POTENSI LIMBAH BAMBU SEBAGAI SUMBER PASOKAN BAHAN BAKU ENERGI BIOMASSA BERBASIS MASYARAKAT DI KABUPATEN BANGLI PROVINSI BALI

by I Gusti Bagus Udayana

THE POTENTIAL OF BAMBOO & BAMBOO-WASTE AS SOURCE OF SUPPLY FEEDSTOCK COMMUNITY BASED BIOMASS FUEL CELL AT BANGLI REGENCY – BALI PROVINCE

POTENSI LIMBAH BAMBU SEBAGAI SUMBER PASOKAN BAHAN BAKU ENERGI BIOMASSA BERBASIS MASYARAKAT DI KABUPATEN BANGLI PROVINSI BALI

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ABSTRAK

Penelitian ini bertujuan untuk menghitung dan memperkirakan potensi limbah bambu sebagai sumber bahan baku energi biomassa yang menghasilkan bahan bakar berbasis masyarakat. Penelitian dilaksanakan dari bulan Oktober hingga November 2012 di Kabupaten Bangli Provinsi Bali. Ada 178 keluarga (KK) yang menanam dan memiliki lahan bambu, dan 50 unit usaha mikro dan pengrajin bambu skala rumah tangga yang memproduksi limbah bambu. Responden merupakan 4% dari total populasi, dan hampir 98% dari responden setuju dan mendukung gagasan energi listrik dari biomassa limbah bambu. Total lahan yang dimiliki oleh rumah tangga petani 205,8 hektar, dan sekitar 105,7 hektar khusus digunakan untuk perkebunan bambu, dengan kepadatan bambu 20 batang/m^2 dan berat per meter bambu adalah 1,5 kg. Berdasarkan pengamatan lapangan, dan dengan asumsi jumlah bambu 30% di wilayah tertentu, maka limbah bambu yang dihasilkan per batang bambu adalah 40%, dan efisiensi limbah bambu yang dikumpulkan adalah 30%, sehingga total limbah bambu yang bisa dihasilkan oleh rumah tangga responden diperkirakan menjadi 31,3 ton/hari. Selain itu, pengrajin bambu yang memiliki lahan sendiri seluas 14,8 hektar, bisa menghasilkan 4,4 ton/hari, dan tambahan 0,6 ton/hari dari sampah/limbah bambu juga bisa dihasilkan dari proses produksi kerajinan bambu. Oleh karena itu, jumlah cadangan dari semua responden dapat menghasilkan sampah bambu dengan volume 36,3 ton/hari. Angka ini adalah 2 kali lebih besar dari 15 ton/hari limbah bambu yang dibutuhkan untuk menghasilkan 1 MW listrik melalui proses Fuel Cell.

Kata Kunci: Potensi Limbah Bambu, Energi Biomassa

ABSTRACT

This report presents the result of survey and mapping of bamboo and bamboo-waste in Bangli Regency done by LP2M/Faculty of Agriculture Warmadewa University in cooperation with Bali Clean Energy TaskForce for the purpose of calculating and estimating the potential of bamboo-waste as source of supply feedstock for 1 MW pilot project Community Based Biomass Fuel Cell (CBBFC) is planned located at Desa Bangkalet, in Bangli Regency. There were 178 households (HH) that having and planting bamboo at their land area, and 50 unit micro and smallscale household handy-crafts (MSSHH) that producing bamboo-waste by-product) surveyed. The respondents constitute of 4% of their total population, and nearly 98% of respondents agrees and supports the idea of the proposed pilot project. The total land area having by the said households is nearly 205.8 Hectare (≈ 2,058,000 m^2), and out of this figure, there are around 105.7 Hectare (≈ 1,057,000 m^2) specifically used for bamboo plantation, with typical bamboo's density of 20 sticks/m^2 and typical weight of 1.5 kg/m of bamboo-length. Based on site observation, and by using conservative-assumption that is default-number of specific bamboo-area is 30%, typical bamboo-waste produced by 1 stick of bamboo is 40% and efficiency of collecting bamboo-waste of 30%, then the total bamboo-waste that could be produced by the said household respondents is estimated to be of 31.3 ton/day. Moreover, there are 39 units (out of 50 units) of MSSHH have their own land area, this accounted of 14.8 Hectare (≈ 148,000 m^2) of land, could produce 4.4 ton/day, and additional of 0.6 ton/day from their by-product-waste. Therefore, the sum up of all respondents could produce bamboo-waste at volume of 38.3 ton/day. The last figure is 2 times bigger than 15 ton/day of bamboo-waste required to produce 1 MW of electricity through Fuel Cell process.

Key word: Potensial Bamboo, Biomass Fuel Cell

INTRODUCTION

Bangli Regency locates at North-Eastern of Denpasar, the capital city of Bali Province. Bangli Regency lays from 200m to 1,800 above sea level. It occupies 520.8 km^2 of land area, has 216,800 of populations, and income of 9,500,000 IDR/capita in 2011 [1]. Bangli Regency can be considered as one of the smallest population and the lowest income per capita, among 9 regencies and 1 city in Bali. Bangli Regency consists of 4 sub-districts, namely: Bangli, Susut, Kintamani and Tembuku. Bangli is the source of fresh water for neighboring regencies that contributes to agricultures and tourism activities surround. In the emerging of tourism industry in Bali over the latest 3 – 4 decades, however Bangli has never felt of receiving direct impact from its strategic position.

Bamboo-handy-craft (and/or bamboo-based related small scale home industries) is Bangli's primary commodity, where its raw-materials is mostly got from within Bangli. Over the last 2 decades, Bamboo-handy-craft in Bangli has shown its significant rapid growth and development. The industry spread over several villages in Bangli, that is Desa (≈ village) Kubu and Desa Kayubihi at sub-district Bangli, and Desa Tenganan and Desa Tiga at sub-district Susut. There were around 2,000 units of bamboo-based small scale home industries in Bangli in 2000, and they absorbed around 4,838 workers [2].

According to Bureau of Farming, Agriculture and Forestry Bangli Regency, Bangli has a potential of 6,119 Hectare of bamboo plantation (planted by local resident) and 4,731 unit micro and small household handy-craft industries exist in Bangli [3]. At present, both bamboo and its waste are scattered and un-treated. The head of Bangli's regency has clear vision to utilize these un-treated resources to use "fuel-cell" technology as a pilot project to produce electricity, and charcoal-bamboo side-process, as well as to improve the income of the households through trade-in process of the supply feedstock. The whole concept of the idea is shown in Figure 1.

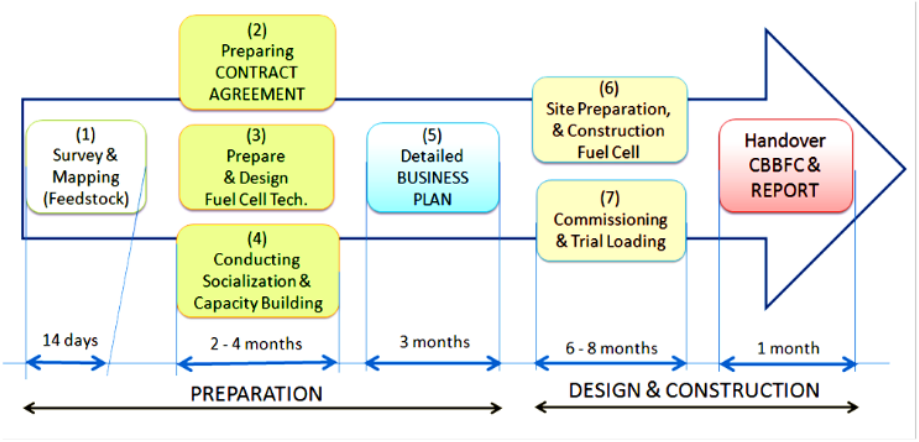

Figure 1 – The One-line diagram activities of the whole concept

GOAL AND OBJECTIVES

The availability and the continuity of bamboo and bamboo-waste as source of supply feedstock for the Fuel Cell Technology are important, necessary and vital. Therefore, in order to get more accurate figures, it is necessary to conduct a detailed survey and make a mapping on their potential and availability in Bangli Regency.

It is known that there are more than 1500 known species of bamboo in the world (Ohrnberger 1999), of these, probably there are some species known very well in Bali, for instance: bamboo-Tali, bamboo-Petung, bamboo-Santong, bamboo-Tultul, etc. Taking the vast potential of bamboo resources and the huge amount of bamboo available in the Bangli Regency along with the considerable annual growth rate, this study will try to find out and verify the potential of bamboo and bamboo-waste as a raw material for feedstock CBBFC, and its value chain. The study will be focused on the community highland-bamboo within Bangli Regency, due to its vast uses. Therefore, the purpose of the study is

- to get a more detailed and accurate figures of bamboo and bamboo-waste as source of feedstock (i.e.: kind of bamboos, the coverage,)
- to mapping their potential and availability in correlating as sourced and collecting/delivery system
- to know to what extend is the bamboo become a source of income for farming-households
- to know to what extend is the likely acceptance, willingness, (the possibility of) participation and buy-in of local farmers and small-enterprises in supporting the above idea
- to create an initial "baseline" for the whole idea (and pilot), as it can be used to evaluate the difference of some key-performances between before and after implementing the program
- to mapping the coverage, and to estimate on to what extend the project can be enlarged, replicated and extended

Due to the limitation of time and resources, this activity focuses on the two major actors of the value chain and concentrates on local-farmers (in the villages) and small-enterprises of 4 sub-districts (i.e.: Susut, Bangli, Kintamani, and Tembuku) that currently exist in Bangli. Moreover, the output of the study (Activity 1) is that

1. Mapping and counting the potential annual volume feedstock of bamboo and bamboo-waste in Bangli
2. Giving a recommendation to related stake-holders about the sustainability of feedstock, and its Feed-stock Conservation Measures (FCMs)

METHODOLOGY SURVEY ACTIVITIES AND ITS MANAGEMENT

The followings are the description of project (survey and mapping) activity and its management:

1. The list of questions – both for households (HH) and micro-small-scale households handy-crafts (MSSHH) are prepared by team leader
2. The activity to collect primary data are divided into some sub-activities (i.e. visiting villages, meeting with local-farmers and small-scale-handy-crafts enterprises, asking relevant information, taking data collection, checking and observing bamboo-land, etc.), tabulating and analyzing the collected information, and mapping the potential
3. All sub-districts in Bangli regency were surveyed; there were 4-5 villages and 15 MSSHH surveyed in every sub-district, and around 10 households were surveyed in a village
4. Searching relevant secondary data from internet
5. The survey and mapping activity was done (was carried out) by 8 (eight) key staff of Agriculture Department of University Warmadewa – Denpasar, and 2 (two) local facilitators from Bangli Regency.

6. The preparation of survey took 3 (three) working-days, and followed by the survey itself that took 7 (seven) working-days, and another 10 (ten) working-days for recapitulating and analyzing data, as well as making a final report
7. Once data is collected and tabulated, then it will be analyzed to find out how is the potential bamboo-waste can be produced and/or collected to support the idea of 1 MW pilot project Community Based Biomass Fuel Cell, and what other conditions are required later on in order to sustain the pilot

DATA COLLECTION AND ANALYSIS

The survey, meeting with local farmers and handycrafts, asking questionnaires, and taking data collection were carried out from 26th October to 3rd November 2012, with random approach. There are 178 respondents-households and 50 unit respondents micro-small-scale household handycraft surveyed. They spread over in 4 sub-districts, 15 villages, and 35 sub-villages in Bangli, as shown in Table 2. The full list of respondents can be seen in Appendix 2 and Appendix 3. In addition, there are 220.6 Hectare of local farmer were surveyed, with specific land area for bamboo-plantation accounted of 120.5 Hectare (≈ 12,050 Are = 1,205,000 m^2).

Most of the surveyed land area bamboos were inherited from their father of grandfather, as they are part of local tradition to continue planting bamboo-plantation, or it is "taboo" to discontinue bamboo-plantation in their own land. It means they plant the bamboo. The respondents use the bamboo – the good one, the good stick bamboo – for the following reasons, i.e.: 4% for own purpose, for instance for making part of houses, 24% for making bamboo related handycraft (if they have their own), 68% is sold to middle-man or others (to get additional income), and only a small fraction is used for fire-work and other purposed. It can be said that the good one of bamboo-stick has its economic value.

The price of 1 no bamboo-stick – with average of 8 to 10 meter length – is vary according to its type and/or its size diameter, which is in the range of 5,000 to 25,000 IDR/stick. Type bamboo-Petung with diameter of 20cm to 25cm can have the highest price. However, although type of bamboo-Tali is small in diameter with price of 5,000 to 8,000 IDR/stick, but this type is widely planted, used, and sold. This is because bamboo-Tali is widely used for making handycraft, especially "GEDEG" and "Sok-kasi".

From the survey, it is revealed that 42% of bamboo-waste is neglected in their land or their backyard, 50% is used for fire-wood for cooking, 2% is re-sold to middle-man for making "bamboo-based-charcoal", and 6% used for other purposed. It can be said here that the bamboo-waste is less utilized (or lacking of utilization). This is mainly due to the fact that the local-farmer do not know and/or having very lack of information for the potential of its utilization.

Table 2 – List of items surveyed for estimating feedstock bamboo-waste

No	Item Surveyed	Volume	Unit	Estimated Aggregate
1	Total respondents-HH	178	HH	
2	Total respondents-MSSHH	50	unit	4,000 unit MSSHH
3	Total banjar (sub-village)	35	sub-village	300 banjar
4	Total desa (village)	15	village	72 desa
5	Total land-area	220.6	Hectare	19,612 Hectare
6	Total land bamboo-area	120.5	Hectare	12,790 Hectare

Note: HH = local-farmer households; MSSHH = Micro-Small Scale Household Handycraft

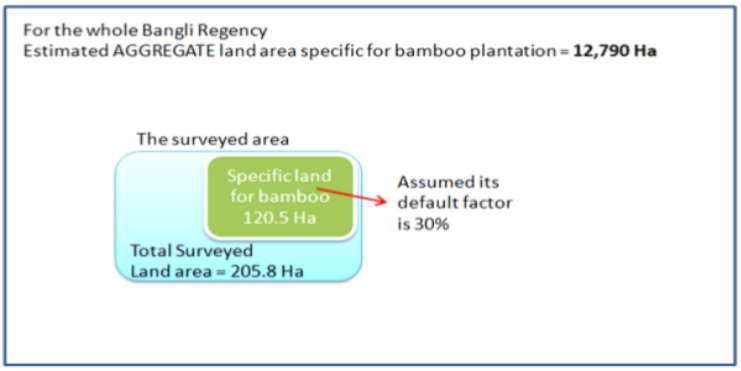

Figure 2 – Sketch-mapping of surveyed land bamboo as compared with whole aggregate

After collecting, compiling and tabulating all data, and from the explanation of aforementioned paragraphs, it can be said that there is a potential of bamboo-waste from both respondents-HH (which is local farmers) and respondents-MSSHH (which is local handycrfat bamboo-based industry) that can be used and utilized as feeding-stock of 1 MW CBBFC pilot project. How much is the potential stock? It will be described in the following paragraphs.

Total land area of bamboo-plantation for household local-farmer is 105.7 Hectare, and for Micro-Small-Scale household handycraft (MSSHH) is 14.8 Hectare. By using the consideration and assumptions that have been described in previous chapters – which is very conservative approach -- then the bamboo-waste that could potentially be produced by both respondents are 31.3 ton/day and 4.4 ton/day, respectively, as they are shown in Table 3 and Table 4. Moreover, an additional of 0.6 ton/day of bamboo-waste can also be produced from process production of MSSHH, as shown in Table 5. Therefore, there are a total of **36.3 ton/day** of bamboo-waste can be produced. Further, if we take into account of 7,500 Hectare of land bamboo area developed by GN-RHL/ (2008), other 3,000 Ha land area bamboo belongs to community and Desa Adat, and forestry bamboo along rivers and gorges of 2,000 Hectare , then the total potential bamboo-waste would be of **3,785 ton/day**.

Table 3 – Estimated calculation of potential bamboo-waste produced by respondents-HH

No	Concern	Notation	Unit	Volume HH
1	Total respondents-HH	A	HH	178
2	Total land area of respondents-HH	B	Ha	205.8
3	Total land area bamboo of respondents-HH		Ha	105.7
	Total land area bamboo of respondents-HH		Are	10,570
	Total land area bamboo of respondents-HH	C	m^2	1,057,000
4	Assumed; default factor of land area bamboo	D		30%
	Total (real) land area bamboo of respondents	E = CxD	m^2	317,100
5	Bamboo density (≈ number of bamboo in 1 m^2)	F	stk/m^2	20
6	Avg. High of bamboo (≈ 1x harvest per year)	G	m/year	12
7	Avg. Length of bamboo-stick (good one)	H	m	8
8	The avg.weight of 1 meter bamboo-stick	I	kg/(m.stk)	1.5
9	Assumed; percent of bamboo-waste of 1 stick	J		20%
10	Possible of Bamboo-waste of respondents-HH	K = ExFxGxIxJ	kg/year	22,831,200
11	Assumed; number of days in a year	L	days	365
12	Possible of Bamboo-waste of respondents-HH	M = K/L	kg/day	62,551
			ton/day	62.6
13	Assumed; efficiency collecting bamboo-waste	N		50%
14	The Potential of bamboo-waste as feedstock	O = MxN	ton/day	31.3

Table 4 – Estimated calculation of bamboo-waste produced by respondents-MSSHH

No	Concern	Notation	Unit	Volume MSSHH
1	Total respondents-MSSHH	A	HH	39
2	Total land area of respondents-HH	B	Ha	14.8
3	Total land area bamboo of respondents-MSSHH		Ha	14.8
	Total land area bamboo of respondents-MSSHH		Are	1,480
	Total land area bamboo of respondents-MSSHH	C	m^2	148,000
4	Assumed; default factor of land area bamboo	D		30%
	Total (real) land area bamboo of respondents	E = CxD	m^2	44,400
5	Bamboo density (≈ number of bamboo in 1 m^2)	F	stk/m^2	20
6	Avg. High of bamboo (≈ 1x harvest per year)	G	m/year	12
7	Avg. Length of bamboo-stick (good one)	H	m	8
8	The avg.weight of 1 meter bamboo-stick	I	kg/(m.stk)	1.5
9	Assumed; percent of bamboo-waste of 1 stick	J		20%
10	Possible Bamboo-waste of respondents-MSSHH	K = ExFxGxIxJ	kg/year	3,196,800
11	Assumed; number of days in a year	L	days	365
12	Possible Bamboo-waste of respondents-MSSHH	M = K/L	kg/day	8,758
			ton/day	8.8
13	Assumed; efficiency collecting bamboo-waste	N		50%
14	The Potential of bamboo-waste as feedstock	O = MxN	ton/day	4.4

Bamboo-waste from land area own by respondents-MSSHH (Micro-Small-Scale Handycraft Household)

Table 5 – Estimated calculation from by-product of respondents-MSSHH (Gedeg)

No	Concern	Notation	Unit	Volume MSSHH
1	Total respondents MSSHH "Gedeg"	A	rp	48
2	Number of bamboo used per month per respondent	B	stk/(mo.rp)	74
3	Total bamboo used per month for all respondents	C = AxB	stk/mo	3,552
4	Length of bamboo-stick	D	m/stk	8
5	Weight of bamboo-stick per meter length	E	kg/m	1.5
6	Total weight of bamboo-stick per month	F = CxDxE	kg/mo	42,624
7	Assumed of percent bamboo-waste produced	G		60%
8	Potential of bamboo-waste produced per month	H = FxG	kg/mo	25,574
			ton/mo	25.6
9	Assumed efficiency collecting bamboo-waste	I		75%
10	The potential bamboo-waste as feedstock	J = HxI	ton/mo	19.2
			ton/day	0.6

FACTs & FINDINGs

There were some points observed and noted from the survey, as the followings:

1. There are 176 respondents-HH (≈ 99%) agree and support the idea of the program i.e. utilizing and purchase bamboo-waste of local-farmers as source of feedstock Community Based Biomass Fuel Cell that, if everything goes well, will be located in Bangli, and 2 respondents-HH (≈ 1%) were not agree about the idea.
2. There are 49 respondents-MSSHH (≈ 98%) agree and support the idea of the program i.e. utilizing and purchase bamboo-waste of local-farmers as source of feedstock Community Based Biomass Fuel Cell (CBBFC) that, if everything goes well, will be located in Bangli, and 1 respondents-HH (≈ 2%) were not agree and support about the idea. The reason for not agree and support the idea is that he were afraid that the CBBFC would increase the price of bamboo-stick as raw material, and would limited the supply to MSSHH
3. Almost 95% of respondents inherited their bamboo land area from their predecessor (i.e. from their grandfather)
4. There is a lot of land area bamboo-plantation in the surveyed banjar (sub-villages) or desa (villages) that are not belongs to the people, but belongs to the villages themselves; this bamboo-plantation is managed by chief of banjar or desa

5. The respondents-MSSHH usually make very simple design of bamboo-based handycraft, they have lack of new idea to utilize their bamboo for other product; They are also lacking of information and knowledge where bamboo-waste can be used as feedstock for Fuel Cell Technology to produce electricity
6. Some bamboo-stick from Bangli Regency is also sold to regencies surround, but this quantity is not well recorded

SUMMARY

1. From random survey, all respondents-HH have their land with bamboo-plantation, and most of plantation is inherited. On the other hand, only 39 unit respondents-MSSHH (out of 50) has their own land for bamboo-plantation.
2. Nearly 42% of the bamboo-waste from respondents-HH is neglected, while 50% is used for fire-wood; They have lack of idea on how to utilize bamboo-waste, and how to maximize its economic value
3. Both respondents giving primary data and proved, although their land area bamboo-plantation is only a small fraction (≈ 3.8% - 4.2%) of total aggregate (≈ 100% ≈ 10,500 Hectare), however they could potentially produce bamboo-waste at total of 36.3 ton/day; this figure is almost 2 times bigger than the required to feeding 1 MW Fuel Cell to produce electricity.
4. Both respondents i.e. 98% respondents-HH and 99% respondents-MSSHH agree and support the idea of utilizing bamboo-waste to produce electricity. Moreover, the average distance of bamboo-waste location to the location of CBBFC is around 13 km.
5. In term of volume of feedstock, supporting and agreeing idea from the respondents, and their distance to the location, it is safe.
6. The secondary data revealed that total land area of bamboo-plantation in Bangli Regency reach the minimum (or conservative) figure of 10,500 Hectare; if this figure is taking into consideration, and is accounted, then the potential bamboo-waste could reach a volume of 3,106 ton/day; this is enough to feeding a Fuel Cell facility with capacity of 200 MW

RECOMMENDATION

1. Bamboo and Bamboo-plantation and its related-household-industry are unique for Bangli Regency. It has a long history, rooted and mixed with local tradition, therefore it is recommended that bamboo needs to be planted, managed and developed accordingly and wisely, so that it would give its maximum economic-value, and eventually could increase the income of the community; For instance: creating and making new and innovative design of "Corrugated-Roof" and/or "Laminated-Floor" from bamboo-stick, to increase its added-value
2. The side product of point 1, in the form of bamboo-waste, has a great potential to be utilized and used as feedstock for Fuel Cell technology to produce electricity and other energy; This mainly due to that bamboo is a unique plantation with advantage, where it can easily grow, and its cycle-of-generation is much more faster as compared with other plants, say for instance coconut tree or "sengon". Therefore, it is recommended that the Bangli's Government could introduce and promote "Bamboo-Cultivation", as well as Capacity Building for its community
3. The result of this survey and mapping could be used as a based to make a better socialization and advocacy program about the background, the objective and the outcome of the CBBFC pilot project, as well as to find out a common understanding and agreement about the price of bamboo-waste per ton, so that every stake-holders would get the benefit from the pilot
4. The price of bamboo biomass for power generation will have to established to create investor's confidence in biomass-based power generation
5. Government of Bangli should adopt this study as inputs for creating local in guaranteeing bamboo as feedstock for power generation
6. Community need to be engaged in the process of creating this Perda and biomass price.

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