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WASTE MANAGEMENT IN FURNITURE AND WOOD SECTOR

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Abstract:
The present paper has been developed based on the frame of an ERASMUS+ project, which have the following aims: to improve the environmental sustainability through education, to ensure a quality culture in VET programs; to enhance access to VET training and qualifications for all. The waste management principles need to be applied both in furniture and wood sector, in order to reduce considerable in the next years the amount of wood waste. In this regard, special attention should be paid to the most efficient use of wood resources, as well as to apply methods to transform them into value added products.

Key words: *waste management; wood waste; furniture; reuse; recycle; prevention; consumption; reduction.*

INTRODUCTION

According to European Directive 98/2008, „waste management” means the collection, transport, recovery and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and also actions taken as a dealer or broker. The effects of all kind of wastes have a great impact on climate change. It is stated that greenhouse gases (GHG), which are emitted in the atmosphere as a result of different humans activities are carbon dioxide (e.g. deforestation and soil degradation), methane (e.g. agriculture activities, municipal solid waste landfill), nitrous dioxide (e.g. agricultural and industrial activities combustion of fossil fuels and solid waste) (https://www.epa.gov/climate-indicators/greenhouse-gases). Waste management includes a series of activities such waste generation, transportation, treatment and disposal, which are significant contribute to GHG globally emissions (Sebastian and Louis 2022).

According to European Environment Agency (EEA) the GHG in EU decreased by 31% between 1990 and 2020, which means an exceeding of 11% over the EU's 2020 target set (https://www.eea.europa.eu/ims/total-greenhouse-gas-emission-trends). Also, following the same trend, it is expected as in EU countries the greenhouse gases to further decline until 2030.

The wood as raw material is used in different industries such as furniture, paper and paper products, lumber, wood constructions (Pentti *et al*. 2002). After wood processing, an important amount of materials will remain, which will be constituted in wastes. Wood waste refers to materials that are unsuitable for the production of wood products (Top 2015). In primary and secondary wood processing, the waste is identified as biomass resources that can be used in obtaining the pallets and briquettes or can be used as raw materials to obtain composites panels (Martinez Lopez *et al*. 2020, Ferreira Martins *et. al*. 2021).

The topic of this article is based on the European ERASMUS+ project, *TAckling Environmental sustainability through Blended Learning opportunities for ivEt in the furniture and wood sector* (TABLE) (https://tableproject.eu/). One of the TABLE project is to green the furniture and wood sector from the production to consumption phase supporting teachers in I-VET school to apply sustainability principles into their courses (e.g. Eco-design of products, sustainable furniture waste management, circular economy etc.). With six partners (ONG ENERGIES 2050, Eurocrea Merchant SRL, Innovative business association of furniture manufacturers and related in the Murcia Region-AMUEBLA, Transilvania University of Brașov, North-East Regional Development Agency-NERDA and Wood Technology and Forestry School Complex in Garbatka-Letnisko) from five countries (France, Italy, Spain, Romania and Poland), the project intends to deliver a completely innovative training system based on microlearning opportunities to i-VET (Initial Vocational Education and Training) teachers in the furniture and wood sector. The Educational tips: learning snacks for I-VET teachers in the furniture and wood sector", consists of a blended training course for i-VET teachers to learn anytime and anywhere about how to integrate sustainability in i-VET training in the furniture and wood sector. The educational courses which were developed by the project partners focused on the following topics:

- From sustainable development to sustainable consumption and production patterns;
- Climate change, biodiversity and renewable energies – The wood industry at the forefront of challenges;
- Sustainable design in the furniture and wood sector;
- Waste management in the furniture and wood sector;
- Impact and use minimization of resources in the furniture and wood sector;
- Green skills, communication strategy and market development in/for the furniture and wood sector.

The present article was developed based on one of those courses, namely „*Waste management in the furniture and wood sector*".

METHODS

Prevention and minimization of hazardous waste

Waste policy is focused on the construction of a sustainable resource recycling society. At EU level, waste policy aims to contribute to the circular economy by extracting high-quality resources from waste as much as possible. Circular economy involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible.

The EU directive 2008/98/EC establishes a waste hierarchy, which consists in Prevention, Reuse, Recycling, Recovery for other purposes (i.e. Energy) and Disposal (Fig. 1).

Fig. 1.
The waste hierarchy.

The reduction of consumption and waste minimization take into account the following:

- Avoid to use plastics, rubber and other materials that needs long time to biodegrade, or treated wood, which biodegrades, but it is harmful for the soil, both in natural state, or burnt;
- Preventing or avoiding waste from accumulating more products that the consumers need. Thus the costs are diminished and environmental advantages increase;
- Waste minimization involves redesigning products and processes and/or changing societal patterns of consumption and production;
- Waste minimization involves efforts to avoid the waste generation during manufacturing, tracking of materials from their extraction to their return to earth and details of the composition of the waste.

The second category, which consist in reuse end-of-life products and recycle (Fig. 1), comes mostly from the building industry which is the world's largest consumer of raw materials in the economic sector and produces significant construction and demolition (C&D) waste. Also, as a structural building material, wood is also well-suited to reconfiguration, reuse, and recovery by new design for end-of-life products and also protect the environment through carbon sequestration. Recycling materials such as plastic or rubber can take centuries to decompose in landfills. They can be crushed in small granules and reused in new designed products. Recycling practices applied in wood industry sector refer to solid wood offcuts, wood dust and shavings with various applications.

Resource recovery (Fig. 1) is the process of recovering materials or energy from solid waste for reuse and also is an important way to turn waste into usable materials of future products and a step toward a cleaner future. Waste items such as aluminum cans, paper and cardboard, plastic bags and bottles, glass and foil are all recoverable. Resource recovery process involves actions to be made in order to turn hazardous and non-hazardous waste materials (which otherwise would have to be stored or disposed of) at a treatment facility, and transformed into clean, reusable products.

The waste treatment and disposal (Fig. 1) are based on the following:

- Landfilling: the action where solid waste (i.e. paper, metal, glass) is buried between layers of materials in such a way as to reduce contamination of the surrounding land. Modern landfills have layers of different materials that keep pollutants from leaking into the soil and water.
- Incineration for energy recovery (Waste-to-energy): it is the process of generating energy (electricity or heat) from the primary treatment of waste, or the processing of waste into a fuel source (solid, liquid or gas state).
- Biological treatments: rely on bacteria or other small organisms able to break down organic wastes by both aerobic and anaerobic biological processes to achieve the optimal removal of organic substances from waste material.
- Material recycling: recyclable materials include glass, paper, cardboard, metal, plastic, tires, textiles, batteries, electronics, and composting biodegradable waste (food and garden waste).
- Disposal: waste poses a threat to public health and the environment if it is not stored, collected, and disposed properly. This category represents the last solution that can be adopted.

In the EU in 2018, more than half (54.6%) of the waste was directed to the following recovery operations: recycling (37.9% of the total treated waste), backfilling (10.7%), and energy recovery (6.0%). The remaining 45.4% was either: landfilled (38.4%), incinerated without energy recovery (0.7%) or disposed of otherwise (6.3%) (https://ec.europa.eu/eurostat/).

Significant differences could be observed among the EU Member States regarding the application of these various treatment methods. For instance, some Member States had very high recycling rates (Italy and Belgium), while others favored landfills (Greece, Bulgaria, Romania, Finland and Sweden) (https://ec.europa.eu/eurostat/).

By 2050, the world is expected to generate 3.40 billion tons of waste annually, increasing drastically from today's 2.01 billion tons (Kaza S *et al*. 2018). The most appropriate methods that can be used in waste treatment are: collecting, sorting and treating which have the following advantages:

- allow the waste to be further processed into reusable materials;
- help in saving of primary resources and energy;
- reduce the environmental burdens.

The waste materials have to be sorted and separated in order to be reprocessed into new materials and used for new products manufacturing. Separation of waste ensures pure, quality material, removing impure materials with less quality. The waste can be divided in:

- dry waste which includes wood and related products, like metals and glass;
- wet waste refers to organic waste usually generated by eating establishments and are heavy in weight due to dampness.

The target for mechanical and biological treatment is to reduce the amount of waste to be disposed by about 2/3. Mechanical treatment is applied to household, commercial and industrial waste and biological waste treatment is applied to organic wastes by both aerobic and anaerobic biological processes using bacteria or other small organisms that broke down the material in its biodegradable components.

Another method that can be used in waste treatment is incineration and composting. Through incineration, non-recyclable and non-reusable waste is burned in an environmental-friendly way through thermal treatment in special incineration facilities. This treatment reduces the volume of waste, having also the advantage of generating electricity and heating. The composting process of the biodegradable materials (e.g. agro-waste and biomass), consists in progressively degrading with the help of aerobic bacteria in a controlled temperature and moisture content environment. Composting reduces landfilled bio-waste and also provides valuable fertilizers for agriculture and landscaping.

Waste reduction

The European Union (EU) accounts for approximately 5% of the world's forests and, contrary to what is happening in many other parts of the world, the forested area of the EU is slowly increasing. In 2020, the EU-27 had an estimated 159 million hectares of forests (excluding other wooded lands) and their area has increased by almost 10% since 1990 (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Forests,_forestry_and_logging). The world's forests sequestered about twice as much carbon dioxide as they emitted between 2001 and 2019. In other words, forests provide a "carbon sink" that absorbs a net 7.6 billion metric tonnes of CO2 per year (Harris *et al.* 2022), therefore reducing emissions from forest degradation and deforestation is one of the most important ways of combatting climate change (Weatherall *et al.* 2020).

However, global warming is permanently affected by people's actions and activities. In order to reduce carbon emission, it is important to re-use the wooden products instead to use them like products as single-use. Reusable pallets used in the transport and storage of products can have a more beneficial environmental footprint than single-use pallets due to the avoided production of new pallets and thus, decreasing the quantities for disposal or recycling. Like most reusable products, reusable pallets may require different material types and a greater weight of material to increase the durability of the pallet during its longer lifecycle.

The single-use and reusable pallets tend to transport different types of products. Single-use pallets are meant for lighter goods whereas reusable pallets can transport heavier goods. Single-use pallets are often tailor-made to their purpose and differ in weight, size and material compared to reusable pallets. This means that the function of reusable and single-use pallets differ slightly. Reusable pallets need to be transported back to the manufacturer where occasional required maintenance and repair. The environmental impact of a reusable pallet differs from the single-use pallet in each life cycle stage due to the reuse feature of the pallet (Fig. 2).

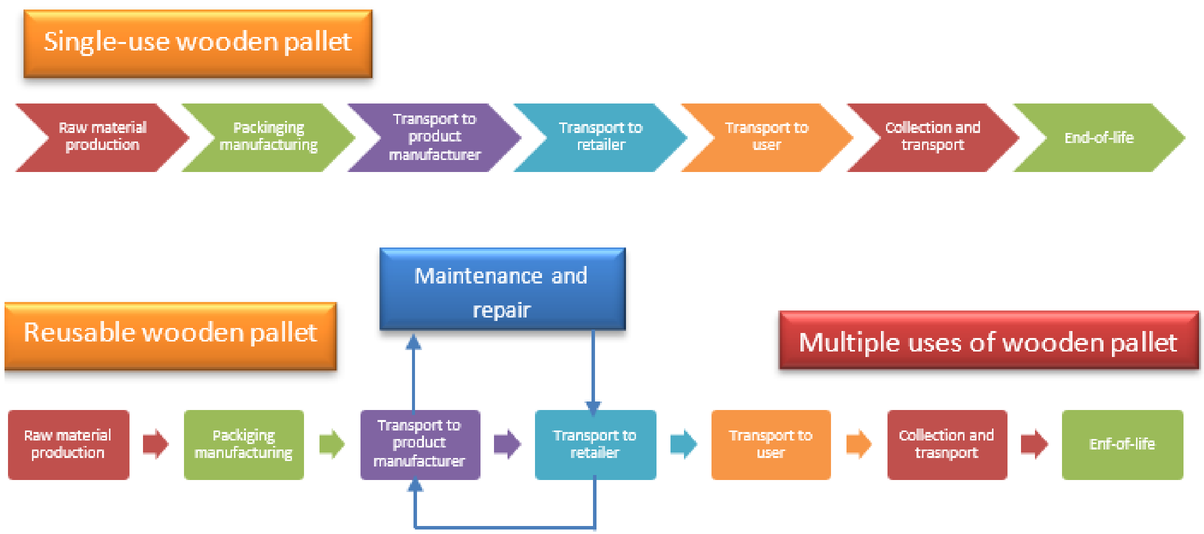


Fig. 2.
Life cycle of different type of pallets.
(https://op.europa.eu/en/publication-detail/-/publication/05a3dace-8378-11ea-bf12-01aa75ed71a1)

The amount of generated packaging waste constantly increased during the period 2009-2019. In 2019 the volume of packaging waste reached the highest value since 2009. Over the 2009–2019 periods, the generation of all types of packaging waste material increased although to a different extent. The highest increase was observed for paper and cardboard followed by plastic, glass and wooden packaging waste (Fig. 3). The recycling and recovery rates have increased steadily over the ten-year period. In 2019, the total volume of packaging waste generated was estimated at 79.3 million tonnes – an increase of 2.4% compared with 2018. This rise was mainly due to the increase in packaging made of glass (+4.7% compared to 2018) and plastic (+3.6%). All other types of packaging also increased: wood packaging by 1.6 %, metal packaging by 1.5% and paper and cardboard by 1.2%.

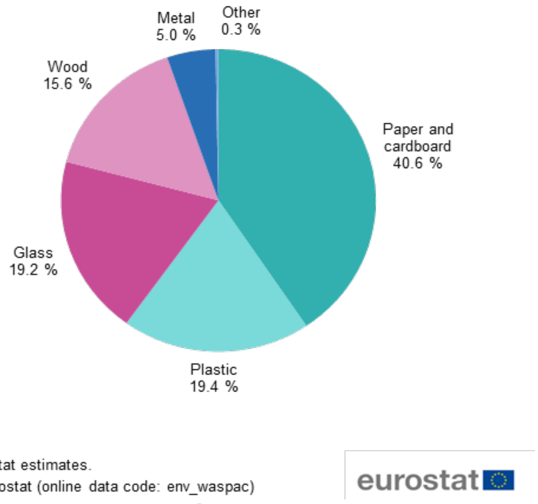


Fig. 3.
Packaging waste generated by packaging material, EU, 2019.
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Packaging_waste_statistics

According to EU directive 2018/852, the waste management in the European Union needs to ensure the following:

- protect, preserve and improve the quality of the environment,
- protect human health,
- ensuring prudent efficient and rational utilization of natural resources,
- promote the principles of the circular economy,
- enhance the use of renewable energy,
- increase energy efficiency,
- reduce the dependence of the Union on imported resources,
- providing new economic opportunities
- contributing to long-term competitiveness.

Also, the EU countries need to take the necessary measures to attain the following targets:

- no later than 31 December 2025, a minimum of 65% by weight of all packaging waste will be recycled;
- no later than 31 December 2025, the following minimum targets by weight, for recycling will be met regarding the following specific materials contained in the packaging waste:
  a) 50% of plastic;
  b) 25% of wood;
  c) 70% of ferrous metals;
  d) 50% of aluminum;
  e) 70% of glass;
  f) 75% of paper and cardboard;
- no later than 31 December 2030, a minimum of 70% by weight of all packaging waste will be recycled;
- no later than 31 December 2030, the following minimum targets by weight for recycling will be met regarding the following specific materials contained in packaging waste:
  a) 55% of plastic;
  b) 30% of wood;
  c) 80% of ferrous metals;
  d) 60% of aluminum;
  e) 75% of glass;
  f) 85% of paper and cardboard.

The methods that can be put into practice in order to reduce the wood waste are the following:

- designing the wooden products based on standards dimension of the raw materials;
- increasing the index of uses, reducing consumption (e.g. efficient cutting diagrams, efficient cutting lists, sharp tools, suitable machine-device-tool systems);
- re-using the wood waste;
- re-using the old furniture by conservation and restoration, in order to preserve the cultural heritage instead to become waste on landfill (Fig. 4, Fig. 5).

Fig. 4.
Chair restoration by Lecturer PhD. Emanuela Beldean.

Fig. 5.
Cupboard restoration by Bianca Lupica, George Pop and Vlad Maxim.

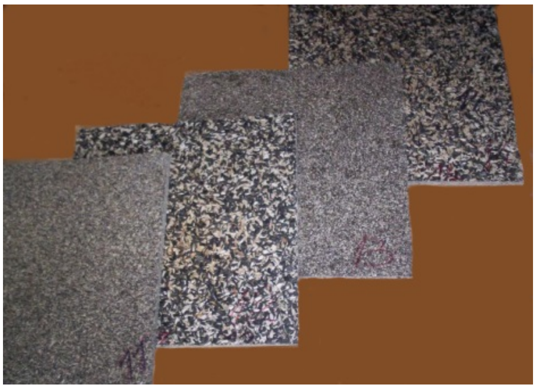
The wood waste collected after different technological processes can be reused in order to get a wide range of added value products with different uses:

- Reconstituted panels can be obtained from wood waste, combining different species such as beech, oak, ash, cherry, walnut (Coșereanu 2015) (Fig. 6). These types of panels have a number of advantages, among which are: the low cost of raw materials, the production of panels in a variety of sizes, the possibility of obtaining panels with a special design. The reconstituted panels can be used as decorative elements for furniture, interior partitions and interior doors.

Panels from beech and cherry lamellas | Panels from beech and maple lamellas | Panels from beech and oak lamellas | Panels from beech and ash lamellas

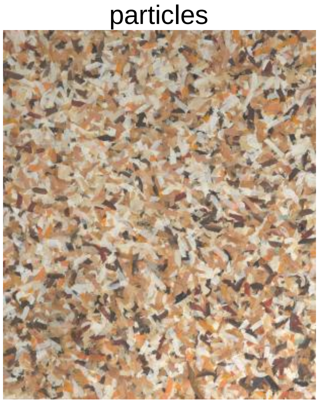
Fig. 6.
Reconstituted panel from different wood species lamellas.

- Particleboard and fiberboard (virgin chips and fiber mixed with chips obtained from wood waste). The amount of wood waste used for particleboard production is limited, due to the fact that they influence the density of the chipboard core (Gurău 2012).
- The types of raw materials recycled into particleboard production are: clean pallets, crates, offcuts, sawdust (particle greater than 1mm), shavings, particleboard offcuts (not MDF). The recycled wood needs to be tested for contamination with wood preservatives and heavy metals. Ferrous metals are separated using magnets and the non-ferrous metals are separated using an eddy air current. The consumption energy used for drying the recycled chips is lower in comparison with the drying process of the virgin chips (50% moisture content) (Gurău 2012).
- Animal bedding - will be used softwood chips without dust obtained from softwood waste, with a moisture content of approx. 10%, which can provide absorbent properties.
- Mulch - the mulch has the appearance of chips with approx. 25mm long. It is placed on the ground in order to control and prevent the formation of weeds, to protect the roots of plants from temperature fluctuations (Wang *et al.* 2021), to reduce moisture loss from the soil and to ensure an attractive design (pavements of paths, various spaces) (Gurău 2012).
- Animal food - if the wood is subjected to enzymatic or microbiological attack, the forest waste can provide large amounts of food for ruminants, which is currently provided only by cereals (Gurău 2012).
- Composite panels, which are obtained from different types of raw materials like wood waste (wood chips, sawdust), agro-waste (sunflower seed husks, rape straws, jute, corn stalks, cane stalks, hazelnut shells, peanuts shells, walnuts shells, almonds fibres, coconut fibres, rice and wheat straw, reed stems), textile waste. These innovative composite panels can be used in the manufacture of furniture as top panels, table panels, decorative boards, etc, or can be used for thermal and acoustic insulation of civil and industrial buildings (Fig. 7) (Coșereanu 2015).



Bio-Composite obtained from sunflower husks

Bio-Composite obtained from wood and rape particles



Composites obtained from sawdust and ABS (Acrylonitrile-Butadiene-Styrene) waste (WPC)

Fig. 7.

Composites obtained from different types of waste.

Extended producer responsibility system (EPR) furniture recyclability evaluation

Extended producer responsibility (EPR) is a strategy that applies at the end-of-life cycle of products and aims to the adoption of remanufacturing initiatives and to the end-of-use treatment of products, so to increase the amount and degree of product recovery and to minimize the environmental impact of waste materials. Extended Producer Responsibility (EPR) is a policy approach under which producers accept

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significant responsibility - financial and/or physical - for the treatment or disposal of post-consumer products (OECD 2001).

Public awareness on waste separation represents a major challenge in the world context. Many countries and regions develop their own strategies based on the local social-cultural and technological environment. In this process are involved the stakeholders: designers and the consummators. Over these two categories the main responsibility is of local, regional, national, and transnational authorities.

The stage of product design directly influences over 70% of characteristics of the final product (Fabrycky 1987) and at this stage the critical decisions should be made concerning the cost, visual aspect, material selection, innovation, performance, impact perception of quality such as product longevity, durability and reparability. In this context designers have the opportunity to promote a sustainable design.

Sustainable design is a set of strategies, criteria and procedures applied in the product development so that negative environmental and community impacts are minimized. These strategies are:

1. Minimizing material and energy consumption.
2. Selecting resources and processes with low environmental impact.
3. Optimizing the product life.
4. Extending the lifetime of materials.
5. Facilitate disassembly.

All strategies mentioned above include criteria for waste reduction amount and waste separation such us:

- minimizing the amount of waste by: selecting processes that reduce the amount of waste during manufacturing; carrying out simulations to optimize the production process.
- facilitating reuse by: increasing the strength of easily breakable components; arranging and facilitating access to removable components; modular and interchangeable design of components; design of reusable ancillary components; design of reusable packaging; design of products for secondary uses.
- facilitating re-manufacturing by: designing and facilitating the removal and replacement of broken components; designing the inner parts so that they are easy to separate from the outer/visible parts; facilitating access to components to be re-manufactured; correctly calculating the tolerance of removable parts.

Life extension of materials means the use of durable materials, which have a longer life than the life of the product of which they are part. After the end of product life, these materials can be processed through two basic processes: re-processed to become secondary raw materials or incinerated to recover the energy embodied in them. The criteria underlying this strategy are:

- Cascading life cycle approach by: facilitating recycling of materials; facilitating energy recovery from materials through combustion.
- Selecting materials with the most efficient recycling technology by: selecting materials that are easy to recover at the end of their initial life stage; avoiding composite materials or, where necessarily necessary, choosing composites that are easy to recycle; designing geometric solutions that facilitate disassembly.
- Facilitating the collection and transport of materials at the end of life of products by: designing the product according to the recovery system; minimising the weight of the product; improving the stacking of used products; designing products so that they are easy to compact at the end of their life cycle; informing the consumer on how to recycle, disassemble the product.
- Identifying materials by: coding them appropriately; providing additional information on the age of the material, the number of recycled materials and additives used; indicating the existence of toxic and hazardous materials; using a standardized identification system; placing coding in an easily visible place.
- Minimising the number of materials incompatible with recycling by: integrated functions to reduce the total number of materials and components; single material strategy; use of a single material but processed in sandwich structures; use of compatible materials (which can be recycled together); use of the same material or compatible materials for joints.
- Facilitating cleaning by: avoiding surface finishing/coating procedures; avoiding hard-to-remove coating materials; facilitating replacement of coating materials; avoiding adhesives or choosing them according to the material to be recycled; avoiding the use of additional materials for marking and coding.
- Facilitating composting by: selecting materials that degrade in accordance with the requirements for a clean environment; avoiding combining biodegradable materials with non-degradable materials in products to be composted; facilitating separation of non-degradable materials.
- Facilitating incineration by: selecting materials that give off a large amount of recoverable energy when burnt; avoiding materials that emit hazardous substances during incineration; avoiding

additives that emit hazardous substances during incineration; facilitating the separation of materials that may compromise combustion efficiency.

Design for disassembly is focused on designing products that can be easily disassembled into component parts (sub-assemblies or materials) and economically separated. The conditions that a disassembly system must meet are: adaptability, flexibility and automation. The criteria for easy disassembly are:

- reducing and facilitating disassembly operations by:
    - prioritising disassembly of toxic, valuable and perishable materials or components;
    - using modular structures;
    - dividing the product into components that are easy to separate and handle;
    - minimising all product dimensions;
    - minimising interdependence between product components;
    - minimising the number of assembly directions;
    - increasing linear assembly directions;
    - using a sandwich system for joining elements;
    - avoiding elements that are difficult to handle;
    - avoiding components that require asymmetric operations;
    - designing components so that they can be easily centred;
    - avoiding joining systems that require simultaneous opening interventions;
    - minimising the number of connectors.
- use of reversible joining systems;
- the use of permanent but easily detachable joining systems;
- design (in parallel with the product) of technology and features for component separation.

When recycling wood and wood-based materials, the rheological character of the raw material and the interventions on it (e.g. impregnation, varnishing etc.) must be taken into account. Recent research (Deák *et al.* 2012, Deák 2013, Deák *et al.* 2013, Deák 2014, Deák *et al.* 2015) has highlighted the following:

- the influence of natural ageing of wood and wood-based materials is insufficiently addressed, and detailed studies on several species and over well-defined time periods are needed, but results so far have shown that old wood is a suitable material for recovery and recycling under certain well-defined conditions;
- recovered wood materials impregnated with creosote or CCA are not suitable for reuse because of their harmfulness;
- wood materials whose formaldehyde content and emission is above the currently accepted limits may be used in combination with other materials so as to result in acceptable mitigation or sealing.

As regards the recovery of waste into high value-added products, a methodology is needed that takes into account the following steps:

- Analysis of the main production structure.
- The rate of change of production.
- Qualitative and quantitative analysis of waste.
- The choice of the optimal waste recovery routes.

If waste is incorporated into new products, it should be taken into account that the new product does not require different technology and workmanship from the main production. Thus a number of designers have designed spectacular products using wood waste from different wood species (Fig. 8).

Fig. 8.
New wood product made from wood waste.
Origami floor lamp concept, designed by Nicoleta Iordăchel (Transilvania University of Brasov).

Another strategy that can be used for changing the public opinion on the reuse of goods is green marketing, designed to generate and facilitate any exchange aimed at satisfying human needs and desires so that their satisfaction is achieved with minimal impact on the environment. The green marketing can also define as a holistic process responsible for identifying, anticipating and meeting customer and societal demands in a profitable and sustainable way (Peattie 2012).

Waste management and waste to energy

Managing waste in an environmentally sound manner and making use of the secondary materials they contain are key elements of the EU's environmental policy, as part of the overall strategy of the European Green Deal (European Commission).

A part of wood waste that cannot be used as raw materials to produce another wood products, or furniture products, can be used in order to obtain energy or bio-energy. There are three technologies used for obtaining energy from wood waste:

- by direct combustion - wood waste can be burned in a boiler to heat water and produce steam. The steam can be used to power machines or heat buildings. Using steam to rotate turbines generates electricity. Both heat and electricity are utilized in a process known as "co-generation";
- by converting wood to gas - gasification uses high heat and pressure, in a low oxygen environment to produce "syngas". Biogas is produced from anaerobic digestion, a process by which different microbial species break down wood (biomass) in the absence of oxygen (Achinas *et al.* 2020). Syngas and biogas can be used in electricity generation;
- by converting wood into fuels - pyrolysis is a thermochemical conversion process that converts wood (biomass) into liquid fuel and biochar. Cellulosic ethanol can be produced from wood and other biomass residues through fermentation. Methanol is generated from anaerobic digestion or through a secondary conversion of syngas. Oils extracted from wood can be combined with alcohol and a catalyst in a process named "alcoholysis" to produce diesel fuel.

If we discuss about biomass, there are few methods to transform it into biofuel:

- thermal (e.g. torrefaction, pyrolysis, gasification),
- chemical (e.g. producing liquid hydrocarbons after biomass gasification),
- biochemical (e.g. anaerobic digestion/fermentation).

Efficient management of wastes will have a positive impact on natural environmental and human health. A possibility to obtain that is green buildings. According to World Green Building Council (WorldGBC), a „green" building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on the climate and natural environment. Green buildings preserve precious natural resources and improve the quality of life. The elements that transform an ordinary building into a "green building", are as follows (https://www.worldgbc.org/what-green-building):

- use efficiency the energy, water and other resources;
- use of renewable energy, such as solar energy;

- reduction the pollution and waste and enabling of re-use and recycling wastes;
- existing a good indoor environmental air quality;
- use of materials that are non-toxic, ethical and sustainable;
- taking into account the environment in design, construction and operation;
- taking into account the quality of life of occupants in design, construction and operation;
- obtaining a design that enables adaptation to a changing environment.

Another concept based on energy-saving is that based on passive houses, which means that these buildings will require little energy for space heating or cooling. According to various authors, average passive houses are reported to be more expensive than conventional buildings: 5% to 8% in Germany (iPHA 2017, Hill 2010), 8% to 10% in UK (Siegle 2013) and 5% to 10% in USA (Loviglio 2013, Adams 2014). Due to careful design and increasing competition in the supply of specifically designed products for passive houses, in Germany, is now possible to construct such buildings at the same cost as those built according to normal German building standards (https://exemplars.world/library/interventions/passive-house/). The costs of meeting the Passivehaus standard increase significantly when building in Northern Europe above 60° latitude (Dokka and Andresen 2006, Nieminen *et al.* 2008, Schnieders *et al.* 2015).

CONCLUSION

- The presented article which comprised the information from the „Waste management in furniture and wood sector" courses developed in the frame of TABLE project will give teachers new knowledge about environmental sustainability and reduction of the consumption of natural resources to increase the engagement of student into VET programs related to furniture.
- Waste management is a major issue that should be a constant concern for all countries in the world.
- Due to the efficient management of wood waste, value-added products can be obtained at much lower costs.
- Achieving energy-efficient constructions will lead to a less waste and more human-friendly environment.

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