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Potential evaluation study and application method for biomass energy from agricultural by-products (rice, corn, peanut) in Namdinh Province

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Abstract. Namdinh is a big agricultural province in Red River delta of North Vietnam, where were planted three main agricultural products: rice, corn, peanut. By case-study investigation and energy analysis, the report put out detail information on biomass energy of rice straw, rice husk, corn straw, corn core, peanut straw and total biomass energy from agricultural wastes in Namdinh province. According to investigation data, yearly the total agricultural wastes in Namdinh province is more than 11 million tons. Most of this agricultural wastes in Namdinh province are not collected and used at current time, it is mean that: Namdinh peasant dissipates a lot of biomass energy every year. In theory, 1 ton of corn by-products generates 477 kWh of electricity; 1 ton of peanut by-products generates 450 kWh of electricity; 1 ton of husk by-products generates 460 kWh of electricity; 1 ton of straw by-products generates 447 kWh of electricity. In comparison with coal, using husk and straw as fuels is more economical effectively. The report aslo have proposed and chosen technological method of electricity production from husk and straw. This method is fluidized sand-bed combustion technology. Ash after being burned can be used as additive for industrial production of cement and bulding materials.

Keywords: Biomass energy; By-products; Straw; Husk, Agriculture.

1. Introduction

Today on a global scale, biomass is the fourth source energy in large (average contribute is about 35% of the total energy supply). Therefore, biomass energy (BE) hold important role in meeting energy needs of the world in the future. Using BE help to reduce the amount of waste and waste reduction of greenhouse gases, help to protect the environment. On the world, many countries are expanding trend using biomass [3,5]. Unlike other forms of renewable energy, BE can not only control but also simultaneously provide both heat and electricity production. Biomass source very diverse and rich, therefore BE technology is also very diverse and can be divided into 2 types: technology of biomass conversion directly into useful energy and technology of biomass conversion into secondary fuel.

Namdinh, a province of Vietnam, in the natural conditions favorable for development of

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agriculture so the annual amount of by-products in agricultural cultivation are very large and very diverse in components. However, until now there is no research project which evaluated a specific quantity, composition, and especially the potential use of biomass in the most appropriate way.

This article gives some results of the investigation, surveys, assesses the potentials, and proposes projects include technology of BE application used to generate electricity in order to contribute to solid waste processing and reduce use of fossil fuel resources in rural Vietnam today.

2. Objects and methods of research

Object of research: The agricultural by-products after harvest (straw, husk of rice, corn leaves and core, peanut straw) in Namdinh province.

Collection documents and data: documents and data for research were received from reports of scientists of the Department of Natural Resources and Environment, Department of Statistics, Namdinh province. The data were collected from the interviews and surveys at the household of some communes of Hai Hau and Vu Ban districts of the province.

Analysis samples in the labor... analyses of moisture, ash cont..nt, tc... of carbon, and quantity of heat are ... Moisture and ash content of the sa... determined by the method of weigh... total amount of cacbon is determi... method Churin; quantity of heat is de... by calorimetric bomb.

Analysis and synthesis documents: basis of collected materials and the re... surveys and interviews, it is evaluate... of collection and use of rice by-prod... calculated the potentials of BE in ... province.

3. Results and discussion

3.1. Status of cultivation of some ag... plants in Namdinh province

- Status cultivation of rice [1]

Namdinh is home to varieties of rice such as Tam Xoan, Tam Tieu, Nep Ba Cai Hoa Vang. These varieties of rice high investment cultivation and provi... very high productivity, but the value of ... times compared to regular rice as we... yield, and rice production in Namdinh p... in 5 years are shown in Table 1.

Table 1. Area, yield, and rice production in the years 2004 - 2008

Year	Area (ha)		Yield (centner/ha)		Production (1000 ton)	
	Rice season 1	Rice season 2	Rice season 1	Rice season 2	Rice season 1	Rice season ...
2004	80913	82059	68,75	47,51	556305	389864
2005	79953	81064	69,60	53,10	556461	430473
2006	78329	79967	69,92	29,37	547671	234878
2007	77618,5	79650	70,55	52,31	547575	416684
2008	77021	79052	67,11	52,48	516875	414894

Sources: Annual statistic of Namdinh province, 2009.

By 2015 the use of rice growing land in the province each year is 82813,9 hectares, including field of 3 seasons of 34765,1 hectares, field of 2 seasons of 48,048.8 hectares with different varieties of rice capable of bearing against the weather conditions and insect diseases such as: Q5, Luong Quang, Khang Dan, Tap Giao... In addition, there are eight varieties of rice, glutinous rice sown in the land undigested water.

- Status of corn cultivation

On the territory of Namdinh province some of sticky corn plants are grown quite popular. Usually sown in September, harvested in December. Current status of corn cultivation in the province is reflected in the Table 2. Trend to 2015 the total area of planted corn is 6000 hectares.

Table 2. Area of cultivation and corn production in the Namdinh province

Year	2000	2005	2006	2007	2008
Area (ha)	3407	4115	4744	5104	4144
Production (ton)	10892	15627	18672	19659	17086

Sources: Annual statistic of Namdinh province, 2009

- Status of peanut cultivation

According to statistics reported by the Department of Agriculture and Rural Development of Namdinh province in 2007, the area of peanut 6000 - 7000 ha (including the 3 season: Spring, Summer-Autumn, and Winter), average yield 33 - 35 centner/ha, the individual spring 2007 average yield was 38,75 centner/ha. Peanut plants were planted at the direction of cultivation, mainly new varieties originated from China. Cultivation area and harvest yeild in recent years are shown in Table 3. Trend area of planted peanut in 2015 in the province is 10000 ha.

Table 3. Area of cultivation and peanut production in the Namdinh province

Year	2000	2005	2006	2007	2008
Area (ha)	3739	6115	6442	6788	6808
Production (ton)	11024	21788	22722	24855	24232

Sources: Annual statistic of Namdinh province, 2009

3.2. Status of collection and use of by-products of agriculture plants (rice, corn, peanut)

- Status of collection and use of rice by-products

The by-products after rice harvest are straw, husk. The data collected on the harvest and at the husking rice to determine the average mass of by-products are given in Table 4.

Table 4. Total mass of rice by-products in Namdinh province in 2008

Plantation	Area (ha)	Production (ton)	Agricultural waste	Mass (ton /ha)	Total mass (ton/year)
Rice	156073	931769	Straw	4,8	749150,4
			Husk	14,7	226305,8

The results in Table 4 are not much difference from the data investigated by farmers in 2 typical districts of Namdinh province, Hai Hau and Vu Ban. Specifically, on average, every 100 kg of paddy equivalent to about 70 kg of dry straw and when husking it creates 25 kg of husk.

Rice stubble is used to get burned ash as fertilizer or disposal or increase up humus content of land.

Straw is used for cooking (straw ash used as compost) or food for buffaloes, cows; or used the material to grow mushrooms (fungus fat, straw mushrooms, wood ear fungus with

productivity of 285kg fungus/1 ton straw). In addition, straw is also used to mix with the animal manure as the organic compost; some local territory use the straw to cover the soil when planting vegetables aim to avoid too high temperatures or heavy rain, keep the soil moisture, keep soil from erode by washing drift... When the straw burned, it creates large smokes and dusts cause harm not only to human health, vegetation, but also impact on safety for participants in traffic; when cultivating it creates the amount of CH_4 gas influencing on the environmental air. Model of mushrooms planting has its own advantages and difficulties in particular.

The amount of husk received from the paddy husking is large. A part of husk was sold to people as a material for cooking, compost... the rest are put to the dumping place that cause environmental pollution. Currently the province has not effectively utilized this raw material.

- Status of collection and use of corn by-products

The secondary products from corn plants include: the stem, leaves, husk and core. When harvest the corncob is often collected separately, and the stem and corn leaves are exposed to dry at the field (approximately 90%), when dried they are taken home, put into heaps in dry place. The collected data in the harvest field to determine the average mass of the by-products are given in Table 5. The amount of by-products by actual calculations in Table 5 and data through surveys from farmers are not much different.

Table 5. Total mass of by-products from corn plants in 2008

Plantation	Area (ha)	Production (ton)	Agricultural waste	Mass (ton /ha)	Total mass (ton/year)
Corn	4144	17086	Stem, leaves	6,4	26521,6
			Core	2,3	9531,2

Table 6. Total mass of by-products from peanut plants in 2008

Plantation	Area (ha)	Production (ton)	Agricultural waste	Mass (ton /ha)	Total mass (ton/year)
Peanut	6808	24232	Stem, leaves	2,8	19062,4
			Shells	4,5	3063,6

Dry corn stem and leaves are used as a material for cooking or a very good food for cattle because corn stem have a high content of fiber (31,5%), crude protein (7,6%) and saccharin powder higher compared with straw [11]. Corncobs after harvest are peeled away from leaves and husk. Most fresh husk are dried as a material to cooking, only a part of corn husk is used as food for cattle. Corn core obtained after separated from corn seeds often are thrown away or dried as a material for cooking.

- Status of collection and use of peanut by-products

Secondary products from peanut plants include: the stem, shells and leaves. Stem and shell are collected after the peanut harvest. Peanut is dried for storage. Peel and seeds have been separated by machine or manually. The data collected in the harvest field to determine the average mass of the by-products are given in Table 6. The amount of secondary products by actual calculations in Table 6 and data through surveys from farmers are not much

:e. Peanut stem and leaves can be cut 15 cm length, and then cultivate down to the green compost. A part of peanut dried as a material for cooking. In , because the fresh peanut stem and ave high content of protein should they e wrapped up as a reserve food for cattle. Peanut shells have mainly used as a material for cooking.

From the data received in Tables 4, 5, 6 and data on the area of cultivation of rice, corn, and peanut by 2015 in Namdinh province, we can predict the amount of by-products obtained in 2015 (Table 7).

7. Prediction of total mass of by-products of some agricultural plants in Namdinh province in 2015

ntation	Area (ha)	Agricultural aste	Medium mass of dry matter (ton /ha)	Total mass of dry matter (ton/year)
:e	165627,8	Straw	48	7950134,4
		Husk	14,7	2401603,1
n	6.000	Stem, leaves	63,6	382800
		Core, husk	22,5	135000
anut	10.000	Stem, leaves	27,8	278000
		Shells	4,5	45000
		Total		11192537,5

Proposed project of using BE technology of roducts from rice, corn, peanut

Energy value of by-products from rice, peanut

nergy/calory value will show the value of producing of by-products. Based on the nate percentage received by-products e analyzed by the heat of the bomb with 4 ples by the corresponding rate:

- Corn: 25% core and peel + 75% stem and leaves;
- Peanut: 15% shell + 85% stem;
- Husk: 100% husk;
- Rice straw: 35% straw + 65% root

The results of analysis are presented in Table 8.

Table 8. Energy/calory value of by-products of rice, corn, peanut at burning pressure of 3000 kPa

Analysis sample		Corn	Peanut	Husk	Straw
Dry mass before burning (gr)	First time	1,0065	1,0220	1,0251	1,0243
	Second time	1,0059	1,0198	1,0212	1,0251
	Third time	1,0071	1,0226	1,0236	1,0222
Energy/Calory	First time	4102,5929	3875,1348	3955,8862	3851,9790
(Cal/gr)	Second time	4096,7651	3863,2762	3927,6125	3866,5978
	Third time	4113,3127	3891,0761	3964,7619	3832,7656
	Medium	4104,2236	3876,4957	3949,4202	3850,4475

Inaccuracy of analysis results in table 8 is significant. Results of analysis and total nount of carbon of by-products (rice, corn, peanut) show that total amount of carbon occupied high rate (about 38,5%). When burned the mainly waste gas will be CO_2. Thus, to

calculate the effect of the environment it is need to calculate and determine the methods of technology that significantly reduce the amount of this waste gas.

- *The scheme of technology of heat and electric generator*

The agricultural by-products from rice, corn, peanut can be used as fuel in heat-electric generator according to the scheme as suggested on Fig. 1, includes the equipment: furnace, boiler, turbine, electric generators, heat exchanger, dryers and other auxiliary parts [2,5].

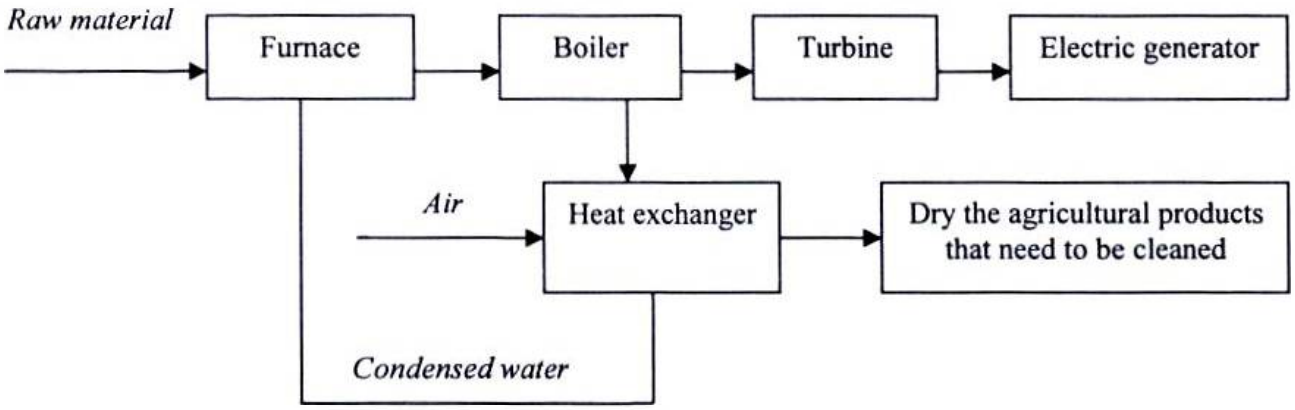

Fig. 1. The scheme of furnace system of bed combustion of heat and electric generator.

Working principle: Water is provided to the boiler by pump system, fuel (husk, straw) are loaded into burning furnace. The burning process in furnate creates a heat supply for boiler and pull turbine to turn the electric generator to supply the power to dryer (or husking). Source gas (heat) from turbine (second gas) is used for drying agricultural products.

Estimated potential ability to provide electricity from biomass of rice by-products: Based on the data analysis of heat/calory (Table 8), 1 ton of husk by-products generates 460 kWh of electricity; 1 ton of corn by-products generates 477 kWh of electricity; 1 ton of peanut by-products generates 450 kWh of electricity; 1 ton of straw by-products generates 447 kWh of electricity.

Based on the data of by-products collected in 2008 (Tables 4, 5 and 6) in Namdinh province there are about 1,040 million tons of which 0,750 million tons of straw; 0,230 tons of husk; 0,030 million tons of stem, leaves of corn, 0,010 million tons of core; 0,020 million tons of stem and leaves of peanut; 0,003 million tons of peanut shells. If the whole of these by-products are used to be converted into electric energy, it would generate: $447 \times 0,75 \times 10^6 + 460 \times 0,23 \times 10^6 + 477 \times (0,03 + 0,01) \times 10^6 + 450 \times (0,02 + 0,003) \times 10^6 \approx 466 \times 10^7$ kWh/year.

And accroding to calculations of actual performance of the equipments from the start line to the end of the heat-electric generator as proposed (Fig. 1) 12%, we can calculate the total electrical energy of using the whole volume of by-products collected from rice, corn, peanut on the territory of Namdinh province in 2008 approximately is about $466 \times 10^7 \times 0,12 = 559 \times 10^6$ kWh/year.

Similarly, one can get the total electric energy from by-products of rice, corn, peanut estimated in 2015 if they are used as fuel for producing electricity-heat is about 606×10^6 kWh. While the total power consumption of Namdinh province in 2008 is 587×10^6 kWh.

- *Choosing the burning furnace*

Practically there are generally 4 types of burning furnace of by-products such as basic fixed furnace, moveable furnace, boiling furnace of bed combustion, turning furnace. Burning furnace is chosen as FBC (Fludized bed Combustion) have more advantages than the other furnace: high burning strength, stability, low remaining of volume cacbon in ash; it can burn the fuels with moisture, high level ash, and low heat/calory (Fig. 2).

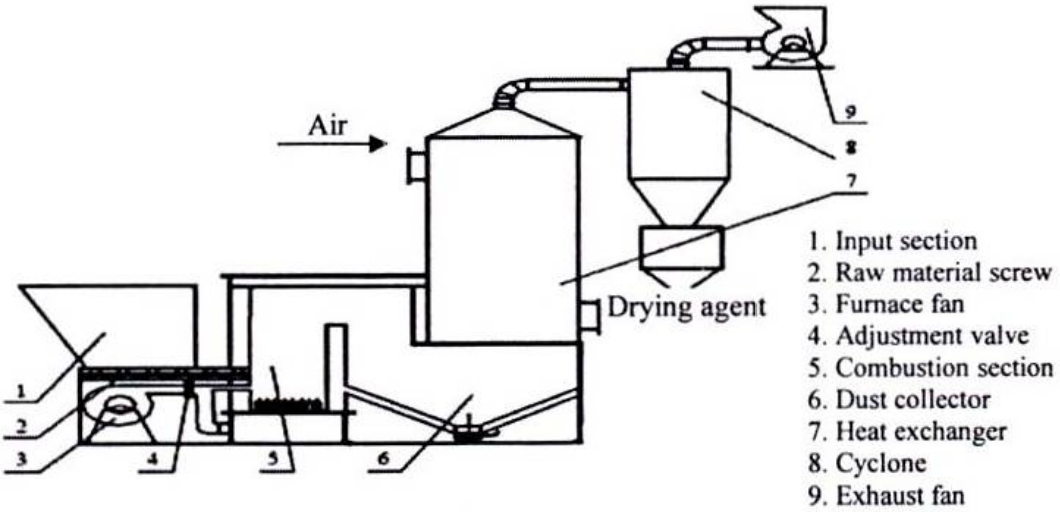

Fig. 2. The scheme of structure of FBC.

Fuel is burned in combustion section 5. Using high-pressure fan 3 and exhaust fan 9 makes the pressure change in furnace and ensures proper sand boiling as required. Elementary and secondary air line to keep the burning process is provided by high pressure fan 3. Elementary line is provided through the spray pipe. Second line is above the level of sand surface to provide more oxygen to help fuel burn better. Ash is settled in dust collector 6, the furnace gases come into heat exchanger, transfer heat to the air forming the drying temperature or supply heat to boiler.

By-products has been burned completely in FBC furnace, mainly gas waste is CO_2, there is only a little amount of SO_2 gas (Table 9).

Table 9. The amount of waste gases while burning rice by-products and coal [3]

Waste gases (kg/ton)	Husk	Straw	Coal
CO_2	40 – 82	30 – 77	200 – 220
SO_2	0,5 - 1,5	0,3 - 1,8	28 – 30
NO_x	-	-	9 – 11

4. Conclusions

- In the recent years in Namdinh province, sources of by-products from rice, corn, and peanut were about 1,040 million tons (in 2008) of which 0,750 million tons of straw; 0,230 million tons of husk; 0,030 million tons of stem, leaves of corn, 0,010 million tons of core; 0,020 million tons of stem and leaves of peanut; 0,003 million tons of peanut shells but until now they have not been collected and used effectively. Potential electricity energy of Nam Dinh province from this biomass source average in one year (2008) generated approximately 559 x 10^6 kWh.

- Estimating in 2015, total mass of by-products from rice, corn, peanut in the whole province is about 1,130 million tons of which about 0,800 tons of straw; 0,240 million husk; 0,040 million tons of stem and leaves of corn; 0,015 million tons of core corn; 0,030 million

tons of stem and leaves of peanut; and 0,005 million tons of peanut shells. Potential electricity energy from biomass source in 2015 is approximately 606 x 10^6 kWh.

- Comparing to coal furnace, after using secondary agricultural products as fuel for the FBC it can reduce the amount of CO_2 into 3-6 times and SO_2 into 18-20 times. This is a great ability to apply the system of Clean development mechanism (CDM) under the Kyoto Protocol.

- Ash after being burned in furnace with bed combustion of high content of SiO_2 can be used as additive for industrial production of cement and bulding materials.

- The use of secondary rice products as fuel for heat and electricity generator means a lot for environment and local economic sociaty: contribute the resolve of waste fuel from the biomass; reduce wastes caused environmental pollution; resolve employment problem for people; increase income from the collection and sale of these by-products.

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