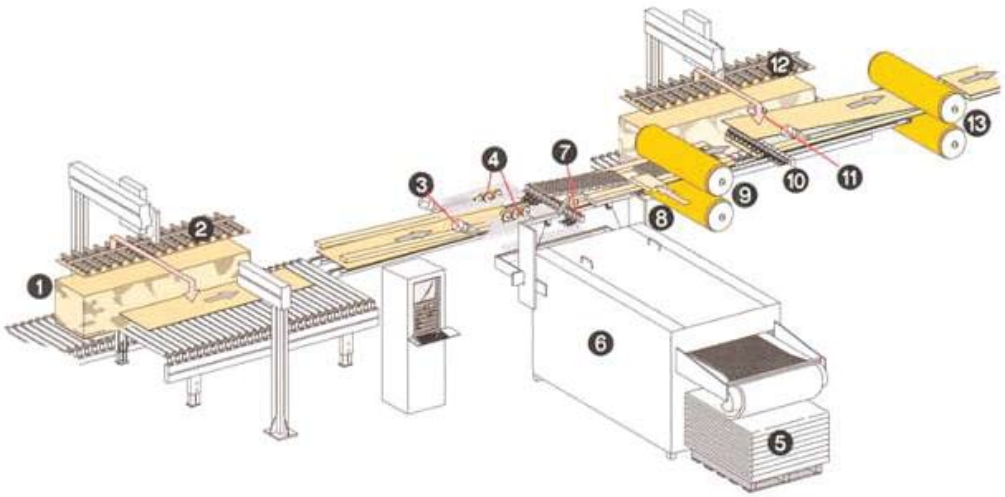
- a reduction of production costs by lowering wood consumption and transportation costs;
- a supply option in the face of the increasing scarcity of raw materials and the increasing price of traditional composite panels;
- a reduction in breakage during transportation and handling;
- a response to international product and design trends (use of thicker panels allows the creation of a colossal and modern design);
- an opportunity for market diversification;
- improved product environmental friendliness by lightening the environmental burden (reducing the pressure on timber resources, reducing energy consumption and reducing or eliminating formaldehyde emissions, etc.); and
- a response to the growing trend in consumer mobility.

The supply of lightweight panels is vast and diversified. This document will focus on emerging trends in the wood products industry, particularly on panels with an expanded paper honeycomb core (honeycomb panels). This is a sandwich-type assembly comprised of an expanded paper honeycomb core layer of lightweight material and two thin layers glued onto both sides of the core layer. The layers can be made of thin wood, plywood, particleboard, high-density fibreboard (HDF) or medium-density fibreboard (MDF), asbestos, aluminum or even laminated plastic.

There are two types of lightweight panels based on an expanded paper honeycomb core: framed panels and frameless panels. A comparison of their structure, properties, features and applications is shown below.

	Lightweight board-on-frame panels	Lightweight frameless panels
Benefits	• Processed using traditional techniques (cutting, coating, assembly) • High material resistance • High mechanical performance at connecting points • Low mass production cost for identical components • Handling and shipping of small elements and components	• Low procurement cost for large panels • Availability guaranteed • Suitable for small production runs • Use of irregularly-shaped components and optimized cutting • No restriction with respect to the location of connecting points • Very light
Drawbacks	• Simple components only (no irregularly-shaped elements; linear connection points) • Unsuitable for small production runs • Limited supply on the market	• Lower rigidity • New cutting techniques • New edge-bending techniques • New assembly techniques • Limited knowledge about long-term performance

Table 1: Comparison of framed and frameless lightweight panels comprised of a paper expanded honeycomb core.



1. Stack of panels; bottom layers
2. Feeder unit for top panels
3. Glue application nozzles for lengthwise and crosswise frame components and automatic infeed of the lengthwise frame components from magazines
4. Pressure rollers for fixing the lengthwise frame components to the bottom layer
5. Expansion honeycomb mat (compressed on a pallet.
6. Expansion and drying unit with feeder and automatic infeed of crosswise frame components from magazines
7. Glue applied to the underside of the honeycomb inlay from a width-adjustable spray nozzle
8. Crosswise frame component infeed
9. Pressure roller for pressing the honeycomb into the bed of glue
10. Nozzles for glue application to the lengthwise and crosswise frame components and the honeycomb
11. Feeder unit for top panels
12. Stack of panels; top layers
13. Press calender
14. Stacking unit (not shown)

Figure 2: Diagram of Torwegge's fully-automated production line (*Think Light – Innovative Lightweight Panels*, 2008).

Manufacturing Processes

In Germany in 2003, close cooperation among equipment, panel and furniture manufacturers, and other sector partners resulted in the introduction of equipment specifically designed for manufacturing frame-on-board lightweight panels based on an expanded paper honeycomb core.

The new type of equipment included the fully-automated production line manufactured by the German company, *Torwegge Holzbearbeitungsmaschinen GmbH*. In large-scale production lines, the entire production process is automated, from the separation of the face layers to the production of frames, the insertion of expanded paper honeycomb cores, gluing, pressing to form the sandwich, packaging and finally stacking of the finished product.

Building on these developments, another German company, *Siempelkamp Handling Systeme GmbH* developed a continuous production process for manufacturing lightweight panels based on an expanded paper honeycomb core. In 2006, *Fritz Egger GmbH & Co.* introduced a new production line for manufacturing large frameless lightweight panels under the trade name Eurolight®.

While the production of frameless lightweight panels is a simpler process, combining the panel elements with a hardening agent can only take place at the pressing phase of the manufacturing process. Initial panel strength develops after a single pass through the press calendar and as a result of the cooling of the thermofusible adhesive. Panels achieve their final strength value after stacking, when panel assemblies undergo a chemical reaction with the moist surrounding air.

Some manufacturing processes include sanding the expanded paper honeycomb prior to pressing. This removes the core thickness tolerance from the material and significantly increases the surface of the webs in the expanded honeycomb. A rough surface also enhances resin absorption and bonding.

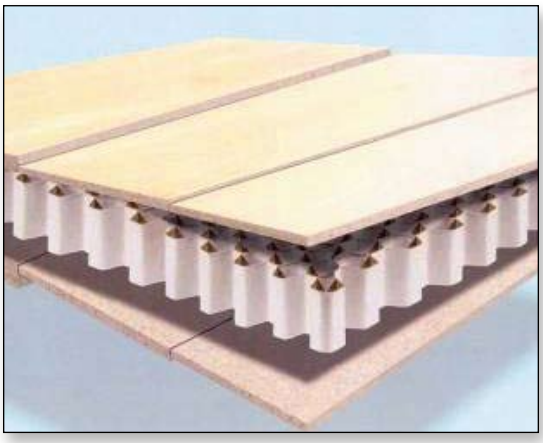


Figure 3: Egger Eurolight Panel: The first frameless lightweight panel available in a large size (*Think Light – Innovative Lightweight Panels*, 2008).

Production Costs

The production costs for a board-on-frame lightweight panel comprising an expanded paper honeycomb core (surface area: 1 m^2; thickness: 24 mm; face layers: particleboard; honeycomb: 21mm; resin: UF; glue application equipment: Kuper) breaks down as follows: 83% for material and 17% for equipment and labour. The major cost factors (88%) have no bearing on panel thickness. Only frame- and core-related costs increase with panel thickness (*Think Light – Innovative Lightweight Panels*, 2008).

The comparative analysis of the production costs for a honeycomb sandwich panel and a traditional particleboard panel based on thickness indicates that the break-even point is approximately 24.5 mm. This means that honeycomb sandwich panels have a financial edge over traditional panels when their thickness exceeds 25 mm.

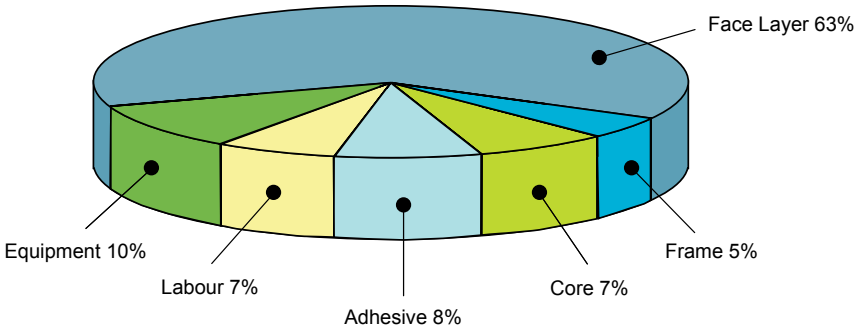


Figure 4: Breakdown of production costs for board-on-frame lightweight panels comprising an expanded paper honeycomb core (*Think Light – Innovative Lightweight Panels*, 2008).

Machining and Edgebanding

Machining lightweight panels based on an expanded paper honeycomb core and cutting such panels to size can be achieved with special tools installed on traditional equipment. Sawing results in smooth edges whereas counter routing, while producing acceptable results, leaves slight honeycomb protrusions along the edge of the panel.

The application of edgebanding material to panels, especially frameless honeycomb core panels, is one of the major challenges that panel manufacturers and processors must address. Edgebanding performs important functions, in particular it:

- seals the sandwich in order to protect the core and face layers against impact;
- prevents the separation of the face layers from the core;
- consolidates and strengthens the edges and the entire panel assembly, making it possible to glue the panels to load-bearing structures or other panels; and
- seals panel edges, thereby protecting them against moisture.

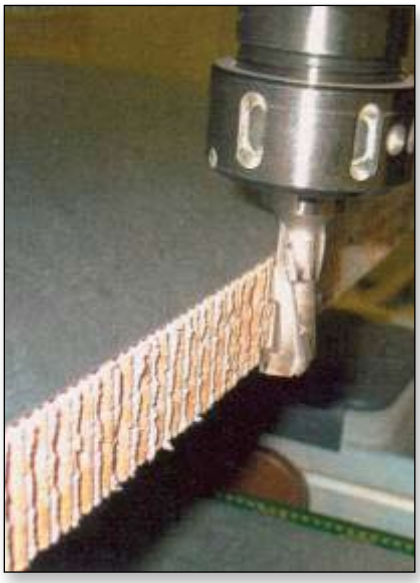


Figure 5: Cutting a lightweight panel based on an expanded paper honeycomb core.

As a rule of thumb, using thin face layers (2.3 to 3 mm particleboard or 2.8 to 3 mm MDF/HDF) does not allow the direct gluing of edgebanding to the face layer edges because the paper honeycomb hardly contributes to adhesive bonding.

Over the years, many methods for applying edgebanding to the edges of honeycomb panels have been developed. Some are still at the concept stage but others, which have proven to be effective, are widely used throughout the German furniture manufacturing industry. Among these are the direct application method, the edge stabilization method and the post-frame method.

Direct Application

This method can be used when the thickness of the face layers is sufficient and the edgebanding material is sufficiently rigid and flat. Under such conditions, the edgeband will adequately bond to both face layers of the panel. Based on empirical data, the situation will be the same for lightweight honeycomb panels and edgebanding materials with the following characteristics: total panel thickness of 400 mm at the most; face layer thickness of at least 5 mm; edgeband thickness of at least 2 mm.

Figure 6: Direct application of an edgeband on a lightweight panel comprised of an expanded paper honeycomb core and particleboard face layers 8 mm thick (www.doellken-kv.de).

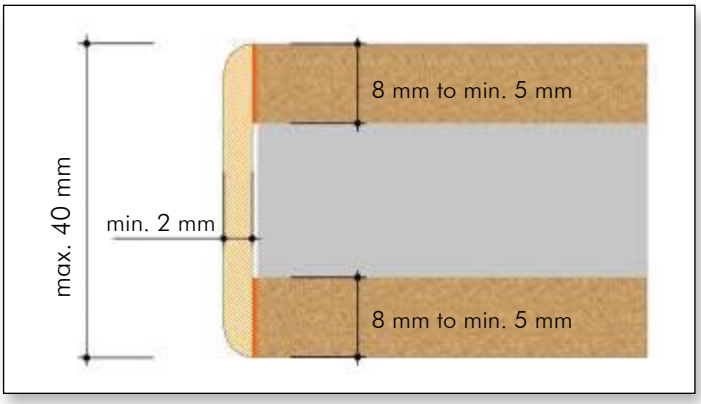


Figure 7: Limits governing the use of the direct edgebanding method (*Think Light – Innovative Lightweight Panels*, 2008).

Edge Stabilization Method

Following the sizing of a honeycomb panel cut from a large panel, a special knife head removes some of the honeycomb core to a depth of 2 to 3 mm and cuts a shallow rabbet in the inside edges of the face layers in a single operation. In the next phase of this method, a stabilization edgeband is glued into the rabbet prior to the application of a decorative edgeband using standard application procedures.

Over the past two years, this method has become well entrenched in the market, especially for the application of supporting edgebanding onto the sides of lightweight panels based on an expanded paper honeycomb core where the face layers are less than 5 mm thick. This method has been adapted for honeycomb panels with the following characteristics: total thickness of 60 to 100 mm; MDF face layer measuring at least 2.8 mm thick or particleboard face layers measuring 3.0 to 3.2 mm thick. In this example, the edgebanding material must be at least 0.4 mm thick.

Figure 8: Application of edgebanding using the stabilization method (IMA Klessmann GmbH, Lübbecke).

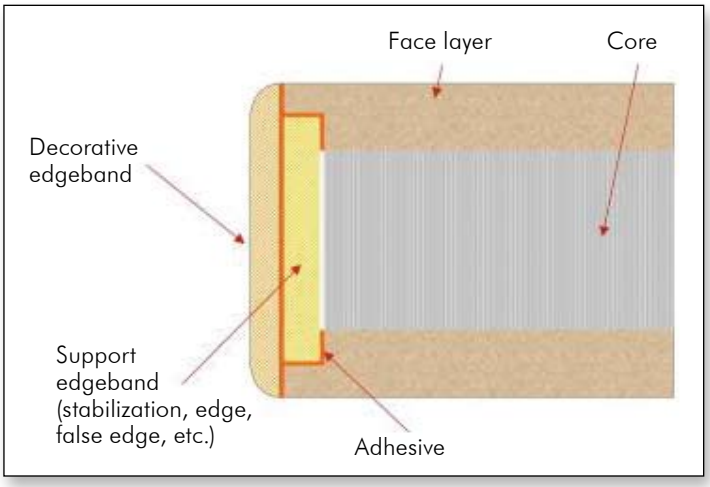


Figure 9: Panel edge structure and adhesive application in the stabilization method (*Think Light – Lightweight Innovative Panels*, 2008).

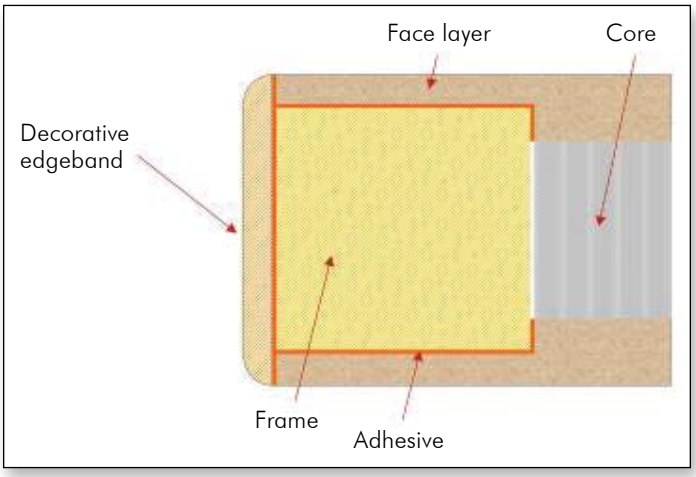


Figure 10: Panel edge structure and adhesive application in the post-frame method (*Think Light – Innovative Lightweight Panels*, 2008).

Post-frame Method

Under certain circumstances, higher requirements for bending strength or the need to install conventional hardware may require the insertion of a frame. It would be wrong, however, to conclude that this type of panel can be made only as a board-on-frame assembly as individual frame elements can be inserted following panel assembly.

For this type of panel, a portion of the honeycomb is removed. A cutting tool cuts a shallow rabbet in the interior face of both face layers. Adhesive is then applied on the resulting contact surfaces before the frame elements are inserted and pressed into place. Subsequently, edges are finished and decorative edgebanding is applied in a continuous operation. Crosswise frame components can be made of particleboard, MDF or OSB.

Assembly, Fittings and Fasteners

In terms of assembly technology, lightweight panel manufacturers can choose among a wide selection of fasteners and fittings.

Whether frame elements are used for the assembly of board-on-frame panels or the post-frame installation of reinforcement components, the use of internal wood frames allows the use of the entire range of fasteners and fittings used with traditional panels. Traditional hardware fittings can also be fastened to frameless lightweight construction components where the face layers measure at least 8 mm in thickness.

However, in the case of frameless panels or panels without any reinforcement and having face layers less than 8 mm thick, special fasteners and fittings must be used. The forces acting on joints under load are distributed in the sandwich panel according to the method used to attach hardware fittings. These can be attached:

- to a face layer;
- in a face layer;
- in a surface layer and the core;
- in both face layers; and
- in the face layers and the core.

The emergence of lightweight panels on the market has led to numerous technological hardware innovations.

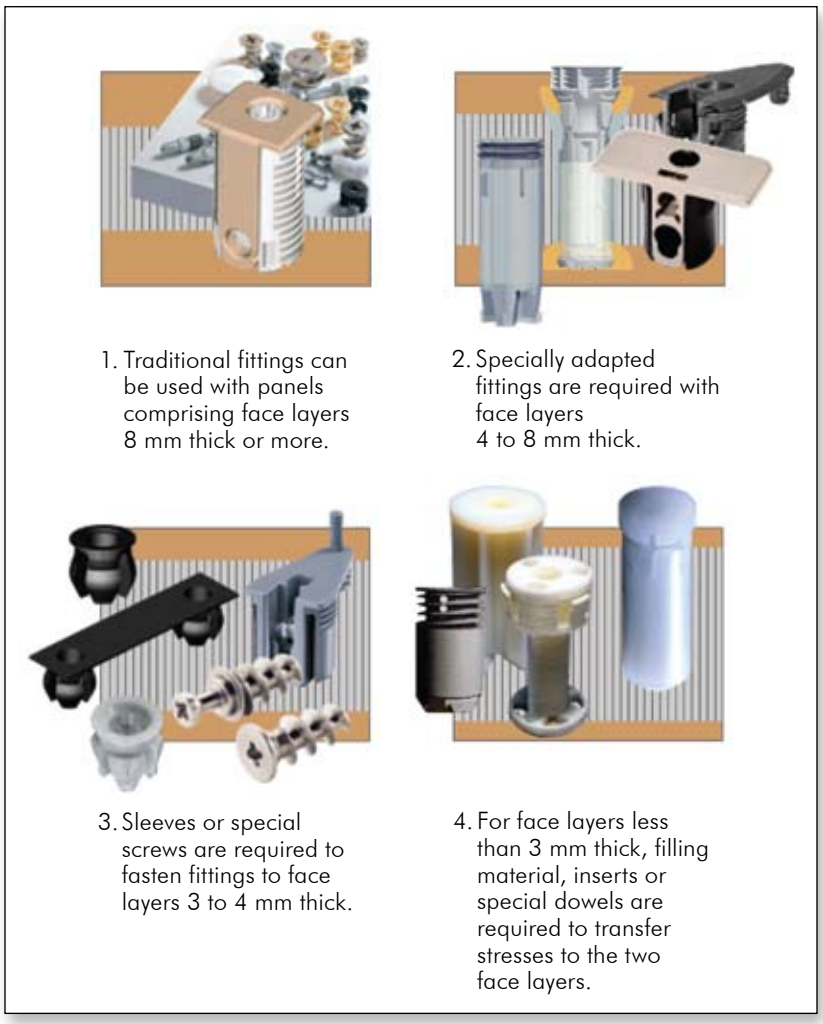


Figure 11: Summary of assembly systems for lightweight panels (*Think Light – Innovative Lightweight Panels*, 2008).

Perceptions of European Consumers

With regard to the relative importance of a given attribute in shaping consumer preference for a product (household furniture in this case) and in subsequent buying decisions, studies have shown that design and price rank the highest with ratings of 45% and 30% respectively while three other attributes (weight, brand and service) trail far behind at approximately 8% each. This highlights the promising potential of lightweight construction given that weight ranks equally with the more traditional product attributes of brand and service (*Think Light – Lightweight Innovative Panels, 2008*).

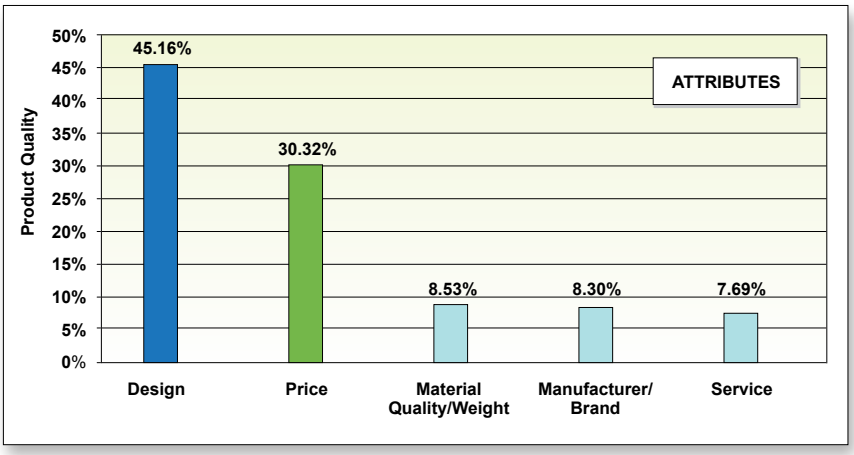


Figure 12: Relative importance of attributes in forming a preference when buying household furniture (*Think Light – Innovative Lightweight Panels, 2008*).

Heavy furniture constructed of MDF panels (660 kg/m^3) barely receives consumer approval. This is not true however in the case of furniture constructed of lighter materials, such as traditional sandwich panels (440 kg/m^3). The "lightweight construction" attribute then compares favourably with other criteria such as "comprehensive service" and "state-of-the-art design." When client requirements in terms of quality, design, price and service are met, brand name furniture manufacturers are free to determine the weight of their products. Currently, the preference seems to hover around the 450 kg/m^3 mark.

The North American Picture

Lightweight panels have been manufactured on an industrial scale in Europe for several years and are now widely used in various markets, including the furniture market.

In North America, there are 13 lightweight panel manufacturers. The majority of these are located in the United States, with the exception of *Panolite Canada Inc.*, a company based in Lac-Mégantic (Quebec) that manufactures lightweight honeycomb panels (board-on-frame or frameless).

In both Europe and North America, there are two niche markets for wood-based lightweight honeycomb panels. The first is the replacement market when traditional panels become too heavy and too expensive. This is when the required panel thickness is equal to or greater than 25 mm. The second niche market involves the development of a new range of products.

There are many applications for lightweight panels. These include:

- doors;
- household furniture;
- office furniture;
- cabinets, counters and other work surfaces;
- shelving;
- components and fixtures for exhibition stands;
- office space dividers;
- tables (especially table tops);
- miscellaneous office furnishings;
- thick contemporary design pieces; and
- displays for department stores and other retail establishments.

However, there are certain differences between European and North American markets. In Europe, lightweight panels are manufactured on a larger scale by manufacturers in large capacity plants with automated equipment. In Europe, relative prices tend to be lower and market growth tends to be greater than in North America where manufacturing is less automated and capacity is lower. As result, marketing lightweight panels will take longer and will require a greater effort than in Europe. The market growth trend for this type of innovative panel will therefore lag behind the growth of the European market. In North America, the lightweight panel market is relatively small, but all signs point to its future expansion.

Acknowledgements

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An electronic copy of this article can be found at www.iforwood.com and www.valuetowood.ca

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