TOWARD SUSTAINABLE BIOMASS USE IN RURAL PROVINCES OF VIETNAM'S MEKONG RIVER DELTA

DANG Thanh Tu[1], Osamu SAITO[2] and Tohru MORIOKA[2]

[1]Graduate School of Engineering, OSAKA University (2-1 Yamadaoka, Suita, OSAKA 565-0871)
E-mail: tu@em.see.eng.osaka-u.ac.jp
[2] Graduate School of Engineering, OSAKA University (2-1 Yamadaoka, Suita, OSAKA 565-0871)

Although biomass is an important energy source in Vietnam, due to lack of baseline data on household energy consumption, it is very difficult to formulate an effective strategy toward future sustainable biomass use. In order to collect the basic data and identify key issues relating to household energy use and socio-economic condition, a survey was conducted against over 350 rural households located in 3 rural provinces of South Vietnam in 2007. The results showed that biomass energy accounts more than 80% of the total household energy consumption. Most of the biomass used at rural households is self-collected, which as a result keeps their energy expense low. Besides, share of biomass use is highly dependent upon to household's income structure and its level. The improvement of living quality, effect of urbanization process and transition of economy should be also considered in making the rural biomass use more sustainable.

Key Words: *biomass utilization, Vietnam rural province, household energy consumption*

1. INTRODUCTION

Energy plays an important role in the socio-economic development of a country. Economic growth and the improvement of living standard are both directly or indirectly related to the increase of energy use [1].

Being the second most populous country in Southeast Asia and with the positive economic transition policy, during the past 20 years, Vietnam's economy has been significantly successful. Total GDP in 2006 is $61 billion while real growth rate reached 8.2%. Up to now, the economic structure has been changed from agriculture-based to mainly base on industry and service sector [2), 3), 4)]. In parallel with the economy's progress in economic reform and industrialization to facilitate closer integration into global economy, primary energy demand has been growing rapidly. It is projected to grow annually at 3.9%, from 38Mtoe in 2002 to 109Mtoe in 2030, and expected to become a net energy importing economy beyond 2020[5)]. Dealing with this situation towards sustainable development, the Government is now taking a lot of effort on seeking and developing alternative energy sources such as solar energy, wind energy and renewable energy especially biomass[6)].

As a tropical and agriculture country, Vietnam possesses abundant biomass resources, including wood residues, firewood, crop residues, and livestock wastes with total potential of 50million MT per annum[7)]. It is estimated that 76% of utilized biomass derived from fuel wood, agriculture residues and charcoal, is used to satisfy 90% of the domestic energy consumption in rural areas. Traditional stoves so far dominate in the rural market because they can accept any kind of fuel and this is preferred feature considering the wide variety of agricultural residues in rural areas. Efficiency of these stoves is however, very low (6-16%) but the improved one with higher efficiencies is still not widespread due to the relative high capital cost, inflexibility to fuel types and inefficiency for short heating tasks [8), 9)].

Although biomass is an important energy source in Vietnam, currently it is generally treated as non-commercial energy source, being collected and used locally. There is a need to develop the appropriate strategy and action plan for enhancing the biomass utilization in Vietnam. However, without baseline data on household's energy consumption, it is impossible to formulate an effective strategy toward future sustainable biomass use.

This paper aims to collect the basic data and identify key issues and factors relating to household energy use and socio-economic condition in rural provinces of Vietnam's Mekong delta. Based on the surveyed data and related analysis, the research also aims to propose an areal typology of Vietnam rural area in terms of biomass utilization and to discuss the perspectives and clues to develop more sustainable biomass use strategy.

2. MATERIALS AND METHODS

(1) Study area

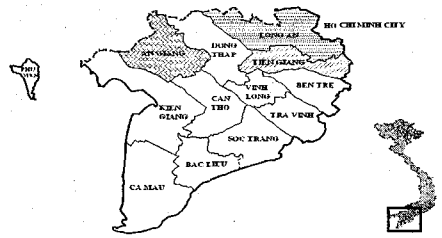

Fig. 1. Map of Vietnam and Mekong Delta

The total population of Mekong Delta in 2005 is 17million, accounted by 21% total national population (**Table 1**). While the Mekong Delta covers only 12% of total Vietnam's land area, its rice production in 2005 reached 19.2 million tons, accounted by 54% of gross rice production. It is therefore supposed that this area will have the highest potential in post-harvest agro biomass sources.

(2) Methods

a) Household interview survey

Household survey was carried out based on direct interview using the questionnaires of over 350 rural household located in 3 rural provinces of Mekong River Delta, the biggest granary in Vietnam, in Feb. and Mar. 2007. The questionnaire is divided into following 3 sections:

General information: number of persons living in the household, total agriculture area, the distance between their house to paddy field(s), and their estimation about yearly income.

Agriculture activities: questions regarding the amount of yearly rice, other agro-products production, and household's post-harvest biomass (i.e., rice husk and straw).

Energy supply and demand: questions related to the source of energy supply, list of electrical appliances as well as the expenses for each type of energy.

b) Estimation of energy consumption

According to Tuan and Lefevre [11], electricity, coal, kerosene, fuel wood, and residues in various forms constitute the primary fuels used by the households in Vietnam. Fuel wood and residue, which are usually freely gathered by household's members, are the main energy types for cooking purpose in rural areas. Therefore, un-purchased biomass use needs to be estimated in order to calculate the overall consumption and its proportion of several energy types.

As the report of IE[12] pointed out, 95% energy consumption in Vietnam rural area, equivalent to 682kgoe/household, is for cooking purpose. The use of energy for lighting and other electrical appliances is negligible and mainly based on electricity which is one of the purchased energy sources. Hence, we considered the data of energy consumption for cooking purpose as the basis for energy consumption estimation.

The following energy conversion factors were used to convert the energy contents of different fuels to one standard unit, kilogram of oil equivalent, with the standard unit of oil equal to 10,748kcal [13].

1kg wood (air dry, humid zone) = 3,702kcal
1kg rice hulls (air dry) = 3,439kcal
1kg LPG = 10,891kcal
1l Kerosene = 8,360 kcal

Price of each energy type is based on the information collected during the direct household interview.

c) Classification of Vietnam rural areas

Under the transition and development process, the changes of Vietnam's economy in recent years has been creating a lot of changes in the socio-economic and peoples' quality of life, including the transition of energy use for daily consumption.

To identify the future trend of biomass utilization as well as create basic assumption for sustainable biomass use in the rural areas, this paper attempted to classify such areas using criteria that include household income and industrialization and/or urbanization level, which is estimated based on the share of agriculture land in total land-use in each province.

3. RESULTS

(1) Energy use

a) Energy consumption patterns by end use

In general, electricity, kerosene, fuel wood, rice husk, and biogas constitute the primary fuels used by the households in Mekong delta area. The percentage of households using certain types of fuel varies across the surveyed areas depending on the availability of the fuel and habit of residents.

Table 1 Statistic data in 2005 of surveyed provinces [2), 10)]

	Population	Land area		Population density	Proportion of	Rice	
	(1,000per.)	Km^2	%	(persons/km^2)	agriculture area (%)	1,000T	%
Long An	1,413	4,491	1.4	315	73.8	1,934	5.4
Tien Giang	1,701	2,367	0.7	719	76.7	1,303	3.6
An Giang	2,194	3,406	1.0	644	75.2	3,128	8.7
Mekong Delta	17,268	39,739	12.1	435	74.8	19,235	53.7
National total	83,120	329,315	100.0	252	28.4	35,791	100.0

Electricity: One hundred percents (100%) of surveyed households have ability to access national electricity grid. It is mainly used to supply electricity for very basic electrical appliances such as lighting, TV, and rice cooker. About one third of total surveyed households have common electrical appliances such as water pump, fans and other audio - video equipment. Sixteen percents (16%) of households, who doing small business at home have refrigerator. Five percents (5%) of households have electric stroke at home, but it's only used in very emergency cases. The use of modern electrical appliances like washing machine, air conditioner, and water heater are accounted by 1 - 2% of households.

Energy for cooking: Almost all of the households in the surveyed areas mainly rely on biomass energy such as firewood and rice husk for cooking purpose (**Fig.2**). More than 80% of households in all 3 provinces use firewood, but the trend is slightly different between provinces. Long An, which has the highest share of miscellaneous gardens per total land area (4%)[14], has the highest share of households using firewood.

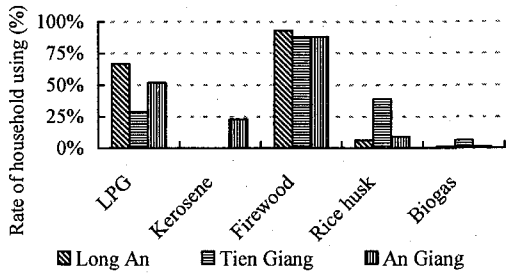

Fig. 2 Distribution of energy sources for cooking

The second highest proportion of energy type for cooking purpose is LPG. Close to 70% of households in Long An and more than 50% in An Giang use LPG for cooking. Lower share of LPG in Tien Giang seems to be compensated by the biogas system which is introduced by 6% households, and also by a large amount of rice husk consumption.

Twenty one percents of households in An Giang use kerosene as alternative energy source for cooking. Located in the flooded regions of Mekong River Delta, a lot of places in An Giang are inundated during flood season, which makes peoples' access to other common energy sources more difficult during this period except kerosene.

b) Energy consumption patterns by fuel type

Besides the constant energy consumption for regular cooking activities like using electricity for rice cooker, firewood is a major determinant and is accounted by 64-79% of total energy use for cooking in rural households (**Table 2**). Tien Giang province which has the lowest proportion of households using firewood (**Fig.2**) also has the lowest firewood consumption (**Table 2**). Long An has the highest number of households using firewood, but their consumption is lower than that of An Giang. Rice husk and firewood are complementary to each other; the province with the lower firewood consumption tends to use more rice husk.

Table 2 Proportion of energy consumption patterns by fuel type

Unit: %

	Long An	Tien Giang	An Giang
LPG	7	2	5
Electricity	10	8	9
Kerosene	0	0	1
Biogas	1	6	1
Rice husk	4	20	6
Firewood	78	64	79

Gas usage for cooking, including LPG and biogas is accounted by 6-8% of the total energy consumption and follow an increasing order from An Giang to Long An and Tien Giang. LPG and biogas consumption may relates to the development level of husbandry sub-sector. Its share in total agriculture sector of Tien Giang is 12% while in Long An and An Giang is 6 and 1%[16]. It is explained by the biogas consumption in Tien Giang is higher (5%) than the other two provinces (1%). Kerosene usage for cooking accounts for merely 1% of the total energy consumption, even though 21% of households in An Giang use this fuel type.

c) Energy expenses

Fig.3 shows information on energy expense and its structure, which provides a basis for future trend analysis, in surveyed household.

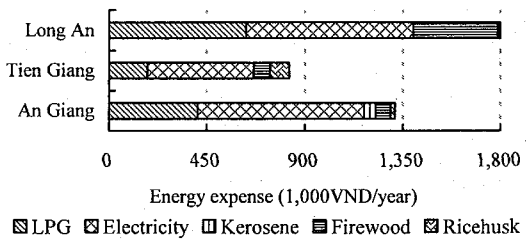

Fig. 3 Distribution of energy expense in surveyed provinces

As described in **Fig.3**, energy expense that each household spend is different; Long An residents spend 1.3 to 2 times higher than those in An Giang and Tien Giang. Electricity accounts for the biggest share, from 43% to 59% of the total energy expenses. The expence that household needs to pay for electricity in Tien Giang is about 30% lower than the other 2 provinces. This is partly because households in Tien Giang use less common electrical appliance than the others, and partly because those who have already installed biogas system use biogas for lighting and electricity generation.

With the highest proportion of household receiving income from off-farm activities (83%) as compared with Tien Giang and An Giang (31% and 23%), 80% of households in Long An have to pay even for biomass energy sources instead of freely gathering to cover their daily cooking demand. Moreover, the use of traditional biomass for daily cooking as main energy source is not feasible for households in Long An. As Anh (2007)[15] pointed out, when using traditional biomass such as rice husk and firewood, people need to spend about 2 hours for preparing firewood and 3 – 4 other hours for cooking. Due to time constraint for daily cooking, they prefer to use more efficient energy sources, such as electricity and/or LPG, even though it is about 10 – 15times more expensive than rice husk and firewood.

Gas expense is the second highest energy source in rural households. It accounts for 22-35% of total expenses. Due to the introduction of biogas system in Tien Giang, the expenses for LPG in this provinces is just accounted by one third or half of those in the other 2 provinces.

(2) Energy expense and household income

Firstly, there are highly significant positive relationship between energy expense and household's income. Correlation coefficient between those 2 factors in Long An, Tien Giang and An Giang are 0.31, 0.31 and 0.42 respectively ($df > 100$; $P < 0.01$). It means that, the household with higher income have the tendency to pay more for energy use, but the trend of such relationship are different between 3 provinces. For example, although the residents in Long An's average household income is the lowest, the yearly expenditure for energy consumption is the highest (**Fig.3**).

Secondly, the structure of energy expense by range is also different between provinces. Only 10% of households in Long An pay less than 1million VND per year for energy, while those figures in Tien Giang and An Giang are 70% and 48%. In contrast, less than 1% of households in Tien Giang have to pay more than 3 million VND for energy, while more or less 5% in Long An and An Giang (**Fig.4**).

(3) Agriculture income and biomass use

Correlation coefficient between share of biomass use and agriculture income in Long An, Tien Giang and An Giang are 0.06, -0.19 and -0.28 with $df > 100$. It means that, there is no relationship between those 2 factors in Long An, while the negative correlations are significant in An Giang ($P<0.01$) and Tien Giang ($P<0.05$). The negative correlation implies that households with higher income from agricultural activities (rice production) tend to consume less biomass than those of lower income in Tien Giang and An Giang, where income from agriculture is accounted by 84% and 92% total income (**Table 3**).

(4) Household typology

Rural area in Vietnam is now under industrialization and urbanization process, which brings them a lot of socio-economic changes, such as quality of life, living standard, and also the habit of energy usage. Therefore, it is important to evaluate the impacts of industrialization and urbanization process to the current situation of biomass use. The level of industrialization and urbanization of rural provinces can be evaluated based on the income from agriculture and the share of agricultural area in total used land of each province(**Table 3).**

Based on Table 3 and the survey results including field observation, we can classify the surveyed households into 3 main types which have difference on socio-economic condition as well as situation of biomass utilization.

Table 3 Rural typologies and its energy use

	Long An	Tien Giang	An Giang
Proportion of agriculture in total used land (%)	80	85	82
Income from agriculture per total income (%)	62	84	92
Rate of purchased energy in total energy use for cooking (%)	81	42	31

- Type 1, which is represented by households in Long An province, has a low proportion of income from agriculture in total income and high level of urbanization. Households in Type 1 tend to use

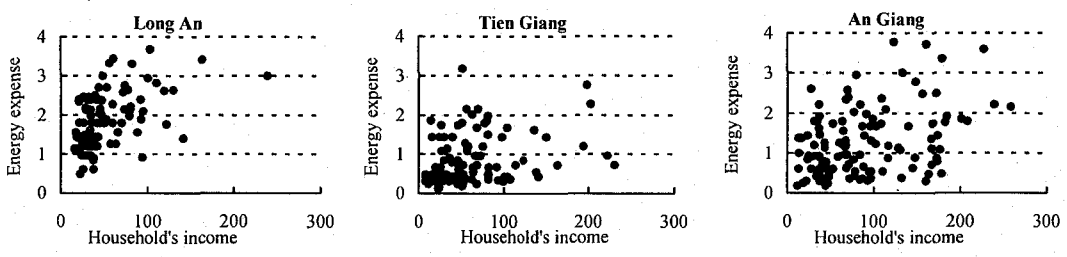

Fig. 4 Relationship between total incomes, energy expense in surveyed provinces (Unit: Million. VND/year)

relatively higher share of new conventional energy like LPG (7%) and electricity (10%) (**Table 2**), and result in the highest share of purchased energy in total energy use for cooking (81%).

- Type 2, which is represented by households in Tien Giang province, has medium share of agricultural production in gross production. The households in this type use biogas at relatively higher proportion (6%) and have to pay for 42% of total energy use for cooking.

- Type 3, which is represented by households in An Giang province, has the highest income from agriculture and lowest share of purchased energy. In terms of the consumption level of both traditional and conventional biomass, Type 3 stands in between Type 1 and Type 2.

4. DISCUSSION AND CONCLUSION

Although the quantity and structure of household's energy consumption vary from province to province, traditional biomass energy such as firewood and rice husk are mainly used for cooking and account for more than 80% of the total daily energy demand in the rural area of Vietnam. Such energy sources which can be easily purchased and/or freely gathered create the gap not only in household's expenditure, but also in total energy expense among provinces. The dependence on traditional biomass sources is likely to continue even with accelerated economic development. It is also similar to Tuan's report[11] which surveyed energy use in 4 Northern provinces in Vietnam.

Tuan (1996)[11] also pointed out that household income has negative relation with the proportion of biomass utilization. The household with higher gross income and/or higher income from non-agriculture activities tends to use less biomass and more fossil fuel based energy. Due to the disadvantages of traditional cook stoves like low efficiency, time and fuel consuming, people come up to more convenient, readily available fuels. It can be seen as the solution to reduce their narrow time for daily cooking and creating the need to better converse biomass by using higher efficient equipment. In turn, energy conservation can result in saving time for collection and preparation of fuel sources. The rural residents therefore may be able to use their free times for other activities, which can bring them more chance to improve their living quality and reduce poverty. For the residents with low accessibility to free biomass sources, higher efficiency equipment can help them to save money spent for fuel. Higher conversion efficiency for traditional biomass energy such as rice husk and firewood will result in the lower disturbance to the agricultural environment.

Our result shows that, besides household income and its structure, the characteristics of rural area influence the energy types and its consumption. Firstly, in highly agriculture-based provinces, agricultural income has negative impact on the share of biomass utilization. Secondly, the more industrialization and urbanization provinces will consume less biomass. Based on our analysis in the previous chapter and the rural statistical data GSO (2005)[2], 13 administration areas (12 provinces and 1 city) in Mekong Delta can be classified into 4 main types (**Fig. 5**). Three types are basically the same as those identified in chapter 3, and we found that we can add another type by using a two-axis matrix of Fig.5.

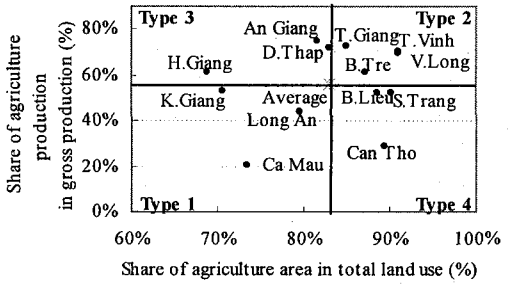

Fig. 5 Province's typology in Mekong Delta

The households in more industrialized areas (Type 1) tend to use more conventional energy such as electricity and LPG, and have to pay more money than those in lower industrialization and urbanization areas (Type 2 and Type 3). In this type with high industrialization development, the provinces can concentrate on industrial waste related energy, especially for rice mill, sugar mill and fisheries processing sectors.

As GSO (2006)[14], in Type 2 provinces, in addition to rice and fruit cultivation, husbandry sector is the most developed. The share of husbandry in total number of farmhouses ranges from 11% to 23%, and creates more opportunities to utilize the advance biomass sources such as biogas from husbandry residues through a low cost technologies at small scale (household scale).

In the Type 3 provinces, the agro-processing sector has rapidly developed for the last 10 years. Besides traditional biomass, there are abundant and more concentrated sources of industrial waste from agro processing sector[2], which can be used to produce bioenergy such as bioethanol and/or thermo energy from rice husk and straw in rice milling enterprises and biodiesel from basa cage fish processing factories[6), 7)]. The utilization of such biomass sources helps communities to establish waste-exchange networks between agricultural an industrial sector at provincial and/or regional scales. Such networks will contribute to

promote the closing loop for economic development and the sustainable biomass utilization.

Beside the common alternatives regarding to conversion technologies (improvement of cook stove, development of small scale gasifier system and so forth), the implications from our study are summarised in **Table 4**.

The key to successful implementation of sustainable biomass utilization should be based not only on technology choices, but also on ways to create an equilibrium development between industry and agriculture, and to maximize the benefit from their exchange networks. This paper has pointed out basic information on energy use and factors relating to biomass utilization in rural households of Vietnam. However, the concept definition of "sustainable" biomass use in rural area has not been fully explored and usefulness of our classification of rural provinces has not thoroughly examined in this paper. Moreover, we need to further investigate the detail evaluation of biomass potential and its distribution at provincial scale. Since each province has its own development paths, depending on future socio, economic, environmental conditions, the next study will develop rural future scenarios in term of sustainable biomass utilization.

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Table 4 Summary of province's condition and implications for sustainable biomass use in Mekong River Delta

Province		Condition	Implications toward sustainable biomass use
Type 1	Long An, Kien Giang, Ca Mau	- Low agriculture production - Low rice productivity[2)] - High industrialisation and urbanisation - Lowest income but highest energy expense - Highest purchased energy consumption (LPG and electricity)	- Optimize the firewood utilisation from miscellaneous gardens by appropriate exploitation and conversion equipment - Consider the use of biogas as alternative energy sources and have subsidy policy to encourage biogas installation in households and/or group of households scales - Change from mono rice cultivation in the low productivity areas to rotating cultivation of rice and oil crops (jatropha, soybean, etc))
Type 2	Tien Giang, Tra Vinh, Vinh Long, Ben Tre	- High agriculture production - Low industrialisation and urbanisation - Lowest energy expense - Highest biogas use - Advantage in husbandry development	- Thoroughly utilize the available biomass sources (rice husk, rice straw, firewood) by higher efficiency equipment - Maintain the advantage of biomass utilization - Subsidy to expand the biogas system (in household and/or community scales)
Type 3	An Giang, Dong Thap, Hau Giang	- High agriculture production - High industrialisation and urbanisation - Highest unpurchased energy consumption - Abundant source of agro related biomass - Husbandry development at small scale [14)]	- Thoroughly utilize the available biomass sources (rice husk, rice straw, firewood) by higher efficiency equipment - Maintain the area of miscellaneous garden in order to stablize the firewood sources - Susidy to encourage the use of improved cook stoves - Subsidy policy to encourage biogas installation in households and/or group of households scales
Type 4	Bac Lieu, Can Tho, Soc Trang	- Low agriculture production - Low industrialisation and urbanisation - Small scale husbandry	- Optimize the firewood utilisation from miscellaneous gardens by appropriate exploitation and conversion equipment - Subsidy policy to encourage biogas installation in households and/or group of households scales