

CURRENT STATUS OF BIOFUEL PRODUCTION IN VIETNAM

Van Dinh Son Tho
School of Chemical Engineering, Hanoi University of Science and Technology, Vietnam
E-mail: tho.vandinhson@hust.edu.vn

ABSTRACT

Gasoline and diesel consumption for transportation in Vietnam are rapidly increasing. It is estimated that 4.4 million tons of gasoline and 10.15 million tons of diesel will be consumed in 2015. The Vietnamese Government oriented the development of biofuel industries since 2007 and encouraged the production and consumption of E5 and B5 for domestic market. As evaluated, the resources for ethanol production are adapted for large scale production while commercial production of biodiesel are limited cause of the shortages of the feedstock. The ethanol production in Vietnam has increased significantly since 2007. The total production capacity for ethanol production was approximately 420 million liter/year. So far, E5 sales have been much lower than expectation therefore ethanol companies had to face with difficulties. There is urgently need solutions to ensure sustainable development for domestic ethanol production.

Keywords: Vietnam, fuel, ethanol, biodiesel, E5, B5

FUEL CONSUMPTION IN VIETNAM

It currently has proven that the oil reserves of 4.4 billion barrels of oil in Vietnam, which is expected to increase with exploration in deeper sea water areas. Income from crude oil exports was 7.3 billion USD and it accounted for around 5.53% of total Government revenues in 2013. The domestic upstream activities for oil and gas exploration are conducted by the Vietnam Oil & Gas Group (Petrovietnam). The main oil-rig fields are Bach Ho, Rong, Dai Hung, Rang Dong, Ruby, Su Tu Den. In 2013, the yield of oil and gas exploration was 16.7 million tons of crude oil and 9.7 billion m³ of natural gas. Dung Quat is the first Vietnamese refinery and it was operated in 2009. It is processing 140,000 barrels (bbl) of oil per day, supplying more than a third of current domestic demand for refined products. In 2011, Nghi Son refinery started construction with initial capacity of 200,000 bbl/day, and the other refinery will be built in Long Son with a capacity of 240,000 bbl/day (table 1). The total refining capacity of three refineries reach 655,000 bbl/day (about 30 million tons). The demand for refined petroleum products is shown in table 2 (Tokyo Electric Power company, 2008). Consumption of refined petroleum products has grown rapidly at an average annual rate of 7% between 2010 and 2025. Transport fuel shares a substantial portion of it, as gasoline and diesel oil shares 30% and 50%, respectively. Among the petroleum products, jet fuel in transport sector and kerosene in commercial /residential remain leveling off, while demand on diesel oil in the transport and industrial sectors as well as gasoline is increasing steadily.

The refineries are able to supply about 72% of expected domestic demand in 2020 and 54.4% in 2025. The country is likely to become a net oil importer within the next five years. In the long term future, Vietnam will become a net oil importing country, and the realistic import origin will be the Middle East. Petroleum product demand by 2025 is forecasted higher three times than the current level in 2010, which cannot be fully supplied with the available domestic resources. At the same time, from the viewpoint of national income, the revenue obtained by the crude oil export is totally used for importing of petroleum products.

Cause of the shortages of domestic supply for petroleum product, it needs to import from outside for satisfied the domestic consumption. Import license of petroleum product is controlled by the government, and eleven

companies are responsible for import of petroleum products. Nam (2013) reported that, the country imports petroleum mainly from Singapore with approximately 37.2%, then China (about 14.6%) and Taiwan (14.2%). The volume of imported petroleum had decreased more and more since Dung Quat refinery went on operation and could meet from 30-35% demand of domestic market. The petroleum product was delivered by approximately 10,000 stations across the country. Three company Petrolimex, PV oil and Mipex accounted for 73.1% market share (fig.1) and Petrolimex is the biggest downstream player among them has a share of more than 50% of the total of petroleum products.

GOVERNMENT POLICY FOR BIOFUEL DEVELOPMENT

Fuel is one of the most important sectors in the economy of the country and the dynamics of the process for national development. With economic growth, Vietnam has been considering energy security at the top priority. With the limitation in exploitation of fossil energy, biofuel are considered an important alternative. In terms of the Government organization law, decrees, regulations and mechanisms for biofuels development and approval of investment projects, there are two important decisions for investment and development of Biofuel.

Decision No 1855/QĐ-TTg of December 27, 2007 approving Vietnam's national energy development strategy up to 2020 with 2050 vision is to assure national energy security. One of the target is to boost the development of new and renewable energies, bio-energy in order to meet the requirements of socio-economic. To increase the proportion of new and renewable energies to about 3% of the total amount of commercial primary energy by 2010; about 5% by 2020 and 11% by 2050.

The plan for biofuel energies have been declared in the Decision No. 177/2007QĐ-TTg by Prime Minister dated 20 November 2007 on "National Program on bio-fuel development up to 2015 with outlook up to 2025" and it target a development of biofuel, a new and renewable energy, for use as an alternative to partially replace conventional fossil fuels, contributing to assuring energy security and environmental protection with the following objectives:

- 2010 : Develop various models of trial production and use of biofuels with a total annual output of 100,000 tons of E5 and 50,000 tons of B5 in order to satisfy 0.4% of the country's gasoline and oil demand;
- 2015 : ethanol and biodiesel will reach 250,000 tons (enough for blending 5 million tons of E5 and B5), satisfying 1% of the whole country's gasoline and oil demand;
- Vision to 2025: The biofuel production technology applied in Vietnam will attain the world's advanced level. The ethanol and vegetable oil output will reach 1.8 million tons, satisfying some 5% of the whole country's gasoline and oil demand

There are also others decision of Government, Ministry of Agricultural and Rural Development (MARD), Ministry of Industry and Trade (MIT), Ministry of Science and Technology (MOST) for supporting the biofuel development such as:

- The Government's decision No. 1842/QĐ-BNN-LN objectives is to create new agricultural production through establishing of the material area in parallel with the development of bio-diesel processing activities of high efficiency and increasing scale based on the efficient usage of uncultivated land, barren, unused land, bared mountain and forest and the cultivated area with low productivity.
- Decision No. 1842/QĐ-BNN-LN by MARD dated 19 June 2008 on "Research and development of Jatropha for the period 2008-2015, with an outlook up to 2025".
- On 17 July 2009, the MIT promulgated Decision No. 3638/QĐ – BCT on establishing a Task force to develop standards and technical regulations on the production, storage, distribution and use of biofuels.
- On 30 September 2009, the MOST issued the Circular No. 20/2009/TT-BKHHCN on the promulgation of the national technical regulation on gasoline, diesel fuel oils and biofuels following QCVN 1:2009/BKHHCN.
- On 25 March 2010, the Vietnam Directorate for Standards, Metrology and Quality (TCVN) issued Decision No. 400/QĐ-TDC on the guidelines for standard-compliance certification of gasoline, diesel and biofuels following QCVN 1:2009/BKHHCN. In 2007, the TCVN approved TCVN7716:2007 the standard specification for ethanol (E100) and blend stock (E5) and TCVN7717:2007 the standard specification for biodiesel (B100) and blend stock (B5).

RESOURCES FOR BIOFUEL INDUSTRY DEVELOPMENT

There are two potential resources for biofuel production in Vietnam: bioethanol from starch, biodiesel from fish fat and plant-based oil. The technology to convert starch-based feedstock into ethanol can be divided into three levels of technological sophistication. First-generation biofuels use conventional technology to convert feedstock such as sugarcane, maize, wheat, barley, sorghum, and cassava, into biofuel. Second-generation biofuels, or cellulosic biofuels, use non-food biomass such as crop residues, and forest residues, such as husk, stalk and leaves, wood chips, or switch-grass, as feedstock. Third-generation biofuel uses biomass crops designed especially for the requirements of the bioconversion process, for example using special algae or weeds. For the country, an agriculture still accounts for a majority with more than 12 million hectares of farmland. Output of rice, sugarcane, cassava and corn, among others, has grown considerably over the past 10 years and these plants are a potentially large source of material for biofuel production (first generation).

Resources for ethanol production

Materials that contain starch, glucose and cellulose are key inputs for ethanol production. Each country chooses technology depending on available materials. Bioethanol can be produced from rice, maize, cassava, sweet potato, and sugarcane. However, these products are in highly demand for both human and animal consumption.

Corn production: Corn has been increasingly grown over the past 10 years. There was 1,172,000 hectares under corn farming with total output reaching 5.5 million tons in 2013. Corn farming is extensive in northeastern, northwestern, central highlands, southeastern provinces, Red River and Mekong deltas. Corn productivity is lower than other countries. Corn is primarily used as food by highland people and as animal feed. There were 124 animal feed factories with a total capacity of 10.5 million tons/year. In 2013, the country had to import 2.2 million tons of maize for animal feed production (National Maize Research Institute, <http://nmri.org.vn/>).

Cassava production: Cassava, one of the country's key short-term industrial plants, has long been grown as food for humans and animals. Currently, farmers grow many new varieties, which have high yield and quality, and high starch content (above 25%). The cassava area has expanded in recent years because of high demand from starch factories and for the export of dry chips. Although suitable land for cassava cultivation is still available, the government discourages cassava expansion cause of soil degradation and water pollution on cassava processing. As reported by Hoang (2011), there was 650,000 hectares for cassava cultivation and output was 9.4 million tons in 2013. The country's average productivity reaches 15.7 tons/hectare, which is much lower than the yield in other countries (up to 50 t/ha). It is about 70% of the output of cassava was exported to China in 2013.

Sugar cane production: Sugar cane is a short-term industrial plant vital to the sugar industry. The cultivated areas are mostly in the north-central region, the south-central coast region. The country had had 37 sugar refineries with total capacity 1.3 million ton in 2012. As mentioned by Nguyen (2009), at present, it has nearly 300,000 ha of land planted to sugarcane. If the average yield can be raised to 65MT/ha, the surplus sugarcane production for bioethanol processing would be about 6 million tons (table 3). If the average yield is raised to 80 t/ha by 2020, about 6.5 million tons of sugarcane would be available for ethanol production. Molasses is by product of sugarcane processing. Sugarcane molasses is a red brown liquid by-product of sugar extraction which contains about 40-45% sugar, some other ingredients. Large amount of molasses was not utilized and it could be used for ethanol production however there is not any information relating to the quantities of molasses in Vietnam currently.

Rising food prices, the risk of national and international inflation, and limited land for food crops are the challenging issues. National food security is the highest priority, so among the agricultural crops are listed; only cassava is potential resource for bioethanol production in Vietnam.

Resources for biodiesel production

It has been mentioned earlier that biodiesel can be produced from a wide variety of feedstock including vegetable oil, animal fats, restaurant waste oils, and trap grease. Another way to categorize this feedstock is to identify those that come from oilseeds and those that originate from rendering plants. Rendering is the process whereby by-products of the food industry, including animal fat, fish are recycled into usable products. The fats may be refined, bleached and deodorized. This provides a product that is suitable for food, cosmetics, and other high value uses.

Larger volumes of material are processed in plants that produce so-called “inedible” products, although the products are suitable for use in animal feeds. These inedible rendering plants may process fat and bone trimmings, meat scraps, restaurant grease, fallen animals, and other sources of fat and protein. In 2013, there are approximately 6000 hectares for fish farming and most of them in the Southern part. There are about 70 fish processing companies and export value attained 1.74 billion USD. It is assumed that the waste of catfish is 120,000MT/year and could be used as a feedstock for biodiesel production. The area for cultivation of soybean, groundnut is limited on the whole country and it mainly uses for food industries. The potential resource for biofuel production is coconut cause of large cultivating area. Cultivation for growing coconut is between 220,000-250,000 hectares, which theoretically can produce between 1.3 and 1.4 billion of coconuts a year. Technical research has proved that coconut oil is one of the most suitable materials for biofuel production, however it had disadvantage of the high clouding point temperature.

The Ministry of Agriculture and Rural Development approved Decision No. 177/2007/QĐ-TTg as “Approval of National Program on *Jatropha curcas* research, development in Vietnam for the period 2008 – 2015, with an outlook up to 2025”. It has been decided that tested plantation and production of *Jatropha* and its products in different geographical regions throughout the country should be implemented during the period 2008 – 2010 with the set targeted area of tested *Jatropha* plantation and production of 30,000ha by 2010 and of 300,000ha by 2015 and 500,000ha by 2025. *Jatropha* has existed in Vietnam as a wild plant since long. Existing *Jatropha* plantation projects are located in some provinces throughout the country. The existing projects are located mainly in the Central and Highland Central and midland and mountainous areas in the North. The concentration of projects in these areas is due to the available land area and suitable natural conditions for the plantation. During the period of 2008 – 2010, there were a number of local and foreign investors who have invested in *Jatropha* plantation projects. As of now there are 10 local companies and 5 foreign companies having their *Jatropha* plantation and production. The first tested plantation of *Jatropha* was carried out in 2006 and there are now over 3,000ha with *Jatropha* plantation area throughout the country. The largest *Jatropha* plantation area is located in Ninh Thuan Province with the total area of 319ha. Recently a large scale new project has been developed by a joint venture of Truong Thanh Furniture Corp. (TTF) and JATRO Singapore Pte. Ltd to plant *Jatropha curcas* in Central Vietnam. Furthermore other international parties like JICA and ADB have showed interest and funding possibilities in the project. As survey by Agrinergy (2012), due to both technical and financial difficulties caused by the economic crisis, a number of *Jatropha* projects have been cancelled, reducing the number of on-going projects from more than 30 projects in 2010 to only 07 projects in 2012 (table 4)

STATUTE OF BIOFUEL INDUSTRY

As reported by AFD Hanoi (2012), Brazil was the first country to use ethanol as a fuel at industrial scale in 1970. Gasohol E25 is the most commonly used fuel in the country and fully replaces the conventional gasoline. More than 3 million cars in the country utilize 100% ethanol as fuel. Brazil produced about 30 billion liters of ethanol in 2010. The United States is the largest ethanol producer in the world. In 2010, the country produced more than 50 billion liters of ethanol and about 6 billion liters of biodiesel. The government has a subsidy scheme for the use of biofuels, which allows tax reduction rates of 0.5 USD and 1 USD per gallon of ethanol and biodiesel respectively.

In China, gasohol E10 was officially used in five large cities and was expanded to 9 more populated provinces by 2003. In 2005, the largest ethanol production facility with capacity of 600,000 tons per year has come into operation. It is expected that the total production of ethanol as fuel will reach 10 billion liters by 2020. Thailand is a pioneer among Asian countries in establishing policies to promote biofuel production and to capitalize on its supplies of feedstock from its vast agricultural production. Ethanol production in Thailand is produced from feedstock of sugar molasses and tapioca products, while B100 biodiesel from palm oil. Ethanol production is estimated at 528 million liters in 2011 while consumption should be limited at 439 million liters. B100 biodiesel production in 2011 is estimated to 680 million liters. B100 production is totally absorbed by domestic consumption and as a result Thailand does not export or import biodiesel. The neighboring country, Malaysia, expects to have five plants producing biodiesel from palm oil by 2015, with a total capacity of up to 1 million tons for domestic demand and export to EU. Another country, Indonesia, plans to popularize biodiesel B5 in the entire country, with feedstock from traditional palm oil farms. (AFD Hanoi, 2012)

Ethanol production

In Vietnam, cassava is ranked fourth in the world with an estimate of 8.5 million tons output in 2010. Most of cassava is used to produce tapioca and, in a smaller extent, dried sliced cassava (up to 80% starch, w/w) used for the

production of animal feeds or ethanol. Previously, ethanol of 95-96% concentration which is mainly used in industries, pharmaceuticals and alcohol drinks production. Since 2007, under GOV encouragement eight plants have started (as of 2010) with a total annual capacity of 680.000MT of ethanol, of which 420.000MT from the first four plants are biofuel and the remainder for other uses in alcoholic drinks, cosmetics, pharmaceuticals industries. Table 4 and figure 4 showed several companies invested in and started a BOT plant for ethanol in 2009 at Quang Ngai, Phu Tho, Binh Phuoc and Dong Nai (Loan 2013).

The total capacity for ethanol production approximately 420 million liter/year for 2012 and it could be used for 8.4 million liter of E5 per year.

- The first one is Dai Tan ethanol factory, it located in Quang Nam. Its capacity is 120 million liter ethanol/year. The total investment was 44 million USD. It started operation in 2009 and consumed approximately 250.000 tons of cassava chip per year.
- Phu Tho Bio-energy ethanol factory was a member of Petrovietnam.. Its capacity is 100 million liters per year. The total investment was 85 million USD and it started construction in 2009.
- In 2009, Petroleum Center Zone Ethanol project was established in QuangNgai. With the total investment 100 million USD for 4 units: Ethanol plant with a capacity of 100million liters/year, power and thermal plant (6.5MW), waste treatment and Utilities plant.
- There is another project for ethanol plant planned at Binh Phuoc province (Orient Bio-Fuels Co.). It is a joint venture between Petrovietnam, Licogi and Itochu (Japan). The total investment 100million USD with capacity 100 million liter per year.

The domestic production cost of ethanol was 0.78cent/liter in 2013, while CIF price of gasoline was 0.73cent/liter (www.hiephoixangdau.org). It means that production cost of ethanol higher than imported price of gasoline. Therefore the petroleum companies such as Petrolimex, Mipex and the others do not ready for purchasing ethanol for blending with gasoline. Just only PV Oil delivered ethanol to the market. Cause of the low demand of E5 in domestic market therefore the ethanol plants have faced with a lot of difficulties. In 2011, just only Dai Tan plant was in operation and it sells 20% product to the market. The Phu Tho plan has been delayed for long time because of the shortages of cassava resources and low demand for ethanol fuel. PV Oil provided only 22.000m³ of E5 for domestic market and it accounted for only 1.1% of an ethanol plant's capacity. PV Oil targeted the total ethanol would be consumed around 100,000m³ by 2013 and it is still one third of the designed capacity of all ethanol plant.

As informed by EIA (2014), the price of biofuel for 2012 and 2013 was shown in figure 4. It could be said that in March of 2013, selling price of ethanol approximately 1USD/gallon while the ethanol production cost of domestic companies was approximately 2.59USD/gallon in 2013. With the higher price of ethanol in comparison with international market, the export scenarios is impossible.

In order to support the consumption of the biofuel and protect the Domestic biofuel production, the Decision 53/2012/QĐ-TTg and Decision 173/2014/-TTg were issued with the main contents are:

- E5 will be mandated in 7 cities (Hanoi, HaiPhong, Can Tho, HCM, Da nang, Ba RiaVung Tau, QuangNgai) from 1st December 2012, and in the whole country from 1st December 2015, and E10 will be mandated in 7 cities from 1st December 2016, in the whole country from 1st December 2017.
- At December of 2014, fee for environment protection must be added to 7.5 cent/l for gasoline and 5 cent/l for E5 và E10. At December of 2015, the fee would be 10 cent/l for gasoline and 5 cent/l for E5 và E10.
- For protection of domestic ethanol plants, the import tax for ethanol was imposed 20% in 2014.

Hope that with the action of Government, the consumption of ethanol will be increased and the ethanol plants will be put in operation again.

Biodiesel production

It has been critical to the successful development of diesel fuel and diesel-powered vehicles to have consensus among refiners, vehicle and engine manufacturers, and other interested parties on the characteristics of diesel fuel necessary for satisfactory performance and reliable operation. It has been mentioned that biodiesel can be produced from a wide variety of feedstock including vegetable oil, animal fats, restaurant waste oils, and trap grease. However, cause of the shortages of the sources for large scale production, some small pilot plan was built for utilization of the waste and production of biodiesel.

The raw material for Minh Tu Company is cat fish oil of the rendering plant. They invested in batch processing with stirred tank reactor. There was a total investment of 830,000 USD. Alcohol mixed with triglyceride and catalysts enter in the reactor. The most commonly used catalyst is sodium hydroxide. The reactor, purification system and others were designed and manufactured domestically. The biodiesel product was supplied to the local customers.

The Institute of Industrial Chemistry (Ministry of Industry) received the Korea sponsor for construct B100 production line. The total investment was 1 million USD in 2010. The process applies a heterogeneous catalyst for biodiesel production. With that technology it could be adapted with low quantity of raw materials (high FFA value) and reduce the cost of the purification of product. It is located in Hanoi and far away from the sources therefore the transportation fee has seriously impacted it. Currently it is not operating continuously because of the shortages in the materials.

ENERFISH is a European project co-funded by the European Commission, within the 7th research Framework Program. Under the coordination of VTT, the Technical Research Centre of Finland, a new polygeneration application with renewable energy sources was built up and demonstrated for the fishery industry. The distributed energy system utilizes cleaning waste of a fish processing plant to produce biodiesel. The biodiesel is used to produce the locally needed cooling/freezing and heating energy. In addition, a power surplus is generated for injection in the electricity network or onsite industrial use. The main product of the fish processing plant is catfish filet (about 40 tons/day). The fat content of 22% in the cleaned fish wastes results in a potential production of biodiesel of about 13 tons/day. A part of biodiesel is used to produce electricity for the locally needed cooling/freezing (0.3 MW) and heating (1.3 MW) energy. In addition, a power surplus (0.8 MW) is generated for the local industrial use. (ENERFISH.2009).

CONCLUSION

The use of biofuel as an alternative for fossil-fuel products may have both positive and negative impacts to the food security and the climate change abatement. Thus, scaling-up biofuel development shall be considered carefully and objectively, based on the specific practices and perceptions in Vietnam. The “Scheme on Development of Biofuels up to 2015 with the Vision to 2025” only provides a general orientation on the targets for each period and the prioritized list of activities. It is expected that a road map for biofuel development shall be completed soon in order to provide detailed instructions on needed steps to achieve the set targets, and a workable implementing plan to follow. Besides, it is also expected that the sources of funding for biofuel projects will be well defined. The lack of human resources needed for biofuel production, including skilled workers and senior technical experts in related areas also limit the capacity of R&D and production.

Biodiesel is produced on a small scale by individual company with limited resources. The source is characterized by small and scattered parcels, and this is likely to pose problems for industrial-scale production. Most ethanol production plants are applied the advance technology, however by using only conventional food crops as the feedstock, the production cost is not competitive to the conventional fossil fuels. Furthermore the investment was based on the shorter term loan or middle term loan of the commercial bank with high interest rate, the cash flow of the ethanol plant was deficient. In fact, low demand of the domestic market and difficulties for export causes of the fatal impact for ethanol plant and also for Vietnamese biofuel industry. There is urgently need solutions to ensure sustainable development for ethanol production in Vietnam.

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Table 1. Oil products volume of refineries in Vietnam

Product (thousand tons)	Dung Quat 2010	Nghi Son 2015	Long Son 2018	Total
Gasoline	2,000	2,100	2,100	6,200
Jet fuel	280	200	200	880
Kerosene	0	200	200	400
Diesel	3,400	2,180	2,180	7,760
Fuel oil	120	270	270	660

Table 2. Refined petroleum product demand in 2010-2025

Product (thousand tons)	2010	2015	2020	2025	Avrg. annual growth (%)
Gasoline	3,850	4,400	5,500	6,700	3.8
Jet fuel	750	1,505	1,400	1,800	6.0
Kerosene	380	400	430	510	2.0
Diesel	7,300	10,150	13,850	18,950	6.6
Fuel oil	1,900	2,750	4,300	6,100	8.1
Total	16,800	22,350	31,880	44,060	7.0

Table 3. Sugar cane production in Vietnam

Year	Total cane areas (ha)	Cane production for sugar (million tons)	Yield of cane (tons/ha)	Total cane production in country (million tons)	Surplus cane production (million tons)
2006	285,000	14.31	55	15.68	-
2010	285,000	13.62	65	19.50	5.86
2015	300,000	15.00	70	21.75	6.75
2020	300,000	17.59	80	24.00	6.50

Table 4. On-going Jatropha projects in Vietnam

No.	Investor	Location (Province)	Planted area (ha)	Current status
1	Local Joint Venture with Eco-Carbone	Binh Thuan	100	Ongoing
2	Lung Lo 5 joint stock company	Quang Tri	34.5	Ongoing
3	PVOIL Joint Venture with Idemitsu Kosan Co., Ltd (Japan)	Binh Dinh	1.8	Ongoing
4	Partnership Agreement between Vietnam Petroleum Institute (PVI) and Bionas (Malaysia)	Binh Phuoc	4	Ongoing
5	Tran Gia company Ltd	Yen Bai	4	Ongoing
6	Dai Thinh agriculture seeds company	Thanh Hoa	1	Ongoing
7	Natural energy technology development joint stock company	Son La	N.I	Ongoing
8	Thanh Tay University	Lang Son	N.I	Ongoing
9	Green Energy Biomass	Ninh Thuan	800	Ongoing

Table 5. Ethanol plants in Vietnam

No.	Company name	Province	Investor	Construction period	Capacity (10 ⁶ l year ⁻¹)	Cassava chip (ton year ⁻¹)
1.	<u>Ethanol plants for biofuel</u>					
1.1	Phu Tho Bio-energy Co.	Phu Tho	PV oil	2009-2011	100	250,000
1.2	Dai Tan ethanol plant	Quang Nam	Dong Xanh Co., BIDV.	2007-2009	120	300,000
1.3	Petroleum Centre Zone Ethanol JSC	Quang Ngai	Petrosetco 51% PVFC, BRS	2009-2011	100	250,000
1.4	Orient Bio-Fuels Co.	Binh Phuoc	Itochu Cor. : 49% PV Oil: 29% Licogi 16 : 22%	2010-2012	100	250,000
2.	<u>Ethanol plants for other products</u>					
2.1	Ethanol DakLak JSC.	Daklak	Ethanol Vietnam JSC	2007-2009	66	165,000
2.2	Dai Viet Co.	Dak Nong	Dai Viet Co.	2006-2008	68	170,000
2.3	Quy Nguyen Co.	Binh Phuoc	Quy Nguyen Co.	2010-2011	50	125,000
2.4	Tung Lam Co.	Dong Nai	Tung Lam Co.	2008-2010	76	190,000

BIDV: Bank for investment and development of Vietnam;
PVFC: PetroVietnam Finance Corporation
BRS: Binh Son Petrochemical Refinery

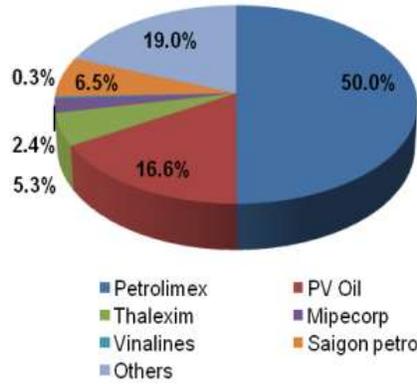


Fig.1. Domestic market share of petroleum companies in Vietnam



Fig.2. Cat fish processing in Southern Vietnam

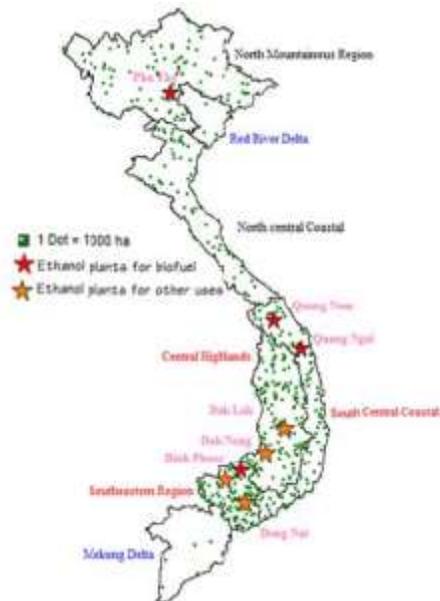


Fig.3. Location for ethanol production in Vietnam

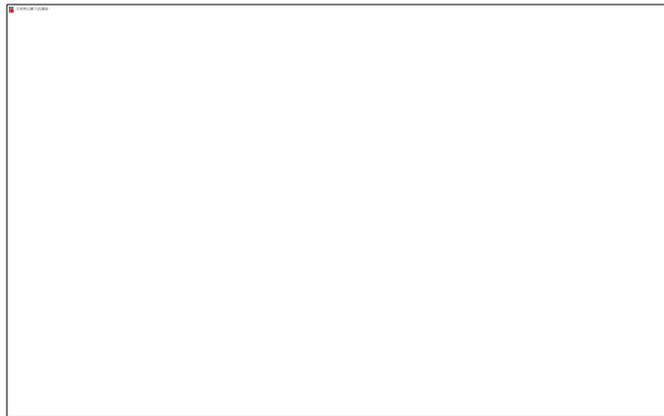


Fig.4. Dai Tan ethanol plant in 2009

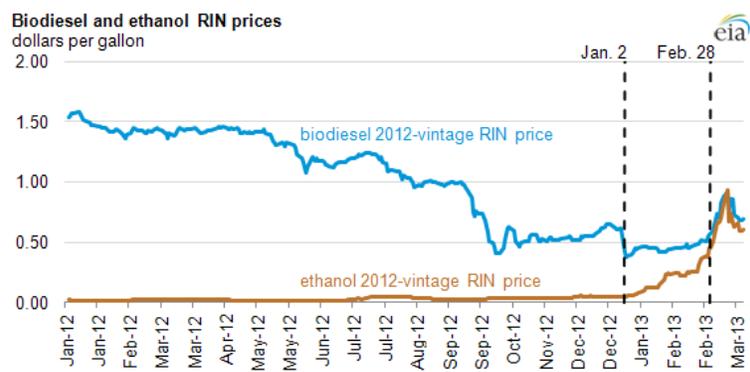


Fig.5. Biofuel price



Fig.6 The biodiesel pilot system of Institute of Chemistry