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WOOD-BASED PANEL INDUSTRIES IN FINLAND – CURRENT STATUS AND DEVELOPMENT POTENTIAL

Anuj KUMAR
Natural Resources Institute Finland (Luke), Production Systems
Tietotie 2, FI-02150 Espoo, Finland, E-mail: anuj.kumar@luke.fi

Erkki VERKASALO
Natural Resources Institute Finland (Luke), Production Systems
Yliopistokatu 6, FI-80100 Joensuu, Finland, E-mail: erkki.verkasalo@luke.fi

Abstract:

Among the Finnish forest industries, production of wood-based panels (WBP) has been concentrated on birch plywood since 1910's and also on softwood plywood and laminated veneer lumber (LVL) since 1990's. Chipboard (particleboard) and fibreboard industries started during 1930's and 1950's, both strongly declining since 1980's owing to the problems in competitiveness in export, limited domestic markets and strong import, and stagnated RTDI and investment activity. The raw materials consist nowadays solely of by-products from saw and plywood mills, such as saw dust, planer shavings, grinding dust, residual wood chips and bark, replacing the more expensive small-diameter wood and less used hardwoods of 1960's to 1980's. Recently, oversupply of the side streams from mechanical wood processing has considerably lowered their prices for WBP mills. Continuous growth and specific product segments in the European WBP markets, advanced technology development, engineered panel products and green building incentives may provide potential for renaissance of Finnish WBP industry. The main purpose of this paper is to review the current status and evaluate the future potential of Finnish WBP industries, covering historical prospects, current scope and structure, raw material and product trends, mill operations, fabrication lines, adhesives systems and technology development, added with up-to-date SWOT analysis.

Key words: *wood-based panels (WBP); chipboard (particleboard, OSB); fibreboard (MDF, HDF); technology development; value chain.*

INTRODUCTION

The European forest industries have recognized the importance of developing innovative forest-based products with higher added value to meet societal demands for materials, energy, employment, and environmental protection. Manufacturing products with greater added value is increasingly viewed as a strategic goal also among wood panel industries, considering the opportunities and the limitations of raw material supply and product palette (Sathre and Gustavsson 2009; Mantau et al. 2010; Berthold et al. 2017). Wood products as a whole provide opportunities to mitigate climate change. The consumption of energy and natural resources and CO_2 emissions caused in the manufacture of wood products is less than in manufacturing using other materials. Wood and wood products are long-term carbon stores as they sequester CO_2 from the air, and replace materials whose manufacture is harmful to the environment. At the end of their life cycle, wood products can be used to produce renewable energy and so replace fossil fuels.

In Finland, wood-based panels (WBP) are an important part of forest industries, albeit far behind sawn wood and further products, pulp, paper and paperboard (Wood products Finland 2017). The industry has concentrated on birch plywood since 1910's and also on softwood plywood and laminated veneer lumber (LVL) since 1990's. Chipboard (particleboard) industries and fibreboard industries started during late 1950's but they strongly declined since 1980's owing to the problems in competitiveness in export, limited domestic markets and strong import, and stagnated RTDI and investment activity (Varis 2018).The raw materials consist nowadays solely of by-products from saw and plywood mills, such as saw dust, planer shavings, grinding dust, residual wood chips and bark, replacing the more expensive small-diameter wood and less used hardwoods of 1960's to 1980's. Recently, oversupply of the side streams from mechanical wood processing has considerably lowered their prices for WBP mills. Continuous growth and specific product segments in the European WBP markets, advanced technology development, engineered panel products and green building incentives may provide potential for renaissance of Finnish WBP industry (Kumar and Verkasalo 2017).

OBJECTIVE

The main objective of this paper is to review the current status and evaluate the future potential of Finnish WBP industries, covering historical prospects, current scope and structure, raw material and product trends, mill operations, fabrication lines, adhesives systems and technology development, added with up-to-date SWOT analysis.

HISTORICAL DEVELOPMENT OF WOOD PANEL INDUSTRIES

Plywood, veneer and LVL industries

Birch plywood has been the flagship of Finnish wood-based panel industries since 1910's. Wiikari Oy started the manufacturing in 1894 with chairs, boxes etc. made from plywood. True plywood production was started for furniture and construction uses in 1912 by Oy Wilh. Schauman Ab. The industry underwent several uprising and downfalls during the century reaching the global market leadership in hardwood plywood during 1920's and 1930's and, after the losses of mills after World War II, new peaks in the mid 1960's and again during mid 2000's. Manufacturing of softwood plywood and laminated veneer lumber (LVL) for construction purposes from spruce was started in 1975 and 1994, respectively (Varis 2018). In 2018, after constant consolidation of plywood manufacturing companies, reduction in the number of mills but rise in their production capacity the following number of mills are operating: 6 birch plywood mills and 2 birch plywood veneer mills, 2 softwood plywood mills and 3 LVL mills, 4 other veneer mills. Finland is the largest producer of softwood plywood and LVL in Europe, and in birch plywood excluding Russia (FAO 2017; Finnish Forest Industries 2017).

Chipboard industries

The first chipboard factory was established in Finland in 1956 by Viiala, with the idea of utilizing wood residues from the plywood mill in parallel with small thinning wood (Varis 2018). This mill used first extrusion technology (Kreibaum method - OKAL) and later flatbed pressing technology (VILA), the product being coated with hardboard (HF). Thereafter, extrusion technology remained marginal compared with flatbed. Following the concept of VILA, further chipboard factories were most often built to the sites of plywood mills, sometimes in connection with saw mill, joinery mill or prefabricated house production. Five more companies started their factories due to 1961 and six more mills followed due to 1973 when the all-time record of 880,000 m^3 of chipboard was reached. Energy crises of 1974 and 1978 and the resultant global economic downturns hit badly the demand of chipboards in the Western world. However, three more mills were built in Finland during 1975-1984. Actual downturn started in 1980's: due to the early years of 2000's the chipboard production had halved and three mills were left only. In 2019, Koskisen Oy Panel Industry in Järvelä, southern Finland, is the only operating mill in Finland. Significant reasons for the closure of mills were the rising raw material price (competition from pellet and biopower industries) and lower product price (too much concentration on bulk products with a hard competition both in export and domestic markets) and omission of technology development investments (lack of own capital, low business profitability) (Kumar and Verkasalo, 2018).

Fibreboard industries

Fibreboard industries begun in Finland in 1931, when Enso-Gutzeit Oy (later part of Stora Enso) started to manufacture both hardboards and softboards with wet-process technology in Karhula (Varis 2018). During 1940's seven more mills were built by several companies, and still one in 1959 (see Fig. 1). Like chipboard mills, most fibreboard mills were built in connection of plywood mills and there is only one fibreboard mill left (Heinola), still being one of the biggest hardboard mills in Europe. It is notable that its production process for LION boards is still fully based on the Finnish fibreboard manufacturing tradition dating back 80 years. Over the decades, the process and the properties of the boards have been honed to perfection in order to comply with the requirements of modern construction. Dry-process technology leading to HDF, MDF or LDF has not been used in Finnish mills, although process testing and product analysis have been realized (Kumar and Verkasalo 2018).

CURRENT STATUS OF PANEL INDUSTRIES

While only one chipboard mill and one fibreboard mill are active among wood-based panel industries in Finland (Kumar and Verkasalo, 2018), they are mostly producing panels for domestic purposes (Table 1). Koskisen Oy mill is producing P1, P2, P4, P6 (dry condition) and P5 (humid condition) types of chipboards. Finnish Fibreboard Ltd. mainly produces six types of hardboards for

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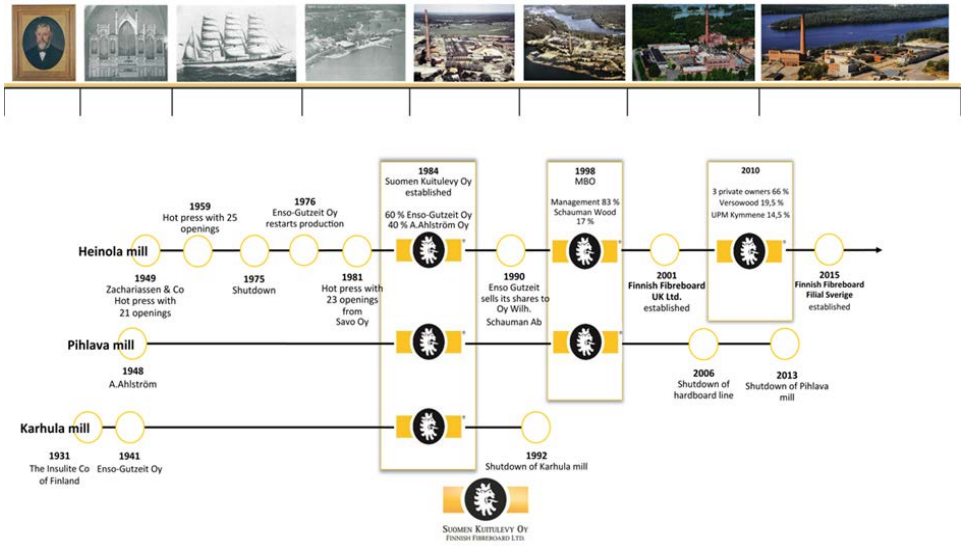

Fig. 1
Historical development of Finnish fibreboard industry (Source: Finnish Fibreboard Ltd).

different applications. Table 2 shows the production and import and Fig. 2 the export of different wood based panels during a period of ten years. In 2007, the production totalled to 1.5 million m^3 with the value of 800 million €, while getting down due 2016 to 1.0 million m^3 and 546 million € (FFI 2017).

It is notable that there is currently no production of many globally important types of wood-based panels in Finland. Of the flake-type products, these include oriented strand board (OSB) and its predecessors like flakeboards and waferboards, and also laminated strand lumber (LSL). Dry-process fibreboards (especially MDF, but also HF or LDF) or parallel strand lumber (PSL) which is a veneer-based product are not manufactured either. Their domestic market needs are satisfied through import, the origin being most often in Russia, Eastern Europe or Western Europe (Berthold et al. 2017).

Table 1

Active wood-based panel mills in Finland (Kumar and Verkasalo 2018)

Panel type	Particleboard	Fiberboard
Company/ Location	Koskisen Oy Panel Industry, Järvelä	Suomen Kuitulevy Oy (Finnish Fibreboard Ltd), Heinola
No. of mills	1	1
Production lines	1	2
Raw materials	By-products: Spruce 80 %, Birch 15 %, Pine 5 % Sawdust, mini chips, cutter chips	Sawdust, wood chips
Resin system	UF, MUF, MF	UF, MUF, MF
Installed capacity annually	100,000 m^3	65,000 m^3
Pressing system	Platen pressing	Platen pressing
Classes of panel produced	P1, P2, P4, P6 (dry condition), P5 (humid)	
Certifications	FSC, PEFC, CPR E1 (formaldehyde emission class) M1 (emission classification for building materials)	CE, FSC, PEFC, M1 (emission classification of building materials)

Table 2

Wood-based panel's production, import estimates in Finland (FAO 2017)

Year	Particleboard		MDF		Hardboard		Other hardboard (softboard)	
	Production (m^3)	Import (m^3)	Production (m^3)	Import (m^3)	Production (m^3)	Import (m^3)	Production (m^3)	Import (m^3)
2011	170000	75924	0	124565	45000	35956	55000	34276
2012	100000	95311	0	125055	45000	30503	55000	22356
2013	96000	87857	0	106024	45000	31479	55000	21471
2014	93000	77630	0	113320	47000	26730	0	33440
2015	92000	79833	0	98974	15000	30255	0	27588
2016	92000	79201	0	121041	15000	27810	0	23996

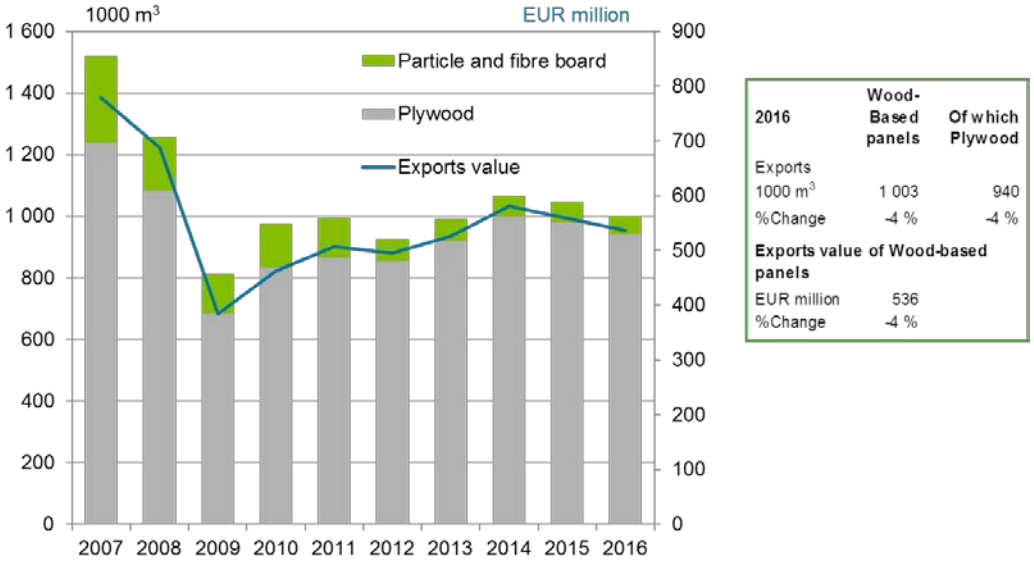

Fig. 2.
Finnish exports of wood-based panels. (Source: Finnish National Board of Customs).

RAW MATERIAL SUPPLY CHAIN

It is vital to understand the value chains of forest industries, and the biomass flows from the viewpoints of different wood using industries. Fig. 3 shows the distribution of forest biomass and flows of wood-based raw materials to the main industries in Finland in 2017 and 2018. Primarily, forest provides three types of biomass in the forms of saw and plywood logs, pulpwood and forest residues.

Large-sized timber, defined as more than 15-18 cm in diameter, depending on tree species, flows primarily to saw mills. There is some competition between allocations to either saw or plywood mills regarding high-quality spruce and birch more than 20 cm in diameter. Pulpwood goes overwhelmingly to pulp, paper and paperboard industries, and partly to sawmilling of small-diameter logs.

As it was stated before, pulpwood and lower quality hardwoods were used before for chipboard and fibreboard. They have been replaced later with saw dust, bark, chips, shavings and other side streams of mechanical wood processing. These are used, parallel with roundwood, full trees, logging residues and stumps, also in bioenergy plants both for heat and power generation, and now growingly to liquid fuels (bioethanol, biodiesel). Accordingly, there is a partial competition of wood raw material between chipboard/fibreboard and bioenergy. Low value woods such as aspen and willow may provide new sources for wood panel industries. Pulping operations may also provide side-streams such as lignin, black liquor, bark waste etc. suitable for valorisation in wood panel industries. Finnish forest industry generated a total 27.7 million tons of side streams, consisting of 49.2% black liquor, 28.5% solid wood-based waste, 14.1% sludge, 4.4% ashes, and 3.8% others (Hassan et al. 2018).

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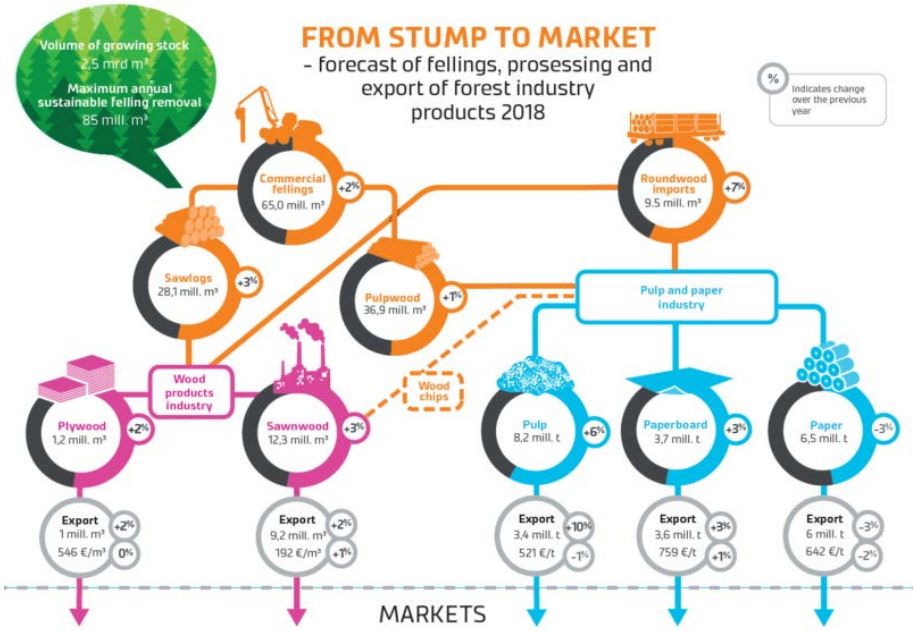

Fig. 3.
Finnish forest industry and products status 2017 and forecast for 2018. (Source: Natural Resources Institute Finland (Luke).

ADHESIVES IN PANEL PRODUCTION

Synthetic resins were the fundamental factor in the successful development of dry-process wood-based panel industries (Maloney 1977, Hemmilä et al. 2017). The synthetic resins are mainly classified into four types: urea resins, melamine resins, phenolic resins and isocyanates resins. The only particleboard factory in Finland mostly uses UF resins and produces panels for interior applications (Varis 2018). MUF adhesives with different proportions of melamine show high resistance against moisture and climate, and they are used in particleboard and high-density fibreboard (HDF) in Finland. Fibreboard industry used both UF and MUF resin in their hardboard production. MF is mostly used as a high pressure laminate for hardboard coatings. PF resins are mostly used for making exterior grade plywood in Finland. Isocyanates, also known as PMDI resins, are important industrial chemicals used in injection moulding and poly-urethane foams. The higher cost of PMDI resins is offset by the faster reaction time, compared to PF, with the very high bond strength and the superior resistance to water and climatic conditions. These adhesives are marketed as formaldehyde-free systems in Europe. However, PMDI adhesives need special precautionary protection measures when used in the industry, and press-sticking problems need special care, when used in the face layer.

PRODUCT DEVELOPMENT OPTIONS

Rigidboard or softboard

Rigidboard is produced from refined and dried wood fibres derived from wood chips. Wood fibre preparation by refining is comparable to that of other fibreboards, including MDF. The resin is applied after drying and the mat is formed in similar processes as in MDF lines. The panel is pressed in a prepress and cured in the main press. Rigidboard is produced in various thicknesses from 18 mm to 240 mm and in densities from 100 kg/m^3 to 220 kg/m^3.

Chipboard using recycled wood particles

The consumption of chipboards and other panels is rapidly increasing in Europe and Finland as well as the growth in international markets is steady. Significant amounts of recycled wood and wood products are used for bioenergy production, without exploring the potential re-utilization in panel products. Production of chipboards using recycled wood particles will support circular economy principles and sustainable supply of raw materials. It is essential to develop the wood and wood products recycling mills and efficient recycling and processing technologies.

Cement-fibreboard or cement board

Bio-renewable materials for cement or concrete industries may be a value-added market for wood fibres and particles or recycled wood particles or residues, lowering the environmental pollution by reducing the use of asbestos-based cement products. The use of lignocellulosic materials as a reinforcement for cement may provide many advantages over synthetic reinforcement (steel fibres, polymeric fibres), providing low density, nonabrasive nature, biodegradability, wide availability of fibres and side-streams from wood processing industries, low cost, and support to circular bioeconomy.

IMPLEMENTATION OF INVESTMENTS AND DEVELOPMENT ACTIONS

European Union and the countries involved are targeted to move towards the fossil free society and reduce the CO_2 and greenhouse gases. In recent years, the development of thermal insulators using renewable raw materials of natural origin brings the interest for researchers and industries. The fossil fuel or crude oil based thermal insulators, i.e., expanded polystyrene, extruded polystyrene, polyurethane are not sustainable and environment friendly due to the drastic depletion of fossil fuels (Kumar et al. 2016). As discussed earlier, the demands of wood fibre based materials such as softboard is increasing every year, and most of the softboard used in Finland comes from import. So, a domestic fibreboard mill with emphasis on fibreboard insulator may be a viable option in Finland.

CIRCULAR ECONOMY AND CASCADING APPROACH

To achieve the most effective climate change mitigation impacts, the wood resources should be used in a way that helps to store carbon or to replace the most emission intensive fossil fuels, while securing development of forest carbon sinks. As a response to the above-mentioned challenges, the concept of cascading use has been presented in many studies and reports. Simply, the cascading use of biomass means that biomass is used (and reused or recycled) at least once or several times as a product before its end-of-life. Minimization of waste of efficient usage of raw materials and energy lies at the core of the work promote the circular economy. For example, Koskisen Group, the only particleboard producer in Finland, has a very efficient material usage as wood raw materials and the processing residues are utilized as well as possible, from wood harvesting to product manufacturing (Fig. 4): logging residues are delivered as energy wood to power stations in close proximity of the factories, saw mill chips and part of veneer chips are delivered to pulping and pellet production, part of veneer chips, cut-offs, saw dust, grinding dust and shavings are used in the chipboard factory.

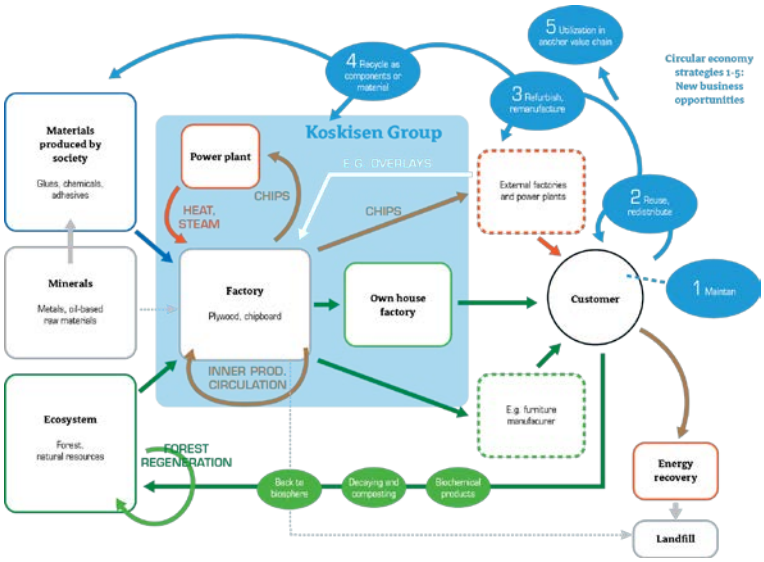

Fig. 4.
Circular economy example in wood based panel industry in Finland (Source: Koskisen group).

GREEN CHEMISTRY APPROACH IN WOOD BASED PANEL INDUSTRIES

The WBP industries should focus on replacing fossil fuel based adhesives such as UF, PF, MUF etc. systems, because of formaldehyde emissions and strict regulations which have partly hindered the development of WBP industries markets (Hemmilä et al. 2017). Renewable resources such as tannin, lignin etc. based adhesives should replace the existing synthetic resins. Recently, Stora Enso started the production of kraft lignin based product Lineo^{TM}, which is a versatile product with numerous potential end uses. Due to its chemical structure, it is especially suitable as phenol replacement in industrial phenolic resins used in the manufacturing of wood panels and engineered wood, e.g. plywood, oriented strand board (OSB), laminated veneer lumber (LVL), and paper lamination and insulation material. Rolkem Oy is a phenolic resin producing company partnership with Stora Enso to use renewable lignin in phenolic resin production and replace fossil-based chemicals, aiming at the future with 100% bio-based resin (Stora Enso 2019).

SWOT ANALYSIS FOR WOOD BASED PANEL INDUSTRY IN FINLAND

According to Thompson & Strickland (1999), a SWOT analysis enables an industry to understand its overall business environment. Various SWOT analyses have been performed in assessing the strategic performance of, for example, overall forest industries (Korpela et al. 2001) and MDF industry (Othman and Samadara. Fig. 5 demonstrates the current and potential strategic performance of Finnish panel industries in the form of SWOT analysis, according to our studies.

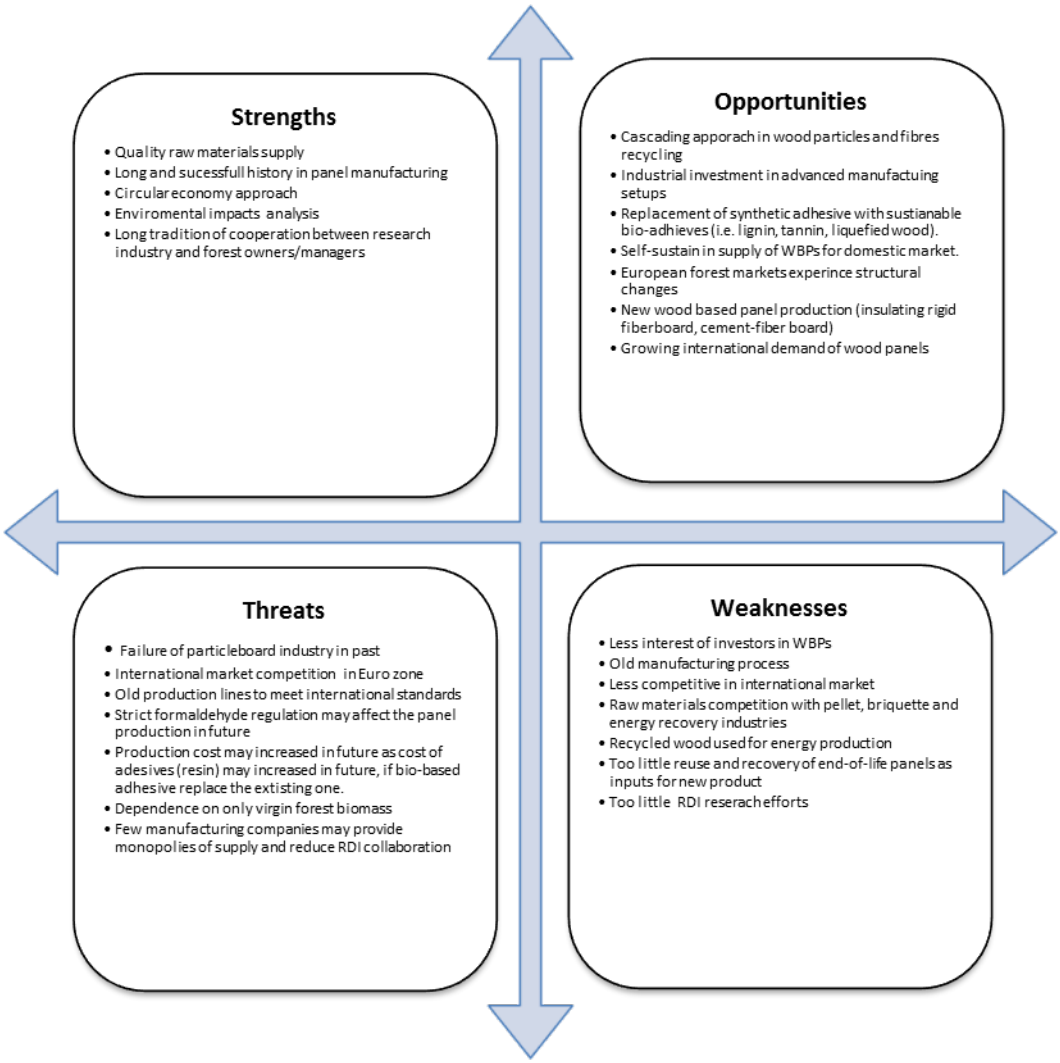

Fig. 5.
The strategic performance of wood based panels industries demonstrated in-term of strengths, weaknesses, opportunities and threats (SWOT).

CONCLUSIONS

Finland is a pioneer of the forest based bio-economy, produces a wide range of sustainable solutions for wood and wood products. On the other hand WBP industry is not moving forward in the similar direction like other wood products industries. There are only two WBP mills active in Finland (excluding the numerous plywood and LVL mills), one being chipboard mill and second a fibreboard mill. Both are using old-tradition production lines without upgrading them with the latest state-of-art technology. During 2010's the price of raw materials has come down in Finland, despite the increased demand for bioenergy sector. Plenty of sustainable side stream and round wood raw materials are still available for the future use in panel industry. Simultaneously, the product markets are growing steadily and several product groups of different volume are available in Europe. Implication of LCA approach is also needed to imply the entire value chain of WBP producing mills to support the circular bioeconomy initiatives in Finland. An up-to-date data on the availability and flows of wood-based residues and their by-products (termed as side streams), their current utilization status and state-of-the-art technologies could provide new knowledge for the development of bio-based value networks and business concepts; in the context of the Finnish bioeconomy, these are imperative.

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