Research paper

An Investigation of Woody Wastes of the Wood Processing Industry in Yilan County and Its Reuse Assessment

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【Summary】

Yilan County, one of the crucial domestic logging districts in early years, contained many businesses related to the lumber industry. Dozens of wood processing plants still continue to operate in this region. In order to understand sources of lumber raw materials and quantity of woody wastes, this study focused on lumber manufacturers and wood processing plants to conduct questionnaires by interview in Luodong Township, Yilan County. Meanwhile, this study not only analyzed international research which applies to woody wastes, but also evaluated the types of woody waste recycling and benefits in this region, providing a reference for developing woody reuse policies in the future. Results indicated that the amount of woody wastes was about 12,954 m^3 and on average 1079.5 m^3 per month, which accounted for 15.4% of the total timber demand. According to the foreign cases analyzed, it is more economically effective for woody wastes to be converted into wood pellets as fuel than other treatments. This study also estimated that the quantity of woody wastes generated could produce 26,009,800 kWh of electric power, which could be a regional energy supply in an area that lacks renewable energy.

Key words: wood processing industry, woody waste, wood pellet.

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研究報告

宜蘭縣木材加工業木質廢料調查分析暨再利用評估之研究

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摘 要

宜蘭縣早期為國內重要林場之一，相關製材產業聚集，目前縣內仍有數十家木材加工廠持續經營，為瞭解該區域製材原料來源與木質廢料量，本研究針對宜蘭縣羅東一帶區域內之製材與木材加工廠進行問卷訪談，同時搜集國際間應用木質廢料成功發展案例進行分析，評估調查區域內之木質廢料再利用形式與效益，以提供作為未來該等資材再利用政策發展參考之用。調查結果顯示，2015年宜蘭縣羅東地區木質廢料量約有12,954 m^3，平均每月產生1079.5 m^3廢料，占木材總需求量15.4%。根據分析國外成功應用案例，以轉型製造木質燃料顆粒最具經濟效益之潛力，本研究調查所獲得木質廢料資材之數量，換算成電力度數約可達26,009,800 kWh，可提供作為區域性替補再生能源供給之用。

關鍵詞：製材業、木質廢料、木質顆粒。

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INTRODUCTION

The mass utilization of fossil fuels such as oil, coal, and natural gas fostered our industrial and economic development; however, it has caused significant damage to the environment such as the ozone hole, ocean pollution, and ecological catastrophes that have seriously affected humans' living environment and ecology. Therefore, in order to control greenhouse gas (GHG) emissions to reduce the greenhouse effect in the global environment, the Framework Convention on Climate Change (UNFCCC), adopted by the United Nations in 1994, proposed that countries of the world should confront the issue of the environment and human living conditions. Recently, the Paris Agreement of 2015, which followed the Kyoto Protocol of 1997, stipulates legally binding global greenhouse gas reductions and sets the global average temperature rise in 2100 to no more than 2℃, and to make efforts to control the target rise to within 1.5℃.

There are effective ways to recycle woody wastes effectively to solve Earth's environment problems in modern times (Wang 2000). Alderman et al. (1999) reported that woody wastes can be converted into wood pellets as fuel for household boilers or as wood composite packing material. Forest biomass is becoming increasingly important worldwide in both industrialized and developing countries as a renewable energy source. Recent trends in woody biomass utilization involving heat and electric power production have expanded our knowledge of the available biomass potential so that it can be used in a sustainable manner (Coban and Eker 2014). The conversion of wastes into biomass fuels can improve the limits of energy cultivation land use, save time and cost of plant-

ing tending, and also reduce waste recycling processes, arbitrary disposal, and incineration dumping (Lin and Pan 2014).

Several countries have successfully used woody wastes as essential sources of heating, electricity, and fuels. For example, in Lithuania, 61% of the energy used in district heating in 2015 was derived from local forestry industry residues. Lithuania's biomass-based heat capacity tripled between 2011 and 2015, to 1530 MW (REN21 2016). In addition, in the region of Piura in Peru, Sánchez et al. (2014) analyzed woody wastes such as sawdust, chips, and shavings from sawmills to make sawdust briquettes which were substituted for firewood and charcoal to resolve severe emissions of greenhouse gasses as a result of the indiscriminate burning of woody wastes by local sawmills. In addition, a UK independent electric power plant, called Revonergy Plc, signed a Memorandum of Understanding (MOU) with the Nigerian government to build a waste-to-energy (WtE) 14-MW power plant. The electricity that is produced by sawdust from sawmills will be directly supplied back to the sawmills, with the excess being sold to the national grid based on a long-term agreement to purchase electrical power (Agbro and Ogie 2012, Oluoti et al. 2014).

In addition to those countries, many developed countries have utilized woody wastes and planned to conduct actions with wood fuels and provide an opportunity for economic benefits. Nzokou et al. (2011) investigated 180 wood residue yards throughout 14 counties in southeastern Michigan in 2007 and 2008. Results of that study mentioned that the total volume of woody wastes was 6.7×10^6 m^3, and total residues from land clearing and tree removal converted into woodchips, mulch, and firewood were estimated to contribute about US $40 million to Michigan's economy. It also reported that many of the wood residue yards were considering new value-added markets, and 3 major product types were mentioned: production of pellets, mulch, and fuel for home stoves. Because of a recent slump in the lumber industry, building a pellet mill in Bancroft would provide economic benefits to the local community. Therefore, Krigstin et al. (2016) analyzed woody wastes from 12 sawmills to evaluate the potential of developing the wood pellet industry. It showed that the potential supply of wood pellets from woody wastes manufactured in Bancroft sawmills to the European market met standards with a minimum annual production of 100,000 tons.

Taiwan is heavily reliant on foreign imports for up to 99% of its energy requirements, because it is surrounded by oceans with a limited land area and high population densities as well as a lack of natural resources. It is an ideal way to develop renewable energy to replace fossil fuels, which will not only reduce GHG emission, but also escalate energy self-sufficiency rates. In response to highly visible international renewable energy trends, Taiwan announced the *Renewable Energy Development Act* in 2009, and also the *Greenhouse Gas Reduction and Management Act* in 2015. The former promotes the utilization of renewable energy, and the latter establishes a reduction goal to reduce GHG emissions to no more than 50% GHG emissions of 2005 by 2050, both of which are in response to global climate change.

However, renewable energies such as solar energy, wind power, and hydroelectric power are often limited by geographical factors and technology development. Not every region has abundant resources such as sunshine, wind, or water. If they can effectively develop biomass energy, people will overcome regional restrictions. Furthermore, compared to solar energy, wind energy, hydro-

electric power, and other renewable energy sources, bioenergy consumes wastes as raw materials. If properly used and developed, bioenergy provides both waste recycling and energy benefits. Over 60% of Taiwan is covered by forests. The government implemented an exploitation ban policy on natural forests and plantations are limited by the cutting area and amount of growing stock. Thus, wood residues are produced in limited quantities. Woody wastes can be obtained from lumber manufacturers or wood processing plants. According to factory registration information from the Department of Statistics in the Ministry of Economic Affairs, there are 1052 wood and bamboo manufacturers in Taiwan. If enough woody wastes manufacturers can be collected and recycled, there would be sufficient sources of raw materials.

About 2/3 of the area of Yilan County, located in northeastern Taiwan, is covered by mountains. The Taipingshan logging district, located in the Luodong region, produces 80,000 m^3, which is more than the Alishan forest, and has the highest production of Taiwan's 3 logging districts. There were important logging districts for producing domestic timber in early years, being an economic lifeline of the 1950s and 1960s. Because the Taipingshan logging district thrived in early years, the county still has numerous wood processing plants. In addition, Lin and Pan (2016) pointed out that Yilan County still has abundant wood materials, with the potential to develop wood energy, as a substitute for the lack of renewable energy supplies which could also improve power distribution and electricity limits in rural areas. If the availability of diversified renewable fuels could be increased, Yilan County would be the best place for developing woody energy and promoting woody fuels. The object of this study was, by interviewing lumber manufacturers in Yilan County, to obtain timber demands and the amount of woody wastes, so that we could further evaluate the potential for developing this regional energy supply.

MATERIALS AND METHODS

Study materials

This study referenced factory registration information from the Department of Statistics of the Ministry of Economic Affairs Taipei, Taiwan. There were totally 57 manufacturers including panel, plywood, wood composite, builders' carpentry and joinery, and other products of wood and bamboo, all of them distributed in Luodong Township, Wujie Township, Dongshan Township, Suao Township, and Sanxing Township of Yilan County.

In order to make sample the representative and have good interviews, this study delegated the Yilan County Timber Manufacturers' Association to assist in face-to-face interviews with lumber manufacturers of Yilan County, and collected information of the amount of woody wastes, waste types, and disposal flow conditions. This survey was conducted for several days in August 2016. Respondents were mainly engaged in timber-related industries in Yilan County. The total number of valid questionnaires was 27.

The questionnaire consisted of 3 parts. The first part asked about the profile of respondents, including the date founded, number of employees, business types, and types of products and equipment. The second part inquired about raw materials and production, demand volume of timber in 2015, quantities of logs and lumber in use and the imported proportion, types and sources of raw materials, product categories and marketing channels. The last part asked about types of woody wastes and disposal treatments.

Study methods

After collecting the questionnaires, we conducted a qualitative and quantitative analysis according to the interview data. The questionnaire was composed of both open-ended and closed questions. Descriptive statistics were subsequently used for open-ended questions as stated by respondents, and the closed questions were checked by respondents. The analysis followed three steps:

1. The research goal was set and respondents were determined. This study collected information and related literature on the existing lumber industry of Yilan County, and further designed a questionnaire on research topics for this study.
2. After completing of the questionnaire, we utilized a pretest to determine whether the contents of the questionnaire were feasible or not. Then, the contents of the questionnaire were adjusted according to this pretest. Meanwhile, we altered inappropriate questions to clarify the current situation.
3. We visited lumber manufacturers in Yilan County, and additionally used the questionnaire, and interviews to produce accurate research statistics.
4. The statistical software SPSS was mainly utilized for computation, and Excel software was also used to conduct descriptive statistical analyses.
5. We focused on the current use of woody wastes in Yilan County by comparing foreign regional woody energy cases to evaluate the feasibility of developing wood energy from woody wastes from the lumber industry in Yilan County.

RESULTS

Profile of lumber manufacturers

During the visit, totally 27 questionnaires were received from respondents. According to the statistics, the earliest founding date was in the 1960s, and 29.6% of the other founding dates were in the 1970s and 1980s, when the domestic economy bloomed and the Ten Major Construction Projects began to be implemented which spurred a blossoming of industries and increased demand for lumber. About 40.8% of companies were founded in the 1980s to 1990.

Most of the lumber manufacturers possessed multiple business types. The proportions from highest to lowest were processing plants of wood raw materials as the major business model at 32.8%, followed by 27.6% which were processing plants of wood products, 15.5% which were wood raw materials and product import and export traders, 13.8% which were wholesalers of wood products, and 10.3% which were retailers of wood products.

The diversified business models required a larger labor force, and 48.2% with 11 to 50 persons accounted for the largest number of employees, these with fewer than 10 persons accounted for around 48.1%, and these with 51 to 100 persons accounted for around 3.7%. As to factory equipment, around 71.4% of factories equipped with large-scale machines for producing lumber, and 82.1% of factories had a band saw machine. There were assorted machines to cut wood, with 60.7% of factories with a double-side planer, and 50% of factories with a side planer. In terms of drying facilities, 29.6% of factories had them among which, 62.5% were steam kilns, and 37.5% were electronic kilns. In total, 11.1% of lumber manufacturers had a boiler to produce steam for their personal use (Table 1).

Sources of raw materials and product categories

Results showed that in 2015 the total demand for wood in Yilan County was 84,080 m^3, of which 68.8% of manufacturers were using logs and 31.2% were using lumber.

Table 1. Profile of respondents

Profile	Variable			Percent (%)
Date founded	1960s~1970			11.1
	1970s~1980			29.6
	1980s~1990			40.8
	1990s~2000			14.8
	2000s~2010			3.7
Business types (multiple choices)	Processing plant of wood raw materials			32.8
	Processing plant of wood products			27.6
	Wholesaler of wood products			13.8
	Retailer of wood products			10.3
	Importer and exporter of wood raw materials and products			15.5
Number of employees	Fewer than 5 persons			11.1
	5~10 persons			37.0
	11~50 persons			48.2
	51~100 persons			3.7
Equipment (multiple choices)	Large-scale machine			71.4
	Band saw			82.1
	Multi-blade saw			60.7
	Four-side planer			46.4
	Side planer			50.0
	Double-sided planer			60.7
	Other (jigsaw, hand press, cutoff saw, and chain saw)			3.6
Drying facility	None			70.4
	Yes	Steam kiln	62.5	29.6
		Electronic kiln	37.5	
Boiler	None			88.9
	Yes			11.1

In regard to the sources of logs and lumber, 98.5% of both of them were imported, while only 1.5% were self-purchased domestic logs and lumber raw materials. Among the imported raw materials, 30.0% were self-purchased from imported raw materials, and 68.6% were purchased from importers and agents. Lumber self-purchased from imported raw materials accounted for 67.7%, while that purchased from importers and agents was 30.8% (Table 2).

This investigation showed that lumber manufacturers produced manifold wood products that could be divided into 12 categories. Only 1 manufacturer specialized in the production of shrine-building materials, while the remaining manufacturers produced more than 2 products. The top 3 product categories accounted for around 41.3% of wood products, with 19.0% being wall materials, and 16.0% being landscape materials (including landscape recreation, landscape engineering, and landscaping materials). The next was 4.9% for kitchen furniture, construction services, various plywoods, and instrument materials, while decorating materials accounted for 3.1%. Finally, 1.6% were for ceiling partitions, shrines, gates, doors and yacht decks (Table 3).

Table 2. Sources of raw materials

Source	Self-purchased from domestic raw materials (%)	Self-purchased from imported raw materials (%)	Purchased from importers and agents (%)
Logs	1.4 (808)*	30.0 (17,338)	68.6 (39,701)
Lumber	1.5 (396)	67.7 (17,759)	30.8 (8,078)

* Values in parentheses are in cubic meters (m^3).

Table 3. Wood product categories

Product	Wood products[1)]	Ceiling partitions	Wall materials	Landscape materials	Construction services	Furniture kitchen
Percent (%)	41.3	1.6	19.0	16.0	3.1	4.9
Products	Various plywoods	Instrument materials	Shrines	Decorating materials	Gates and doors	Yacht decks
Percent (%)	3.1	3.1	1.6	3.1	1.6	1.6

[1)] Including semi-finished products.

Marketing channels

Regardless of whether the demand for timber was foreign or domestic, the major marketing channel of Yilan County at 22.6% was selling wood products to architectural manufacturers, followed by 21.0% for export, 14.1% for the construction industry, 12.6% for processing factories and 9.2% for wooden furniture manufacturers (Table 4).

Table 4. Marketing channels

Marketing channel	Percent (%)
Wood products to architectural manufacturers	22.6
Exports	21.0
Construction industry	14.1
Processing factories	12.6
Wooden furniture manufacturers	9.2
Creative design studios	4.8
Retailers (building material stores)	3.9
Production for own use	2.9
Cooling tower factories	2.3
Wetsuit manufacturers	2.3
Machine works	2.3
Other timber and bamboo product manufacturers	2.0

Woody waste disposal flow conditions

Woody wastes are inevitably produced during the timber process. According to statistics this study produced, the amount of woody wastes was about 12,954 m^3, an average of 1079.5 m^3 per month, which was around 15.4% of the total timber demand. There were different types of woody wastes: powdered sawdust produced by cutting processes by manufacturers (Fig. 1A); bark wastes with timber cut from edges of trees (Fig. 1B); factors such as chipping, cutting boards, moth and rot, small pieces of sawn timber remaining after eliminating timber (Fig. 1C); woodchips (Fig. 1D); and wood leftovers besides sawdust, sawn timber, and bark wastes (Fig. 1E).

Sawdust was the largest category of woody wastes of lumber manufactures in Yilan County which accounted for 31.6%, with bark wastes at 30.6%, woodchips at 24.1%, wood leftovers at 12.6%, and sawn timber at 1.1%. In order to dispose of these woody wastes, lumber manufacturers adopted varied disposal methods based on the type of woody waste. As shown in Table 5, there were multiple ways to dispose of sawdust,

with 59.6% given away, and 22.0% sold. As to bark wastes 42.9% was given away and 27.6% was sold. For wood leftovers 50.0% was given away, and 26.9% was sold with sawn timber, 54.3% was given away, and 28.6% was sold. As to woodchips, 50.0% was sold and 50.0% was given away.

DISCUSSION

Results of this study showed that the most common treatment of woody wastes was being offered to other manufacturers as raw materials such as atomic carbon, boiler fuel, joss papers or incense, followed by being sold for pulp or footpath construction, with only a small amount left untreated. The reuse rate of woody wastes was 98.3%. Even though domestic lumber manufacturers employ woody wastes for many other purposes, these treatments are relatively ineffective.

Based on the foreign literature, wood processing plants use woody wastes for wood fuels. Nevertheless, the potential of domestic woody wastes for woody fuels has not been evaluated. Thus, this study investigated the current status of utilizing woody wastes in the UK, US and Canada as references, and further assessed the feasibility and benefits of woody wastes to generate wood pellets.

According to the Waste and Resources Action Program (WRAP) in the UK, the amount of woody wastes was 582,324 tons from 1065 collection hubs and 602 individual facilities that WRAP surveyed, among which sawdust and shavings accounted for 0.2% and other wood wastes for 99.8%. As to treatments of woody wastes 86.2% were of re-processed, 7.9% were sent to transfer stations, 2.5% were unknown, 2.2% were sent to landfills and 1.2% were sent to incinerators. The total recovery rate of woody wastes was > 90% (Greenhalf and Brown 2012). In the US, the main sources of woody wastes were from land-clearing, pallets, sawmill residues, and tree removal. The types of woody wastes were woodchips, logs, branches and brush, mulch, stumps, scrap pallets, woodchips from pallets, and mixed. The largest proportion was from branches and brushes at about 31.8%, with 30.4% from logs and 28.5% from woodchips. In addition, woody wastes were used for mulch which accounted for 42.0%, woodchips accounted for 38.7%, firewood accounted for 6.7% and industrial fuels accounted for 6.5%. The overall utilization rate was estimated to be 30.6% (Nzokou et al. 2011). In Canada, Krigstin et al.

Fig. 1. Types of woody wastes. (A) Sawdust; (B) bark waste; (C) sawn timber; (D) woodchips; (E) wood leftovers.

Table 5. Types and treatments of woody wastes

Types of woody wastes		Sawdust (%)	Bark wastes (%)	Wood leftovers (%)	Sawn timber (%)	Woodchips (%)
Woody waste		31.6 (4,091)*	30.6 (3,959)	12.6 (1,636)	1.1 (147)	24.1 (3,120)
Treatment	Idle untreated	-	-	7.7	-	-
	Firewood	-	2.9	-	-	-
	Pay for delivery	4.0	-	7.7	-	-
	Raw materials of bag cultivation	4.4	-	-	-	-
	Given away	59.6	42.9	50.0	54.3	50.0
	Sold	22.0	27.6	26.9	28.6	50.0
	Composted	4.4	2.9	-	-	-
	Fuel for boiler	5.6	23.5	7.7	17.1	-

* Values in parentheses are in cubic meters (m^3).

(2016) reported that woodchips accounted for 60.0% of woody wastes, bark accounted for 20.5%, and sawdust and shavings accounted for 19.5% from 12 sawmills. In addition, Bradley et al. (2009) investigated that in 1998 the quantity of wood residues in Canada was 17.7×10^6 tons, including sawdust, shavings and bark. Approximately 12.32×10^6 tons was used in the production of fiberboard, energy, or other value-added products, and the utilization rate was 69.6%.

In conclusion, this study compiled types of woody wastes, proportions, treatments, and utilization rates from the UK, the US, Canada, and Yilan County as shown in Tables 6 and 7.

After comparing Tables 6 and 7, the findings show that the amount of woody wastes used for energy utilization or biofuels was significantly higher than the other uses, with timber-processing facilities in the US producing value-added pellets, and also there was a strategy of constructing wood pellet fuel plants to boost the local industry in Canada. Consequently, this study evaluated the feasibility of woody wastes from lumber manufacturers in Yilan County being used to generate bioenergy, and appraised the benefits of bioenergy from woody wastes. To estimate the profit of wood pellets from woody wastes in Yilan County, this study also collected the statistical data from domestic and international literature to determine the profit.

As reported by the Food and Agriculture Organization of the United Nations (2010), conversion factors of wood and wood pellets related that 1 m^3 of wood pellets is equivalent to 1.52 m^3 of wood. Thus, the 12,954 m^3 of woody wastes in Yilan County in 2015 could theoretically be converted into 8522 m^3 of wood pellets (12,954 m^3/1.52). Then, a study by Kofman (2010) showed that the wood pellet conversion factor of weight and dimension was 1 ton is equivalent to 1.54 m^3, and the weight of wood pellets would be is around 5534 tons (8522 m^3/1.54). Finally, Murray (2013) declared that the heat value of wood pellets per ton generates 17.5 GJ, so in terms of wood pellets, the heat value of woody wastes in Yilan County would be about 96,845 GJ (5534 tons$\times$17.5 GJ/ton).

Moreover, according to the energy performance of wood pellets, the Sustainable Energy Authority of Ireland (SEAI) in 2017 disclosed that the energy of wood pel-

Table 6. Types of woody wastes and proportions of lumber manufacturers in the United Kingdom, United States, Canada, and Yilan County

Country	UK[1]		U.S. Southeastern Michigan[2]		Canada Bancroft[3]		Yilan County[4]	
Type of woody waste (%)	Sawdust and shavings	0.2	Woodchips	28.5	Woodchips	60.0	Sawdust	31.6
	Other wood wastes	99.8	Logs	30.4	Bark	20.5	Bark wastes	30.6
			Branches and brushes	31.8	Sawdust and shavings	19.5	Wood leftovers	12.6
			Mulch	3.4			Sawn timber	1.1
			Stumps	0.1			Woodchips	24.1
			Scrap pallets	0.2				
			Mixed	5.6				

[1] Greenhalf and Brown. 2012.
[2] Nzokou et al. 2011.
[3] Krigstin et al. 2016.
[4] From this study.

Table 7. Utilization and reuse rates of woody wastes of lumber manufacturers in the United Kingdom, the United States, Canada and Yilan County

Country	UK[1]		US Southeastern Michigan[2]		Canada[3, 5]		Yilan County[4]	
Utilization of woody wastes (%)	Re-processing	86.2	Mulch	42.0	Fiberboard	-	Firewood	0.8
	Transfer stations	7.9	Woodchips	38.7	Energy	-	Pay for delivery	3.3
	Unknown	2.5	Firewood	6.7	Other value- added products	-	Raw materials of bag cultivation	1.8
	Landfills	2.2	Industrial fuels	6.5			Given away	52.2
	Incinerators	1.2					Sold	25.9
							Composted	2.6
							Fuels for boiler	11.7
							Idle untreated	1.7
Reuse rate (%)	90.0		30.6		69.6		98.3	

[1] Greenhalf and Brown. 2012.
[2] Nzokou et al. 2011.
[3] Bradley et al. 2009.
[4] From this study.
[5] Due to a lack of proportions of woody wastes in Canada, only utilization is listed.

lets with a moisture content of 8%, a dry matter content of 90~92%, an ash content of 0.5%, and a density of 650 kg/m^3 was approximately 4.7 kWh/kg electric power. Therefore, 26,009,800 kWh (5,534,000 kg×4.7 kWh) of electric energy could be generated if all woody wastes were produced into wood pellets from Yilan County in 2015 (Table 8).

Table 8. Benefits of wood pellets from woody wastes in Yilan County 2015

Item	Estimate	Reference
Woody wastes	12,954 m^3	This study
Wood pellets	8522 m^3	Food and Agriculture Organization of the United Nations 2010
	5534 tons	Kofman 2010
Heat value	96,845 GJ	Murray 2013
Electric power	26,009,800 kWh	Sustainable Energy Authority of Ireland 2017

CONCLUSIONS

In response to a global climate change strategy, Taiwan has followed international footsteps to enact the *Renewable Energy Development Act* and the *Greenhouse Gas Reduction and Management Act*, which will accelerate the development of domestic renewable energy. However, as a result of the regional environment, natural resources, and other restrictions, renewable energy sources such as solar energy, wind power, and hydroelectric power may be ineffective in a particular geographical environment. The lumber industry is different from other industries; besides producing valuable products, the remaining waste after processing can be used to generate energy. There have been some success stories of wood processing plants in the UK, US and Canada converting woody wastes into energy. Wood processing plants in the US are even expected to be transformed into wood-based processing plants for developing wood pellet business opportunities in the world. This study investigated the current situation of wood demand and woody wastes of local manufacturers of Yilan County, and estimated that wood pellets could potentially supply 26,009,800 kWh of electrical power that should be used as a renewable energy supply.

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