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Development of Biomass Resource Conversion Technology in Vietnam

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***Abstract*—Before the situation of traditional energy reserves on ports decreased, people now focus on researching, exploiting and applying new energy sources. These energy sources are considered clean, renewable energy and they do not pollute the environment. In these energy sources, biomass (biomass) plays an important role to produce biofuel gradually replacing traditional fuels. The article summarizes the results of research and development of mining technology - effectively processing diverse and abundant biomass resources of Vietnam. Along with methodological contributions, basic studies supplement the database of biomass resources. On that basis, it contributes to saving energy, promoting biogas production, syngas from biomass gasification for generators, heat utilization or biodiesel production, environmentally friendly bio-petrol. Ensure the goal for sustainable development, against climate change when energy security issues in Vietnam are threatened.**

***Index Terms*—Biomass energy, conversion technology, biomass resources, biodiesel production.**

I. Introduction

Facing the instability of oil prices, the anticipated exhaustion of fossil fuel resources around the world, forewarned environmental disasters, countries and scientists are trying to find solutions. New method to put renewable energy into the use [1][2]. Among these types of energy, bioenergy is considered one of the most reliable sources of energy because of the CO_2 cycle it produces [3].

Biofuels can be produced from a variety of fuels: starch, synthetic gas, Cellulose (ethanol, butanol) [4], oil, fat, microalgae (biodiesel), animal waste (biogas) [5][6], ... in which starch and cellulose are believed to be the most potential in terms of reserves and applicability of the product [7].

For many countries including Vietnam, starch is still considered an important food source[8]. The tradition of using starch in many places does not agree with the use and use of them as industrial fuels[9]. However, the use of starch produced into fuel is relatively easy, the product cost is low [10][11].

Vietnam is a developing country mainly based on agriculture and forestry, so the potential of energy from biomass is very diverse and has a large reserve [12]. Therefore, in Vietnam, the research on the use of energy from biomass gradually replaces fossil energy sources that are of interest to state agencies and scientists [13][14].

Biomass used for bio-oil production is plant biomass, including: wood, grass and agricultural crops, identified as a renewable energy source [15][16]. The main chemical composition of biomass includes cellulose, hemicellulose and lignin [17][18]. The major elemental components of biomass are hydrogen, carbon, oxygen; whereas sulfur and nitrogen elements can be present in very small quantities [19][15].

With diverse applications of bio-oil, today scientists around the world are focusing on research to complete theoretical basis and experimental study of biomass pyrolysis process to improve the efficiency and quality of recovered bio-oil [20][21].

The energy source from biomass is mainly used from combustion, gasification and pyrolysis [22]. In particular, the combustion process has the highest efficiency, the gasification process works in high temperature conditions [23][24]. The downside of these two processes is that the generated energy is used locally, cannot be stored and transported [25][26]. Meanwhile, the pyrolysis process works at lower temperatures, the desired product of the fast pyrolysis process is liquid called bio-oil which is very convenient for storage and transportation, used in the transportation industry, providing heat, producing electricity.

From biomass sources are converted into other forms of energy such as electricity, heat, steam and fuel through metabolic methods such as direct combustion and steam turbines, anaerobic decomposition, gasification and heat stool. These types of energy are called biomass energy [27][28]. Biomass energy is considered renewable because it is added much faster than the additional speed of fossil energy that requires millions of years[29].

In this article, the authors will present a brief review of the biomass energy conversion process, with an emphasis on the production of gas fuels suitable for internal combustion engines [2][12]. The purpose of this production is to supplement the supply of methane rich gas produced by the anaerobic process of organic waste in waste treatment and residues [30][31]. Currently in developed countries, the gas produced from the decomposition of organic matter is widely used as fuel for power plants. Electricity produced in this form is considered as an environmentally friendly renewable energy source at competitive prices. The use of gas from organic matter dispersal also provides an opportunity to use waste to produce biomass energy, thereby helping to promote landfill waste disposal as a sustainable form of waste management [3][32].

Demand for energy use of Vietnam increases with economic growth and industrial development [21][33]. Vietnam's energy source is based mainly on coal and oil resources are gradually depleting in reserves and territorial waters. Hydropower is based on abundant water resources but 60% of water resources come from outside the territory

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[34]. In 2010, more than half of the nation's electricity capacity belonged to coal-fired thermal power, oil was the major source of CO2 emissions in Vietnam. Coal thermal power accounts for 18.5%, gas and oil thermoelectricity accounts for 36.6%. In the energy sector, coal-fired power plants generate 54% of CO2 emissions, gas-fired power plants contribute 40%. Each kWh of Vietnam's electricity emits 0.52 kg of CO2 (Ministry of Industry and Trade, December 2011, Carbon Recovery and Retention Technology Project) [35]. Vietnam has a lot of sunshine, rain, flora and fauna, diverse microorganisms grow fast. Looking at Vietnam's Statistical Yearbook, we can see potential biomass from rice, maize, sugarcane, cassava, coconut, coffee, rubber, oil crops, algae, aquatic resources and many natural sources. This article summarizes the researches on using biomass to create bio-energy sources, especially the generation source of biofuels of the second generation from waste biomass.

II. Potential of Waste Generation in Vietnam, Rate of Generation, Collection and Transportation

Biomass is all organic matter capable of biodegradation, vegetation, animals, terrestrial microorganisms, underwater, other organic substances and also waste biomass, biomass of forestry, agriculture, industry and daily life.

Biomass from agro-forestry waste: mainly Lignocellulosic biomass including cellulose, hemicellulose and lignin, small amounts of pectin, protein, chlorophyll, and inorganic waxes and minerals [20]. Organically structured fibrous cellulose with amorphous form easily decomposed by enzymes [36]. Hardwood has a lot of cellulose, rice, straw, leaves have hemicellulose with most mannose in soft bodies, xylose sugar in hardwood of agricultural waste [37]. In contrast to cellulose, hemicelluloses are easily hydrolyzed. Herbaceous plants have the lowest lignin, soft woody plants have more lignin so the structure is stable, less permeable, chemical resistant, biodegradable [38][39].

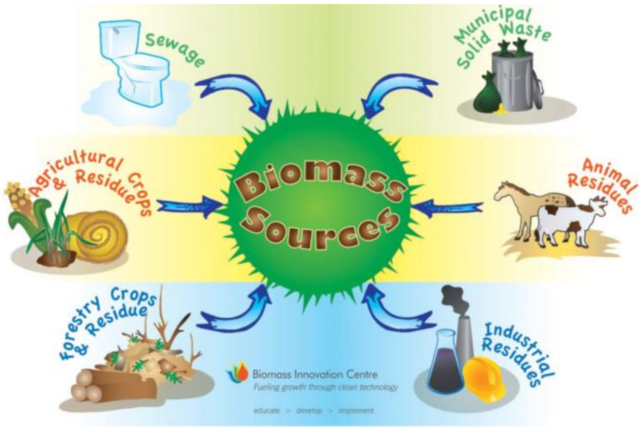

Fig. 1. Sources of biomass materials [38]

Biomass from livestock waste: Animal manure includes organic matter, moisture and ash. When decomposing CH4 aerosols, CO2, and organic matter are stable for soil and biogas fuel. The project 2010 has specifically evaluated the characteristics of biomass in Yen Lac - Vinh Phuc area with the rate of waste biomass generation, the ratio of TS dry matter, the ratio of VS volatile substances, C / N ratio, biogas birth rate of biomass of cow dung, pig, water hyacinth, tapioca processing waste water[40]. Appropriate anaerobic decomposition occurs when the C / N range of 25-30 can yield up to 20-30 l of gas / kg of cattle manure, pig manure with C / N of 12-15 is collected as 40-60l / kg, water hyacinth C / N is 12-25 births 0.3- 0.5 liters / kg, rice straw has a C / N ratio from 48 to 117 births 1.4-2liter gas / kg of raw materials. Estimated livestock waste biomass in 2010 is over 145 million tons / year.

City and industrial waste: is a huge organic biomass, generating over 80% in urban areas. The amount of urban solid waste generated has been studied in Hanoi and Ho Chi Minh City from 2004 to 2009, at the rate of 0.85 kg / person / day and 0.75 kg / person / day. Meanwhile, this ratio in Dong Nai, Ba Ria - Vung Tau, Hai Phong, Da Nang and Hue respectively 0.73; 0.7; 0.74; 0.72 and 0.6. This rate is expected to increase rapidly to over 1.3 kg / person / day in 2025. Study on the potential of methane generation from the landfill of Nam Son - Soc Son - Hanoi and Thuy Phuong - Hue for conclusion air berries up to 280 liters CH_4 / kg VS from domestic waste at landfills. Research on clean development mechanisms and sustainable technologies to reduce the greenhouse gas emissions of landfills for major cities in Vietnam has been addressed, with a focus on solutions to convert waste into energy. The results of the study on the potential of methane gas production from food processing waste obtained experimental results reached 0.35m3 CH_4 / kg COD.

III. Technologies for Converting Biomass Energy

Biomass can be converted into useful energy forms using a number of different processes. Factors affecting the selection of conversion technology are: types and quantity of biomass materials, technical requirements of products, economic conditions as well as other factors for implementation of each project. Biomass can be converted into three main product categories, of which two related to energy are electricity / heat and transport fuel, another is chemical materials.

Converting biomass into energy is done using two main technologies: thermal and biochemistry. In addition, there is another form to convert biomass into energy that is bio-gasoline production. However, bio-gasoline is not yet popular, but with increasing pressure on reducing emissions, reducing environmental pollution, especially in big cities, will change to the use of bio-fuels. in the near future[35]. Currently, there are four forms of thermal conversion: burning, pyrolysis, gasification and liquefaction. Biochemical transformation consists of two main forms: digestion and fermentation.

Converting biomass into bio-energy through: biogas, ethanol, biodiesel biogas, syngas is a sustainable low-carbon growth model. The survey investigation is linked to specific technology development: 1) Experimental determination of metabolism and influencing factors; 2) Develop an optimal problem; 3) Establishing calculation and experiment models, establishing optimal technological factors; 4) Compatibility testing; 5) Carry out technical research and design of biomass conversion equipment based on: heat transfer, mass transfer, hydrodynamic process. The device is studied and designed according to the principles of heat transfer, mass transfer and forward and reverse phase contact, through fixed or suspended layers for converting biomass into bio-energy and creating a calculation basis. transform scale, put research results into practice.

A. Research - develop gasification technology

In addition to waste biomass conversion to create compressed, pressed, direct burning fuels, waste gas gasification is an effective and environmentally friendly way to produce energy, convert solid biomass into gas fuel, less air pollution than coal burning due to low sulfur, application for generator engine, fuel combustion for boiler. The optimum working temperature of 700ºC has been found, the amount of oxygen is limited to not completely burn solid fuel. Synthetic gas is flammable fuel gas including H_2, CO, CH_4, CO_2, nitrogen, sulfur (small amount, depending on input), alkali and tar compounds are high calorific fuel sources. Air supply location, temperature, air and secondary feed rate affect the composition of syngas. When there is CO reduction reaction and water needs to burn / supply secondary heat. Concentrations of CO_2, CO, H_2 and CH_4 increase with the concentration of O_2 of the inlet air and how to maintain air flow. The composition of synthetic gas differs when the rate of secondary gas flow changes. With heat recovery and waste gasification and combustion technology, the KC03.DA02 project, under Program KC03, has researched, designed and manufactured waste incinerator systems and emission control for urban and industrial areas with the result of building mathematical models to determine the elements of the source: humidity (internal and external), calorific value, ratio of raw materials (C, H, N, P, S) and volatile substances, ash / residue, alkali metal content, cellulose / lignin / hemicellulose ratio to the calorific value and thermal yield of the device [27].

The optimal problem in industrial solid waste combustion has been developed to control emissions according to environmental standards with the proposal of mixing waste with different calorific value, gas supply and transfer regime. change garbage into heat, fuel-saving heat, control air pollution to serve urban waste treatment, save fuel for the system and have modeled the optimal calculation of technology and data sources to control get the process of realization and reduce pollution of emissions [41]. A system of energy research and biomass research equipment funded by NEDO is installed in Cat Que village - Hoai Duc - Hanoi and the project "Research and improve the process of biomass gasification technology for business Industry "is being developed to create an alternative energy source of 10kW capacity for food processing enterprises from available waste biomass.

B. Research on exploiting and processing methane biomass

Research on fermentation technology, anaerobic decomposition of organic waste sources with the topic of Vietnam Academy of Science and Technology "Biogas model to improve treatment of high-carbon pollution sources and credit fund applications carbon in environmental protection (2009 - 2010). Results of biogas collection from livestock waste are combined from plants, especially with water hyacinth[24]. Water hyacinth and other organic biomass such as cassava starch production waste. Pre-treatment of lignocellulosic biomass minced / crushed, soaked with wastewater (taken from the output of the biogas tank), treated with 1% caustic soda, weak acid, treated with heat, enzymes and then added to the raw material Anaerobic decomposition device has a markedly increased effect on gas production. Research cooperation funded by Japan New Industrial and Technical Energy Organization (NEDO) (2011 - 2012) when combined yeast has received methane conversion from cassava production waste with CH_4 biogas yield 380l / kgVS, methane gas has a content of 52% CH_4, 43.4% CO_2 gas other 4.7% used for generators, replacing 90% of fuel DO used in the traditional way. In addition, waste oil, palm oil and biodiesel have also been tested to show the effectiveness of replacing fossil fuels well, improved emissions, and good performance.

Fermentation of methane biomass of waste water with a load of 1kg COD / m^3 / day transferring waste into biogas to heat and generate electricity for the point project in Nguyet Duc Commune - Yen Lac - Vinh Phuc (2009 - 2010) and Minh Duong Food Company (2012 - 2013). Wastewater after anaerobic decomposition, further treatment with anaerobic system enhances, good separation of liquid solid system of post-treatment waste (sand/sludge filtration) allows to receive waste stream with COD lower than 400mg/l. In order to effectively apply wastewater treatment methods with biofiltration technology or measures, stable bio-waste and wastewater treatment ponds meeting environmental standards QCVN14-2009, low cost. Applying methods are used to reduce greenhouse gas emissions such as AMS.III method. D (recovery of CH4 for manure management system), AMS.III.E (gasification combustion control, thermo-mechanical reduction CH_4), AMS. III.F (Biological treatment of controlled biomass CH_4), AM0010 (CH_4 emission reduction for livestock waste management systems), AMS.III.H (CH_4 recovery from wastewater treatment system), AMS. III.I (replacing CH_4 non-aerobic anaerobic wastewater treatment system with CH_4 reducing aerobic treatment system), AMS.R (CH_4 collection from small-scale agricultural production), AMS.Y (Separation solid - liquid, livestock waste treatment reduced CH4), AMS. IC (using thermal energy from renewable energy), collecting biogas, treating waste, taking advantage of gas generation to reduce to 0.476t CO2 / emission (pig) / year Compared to no treatment to see the potential of waste biomass conversion has contributed greatly to combating climate change. Fermentation of methane gas versus ethanol yield shows the ratio of methane/bio-ethanol from lignocellulose biomass of corn and rice, about 1.15; 1.07 high methane energy generation rate, less energy input, low anaerobic investment, production of environmentally friendly, environmentally friendly methane gas with little harm.

C. Study on technology of trans fat ester removal into biofuel

The amount of waste oil and grease in Vietnam that has not been managed is the source of food insecurity and environmental pollution. With the main characteristic of the free fatty acid content (FFA) in high acid index waste oil, the study found the appropriate technology that can be removed by the esterification reaction with the thermally reactive ethanol H2SO4 Reaction level from 50-70°C[42]. The optimum found conditions were: molar ratio of ethanol / FFA = 50/1, 5% catalyst of H_2SO_4, 70°C after 2 hours of reaction time, acid index of original waste oil decreased from 25.2 down to 1.8 mg KOH/g oil. For ester displacement reaction, the optimal efficiency of step one is 84.1% achieved when molar ratio of ethanol/oil = 9: 1, 70°C, 120 minutes. Meanwhile, the efficiency of step 2 reaches 99.5% provided ethanol/oil = 9:1; 70°C, 60 minutes. The process of testing the process of washing anhydrous biodiesel with Truc Thon bentonite and clay adsorbent, MgSiO3 and purifying through microfiltration ceramic filter applied to the production process of biofuel from grease and waste using low ethanol waste generation. This orientation was confirmed when synthesizing nano-catalyst ZrO2 Vanadium doped by hydrothermal method in alkaline environment, at 190ºC, for 24 hours collecting catalytic monoclinic crystal structure, spherical particles, size 15 ÷ 20 nm. V/ZrO2 material has good catalytic ability in the synthesis of Biodiesel from waste oil and ethanol. The survey results of some factors affecting biodiesel synthesis with ZV catalyst samples (1% V/ZrO2 doped sample) were found at 70°C, 12% catalyst, oil / ethanol volume ratio was 1:12, the 7-hour time to get biodiesel is 83%; increasing the ethanol utilization rate and reaction time to 8 hours, the efficiency was over 96%, the catalyst was reusable. The study comparing FAME methyl ester and FAEE when using ethanol, the results showed that it is possible to use the same device to perform methylation or methylation (FAME, FAEE), using ethanol has many outstanding advantages. Environmental friendly opens up a wide range of applications for waste oil collection businesses to convert waste biomass into biodiesel to serve the needs of businesses. Besides, the research results of ethanol production technology from cassava production and research and production of bio-blending additives E5 and diesel fuel were implemented and tested.

IV. Modeling the Process of Biomass Conversion Equipment and Some Application Results

On the basis of applying modeling techniques in the study of technological process - biomass transformation device has been researched and designed to test some device configurations:

1) *Downdraft Fixed Bed Gasifier*: less sludge generation, suitable for small and medium sized generators. The gas enters below the biomass through a one-way valve, the combustion gas in the combustion chamber at the bottom of the equipment, on the ash layer, high temperature in the combustion chamber. It has a high carbon conversion coefficient, long retention time, low air flow rate, small ash / scale ratio. Follow the method of loading data into different devices to name the device.

2) *Updraft gasifier*: Gas enters from the bottom; the product gas is collected above. Complete combustion at the end of the combustion chamber releases CO_2 and H_2O. High temperature flammable gas (1000ºC) through coal layer and reduced biomass of H_2 and CO cool down to 750ºC. The gas rises to synthesize gas, drying the charging material, the gas from the biomass layer is about 500ºC, further processed. Models of horizontal push-down methane or reverse flow gas flow device, tower-type high-pressure organic waste water treatment model of high-load filter tower are calculated and designed using the model of calculated equipment. evidence suitable between theory and experiment.

V. Conclusion

Research and develop mining technology - effectively processing diversified and abundant biomass resources of Vietnam with scientific researches that have contributed methodologies, additional basic research databases on biomass resources. Developing technology for sustainable processing and processing biomass in energy saving, developing bioenergy production for sustainable development, combating climate change.

The integration of gasification and utilization of combustion heat will ensure a conversion efficiency of 40-50% for a plant with a capacity of 30-60 MW. However, at present, BIG / CC technology only stops at the testing stage. In addition, the production of synthetic gas from biomass allows the production of methanol and hydrogen, in the future they can all become transportation fuels.

The process of pyrolysis is mainly used for bio-oil production, if using pyrolysis flash allows conversion of biomass into raw biofuel with efficiency up to 80%. Bio-oil can be used in engines and turbines or its use as a raw material for refineries is also being considered. However, the problems of transition and the use of bio-oil products still need to be studied such as low thermal stability or engine corrosion. Currently, bio-oil can be improved by reducing the amount of oxygen and removing the alkaline by hydrogen and the catalytic cracking of the oil for use in certain applications.

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