Waste Management 35 (2015) 3–11

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Waste generation and utilisation in micro-sized furniture-manufacturing enterprises in Turkey

Y. Top *

Vocational School of Gumushane, University of Gumushane, Baglarbasi Mah., 29100 Gumushane, Turkey

ARTICLE INFO

Article history:
Received 22 May 2014
Accepted 30 September 2014
Available online 19 October 2014

Keywords:
Waste
Furniture
Wood
Micro-sized enterprise

ABSTRACT

The number of small-scale businesses within most national economies is generally high, especially in developing countries. Often these businesses have a weak economic status and limited environmental awareness. The type and amount of waste produced, and the recycling methods adopted by these businesses during their operation can have negative effects on the environment. This study investigated the types of waste generated and the recycling methods adopted in micro-sized enterprises engaged in the manufacture of furniture. An assessment was also made of whether the characteristics of the enterprise had any effect on the waste recycling methods that were practised. A survey was conducted of 31 enterprises in the furniture industry in Gumushane province, Turkey, which is considered a developing economy. Surveys were undertaken via face-to-face interviews. It was found that medium-density fibreboard (MDF), and to a lesser extent, chipboard, were used in the manufacture of furniture, and two major types of waste in the form of fine dust and small fragments of board are generated during the cutting of these boards. Of the resulting composite board waste, 96.9% was used for heating homes and workplaces, where it was burnt under conditions of incomplete combustion. Enterprises were found to have adopted other methods to utilise their wastes in addition to using them as fuel. Such enterprises include those operating from a basement or first floor of a building in the cities, those continuing production throughout the year, those in need for capital and those enterprises not operating a dust-collection system.

1. Introduction

Waste wood can be a potentially valuable resource for the manufacture of various materials and products (Lykidis and Grigoriou, 2008). The type and volume of wastes generated during the manufacture of forest products have changed over time depending on various factors. One of these factors is the reduction in the amount of wood resources available. One example is the change in the past and present utilisation of bark, a by-product of the forest-products industry. The economic value of bark is much lower than that of wood, both quantitatively and qualitatively. Therefore, it has been considered a worthless by-product of the forest-products industry, and has mostly been given away or sold at a low price (Lu et al., 2006). Today, bark can be used as a medium-layer material in board production (Pedieu et al., 2008) and as a raw material in insulation board production (Kain et al., 2012). Ilomäki and Melanen (2001) reported that small and medium-sized enterprises (SMEs) in Finland, which is rich in forest resources, have shown less effort in reducing material losses compared to the country's metal industry.

One of the factors affecting the utilisation of industrial wood waste is the environmental pollution caused by fossil fuels and the regulations imposed to control such emissions (De Hoop et al., 1997). At a time when fossil fuels were much cheaper than wood, wood waste was destroyed by burning. The increase in fossil fuel prices and the environmental pollution caused by their use has resulted in the use of wood for generating energy (Hahn, 1982). The effects of legal regulations on wood waste management can be seen in the management of MDF waste. In Tennessee, where it is a legal requirement for MDF residues to be disposed of in a landfill, the number of landfill sites has diminished and burial costs have subsequently risen, resulting in efforts to demonstrate that these wastes can be utilised to improve soil (EPA, 2011). Lippke and Puettmann (2013) reported that in the forest-products industry, in which biomass is generated as a by-product, it was prohibited to burn wood wastes in boilers for heat production and it is only relatively recent that fossil-fuel boilers have been converted into renewable biomass-burning boilers.

Another change in the management of industrial wood wastes is the reduction in the amounts of waste generated. In commercial

* Address: Gumushane MeslekYuksekokulu, Baglarbasi Mah., 29100 Gumushane, Turkey. Tel.: +90 456 233 73 20; fax: +90 456 233 7322.
E-mail address: yenertop@gumushane.edu.tr

http://dx.doi.org/10.1016/j.wasman.2014.09.028
0956-053X/

forestry applications, the amounts of waste generated in the process from cutting a tree to delivering it to the end consumer as a product has been reduced. Those parts of felled trees that are unsuitable for lumber and plywood production are used in paper production. Wastes generated during lumber and plywood production are used in the production of composite panels, whereas bark is used to generate energy by burning (Hahn, 1982). Blatner et al. (2012) reported that by-products generated as a result of lumber production in the western United States fell from 59% to 51% in the last 40 years, despite the decline in lumber volume.

Recycling of all industrial wood waste is theoretically possible, but in practise there are factors that limit recycling practises. These include waste collection and transportation, the scale of the business, the industrial sector in which the company operates, the amount and type of waste produced, environmental regulations and the level of development within a particular country.

The presented study aimed to identify the types and utilisation methods of solid waste generated by micro-enterprises operating in the furniture industry in the province of Gumushane, Turkey. This region is considered a developing economy by gross national income per capita (The World Bank, 2014). The presented study evaluates if certain properties of these businesses have any impact on solid waste utilisation. For these purposes, the research questions were defined as follows:

- What kind of solid wood wastes are generated in the micro-sized enterprises?
- How are these wood wastes utilised by these enterprises?
- How does location in the province, sites in city, and operating periods of the businesses affect the selection of waste utilisation methods?
- How do problems faced by businesses affect the utilisation of wood wastes?
- Are there any differences in the utilisation of wood wastes between businesses with and without dust collection systems?

1.1. The forest-products industry and its waste materials

The forest-products industry uses wood as a raw material. This industry includes lumber, furniture, paper and paper products, pulp, and other wood industries (Pentti et al., 2002). It is usually divided into two distinct industrial sectors. The first is the primary wood-products industry, which covers a wide range of operations from lumber production to the manufacture of finished products that are mostly or completely made of wood or composite wood materials (Burton et al., 2003). The second is the value-added or secondary forest-products industry, which manufactures products by processing raw materials or semi-processed materials, and generally includes the production of pallets, light furniture, cabinets, doors, and windows (Monroe et al., 1999).

A portion of the raw material becomes waste during the production process (Gombatz, 2007). These wastes vary due to the differences in raw materials that are involved in production, in the actual production processes, and in the different finished products in the primary and secondary wood-product industries. Wood waste refers to materials that are unsuitable for the production of wood products. They take different forms such as bark, small chips, sawdust, wood edges, and low-quality wood rejected by the manufacturing process (Burton et al., 2003). These wood wastes can be classified into three types: bark, coarse, and fine waste. Bark waste consists of the bark on the exterior part of the log. Coarse wastes include slabs, timber edges, and veneer cores that are suitable for chipping. Fine wastes include by-products that are not suitable for chipping, such as sawdust and veneer clippings (Murphy et al., 2007).

Wastes generated in primary and secondary wood-product factories are biomass resources (Skog and Rosen, 1997). The intended use of this biomass can be divided into energy and non-energy applications. The use of biomass for energy involves combustion to meet the energy needs of homes and industrial enterprises. Non-energy uses include the production of composite boards and wood pulp, land reclamation, animal bedding materials, landscaping, and agricultural mulch; the remainder is sent to landfills (MERAF, 2002; Murphy et al., 2007).

The large-scale use of sawdust and shavings is very problematic. The geographical location of the waste resources and the markets that could use them limit the development of a significant market for these wastes. Long transport distances are generally acceptable only for highly valuable products such as high-quality wood flour. Low-grade products can be used for agricultural applications. Timber shavings can be sold to markets close to where the waste is generated (Harkin, 1969). Other reasons for the limited use of wood waste are the lack of integration of the companies that generate the waste and those that ultimately use it (Nemerow, 2006) and the long delays during waste collection, which can degrade the quality of the waste (Nemli et al., 2007).

It is technologically possible for some factories to meet all of their energy needs by burning the wood waste that they generate; however, it may not be an economical investment (Carll et al., 1982). In some cases, it may not be possible to use waste as a fuel or in other beneficial ways. In such circumstances, the only benefit of wood waste disposal by incineration is to reduce the volume of the waste material (MERAF, 2002).

The type and quantity of emissions arising from burning wood wastes depend on two main factors: the type of biomass (chemical composition) and its physical properties, and the technology used to burn the biomass (Suzdalenkol et al., 2012). Although there are limited data regarding the exact emissions generated in the combustion process, biomass is also an important source of particulate emissions as well as combustion by-products. This is particularly true when they are not incinerated correctly or under conditions of incomplete combustion. The burning of wood wastes can cause serious particulate matter emissions. Pollutants other than particulate pollutants, particularly carbon monoxide, manganese, and organic compounds, can be released in large quantities under conditions of incomplete combustion (Burton et al., 2003). The main drawback of biomass burning is the large amount of emissions that result from improper combustion compared to fossil fuel combustion. This is especially true for the burning of biomass using devices such as woodstoves, ovens, and wood boilers (Van Loo and Koppejan, 2008). Therefore, to reduce emissions, wastes generated during the processing of engineering panels, such as MDF, should be burned only in industrial locations rather than in conventional home stoves, and at temperatures of about 1000 °C (URL 1, 2013).

1.2. The Turkish furniture industry and the quantity of wastes generated

SMEs have an important role in the global economy. Although their contribution varies from country to country, they globally constitute 70% of domestic gross national product (O'Laoire and Welford, 1996 cited in Ilomäki and Melanen (2001)). This type of enterprise (with less than 200 employees) comprises 99% of all businesses in the European Union and 85% of the gross national product. They pollute the environment during their activities but they are often not aware of their impact (Mitchell et al., 2011). Redmond et al. (2008) determined that 39% of small businesses (with 1–20 employees) believe they have no effect on the environment (Redmond et al., 2008). Only 24% of SMEs in the European Union are engaged in activities to mitigate their effects on the

environment (Mitchell et al., 2011). A limited number of studies (Aragón-Correa et al., 2008; Redmond et al., 2008) has been conducted regarding the waste utilisation and environmental impact of these enterprises. In studies on the waste disposal of small-scale enterprises (Casares et al., 2005; Ilomäki and Melanen, 2001; Mitchell et al., 2011; Redmond et al., 2008), enterprises operating across various sectors, rather than a single sector, were investigated.

The furniture industry in Turkey consists of micro-scale enterprises engaged in workshop-type production using mostly traditional methods. However, the number of small enterprises, as well as medium-sized and large enterprises, has increased rapidly in the last 15–20 years (Kades, 2012). The total number of enterprises engaged in furniture production in different employment size classes in Turkey is given in Table 1. It can be seen that 96.5% of all enterprises engaged in furniture production are micro-sized enterprises that employ 1–9 people. The official number of businesses operating in the furniture sector in Turkey is 35,053, and this number makes up about 2% of all industries. However, there are also unregistered businesses operating in the furniture industry, and therefore this figure is not exact. The proportion of businesses that are unregistered is estimated to be between 50% and 60% (Anonym, 2006).

Wood and composite products of wood, including particleboard, plywood, and MDF (Güneri, 2005) are widely used in the manufacture of products used inside buildings such as furniture, flooring, doors, and cabinets. In particular, particleboard and MDF are widely used in the manufacture of furniture. United Nations data on plywood, fibreboard, and particleboard production in Turkey are given in Fig. 1 (URL, 2). The total numbers of boards produced have increased over time. Furthermore, while the production of particleboard has decreased in recent years, fibreboard production has increased.

Industrial waste is the waste resulting from production across many industrial sub-sectors (Casares et al., 2005; Christensen, 2010). Furniture manufacturing is one of these sub-sectors. Wastes are generated during both the production and processing of the composite boards used in furniture production. The Turkish Statistical Institute (TSI) defines waste in the wood product industry as "loss that occurs during the felling of trees, processing, and transport of timber". According to TSI data, during the manufacture of furniture in 2004, 149,265,000 m^3 of solid waste, 140,000 m^3 of which was hazardous waste, was generated by manufacturing industry establishments with 50 or more employees (TUIK, 2005). However, wastes generated by micro-sized enterprises are not included in these statistics.

1.3. Legal background of waste management in Turkey

The accession process of Turkey to the European Union (EU) as a full member has had an impact on making laws related with waste management and environment. Until 2005, only three by-laws on waste management have been forced in law. After launching accession negotiations between EU and Turkey, already 13 regulations have been put into practice until present (URL, 3). One of the EU acquis, that includes 35 chapters, is the environment. In order to meet legal environmental requirements, it is estimated that Turkey needs to invest approximately € 60 billion (Kose et al., 2007).

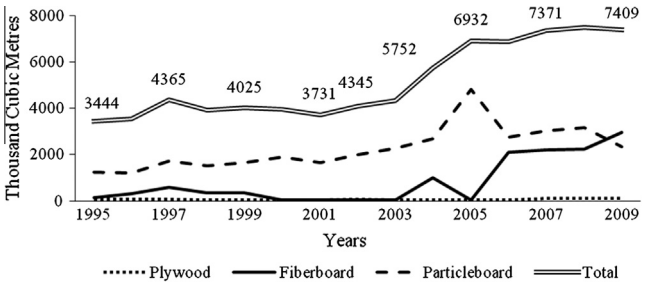

Fig. 1. Board production in Turkey between 1995 and 2009.

With the technical and financial projects supported by the EU, regulations in Turkey have substantially been harmonised with the EU waste management directives. However, the lack of existing infrastructure and institutional and technical capacity hinder their implementation (Kose et al., 2007). Furthermore, Agan et al. (2013) reported that enforcement of current environmental laws is impossible due to high numbers of SMEs in Turkey and existing confusion among legal institutions regarding responsibilities.

According to Turkey's climate change strategy 2010–2020, the percentage of renewable energy usage in electricity production will be increased to 30% until 2023. Biodegradable wastes will be directed to be used for energy and compost production (The Ministry of Environment and Urban Planning, 2012). The Kyoto Protocol has been signed in 2009, and Turkey was removed from the Annex II list in 2001 (Wikipedia, 2014). But Turkey has not committed to any greenhouse gas (GHG) emission reduction so far (Baykan, 2011).

2. Materials and methods

2.1. Materials

In this study, micro-sized enterprises (with 1–9 employees) operating in the furniture manufacturing sector in Gumushane province, one of the 81 provinces of Turkey, were selected for investigation. The furniture-manufacturing industry is classified as a sub-section of the manufacturing sector and is coded as Section 36 within the Statistical Classification of Economic Activities in the European Community. According to TSI data, there are 33 enterprises in Gumushane that fall under Section 36 coding. The number of enterprises engaged in the production of furniture in the province of Gumushane corresponds to 4% of all of the manufacturing industry in the province. In addition, 47% of provincial manufacturing sector businesses are micro-sized enterprises, 48% are small enterprises, and 5% are medium-sized enterprises (Anonym, 2012). All businesses operating in the furniture-manufacturing industry in the province of Gumushane are micro-sized (Top et al., 2013).

Table 1
Number of local units and employment size classes in Turkey.

Sectors	Employment size classes					Total
	1–9	10–49	50–150	151–250	251+	
Number of local units						
All sectors	1,788,835	58,521	7407	1577	1851	1,858,191
Furniture manufacturing	33,852	1052	107	25	17	35,053

2.2. Method

A face-to-face interview method (Arıkan, 2011) was used to collect data. The questionnaire has been applied to the SME owner–manager, and its questions were prepared as open-ended, multiple choice, or with two options (yes–no). In addition, a field study was initiated to survey each business selected. However, it was not possible to visit some businesses for various reasons (e.g., not all addresses could be identified in the records of the Gumushane and Kelkit Chamber of Commerce), while other non-registered businesses were identified following information obtained from the businesses that were interviewed. As a result, the final number of completed questionnaires was 31. As confirmed by the 2002 General Industry and Business Census conducted by the TSI, 93% of the businesses that make up the main segment of the furniture manufacturing sector were reached (TUIK, 2002). The research was conducted between the years 2012 and 2013.

The data obtained were arranged into a cross table using a software, Statistical Package for Social Sciences (SPSS©). However, correlations among categorical variables in the table could not be made because more than 20% of the expected frequency values in cells were below five and the expected frequency of any given cell was less than one.

3. Results and discussion

3.1. Properties of the businesses

To understand the facilities and capacities of the micro-sized businesses selected better, various types of data on each business were collected. Statistical values of employment, the educational background of employees, and the period of operation are given in Table 2.

The mean number of employees per enterprise in the furniture-manufacturing industry in Gumushane province was less than 3.4, which is the mean value across Turkey. The mean number of years of operation of these businesses was less than 34, which is the mean value across Turkey (Fırat, 2013). Although there are many vocational schools in Turkey that provide education related to furniture manufacturing, as well as institutions that grant degrees in furniture manufacturing, the employment rate of graduates in this sector is low (Aksu and Koc, 2009). Only 13.2% of vocational school graduates are employed in this sector. However, the employment rate of graduates from non-vocational educational institutions employed in this sector is 68.4%. It can be concluded from this that the majority of employees in the sector do not have an in-depth knowledge of the physical and chemical properties of wood or wood composites.

In a study conducted in an industrial zone comprising SMEs, it was concluded that the environmental responsibilities of companies are usually limited and directly proportional to the scale of the company (Casares et al., 2005). Ilomäki and Melanen (2001) demonstrated that small businesses, most of which were micro-sized businesses, had very little interest in environmental protection. In Europe, SMEs include businesses with less than 250 employees and an annual turnover of a maximum of € 40 million, whereas micro-sized businesses are those with less than 10 employees and an annual turnover of less than € 2 million (Anonym, 2003). Given this definition and the studies referred to here, it is understandable that the micro-sized businesses in Gumushane have few or no environmental concerns.

Table 2
Number and educational background of employees, and the period of operation for the businesses selected.

	N	Sum	Mean
Employees	31	76	2.45
Years of operation	31	624	20.13
Graduated from primary school	12	13	1.08
Graduated from secondary school	12	17	1.42
Graduated from high school	12	22	1.83
Graduated from vocational schools	6	10	1.67
Graduated from university	11	14	1.27

3.2. Types of waste and methods for their utilisation

Fig. 2 shows the typical waste generated by a company that produces furniture in Gumushane. The waste produced during the cutting of boards is in the form of fine dust, while those generated during drilling and milling operations have a less dense structure. As seen in Fig. 2, some businesses collect the wastes in a mixed manner without sorting them at source.

Some businesses collect their wastes in the form of sawdust using vacuum systems, such as that shown in Fig. 3.

Fig. 4 shows waste in the form of small pieces of board generated after cutting MDF and particleboards. These pieces, which are too small to be used in the manufacture of furniture, are left after cutting out the sections needed. This type of wood waste can be used to make new boards (Lykidis and Grigoriou, 2008).

Two major types of solid waste are generated during the processing of boards in the manufacture of furniture: sawdust and small pieces of boards. Half of the enterprises investigated in this study utilised a system to collect dust. However, businesses usually do not do so diligently. The most important reason for this is the lack of available space and tools for collection (Fig. 2). Casares et al. (2005) reported that specific technologies are required to collect bulky wastes such as paper, cardboard, plastic, and wood.

The methods adopted to utilise wastes generated during the production of furniture were determined and are shown in Fig. 5. Wastes are basically utilised in three different ways. Individual businesses usually prefer to adopt only one of these different methods. Only one company stated that it utilises its wastes in two different ways.

A very large proportion (96.9%) of the wastes generated in furniture-manufacturing businesses in Gumushane province was found to be utilised as fuel in workplaces and homes. This is not surprising, given that half of the world's wood is consumed as firewood, and wood is still the primary energy source for the vast majority of the world's population (Sutton, 1993; Risbrudt, 2012). In many developing countries, wood and charcoal are the primary fuels used by people to prepare food and they are also important fuels for SMEs (Zerbe, 2004).

The primary condition for the use of wood as an environmentally sustainable fuel is that it burns completely and efficiently.

Fig. 2. Wastes generated during the processing of MDF and particleboard in furniture manufacturing.

Fig. 3. Collection of dust generated during the cutting of wood by suction using a vacuum system.

Fig. 4. Small pieces of board left over after the cutting of larger boards.

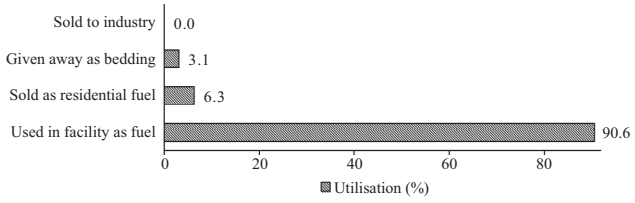

Fig. 5. Methods adopted to utilise wastes.

The combustion process should allow the wood to be burned completely to avoid the formation of environmentally undesirable components (Vos, 2005). In combustion tests using composite wood materials, Tatàno et al. (2009) reported high emissions of carbon monoxide as a result of incomplete combustion, as well as nitrogen oxide emissions, which can lead to the formation of acid rain. Therefore, composite board wastes should be fully burned in special furnaces and at high temperatures (1000 °C) (URL 1, 2013).

The use of wastes generated during the manufacture of furniture as a source of heat in houses was found to be low. Kumar (2011) reported that the residents of cities burn solid waste to produce heat and may go to sawmills to collect sawdust.

In this study, it was found that only 3.1% of the waste produced was used as bedding. However, Top et al. (2013) reported that 20.8% of timber-industry wastes in the same province were used as bedding. This large difference may arise from the quality and quantity of furniture-industry wastes, which differ from those produced in the timber industry. In addition, waste from the timber industry does not contain any artificial chemicals.

Waste particles generated during the manufacture of furniture can be re-used in the production of particleboard. Garay (2012) established that 30% of the raw materials used in particleboard plants in Chile is wood waste generated by other industries, and thus businesses can earn higher profits by utilising this waste. However, in Gumushane, wastes are not typically sold to other businesses for other uses. There are two reasons for this: (1) businesses are micro-sized so the amount of waste produced is low, and (2) there is no business engaged in the manufacture of boards close to Gumushane.

Similarly, particles generated during the manufacture of furniture can also be used in the production of MDF. Fibres contained in the waste particles can be recycled using microwave technology (Harrison, 2012). In addition, end-use wood panels can also be re-used in the manufacture of MDF (Mantanis et al., 2004). In a study in an industrial zone comprising SMEs, 27% of all wastes, including glass, metal, and wood, were shown to be re-used in manufacturing industries. However, industrial sectors were not separated (Casares et al., 2005). It has also been shown that MDF wastes can be utilised to improve agricultural soil (EPA, 2011). However, no such use was identified in our study sample.

Basic stoves, such as those shown in Fig. 6, are used to burn wastes. These stoves are not considered suitable for burning composite board wastes because they create conditions that lead to incomplete combustion. It is important to have suitable combustion conditions during the incineration of particleboards. Incomplete combustion can result in the formation of toxic components (Risholm-Sundman and Vestin, 2005, cited in Lykidis and Grigoriou (2008)). Because these stoves are used in Gumushane to burn waste, the waste produced in the region is likely to be burnt under conditions of incomplete combustion.

3.3. Effects of certain business properties on the methods adopted to utilise wastes

The businesses selected for this study operated in the city centre and the counties of Gumushane province. The waste utilisation by the businesses in different locations is given in Table 3. Regardless of whether a business operated in the city centre or in a rural area, utilisation of waste materials was similar, with the majority of wood waste used as a fuel.

Micro-sized furniture manufacturing enterprises are located in different types of sites (e.g., ground floor of a building, etc.). The relationship between site of operation and the method of waste utilisation is given in Table 4.

Local businesses operating from the lower floors of buildings utilised their waste in three different ways. These businesses used 80% of their wood waste as fuel, a high rate. Businesses operating on industrial sites are close to each other, allowing them to make

Fig. 6. An example of a stove used for the incineration of waste in Gumushane.

Table 3
Waste utilisation by businesses in different locations.

		Location of business			
		City centre	Kelkit	Siran	Other counties
Used in facility as fuel	Number	6	17	4	2
	% Within column	85.7%	100.0%	100.0%	50.0%
Sold as residential fuel	Number	1	0	0	1
	% Within column	14.3%	0.0%	0.0%	25.0%
Given away as bedding	Number	0	0	0	1
	% Within column	0.0%	0.0%	0.0%	25.0%
Total		7	17	4	4

Table 4
Waste utilisation by businesses operating from different sites.

		Site where a business operates			Total
		Ground floor	Industrial site	Detached land	
Used in facility as fuel	Number	3	24	2	29
	% Within column	60.0%	96.0%	100.0%	
Sold as residential fuel	Number	1	1	0	2
	% Within column	20.0%	4.0%	0.0%	
Given away as bedding	Number	1	0	0	1
	% Within column	20.0%	0.0%	0.0%	
Total	Number	5	25	2	32

use of each other's waste materials, (e.g., collecting and selling wastes between businesses); however, this was not happening in Gumushane. Almost all (24 out of 25) of the businesses operating in an industrial site burned their wood waste to generate heat. The relationship between waste utilisation and the period of business operation is given in Table 5.

The furniture industry is linked to the construction sector (Cındık and Akyüz, 1998; Top et al., 2013). In Gumushane, due to climatic conditions, building construction is suspended in winter. Therefore, some furniture manufacturing businesses suspend their activities due to insufficient demand. All businesses that operate seasonally burn their waste to meet their own fuel needs. In those that operate throughout the year, surplus waste is sold for use as residential fuel and bedding. Thus, there is some variability in the utilisation of surplus waste.

Operational problems faced by enterprises can influence their waste utilisation. For example, a business is expected to choose the most cost effective method to dispose of their waste. The relationship between the methods used for waste and the operational problems faced by businesses are given in Table 6.

Utilisation of by-products in the forest-products industry has developed in response to various operational problems that have been experienced (Hahn, 1982; Ilomäki and Melanen, 2001; Lu et al., 2006). Therefore, in the present study, it was expected that the operational problems experienced by the businesses under investigation would also influence the methods adopted to utilise waste materials; however, the results did not support this assumption. Only 1 of 23 businesses that stated that they were short of capital utilised their waste by selling it rather than using it to meet their own fuel needs.

The relationship between businesses with waste-collection systems and their waste utilisation methods is given in Table 7. All of the businesses with a system for collecting the fine dust that is generated during cutting declared that they used their waste for meeting their own fuel needs, while 18.8% of businesses without these systems reported that they sold the waste for use as fuel or bedding.

The operating systems and machines owned by businesses may indicate their capital structure and status. Enterprises with systems for collecting the fine dust generated during the cutting of boards are likely to be in a better position in terms of capital than businesses without such systems. Businesses that do not have such systems utilise their waste in various ways. The results of this study indicate that the operational problems experienced by a business do not influence their utilisation of waste materials. When these two results are considered together, businesses facing economic problems are likely to be making effort to utilise their wastes in a more cost effective way.

Table 5
Waste utilisation by businesses operating for different periods of time.

		Operating period of businesses		Total
		Seasonal	Annual	
Used in facility as fuel	Number	17	12	29
	% Within column	100.0%	80.0%	
Sold as residential fuel	Number	0	2	2
	% Within column	0.0%	13.3%	
Given away as bedding	Number	0	1	1
	% Within column	0.0%	6.7%	

Table 6
Waste utilisation by businesses facing different operational problems.

		Problems faced by the business					Total
		Capital	Raw material	Workforce	Demand	Other	
Used in facility as fuel	Number	21	6	14	15	7	63
	%Within column	91.3%	100.0%	100.0%	100.0%	87.5%	
Sold as residential fuel	Number	1	0	0	0	1	2
	% Within column	4.3%	0.0%	0.0%	0.0%	12.5%	
Given away as bedding	Number	1	0	0	0	0	1
	% Within column	4.3%	0.0%	0.0%	0.0%	0.0%	
Total		23	6	14	15	8	66

3.4. Options and solutions from other countries

Daian and Ozarska (2009) have analysed the wood waste management practices and strategies in the Australian wood furniture manufacturing sector. There, trading of wood waste is completely organised among wood waste producing manufacturers and those recycling these wastes. Wood waste producers cover the expenses for transport, acceptance and the handling of material. This recovered wood is then mainly used in the production of mulch, fuel, salvaged timber, animal bedding, and fibreboard. But some regulations have been made for the use of wood waste in above mentioned areas. Waste, which is contaminated with more than 5% of chemical or organic pollutants, may not be used in compost production. Composting engineered wood products is possible; however, several special treatments need to be conducted. For example, even smallest MDF pieces, which are intended for use in animal products, need to be cleansed of glue as well as any kind of pollutant used in treated softwood products. Primary and secondary wood wastes can be used for fibreboard production, however their utilisation rate is limited. In Australia, the use of wood wastes in the bioenergy sector is still at the developmental stage, including only pilot experiments yet.

Germany, as a member of the European Union (EU), has harmonised its wood waste management laws to those of the EU. The goals in waste management have been defined as follows: (i) to hamper and (ii) to reduce waste production, (iii) to reuse or recycle and (iv) eliminate waste. In this regard, elimination has to occur by thermal processing, since land burial is prohibited (Peek, 2004).

Wood wastes have been clustered into four subgroups based on the degree of their contaminations. Furniture wastes are grouped into category II, which allows further use in (i) fibreboards production, (ii) synthetic gas production for other chemical use and (iii) the production of industrial charcoal. The production of synthetic gas and active coal is only permitted in registered facilities (Peek, 2004).

In Europe, wood wastes are examined by the waste disposal units first. Based on the contamination rate, these units either pay (contamination is low) or charge (contamination is high) a certain amount of money and operate their business. Later the collected wastes are sold to wood waste processing industries again (Daian and Ozarska, 2009).

A study analysing the wood waste recourses in Michigan, United States, revealed that the waste processing businesses are generally small, family-owned and employ 6 people (mean). Approximately 12% of these businesses, charge between 10 $ and 25 $ per ton waste displacement, depending on the type of material. Some of these businesses pay wage for certain wood wastes. As a result of wood waste processing, wood chips, mulch, industrial fuel, firewood, compost, logs and sawn products are obtained (Pascal, 2009). Another research in Michigan reported that 6% of United States energy has come from renewable sources (e.g., biomass, hydroelectric power, geothermal, solar and wind). Biomass energy surpassed hydroelectric to supply 2.8% of national energy needs in 2005. 83% of biomass energy derived from wood residue. During 1970s, pollution generated by emissions from industry and other pollutants prompted the attempts to regulate the quality of energy production. "The Clean Air Act" established mandated quality level for the pollutants in 1970 and the Interagency Council on Biomass Products and Bioenergy in 1999 (Simpkins, 2006).

In Michigan there is increased demand for wood residues and many sawmills already use their residues for their own energy needs. Pellet manufacturing, animal bedding and landscaping suppliers have also increased demand on wood residues. As a consequence of this trend, residue generated by the wood sector is no longer a free unwanted waste that nobody wants (Simpkins, 2006). Because of their relatively low moisture and high energy content, the production of plywood and particleboard generates cutting wastes that are attractive fuels for energy producers (EUBIONET, 2003).

Michigan landfills do not accept wood fragments under 4 feet in length and 2 in. in diameter, but in practice this limitation is not strictly enforced. Most states have legislated a surcharge on waste to landfills in order to encourage diversion, reuse, and recycling (Simpkins, 2006).

Table 7
Utilisation of waste materials in businesses with and without dust-collection systems.

		Dust-collection system		Total
		No	Yes	
Used in facility as fuel	Number	13	16	29
	% Within column	81.3%	100.0%	
Sold as residential fuel	Number	2	0	2
	% Within column	12.5%	0.0%	
Given away as bedding	Number	1	0	1
	% Within column	6.3%	0.0%	
Total		16	16	32

4. Conclusion

The manufacturing industry is one of the solid waste resources in Turkey as in other developing countries. Around 17,497 thousand tonnes of solid waste were generated in 2004. In the same year 149,265 thousand m^3 of solid waste, 140 thousand m^3 of which were hazardous, were generated by the furniture industry, a sub-sector of the manufacturing industry. There are infrastructural and technical capacity issues in management of those solid wastes created by the manufacturing industry in accordance with by-laws and requirements on waste management.

The Turkish furniture-manufacturing sector is a labour-intensive industry, in which micro-sized enterprises are predominant. The mean number of employees and period of operation of the enterprises in Gumushane were found to be lower than the mean values for Turkey as a whole. These micro-sized enterprises are important in terms of job creation in places where there is relatively little capital available, such as Turkey, which is a developing country with little capital accumulation. However, the percentage of the workforce that has received vocational training in furniture manufacturing is low, which is an obstacle to the utilisation of waste materials in a variety of ways. Waste management practices in SMEs in EU or other developed countries can serve as precedent for SMEs in developing countries. (Ackroyd et al., 2003; Redmond et al., 2008; Daian and Ozarska, 2009; Laner and Rechberger, 2009).

The number of systems used to collect the wastes generated during conversion of materials is inadequate, including those for the collection of fine dust. In addition, the wastes generated in one process are not collected together, or separated according to their properties. Another important observation is that the wastes generated at the sites investigated were not disposed in landfills or by incineration in open conditions.

Composite board wastes are used to heat the workplace by burning them under conditions of incomplete combustion, using stoves that are insufficient for effective incineration. Very few businesses choose to utilise their wastes other than using them for their own needs. These businesses either sell wastes to provide for the energy needs of others or give them away as bedding. It was found that wood waste is primarily used for energy purposes, consistent with the results of previous studies. Waste materials from the furniture industry contain urea or melamine formaldehyde, and therefore must be incinerated by complete combustion in a special furnace at high temperatures. However, this was not observed in the study area. Waste was burnt using inappropriate devices under inappropriate conditions. The amount of waste generated in these businesses and incinerated under inadequate conditions is low; however, there are large numbers of such businesses and it is evident that the total emissions generated by them as a whole has a significant negative impact on the environment.

There are reports of re-utilisation of composite board waste in the manufacture of boards and the safe agricultural utilisation of dust generated during the cutting of boards. However, in this study, the utilisation of wastes for board production and agricultural purposes was not identified.

The relationship between the methods used to utilise waste in the furniture industry and certain properties of the businesses can be summarised as follows: enterprises that operate from the basement or first floor of buildings in cities, those that continue production throughout the year, those in need of capital, and those that do not have dust-collection systems utilise their waste in three different ways: as fuel in the facility, as residential fuel, and as bedding for animals. In contrast, enterprises without these characteristics utilise their waste only as fuel. The proportion of waste used as fuel is also higher than that of the other utilisation methods in the enterprises that utilise the three different methods.

The quantity and type of waste generated by micro-sized enterprises should also be included in annual waste statistics. Actual waste data that include businesses of all sizes will facilitate an understanding of the importance of the potential for waste utilisation and waste management. More importantly, the by-laws related with waste management in Turkey must be put into practice. Combustion of wood waste with improper equipments have to be prevented as well.

The waste generated by the wood products industry represents one of the biomass resources and the energy generated from this resource is clean and renewable. In this regard, the enhanced reutilisation of the wood waste generated in furniture manufacturing enterprises for the production of electricity is significant since Turkey imported 78% of its energy needs and supplied 87% of its energy from fossil fuels in 2004, respectively (Erdogdu, 2008). Each generated energy unit from biomass will reduces the GHG emission and the amount of imported energy in Turkey.

Studies which reveal the economical and environmental potential from recycling and aiming to remove existing barriers in waste recovery will help to develop proper policies.

References

Ackroyd, J., Coulter, B., Phillips, P.S., Read, A.D., 2003. Business excellence through resource efficiency (betre): an evaluation of the UKs highest recruiting, facilitated self-help waste minimization project. Resour. Conserv. Recycl. 38, 271–299.

Agan, Y., Acar, M.F., Borodin, A., 2013. Drivers of environmental processes and their impact on performance: a study of Turkish SMEs. J. Clean. Prod. 51, 23–33.

Aksu, B., Koc, K.H., 2009. Opportunities and future in technical and vocational education in the light of global developments. In: 1st International 5th national vocational schools symposium '09, proceeding book, May 27–29, Konya, Turkey, University of Selcuk, pp. 3378-3389.

Anonym, 2003. Concerning the definition of micro, small and medium-sized enterprises. European Union.

Anonym, 2006. The specialization commission report for the wood products and furniture industry. <http://plan9.dpt.gov.tr/oik57_agacmobilya/agac_mobilya.pdf> (retrieved 23.06.13), p. 141 (in Turkish).

Anonym, 2012. Status Report of 81 Provinces. Ministry of Science, Industry and Technology, Ankara (in Turkish).

Aragón-Correa, J.A., Hurtado-Torres, N., Sharma, S., Garcia-Morales, V.J., 2008. Environmental strategy and performance in small firms: a resource-based perspective. J. Environ. Manage. 86, 88–103.

Arıkan, R., 2011. Research Methods and Techniques, first ed. Nobel Akademik Yayıncılık, Ankara (in Turkish).

Baykan, B.G., 2011. Türkiye Sera Gazı Salımı Azaltma Taahhüdü Vermekten Kaçınıyor. Arastirma Notu 11/121. Bahcesehir Üniversitesi Ekonomik ve Toplumsal Arastirmalar Merkezi, Ankara (in Turkish).

Blatner, K.A., Keegan III, C.E., Daniels, J.M., Morgan, T.A., 2012. Trends in lumber processing in the Western United States. Part III: Residue recovered versus lumber produced. For. Prod. J. 62, 429–433.

Burton, J.P., Messier, C., Smith, D.W., Wiktor, L.A., 2003. Towards Sustainable Management of the Boreal Forest. NRC Research Press, Ottawa.

Carll, C.G., Youngquist, J.A., Dickerhoof, H.E., 1982. U.S. wood-based panel industry: energy, environment protection, and occupational safety and health. For. Prod. J. 32, 14–22.

Casares, M.L., Ulierte, N., Mataran, A., Ramos, A., Zamorano, M., 2005. Solid industrial wastes and their management in Asegra. Waste Manage. 25, 1075–1082.

Christensen, T., 2010. Solid Waste Technology and Management. Wiley, Hoboken.

Cındık, H., Akyüz, K.C., 1998. The structure and suggestions to solve problems of small and middle-sized forest products industry establishments in Trabzon. Tr. J. Agric. For. 22, 7–11.

Daian, G., Ozarska, B., 2009. Wood waste management practices and strategies to increase sustainability standards in the Australian wooden furniture manufacturing sector. J. Clean. Prod. 17, 1594–1602.

De Hoop, C.F., Kleit, S., Chang, S.J., Gazo, R., Buchart, M.E., 1997. Survey and mapping of wood residue users and producers in Louisiana. For. Prod. J. 47, 31–37.

EPA, 2011. Potential Recycling of Medium Density Fiberboard. United States Environmental Protection Agency. <http://www.epa.gov/oswer/docs/iwg/fiberboard.pdf>.

Erdogdu, E., 2008. An expose' of bioenergy and its potential and utilization in Turkey. Energy Policy 36, 2182–2190.

EUBIONET, 2003. Biomass Co-firing-An Efficient Way to Reduce Greenhouse Gas Emissions. Yväskylä, Finland.

Fırat, E., 2013. Capital İş & Ekonomi: Yönetim. <http://www.capital.com.tr/sirketlerin-omru-daha-da-kisalacak-mi-haberler/19358.aspx> (retrieved 08.07.13) (in Turkish).
Garay, R.M., 2012. Lab testing for p3 moisture resistant overlaid particleboards made from wood residues. BioResources 7, 3093–3103.
Gombatz, E., 2007. Managing Our Waste Series: Waste Management Big Book. Classroom Complete Press, San Diego.
Güneri, A., 2005. Handbook of Polymers in Construction. Smithers Rappa, Shrewbury.
Hahn, T.M., 1982. Wood in our energy future. J. For. History 26, 148–153.
Harkin, J.M., 1969. Uses for Sawdust, Shavings and Waste Chips. U.S.D.A. Forest Service, Madison, Wisconsin.
Harrison, M., 2012. Recycling MDF: Are we there yet? <http://www.wbpionline.com/features/recycling-mdf-are-we-there-yet/> (accessed 02.07.13). Wood Based Panels International.
Ilomäki, M., Melanen, M., 2001. Waste minimisation in small and medium-sized enterprises do environmental management systems help? J. Clean. Prod. 9, 209–217.
Kades, C., 2012. Adana Ticaret Odası Mobilya Sektör Raporu 2012. Adana Ticaret Odası, Adana (in Turkish).
Kain, G., Barbu, M.-C., Teischinger, A., Musso, M., Petutschnigg, A., 2012. Substantial bark use as insulation material. For. Prod. J. 62, 480–487.
Kose, H.O., Ayaz, S., Koroglu, B., 2007. Waste Management in Turkey: National Regulations and Evaluation of Implementation Results. Turkish Court of Accounts, Ankara.
Kumar, E.S., 2011. Integrated Waste Management-Volume II. InTech, Rijeka.
Laner, D., Rechberger, H., 2009. Quantitative evaluation of waste prevention on the level of small and medium sized enterprises (SMEs). Waste Manage. 29, 606–613.
Lippke, B., Puettmann, M.E., 2013. Life-cycle carbon from waste wood used in district heating and other alternatives. For. Prod. J. 63, 12–23.
Lu, W., Sibley, J.L., Gilliam, C.H., Bannon, J.S., Zhang, Y., 2006. Estimation of U.S. bark generation and implication for horticultural industries. J. Environ. Hort. 24, 29–34.
Lykidis, C., Grigoriou, A., 2008. Hydrothermal recycling of waste and performance of the recycled wooden particleboards. Waste Manage. 28s, 57–63.
Mantanis, G., Athanassiadou, E., Coutinho, J.-O.A., Nakos, P., 2004. A new recycling process for waste panels. In: European COST E3I Conference: Management of Recovered Wood Recycling, Bioenergy and Other Options, Thessaloniki, pp. 204-210.
MERAF, 2002. Multi-Pollutant Emissions Reduction Analysis Foundation (MERAF) for the Lumber and Allied Wood Products Sector. The Canadian Council of Ministers of Environment.
Mitchell, S., Dimache, P.O., Roche, T., 2011. The issue of waste in european manufacturing SMEs. In: Thirteenth International Waste Management and Landfill Symposium, Proceedings Sardinia 2011, S. Margherita di Pula, Cagliari, Italy.
Monroe, P.A., Blalock, L.B., Vlosky, R.P., 1999. Work opportunities in a non-traditional setting for women exiting welfare: a case study. J. Family Econ. Issues 20, 35–60.
Murphy, J.A., Smith, P.M., Wiedenbeck, J., 2007. Wood residue utilization in Pennsylvania: 1988 vs. 2003. For. Prod. J. 57, 101–106.
Nemerow, N.L., 2006. Industrial Waste Treatment: Contemporary Practice and Vision for the Future. Butterworth-Heinemann, Burlington.
Nemli, G., Hiziroglu, S., Serin, Hasan, Akyuz, K.C., Akyuz, I., Toksoy, D., 2007. A perspective from furniture and cabinet manufacturers in Turkey. Build. Environ. 42, 1699–1706.
Pascal, N., 2009. Wood Waste Processing and Utilization in Southeastern Michigan. <http://semircd.org/ash/research/nzokou_wood_waste_study_0709.pdf> (retrieved 08.11.14).
Pedieu, R., Riedl, B., André, P., 2008. Properties of birch outer bark panels reinforced with wood strands in the surface layers. BioResource 2, 771–778.
Peek, R.D., 2004. EU directives and national regulations for the recycling and disposal of waste wood. In: Environmental Impacts of Preservative-Treated Wood Conference, Pre-conference Proceedings Feb. 8-11, 2004, Orlando, Florida, USA.
Pentti, H., Anssi, N., Andreas, O., Markku, T., Johanna, V., 2002. Forest Related Perspectives for Regional Development in Europa. Brill Academic Publishers, Leiden.
Redmond, J., Walker, E., Wang, C., 2008. Issues for small businesses with waste management. J. Environ. Manage. 88, 275–285.
Risbrudt, C.D., 2012. Wood and society. In: Rowel, R.M. (Ed.), Handbook of Wood Chemistry and Wood Composites, second ed. CRC Press, pp. 12–16.
Simpkins, D., 2006. Michigan Biomass Energy Program. <www.michigan.gov/biomass> (retrieved 08.12.14).
Skog, K.E., Rosen, H.N., 1997. United States wood biomass for energy and chemicals: possible changes in supply, end uses, and environmental impacts. For. Prod. J. 47, 63–69.
Sutton, W.R., 1993. The World's need for wood. In: The Globalization of Wood: Supply, Processes, Products, and Markets, Forest Products Society, Portland, pp. 21-28.
Suzdalenkol, V., Gedrovics, M., Zeka, M., Barmina, I., 2012. Regulation possibilities of biomass combustion. Environ. Clim. Technol. 8, 49–55.
Tatàno, F., Barbadoro, L., Mangani, G., Pretelli, S., Tombari, L., Mangani, F., 2009. Furniture wood wastes: experimental property characterisation and burning tests. Waste Manage. 29, 2656–2665.
The Ministry of Environment and Urban Planning, 2012. Republic of Turkey on Climate Change Action Plan 2011-2023. <http://www.csb.gov.tr/db/iklim/banner/banner591.pdf> (retrieved 08.01.14).
The World Bank, 2014. Country and Lending Groups. <http://data.worldbank.org/about/country-and-lending-groups> (retrieved 09.03.14).
Top, Y., Adanur, H., Öz, M., Yaşar, M., 2013. Structural Analysis of Manufacturing Enterprises in Forest Products Industry's Sub-Sectors in Province of Gümüşhane. Gümüşhane: Unpublished Final Report (in Turkish).
TUIK, 2002. Number of local units and employment by economic activity sections, SRE and locality, 2002 General Census of Industry and Business. <http://www.tuik.gov.tr/PreIstatistikTablo.do?istab_id=386>.
TUIK, 2005. The data used in sectoral analysis, Appendix 5, Environmental Statistics. <http://www.ttgv.org.tr/content/docs/ek-5.pdf> (in Turkish).
URL 1, 2013. How to manage MDF waste? <http://www.daiken-nz.com/assets/files/Daiken-MDF-disposal-flow-sheet-v3.pdf> (retrieved 24.06.13).
URL 2, 2013. UNdata, Record View. Particle Board and Similar Board of Wood of Other Ligneous Materials. <http://data.un.org/Data.aspx?d=ICS&f=cmID:3143-0> (retrieved 28.06.13).
URL, 3. Regulations. <http://www.csb.gov.tr/gm/cygm/index.php?Sayfa=sayfa&Tur=webmenu&Id=266> (retrieved 24.06.13).
Van Loo, S., Koppejan, J., 2008. Handbook of Biomass Combustion and Co-firing. Earthscan, London.
Vos, J., 2005. Biomass Energy for Heating and Hot Water Supply in Belarus. UNDP/GEF, Enschede.
Wikipedia, 2014. List of parties to the Kyoto Protocol. <http://en.wikipedia.org/wiki/List_of_parties_to_the_Kyoto_Protocol> (retrieved 08.10.14).
Zerbe, J.I., 2004. Non-wood products. In: Burley, J., Evans, J., Younquist, J.A. (Eds.), Encyclopedia of Forest Sciences. Elsevier, Madison, pp. 601–607.