

Introduction of a New Line of High-Density Polyethylene (HDPE) Based Furniture

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Abstract—Industrial development usually has an inherent environmental impact due to the unsustainable practice adopted to support this growth. Furniture industry is an example of this trend since its growth is sustained by the exploitation of the forest from where the timber is extracted. High density polyethylene (HDPE) has been selected as a suitable alternative for wood because of its physical properties, economic benefits and environmental friendly characteristics. The reports will illustrate how furniture industry creates environmental pressure, aspects that will be affected by adopting the new sustainable philosophy, cost saving opportunities and example of best practices currently implemented. HDPE based furniture are made from the same material used in containers for milk, shampoo, oil and other products, which makes it highly recyclable. Furthermore, at the end of their working life the product can also be recycle, making them totally eco-friendly and economically profitable. Moreover, these products offer excellent resistance and longevity characteristics that closely resemble and exceed the ones found in real wood. Finally this sustainable practice has already been successfully implemented by many companies around the world for several years.

Index Terms—Sustainable, environmental, high-density polyethylene, cost savings.

I. INTRODUCTION

BBJ Company is one of the world's largest furniture retailer establishing 351 stores world widely in 43 different countries. Our various types of products including furniture and appliances have combined the most modern architectural design as well as the idea of more efficient and practical products. Currently, wood is the main material used to manufacture furniture products in our company and the statistics showed that there are approximately 1 % of earth's woods have been taken from the forest in relation to our manufacturing. According to the financial report, we have significantly growth 7.7 % revenue since 23.1 million worth products had been sold over 2013.

However, over the past few years, extreme climate change became the harshest issue all over the world due to massive human activities (Change, 2007). Therefore, consumers have remarkable arisen sustainable concept during the past few years in response to minimize earth's negative impacts as well as purchase eco-friendly products. Moreover, in terms of different consumer's culture, company is required to select manufacture material wisely and design sustainable products efficiently since consumers have different material

expectations and environmental protection senses. Besides, our company recently inspired by a British carpet company that is operated by Ray Anderson since the products of the company has successfully implemented environmental friendly regarded as a sustainable practice.

The BBJ Company desires to reformate its manufacture process based on sustainable practice as well as replace logging trees from forest. Critically regard to material selection, we are planning to adopt a material that is more recyclable and environmental friendly and better quality than wood.

II. FURNITURE INDUSTRY AND ENVIRONMENTAL IMPACT

Wood timber is the main material from which the furniture industry manufactures its products and it can only be obtain by logging in forests. Thus, there is a genuine cause of concern from the BBJ Company over the excessive exploitation and rapid depletion of forest around the world from which it is partly responsible. Around 64 acres of the world's forest, which is approximately equivalent to 37 football fields, are lost every minute because of forest fires, land clearance and logging in particular [1]. As the wood-based furniture demand increase, so it does the demand for timber, this rises the price of the raw material and at the same time promotes deforestation since it makes logging more profitable [2]. As can be seen in Figure 1, is no action is taken to prevent, diminish or fully stop the exploitation of the forests, in a near future there will be not enough resources to satisfy the world's demand for timber, food, medicines and livelihoods [3]. Therefore, unsustainable timber production poses a serious threat to the forest, wildlife and environment of the planet and that's the reason why BBJ Company should start adopting a sustainable practice policy.

So far BBJ has based its product catalog in wood-based furniture not taking into account the cost to the ecological footprint in the countries from which the timber is extracted. To put into context how essential the forests are, the grade of its degradation and to raise conscious on the importance of its conservation, statistics from the World Wild Life fund of Nature (WWF) report "Living forest" are presented [3]:

87% of global deforestation occurs in 10 countries being Australia the second country with the largest annual net loss of forest area, only overcome by Brazil.

Deforestation counts for 15% of all greenhouse gases emissions

1.6 billion People are supported by forest and 300 million live on them.

31% of the world's land surface is forest.

12 to 15 million of hectares of forest are lost each year

The annual loss of forest in the amazon (20000 km²) is

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almost equivalent to the size of Belgium.

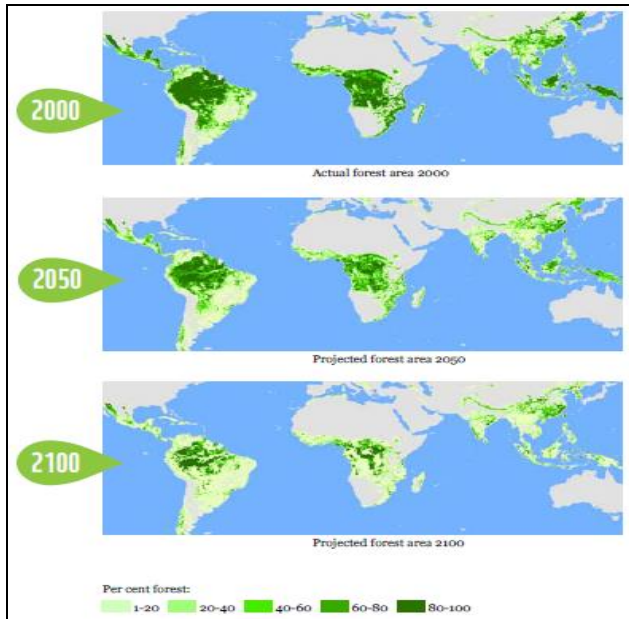


Fig. 1. Forest area in 2000 and projected forest area in 2050 and 2100 in a do nothing scenario [3].

Moreover, wood-based manufacturing companies, as it is BBJ, daily creates solid wastes like adhesive and resin particles, sawdust, wood chips and trash in general that affects not only the environment but also its employees [4]. Management systems and policies have already been implemented in countries like India to achieve a sustainable exploitation and distribution on non-timber based products [5] but there is yet a lot of room for improvement in developed countries like Australia. Burgess (1993) asserts that tropical deforestation has sharply increased over the last decade due to increasing international trade in timber products, intemperance of developing agriculture land, and unsustainable harvest practices, which contribute the most. Moreover, overexploited and excessive logging not only causes deforestation in the tropical countries but also loss of biodiversity, trees may be logged from different areas in order to manufacture various timer products, to clean out for new construction projects, or creating land for agriculture used. However, when trees are logged or massive destroyed, the species the rely on the forest may not be survived since their habitat has been entirely changed [6].

BBJ has businesses in 43 different countries from which timber is extracted and manufactured; As can be seen, developed countries like United States and China have the greatest rate of wood furniture production [7] and therefore they represent an enormous portion of BBJ's revenues. However, studies have shown that developed countries with higher national income and economic growth are associated with a substantial rate of deforestation [8], this is because of the link between the economic growth of the furniture industry in these Countries and the subsequent environmental pressure put into the ecosystem to sustain this growth. Thus BBJ, as a furniture retailer with worldwide presence with a new environmental friendly approach, should start implementing sustainable practices in developed countries where the rate of deforestation is higher.

III. HDPE CHARACTERISTICS

In terms of wisely selecting material prospective, high-density polyethylene (HDPE) is a recently advance commodity raw material which has been widely used in the different industries including pipe and furniture. Since HDPE has a range of advantages such as water, impact, weather, chemical and thermal resistances see in table 1, it can be seen as an ideal material to use in electrical, natural gas and irrigation system as well as utilize in manufacturing furniture products [9]. There are several advantages that can be considered to entirely replace wood manufacture material being it an unsustainable practice.

Table I illustrates some of the most significant benefits of using High-Density Polyethylene (HDPE) in the furniture manufacturing process over other types of materials. These benefits are not only positive for the retailer company but also for the consumer and will be further explained.

A. Flexibility and Lightweight

The first characteristic of High-density polyethylene is flexibility. In furniture manufacture industry, materials are the key aspect of built environment for manufacturers simply changing right material without any additional cost and environmental effects that can significantly increase revenues and reputation of eco-friendly. HDPE is a widely accepted material in manufactory industry since it is typically easy to form, reform, and shape into the designed products, the common techniques including injection, molding, extrusion, and thermoforming are widely applying in the industry [10]. Woods furniture requires substantial investment in time and money compare to the HDPE products since the tree was logged from the forest, transportation, labors, and gravers are emerged in the financial cost.

B. Toughness

HDPE is an extremely strong, durable material compare to wood. Overall the density of HDPE is 0.95g/cm³ and original material wood density is 0.13 to 0.75g/cm³ [11]. Wood products are likely to splinter, chip and crack when transporting furniture and through long term using. However, products made by HDPE can be stronger and more resilience during the using period, which means they can be maintained for longer period in a better condition than the timber. Thus, because of HDPE unique characteristics, the average consumer can positively save money in the long term and enjoy of a more reliable and efficient product.

C. Resistance

Since HDPE products are manufacture with a single, purified polymer, they have a significant higher resistance to corrosive environmental stresses including corrosion, abrasion and chemical products. Since most of outdoors furniture is expose to several, and sometime extreme, weather conditions like rain, snow, and radiation, HDPE products offers an excellent corrosion and chemical resistance which can entirely maintain furniture's condition. Secondly, wood furniture wear and tear occurs naturally and inevitably during the cycle of normal use. However, throughout the experimental test, the result has remarkably

shown that HDPE products have better abrasion resistance compare to other material [12].

D. Recyclability

HDPE is widely accepted by most recycling centers since it is the one of the easiest plastic polymers to recycle. Due to the fact that it has a specific density of 0.93 to 0.97 g/cm³, which means HDPE products can be used again and again (Thomas, 2012). Additionally, recycled HDPE products does not produce any toxic emissions during both manufacturing and recycling process therefore many organizations are already using HDPE as their raw material since it is an easily recyclable and sustainable material. Furthermore, recycling contributes to the reduction in resource consumption and pollution as well as cost saving.

E. Cost

Since HDPE products have extraordinary corrosion, abrasion and chemical resistance, consumers can significantly reduce their expenses in terms of maintenance and repairs. Secondly, because HDPE is a recyclable material, it is much more cost-efficient than creating the materials from scratch. Therefore, the overall cost of products can be reduced through recycling processes. Moreover, in terms of energy consumption prospective, manufacturing timber products consume more energy, for instance, in miles spent in shipping [13]. HDPE products are typically manufactured from west stream which mean it can possible reduce further waste as a zero scrap material.

TABLE I: DIFFERENT FEATURES OF HDPE, WOOD ,PVC, AND WOOD COMPOSITES PRODUCTS (PERENNIAL PARK PRODUCTS, 2014)

Features	Perennial Park Products Mineral-Composite HDPE	Wood	PVC	Wood Composites
Maintenance Free	●		●	
No Replacement/Lasts Forever	●		●	
No Noticeable Fading	●			
Stain Resistant	●		●	
Mold & Mildew Resistant	●		●	
No Special Tools	●	●	●	●
Limited Lifetime Warranty	●		●	
Slip Resistant	●	●	●	●
No Pre-Drilling/Special Screws	●	●	●	
Smooth Edge Cuts	●	●		●
Impervious to Insects	●		●	
Scuff Rwsistant	●	●		●
Solid Color	●	●		●
Rich, Vibrant Colors	●	●		●
Cleans Easily	●		●	
Environmentally Friendly	●			●
Made with Recycled Material	●			●
Easily Recycable	●			
Releases No Greenhouse Gases	●	●		●
No Fibrous Material	●			
Impervious to Water	●		●	

IV. SUSTAINABLE DEVELOPMENT WITHIN THE ORGANIZATION

BBJ Company has the potential to improve its industrial practices to be more competitive, increase business success and ensure environmental protection by engaging in sustainable practices. As previously explained, current furniture manufacturing approach poses a serious threat to the environment not only for the detriment of forest lands but also because of the amount of waste created at the end of the product life. The idea of adopting an environmental friendly approach, by launching a new line of HDPE furniture, is to be conscious not only about the manufacturing process and the material used but also about the end product and its disposal. Because of the non-recyclable property of the material and the way it is obtain, wood-based furniture life cycle is a linear system that starts with de logging of the forest to produce timber and finish with the disposal of deteriorated product. Furthermore, we life in a finite planet and a linear system like

this cannot run in a in a finite system indefinitely [14]. Partially replacing wood raw material into intelligent HDPE material will not only significantly reduce the amount of waste problems but it will also minimize negative environmental impacts including deforestation, biodiversity loss, and pollution. Being one the largest wood furniture retailer, BBJ permanently consume tons of wood as raw material and, as a result, hectares of trees are logged to be manufactured into products. This remarkably contributes massive negative impacts to the environment such as deforestation and biodiversity loss (Angelsen & Kaimowitz, 1999) [2].

Waste disposal tends to be one of the most serious issues in the furniture industry since it increases the cost in waste management. There are approximately 40 to 50 percent of construction materials made of wood according to National Association of Home Builders Research Center (US EPA, 2014). Most wood furniture is likely to end up in the landfill or illegally burned because of difficulties for manufactures to

dispose or reuse them [15]. As a result, these inappropriate disposal actions not only contribute to greenhouse emission but also enormously increase land space usage and deterioration by waste [9].

The new natural capital economy is encouraging companies to invest capital in designing and adopting a new business models to invest in modifying processes that require less natural resources and produce less waste and pollution . Moreover, the conscious revision of the current manufacturing system used by BBJ has the determined that it has the potential to be redesign and improved with an appropriate time and money investment to make both economic and environmentally sustainable. Thus, adopting HDPE as a new raw material for its manufacturing products will allow BBJ to close the loop of the furniture life cycle and create an environmental friendly practice: illustrates the life cycle of the HDPE-based furniture; raw materials are mostly derived from post-consumer bottle waste, such as milk and detergent bottles or other post-industrial material, and from recycled furniture allowing a closed loop cycle. Since all the material is cleaned through a decontamination process to a high purity level and HDPE is recyclable and non-toxic, in can be compounded into a rigid board stock material resulting in an eco-friendly and finished product ideally suited as raw material to be adopted in our manufacture process. As can be seen, the implementation of this practice will not only stop the exploitation of forest, since there is no timber involved in the manufacturing process, but also to decouple economic growth from the environmental pressure involved (Smith *et al.*, 2010). Furthermore, by replacing wood with HDPE within company, it may significantly address the dispose issues for the consumers as well as reduces waste management cost. Meanwhile, company can also offer some realistic promotions to stimulate customers' return as well as build company reputation, which regard as sustainable development.

Of course implementing these changes implies a large initial investment, as will be seen in the cost analysis, and will result in an major impact in the business in areas as:

- 1) Logistics: the transportation of delivery process used for regular wood furniture is different from the HDPE based, therefore, changes will be conducted in logistic resources and procedures.
- 2) Production: Set up of a new plant to produce a line HDPE based furniture will have a significant initial investment and will require specific machinery to be purchased, as estate in further cost analysis.
- 3) Administration: New personal will be required to be hired in order to administrate the new plant.
- 4) Operations: Operation personal needs to be train in the new machinery and process to manufacture HDPE furniture.
- 5) Sales: New clients and strategic alliances will need to be create in order to ensure the success of the new plant.
- 6) Marketing: The news of the new products produce by BBJ ought to be spread around all countries in which the company has businesses in order to rapidly increase sales and have the investment return.

V. COST BENEFITS ANALYSIS AND FUTURE OPPORTUNITIES

Consumers are now aware of the world's environmental issues and are willing to contribute in what they can to help address this problematic. However there is a demand in the furniture industry that is not being satisfied since customers argue that there are not readily available environmental friendly products to be purchased [16]. This has created a business opportunity for BBJ to start a new line of "green furniture options" to deal with this demand and increase its revenues. Accounting for all measurable impacts during the initial stages of the project will potentially reduce costs significantly due to changes in the final phase of the business design.

While the initial cost of recycled plastic is higher, it is a more cost-efficient long-term investment because it does not require maintenance or replacement after several years. Cost benefits from the implementation of a HDPE furniture into the production line has a giving short payback period and reduced prices of material. Because of the high prices of products made from wood or metal materials, HDPE products will be another option for customers to compare with previous products. Consequently, lower prices of HDPE products will allow so people with low purchasing power to buy furniture; this also applies to other clients with low to upper middle income. For these reasons, the project can give short payback period to the company within five years.

The project has a roughly cost of investment of \$917,450 AUD. From the capital that include essential things for new plant, such as land, plant, civil work, office equipment, and machinery. The machinery needed to produce HDPE furniture includes chiller plant, injection moulding machines, hopper, cutter, crusher, and mixer. The project investment can be divided into fixed cost and working capital. Firstly, fixed cost is the capital invested in land, plant, civil work, office equipment, and machinery. Estimation of fixed cost in the project is \$809.533 AUD. Set up a plant to produce HDPE furniture requires a land usage of approximately 40500 ft². Moreover, the process of making HDPE furniture requires a range of moulding injection capacity such as 1000 tons, 800 tons, 650 tons, 250 tons. For this project, it has been initially suggested to manufacture the following types of furniture:

- 4 arms chairs
- Chair without arm
- Baby chair, 2x3" rectangular table
- 32" and 39" square table
- Chair insert stool
- Shell chairs.

In order to produce these products many types of modules need to be purchased. From the market trend, the plant will produce HDPE furniture at a rate of at least 66,500 units per month. It is estimated that initially the plant will start producing at 60 percent of capacity. The estimated cost of materials needed for producing HDPE furniture including steel, battery, masterbatch, teeka, titanium, and uvtax is \$103,155. Sale volume forecasting for HDPE furniture is 66,500 units per month and estimation prices for each product are \$3 for all model of chairs, \$9 for all model of table, \$2 for baby chairs, \$7 for shell product, and \$2 for

stools. Therefore, estimation for total sales is \$206,310 monthly. The shortest payback period of the project that the company will receive is 4.05 years.

HDPE furniture has a good future opportunity in the world market. Table I shows the situation of international market of plastic furniture. In 2007, the USA was the highest plastic furniture importer by \$463,465,731 from \$1,457,716,789 [17]. In 2006, the volume of trade in GCC region was \$393.22 million (National Small Industries Corporation Ltd.). Another market target group is furniture used in hospitals, physicians' offices, and nursing homes. Because of baby boomer population becoming elderly contributes to the increase of demand in medical sector. In 2008, revenue from medical technology and support systems for patient in healthcare sector has increased by \$366.8 million. Reported from Stryker Corp. that produces variety furniture for hospitals such as overbed tables, transfer apparatus, and beds. Growth of net sales 16.2 percent that growth has reached double-digit for 31 month consecutively [18].

VI. EXAMPLES OF BEST PRACTICES

Existing systems used in the furniture manufacturing and retailer industry are sub-optimal and create design constrains for new sustainable practices. However, by benchmarking against the best optimal system will allow us to set ambitious targets and explore new business opportunities. The use of HDPE as a raw material for the manufacturing of furniture is a sustainable practice that has already been adopted by multiple companies around the world. Most of the products made from HDPE are design to be used as outdoor furniture, but there is still a wide range of applications to be implemented for this trend.

VII. CONCLUSIONS

Action ought to be taking the company to address the problematic deforestation in the next years or irreversible consequences in the human life and environment will be faced. This will be ensure by engaging in new commercial and manufacturing strategies in order to decouple the economic growth from the environmental pressure caused by the detriment of the forest land. Literature review has shown that forests are already at a critical stage and the relentless logging of trees to obtain timber for furniture is exacerbating the situation. HDPE has proven to be the most reliable material to be used as an eco-friendly alternative for real wood. It is not only highly recyclable and non-toxic but it also has economic advantages for the consumers and the company. This is because, although the initial investment of recycling the material is significant, the long-term revenues are higher since the product does not require any maintenance after several years and it can be recycled indefinitely. Moreover, customers are aware of the current environmental crisis and are asking for green products that are not readily available. Therefore introducing a new line of HDPE furniture in the BBJ manufacturing with a reasonable investment will allow the company to gain new customers, social respect, environmental consciousness and revenues

according to a 5 years planning.

Another strategy to encourage the customers return to purchase products again is by bring the old HDPE furniture to get discount prices when purchasing new furniture. The furniture which is made from high density polyethylene (HDPE) can be recycled once returned to the company. When the furniture has a malfunction or the customers wants to buy new products instead of old fashion furniture, the customer can bring the furniture to shop and receive discount prices for buying new furniture. The company has advantages from the strategy are customer loyalty and receiving materials to recycle for new product. This strategy will encourage customers' loyalty to the company and reduce expenses in raw material purchase. Furthermore encouraging costumers to send post-consume HDPE bottle and containers waste will allow the company to save expenses in raw material recollection.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION

Sun Yilong and Qin Jianyun were together at the Automotive Inspection Center (Tianjin) Co., LTD., and all authors approved the final version.

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