



**UTILIZATION OF SMALL DIAMETER LOGS FROM
SUSTAINABLE SOURCE FOR BIO-COMPOSITE PRODUCTS
PROJECT CODE: CFC/ITTO 62 – PD 40/00 REV 4(1)**

TECHNICAL REPORT

Assess market needs

Review market data and examine trends to understand what bio-composite products are sold today and where they are sold

By:

**Dwight A. Eusebio
Carolyn Marie C. Garcia
Grecelda A. Eusebio
Norma K. Toreta**

**FOREST PRODUCTS RESEARCH AND DEVELOPMENT INSTITUTE
Department of Science and Technology
PHILIPPINES
2009**

INTRODUCTION

Wood-based industry is one of the pillars of the Philippine economy for the past many years and had contributed substantially to employment generation. Its production and consumption are associated with various measures of economic activity. The consumption of various types of wood-based panels is directly related to the demand in housing and building construction as well as for the furniture and cabinet industries. Market trend is greatly affected by the shortage and high cost of raw materials; the significantly large volume of imported particleboard, fiberboard (hardboard & medium density fiberboard, plywood, cement bonded board, fiber cement board, gypsum board); and the global financial crisis. The industry engaged in the manufacture and trading of these wood-based panels are beset with many problems that include the rising production cost, the ever increasing energy cost and the regional currency fluctuation.

This report focuses on sales of veneer, plywood, blockboard, particleboard and oriented strandboard. Initial discussions during project formulation included engineered wood products such as glued-laminated timber, laminated veneer lumber and parallel stand lumber, but it was determined that the technical issues to be addressed with producing these products from SDL could not adequately be addressed within budget or time constraints of this project. Although these products represent merging markets for tropical timber, such efforts would involve considerably more laboratory research and prototype evaluation. As such, the project will focus on using SDL to meet and increase the market demand for known commodities that have been proven in the marketplace.

Among the group of wood products collectively known as bio-composites, plywood is perhaps the Philippines' most enduring secondary processed wood product. The Philippines took the early lead in veneer and plywood production in Asia and up until the 80s, continued to be a major industry player in the region. From the 1950s up to the early 60s the industry exhibited a remarkable and steady growth, largely due to the demand from the United States which absorbed about 97% of the country's total plywood exports. Then, in 1974, the Philippines' share of the market dropped to 15% (Sanvictores, 1975).

Since then major realignments have occurred. Declining availability of local timber and drastic reduction in logging quotas have resulted to the contraction of the local industry, further resulting to the gradual erosion of the country's share of the market by more competitive countries, notably China, which in 2003, became the largest veneer and plywood producer in the region, overtaking Ghana, Brazil, the Philippines and Malaysia (INFOCOM, 2007).

Over the past four decades the wood processing industry in the region and in the Philippines has been constantly challenged by new technologies and products, changing demand, shifting environmental issues and economic upheavals. But initiatives to re-examine the industry are not wanting. A recent ITTO project led by Indonesia looks at the future of bio-composites and engineered wood products in the region. This study is a component of the country program for the Philippines and in general, aims to review the market for bio-composite products in the country and to determine the potential for future growth of bio-composite products.

DATA SOURCES

Information used in this study were obtained from responses to mailed questionnaires, interviews of key informants in the industry, from official statistics published by the Forest Management Bureau (FMB) of the Department of Environment and Natural Resources (DENR) and from published reports and papers.

Questionnaires were mailed to 17 representatives of the Construction Industry Authority of the Philippines (CIAP), an attached agency of the Department of Trade

Table 1. Number of respondents

Sector	Number
Construction Industry Authority of the Philippines (CIAP)	17
Plywood producers	8
Particleboard producer	1
Cement bonded board producer	1

and Industry mandated to “promote, accelerate, and regulate the growth and development of the construction industry.” These respondents were civil engineers and represent the users of bio-composite products (Table 1). Eight questionnaires were returned. A different set of questionnaires was mailed to bio-composite producers.

BIO-COMPOSITE PRODUCTS IN THE PHILIPPINES

Bio-composites are a combination of natural fibers such as wood fibers (hardwood and softwood) or non-wood fibers (e.g., wheat, kenaf, hemp, jute, sisal, and flax) held together with some type of bonding material such as adhesive (Golbabaie, M. 2006; Rowell, R 1998). Bio-composites may be adhesives-based or cement-based. The major types of bio-composites in the Philippines are the more traditional adhesive-based bio-composites such as plywood, fiberboard, blockboard and particleboard. Cement-based bio-composites are fiber-cement boards and wood or agri-based cement-bonded boards.

Plywood was the first bio-composite introduced in the country. The plywood industry started in the 1950s and has remained a viable industry despite economic and environmental challenges. Particleboard production was introduced in the 70's but has not gained a strong foothold in the industry. The country produces high density fiberboard, but production is also minimal. In a report on particleboard, it was written that the Philippines has four existing particleboard plants as of 2008 namely: Bunyan I & II, Enviroboard, Philippines Compak and Sagay (Wood Based Panels International January 2010). According to survey and personal interviews, only Philippines Compak is operating at present. Bunyan is importing particleboard intended for lamination. Enviroboard on the other hand stopped operating due to the problem in using bagasse and because imported boards has become cheaper than those being produced by the company.

There are 40 plywood producers in the country with a total daily rated capacity of 2,864 cu m as of 2008 (Table 2). Presently, however, plywood plants operate on average, at less than 80% of capacity because of difficulties in the supply of wood raw materials.

Table 2. Number of bio-composite producers and daily rated capacity.

Bio-composite products	No. of producers	Daily Rated Capacity
Plywood	40	2,864 cu m
Blockboard	6	42 cu m
Fiberboard	1	10 cu m
Particleboard	1	1000 panels
Cement bonded boards	2	50 panels per day

Source: Philippine Forestry Statistics 2008 and personal interviews

PRODUCTION AND DISTRIBUTION

PRODUCTION OF MAJOR BIO-COMPOSITE PRODUCTS

Plywood is still the major bio-composite product produced in the country. From 2003 to 2008, the production ranged from 2,864 to 2,809 cu m, with the highest production in 2007 which is 2,920 cu m. Fiberboard and blockboard

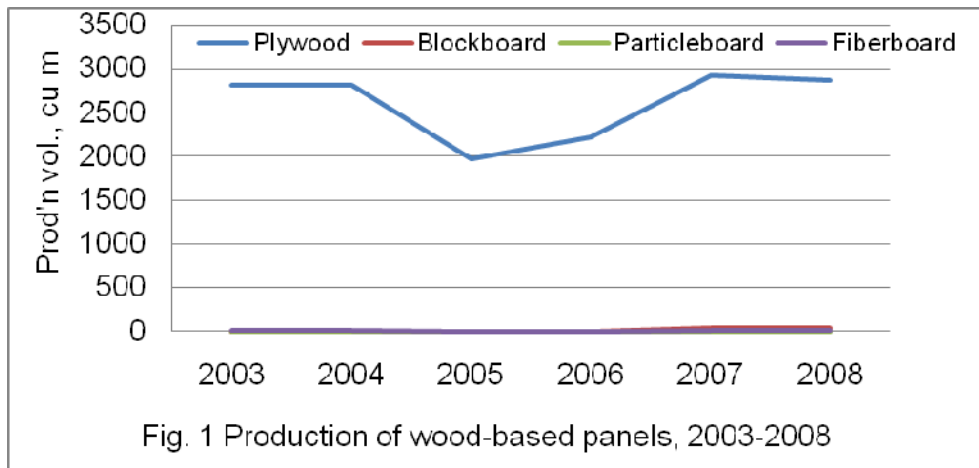


Fig. 1 Production of wood-based panels, 2003-2008

production, on the other hand was below 100 thousand cu m and was fairly stable from 2007 to 2008 (Fig. 1). One fiberboard plant located in Taguibo, Butuan City, Mindanao has a daily rated capacity of 4,000 board feet (9.4 cu m).

PRODUCT FLOW

The production and distribution chain of processed wood products in the Philippines starts at the natural or plantation forest. *Paraserianthes falcataria*, *gmelina arborea* and *shorea negrosensis* species are the more common types of local roundwood species used in bio-composites. The country also imports logs. In

2006, the country imported 65,185 cu m of roundwood, the lowest so far since 1996 when imports peaked at 877,000 cu. m.

Sawlogs are further processed into lumber in sawmills. Veneer logs may either go to veneer plants or plywood plants. Plantation thinnings go to particleboard, fiber board or wood wool cement board plants. The bulk of fiberboards used in the local market are imported by local distributors whose buyers come from the furniture and construction sector (Fig 2).

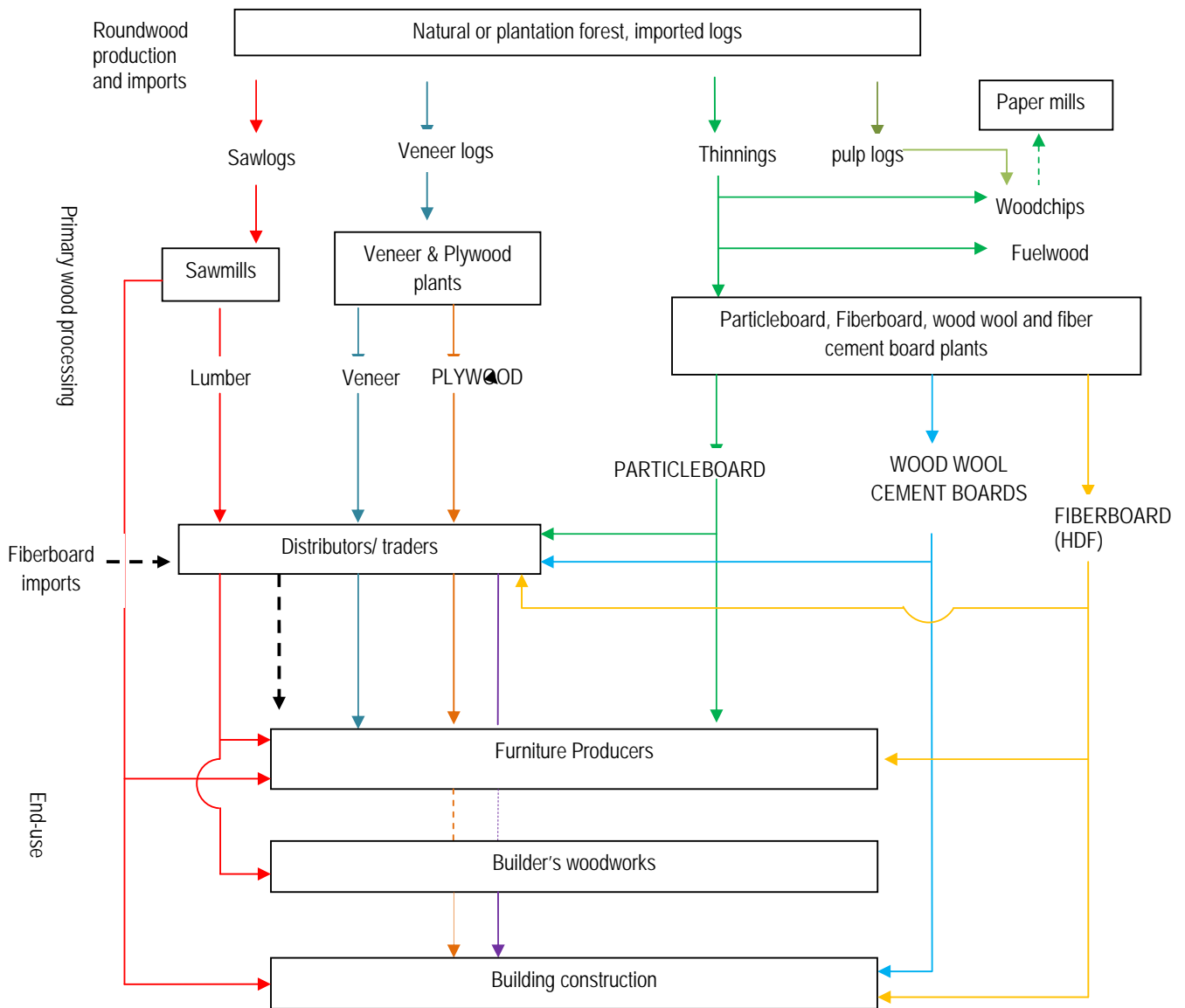


Figure 2. Production and distribution flow of bio-composites

Major end-use markets for bio-composites are the furniture and construction industries and to a smaller extent, builder's woodworks. More than 80% of the direct buyers of plywood and blockboard are traders and 31% of direct buyers are contractors. About 20% are more or less equally distributed between furniture makers and builders woodworks (Table 3).

Twenty five percent of the volume of cement bonded boards is channeled through traders; 65% are bought directly by building contractors. The lone producer of particleboard ships directly to furniture producers in Manila and Cebu, the Philippines' major furniture production center.

Table 3. Composition of direct buyers of bio-composites

Type of Buyers	Plywood and Blockboard Ave %	Particleboard Ave %	Cement bonded boards Ave %
Traders	87	20	
Furniture makers	11	80	
Contractors	31		100
Builders woodworks	10		

Production Centers

The Philippines is divided into three major island groupings—Luzon in northern Philippines, Visayas in the Central part and Mindanao in the south (Fig. 3). The only operating particleboard plant and 29 plywood producers out of the country's total of 40, are located in the Mindanao region, which is also known as the country's "timber corridor." In 2007, 286 thousand cu meters of plywood were produced in these regions, representing almost 96 % of the country's total plywood production of (Table 4).

Table 4. Plywood production by region, 2007.

Region	Total Production (cu m)	%
Philippines	286,457	100.00
Luzon	12,585	4.47
National Capital Region	4,597	

(NCR)		
Region 4-A	7,628	
Mindanao	268,872	95.53
Region 9	10,289	
Region 10	78,689	
Region 11	39,910	
Region 13	139,984	

Source: Philippine Forestry Statistics

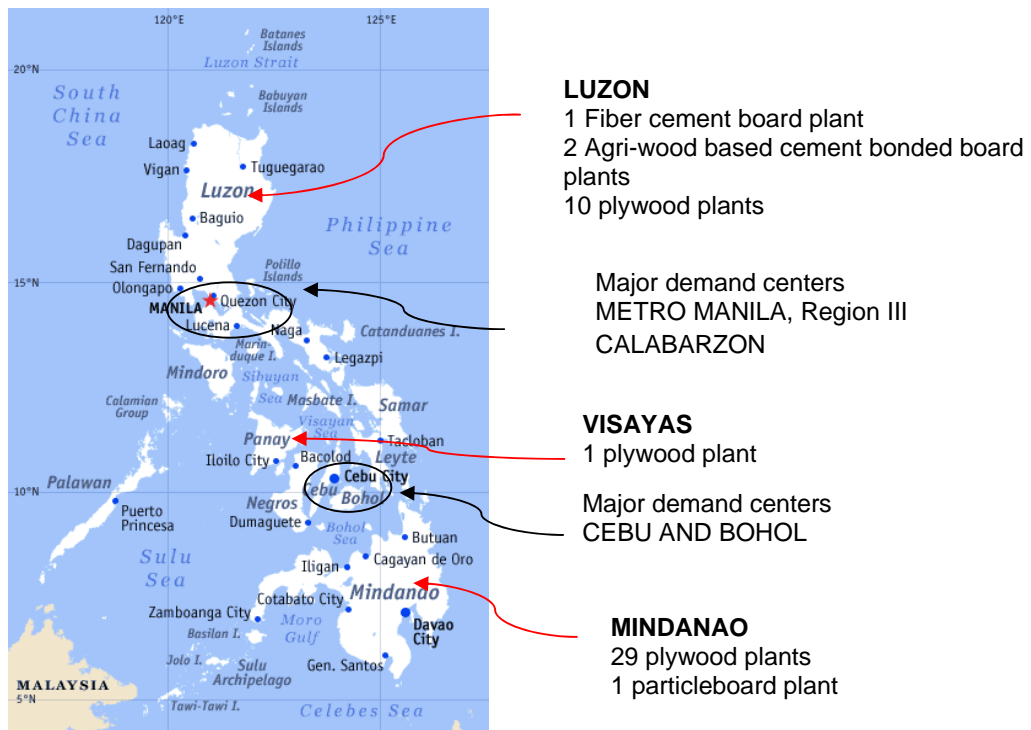


Figure 3. Location and distribution of wood based bio-composite plants and major demand centers for wood bio-composites

In 2006, the Philippine Forestry Statistics listed ten plywood plants in Luzon and only one in the Visayas. However, since there was no recorded plywood production in the Visayas in 2006, this may imply cessation of operations.

While majority of plywood plants are located near the sources of raw materials, fiber cement boards (FCB) and wood wool cement bonded boards

(WWCB) are produced in Southern Luzon nearer to the larger markets of Metro Manila and outlying provinces (Fig 3). The FCB plant uses virgin pulp that are imported from New Zealand while the WWCB plant uses *Gmelina arborea* and other materials available in the vicinity. The WWCB plant has also started using bamboo in combination with wood.

THE MACRO-ENVIRONMENT OF THE BIO-COMPOSITES INDUSTRY IN THE PHILIPPINES

THE CONSTRUCTION AND FURNITURE SECTORS

The demand for bio-composites is tied primarily to the state of activities of the construction sector and the furniture industry.

Construction Industry

Despite the global financial crisis, the local construction sector did not suffer major slumps in activity. There has been an increasing trend in residential and building construction for the past three years (Fig 4).

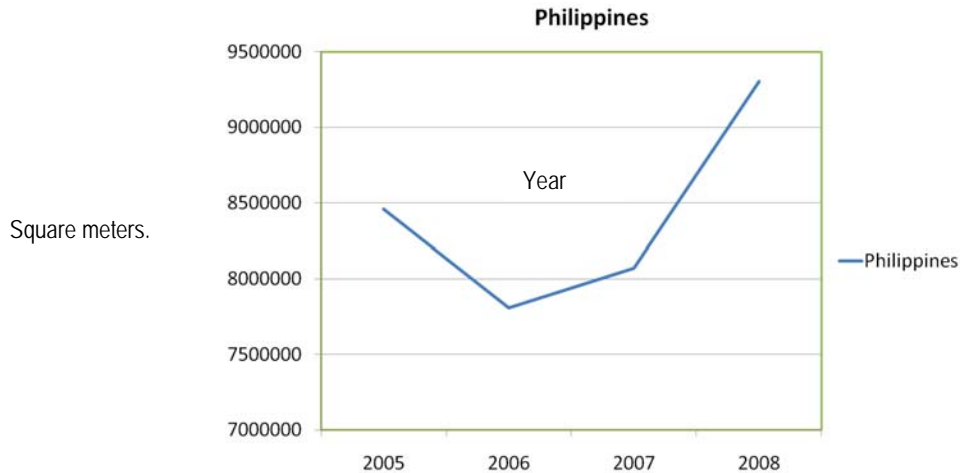
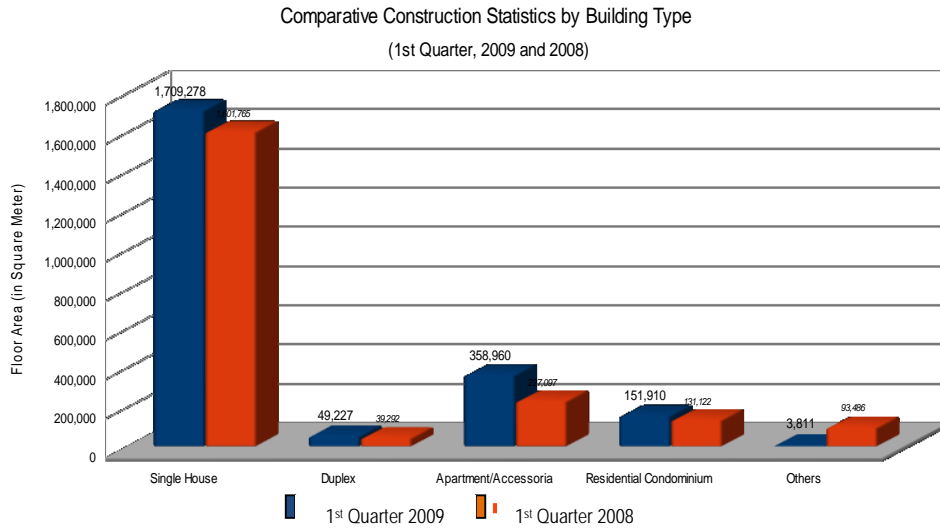


Figure 4. Total construction in square

Comparative figures for the first quarter of 2009 and 2008 also show an increase in residential building construction which rose by 21.3 percent in the first quarter of 2009 compared to the same quarter of 2008. Similarly, non-residential building construction grew to a remarkable 42.6 percent (Fig 3).

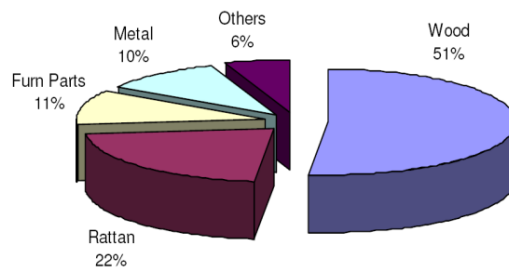
Construction is focused on single-type residential houses, followed by residential condominiums and apartments. There has been an increase of around 180,000 sq m in total floor area for all types of buildings.



Furniture Industry

An estimated 15,000 firms comprise the local furniture industry (Department of Trade and Industry, 2005). Only 2% are considered large ventures and the remaining 98% are small and medium-sized firms.

Wood furniture, mostly in solid wood, is the most common material used in furniture exports, accounting for 59% of total Philippine furniture exports to the world.



Bio composites such as plywood, medium density fiberboard and particleboard are used for panel furniture such as office tables and cabinets, most of which go to the domestic market. Domestic furniture production fills the requirements of new residential, hotel and office buildings. Thus, demand for local furniture and the raw materials used in their manufacture is also fuelled by the construction sector.

INSTITUTIONAL

Major institutions that impact on the bio-composites industry are the Department of Trade and Industry (DTI), Department of Environment and Natural Resources (DENR) and trade associations such as the Philippine Wood Producers Association (PWPA).

The Bureau of Product Standards (BPS) of the Department of Trade and Industry (DTI) develops, implements and coordinates standardization activities. Of the bio-composite products in the Philippines, standards have been developed only for plywood. Thirty-three plywood plants have been granted product standards certification and can thus use the PS Mark on their products.

The BPS conducts regular and special assessment of manufacturers of plywood, ensuring that no plywood produced by Non-PS Mark License holder shall be sold to, or offered for sale by any marketing outlets. The BPS can also take action and impose fines and penalties against manufacturers, importers, traders, distributors and/or marketing outlets selling substandard plywood or plywood without PS or Import Commodity Clearance (ICC) from the BPS.

The DENR, on the other hand, may cancel a company's Wood Processing Plant Permit (WPP), deny the application for renewal of WPP, padlock the plywood mill and impose fines or penalties against non-WPP holders or violators of the PS mark. It can also cancel the Certificate of Registration for Authority to Import Wood Materials of importers of substandard plywood or plywood without ICC mark.

The PWPA works together with the DENR and BPS to ensure that plywood, whether imported or locally manufactured, conforms with the specific national standard for the protection of the consumers. The PWPA is an association of lumber, veneer and plywood producers and gives voice to the issues currently faced by the wood processing industry.

Policies that impact on the raw material sources of bio-composite plants are shaped by the DENR. Supply of wood raw materials have been affected by policies on “the non-renewal of timber leases and licenses; the prohibition of cutting from old-growth forests (through NIPAS Act or RA 7586 & DAO 02, 1992), the cancellation or suspension of timber concession activities in secondary; and the on and off policy of banning timber” (Carandang, 2005).

TECHNOLOGICAL

New technologies and processes have given rise to alternative materials and products that directly compete with the more “traditional” wood bio-composites. Fiber cement board is seen as a direct competitor by plywood producers.

On the other hand, most plywood plants were established in the 70s and some are still operating on vintage equipment. Despite these, the industry has managed to adapt and survive. Most advanced technologies for bio-composites in general, is externally acquired from the more developed nations which have developed newer technologies on bio-composites, particularly on adhesives and the use of different fiber-base resources in combination with other materials.

ENVIRONMENTAL

One of the big issues faced by the bio-based composites industry is on the nature of adhesives used, particularly on the volatiles they release when used in bio-composites products. Most local firms have yet to shift to non-formaldehyde based adhesives, partly because of cost considerations and partly, because the local market in general, is not as particular and demanding.

TRADING OF BIO-COMPOSITES INDUSTRY IN THE PHILIPPINES

In 2008, The Philippines has imported Particleboard (included here are oriented strand board and wafer board) from many countries as shown in Table 5. For items 1.1 and 1.2, the bulk of importation came from Thailand and Malaysia which are 1,381,282 and 11,308,771, respectively. The bulk of surface-covered with melamine impregnated paper came from Thailand which is 1,345, 252 in gross kilograms. Total importation in 2008 was 34,480,251 gross kilogram. The value was USD 12,276, 278 FOB or USD 13, 568, 192 CIF.

Table 5. Particleboard Imports: 2008

Commodity/Country of Origin	Quantity, Gross Kilogram
1. Oriented strand board and wafer board of wood	
1.1 Unworked or not further worked than sanded	
China, People's Republic of	7,876
Hongkong	1,436
Japan (excludes Okinawa)	802,890
Malaysia	608,025
Singapore	6,025
Thailand	1,381,282
1.2 Other	
China, People's Republic of	1,151,394
Germany	19,285
Hongkong	30,539
Japan (excludes Okinawa)	1,261,960
Korea, Rep of (South)	1,810
Malaysia	11,308,771
New Zealand (excludes Western Samoa)	29,900
Singapore	133,684
Thailand	4,771,285
2. Other Wood	
2.1 Unworked or not further worked than sanded	
Japan (excludes Okinawa)	218,970
2.2 Surface-covered with melamine impregnated paper	
Austria	50,000
China, People's Republic of	89,243
Hongkong	69,260
Malaysia	241,429
Thailand	1,345,252
2.3 Surface covered with decorative laminates of plastics	
Austria	25,000
China, People's Republic of	18,000
Thailand	25,072

Source: National Statistics Office

The Philippines has imported fiberboard from several countries totaling to 34,336,228 in net kilogram with a value of USD 12,534,875 (FOB) (Table 6). Importation of fiberboard varied with densities such as 0.80 g/cm³, 0.50 g/cm³ but not exceeding 0.80g/cm³ and 0.35 g/cm³ but not exceeding 0.50 g/cm³. The bulk of importations with density exceeding 0.80 g/cm³ came from Thailand, China (Peoples Republic) and Malaysia with quantities of 1,191,299; 1,179,665; and 1,100,572 in net kilogram, respectively. Few quantities of this kind were also imported from Australia, Chile, Taiwan, India, Japan, Singapore and USA.

For fiberboard of wood or other ligneous materials of a density exceeding 0.50 g/cm³ but not exceeding 0.80g/cm³ that are not mechanically worked or surface covered, the bulk of importations came from Malaysia (6,488,516), China, People's Republic of (2,082,926) and Thailand (1,845,776). On the other hand, item 2.3 which is considered as other, the top three country of origins were from Thailand (3,597,355), Malaysia (2,972,017) and People's Republic of China (2,933,193).

There were also initial data gathered that the Philippines exported particleboard and fiberboard in 2008. For particleboard with surface covered with decorative laminates of plastics, it has exported a quantity of 1,499 in gross kilogram to Egypt Arab Republic. These particleboard with laminates of plastics are believed as re-exportation although there is a plant in the Philippines that does the lamination of imported particleboard. The Philippines has also exported fiberboard to Japan with a quantity of 2,945 in net kilogram.

For fiberboard of wood or other ligneous materials of a density exceeding 0.35 g/cm³ but not exceeding 0.50 g/cm³, the countries of origins were Australia, Malaysia, People's Republic of China, Germany and Norway with a total quantity of 479,614.

Table 7 shows that veneer and other wood; plywood and other plywood and veneered panels; fiberboard as well as particleboard are among the top imports of the forest based products. Importation of particleboard has the lowest percent share compared to others while importation of fiberboard was almost consistent at 2% share from 2001 to 2006. On the other hand, Table 8 shows that export of plywood, veneer and fiberboard was much lower compared to other forest based products.

Table 6. Fiberboard Imports: 2008

Commodity/Country of Origin	Quantity, Net Kilogram
1. Fiberboard of wood or other ligneous materials of a density exceeding 0.80 g/cm ³	
1.1 Not mechanically worked or surface covered	
China, People's Republic of	128,000
Malaysia	410,711
Thailand	61,563
1.2 Other	
Australia	62,300
Chile	25,989
China, People's Republic of	1,179,665
Hongkong	38,189
India	1,670
Indonesia	190,296
Japan	48,020
Malaysia	1,100,572
New Zealand	640,969
Singapore	15,061
Taiwan (Republic of China)	682
Thailand	1,191,299
USA	35,726
2. Fiberboard of wood or other ligneous materials of a density exceeding 0.50 g/cm ³ but not exceeding 0.80g/cm ³	
2.1. Not mechanically worked or surface covered	
Australia	59,280
China, People's Republic of	2,082,926
Hongkong	16,813
Indonesia	485,229
Italy	336,760
Malaysia	6,488,516
New Zealand	1,772,482
Sarawak	184,788
Singapore	54,641
Thailand	1,845,776
USA	105,700

Source: National Statistics Office

2.2 Wooden beading and mouldings	
Chile	24,362
China, People's Republic of	4,657
Malaysia	23,845
2.3 Other	
Australia	25,500
Austria	34,282
Chile	67,322
China, People's Republic of	2,933,193
Hongkong	105,205
Indonesia	1,821,773
Korea, Republic of (South)	32,840
Malaysia	2,972,017
New Zealand	581,144
Singapore	55,816
Thailand	3,597,355
USA	29,022
3. Fiberboard of wood or other ligneous materials of a density exceeding 0.35 g/cm ³ but not exceeding 0.50 g/cm ³	
3.1 Not mechanically worked or surface covered	
Australia	9,266
Malaysia	48,240
3.2 Other	
Australia	24,864
China, People's Republic of	189,754
Germany	196,875
Norway	10,615
4. Fiberboard of wood or other ligneous materials	
4.1 Not mechanically worked or surface covered	
Indonesia	325,996
Malaysia	253,093

Source: National Statistics Office

Table 7. TOP FOREST-BASED PRODUCTS IMPORTS, 2001 – 2007

Product \ Year	2001	2002	2003	2004	2005	2006	2007	
	% Share to Total							
Paper and Paperboard and Articles of Paper & Paperboard	56.37	55.91	63.04	60.66	57.29	62.48	69.16	
Lumber	13.35	16.41	17.06	12.95	15.71	12.15	9.29	
Pulp and Waste Paper	12.52	11.22	1.11	10.29	7.61	7.87	7.19	
Log	6.92	6.42	5.36	2.62	3.18	2.51	2.45	
Veneer and Other Wood, worked not exceeding 6mm, n.e.s	4.49	3.13	3.95	2.41	2.39	1.47	0.97	
Forest-based Furniture	2.51	0.76	1.01	2.85	2.82	3.23	2.84	
Fiberboard	2.03	2.72	2.05	2.87	2.43	2.27	1.52	
Wood Manufactured Articles, n.e.s.	0.85	0.97	1.53	0.93	1.05	1.07	1.15	
Plywood and Other Plywood and Veneered Panels	0.66	2.23	4.60	4.19	7.36	6.49	4.25	
Wood continuously shaped along any of its edges or faces	0.29	0.24	--	--	--	--	--	
Particleboard	--	--	0.29	0.24	0.16	--	1.18	
Wood chips and particles	--	--	--	--	--	0.48	--	

Source: Philippine Forestry Statistics 2001 - 2007

Table 8. TOP FOREST-BASED PRODUCTS EXPORTS, 2001 – 2007

Year \ Product	2001	2002	2003	2004	2005	2006	2007	
	% Share to total							
Forest-based Furniture	42.03	46.04	33.00	43.19	40.26	18.80	14.66	
Wood Manufactured Articles, n.e.s	23.72	22.88	---	22.94	23.15	59.39	64.57	
Paper and Paperboard and Articles of Paper & Paperboard	18.91	14.75	19.27	14.78	18.31	12.50	11.97	
Pulp and Waste Paper	6.05	6.47	1.21	7.69	8.84	4.86	4.16	
Selected Non-timber Manufactured Articles	3.94	3.99	4.93	3.83	2.67	1.15	1.10	
Lumber	3.19	2.09	3.28	1.83	1.43	1.20	1.20	
Wood Charcoal	1.06	1.03	---	1.40	1.31	---	0.72	
Plywood and Other Plywood Veneered Panels	0.63	1.99	1.53	3.32	2.99	0.87	1.24	
Veneer and Other Wood Worked not exceeding 6 mm n.e.s	0.32	0.63	0.65	0.61	0.62	0.37	0.32	
Non-timber Forest Products	0.15	0.13	0.22	--	--	0.05	0.06	
Fiberboard			0.44	0.41	0.42	0.05		

Source: Philippine Forestry Statistics 2001 - 2007

CONCLUSION AND RECOMMENDATIONS

The plywood industry was in its growth stage in the early 60's. During this period, efficiency and productivity of plywood plants established during this period was quite high because equipment and machinery were still new. Today, most of the plywood plants have antiquated equipment and productivity has remained low (Candelaria, C., 2007). This leads to uncompetitive price and quality, in comparison with other bio-composites.

Plywood production depends heavily on timber. The two opposing perceptions on the sustainability of wood resources for plywood stem from differences in the status of plantation development in the locality. Replanting and plantation development efforts of the private and government sector should be doubled to increase the timber supply base and thus meet the volume requirements of plywood producers.

The issue of quality is a major concern of both producers and consumers of bio-composite products. One reason for the increasing market share of fiber cement boards, aside from the perceived durability, is the substandard quality of plywood. Building contractors specifically complain of undersized panels. Plywood producers, on the other hand, recognize that substandard plywood produced by small players can also affect market shares of producers who strive to preserve their "PS Mark" of quality.

Quality standards for plywood have been in place and are constantly being reviewed. The recent agreement forged between PWPA and the BPS towards strengthening product standard implementation for plywood is a welcome development. Strict implementation of quality standards across the plywood industry should give a fighting chance for the industry to win back the share lost to new products.

Quality standards should not be limited to plywood. Standards should also be developed for wood-based and agri-based cement bonded boards to ensure consumer confidence on the product, improve its marketability and sales, and encourage private investment in CBB production. FPRDI is the lead institute in the

country which has the capability not only to conduct research on bio-composites but also to develop standards.

Bio-composites compete with each other for a share of a market that has remained fairly constant. Thus the share of the pie of traditional bio-composites is affected by the introduction of new products such as fiber cement boards, which has a wider range of application, particularly in housing construction. Plywood producers have reportedly experienced on the average, a 25% decrease in sales due to the shifting preference towards fiber cement boards (Candelaria, C., 2007).

REFERENCES

1. "Philippines Solid Wood Products Annual 2001". GAIN Report.
<http://www.fas.usda.gov/gainfiles/200506/146130054.pdf>
2. Candelaria, C. (2008) "Status of the Plywood Plants in Luzon"
3. Focus of Particleboard Part 2: Rest of the World – Existing Plants, December 2008. Wood Based Panels International Dec 2009/Dec 2010 Issue
4. Golbabaie, M. (2006) "Applications of Bio-composites in Building Industry" Department of Plant Agriculture, University of Guelph, Ontario, Canada, Dec. 12, 2006.
5. INFOCOM. "Market Information in the Commodities Area", UNCTAD.
<http://www.unctad.org/infocomm/anglais/oil/sitemap.htm>
6. National Statistics Office 2008
7. Philippine Forestry Statistics (2003 – 2008), Forest Management Bureau, Department of Environment and Natural Resources.
8. Rowell, R. M. (1992) "Opportunities for Value-added Bio-based Composites," in Proceedings of the Pacific Rim Bio-based Composites Symposium; 1992 November 9-13; Rotorua, New Zealand. FRI Bulletin 177. Rotorua, New Zealand: New Zealand Forest Research Institute; 1992: 244-252.
9. Rowell, R. M. "The State of the Art and Future Development of Bio-based Composite Science and Technology Towards the 21st Century." In: Proc, the 4th Pacific Rim Bio-based Composites Symp, Nov 2-5, 1998, Indonesia. p. 1-18.
10. Sanvictores, B. "Moving Moving away from Log Exports" originally presented at the FAO World Consultation on Wood-based Panels held in New Delhi in February 1975. <http://www.fao.org/docrep/f6137e/f6137e09.htm#TopOfPage>
11. Winandy, J. E. "Advanced Wood- and Bio-composites: Enhanced Performance and Sustainability" in Advanced Materials and Processing IV : Selected, peer reviewed papers presented at the 4th Intl Conf on Advanced Materials and Processing, 10-13 Dec, 2006, Hamilton, New Zealand. Zurich : Trans Tech Publications, Ltd., 2007. Advanced materials research ; v. 29-30: ISBN: 0878494669: 9780878494668: Pages 9-14.