Potential of Distributed Power Generation from Biomass Residues in Vietnam – Status and Prospect

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ABSTRACT

Vietnam is a developing country with an ever increasing power demand. The development of power sources are limited mainly to large central power plants using hydropower and traditional fossil fuels. Agriculture still plays a vital role in production activities generating high quantity of residues (biogas, straw, rice husk, etc..). These biomass residues could be a potential source for energy supply as well as for power production.

This paper summarizes and quantifies the potential of distributed power generation and cogeneration from biomass residues in Vietnam. Besides, present situation, obstacles and future trends of producing power from renewable energy in general and biomass energy in particular, are also discussed.

COUNTRY PROFILE

Vietnam, located in South East Asian region, has a total geographic area of 329,241 km^2. Nearly 35% of the natural area is forest land, and 28.5% is reserved for cultivation, which is concentrated in two main regions: Red River Delta in the North and Mekong River Delta in the South.

In 2002, Vietnam's population was about 79.7 million with an average growth rate of 1.4% per year. Urban population accounts for 25%, concentrated mainly in Ho Chi Minh City (5.8%) and Hanoi (2.2%) [1].

Gross Domestic Product (GDP) grew by 7.6%, to reach VND 536,098 billion in 2002 [1]. The GDP per capita in 2002 is estimated at 410 USD[2]. Compared to 2001, GDP in agriculture rose by 4% and in industry, by 9.4%. The service sector growth rate increased by 6.5% in 2002. The overall GDP is projected to a growth of around 7.0% in 2003 (VN agency 17/10/2003).

It can be seen that the economic structure has been changing from an agricultural-based economy to a non-agricultural one. Share of agriculture in GDP structure has decreased

from 40% (in 1991) to 23% (in 2003), while the industry sector account has increased gradually from 24% to 39% during that period.

POWER DEMAND AND SUPPLY IN VIETNAM

Vietnam is one of the few countries having a low level of energy consumption in the developing world with an estimated amount of 210 kg of oil equivalent per capita/year (end-use energy at the end of 2000).

In the period of 1995-2000, the electricity consumption increased at a quick pace at an average rate of 14.7% per year. During the last 2 years, the yearly power demand has increased at a rate of 16.6%. The highest rate of growth seen was in industrial and service sectors, 19.5% and 18.3% respectively. Growth in household usage demand was the third, at 14.2% per year, with a strong decline comparing with period of 1995-2000 during which consumption increased at a rate of 22%/year. The demand from agricultural sector also increased at a rate of 7.4%, after the period of setback in 1995-2000 (at a rate -21.8% per year). The composition of electricity consumption in 2002 is shown in figure 1. It shows that residential and industry sectors formed the majority amongst the total electricity consumption at 47.2% and 42.3% respectively.

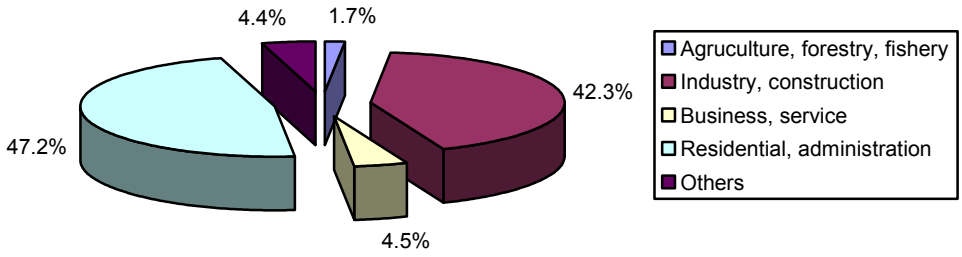

Figure 1. Composition of electricity consumption in 2002 [3]

In 2002, the total installed power capacity was around 8,860 MW, of which 51% was from hydropower plant, 17% from steam condensing turbine and 27% from gas turbines and diesels engines(16.5%, gas turbines 26.5%, diesel 0.3% and from independent power plants 5.9%). The power networks from the North to the South of the country are unified by putting into operation of a 1500km - 500 kV transmission line, with a peak capacity of about 550 MW and maximum annual load of around 4 TWh. In this year, total electricity generation was around 35.8 TWh.

According to Vietnam Power Development Master Plan for the period of 2001 – 2010, the demand for electricity generation should be 48.3-53 TWh by 2005, 88.5-93 TWh by 2010 and 160-200 TWh by 2020. To provide for this large capacities power plants of extremely high capacities are to be built. The annual investment capital requirement for these expected power sources and electricity grids is about 1.5 billion USD.

MAJOR BIOMASS SOURCES IN VIETNAM

Vietnam possesses abundant biomass resources which can be more efficiently utilized to substitute an important part of the fuel and electricity needs of the country. The major

biomass sources in Vietnam include (i) wood residues and firewood, (ii) crop residues, and (iii) livestock wastes.

- **Wood residues and firewood:** In 2002, the gross output of lumbered wood logs was around 2.43 million m^3. Most logs (locally lumbered and imported) are processed in sawmills. In that year, about 1.51 million m^3 of lumber was produced. With an average volume ratio of wood residues to log to be 0.6 for the sawmills in Vietnam, the total wood residues generated in sawmills was about 2.27 million m^3 or 1.59 million tons (about 0.27 million tons of sawdust and 1.33 million tons of wood chip). In 2000, exploited firewood was about 24.8 million stere (equivalent to 12.4 million tons)

- **Crop residues:** Crop residues can be classified into two main groups: agricultural wastes after harvesting (rice straw, cane trash, peanut shell, corn leaves and cobs, cassava stem, coconut shell and leaves, etc), and agro-industries' residues after processing (rice husks, bagasse, cassava peels, peanut shells, coffee husks, etc).

  The production of paddy in 2002 reached 24.1 million tons [1], reveals that 6.8 million tons of rice husk and 64.7 million ton of paddy straw has been generated. These waste residues concentrated mainly in two delta regions: Mekong River Delta (51.3%) and Red River Delta (19.6%) [1]. In these areas, the residues is used mainly as fuel in brick making (rice husk), household cooking (rice husk, paddy straw) and burning on fields to produce fertilizer (ash).

  With the production of 16.8 million tons of sugar cane in the 2002-2003 milling season, 5.5 million tons of bagasse has been produced. Out of 16.8 million tons of sugar cane processed, 67% of this has been fed in to 44 small and medium scale sugar mills (>500TCD) [4]. In these mills, the bagasse has been used as fuel in the cogeneration plant to generate electricity and steam, satisfying the demand of the factory. However, due to the use of outdated technology with small milling capacities, electricity generated has been optimised. The remaining (33%) sugar cane has been processed by small, hand-made mill. In these small mills, bagasse is used as fuel for juice condensing causing energy from this bagasse to be less efficiently utilized.

  Moreover, other biomass sources such as cassava stem, cane trash, maize husk, coconut shell and leaves are also available due to their high production, table 1 summarizes the quantity of these biomass sources. Applications of these biomass sources vary from area to area many of which are either used as fuels for cooking in households or for burning purposes in brick factories.

- **Livestock wastes:** In 2002, total number of livestock in Vietnam was around 23.2 million pig-heads, 4.1 million cattle-heads, 2.8 million buffalo-heads and 233 million poultry-heads. Numbers of other livestock (horses, goats, sheep, etc.) are small in comparison with the above mentioned. The livestock farm sector in Vietnam is concentrated to small individual household farms with between 5 to 20 heads (above 99%). At present time, the majority part of livestock wastes (manure) is re-used, mainly to feed fish, to fertilize fields and gardens. The remaining is disposed in streams or rivers, posing a serious threat to the environment. The biogas production could be an effective option for utilizing livestock wastes optimally and efficiently.

Table 1: Availability of Major Biomass Sources in Vietnam (2002)

No.	*Agro-Industries residues*	*Amount (million tons)*	*Primary Energy Content (GJ)*
I	***Wood residues & fire wood***		
1	Saw dust	0.27	3,132
2	Wood chip	1.33	19,950
2	Firewood[1]	12.4	186,000
II	***Crop Residues***		
4	Paddy straw	64.7	905,800
5	Rice husk	6.81	77,634
6	Maize husk	5.8	72,500
7	Cassava stem	1.25	15,625
8	Cane trash	1.68	21,000
9	Bagasse	5.5	39,655
10	Peanut shells	0,12	1,500
11	Coconut shells & leaves	5	90,000
12	Coffee husk	0.28	4,359
III	***Biogas from livestock manure***		
1	Pig dung	634 mil. m^3	12,685,301
2	Cattle dung	460 mil. m^3	9,194,343
3	Buffalo dung	446 mil. m^3	8,916,582

The share of energy in biomass sources is shown in figure 2.

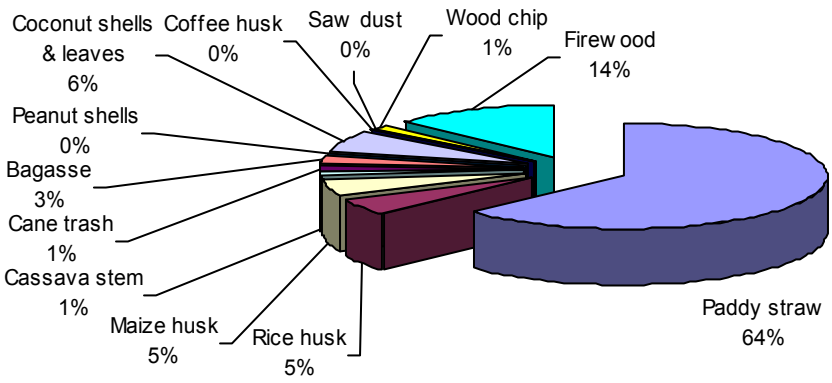

Figure 2. Share of energy content in main biomass residues

Considering only some large potential biomass sources like wood residues, paddy straw, rice husk, and bagasse, the estimated energy can be generated upto1430 MW with the annual electricity production of 9020 GWh.

[1] Data of the year 2000

STATUS OF POWER GENERATION FROM BIOMASS WASTES IN VIETNAM

Biomass Combustion Technologies: Until 1993 there were at least six boilers using rice husk as fuel in Vietnam, which provided heat supply to paddy dryers. They were less efficient and built on low costs too. At the end of 1999, in framework of a program financed by the Government of Australia, a 50 kW rice husk fuelled cogeneration system has been installed at the Food Milling & Processing Enterprise No.2 (in Long An province) as a demonstration plant. The cogeneration system provides 50 kW of power output and heat for 3 paddy dryers. First results of testing operation show that the cogeneration system is operating with the parameters lower than actually designed. It is of consensus that this plant continues its operation for further time though no concrete conclusions can be declared of its current lag in efficiency and the decisions of implementations of similar technologies in the future.

The fluidized bed boilers using rice husk, coffee husk and bagasse as fuel have been studied, designed and installed in some places in Vietnam. They were used only for drying crops. However, the number of installed boilers is not many, and the evaluation of their performance is not available.

Almost all medium and large scale sugar mills (>500 TCD) in Vietnam have their own cogeneration systems that provide their electricity and steam demands during milling operations. Up to now, more than 40 cogeneration systems with a total electric capacity of around 150 MW have been installed in large scale sugar mills. The fuel used for the boilers in the sugar mills is bagasse. The designs vary from boiler to boiler, though most of them are fluidized bed types. Most of the existing boilers in sugar mills in Vietnam are imported. Local manufactures cover only a small portion on this market. The efficiency of these boilers varies between 45% for old boilers, to 75% for new boilers with good maintenance and operation conditions. The boilers' parameters are different from each sugar mill, however most of boilers have working pressure range from 18 to 25 bar and steam temperature range from 300 to 400^{o}C. Table 2 shows some characteristics of boilers in few of the sugar mills of Vietnam.

Table :. Boiler characteristics in some sugar mills of Vietnam

No.	Name & capacity of factory	Boiler capacity (ton/hour)	Pressure (bar)	Boiler temp. (^{o}C)
1	Tuy Hoa (1.250 TCD)	2 x 10	20,6	350 max
2	Ea Knop (500 TCD)	2 x 10	24,5	400 (saturated)
3	Khanh Hoa (500 TCD)	2 x 7	20,0	120
4	Binh Duong (1.250 TCD)	2 x 25	18	360
5	La Nga (2.000 TCD)	2 x 35	22,0	365
6	Bourbon-Tay Ninh (8.000 TCD)	1 x 220	45	440 (saturated)
7	Hiep Hoa (2.000 TCD)	1 x 25 + 1x 22	18 & 22	340 & 360

Source: Enerteam's survey

In the recent years, several local equipment manufacturers have been pushing up the production of the boilers for sugar industry. Vietnam Boiler Company, a society under the Ministry of Agriculture and Rural Development, is the leader in this field. Up to now, the Vietnam Boiler company fabricates the boilers that use coal, oil, saw dust, wood or bagasse as fuel with a capacity range from 0.1 to 10 T/h and steam working pressure range from 8 to 18 bar.

All turbo-alternators are imported. At present, there has been no local manufacturer identified capable of fabricating steam turbines and power generators.

Biomass Gasification Technologies: In Vietnam, biomass gasification received wide attention in the early 1980's due shortages imposed by petroleum products. The gas produced from wood gasification was used as supplementary fuel for internal combustion engines in buses.

Using gas produced by rice husk gasification for electricity generation was developed in the south of Vietnam since 1980s. There were about 15 such installations with capacities of 75 kW-each in the provinces of Mekong River Delta, and Ho Chi Minh City. However, the technology was neglected in other provinces due to the improved situation of petroleum and electricity supply, and the more economical and practical utilization of rice husk for other purposes overruled further decisions (brick making, potteries). The last power generator using rice husk gasifier (120HP) has been closed down in 1995 due to its drawback in technology [6]. Recently, Institute for Post-Harvest Technologies has designed and manufactured some pilot rice husk gasifiers. The gas generated from the gasifiers is used as fuel for food dryers. In general, the biomass gasification technologies are still at a nascent stage of market acceptance in Vietnam due to which the experiences gained here has been subsequently low even for the biomass experts.

Recently, the technology of producing electricity by rice husk gasification has been implemented in some parts of Mekong River Delta by a Chinese manufacturer which has been commercialized in this country. Specific rice husk consumption is about 2kg to produce 1kWh of power. The average system has a capacity ranging from 400kW to 1000kW.

POTENTIAL FOR BIOMASS-BASED POWER GENERATION IN VIETNAM

As shown in the Table 1, without taking into consideration, the potential of biogas, the largest biomass fuel source is paddy straw, which accounts for around 64% of total biomass sources in Vietnam. This residue has been used for multiple purposes traditionally over a long time for purposes such as cooking fuel in rural households, as the livestock's feed, as dunnage of the fruits for anti-shock during transportation, as fuel in brick-kiln or paddy-dryers, etc. In the southern provinces, where paddy straw is abundant, a large amount of straw is used as bio-fertilizer by direct burning on the field. Although the energy potential of paddy straw is very high, it is still not exploited widely for power generation purposes. The main reasons attributed have been difficulties in logistics of the same.

The second largest biomass source is firewood (about 14% of total energy from biomass). As of now, firewood is used as a main cooking fuel in households in rural areas of Vietnam. Besides, it is also a preferred fuel in many commercial and industrial activities such as bakeries, small restaurants, handicraft foundries (cast-iron, copper, etc) handicraft brick-kilns, pottery kilns, glass furnaces, steam boilers in individual textile establishments, distilleries, etc. The demand for firewood specific to these activities is so high that they often cause irregularities in supply. Obviously, the firewood is not a possible potential resource for electricity generation in the next few years.

Maize husk, cassava stem, cane trash, peanut shells, coconut shells and coffee husk are also used partly as fuels or fertilizers at household levels and the remaining are just not used for any other purposes. In industrial level, using them for power generation faced big problems, mainly due factors like their scattered and limited availability.

The other biomass sources such as wood residues in sawmill, paddy straw, rice husk and bagasse qualify as potential resources for electricity production in the future. Up to now, despite the availability of large processing quantity, the total power capacity that those sugar mills sold to EVN grid was only about 16MW. This shows a large hidden potential in expanding power capacity to sell surplus power to the grid which if effectively exploited could reach 150MW. Moreover, if the remaining sugar cane (25% or 44 thousand TCD) that is being under processed as of now by small, handmade, when processed by efficient plants can generate power upto 132MW of which, an excess of 77MW of power could also have been sold to grid.

Table 2 summarizes the potential of some biomass resources that can be exploited in the near future.

Table 2: Potential Resources for Power Production from Biomass Residues in Vietnam (2002)

No.	*Agro-Industries residues*	*Estimated amount of residues*	*Technical Potentials*		*To be exploitable in the near future*	
			(MW)	*(GWh)*	*(MW)*	*(GWh)*
1	Paddy straw	12.94 mil. ton	690	4,970	530	3,800
2	Rice husk	6.81 mil. ton	378	2,724	50	250
3	Bagasse	5.5 mil. ton	282	845	150	450
	Total		1350	8,539	730	4,500

Source: compiled by author

It is suggested that commercial exploitation of these biomass should be focused in larger geographic areas closer to the cultivation areas. In the case of paddy straw, the concentration should be in provinces adjacent to the Mekong River Delta (Kien Giang, An Giang, Can Thơ, Dong Thap, Long An, Soc Trang) supposedly having higher density of biomass.

Currently, in the programme of increasing rice quality in Mekong River Delta, The Vietnamese government has plans to invest in some provinces like Kien Giang, An Giang, Long An and Can Tho to incorporate complete rice processing systems including

storages, dryers and mills. However the types of energy systems have not been mentioned. The application of cogeneration system to utilize the rice husk as fuel to provide energy for drying (steam) and milling (power) could be considered a good option.

BARRIERS TOWARDS SUCCESSFUL DISSEMINATION OF BIOMASS ENERGY TECHNOLOGIES IN VIETNAM

There are several barriers towards successful dissemination of biomass energy technologies in Vietnam:

(1) Lack of an adequate policy and regulations to purchase power from small power producers. Studies carried out showed that the stand alone bagasse and rice husk fuelled power plants were uneconomical. Although Electricity of Vietnam (EVN) is purchasing electricity from several private power companies, up to now, the regulations to purchase power from private power producers are not issued. Power purchasing contracts between EVN and the private power companies are negotiated case by case basis. The policies, regulations and procedures for encouraging renewable energy in general and biomass energy in particular are required to level the playing field with conventional generation.

(2) EVN often thinks that the extension of electricity network to cover widely the country and the construction of big central power plants are the economical ways for development of power sector in Vietnam. This is a clear indication that the EVN is not interested in promoting the small power producers.

(3) Low electricity prices: normally, EVN purchases electricity from the private power companies with prices less than their average tariffs. Currently, the EVN's average tariff is about 5.5 US cents/kWh, but the selling price of the electricity from private small power producers to the EVN is only around 4US cents/kWh. The low selling price of generated power leads to longer payback period of biomass power projects. This will also not attract the investment of the private power producers.

(4) Lack of capital availability: At the present, most of the rice mills and sugar mills are facing difficulties in investment capital. It seems that their main investment objective is to improve equipment in order to increase the product quality and to reduce operation costs.

(5) Lack of updated information on biomass energy technologies: Most of sugar mill and rice mill managers do not have updated information on biomass energy technologies. They still think that the investment costs of biomass power plants are very high, which leads to the high price of electricity produced. The dissemination of biomass energy technologies in Vietnam is very limited until now. Several workshops and seminars on biomass technologies were organized by energy related consortiums and EC-ASEAN COGEN3 Programme in Vietnam, with main participants being government officers, researchers and engineers though not any of the potential biomass power producers attended. Furthermore, up to now there is not any pilot project which demonstrates the feasibility of a biomass power project due to which its advantages and

disadvantages obvious to the industries and power sector investors could not be showcased.

(6) Lack of the technical knowledge and skills to implement biomass power project are also reasons for hindrances. Besides, there is lack of availability of right kind of equipment such as condensing turbine generators to carry out such projects and also a lack of contractual vehicles to facilitate the project financing and implementation. In order to reduce the specific investment costs of biomass power plants, the conversion of existing boilers from 10-25 bar to higher pressure boilers (45 bar or higher) is necessary to specifically cater to the existing market needs.

(7) Local biomass energy technology is not yet available. Importing of expensive equipment leads to higher investment cost while the selling price of electricity is still low leading to prolonged payback period.

PROMISING SIGNS FOR PROMOTING BIOMASS POWER PROJECTS IN VIETNAM

Possibility of selling power to EVN at higher price

In the recent years, it required a 2.17% increase in power sale to have a corresponding 1% increase in GDP. It shows that EVN has to deal with the pressure of increasing capacity of power source to satisfy the demand. Therefore, EVN has some flexible schemes to lighten the burden of investments in new power projects.

- Encouraging independent power producers: in 2002, 612 MW from independent power producers (IPP) has been purchased, satisfying 7% electricity demand of the whole country. Total power purchased in 2002 reached 2.1 billion kWh at the average rate of 923.5 VND/kWh (0.59 UScent/kWh) [5]. However, the selling price is negotiated case by case, depending on power capacity and electric capacity. Presently, there are two BOT power plants that sell electricity to EVN (Phu My 2-2, Phu My 3) and other five power plants are under construction still to negotiate about selling price.
- Opening the electric market: EVN is formulating laws pertaining to electricity sector and also a five-year action plan towards the re-construction of electric market. This scheme is aimed to encourage IPPs in improving the efficiencies of own power plants to sell more electricity at a suitable tariff. An announcement by EVN on 21/8/2003 has highlighted that the power plants which belong and the ones that do not belong to EVN are all treated the same in offering the selling price of power to the grid.
- Raising the electricity tariff: in order to have enough capital for the new-investments to new power sources, electric tariff is increasing during the past years to a considerably high level. At the present, this average tariff is about 5.5 US cents/kWh. In the coming year, power tariff will be adjust and is widely expected to reach 7 US cents/kWh by Jan 1st, 2006

New policies encouraging renewable energy use in Vietnam

Up to now, Vietnam still develops the power sector based on the conventional power sources: hydro power, coal fired, oil fired and gas fired power plants. The renewable energy sources are often discouraged that them not being reliable and more expensive when compared to the other energy sources. The new power plants tend to have a big capacity following the philosophy that bigger is better.

In the recent years, through new attitude towards renewable energy, Vietnam has begun to pay attention to the possible benefits posed by renewable energy technologies particularly like lower investment costs and reduction in environment pollution. These concerns have been exposed through some decisions.

- The Prime Minister's Decision dated 13 February 1999 stated that the rural electrification should be implemented in a combination between the extension of the national power grid and the development of the local power sources such as small hydro power, wind power, solar power, biomass/biogas power, etc.. based on the evaluation of project costs and other related factors, and on the selection of an optimal alternative. It should thoroughly implement the joint-implementation scheme (Government and people, central and local) in order to mobilize various capital sources for investment in the rural electrification projects.
- The other Prime Minister's Decision dated 22 June 2001 also stated that it should classify the rural to the areas where could be electrified by national power grid, and where should be electrified by local power sources such as diesel generators, small hydro power, biomass/biogas power, solar power and wind power. These households locate in the remote areas where the connection to the grid is impossible or ineffective. Even in the rural areas where being connected to the national grid, the attention should be paid on the development of decentralized power sources if they are economically effective.
- The Prime Minister's Decree No.102/2003/ND-CP date 3/9/2003 about Energy Conservation also stated that it is necessary to conserve fossil fuels (coal, oil, natural gas) through the promotion of renewable energy.

Promotion of R&D programmes and projects relating to biomass energy use

Several R&D programmes on biomass energy technology have also been perceived.

- On 22 August 2001, Ministry of Science, Technology and Environment (MOSTE) held a meeting to evaluate and select organizations, individuals to lead a national-level research program namely "Research and Selection of Technologies and Equipments to exploit and to use the renewable energy sources in processing of agricultural, forestry and sea products, in rural areas for environmental protection". The program will focus on research, design and manufacture of three products (i) small hydro power units of 0.2 to 200 kW, (ii) wind power turbines of 500 to 1,500 W, and (iii) small scale furnaces/boilers using agricultural wastes and agro-industries residues as fuel. The implementation time should be 36 months (to the end of 2004).

- A national research program, lead by MOSTE about studying and selection of technology and equipment to exploit renewable energy sources. This program aimed at studying, designing and fabricating small hydropower turbines (0.2 to 200kW), wind power turbine (0.5 to 1.5kW) and small scale kilns using biomass residues as fuel. The program initiated in 2001 and expected to finish in the end of 2004.
- A technical assisting project lead by MOI about Promotion of Renewable Energy, Energy Efficiency and Greenhouse Gas Abatement (PREGA) has also been started. This project concentrates on the (i) development of a list of investment for projects of renewable energy, energy efficiency and greenhouse gas abatement (REGA) (ii) preparation of national studies on the relevance policies and regulations to promote REGA technology, (iii) development of suitable financial models for the REGA technologies, and (iv) establishment demonstation projects for REGA and evaluation of those projects.
- A project of strengthening the effectiveness, equitization and renewable energy for the period of 2002 – 2007, supported by GEF2 and leaded by EVN/MOI, also mentioned about the development of hybrid power system, incoporate with renewable energy for 20 communes in remote areas.

In concrete, Vietnam has opened the door for the development of renewable energy in general, and biomass energy in particular.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

(1) Vietnam has an immense potential for energy production from various biomass sources. Biomass energy potential is estimated at 1,430 MW by 2002, and could supply 9,020 GWh of electricity annually. The possible major biomass sources likely to be exploited in the near future for power production are paddy straw, rice husk and bagasse. Their estimated potential is 730 MW, and could provide 4500 GWh of electricity yearly
(2) There are certain barriers which must be overcome, especially the lack of policy and regulatory framework to promote the biomass power production, and lack of accessibility to finance for project developers;
(3) With the ongoing activities related to biomass, Vietnam has begun to realize the economical benefits of using renewable energies in general and biomass energy in particular, and
(4) Many international financing institutions such as WB, ADB, etc. are supporting Vietnam in research, development and implementation of renewable energy projects which could further aid in promoting the utilization of renewable energy resources.

[2] Global Environmental Fund

Recommendations

(1) The Government of Vietnam should prepare adequate policy and regulatory framework to encourage biomass energy production and to improve the accessibility to financing for small power producers;
(2) Promoting research and development of the biomass energy technologies in Vietnam to reduce the imported equipment cost; (3) Dissemination and capacity building of biomass energy technologies in Vietnam through demonstration projects and organizing workshops, seminars and training courses catering to all stake holders in this field (4) Vietnamese government to develop institutional markets for biomass power plants, and (5) The private sector participation should be encouraged.

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