NL Agency
Ministry of Economic Affairs, Agriculture and Innovation

Sustain-able Bio-mass

Biomass Business Opportunities Viet Nam

>> Focus on energy and climate change

Colofon

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Executive summary

In the last decade, fast industrialization and the economy's progress of Vietnam lead to its rapidly growing energy consumption. An increased dependency on fossil fuels is foreseen, and Vietnam is currently already an net energy importer. Vietnam's targets to increase the share of renewable energy in total commercial primary energy from 3% in 2010 to 5% in 2020 and 11% in 2050. This suggests there will be a high potential for bioenergy in the nearby future. With this report NL Agency identifies the business potential for biomass in Vietnam.

Biomass is abundantly available, both centralized as scattered over small holders country wide. There is little awareness and knowledge on sustainability criteria in Europe and the Netherlands. Energy crops have not been cultivated much and therefore this was not critical. With the new decree focusing on R&D and usage of products of Jatropha, and the increasing pressure on the cassava market, sustainability issues become more important and should be monitored. Awareness related to sustainability issues should be raised.

There are several policies related to energy en environment, mainly focusing on targets but also reflecting incentives, support on land or capital, tax exemption, reductions of tax, fees for environmental protection activities etcetera. Nevertheless it is seen that these incentives are not sufficient for the feasibility of bioenergy projects in Vietnam. Favorable feed-in tariffs for renewable are not present and negotiations for electricity purchase contracts are done on a case to case basis never reaching prices above average tariffs. Which is one of the major barriers identified.

Cooperation and investment in Vietnam, requires involvement with its government. Government structures and ministries are elaborated upon. Foreign organizations will always be appointed a contact person from ICD (International Cooperation Department). ICD is a unit that is active in each ministry and responsible for building and managing international cooperation.

Many opportunities are identified for cooperation between Vietnamese and Dutch organizations. The main opportunities are divided into several categories

- **Knowledge transfer and capacity building**
  There is a general need for knowledge transfer and capacity building, furthermore on all bioenergy technologies. Another field is cooperation in the R&D sector.
- **Management and advisory skills**
  International Management and Advisory is also requested, especially when it comes to large scale industrial projects. Even though there are already several such Dutch companies active in Vietnam in this field, the bioenergy sector is not yet aware of this offer from BV Nederland.
- **Biogas and landfill gas**
  Biogas is one of the most growing and booming sectors in Vietnam. This automatically results in a larger demand for upstream and downstream equipment. Gas recovery from landfill is not yet introduced, and is a high potential area of cooperation.
- **Technological requirements**

  - Densification (pelleting, briquetting) technologies, as well as combustion and (co-)generation technologies are not widely available in Vietnam. Supply of technology as well as knowledge is desirable.
  - On a household level Improved Cookstoves is a business opportunity for both NGO's as well as commercial parties.
- **Biomass availability**
  The following biomass resources are not only available but also are of harm to the environment at the moment: rice husk, rice straw, coconut pith, sugar cane bagasse and coffee waste. The utilization of these resources creates opportunities and will benefit the environment. Rice straw can be identified as the largest potential, but at the same time also the most challenging.
- **Financial issues**
  There is a need for financial cooperation in many different ways, creating a loan environment with more favorable conditions that currently is high on the list of priorities.

The biggest barrier identified is the lack of support or feed-in tariffs for green electricity. For the promotion of renewable energy in general such support is needed due to the often high initial investment in technology (which is often outside the core business). This barrier can be reduced by focusing on decentralized production, preferably close to and in cooperation with a biomass producer/owner. Financial burdens can be reduced by co-ownership and purchase of biomass and supply of energy to and from the biomass producer.

Five barriers were identified; the most important one is related to lack of feed-in tariffs from bioenergy. For biofuel sector and the waste sector there is also no additional incentive. Furthermore investment in European equipment is relatively high for the Vietnamese market and therefore technologies need to be low-cost and adjusted to the local setting. Biomass scattered availability, knowledge levels and the difficult entrance into the non-governmental sector are the other barriers.

The most important recommendations are as following:
- Facilitate networking and promotion of BV Nederland to improve its brand in the bioenergy sector.
- Cooperate with other governments, like Germany and Denmark, who are executing a similar scoping mission in Vietnam, also focusing on bioenergy. NL Agency could cooperate with both other governments to together support the bio-energy market in Vietnam.
- Provide assistance, support and knowledge to the Vietnamese government in the long and intensive path of opening up the energy market in Vietnam.
- Fund joint innovation and research initiatives involving and focusing on the private sector
- Create more awareness of the opportunities in Vietnam to attract more interest from BV Nederland.
- Small scale solutions, like for example ICS, should not be overlooked and should be supported as well.
- Financing and/or support for the further development of the bio-energy market.
- Financial support that can provide favorable conditions for loans for local entrepreneurs if there is cooperation with a Dutch organization.
- Focus should not be limited to conversion technology but also include biomass handling.

1 Introduction

Through various regulations and programmes NL Agency facilitates and stimulates projects and supplementary research in order to gain experience in the production and certification of sustainable biomass.

The Netherlands Programmes Sustainable Biomass (NPSB) cluster the knowledge from the biomass project portfolio of NL Agency and fill the knowledge gaps with supplementary research. The project portfolio for NPSB consists of the programmes Global Sustainable Biomass and Sustainable Biomass Import and the relevant projects of the Daey Ouwens Fund. Also, the experience of other programmes and players is used. The mission of the NPSB is to make biomass production sustainable, in order to facilitate the transition to a bio-based economy.

In July NL Agency visited the Ministry of Natural Resources and Environment of Vietnam to further discuss the potentials and opportunities for and barriers to biomass projects in Vietnam. Based on the findings of this mission, combined with the conclusions of the Cleantech mission of June 2011, Agency NL concluded that the Dutch private parties need a more specific and integral perspective in which also niches, relevant policy development by the Vietnamese government, legislation and sustainability criteria are clearly addressed. These insights would also benefit the Vietnamese government, which is also searching for tangible options to develop the desired enabling environment for a sustainable biomass/biofuel market. Therefore NL Agency published a "Terms of Reference business opportunities Biomass Viet Nam" in which the integral perspective is dealt with.

SNV was selected and executed the assignment in the period October 2011 – February 2012. With this report SNV Netherlands Development Organisation Vietnam would like to present its results.

1.1 Short introduction in the energy sector of Vietnam

In the last decade, fast industrialization and the economy's progress of Vietnam lead to its rapidly growing energy consumption. Total primary energy consumption of Vietnam increased from 32,236KTOE in 2000 to 53,364KTOE in 2008, reaching more than 8% per year. During this period of 200-2008, gas demand was rising at the highest rate of 20.5%/year (IoE, 2010).

However, the energy sector of Vietnam foresees an imbalance in near future with increasing dependence on fossil fuels. The share of fossil fuels in the total primary energy consumption is forecasted to increase from 42% in 2002 to 69% in 2030, while renewable energy source shares reduced from 58% to 22% over the same period (Bal, 2011).

While Vietnam is today still a net energy exporter, the national energy development plan indicates that it is expected by 2015, that Vietnam turns to a net energy importer with import increase steadily each year. Expected primary energy imports will account for 36% of total primary energy consumption in 2020 and it will increase to 57% in 2030.

The power sector is under pressure of high demand increase and high dependence on hydro power (over 30% by 2009), therefore black outs or power cuts are more frequently as draught occurs more frequently. In the long term, the electricity demand is forecasted to increase remarkably with nearly double capacity in 2020 as compared with it's of 2008. One of the concerns in the power sector of Vietnam is the subsidy for electricity tariffs, resulting in inefficient power consumption in numerous economic sectors (transportation, construction, industry). A measurement to strengthen energy security, and reduce the influence of subsidies is to encourage more involvement of independent power producers by develop a competitive power generating market. Up to 2014, independent power producers are not allowed by EVN to sell directly to the market, while IPPs are estimated to account for nearly 20 % of electricity generating capacity in Vietnam (which was 7% in 2002) (Truong, et al., 2004). After 2014 EVN will transform into an independent distributing companies, which will be completed in 2022. By 2022 the market will be open and customers nationwide will have the right to select an electricity supplier (Ministry of Finance, 2011). By announcing these changes in the market, a lot of movement has been created and such a change creates an interesting environment for foreign (Dutch) organizations to play a role.

Realizing the problems, the Government has issued the Energy Efficiency Laws which will be in force from 1st January, 2011. According to the National energy strategy document (so-called Master Plan VII), the share of RE in electricity generation was set to increase (slowly even though) from 3.5% in 2010 to 4.5% in 2020 and 6% in 2030. In order to adapt to the shortage of fuels, bio-fuels are an option of the energy development strategy. The decision by the Prime Ministry 177/ 2007/QD-TTg has set out targets for bio-fuel development (mainly E5 and B5 products) up to 2025. The goal is to reach 5 million tons of E5, B5 which is equivalent to 1.0% national demand for gasoline and diesel by 2015; by 2025 the governments wants to reach 1.8 million tons of ethanol and vegetable oil, or 5% of oil and gasoline demand by 2025.

With both challenges and opportunities in the energy sectors for renewable energy in general and bio-energy in particular, Vietnam would need to have more involvement of private sectors from both national scale and international scale.

1.2 Activities

The goal of this survey is to provide a more specific and integral perspective in which niches, relevant policy development by the Vietnamese government, legislation and sustainability criteria are clearly addressed to benefit both the Dutch Private sector as well as to stimulate Dutch-Vietnamese cooperation and support the Vietnamese government in its search for tangible options to develop the desired enabling environment for a sustainable biomass/biofuel market.

The scope of the survey is given below.

Beneficiaries	Vietnamese Government	Dutch Biomass Sector
Objectives and questions	What is the biomass/biofuel potential in Vietnam? How can it be used optimally and sustainable?	What are the biomass/biofuels business opportunities in Vietnam?
Presentation	Discuss survey and consequences within relevant ministries	Workshop based on survey. (organized and executed by Agency NL)

The following activities are defined by SNV to be executed to reach the goal of the project:

1. Biomass availability in Vietnam (Chapter 2)
2. Government of Vietnam and Energy (Chapter 3)
3. The opportunities and barriers to enter the market in Vietnam (Chapter 4 & 5)
4. Stakeholder analysis of the bio-energy sector (Chapter 6)
5. Recommendations (Chapter 7)

2 Biomass Availability in Vietnam

Biomass is an important source of energy in Vietnam and one that the country is well endowed in. It is estimated that approximately 90% of domestic energy consumption in rural areas is derived from biomass such as fuel wood, agricultural residues (e.g. rice straw and husks) and charcoal. Moreover, biomass fuel is also an important source of energy for small industries located mainly in rural areas.

This report will assess the potential utilisation of biomass from the following sources: agricultural residues, energy crops and residues, forest and other, as indicated in Figure 1.

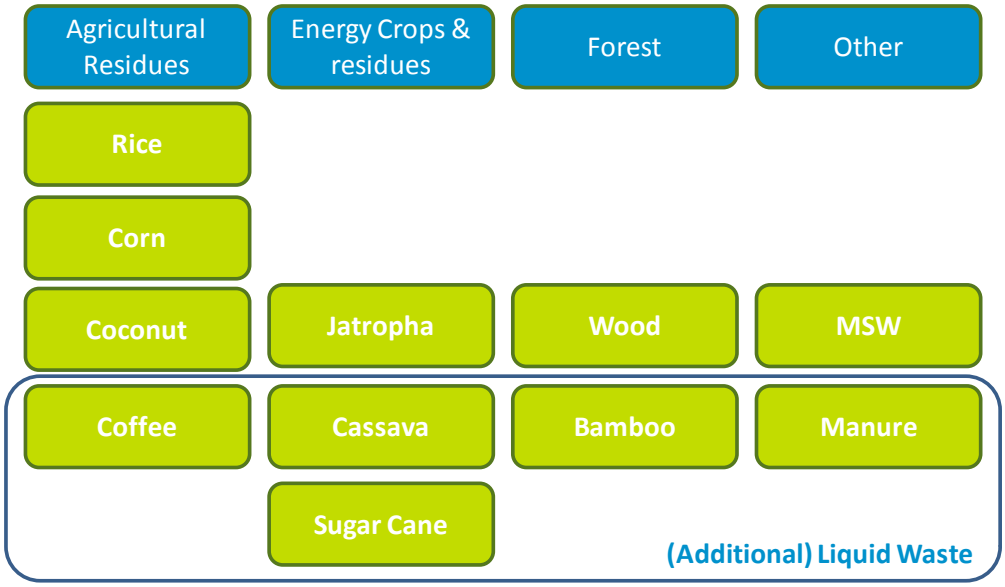


Figure 1. Selected residues for further research

These sources were selected based on the list that represents the production of the most important food and agricultural commodities (ranked by value) in Vietnam (for 2009). For the value of the resource international commodity prices are used (FAOStat, 2010). Wood is added to this list of resources, and the resources without sufficient residues or potential are taken out.

Rank	Commodity	Production (MT)	Production (Int $1000)
1	Rice, paddy	38,895,500	10,405,074
2	Sugar cane	15,246,400	495,139
3	Cassava	8,556,900	893,879
4	Vegetables fresh	6,313,390	1,189,702
5	Maize	4,381,800	78,430
6	Indigenous Pig meat	2,906,330	4,467,730

7	Fruit Fresh	2,616,910	913,391
8	Banana	1,532,420	431,577
9	Sweet potato	1,207,600	82,087
10	Coffee	1,176,000	1,263,447
11	Coconut	1,128,500	124,782

2.1 Biomass potential – terminology and considerations

An initial assessment of the available biomass residues in Vietnam indicates there is a large resource, as it is a resource rich and agricultural country. The ***theoretical potential*** represents the theoretical maximum of biomass and/or residues for energy purposes, but does not account for technical limitations. When such factors are considered the amount of biomass residues available for energy production is called the ***technical potential***.

Most studies in Vietnam related to biomass potential focus on theoretical or technical potentials only. This particular approach is considered unsatisfactory, discounting factors such as sustainability, ownership, distribution and seasonality, and typically results in overestimating the resource potential. In this report the term ***practical potential*** is used to describe the available biomass resource accounting for the factors just described.

Practical potential considers the resource in terms of its future sustainability. In-line with NL Agency's broader requirement to promote sustainability, this study describes biomass availability in terms of its potential for ongoing future use.

Practical potential also considers that biomass residues are normally scattered and subject to seasonal variations, making collection and transportation challenging, as well as costly and labour intensive. Furthermore, some of these residues are already exploited by the market for small scale/decentralized energy purposes – e.g. manure form the small-scale piggery sector for biogas production. Biomass residues can also be productively used for other non-energy purposes – e.g. coir (i.e. coconut husk) from coconut processing is used to make rope, mats and other fibre products. It is not practical to consider a resource that is already being utilised in a productive or economic way. This does not, however, ignore potentials for energy efficiency improvements, improved utilisation or both.

Ownership is also an important issue when it comes to biomass. More specifically, who is the rightful owner and what is the current and the expected value of the biomass. Because transporting biomass means transporting a lot of water and air, ownership, distribution and logistics are of importance.

2.2 Biomass availability by type

Data collection has been done in a systematic and active way. Systematic implies that the data presented here has been sourced from reliable and verifiable sources. With the active approach SNV contacted as many sources as possible of biomass (large scale) owners, associations and private sector parties that represent the sector. SNV advisors personally visited the most leading organizations or

associations in the field for background information and data. A list of visited and interviewed experts will be made available to NL Agency, but will not be part of the final report due to privacy reasons. This approach has delivered a comprehensive and reliable set of verifiable information, which provides a practical understanding of the market and where opportunities may exist.

Potential volumes are presented in quantities and where possible, the distribution within the country is also provided. Suggestions for different conversion technologies are provided at the end of this chapter.

2.2.1 Bamboo

Bamboo is a local forest product used mainly for handcrafts production at village level for local markets and for floor production at an industrial scale for export markets. Its utilisation and processing for handcrafts presents low competitiveness and currently there are some health and environmental concerns associated with its processing. Bamboo is among the 10 fastest growing sectors for export according to Vietnam Trade Promotion Agency (Vietrade), primarily driven by the floor making industry (HRPC, 2007), (Smith, 2011).

Figure 2. Vietrade Bamboo and Rattan handcrafts for export

The estimated cultivation area of bamboo in Vietnam is 800,000 hectares of plantations with an average annual yield of 10 to 13 tonne per hectares and 600,000 hectares of mixed forest, comprised of up to 70% bamboo (IPSARD, 2003).

Bamboo utilisation is focused on three major sub-sectors in the south; value added processing (20% for pressed flooring), bulk processing (80% homeware, chopsticks and handicrafts), construction material (wattles) and emerging bamboo shoots sector at local level (Ding, 2011).

In Southern Vietnam, bamboo production is concentrated in Lam Dong Province, which contains 6.2% of the bamboo plantations and 16% of national mixed bamboo forest (Smith, 2011). In Northern Vietnam, bamboo production is concentrated in the four north-eastern provinces of Tuyen Quang, Son La, Bac Kan and Yen Bai. Combined these provinces account for 7% of bamboo plantations and 43% of mixed forest (FIPI, 2008).

Presently the demand for bamboo in Vietnam is larger than supply. Bamboo production faces land pressure issues due to the diverse demand for other forest species and forest protection enforcements. Bamboo stems are commonly harvested before reaching maturity, which threatens the potential productivity.

At cottage industry sized processing facilities, which are primarily involved in chop stick and tooth pick production, the resultant fine residues are predominantly used for paper and pulp manufacturing. Nodes, being the joints along a bamboo stem, are used as a domestic cooking fuel and also for charcoal production. Charcoal is produced with low efficient technologies at these facilities and is used locally as a domestic fuel.

Figure 3. Small processing unit: bamboo nodes (right) shaving of chop sticks (left)

Larger scale bamboo processing facilities for floor manufacturing produce waste residues ranging from 50% to 70% of the total bamboo processed (Ding, 2011), (PI, 2006). At this industrial scale all waste is typically used as primary energy source to heat boilers and provide process heat to the factory. Given the volumes concerned and the inefficiency of this form of energy conversion, there is significant potential for integrated RE and heat production at these factories.

70% of total bamboo used in Vietnam is presently utilised in handicraft and cottage industry scale enterprises. The biomass waste derived from this sector, although significant, is presently exploited for paper production and as a domestic fuel. Improved utilisation of this waste is considered practically infeasible due to the scattered and irregular volumes produced.

Stakeholders are mostly International Aid Agencies (GIZ, Winrock, OXFAM, GRET, etc), UNIDO, and Bamboo Mekong Consortium. Private sector has been difficult to identify so far and Government bodies such as IPSARD and SFE (State Forest Enterprise).

2.2.2 Cassava

Cassava production has developed rapidly in Vietnam; from 1.99 million tons in 2000 to 9.45 million tons in 2009 (see figures below). It is the result of the expanding cultivation from 237,600 hectare to 560,400 hectare and the yield from 8.36 t/ha in 2000 to 16.90 t/ha in 2009. Vietnam has made rapid technical progress in Asia in the selection and breeding of cassava. There is a large demand for cassava chip and cassava starch. The combination of development and production of cassava as starch processing, animal feed and bio-ethanol has created more jobs, increase exports, attract foreign investment and contributed to industrialization, modernization of some rural areas.

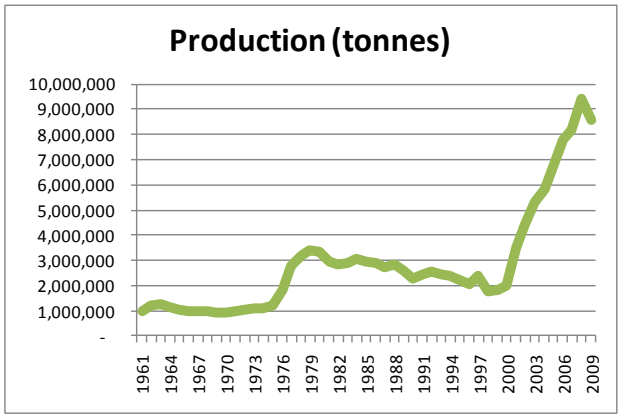


Figure 4. Production of Cassava over the years

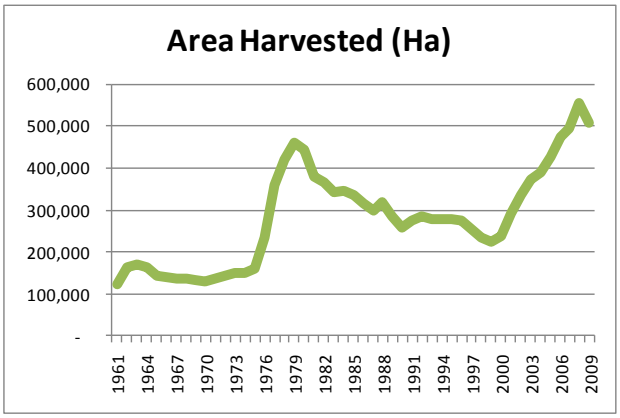


Figure 5. Planted area of Cassava over the years (FAOStat, 2010)

According to Nguyen, et al. (Nguyen, et al., 2004), Vietnam could get 1.25 million tons of cassava stem as residues from 4.15 million tons of cassava, with a primary energy content of 12,625 (GJ). Given the cassava production yield of Vietnam in 2009 is approximately 9.5 million tons, it is estimated that Vietnam could get nearly 3 million tons of cassava stem as residues equating to 30,000 GJ of primary energy.

Cassava is an annual crop and its harvest season varies from region to region within Vietnam, therefore, the previously mentioned source of cassava stem as residue could be collected throughout the year. Although the volume of cassava waste stems is considerably large the existing collection rate is practically zero. In areas where cassava farmers are organized in groups or cooperatives, the collection of stems could be realistic.

The fibrous residues coming from the starch processing industry are sold as raw materials for livestock feed production or used for compost. Waste water from cassava starch processing and ethanol production industries can be used for biogas production at more than 70 starch processing factories and 5 ethanol production plants all over Vietnam (from 50 to 100 million liters/year/plant). It is not known in how many cases biogas is already produced, but it is known that the covered lagoon technology is applied (in a few cases CDM is applied for this, see below). A medium scale cassava starch factory with yearly production capacity of 22,000 tons needs about 1,400 tonne of coal (70kg coal/1 tonne starch drying) for its process. With a coal price of about 3,000 VND/kg, energy costs are around 4.2 billion VND per year, which is equivalent to 210,000 USD.

Some CDM studies have been conducted in Binh Duong, Binh Phuoc, and Quang Ngai by Japanese and Swedish companies. With the number of cassava starch factories around 70, generating 2,000 – 4,000 m^3 of waste water/day, the potential for CDM projects is high. In Quang Tri province of North Central region, in 2010 a CDM project valued at 2 million USD was initiated by AES (American Energy Company) for Huong Hoa tapioca starch processing factory in which waste water from tapioca starch processing is treated in the biogas plant for heating and generating electricity for the factory.

The ethanol production industry in Vietnam now accounts for 50% of the current cassava production. Increasing demand for more primary product competes with food cultivation. Cassava cultivation has been promoted strongly by the

government; however, there is not an integrated master plan on land use planning and sustainable cultivation practice.

2.2.3 *Coconut*

Vietnam has 130,000 hectares of coconut plantations and harvests around 700 million of nuts yearly. Vietnam is the largest international exporter of coconuts for fresh consumption, with high demand coming from China. Coconut oil production is less attractive due to significant price volatility and a highly competitive market driven by palm oil. Consequently copra production is low and this by-product of coconut oil production is imported from the Philippines for animal feed.

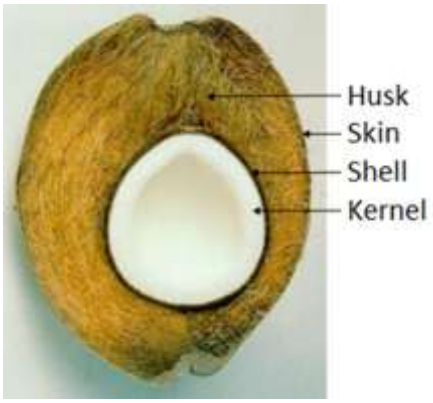


Figure 6. Morphology of a coconut

Coconut cultivation is concentrated in the Mekong Delta area of southern Vietnam, which generates 84% of the nation's total production. Ben Tre province has the highest concentration of plantations and produces 30% of the national harvest (Smith, et al., 2009). Infrastructure and the export business environment in the Mekong Delta have continued to improve in recent years in support of the industry.

The approximate breakdown of the coconut industry in the Mekong Delta area is:

Nuts	Production Outcome	Residue
31%	Nuts processed to coconut candy and desiccated coconut for international export	Shell and husk
30%	Nuts processed to coconut candy for local market	Shell and husk
32%	Raw nuts exported internationally (husk removed locally)	Husk
7%	Raw nuts sold locally for consumption	Husk – approximately 50% as drinking nuts retain their husk

Waste residues from processing coconuts in Vietnam are typically low compared to other coconut producing countries. Shells are practically 100% utilised, either for production of activated carbon or as fuel for domestic or industrial thermal applications. 96% of coconut husks are processed into coir, which is the fibrous material of the husk and used for making ropes, mats, nets and a multitude of other fibre products. The by-product of making coir is a fine dust called coconut pith. Accounting for about 12% of a coconut by weight, its primary applications are as a plant growing substrate and soil conditioner. In Vietnam, however, only 20% is value added in this way and the remainder, in excess of 80,000 tons, is dumped into the Mekong River to create an environmental burden (Smith, et al., 2009).
Local stakeholders include: two main exporters of processed products which are Wonderfarm (Ben Tre) and Betrimex (HCMC). The NGO Prosperity Initiative works in the Mekong region and is a valuable source of information. MARD is the ministry responsible for coconut production and trade.

2.2.4 *Coffee*

Coffee is the second most important export commodity in Vietnam in value and quantity (FAOStat, 2010). Vietnam today ranks as the world's second largest coffee producer (IPSARD, 2011). After a boom in plantations in the late 1990's and early 2000's, the focus has shifted towards the improvement of processing technology in order to obtain a higher quality final product, in order to grow the export market.

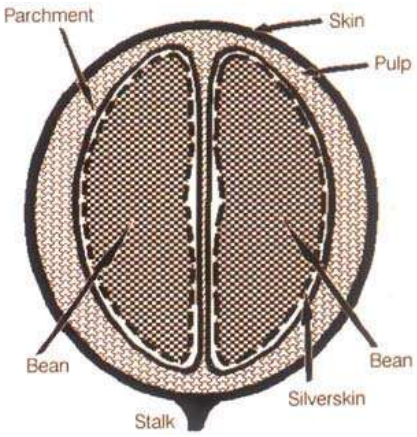


Figure 7. Morphology of the coffee cherrie

There are 500,000 hectares of coffee plantations in Vietnam. This is made up of 93% Robusta concentrated in the central highlands and 7% Arabica grown in the north. The majority of Vietnamese coffee is harvested between the months of October and January. 85% of the coffee production is carried out by small holders (typically less than 2 hectare land tenure) and 15% is state-owned (larger farms).

In Vietnam three different processing technologies are used; wet processing for Arabica, semi-wet or dry processing for Robusta. The objective of each process is to remove husk and flesh from the cherry, which in turn becomes the coffee bean.

The different processing technologies produce residues with different characteristics in regard to moisture and composition. Coffee residues represent 15% of the cherry weight when dried. Average coffee yield per hectare is 1.8 tonne, thus there is 270 kg of residues per hectare resulting in 135,000 tonne total in Vietnam.

There are about 500,000 smallholders supplying 1500-2000 small traders and primary collectors, who provide their goods to

- 5-6 multinationals,
- 140-150 domestic private firms and
- 5-6 joint stock companies

The residues are produced mainly on these final destinations.

Current practices of husk disposal are similar to those of rice husk, either burned out in the open or disposed along ways and countryside, either as a fertilizer or just left on the road. In *semi wet processing* systems, water is reutilized and sludge is used as fertilizer. No integration of the residue into the productive chain energy supply in Vietnam has been identified; therefore within wet and semi wet processing utilization of sludge for biogas and electricity generation is a promising opportunity, particularly in Arabica.

Residues from *dry processing* coffee beans are sometimes used as a primary fuel source for coffee driers at some small-scale facilities. Around 35% of production, however, is currently processed in large high technology plants with requirements for power and heat.

Coffee production demands high amounts of energy (typically diesel) for water pumping and the application of synthetic fertilizers. The bio-digestion of sludge from

wet and semi-wet processing represents a potential enhanced utilisation to provide energy for water pumping and bio-slurry as fertilizer.

Stakeholders include: 4C Coffee Growers Scheme (has been put in place in Vietnam by Nestlé), Buon Ma Thuot Coffee Exchange Center (BCEC), DAKMAN Company, Di Linh sustainable coffee cooperative, Joint Stock Investment and Export Coffee Highlands (state-owned company), MARD Department of crop production, MARD Department of processing, Nam Nguyet Company (Private company), Nestle VN company (Roaster), Thai Hoa company, The EaKmat Coffee - Cocoa research center, The Western Highlands Agro-Forestry, Scientific and Technical Institute (WASI), Trung Nguyen company, VICOFA, VINACAFE (Vietnam national coffee corporation), VINACAFÉ Bien Hoa joint stock company (Processor and Roaster), Vinacontrol (Quality control and certification). Currently ODA funded projects aim at enforcement of sustainable production schemes and do not take residue use into account, RainForest Alliance, 4C Association, Utz Certified and Fairtrade standards. Eurepgap certification is widely followed within the sector too.

2.2.5 Corn

During the last 10 years, Vietnamese corn production has increased progressively primary as a result to increasing demand of animal feed. Corn production in 2010 in Vietnam reached 4.6 million tons compared with 2 million tons in 2000. This increase is reflected in an increase from 730,000 hectare to 1,125,000 hectares during the same period (GSO, 2010).

The main producing regions are the north-east (50%) and the south-east (10%) of Vietnam with the remainder scattered throughout the country. The main production seasons are the Dong Xuan (from December to April) and He Thu (from April to August).

In the corn production plan for 2011-2015, MARD maintains the production area at 1.2 million hectares with the main focus towards increasing crop yields. Currently, the yield of maize production in Vietnam is 51.6 t/ha, compared to 55.5 t/ha in China and 96.5 t/ha in US. In 2010, corn imports into Vietnam reached 1.8 million tons, compared to 1.49 million tons in 2009 (Tran, 2011). This increase is being driven by the animal feed industry, which is presently growing at 8-10% annually and outstripping growth in local supply. There is an average waste to maize ratio of 2.5 (Cuong, 2009).

Figure 8. Corn residue

Figure 9. Corn Cobb

For corn seed harvest 3-5 out of total 12-15 green leaves are removed and used as animal feed when the cob is young. After the maize corn is harvested, the top part of the maize stalk is used for animal feed and the corn cobs and maize stalks remain. Sweet corn is harvested in the "milk stage", after pollination but before starch has formed (VNFOREST, 2011) (FAO, 1997). Maize residues include empty corn cobs, maize stalk and corn husk.

The primary uses of maize residues include animal feed and domestic fuel. For animal feed 18% of the maize stalk, green leaves and some of the corn cobs are utilised. Corn cobs are used at village level as a cooking fuel, however, in the main growing areas of the country dumping of corn cobs post-harvest is still common and can present an environmental issue.

Figure 10. Corn Cob being used directly for cooking

Main stakeholders include: Maize Research Institute of Vietnam (under VASS), Hanoi Agriculture University, Nong Lam HoChiMinh University, Nong Lam Hue University (Research Institutions). Plant Cultivation Department (governmental institution), Vinafood2, Bioseed Vietnam, Vinafood1 (business, import, export).

2.2.6 *Jatropha*

Jatropha curcas, an energy crop, is a long life plant and can live in difficult conditions area. After harvesting, the hulls of the seeds are removed in a dehulling step. The kernels are (mechanically) pressed or extracted, and the resulting oil is filtered. Typical oil extraction rates are 75-85% (BTG, 2009). Both the oil and the by- products (press cake and hull) can be used for energy production or further processing. The oil is a source for the production of biodiesel, electricity production and/or cooking fuel and often linked to small holders and income generation for the poor.

When all growth conditions are optimal and only water and nutrient levels determine jatropha yield, the following jatropha yields and potential seed yields are estimated for different levels of water and nutrient supply (see table below).

Table 1. Expected Jatropha seed yields for different water supply & soil fertility (FACT Foundation, 2010).

Water Supply	Soil Fertility	Dry Seeds (kg/ha/yr)
Optimal	High	6,000
	Medium	2,500
	Low	750
Normal	High	3,500
	Medium	1,500
	Low	500
Sub-optimal	High	1,500
	Medium	750
	Low	250

Nevertheless we have found that opinions about effectiveness of Jatropha are divided. Besides the actual companies and institutes really involved (There are about 10 Vietnamese companies and 5 foreign companies cultivating and focusing on Jatrọha projects in Vietnam (Tường, 2008)) most other experts in Vietnam on biofuels are skeptic like Mr. Man (Man, 2011) Ms Thoa (Thoa, 2011) and Mr. Do (Do, 2011), they show only unsuccessful stories in Jatropha. Reported yields by the projects are between 1 and 5 ton/ha in Vietnam.

Table 2. Identified planted Ha in Vietnam (larger than pilot)

Company	Area	Reported yields
Local Joint Venture with Eco-Carbone	250 ha	1 ton/ha
Nui Dau Company	150 ha	-
Green Energy Biomass	850 ha	Available upon request
Thanh Tay University	1.080 ha	-
Total	2.330 ha	

Jatropha has been grown in Vietnam since 2006. More than 2000 ha of Jatropha is planted mainly in Lang Son, Son La, Nghe An and Lai Chau. The areas south of Quang Tri are expected to be more fertile for Jatropha growing. The flower blooms in February, and has its fruit in March and can be harvested in May (Võ Thị Mai Hương, 2010). Harvesting starts in the second year and is done yearly since, with expected stable yields from the 3rd to 6th year, depending on many factors. If the sector grows the application of the jatropha residues becomes another opportunity. Press-cake for fertilizer or biogas and the hulls (30% of the seed weight (BTG, 2009) can be used for bioenergy or biofuels production.

Reported needs for the sector are mainly:

1. Support and knowledge exchange in the field of farming techniques, and further support for the farmers
2. Financial support for larger demonstration areas and/or commercial scale up (30.000 ha and above)

3. Technical support for the technology to conversion into oil techniques for the Vietnamese context and suppliers. Worldwide available technologies are not yet available in Vietnam or not applicable in the context.

Recently, a large scale new project was presented, Truong Thanh Furniture Corp. (TTF) and JATRO Singapore Pte. Ltd together are planning on growing 100.000 Ha of Jatropha curcas in Central Vietnam. Furthermore also other international parties like JICA and ADB showed interest and funding possibilities.

2.2.7 *Manure*

The livestock sector in Vietnam is continuously changing. The livestock subsector's share of the Gross Value of the agriculture sector has increased from 19.3% in 2000 to 27.1% in 2009. Statistics show that the total number of households raising pigs is decreasing, while the number of animals per household is increasing. For cattle both the number of households raising animals as well as the number of animals is increasing, this is because of the rising demand for milk and milk products[1]. When household sized farms are taken into account, numbers are significantly higher, estimated at 2 million pig farms.

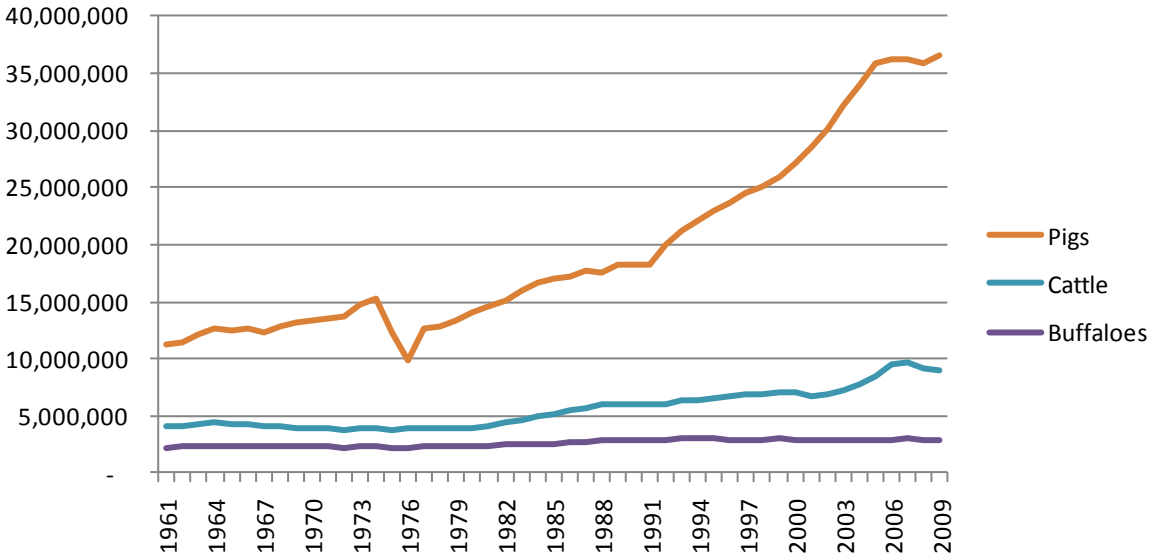


Figure 11. Increasing number of animals in Vietnam (FAOStat, 2010)

Furthermore the overall number of medium and large-scale farms raising pigs and cattle is increasing. This centralized and industrialized way of farming is supported by the government who identifies larger farms as one of the solutions against disease spreading country wide (a recurrent problem in Vietnam).

Vietnam had about 8.5 million households raising livestock in 2010. The described trend leads to a growing environmental problem due to the lack of proper manure management systems. Vietnamese laws on manure management are difficult to enforce and awareness of the issue and its solutions with the farmers is minimal.

1 Vietnam at present cannot meet the demand for meat and milk products from its national production. Instead the country imports e.g. pork in bulk and the vast majority of the milk powder required.

The total manure production in Vietnam is estimated around 95 million tonne per year (GSO, 2010). 50% of solid dung and 80% of liquid dung are currently not treated before re-use or being disposed into waterways (Doan, 2006).
Vietnam has a long history with using biogas digesters to treat manure. The biggest stakeholder on household level is MARD who is implementing a country wide "Biogas Program for the Animal Husbandry Sector in Viet Nam" since 2003 with support from SNV and financed by the Dutch Government (DGIS). More than 115,000 units have been built between 2003 and 2011. MARD is also implementing 2 smaller household biogas programs funded by the ADB[2] and WB[3]. The total number of biogas digesters in Vietnam is estimated to be 500,000, of which about 300,000 replace coal for cooking in flat rural areas and 200,000 replace wood for cooking in mountainous areas (Hoa, 2011).

The medium and large scale biogas sector is now under development. While most large commercial developments involve the "covered lagoon" type of digesters, donors are trying to introduce appropriate models to stimulate the medium-scale market. In the medium and large scale biomass sector there are still many opportunities. Biogas production from manure is previously mentioned, but also biogas production from waste water. There are also opportunities relating to equipment supply such as H_2S filters along with biogas generators, heat exchangers, fertiliser production, etc.

Main stakeholders include: SNV (funded by EEP Mekong, in a consortium with IE, GECI and SEI) and MARD (funded by the ADB). MARD invited SNV to support the Medium Scale Biogas Sector in September 2011. A WB program for medium scale biogas has just ended and has not yet obtained follow-up. All these programs are relatively small scale, piloting 10 to 20 units in North Vietnam. SNV is currently aiming, potentially in combination with the program of the ADB which is focused on the provision of credit for the farmer, to further structure the market and introduce quality control systems as well as proper training for constructers and end users.

2.2.8 (Organic) Municipal Solid Waste (MSW)

Currently 29% of the population is living in urban areas (Cardomy, 2011) and urbanization rate is 3% yearly. Urban populations are concentrated in Hanoi and HCMC where altogether around 9 million people live. In Vietnam it is estimated that 15 million tons of waste is produced annually, of which 50% comes from urban areas, of which an estimated 70% is collected (Than, 2011). In rural areas less than 20% is collected causing various environment and consequent health problems.

As the country develops and relative consumption rates increase, the volume and diversity of waste becoming a major environmental issues. Systems relating to waste collection, transport, storage, treatment and disposal are inadequate and unsustainable. Currently Vietnam government is pursuing solutions to these problems in partnership with several European countries, including Sweden, Germany, Belarus and Finland.
Currently municipal solid waste corresponds to 80% of the total waste collected (not including agricultural wastes) and has an organic fraction between 45% to 80% in urban areas (Urenco, 2011) (WB, MONRE, CIDA, 2004). Recent figures provided by Urenco show a slightly lower organic percentage for Hanoi, 42% organic and 5%

2 The Quality and Safety Enhancement of Agricultural Products and Biogas Development Project(QSEAP) househ old biogas is only a small component of the total program
3 Livestock Competitiveness and Food Safety Project (LIFSAP), household biogas is only a small component of the total program

paper[4]. The biggest company responsible collection, transport, storage and treatment is URENCO under the supervision of MONRE and DoNRE (Government owned). There is an organized system for collection and transport in residential areas, urban districts and communes, where daily URENCO garbage collectors load it into trucks for transport to municipal landfills. All municipal solid waste is sent to landfill without treatment and there are no gas recovery systems in the country.

Even though Law on Environmental Protection and decrees on solid waste management exist and address proper waste disposal, it has not been enforced. The government budget for the sector is supplemented by households (approximately 1.25USD/person/year), hospitals and industry.

2.2.9 *Rice*

Vietnam is the second biggest rice exporter in the world and has a long history of rice cultivation. During the last 5 years, rice production in Vietnam has increased steadily, reaching approximately 40 million tons of paddy in 2010 (GSO, 2010). Based on the residue to product ratio (RPR) reported by Bui Quang Tuan (Tuan, 2007), it is estimated that Vietnam produces 23 million tons of rice straw and 8 million tons of rice husk every year. While rice straw is mainly left in the fields after harvesting, rice husk is produced in large quantities in hundreds of thousands of rice mills all over the country.

Vietnam has large rice production centers; the Mekong delta region in the South accounts for 50% of total rice production and the Red river delta area in the North produces about 20%. There are 3 main rice cultivation seasons in Mekong delta, while Red river delta can only plant two seasons of rice per year. As such, rice straw is produced in-line with harvesting times throughout the year. The production of rice husk, however, depends on the supply chain of the paddy market, where paddy is usually stored, processed and sold based on the market demand. Therefore, rice husk production is more or less stable throughout the year.

Picture 12. Briquette making in Tien Giang

Rice husk is currently used in Vietnam in many different ways. Traditionally, rice husk is used for domestic cooking, as fuel for ceramic/brick kilns or returned to the field as fertilizer. More recently, several projects utilising rice husk for energy production have been developed. Six 10MW rice husk-fired power plants in the provinces of Tien Giang, Can Tho, An Giang, Kien Giang, and Dong Thap have been developed (TPO, 2010). Each 10MW rice husk power plant consumes 85,000 tons of rice husks per year.
There is presently work underway to develop rice husk gasification systems for use in brick kilns and instead of direct combustion (Enerteam, 2009)[5]. Direct combustion of rice husk, however, is the common practice among more than 6,000 brick kilns in the Mekong delta area alone. This uses almost 50% of the total rice husk residue in that area (Hien, 2010). In Tien Giang province in the Mekong delta, the price for rice husk ranges from 100VND to 500VND/kg,

4 Based on meeting with Urenco on 06 Dec 2011
5 Also extensively discussed with experts from Enerteam, and independent consultant Marc Pare in November 2011.

depending on the selling quantity and the season. Large ongoing purchasing contracts are able to demand more competitive rates.

In the last 5 years, production of rice husk briquettes have become more common, supplying a valuable fuel for small and medium industrial boilers in Vietnam. There have also been a few rice husk pellet manufacturers, targeting foreign markets of Korea, Philippines and EU or local markets. In Mekong delta, paddy drying systems consume about 100,000 tons of rice husks. Of the total 4 million tons of rice husk production in the Mekong Delta region an estimated 1 million tonne is unutilised (Hien, 2010). The rice husk is also used in the brick making sector, one of the most polluting sectors of Vietnam.

Rice straw, unlike rice husk, is not utilised to nearly the same extent. In the past straw was also used for domestic cooking, but improved living conditions have ended this practice. Nowadays, rice straw is utilised for potato planting, cattle feed, pig bedding, mushroom cultivation and soil incorporation. According to Bui Quang Tuan (2007), 23% of the total rice straw is used for animal feed. According to SNV's recent survey in Central of Vietnam in Quang Binh province (Dec 2011), about 25% of rice straw is utilised, another 25% is freely burnt in the field and 50% is composted in the field. In Mekong delta, SNV also conducted a survey in Can Tho province (Dec, 2011) and the result showed that 60% of rice straw is burnt while 40% is incorporated into soil. In the Red delta area, in 2011, Hai Duong is the first province which promoted bio-fertilizer production from rice straw in large scale. 2,507 tons of rice straw (accounts for 26% of total rice straw production of this whole province) was used as bio-fertilizer (Hai Duong Science and Technology Department).

The main stakeholders in this field are Vinafood 2 (Government owned rice producing company in the South) (50% market share), Vinafood 1 (10% market share) (Government owned rice producing company in the North) of rice production/export. Some important research institutions are the Cuu Long Delta Rice Research Institute (CLRRI), Nong Lam University, Hanoi Agriculture University, Vietnam Institute of Agricultural Engineering and Post Harvesting Technology (VIAEP, under MARD).

2.2.10 Sugarcane

The production of sugarcane in Vietnam has steadily decreased in the past 10 years with plantation areas dropping from 344,000 hectares in 1999 to 266,000 hectares in 2010. In that year, Vietnam processed approximately 16 million tonne of sugarcane (GSO, 2010). At the same time demand for sugar has increased and the demand in 2010 was 30% higher than local supply (Dang Thanh Huong, 2010).

In Vietnam sugarcane is harvested once a year in the North and twice per year in the South. The cane stalk is removed for processing and the leaves are stripped off and left on the field to dry to be later burned. Harvest sugarcane is transported to the factory for processing to sugar and various by-products and residues (Figure 9).

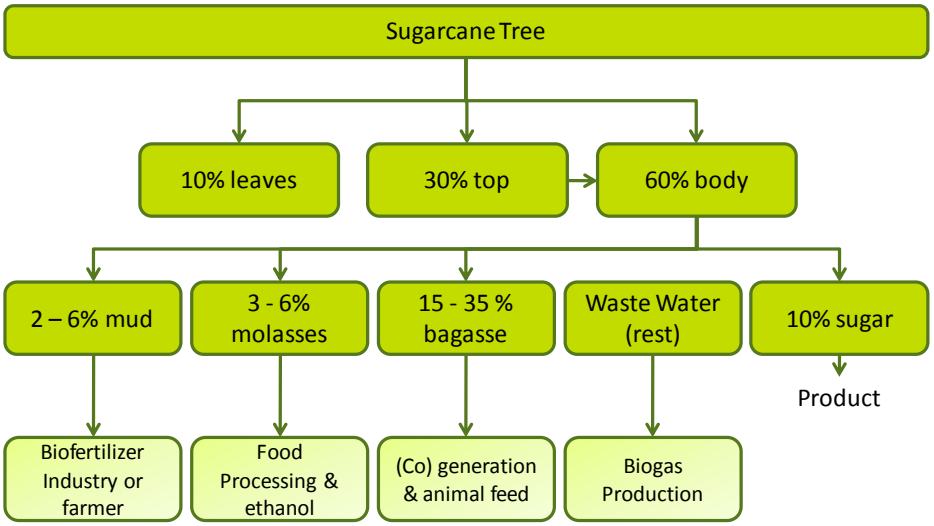


Figure 13. Sugarcane production and residues (Hai, 2008) and (Casuco, 2011)

Using bagasse as a fuel for primary process heat and/or electricity generation is mature technology in the sugar industry. The current utilisation of bagasse in Vietnam is 100%, which is primarily for energy production at sugar factories and a minor amount going to animal fodder. Nevertheless most processing factories have low efficient (co)combustion technologies that present opportunities for optimisation.

It is estimated that about two million tons of bagasse are used annually by sugar plants for burning in steam boilers to produce at least 4 million tons of steam and 560 million kWh of power (Cuong, 2011), (Tho, 2011). Most of this is used onsite for processing and at present, only 3 power plants are selling their surplus electricity to the national power grid. The highest feed-in tariff received by these plants is 4US cents/kWh. All three plants are located in Tay Ninh province and the biggest power plant is 24MW capacity. There are 38 sugar factories that are producing heat and power from bagasse.

MARD has high demands when it concerns waste water and the after treatment necessary to reduce the COD. The waste water from sugar processing can be used for biogas production. Unfortunately the biogas is almost never used, the factory also has no indication of the amount of biogas produced (Association, 2011) (Casuco, 2011).

Sugar, bagasse and molasses can be used for ethanol production. In Vietnam there is only one factory in Phu Tho province presently using molasses in combination with cassava to produce ethanol. This factory is producing 100 million tonne of ethanol annually (of which the molasses part is really small) (PetroVietnam, 2011).

With the declining sugar production and increasing demand the market in Vietnam is stressed. Using primary products for energy production is not recommended. Bagasse from the production process is presently being 100% exploited for energy production, however, there is potential for improvements in efficiency, primarily through cogeneration.

Figure 14. Bagasse being prepared for temporary storage at Casuco Factory

Stakeholders are: Department of Crop, MARD; Institute of Agricultural Science of South Vietnam; and PetroVietnam (PVN). In the private sector, the Bourbon Tay Ninh Joint stock company takes 10% of market and has integrated power plants. Second largest is the Bien Hoa Joint Stock Company. Furthermore there is the Viet Nam Sugar Cane Association.

2.2.11 *Wood residues*

By December 2009, the country has more than 13 million hectare of forested area, in which more than 10 million hectare is natural forests and 3 million hectare are plantations. The wood processing industry in Vietnam has developed and progressively changed in the last decade. The volume of harvested timber increased from 3.2 million m^3 2006 to 3.8 million m^3 in 2009 and expected to increase up to 4.95 million m^3 in 2010, of which 90% timber was harvested from plantation forest (VNFOREST, 2011). The main wood products include rough products (sawn wood, plywood panel, composite panel), refined products (wooden board, wooden beds, etc), and handicraft or artisan products.

In the Central Highlands, Central North and Northeast areas forest cover is high at over 40%. In the Southeast forest cover is about 20% whereas in the Red River Delta and Mekong River Delta, most of the area is used for agriculture and forest cover is below 10% (VNFOREST, 2011).

In 1943, Vietnam had 14.3 million hectare of forest area, with 43% of forest cover. It reduced to 9.18 million hectare in 1990, with only 27.2% of forest cover remaining, losing 100,000 hectare annually from 1980 to 1990. From 1990 to present forest area has been increasing, albeit slowly in the last decade. Additionally, the loss of mangrove forests has been and continues to be particularly acute, from 400,000 hectare in 1943 to less than 60,000 hectare in 2008.

The new plantation forests consist of single fast-growing species that have very low biodiversity value. Competition of demands for agricultural and forest uses in some natural forest area have resulted in illegal changes to the intended land uses, leading to extensive deforestation. Some reserved forest is being burned to make way for coffee and maize production (Joint Development Partner Report to the Vietnam Consultative Group, 2011).

Up to 70% of the input material for timber processing in Vietnam comes from imported products, for which the price has been increasing in recent years at 10-20% annually. Vietnam has about 2,500 wood processing enterprises, of which 500 export wood products. Only about 200 of these have Forest Stewardship Council (FSC) chain of custody certificates. In order to move forward, Vietnamese enterprises need to find ways to comply with the Lacey Act in the United States and Due Diligence Regulations in the European Union if they are to access these two large markets.

Wood residues can be divided into three smaller sub categories:

- Logging residues
  Estimated amount of residues from logging is 2.2 million tonne (2009), based on a fuel wood yield of 40% from logging (FAO, 1997). In 2010, 4.7 million tonne of logged wood processed (0.7 ton/m^3). Most of these residues are left in the forest due to difficulty of logistics and low demand (Quyen, 2006).
- Saw milling
  The amount of wood residues from saw milling is 2.35 million tons, based on a yield of 50% and including solid wood waste (38%) and sawdust (12%) (FAO, 1997). In large sawmills these wood residues are typically used for providing process heat for timber drying purposes, whereas the waste from small mills is typically used locally for domestic cooking. Some facilities additionally utilise sawdust by mixing with binding material to produce particleboard (Quyen, 2006). In family-scale sawmills, sawdust is used for domestic cooking (from observations).
- Scattered trees
  Scattered trees are the small uneconomical trees left behind with logging residues. It is estimated there is more than 200 million scattered trees per year in Vietnam, equivalent to 100,000 hectare of plantations (VNFOREST, 2011). A fuel wood yield of 0.4-0.5 tonne/ha/year is expected, therefore, the fuel wood potential is about 50,000 tons per year (FSIV, 2009).

There are some notifications of wood fed pellet plants in Vietnam, mainly small scale. Examples are Tan Phat Company, Kim Anh Minh Co., LTD (pellets, briquettes and chips). No larger scale production is identified.

The main stakeholders in Vietnam when it concerns forest are Viet Nam Administration of Forestry (VNFOREST), Forest Inventory and Planning Institute Vietnam Forestry University. Main processors / industrial parties are Truong Thanh furniture and wood processing company, MDF COSEVCO – Quang Tri, MDF Gia Lai, MDF Thien Son (Binh Phuoc),

2.2.12 Fish waste

Fish oil from fish waste can be used as a feedstock to produce biodiesel. Fish oil is derived (through pressing and separation) from the leftover guts and other waste after fish fillets are produced and this is mixed with methanol and other products. According to a market study done by Energyfish (Enerfish Consortium, 2011) Vietnam is worldwide one of the major players in quantity (ranked 3rd) and the pangasius (catfish) is the main species used for aquaculture which has a high fat content in its waste stream (22% in mass) and it is therefore well-suited for biodiesel production (high yield).

To reach the 5% of biodiesel goals as described above would mean approximately a production of 500,000 tons biodiesel per year. Knowing that about 10 ton cat fish is needed to produce 1 ton of biodiesel, 500,000 ha of land would be required to provide this amount. This is twice the aquaculture production of Vietnam (Enerfish Consortium, 2011).

As there is a lot of fish grown in Vietnam, the potential seems high, in 2010 1,140,000 million tons of catfish was produced, mainly in the Mekong Delta. There are 2 other companies producing biodiesel from fish waste, in Can Tho (Minh Tu Ltd Company) in An Giang (An Giang Fisheries Import Export Joint Stock Company - AGIFISH Co.). Both companies are considered small scale producers with a variable output.

Nevertheless one of the conclusions of the EU funded Enerfish program (EnerFish, 2009) that the distribution as a transport fuel, on a larger scale, of biodiesel is challenging as this is in hands of PetroVietnam, a state owned enterprise that is not yet open for cooperation in this field. Furthermore diesel is subsidized in Vietnam and currently has a price around 22.000 VND which is below the market value. As for electricity, there is also no premium for fuels when the are green.

2.2.13 Tea

Tea is grown in 34 provinces of Vietnam, mainly mountainous areas, with a total cultivation area of 113,200 hectares (FAOStat, 2010). The processing factories' demand is more than double the capacity of supply. Little residues are produced during the process and the energy demand for drying tea is high. Typically wood is used for tea drying. At times of replanting volumes of wood are generated, but these are used onsite for drying. Tea is not identified as a high potential for its residues.

2.2.14 Miscanthus

Miscanthus, also known as elephant grass, is a fast growing grass crop. It grows mainly in medium high altitudes and in the North of Vietnam. The root can also be used to make medicine. In Vietnam the main purpose of the use is to feed cattle. High yields of 200-250 t/ha/year are typical in Vietnam because there are several crop within a year. As far as could be identified, there is no research in Vietnam to use the crop for energy purpose.

2.2.15 Algae

The Dutch Government, NL Agency is already financing an algae project in Vietnam set-up by Department of Ecology, part of the Institute of Tropical Biology at the Vietnamese Academy of Science and Technology. The Vietnam Aquatic Biofuel Project focuses on the production of algae by smallholder farms for improved income generation from the sales of the product and increased shrimp production and quality. Nevertheless all activities are still in the R&D phase and the road to commercial production is yet to be proven.

2.3 Resources summarized

In the table below the availability and use of the resources is described as far as the information is available.

	#Ha	Yield/Ha	Location	% of resource is residue or waste	Current practices	Theoretical Availability (ton)	Characteristics	Practical Availability	Trends
Bamboo	800,000 plus 600,000 mixed forest	10 - 13 t/ha	Northwest and east (33%). Mostly: Lam Dong (6.2% bamboo plantations and 16% mixed forest). Tuyen Quang, Son La, Bac Can, Yen Bai (7% BP and 43% MF)	50 - 70%	1) floor manufacturing: Combustion for primary energy 2) charcoal 3) used for paper and pulp production (50 - 80%) 4) domestic fuel	Around 7 million ton/year	-	unknown	High demand and pressure on its production
Cassava	560,400	17 t/ha	Central, North East, Mekong	Stem is 30% of the cassava harvest The peel: 3% The cassava root: 40% (moisture 50%) Waste water: 31%	1) Agricultural waste after harvesting: cassava stem and agro-industries' residues - fertilizer and as seedling for next harvest (not collected) 2) Waste of tapioca starch processing can be used for raw fodder and/or fodder processing 3) Waste water for biogas production	3 million tons of cassava stem	-	unknown	
Coconut	130,000	13 t/ha	84% in Mekong Delta (Ben Tre 30%)	30% weight is husk, plus leaves and bark it is 6.5 tons/ha of fuel wood	100% shell: activated carbon or domestic fuel or industrial thermal. 96% husks: processed into coir	975 tons only husk + 1.6 million tons fuel wood + 1 million tons pith	Coir is fibrous, high ash content (±18%)	80,000 ton of fine pith	Coconut oil its loosing share in the vegetable market, palm oil is gaining
Coffee	500,000 (7% Arabica, 93% Robusta)	1.8 t/ha	Robusta in the Central Highlands Arabica in the North	15% of the dried cherry weight	Combusted, fertilizer, dumped	135,000 tons	Max 12% moisture (Depend on processing technique)	unknown	Emphasis on processing quality, no increase in #Ha

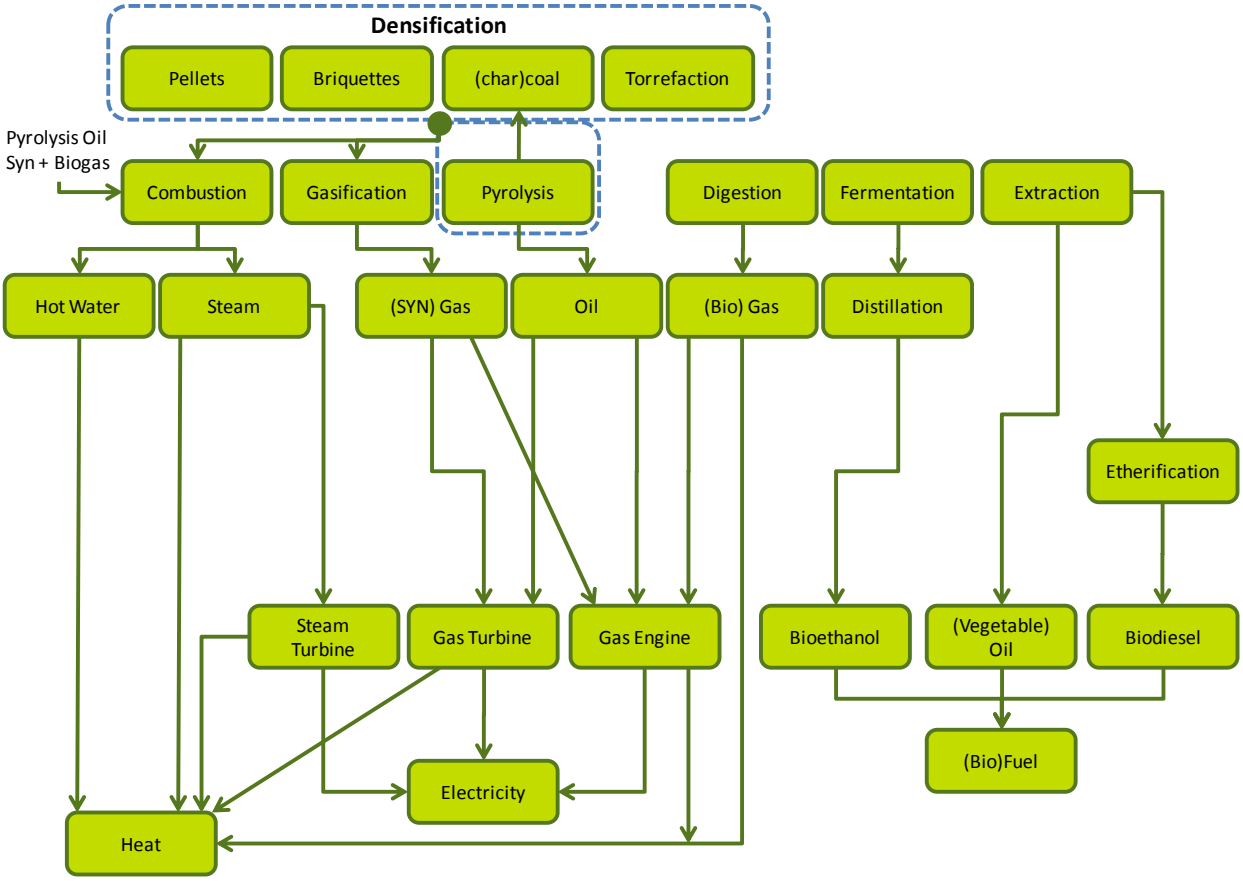
	#Ha	Yield/Ha	Location	% of resource is residue or waste	Current practices	Theoretical Availability (ton)	Characteristics: i.e. moisture	Practical Availability	Trends
Corn Cobb	1,125,000 ha	4.0 t/ha	50% Northeast and 10% in south east	20-50%	animal feed, cooking, fertilizer production, export (mainly)	1,066,500 tons	LHV (18.25 – 19.18MJ/kg), moisture content (28-38%)	unknown	higher productivity, but land use fluctuates
Corn Stob				200%	animal feed, cooking	9 million tons	Moisture content (10-20%), LHV (5-20MJ/kg), ash content (5-15%)	unknown	
Jatropha	> 2,000 ha	1 - 5 t/ha	Lang Son, Son La, Nghe An, Lai Chau	Seed: 30% oil; 70% cake	mainly test farms, vegetable oil	Seed: 780t - 1,200t oil; 1,820t - 2,800t cake	Seed: 30% oil; 70% cake	3,600 t - 4,000t seeds	Government focus on Jatropha
Manure	-	±30.000 million heads, manure 2kg/head	Nation wide	n.a.	biogas, dumped, fertilizer	almost 1 million ton		almost 1 million ton	Farm size is increasing
OMSW	-	15 million ton of waste/year, ±35% collected	50% in urban areas (Hanoi and HCMC)	45 - 80% is organic	Landfill (almost 100%)	15 million ton		1 - 1,5 million ton	Interest in combustion, increased waste amount

	#Ha	Yield/Ha	Location	% of resource is residue or waste	Current practices	Theoretical Availability	Characteristics	Practical Availability	Trends
Rice husk	7,500,000 ha	5.32 t/ha	20% in Red river delta and 50% in Mekong river delta	20%	Cooking (15%), brick kiln (40-45%), power plant, briquette (10%), left over (20-25%)	8 million ton	ash (23%), moisture (10%): HHV (3000kcal/kg)	2 million ton	larger field, machinery applied harvest
Rice straw				85% (on average)	mushroom, cooking, burning in field, fertilizer, animal feed, bonsai, fruit bed (58%), burning (42%)	23 million ton	ash (15%), moisture (13%). LHV (15-16MJ/kg)	17 million ton	
Sugar Cane	266,000 ha	51.7 t/ha	Mekong River Delta, North Middle and Coastal Plain, and East South	Top: 30%, Leaves: 10%, Bagasse: 9%, Fructose: 1.8%, Others: 1.2%	50-60% bagasse: combustion in Furnace; bagasse: fertilization	Top: 4,110,150t; Leaves: 1,370,050t; Fructose: 246,609t; Others: 164,406t	Top: 30%, Leaves: 10%, Bagasse: 9%, Sugar: 6%, Water: 42%, Fructose: 1.8%, Others: 1.2%	Leaves: 2.1 mill t; Molasses: 0.4 - 0.8 mill t; Bagasse: 2.4 - 5mil t	Demand sugar > production sugar
Wood residues	13 million (*)	residues: 5 million tons/year (**)	Central Highlands, Central North and Northeast (40%), Southeast (20%)	40% Logging, Saw-milling (38% solid, 12% sawdust)	wood chip export, particle boards, burning in kilns, domestic cooking	11 million ton residues. 4million m3 wood production		unknown	Planted area increases but forest cover is reducing. Productivity of planted forest is expected to increase to 25% by 2020

(*) 13 million ha in total, 10 ha natural forest and 3 ha planted forest
(**) 2 mil. tons from logged timber, 2.5 mil. tons from sawmills, 500,000tons from scattered trees

2.4 Conversion Technologies

Different biomass sources can be converted into several energy carriers (like oil, gas, pellets, or charcoal) or can be converted into energy directly (through combustion). The different conversion technologies are briefly highlighted in **Error! eference source not found.**. In the figure below you see the different conversion routes possible, and realistic for the Vietnamese situation.



Furthermore, in the table below the different routes for the previously discussed biomass sources is shown. In the previous paragraph it is already discussed what is currently done (of these routes) in Vietnam, in next chapter the main opportunities related to these conversion technologies and a Dutch – Vietnamese cooperation will be discussed. The figure above and table below are for indicative reasons; to indicate what options has been explored to come to the conclusions in the next chapter on opportunities.

Table 3. Conversion Technologies

	Pellets	Briquettes	Charcoal	Torrefaction	Combustion	Gasification	Pyrolysis	(An)aerobic (co-) digestion	Biodiesel Bio ethanol
Bamboo			X	?	X	X	X		
Cassava									X
Coconut (Coil and Pith)	X	X	X	?	X	X	?		
Coffee Pith	X	X			X	?	X		
Corn (Cobb and Stob)		X		?	X	?		?	
Jatropha									X
Manure								X	
Manure (poultry)					X	X	X	X	
OSW					X			X**	
Rice Straw				X	X		X	X*	
Rice Husk					X	X	X	X	
Sugar Cane Bagasse				X	X	X	X		
Sugar Cane Molasse									X
Wood	X	X	X	X	X	X	X		

* Not fermentable in a biogas plant without special pretreatment: Thermally / Chemically
**landfill MSW / digestion OMSW
Note: Energy efficient fermentation particularly of straw and leaves could make a substantial contribution to power supply.

2.5 Sustainability issues

The utilization of biomass for renewable electricity, heat and transport fuels can achieve greenhouse gas emission reductions and a decreased dependency on fossil fuels. Vietnam's targets to increase the share of RE in electricity generation to 4.5% in 2020 and 5% in 2030 and to increase the use of biofuels to 5% the total oil and gasoline demand by 2025. Unfortunately ambitions, commercial private sector involvement in combination with government incentives or pressures this can lead to unsustainable biomass production.

Box 1. Sustainability Criteria the Netherlands

The 'commission Cramer' criteria cover mainly six relevant themes **(Project Groep "Sustainable production of biomass", 2007)**:

1. **Greenhouse gas emissions**: How much emission reduction does the use of biomass yield for a specific producer, calculated from its source up to its use, and compared with the average use of fossil fuel?
2. **Competition with food and other local applications**: Does large-scale production of biomass for energy supply supplants other use of the land, for example for the cultivation of food or wood as building material, and what are its consequences?
3. **Biodiversity**: Does the local natural ecological system of land and water lose any variation in forms of life because of the large-scale cultivation of energy crops?
4. **Environment**: Are there any effects of the use of pesticides and fertilizers, or are there other local effects on soil, water and air because of the large-scale production of biomass?
5. **Prosperity**: Does the production of biomass contribute towards the local economy?
6. **Social Well-being**: Does the production improve the social living conditions of the local population and employees?

The "Corbey Commission" or commission on sustainability questions concerning biomass was established in 2009 to continue the work of the Cramer commission. Many of these sustainability criteria for biomass have been adopted by the European Commission, in the European Renewable Energy Directive (2009/28/EC).

Recently, in May 2011, the Dutch biofuels legislation was published in which sustainability requirements play a key role. Only biofuels that have been demonstrated to meet European sustainability requirements count toward the objectives mentioned above. These requirements are similar to the Cramer Criteria and involve greenhouse gas reduction, the biomass may not be derived from land with a high biodiversity value or produced on land with high carbon stocks, unless it can be proven that the production of biomass does not lead to the drying out of previously wet soils. Furthermore companies are required to report on other environmental effects, such as soil, water and air, as well on the recovery of degraded lands, social aspects, food prices and land-use rights.

The food versus fuel discussion is very overlapping with the sustainability criteria. The importance of this issue for the Netherlands was again confirmed during the Sustainable biomass and food security meeting on the 14th of October 2011 organised by NL Agency. When it comes to food the Dutch policy of the ministry of Foreign Affairs on food security focuses these priorities (NL Agency, 2011):

- Sustainable and more efficient production, with sustainable use of land and water
- Efficient markets that result in benefits from local and international value chains for local farmers
- Better access to high quality food for the poor

- Creating favorable circumstances for producers in developing countries (i.e. better infrastructure, support to farmer organizations and financial services).

When it comes to land ownership a revision of the law in 2003, rearranged the land into 3 groups,

1. agricultural land
2. non-agricultural land
3. non-used land

The agricultural land can be further divided into different groups:
(1) annual crop land; (5) special-used forest land
(2) perennial crop land; (6) aquatic land
(3) forest-used land; (7) land for salt production
(4) protected-forest land (8) other (in accordance with the government regulations)

These lands are divided by the Vietnam Law into annual land use and long-term land. When it concerns annual land, the farmers can decide on the crops they are growing, even if this land is inside an area in the Agricultural Master Plan.

In case the government really wants to plan crops for a specific area they will sign contracts with farmers (suppliers) that want to join this project and with companies (buyers) for this (energy) crop. For long-term land there are agreements on its crops. In case a farmers wants to change his area of land from long-term to annual, an approval is needed from local authority (cooperative/enterprise need approval from provincial level while farmers can get approval from district level).

Nevertheless the government does give incentives, through its provincial government offices for specific crops in specific areas (providing seeds or fertilizer for example). Therefore sustainable biomass production in Vietnam still starts with the government.

These criteria are focusing on the sustainability of biomass production. There is little actual production of biomass for energy purposes in Vietnam, mainly cassava (for ethanol) and a small amount of Jatropha plants (for vegetable oil for further processing). Experts indicate that deforestation takes place in Vietnam due to the increased growth of cassava, but no researches were found to confirm these presumptions. With the ethanol plants not utilizing their capacities and an increasing demand for ethanol it is expected that the demand for cassava will further increase which may lead to negative land-use change. The short term vision of farmers influences the land-use change as well. As farmers in Vietnam tend to follow trends, resulting in them growing the crop with the highest market price, making this market price drop after their harvest due to increased. Cassava is the clearest example of this in Vietnam.

If Dutch companies are interested into entering the cassava, cassava ethanol or cassava residue market further research on its sustainability is desirable.

The Vietnamese government recently released the objectives to have 300,000 hectares of Jatropha under cultivation by 2015 (MARD Decree #1842), which is part of a larger government focus to "master" the production of oil seeds for biofuel feedstock (Prime Minister's Decree #177). The Center for Biotechnology in Forestry

(Department of Forestry) is mentioned as the prime research agency. The actual implementation and available funds for this degree is unclear.

2.6 Sustainability, other social-economic issues

The biomass resources in Vietnam are mainly residues, or waste materials and by-products. They are not dedicated grown for energy purposes. Therefore when it comes to sustainability in these cases, other issues are of importance. How these residues are currently utilized? Are they providing an income for (other) households, are they used as animal feed? What would the effect be on the situation of these dependants if those residues will be utilized for energy purposes? This issue is already covered in some of the chapters above, but some critical issues will be summarized below.

The use of corn should not be promoted as energy crop, unless there is additional focus in the Agriculture Master Plan for this. The crop area is kept the same and a yield increase is desired. Currently maize is already used as animal feed. A similar situation is the case for sugar cane, demand of sugar is higher than the supply and currently sugar is imported from neighbouring countries. The sugar market is under stress without its raw material (the cane) being used for energy purposes. Focus for both corn and sugar should be on its residues.

In the bamboo sector there is also a lot of pressure on the trees as again the demand is much larger than the supply. Harvest is often pushed, and trees are not given its proper time needed to grow. This endangers both the forests as well as the quality of the products.

The environmental impact of the coconut industry is currently high, waterways are used as dump areas, as in this area most of the processing and export preparations is taken place (China; 14% Vietnam exports demand).

3 Government of Vietnam & Energy

Realizing the importance of energy in sustainable economic development, Vietnam in the last decade has prioritised investment into developing energy sector infrastructure and policy. The current electrification rate of >96% is a testament to these efforts. The current national energy development strategy aims to ensure energy security, increase low-carbon energy production, diversify energy supply sources and promote energy efficiency.

3.1 Energy Policies

Some of the energy policies listed in the table below (arrange by date of approval).

Legal document	Time approval	Related contents
Decision 1208/QD-TTg, by Prime Minister	21/07/2011	Title: **National Power Development Plan period 2011-2030 (Master Plan VII)** **Objectives and targets:** - Increase the share of renewable energy in total commercial primary energy from 3% in 2010 to 5% in 2020 and 11% in 2050 - Increase the share of electricity generated from renewable resources such as wind and biomass from 3.5% of total electricity generation in 2010 to 4.5% in 2020 and 6% in 2030
Decision 37/2011/QD-TTg	29/06/2011	Title: **Mechanisms to support wind power** **Contents:** - 20 year power purchase agreement - Investment incentives, taxes, fees, land infrastructure - Support for electricity prices (grid): purchase price equivalent to 7.8 US cents / kWh - The application of CDM[6]
Decision 2149/QD-TTg by Prime Minister	17/12/2009	Title: **National strategy on comprehensive management of solid wastes for period up to 2025, vision to 2050** **Objectives and targets concerning recycling, reuse and energy recovery of solid waste, :** - By 2015: 60% - By 2020: 85% - By 2025: 90% - By 2050: 100%
Decision 1855/QD-TTg	27/12/2007	Title: **National energy development strategies for Vietnam up to 2020, outlook to 2050**

6 This is shown to show that with the right pressure and lobbying, the government and EVN do make exceptions to the current strategy. For wind power a higher feed-in tariff was accepted and now implemented to make wind power more economically feasible.

		Objectives and targets: - Share of RE is 3% of total primary energy supply in 2010; 5% (2020), and 11% (2050). - Completion of RE, mountainous program. Share of households using RE in cooking is 50% (2010) and 80% (2020). By 2010, 95% rural households have electricity, by 2020, 100% HHs have electricity - Considering establishment of RE development fund
Decision 18/QD-BCT	18/07/2008	Title: **Promulgation of regulation on avoided cost tariff and standardized power purchase agreement for small renewable energy power plants** **Objectives and targets:** Regulation on conditions, procedures and construction of small RE power plants connected to the national power grid (Small Power Purchase Agreement) SPPA
Circular 58/2008/TTLT-BTC-BTN&MT	04/07/2008	Title: **Guideline on implementation of some articles of Decision No.130/2007/QĐ-TTg on financial incentives for CDM projects** **Objectives and targets:** Regulation on price subsidy for products from CDM projects, including: - Electricity produced from wind, solar, geothermal and tide - Electricity produced from recovered methane gas (landfill, coalmining) - (Grant amount/kWh = Production cost/kWh + reasonable profit / kWh - the selling price / kWh – selling prices CERs from CDM) *For instance: the 30MW Tuy Phong wind farm gets 4US cent/kWh as subsidy for the CDM project.* (CDM UNFCCC, 2009)
Decision 177/2007/QD-TTg	20/11/2007	Title: **Bio-energy development study report for period up to 2015, outlook to 2025** **Objectives and targets:** - 2010: development of models for experimenting and using of bio-energy, meeting 0.4% of gasoline and oil demand in country - 2015: production of ethanol and vegetable oil is 250,000 tons, meeting 1% of gasoline and oil demand in country - 2025: production of ethanol and vegetable oil is 1.8 million tons, meeting 5% of gasoline and oil demand in country
Decree 151/2006/ND-CP	20/12/2006	Title: **The state's investment credit and export credit** **Contents:** - Project owner (investors or exporters) have access to loan or credits of the Vietnam Development Bank - The loan capital level for a project shall be at most equal to 70% of the total investment capital level of that project - The interest rate applicable to investment loans in Vietnam

		dong shall be equal to the interest rate applicable to the government bonds of a five-year term plus 0.5%/year - The loan capital level shall be equal to 85% of the value of a signed import or export contract or the L/C value for a loan provided before goods delivery or the value of valid drafts for a loan provided after goods delivery
Decision 79/2006/QD-TTg	14/04/2006	Title: **National Energy Efficiency Program** **Objectives and targets:** Saving 3 -5% for the period of 2006-2010 Saving 5 -8% for the period of 2011-2015

3.2 Environmental policies

Legal document	Time approval	Related contents
Decree 04/2009/ ND-CP	14/01/2009	Title: **Decree on incentives, support on environmental protection activities** **Incentive:** - Regulation on incentives, support on land, capital - Tax exemption, reduction of tax, fees for environmental protection activities - Price subsidy, support for products from environmental protection activities, other incentives, support for environmental protection activities and their products - In the list of products with incentives, there is energy generated from waste treatment *For instance: Solid waste treatment project gets 50% investment capital from the Government.*
Law 52/2005/QH 11	29/11/2005	Title: **Environmental protection law – 2005** **Related contents:** - **Article 6.** Environmental protection actions which encourage development, use of clean energy, renewable energy, GHG emission reduction, reduction of ozone layer destruction - **Article 33.** Development of clean energy, renewable energy and environmental friendly products - Organizations or individuals who invest in development, use of clean energy, renewable energy, production of environmental friendly products get support from the state on tax, investment capital and land for project construction
Decision 115/2001/QĐ-TTg	01/08/2001	Title: **Approval on Planning of the construction material industry to 2010.** Ban of traditional brick kilns in Vietnam by 2010. *(Potential for new, modern technology and change of biomass fuels)*

3.3 Government Structure

The structure and mechanisms of Vietnam's political system are very different to the typically liberal democratic systems common to Western countries. It is critical for a foreign company wishing to enter the market in Vietnam to have a sound understanding of the political system and its influences on business practice. In SNV's discussions with international companies in Vietnam, one commonly raised point was the "untransparancy" when it comes to responsible ministries. Often several ministries can be responsible for one sector or topic. For implementation of projects several ministries have to provide approvals. More detail is provided below with regard to how foreign businesses can enter the Vietnamese market, however; first we will examine the broad government structure.

The highest institution of the Socialist Republic of Vietnam is the National Assembly. The assembly appoints the President (head of state), the Prime Minister (head of government) and the Head of the Supreme People's Procuracy of Vietnam, which is the Communist Party's uppermost institution responsible for supervision and inspection.

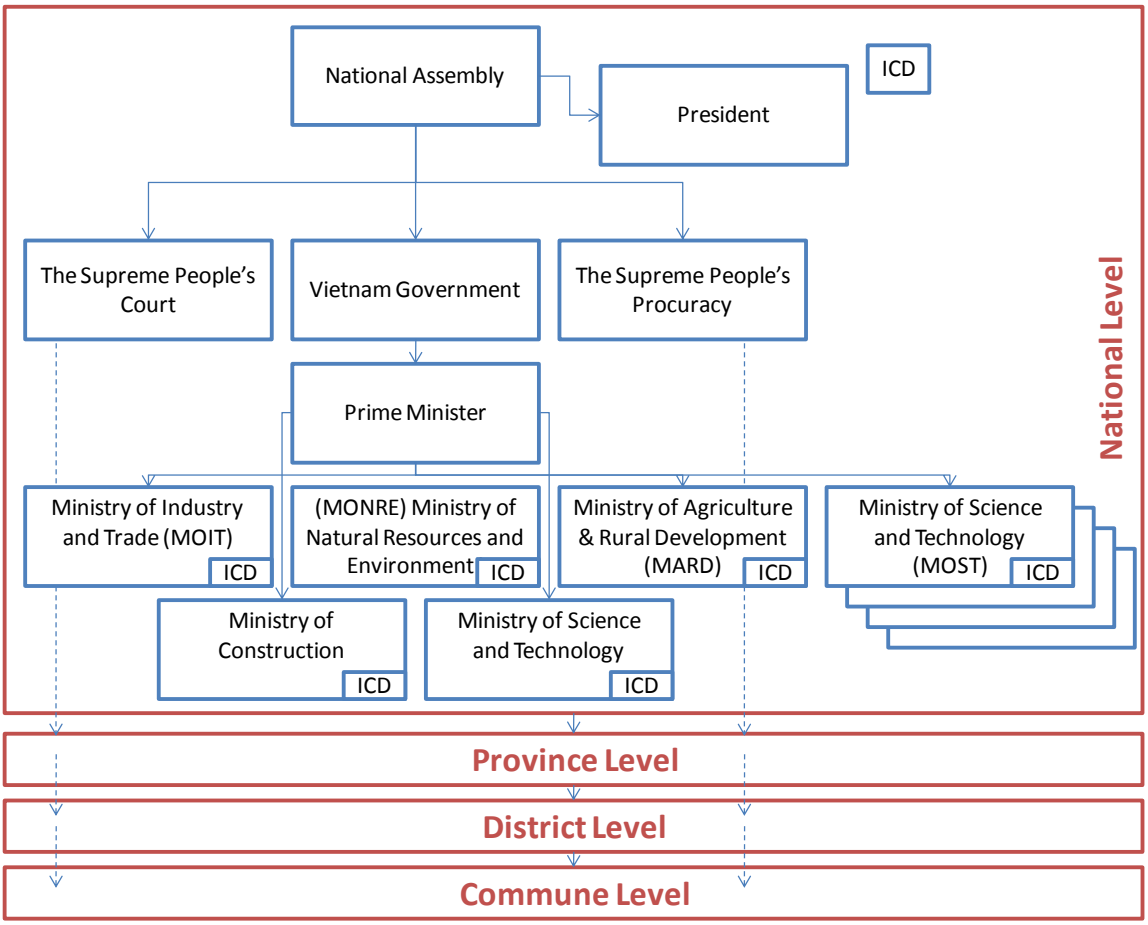


Figure 15. The structure of Vietnamese Government - Source: Ho Chi Minh City's official University

The ministries support the Prime minister with managing national affairs. For example, the Ministry of Industry and Trade will is responsible for implementing

policy relating to import and export of goods, decides on electricity prices or sets up the National Energy plan and policy.

In regard to the energy sector, the relevant ministries are the Ministry of Industry and Trade (MOIT), Ministry of Natural Resource and Environment (MONRE) and the Ministry of Construction (MOC). More specifically related to bioenergy, the Ministry of Agriculture and Rural Development (MARD) plays a part in controlling feedstocks that can be used for energy. An example of the involvement of all ministries is a decision made in June 2011 to increase the cost of electricity. It was decided by the prime minister that if Electricity Viet Nam (EVN) wants to increase the electricity price by 5% they need to send a request to MOIT and the Ministry of Finance (MOF). When they want to increase more than 5% the whole government will be involved (Luat Vietnam, 2011).

3.3.1 Ministry of Industry and Trade (MOIT)

As a government agency MOIT undertakes the state management of industry and trade. Branches and fields under the supervision of MOIT include: mechanical engineering, electricity, renewable energy, oil and gas, chemicals, mining and mineral processing industries, domestic trading, import and export, etc. There are many state level departments within the Ministry that are directly responsible for the above functions, for example, Planning Department, Export-Import Department, Heavy Industry Department, etc. Those relating to energy include *the Institute of Energy* and *Energy Directorate*.

The Institute of Energy conducts research and development relating to energy technologies and advises the government with energy policy and planning (IE website, 2012). Most research related to bioenergy is executed by this institute, employing Vietnam's bioenergy and biogas experts. IE is a commercial institute, and is also involved in the development of the master plan for (Renewable) Energy.

The Energy Directorate works on national level and manages electricity, nuclear power, petroleum, coal, new and renewable energy, energy saving. In short it is in charge of policy and strategy development. Energy Directorate took over responsibilities of the former Department of Energy. The Government of Vietnam has already approved the establishment of the Energy Directorate as the focal point for (renewable) energy in the nearby future. Energy directorate has 14 units. They advise and develop the national energy plan and strategy, zone plan, territory plan and develop long & short term investment plans related to energy on both a provincial and urban level (Dien, 2011). As the role of the Energy Directorate is new and there are no pubic published regulations from MOIT its exact role is still unclear. Nevertheless it is expected that the Energy Directorate will have responsibilities on electricity development, nuclear power development, renewable energy, management of energy related issues, petroleum and coal demand and saving (Dien, 2011).

3.3.2 Ministry of Natural Resource and Environment (MONRE)

MONRE is the lead institution for environmental management throughout Vietnam with activities in land use, water resource, mineral resource, geological environment, meteorology and hydrology, surveying, mapping, general management & agreements on the sea and islands. MONRE is also responsible for long term national environmental planning and for coordinating environmental impact assessments, compliance monitoring, inspections, and enforcement.

MONRE's consists of 24 units that support the national management. Relevant state bodies include the Vietnam Environment Administration (VEA), which houses the Department of Waste Management and Environment Promotion (DWMEP).

The VEA is responsible for pollution control, pollution prevention, conservation, solid waste management, waste water and air pollution. The DWMEP is responsible for the waste sector. This department helps the VEA on advising the waste management, environment improvement, river side and coastal line environment protection, and punishes the participant causes environment pollution. For instance, this department will survey, do statistic and forecast about the waste management (VEA website, 2012).

On the commercial side of MONRE is the Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE), a research institute focusing on strategy development related to environmental and resource issues and the Institute of Meteorology, Hydrology and Climate Change (CC) who has a main focus on adaptation (less on mitigation) and develops CC strategies, but also promotes RE solutions.

3.3.3 Ministry of Agriculture and Rural Development (MARD)

MARD is the state agency responsible for agriculture, forestry, irrigation and rural development. MARD has representatives in each province through the Department of Agriculture and Rural Development (DARD). Although MARD is not directly in charge of any energy policies or strategies, many by-products from its sector constitute bioenergy feedstocks. In this field, MARD has been supportive of many bioenergy initiatives, namely the household biogas programme that has implemented 160,000 biogas digesters throughout the country.

There are 24 supporting state level departments under MARD, which oversee separate fields relating to the ministry. The most relevant to the bioenergy sector include the Department of Livestock and Production (DLP), Vietnam Administration of Forestry (VAF), the Department of Crop Production (DCP) and Industrial and Fruit Trees Division (IFTD).

The DLP manages animal husbandry activities and strategies, as well as knowledge sharing with farmers via the local provincial offices. They are a partner in any biogas project in Vietnam related to animals. What the DLP is for animals the VAF is for forestry. They administer forestry issues like development of proposals, national plans, forestry planning, and implementation. The DCP and IFTD are responsible for policy, planning and management of their respective sectors.

3.3.4 Ministry of Construction (MOC)

MOC is responsible for state matters relating to construction, building materials, housing and office buildings, architecture, planning of urban construction, rural development planning, infrastructure urban, state management of public services. MOC has 17 supporting national bodies, of which two are relevant to bioenergy. These are the Department of Solid Waste and Department of Technical Infrastructure, who look after the countries waste water systems.

3.3.5 Ministry of Science and Technology (MOST)

MOST performs the function of state management in relation to science and technology, and includes developing potential of science and technology,

intellectual property, quality measurement standard, nuclear energy, radiation and nuclear safety, manage public services. Under MOST are 19 units of which many are overlapping with bioenergy topics. These departments would be good partners for further R&D and knowledge sharing and the relevant institutes are therefore highlighted in the stakeholder chapter.

3.3.6 International Cooperation Department (ICD)

ICD is a unit that is active in each ministry and responsible for building and managing international cooperation between the specific ministry and ministries from other countries or international funded organisations (i.e. not commercial entities). When foreign governments or agents of cooperate with a ministry, an ICD member from that ministry is always assigned to the enterprise. They are the focal point for every international relationship or cooperation with international organizations. Furthermore they support the ministers with negotiation and signing of international documents and contracts.

3.4 Foreign Direct Investment (FDI)

Vietnam has been remarkably successful over the last two decades or so in attracting substantial foreign direct investment inflows. Since first introducing a relatively liberal foreign investment law in 1987, in 20 years Vietnam has attracted around US$98 billion in 9,500 foreign invested projects (Phuong, 2008). In recent years there has also been an increase in 100% foreign-owned projects, which now account for 76% of total licensed projects in the country.

In Vietnam's economic system, officially named the "socialist-oriented market economy", the state plays a decisive role in the economy, but private enterprise and cooperatives play a significant role in commodity production. Within this system there are four approaches for foreign investors to enter the Vietnamese market and include joint ventures, business cooperation contracts, 100 percent foreign-owned enterprises and build-operate-transfer enterprises. Specific regulations pertaining to these avenues are defined in the Law on Foreign Investment.

The government of Vietnam, through the national Ministry of Planning and Investment (MPI), continues to make the process of FDI easier for international enterprises. Efforts to improve government transparency and remove bureaucratic red tape has made the investment environment more attractive, however, there are still significant gains to be made in streamlining the bureaucratic process and weeding out an ingrained culture of corruption and kickbacks.

To encourage development in particular sectors of the economy or regions of the country, a number of incentives are provided by the government. These typically come in the form of reduced tax on profits, but can also include other incentives such as reduced import duties. Profits from foreign enterprises are subject to a tax rate of 25%. When the investment is encouraged by the government, profits tax is reduced to 20%. This can be further reduced to 15% and as low as 10% for particularly encouraged investments.

The MPI is responsible for developing policy and regulations about which sectors are entitled to incentives. In the current list spanning eight broad economic

sectors, "production of new energy" and "processing of agricultural, forestry and aquaculture products" are qualify for incentives (MPI website, 2012).

The process for foreign companies wishing to invest in Vietnam can be a difficult path to navigate for the uninitiated. It is advisable in all instances that a foreign investor makes initial advances with the assistance of an established in-country counterpart or stakeholder, such as an embassy, NGO working in the sector or private business.

Ultimately, any foreign business development must be approved through the MPI. For very large projects of national significance the approval process will be performed by the MPI itself. Typically, however, most approvals are processed via the MPI's provincial counterpart, the Department of Planning and Investment (DPI). At this level approval is also required from Provincial Peoples Committee, a local division of the Communist Party. In instances where a project is to be developed inside a pre-designated industrial zone, it is possible for the industrial zone management to arrange all approvals. Additionally, if a particular project is aligned or collaborating with a government body (e.g. Department of Crop Production); representatives within that body can manage the approval process internally. While the number of paths discussed here may appear confusing, the great majority of projects require approval from the DPI and consequently, this government division is typically the most appropriate to work with. It is advisable in all instances to receive sound legal advice from a local firm, of which there are a number that specialize in foreign investment law.

4 Opportunities

Several opportunities are identified for future cooperation between the two private sectors from Vietnam and the Netherlands, or for cooperation between other organizations and institutes. This chapter is divided into several paragraphs highlighting the largest needs identified as part of this survey in the bioenergy sector in Vietnam. The first two chapters have a focus on the capacity, knowledge and human resource side of the market, followed by two paragraphs that have a technology angle and show needs for equipment (§4.3 and §4.4). The last paragraphs show the results from an environmental point of view (which biomass is causing a problem for the environment) (§4.5) and the financial needs (§4.6).

4.1 Knowledge and Capacity building

4.1.1 Research

There is a large demand in knowledge sharing, as many Vietnamese institutes and universities acknowledge the knowledge levels in Europe are (on average) higher than in Vietnam due to higher available budgets for research and development (R&D). Unfortunately knowledge is often not transferred to the less developed countries. Especially the newer technologies like ethanol production (small scale, blending etc), algae production and use, jatropha (farming techniques, conversion techniques etc) were indicated as sectors with need for such support. Also agricultural related research to increase yields and quality are of interest for the local situation as in some cases demand is higher than supply (see sustainability chapter).

Improved cooperation between Vietnamese parties and foreign parties is a must as many foreign countries try to introduce European technology in a Vietnamese context. This often leads to failures, while adaptation through cooperation can prevent such failures.

4.1.2 Capacity Building

Even though many institutes and universities are supporting the government in the development of policies, strategies and other renewable energy related issues. It can still be observed, like in many other countries that the knowledge level in the field, where the opportunities can be identified, is still limited in some cases. Therefore additional training for Government Officials on Provincial (and maybe district level) will increase opportunities in the future.

4.1.3 Sustainability Criteria

Biomass certification will provide biomass producers access to environmental conscious markets like the Netherlands. All biomass imported and used in the Netherlands need to comply with specific sustainability criteria.

Different buyers and traders work with different criteria. Used sustainability criteria are: Green Gold Label (RWE/Essent), Electrabel / Laborelec, Drax, NTA8080/8081, the "EN-plus" label specifically for wood pellets or the Blue Angel Label. Even though the Accredited Certification Bodies are present in Vietnam no biomass has been certified -as far as known- to be shipped in bulk to Vietnam (see also barriers chapter 5).

4.1.4 Summary knowledge and capacity building

These opportunities and needs reflect the potential cooperation for Universities and other knowledge institutes (like ECN, Copernicus Institute etc) for research and development purposes. Furthermore there are potentials for knowledge sharing and capacity building though training development for example (FACT Foundation, BTG, and Ecofys).

Vietnamese knowledge institutes, universities and private sector parties are in need of the above mentioned knowledge and support and have indicated to be very interested in cooperation (see a list of VN stakeholders in chapter 6). Cooperation can be commercially funded by private sector parties or initially supported with (international) grants and subsidies. Especially introduction of new technologies to the market should be done in cooperation with Vietnamese counterparts to optimize the effectiveness of the introduction and create the highest benefit for the seller or implementer.

4.2 From a leadership perspective: management & advisory

Large scale biomass-to-electricity projects are limited in Vietnam. As there is no favorable feed-in tariff for green electricity from biomass (see chapter 5), such projects are financially challenging. Nevertheless with the energy market slowly opening up (see §1.1) there are ongoing developments in this area. Several plans for bio-energy plants or co-firing[7] are being developed, both by private sector parties as well as by governmental organizations. The same is happening in the municipal solid waste sector.

Currently there is a lack of management, leadership and organizational skills when it comes to large industrial scale project. Project managers, factory operational management and other key players are attracted from abroad. With a developing sector, the need for experienced project management, engineering and consultancy skills is increasing. This is both for the development of large scale plants, as well as for initial operation and plant management after commissioning. Interesting for Dutch companies like Tebodin, Royal Haskoning (that are already present in Vietnam), or others like Ingenia and Host could provide such services.

The biofuels sector is dominated by PetroVietnam (http://english.pvn.vn/) which is a state owned organization. This sector is solely focused on ethanol production (industrial scale). No opportunities were identified on industrial scale ethanol production. Other biofuels like Jatropha will be discussed below.

4.3 Opportunities with biogas and landfill gas

When it comes to gas production there is still a big opportunity in Vietnam, both from biogas (gas produced by the biological breakdown of organic matter) or from landfill gas (a complex mix of different gases created by the action of microorganisms within a landfill).

4.3.1 Organic Municipal Solid Waste (O)MSW

When MSW is land filled, the organic components start decomposing naturally in an anaerobic digestion process, landfill gas is produced (mainly methane and CO_2). In

7 Combustion of multiple fuels at the same time, potentially one is biomass

Vietnam this gas is hardly recovered8. Almost 100% of all waste in Vietnam is currently land filled, creating an environmental hazard for the country but also creating an opportunity for organizations active in this sector. The landfill gas can be extracted from the landfill using a system of pipes, and then be used for energy generation in gas engines, turbines or boilers. This is common practice in the Netherlands for years, an example is Ambt Delden (Province of Overijssel).

Another opportunity is, after separation, the usage of the organic fraction as a co-product for digestion. Even though the ranking of MSW as biomass or renewable energy is continuous under discussion, it is clear that the use of MSW for energy production does not compete with the food chain. Furthermore, as it is a huge problem in Vietnam, it is the writer's opinion that it should be fully used and is part of this survey.

4.3.2 Biogas Production and Application

As biogas is a continuous growing market in Vietnam, the demand for downstream equipment is also increasing. Currently industrial scale biogas installations and downstream equipment is imported or existing equipment is adjusted. It is furthermore observed that often biogas is not utilized, but flared, or worse, being released to the air. The right equipment is either not available, too expensive or from China (Chinese technologies are sometimes rejected by Vietnamese people).

Large amount of manure are still being dumped, stored in open pits and/or sundried / sold. With the large amounts of animals as shown in paragraph 2.2.7, there is a huge potential for (low-cost) medium and large scale biogas technology in Vietnam.

Current biogas programs funded by the Dutch and Scandinavian Government, World Bank and ADB are introducing a new approach on the market. Biogas projects should be from a 'system' point of view including the pretreatment, (optimal) digestion, post-treatment and usage of bioslurry as well as biogas. This to be able to make optimal use of the available resources and biogas.

This developing biogas market creates opportunities for BV Nederland. The Netherlands is very strong when it comes to biogas due to its large amount of livestock and manure rules and regulations. Furthermore the Netherlands is well known for its dairy sector all over Vietnam, the linkage with a strong biogas sector is easy understood and therefore this lowers barriers. Below a few examples of the demand are given. The opportunities go beyond the examples below. Please note that the demand for these products will also increase when landfill gas technology is introduced and scaled up in Vietnam.

- **Pretreatment of input and co-feeding**
  Pretreatment of feedstock is not yet introduced, as well as co-feeding with non-manure feedstocks (like OMSW). The introduction of pretreatment steps like mixing, adjusting the feed concentration and temperature, co-digestion, feed quality measurements, hydrolysis tank to degrade the organic molecules into small molecular organic compounds, sand-removing machine (in the tank), a shredding pump and potential return of digestate to increase the heat.

- **(H_2S) Filters**

8 Several test sites and one larger site in Nam Son: Tay Mo landfill in Hanoi (registered for CDM)

The hydrogen sulfide content in biogas is expected between 500 ~ 2000ppmv in anaerobic digesters using manure. These numbers need to be reduced for continuous biogas use in engines or other applications (even for domestic cooking). There are 2 options for desulfurization, biological desulfurization (the oxidation of H2S into elemental sulfur or sulfite, reducing the H2S concentration) or chemical desulfurization. For household scale imported filters (mainly active coal) from china are being used, if used. No local product is available.

- **Generators**
  Poor-adapted diesel generators from China or Vietnam are being used, or adapted car/truck-engines. While there is sufficient knowledge on generators in general in Vietnam, there is no commercial / private sector party specialized in the production of biogas / dual-fuel generators (all sizes).

4.3.3 Other biogas related opportunities

Other sectors also create opportunities for biogas production and utilization that are not utilized. For example the waste water sector and waste water from industries. Processing industries produce large amounts of waste water (coffee, sugar cane, bamboo, cassava). Many of them are already producing and capturing biogas, to purify the water, unfortunately it is reported that only a small amount of this captures biogas in these sectors is being used. Often it is flared (or released); reasons given are the fact that this is not their core business, there is no technology available or unawareness of the opportunity.

4.3.4 Household biogas technology

With over 2 million household farms in Vietnam there is a big potential for household biogas in Vietnam. With currently several donors being involved, of which the largest program is the Dutch Government Funded program implemented by SNV and MARD, there is no need for additional programs. Nevertheless there is a huge opportunity for private sector involvement through Corporate Social responsibility (CSR) funding, Carbon Credit purchase or otherwise.

Investment from the private sector will directly benefit the farmers in Vietnam, as the program is often externally evaluated by –for example- KPMG, or biogas/sustainability experts, as well as by the Dutch Government as a donor. This is a perfect opportunity for cooperation between for example the animal husbandry sector in the Netherlands or for Carbon Offset.

Other involvement is mainly related to knowledge sharing on bioslurry use and small scale biogas application where there is still a lot to learn from the Netherlands (research institutes).

4.3.5 Summary Biogas Technology Opportunities

There is a large demand for biogas technology in the Vietnamese market. There are limited to no players on the market. The following opportunities are there:

1. Recovery of landfill gas
2. Introduction of (low-cost) biogas technologies
3. Supply of downstream equipment for biogas treatment, usage etc.
4. Introduction of knowledge and technologies for co-digestion of OMSW or other resources
5. Household biogas involvement

Opportunities in the household biogas sector are different, carbon offset through the utilities like Essent (Trading), or carbon trading and development agencies like the Climate Neutral Group for example. The advantage for Dutch organization is that the project is financed and therefore controlled and approved by the Dutch Government. This improves the value of the credits. Or cooperation between sustainable minded companies in the Netherlands and household biogas programs in Vietnam. A good example is cooperation between animal husbandry companies in the Netherlands and in Vietnam, like Friesland Campina or Farm Dairy.

There are many Dutch Organizations active in this field; Thecogas (biogas technology), Alke BV (Egg Incubators on biogas), Colson B.V. (filters), Paques (filters etc.), Host (biogas technology, Engineering, etc.) of which several area already active in Vietnam. Van der Wiel Group and Green Gas international are experienced parties with landfill gas but not yet active in Vietnam.

4.4 From a Technological Perspective

4.4.1 Introduction densification technologies

There are several plans for large scale pellet factories, and smaller scale briquette factories in Vietnam. Knowledge levels on quality and sustainability (see below) requirements for pellets in Europe are low. There is an opportunity for the Netherlands with its large demand for wood pellets for co-firing in coal fired power plants. While the maximum theoretical co-firing capacity is not yet reached, the market is quickly getting mature. Nevertheless the opportunity exists because raw materials are becoming scarce in North-West Europe. It is foreseen that e.g. the Rotterdam harbor will become a major hub where wood pellets are transferred from large ocean-going dry bulk carriers to smaller river vessels and coasters (Pelletsatlas c/o FORCE Technology, 2009) to be transported further.

To be able to fulfill Europe's and the Dutch demand in pellets Vietnam can export its pellets. Nevertheless pellets for the European market have to be produced according to the German DIN 51731 norm (or other wide accepted norms) to be interesting for large scale application. See also below for sustainability criteria and related barriers (chapter 5).

Eneco New Energy is, for example, already operating in this same field, aiming at the implementation of an innovative system for a pellet plant and logistic chain in Vietnam, realizing a sustainable biomass import stream to the Netherlands (partially funded by NL Agency). Furthermore VINAFOODI and II, the largest rice producer and exporters of Vietnam (both are state owned, one located in the north and one located in the South) are both preparing for the implementation of a pellet plant or already implemented at site. Other pellets producers and sellers can be found at www.pelletbase.com for example.

BOX 2. Potential Business Case for Pellets - Manh Thong J.S.C.

Manh Thong J.S.C. is a wood processing company; with 2500 Ha own concessionaries, making products from the Hybrid Acacia tree, one of the most common trees in Vietnam.

During this process large amounts of residues are produced, as shave-wood, bark, sawdust (estimated in 10% humidity, around 125MT / working day). They are planning on constructing three Completed Wood Pellet Plants with 2 - 4 MT/Hr each plant on their plantation in Daknong Province and their Sawmill in Binh Duong Province.

After obtaining quotations, and visiting providers, in several countries among them, US, Italia, Germany and China, Manh Thong is still looking for support in technology and financing, even though they are ready to invest themselves. Feasibility studies show acceptable payback times as potential prices are below the current market value of wood pellets. Furthermore the (co)ownership of Manh Thong of the concessionaries, wood processing and pellet production plant will give multiple benefits, secured feedstock supply is the most important one.

BOX 3. Potential Business Case for Pellets - VINAFOODI

Phuong Anh rice mill is a new plant of VINAFOOD1, one of the biggest State-owned enterprises. Phuong Anh is a rice mill located in Mekong Delta, producing 250.000 tons of rice and 50.400 tons of rice husks pellets annually.

Determining to grow and realizing the increasing environmental pressure, the mill has invested in producing rice husk pellets. The pellets are compressed into small bars with diameters ranging from 10 – 15 cm.

VINAFOODI is currently looking for interested buyers, even though no official international certificates are obtained. Yearly production is over 50.000 ton of pellets.

Potential business opportunities for Dutch Organizations are:

1. Purchase of pellets, especially Dutch Utilities (E.On, Essent, Eneco etc.) and/or biomass traders like GF Energy.
2. Knowledge and technology transfer for densification technology and biomass handling. For example Van Aarsen or PTN Pelleting Technology Netherlands are international suppliers of pelleting technology.
3. Certification and monitoring for the European market. Even though it is a growing market, it seems that the demand for certification is not increasing, as export is rare. Control Union is an accredited certification body for the Green Gold Label (sustainability label) and already present. Other similar organizations could enter.

4.4.2 Thermal Conversion of biomass into energy

In many sectors like (but not limited to) bamboo, rice and sugarcane **combustion or co-generation technologies** are applied. Unfortunately all our expert conversations, as well as observations, have learned that low-efficient and old technologies are being used. All interviewed experts and stakeholders are aware of newer more efficient technology but do not have access to such technologies. For example in the bamboo sector there is a significant potential for integrated RE and heat production at the large scale processing factories, as currently low efficient technologies are being used.

The technologies as shown in table 3 are of interest in the Vietnamese context and are proven, commercially available cogeneration technologies. Furthermore as also

indicated in the sugar cane chapter, biogas is sometimes produced as a mean to clean wastewater. The usage of the biogas is not often included in the implementation and biogas is being flared or released to the air. The same happens with biogas from animal husbandry plants in many cases. There is a big opportunity for further use of biogas in Vietnam for electricity and heat production. Nevertheless with the low electricity prices, limited investments can be done (see Barriers chapter).

Table 4. Advised (co) generation system (Cogen 3, 2004)

Sector	Plant Size	Biomass	Waste	Biogas
Domestic	<15 kWe	-	-	Gas Engine
Commercial	15 – 100 kWe	Steam Turbine	Steam Turbine	Gas Engine
	100 kWe – 1Mwe	Steam Turbine	Steam Turbine	Gas Engine
	1 – 5 MWe	Steam Turbine	Steam Turbine	Gas Turbine / Gas Engine
Industry	1 – 5 MWe	Steam Turbine	Steam Turbine	Gas Turbine / Gas Engine
	5 – 50 MWe	Steam Turbine	Steam Turbine	Open Cycle Gas Turbine
	>50 MWe	Steam Turbine	Steam Turbine	Open Cycle Gas Turbine

Gasification technology is not commercially used or well known in Vietnam, currently there is some piloting with this technology in the brick sector

In the **Municipal Solid Waste (MSW) sector** the need is even bigger and there is already awareness of the need (Box 5). Combustion of MSW is not applied, besides some piloting. In general, the processing of (O)MSW is primarily intended to dispose of the waste, while the production of energy could make the sector more viable. As mentioned above land filling is the normal operation, and incineration is seen as an opportunity. For incineration separation needs to take place, this step needs to be added to the normal operation. The organic fraction is best to be digested or used for composting (if separated from the rest).

As also described above MSW consists of many components, from food residues to paper and plastics. Its energy content depends on the actual composition and diffuse per country, but in general it will be between 8-12 GJ/t (comparable with fresh wood). The Netherlands has a strong track record in waste incineration (AVI's – Afval Verbrandings Installation / waste incineration systems), and knowledge as well as technology transfer is an opportunity. The government (as waste handling is still mainly government owned) expressed interest to invest in such new technology but also identified they need financial support for part of the investment (Urenco, 2011, direct communication) see also text box below.

BOX 4. Potential Business Case for (O)MSW in Hanoi– Urenco

With over 6 mln people living in Hanoi there is a waste production of 3.500 ton/day in this area. About 42% of this amount is organic, and another 5% is paper. There is also another 150 ton/day septic sludge.

Urenco, a state-owned company, is in charge of collection, transportation and treatment of waste

in 4 districts, another 12 private companies also participate in the collection and transporting of the domestic waste.

MSW is currently fully land filled, besides a pilot with composting, and recycling. Besides on location, no methane (landfill gas) recovery is taking place at the landfill sides. For the site of Nam Son, which is 53 Ha Urenco already published a public call for investment (tender) for a Combustion System for 3000 ton/day of MSW. As Urenco is a state-owned company the barrier of EVN (Chapter 5) is not an issue when it comes to electricity generation and sales to the grid.

The aim is to cooperate with a partner who is the (co-) owner of the cogeneration unit on the premises of Nam Son, therefore close operation and (co)ownership of the feedstock is linked securing long term cooperation and setting feedstock prices and long term contracts. Interest is both in the investment side as well as the equipment and expertise side. Interested parties can directly contact Urenco in for Hanoi.

Furthermore there is an increasing demand for **second hand** materials. A one of the barriers in upcoming markets is the investment costs, several entrepreneurs (among which, Mr. Son from Manh Thong, Box 3), as well as entrepreneurs from the sugar cane sector, have identified the opportunity to import second hand combustion equipment from Europe. Material that is written off in Europe can still be used in Vietnam for many years. Only KEMA was identified as a supplier of second hand materials. Chinese materials are the alternative, and this is not preferred by the Vietnamese (in general).

The examples of Box 3 and 4 show both **decentralized production** of energy for industrial purposes and for sales to others. Decentralized energy production is a way to generate renewable energy without the dependence on the EVN network and negotiations. It is recommended to focus on decentralized production in cooperation with the residue producer and/or owner. Its advantages are:

- You can overcome the difficulty of cooperation with EVN (chapter 5). Energy produced can be used by nearby industry(s). Produced heat (a by-product) can also be used in the process or for drying purposes.
- Cooperation with the biomass owner will limit the risk of long term biomass contracting and supply, a well known issue in all bioenergy projects.
- Contracting the quality of the supplied biomass is easier (moisture content, size etc.)
- Flexible delivery and additional storage of biomass in case of non-operation of the unit
- Energy generated can be used onsite for production purposes, think of paddy drying and/or coffee production.

Every large industry, especially industries producing 24 hours, 7 days per week have back-up systems due to the regular power cuts. With decentralized conversion and energy production you cannot only replace these back-up systems but you can supply factories continuously with renewable energy. The same can be done (on a more local, and smaller scale level) with replacement of back-up generators for TV poles, mobile phone poles / centers etc.

In line with the chapter on pellets, knowledge on **biomass handling** (logistics and pre-treatment of biomass) is limited. This can concern separation of MSW, the collection of rice husks or straw or pre-treatment of materials for co-digestion.

Especially collection of biomass from household level, and a good structure scheme for both waste as well as agricultural residues.

Identified opportunities:

1. Supply of (decentralized) conversion technologies for both gas and solid biomass. Companies like KARA, Stork Thermeq (for boiler systems), Dordtech Engineering, AEH Power and Green Gas International and others might be interested in entering this market. Gasification would be an option, but is not very well known or accepted yet in Vietnam. Simple combustion technologies or cogeneration make more sense in this context.
2. Combustion of MSW. The market is ready for this technology, investment needs to be found.
3. Support / consultancy for companies that want to invest in renewable energy. Many companies are unaware of the opportunities they have with their waste materials and residues. Consultancy companies like BTG, Ecofys, Kema or others can easily support these feasibility studies and fund requests for banks or other funders.
4. Supply of second hand equipment. This demand is not only for thermal conversion, but also for densification and other technologies.
5. Material handling technology and knowledge transfer.

4.4.3 Improved Cookstove – ICS (household scale)

Cooking is a large part of total household energy consumption, 9 million households in Vietnam use low-efficiency traditional stoves. This consumes large amounts of biomass, contributing to deforestation and depletion of local resources as well as an increase in GHG emissions. Traditionally, open cook stoves and poor ventilation in the kitchen creates indoor air pollution (IAP), a major cause of lung and respiratory disease, secondary heart disease and eye inflammation. Women and children are particularly affected. To mitigate these adverse effects Improved Cook Stoves (ICS) can be introduced to the market. The ICS can be adjusted to the cooking habit, which are divers is a large country like Vietnam. Different models as well as different resources (wood, husks) are being used.

This is a (business) potential for both NGO's (like SNV, Dutch Red Cross) as well as commercial parties like Philips or Unilever. The latter is already active with ICS on other markets in Africa and Asia (Indonesia). New models can be introduced into the local market in a commercial way creating a win-win situation for all parties. Local (I)NGO's with actual market knowledge can support such market introductions.

4.5 From a biomass perspective

The above perspectives were given from the business point of view, existing markets were identified and evaluated and the gaps were located. Below you can find the opportunities from a biomass point of view. Which biomasses are not being used fully, and are a serious hazard to the environment.

4.5.1 Rice Husk

While we had to conclude that rice husk is in Vietnam on a larger scale already utilized, the practical availability is small, and mainly scattered. Nevertheless with

the large amounts of rice produced, especially in the Mekong area, it still is a good source for bio-energy.

4.5.2 *Rice Straw*

Rice straw is almost not used (§2.2.9) and people are burning it out in the open as way of disposal. This creates and environmental hazard, and air pollution for the surroundings. Local people have no other option than open firing and use the burned material as fertilizer.

The application of rice straw is widely studied, for example by Wageningen University for a case in Egypt.

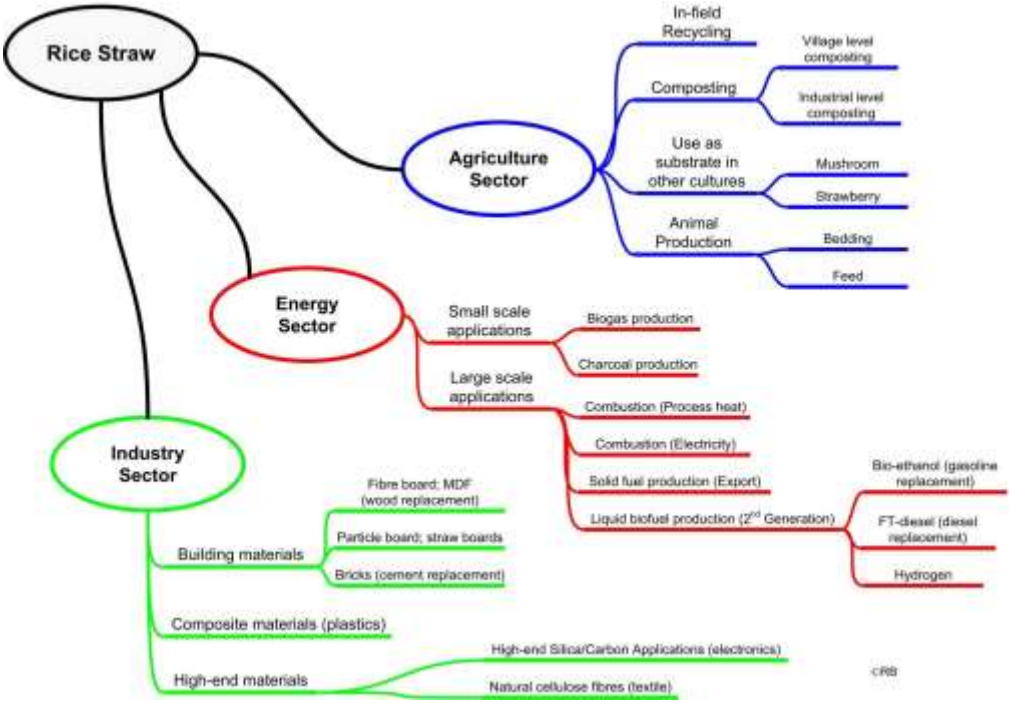


Figure 16. Mapping rice straw utilization (Bakker, 2010)

The reason why rice straw is not already applied is the difficult morphology. It is technically a challenge to convert it due to its composition. For example its ash melting point is at relatively low temperatures, and its ash softening starts already around 600 °C. For small boilers in particular this might be an issue, for large application this problem is of less importance. Co-firing of straw in coal fired boilers is also a very feasible solution (up to 20%).

Compared to other biomass sources, or traditional fuels initial costs for energy use will be higher. As shown in the figure above there are potentials for small scale application. On the larger scale ethanol production is under development and widely piloted in Europe, there is no commercial application yet and therefore this seems farfetched for the Vietnamese context.

Straw torrefaction and pyrolysis are two options that are not mentioned in the figure above. The Netherlands is one of the front runners worldwide when it comes

to these two technologies, organizations like Topell, ECN, BTG and BTG-BTL are already (commercial) suppliers of such technologies.

Torrefaction of straw with a pelletisation step afterwards increases the energy density of the resource, making it possible to transport it over longer distances and still be economically interesting. This also simplifies storage. Torrefied straw pellets can be directly co-fired with coal without having to adjust the processing infrastructures at existing plants. Torrefied straw pellets have superior structural, chemical and combustion properties compared to coal.

As rice straw is such a big challenge and at the same time opportunity in Vietnam, many local institutes are also looking into the more traditional options (like combustion).

Potential cooperation in the field of rice straw:

1. Introduction and sales of rice straw pelleting and/or rice straw torrefaction and pelleting into the Vietnamese context.
2. Introduction and sales of straw co-feeded biogas units into the market (potentially with pre-treatment of the rice straw).
3. Combined research on other applications related to rice straw (2^{nd} generation technologies, pyrolysis, and small scale combustion).

4.5.3 Coconut pith

As indicated in paragraph 2.2.3, one of the by-products in the coconut sector is coir; in the process of making coir a fine dust called coconut pith is produced. Little of this pith is being used and it is estimated that 80,000 tons is dumped into the Mekong River which creates and environmental hazard. It is mainly being produced decentralized but in Ben Tre River area.

There could be several opportunities for this coconut pith:

1. Densification – briquettes and/or pellets
   In this area there are a large amount of brick kilns running on coal, these kills could also run on densified coconut pith (briquette/pellets). Furthermore a demand already exists for briquettes for small industries.

2. Biogas
   It has been studied in the past that a mixture of coconut pith with cow dung creates biogas (A study of biogas generation from coconut pith, 1983). As Ben Tre is part of both SNV and Danida biogas/climate change oriented project, this study might be interesting to look further into.

3. Direct combustion
   The coconut pith could be used as a fuel for direct combustion in nearby industries or for cooking purposes in households. Nevertheless, a densification step is preferred before combustion due to its powdery state.

There is a big potential, institutes in combinations with NGO's and technology suppliers could enter this market; for example ECN, Wageningen University, Delft University and others.

4.5.4 Sugar Cane Bagasse

Sugar Cane is already mentioned in several of the opportunities described above. There is mainly a high potential for the supply of combustion technologies for sugar cane bagasse. The advantage of this available biomass is that the sugar cane factories, as well as the association are open for improvements; they are biomass owners (reducing the risks of bioenergy projects) and can be (co)investor.

4.5.5 Coffee waste

Coffee waste from either wet processing or dry processing is not fully utilized. At the same time coffee processing is an industry with a high energy demand. In Vietnam mainly diesel is used to fulfill this demand. The use of coffee waste for biogas production (wet processing) or direct combustion should be further explored.

4.5.6 Summary biomass availability

There are biomass residues available that are not fully utilized yet, or even endangering the environment. Examples are given in this chapter and are rice husk, rice straw, coconut pith, sugar cane bagasse and coffee waste. Each resource creates other opportunities. The biggest opportunity is the available rice straw, even though no Dutch technologies providers are obviously available to enter the market in this area in Vietnam; there is recently a lot of interest in this area. Torrefaction, Pyrolysis, densification and biogas production are some of the options for this environmental problem.

4.6 From a financial perspective

Financial support is mentioned by almost every project developer or stakeholder that is interviewed for this survey. Support can be given in many different ways:

- Co-investing
- Favorable loan conditions through guarantees or other support
- Grants / subsidies to attract suppliers to Vietnam
- Grants for investment

Dutch organizations like FMO and/or Triodos bank are not known by the Vietnamese market but could have a large influence. Other existing programs like ICCO, the Private Sector Investment programme (PSI) and the future Vietnam Facility could also contribute and lower the barrier for Dutch companies to enter the Vietnamese market. There are also some private sector funders that are interested in financing renewable energy or bio-energy projects in emerging markets like WWE Sustainable Solutions

Furthermore as Vietnam is an emerging market, there is in general an emerging movement towards obtaining foreign loans or getting foreign investors interested. Vietnamese project developers struggle with preparations of proposals and preparation of international loan requirements. Besides the language barriers, the formats and requirements are very different from the Vietnamese styles and approaches. Organizations like Ecofys, BTG, BGP Engineers, FRES Foundation and other can support such developments. On the other hand it is therefore seen that Vietnamese proposals (in general) that do not come from multinationals are not that well accepted by international parties according to several stakeholders. There is a need for support for proposal development as well as proper due diligence of the projects itself.

Therefore concluding there is potential for:

1. Financial support in many different ways
2. Expertise in project due diligence (both technical and financial)
3. Support in project set-up and proposal development

4.7 Cooperation recommendation

Cooperation with existing active Dutch not-for-profit iNGO's like Netherlands Red Cross or SNV Netherlands Development Organization is recommended. These iNGO's have been active in the culture, know the market, have a network and are aware of the needs as well as possibility of the target group in Vietnam. At government level, household level and private sector level NGO's are already active. Initial cooperation with iNGO's can stimulate initial market introduction, create awareness for the products being implemented or secure the knowledge transfer. Furthermore Vietnam is a challenging country to enter due to his broad history, culture differences and language barrier, local active parties, with long track records and experience, can support the private sector from both countries (NL and VN).

Box 5. Inclusive Business
Win-win situation for private sector

An inclusive business is a sustainable business that benefits low-income communities and commercial enterprises. It is a business initiative that, keeping its for-profit nature, contributes to poverty reduction through the inclusion of low income communities in its value chain. In simple words inclusive business is all about including the poor in the business process and the value chain, be it as producers, consumers, employees or otherwise.

Large corporations traditionally target consumers in the middle and high-income segments of society, and established suppliers and service providers from the formal economy. Inclusive businesses find profitable ways to engage the low-income segment into their business operations in a way that benefits the low-income communities and creates sustainable livelihoods.

An example of services for agricultural activities:

- *Market scans and value chain analysis* to ensure that the intervention strategy will benefit poor people and meet market needs
- *Organization of smallholder groups* and capacity building to enable small-scale growers to access the market, improve their business skills, and strengthen their negotiation powers while reducing transaction costs
- *Development of better local business services* available to smallholders, in collaboration with the private sector
- *Brokering and fostering connections* within the value chain through increased capacity, facilitating dialogue, and formulating contracts between the private sector and smallholder groups
- *Facilitation of public-private dialogues among smallholders*, the private sector and policy makers, raising awareness and good intentions of policy makers through heightened awareness of issues faced by actors in the chains

5 Barriers

Based on the analysis above, existing obstacles for the Dutch private sector will be identified. These can be obstacles related to policy, financing, starting up businesses in Vietnam, culture and more.

5.1 Energy (carrier) sales

5.1.1 Electricity sales to the net

When it comes to electricity production in Vietnam there is a lack of adequate policies and regulations to purchase power from (small) power producers. For example stand alone bagasse and rice husk fuelled power plants are uneconomical.

Another issue is the government promotion of traditional fuels. When it comes to electricity production, there is a price system that promotes coal for power generation (this is regulated by the government) creating prices that are (generally) lower than the market prices. These low prices encourage the Electricity of Vietnam (EVN) and other coal-based power producers to promote the use of coal for electricity production. Extension of the electricity network is done by constructing big central power plants, as EVN sees this as the most feasible ways for development of the power sector in Vietnam.

EVN is a state owned company that is in charge of production, transmission, distribution and power trading, in charge of the operating, transmission, distribution and allocation of power in the national electricity system. Furthermore EVN does the import and export of electricity, investments and management of power projects and everything else that is related to the electrical network of the country.

EVN is therefore the entity that is purchasing electricity from several private power companies; 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 for bio-energy projects. Luckily there is an increasing number of IPP's (from 7% in 2002 to almost 20% in 2011).

Unfortunately coming to favorable agreements on feed-in tariffs for non-state owned enterprises and initiatives have until now not been successful. Sales and contracting of green electricity to the grid is possible for normal prices based on (large scale) production prices with fossil fuels. For example as shown in paragraph 2.2.10, only 3 power plants fed with sugar cane bagasse are selling their surplus electricity to the national power grid at the highest price of 4US cents/kWh (all Bourbon sugar plants in Tay Ninh province). This is a price below the average tariffs (in 2011 this was for households between 5 and 10 US cent/kWh depending on the consumption) (EVN, 2012).

Therefore both large scale bio-energy initiatives as well as small-scale bio-energy initiatives cope with a large hurdle when it comes to electricity sales. On the short term it is recommended (see chapter above) to focus on decentralized production with electricity consumers (potentially biomass producer industry (preferably a small industry that produces the biomass, or other industries and/or communities).

For wind energy (international) lobby has secured adjusted favorable feed-in tariffs for a longer period of time. This is already a sign that such contracts and agreements are a possibility. At the moment no (international) lobby is taking place for bio-energy.

5.1.2 Other

For liquid biofuels the same problem as above is identified in cooperation with PetroVietnam. Distribution of transport fuels is in hands of PetroVietnam, a state owned enterprise that is not yet open for cooperation in this field.

Furthermore, when it comes to waste, a similar issue is identified. Even though Urenco is very open for cooperation to introduce combustion technology in the sector as soon as possible. It is the government that decides on waste prices or investments.

5.2 High investment costs equipment

When it comes to investment in (energy) technology many organizations are reserved. Several reasons are identified for this attitude:

- Vietnam is a producing country, as well as their neighbor China. Cheap technologies are produced or imported, often of low qualities. When products break or stop working, it is inexhaustible fixed. Therefore technologies have a much longer lifetime in Vietnam.
- Many of the agricultural processing factories, and therefore the residues owners, are state owned and therefore are limited to government policies and available financing. As long as (decentralized) renewable power production is not part of the policy there will be limited money available for such organizations.
- Energy prices in Vietnam are low, and still (in)directly subsidized, therefore the energy costs as part of the operational costs is relatively a low. Nevertheless, prices have been increasing, and this is already noticeable on the market. There is more interest for own energy production slowly.
- Furthermore businesses focus on their core business, like rice or sugar production. They rather improve equipment and therefore the quality of their product than invest in their own energy production facility (this is of course linked to the low electricity prices).
- Businesses like the sugar sector often have boiler systems, or old cogeneration systems. This long lifetime does not encourage organizations to invest in new and improved systems.

Products with high investment costs, similar to the European market, are unlikely to be widely accepted. Technology is easily produced (with high quality) in Vietnam or surrounding countries and this is therefore expected from the market to reduce investment costs. Furthermore stakeholders indicate that European or Dutch technologies should be adjusted to the local Vietnamese market as it is experienced that applications are too complicated or advanced for the local setting.

This being said, a shift is noticeable. More awareness is created among directors and owners of processing factories about the environment and emissions. Policies that prohibit dumping or burning of waste material also encourage organizations to think about new solutions (even though often the cheapest and easiest solutions

are chosen), even though often these policies are not enforced. Therefore more interest from the market for new technologies is seen. Ideally it is expressed by several entrepreneurs there is co-ownership of (co)-generation systems where the residue is provided in exchange for heat and electricity if applicable. A good example of this is shown in Box 4. Potential Business Case for Pellets - Manh Thong J.S.C..

5.3 Export Biomass and biomass availability

Barriers in the biomass sector stem from the scattered locations of the residues throughout the country. Especially rice is a good example of this scatteredness, as it is also not process in a central, large scale, location the residues are spread over a large area. But the same is true for MSW, corn residues and bamboo residues. As a result a system needs to be developed where residues can be efficiently picked up and dropped off at a central power station or processing location. The ideal situation is already presented above where the energy system is placed near a central source of residues or biomass.

For export of biomass from Vietnam to the Netherlands only the export of large amounts are economically interesting. While at the same time the scatteredness of residues makes contracting these large amounts difficult. Transport from inland or mountainous areas to the harbor is cost intensive. Loading and unloading in the harbors is not with similar fast technologies to European harbors.

Three major harbors in Vietnam are Hai Phong (10 – 20.000 DWT)9, Da Nang (up to 45.000 DWT) and Saigon (up to 20.000 DWT). This means Vietnam can only receive Medium Range Tankers or Small/Handysize Bulk Carriers, which is small in size when it comes to importing/exporting biomass. Ports in Malaysia and Thailand for example are respectively more than 5 and more than 10 times larger than in Vietnam. The limited size of Vietnamese ports can be solved by transportation of goods from Vietnam to neighboring larger ports (Hong Kong and Singapore) to be transshipped. This means additional handling of shipments, which is more expensive. This added shipping cost drives up the costs of the product.

5.4 Knowledge levels

In the field and rural areas there is a lack of updated information on bio-energy technologies, biomass or residue owners do not have updated information or knowledge on suppliers. There is still the perception that investment costs of biomass power plants are always very high, even though cheaper solutions are available.

Opportunities of Carbon Funding through CDM or VGS systems is unknown, and only industrial, large scale projects have access to this type of information.

Current bio-energy projects are often developed by enthusiastic individuals and entrepreneurs based on experience abroad. Little promotion and awareness raising is done in general in Vietnam besides on biogas (also due to government policies).

9 The recently approved extension Dinh Vu is modified to be able to accept upto 30.000 DWT

5.5 Private Sector

It is difficult for non-Vietnamese companies, when entering this market to distinguish between state-owned companies and private sector companies. State-owned companies have other ways of operation. Often less money is available for activities that are not core-business or are related to Renewable Energy. Commercial Dutch companies prefer to operate in a business-to-business way, but entering this private sector market in Vietnam is challenging.

6 Stakeholder analysis bio-energy sector

The stakeholder analysis is an important part of this survey, and is presented below. In cooperation with the Dutch Embassy, Agency NL and SNV a summary of the most important stakeholders is presented in Appendix 2. It is decided to present the relative stakeholders according to the same structure as the opportunities, so that relevant companies are linked to potential partners in Vietnam. Of course the presented cooperation and partnerships are suggestions and many other and more combinations are possible. All partners of this project; the Dutch Embassy, Agency NL and SNV as well as the Vietnamese counterparts are more than happy to assist future partnerships or provide introductions.

Stakeholders of Vietnam can be divided into several groups, of course there is a large government involvement both in research and development as well as in commercial state companies. An increasing private sector, and increasing interest in bioenergy is noticeable. In the boxes in this report some specific examples of cooperation are shown.

The Dutch private sector is already really active when it comes to bio-energy internationally. Unfortunately in Vietnam limited number of organizations is already active. For the stakeholder analysis a large amount of companies in the bioenergy sector in Vietnam are studied, and relevant partners who are either already active in Asia or expressed interest in working in Asia/Vietnam are selected as relevant stakeholders.

7 Conclusion and Recommendations

7.1 Conclusions

In conclusion it can be said that there are opportunities for cooperation between Dutch and Vietnamese organizations. At the same time there are some barriers that make entry into the market challenging, but not impossible. As the energy market is opening up, and the economy is continuously rising, this is the right moment for private sector parties to enter the moment and make a difference.

There is a general need for knowledge transfer and capacity building on all bioenergy technologies. Furthermore Vietnam research institutes also indicated their interest in cooperation with Dutch research institutes and the private sector for technology adjustment to the local market as well as further R&D in some specific areas like for example ethanol.

International Management and Advisory expertise is also requested, especially when it comes to large scale industrial projects. Even though there are already several such Dutch companies active in Vietnam in this field, the bioenergy sector is not yet aware of this offer from BV Nederland.

Biogas is one of the most growing and booming sectors in Vietnam. This automatically results in a larger demand for upstream and downstream equipment. The offer is limited, and BV Nederland has an opportunity here as it is a strong player in the market when it comes to biogas. The Netherlands also has a few players that are strong in the field of landfill gas. With all waste being land filled another opportunity arises. These opportunities are closely linked to the supply of technology, advice and services. While in the household biogas sector there is already a lot of supply, but finances is needed to be able to provide the small holders (farmers) with the support needed for a sustainable and durable implementation of household biogas. Cooperation with the Dutch dairy or meat sector is a good example for this sector.

Densification (pelleting, briquetting) technologies, as well as combustion and (co-)generation technologies are not widely available in Vietnam. Supply of technology as well as knowledge is desirable. As mentioned in the previous paragraph, all (O)MSW is currently land filled. Nevertheless there is a lot of interest in combustion of (O)MSW, but technologies as well as finances need to be in place in Vietnam.

On a household level Improved Cookstoves is a business opportunity for both NGO's as well as commercial parties. New models can be introduced into the local market in a commercial way creating a win-win situation for all parties. Local (I)NGO's with actual market knowledge can support such market introductions.

In the first chapters the biomass availability is studied, and although many different types of biomass are available, it can be concluded that the following biomass resources are not only available but also are of harm to the environment at the moment: rice husk, rice straw, coconut pith, sugar cane bagasse and coffee waste. The utilization of these resources creates opportunities and will benefit the environment. Rice straw can be identified as the largest potential, but at the same

time also the most challenging. There is already interest from the Dutch sector in this resource for combustion and torrefaction for example.

Biomass availability is also a barrier at the same time. Biomass is available scattered over the country. Agricultural related resources are often available at farmer level or at decentralized processing level creating a barrier of biomass collection and transport.

There is a need for financial cooperation in many different ways, creating a loan environment with more favorable conditions that currently is high on the list of priorities (for example through a guarantee system). There is also a need for expertise in project due diligence (both technical and financial) to be able to obtain international financing. Furthermore initial support in project set-up and proposal development is needed.

The biggest barrier identified is the lack of support or feed-in tariffs for green electricity. For the promotion of renewable energy in general such support is needed due to the often high initial investment in technology (which is often outside the core business). This barrier can be reduced by focusing on decentralized production, preferably close to and in cooperation with a biomass producer/owner. Financial burdens can be reduced by co-ownership and purchase of biomass and supply of energy to and from the biomass producer.

7.2 Recommendations

As concluded there are many opportunities in the field of bio-energy in Vietnam. Nevertheless not all opportunities can be fully utilized yet due to barriers in the macro and/or micro environment. NL Agency, as part of the Ministry of Economic Affairs, Agriculture and Innovation of the Dutch Government can provide support to lower these barriers and create a more favorable environment for Dutch Companies to invest, trade or work with the Vietnamese market.

1. Through active networking and promotion, NL Agency together with the Royal Dutch Embassy in Hanoi can improve the BV Nederland brand related to bioenergy. Increased knowledge in Vietnam on the potential offer of BV Nederland in bioenergy is necessary.

   An approach similar to the Advanced Energy Technology International (AETIN) consortium was mentioned by present Dutch Organizations. It is a consortium of leading Dutch companies and research institutes active on the international energy market (Oil and Gas), that have joined forces to offer advanced expertise, technology and solutions for oil and gas projects in Vietnam.

2. NL Agency together with the Royal Dutch Embassy can facilitate the introduction and networking of companies entering the Vietnamese market to improve and speed up the process of getting into contact with commercial, private sector parties in Vietnam.
   a) This activity can be linked to the first recommendation.
   b) Organization of matchmaking events for local and Dutch organizations, entrepreneurs and financers should be part of this approach.
   c) NL Agency can encourage parties that enter the Vietnamese market to have local representation. This can be either through representation offices

or through cooperation with (Dutch) iNGO's. These organizations have hands-on experience in the field, they can be the eyes and ears in the market, as well as a facilitator when introducing new products or projects into the market. Such cooperation, in a difficult context and culture as Vietnam, will add value to the value chains of the commercial organizations. Cooperation can be both from an inclusive business point of view, as well as from a more advisory or project management kind of view. This public – private approach of market development (or development aid) is now preferred by many governments.

3. Currently at least the government of Germany and Denmark are executing a similar scoping mission in Vietnam, also focusing on bioenergy. NL Agency could cooperate with both other governments to together support the bio-energy market in Vietnam.

4. As mentioned, the energy market is opening up; the Vietnamese Government together with EVN wants an open market by 2020. This is a long and intensive path to go. As it is difficult for individuals and companies to influence and support this process, the Dutch Government might have (in cooperation with other governments) more influence and success in providing leading advice and services.

5. Funding joint innovation and research initiatives involving and focusing on the private sector and not only research institutes. This is similar to the Private Sector Investeringsprogramma (PSI), but with more attention also on 'development with a market approach'. Besides this also continue with the PSI programme, which is a great support program for the private sector.

6. Create more awareness of the opportunities in Vietnam, to attract more interest from BV Nederland.

7. Small scale solutions, like for example ICS, should not be overlooked as many multinationals already have programs in this area in other countries. Networking and information sharing on potentials can interest organizations to enter into the Vietnamese market. This lowers barriers like initial investment and scattered availability of biomass. It has to be taken into account that such solutions need to be adapted to the local context and setting.

8. Financing and/or support for the further development of the bio-energy market. Small initiatives have difficulties scaling up, therefore support to transform a pilot/demonstration project into a scaled up commercial approach that can be picked up by the market. Capacity building needs to be a significant component of these programs, this can secure the uptake from the market.

9. Financial support that can provide favorable conditions for loans for local entrepreneurs if there is cooperation with a Dutch organization. Requirements for loans are high, as well as the interest which hinders local organization to move forward with their projects.

10. When supporting programs for biomass are developed, focus should not be limited to conversion technology but also include biomass handling (logistics

and collection), based on the scattered availability of many biomass sources in Vietnam.

11. When it comes to sustainable land use, support needs to start at government level as their involvement in land use is still high. Nevertheless a logical second step would be, together with the government, to create awareness among farmers to prevent ad-hoc trend-based land use change.

12. Fish residues and waste was only briefly touched upon in this research, nevertheless after the initial quick scan there seems to be a big potential and an opportunity to build upon knowledge from EU-funded project(s). It is recommended to look further into this potential opportunity together with, for example, companies from this sector.

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Appendix 1. Conversion technologies

Pellets
The production of pellets is a densification process compressing or molding a material into a small pellet. Pellets can be made from wood, husks and many other kinder of materials. Also torrefied materials can further be pelletized for transport. Pellets can be used for industrial power production or on household level for heating systems (with automatic feeding).

Briquettes
Biomass briquettes are already produced in Vietnam from rice husks for example. Briquettes are used to heat industrial boilers or for co-firing, where it can be combined with coal. The briquettes currently produced in Vietnam are used locally. No party has expressed initiative to export large quantities, especially because of the high demand in the Vietnamese industry.

Charcoal
Carbonization technology production is a very old, standardized process to make charcoal from wood; it is commonly used worldwide in both developed countries as developing countries. Charcoal is used in Vietnam in small amounts, mainly for domestic cooking and made from, for example bamboo residues.

Torrefaction
Torrefied biofuels are more brittle than untreated biomass, but have lower carbon content than charcoal and other carbonized fuels. Torrefied biomass can for instance be fed easily in existing coal-fired power plants without expensive adjustments of the feeding system. Its technology is based on thermal treatment of biomass at temperatures of approximately 300 to 400 º C. The process itself is old and closely related to pyrolysis and gasification, it can be compared to burning coffee beans.

The advantages of torrefaction:

- the energy density increases, therefore it is more attractive transportation over long distances;
- the brittleness makes the material easy to meal in (coal) mills and can therefore be easily used at coal plants;
- the torrefied biomass gets hydrophobic properties, storage outside is therefore no problem

The Netherlands is a front runner when it comes to torrefaction and many companies are working on this.

Combustion
Combustion is the biomass conversion technology that is applied most worldwide. At all levels of the community people depend on the combustion technology. This technology is used to produce process heat, steam and/or electricity. All kind of sources can be used for combustion, pellets, briquettes, (char) coal, pyrolysis/vegetable oil, torrefied material, but also husks directly.

Gasification

Gasification: biomass gasification is an endothermic thermal conversion technology where a solid fuel is converted, with a limited amount of oxygen, into a combustible gas mainly existing of carbon, hydrogen and oxygen. Gasification of coal is done at high temperature (1300-1500 ° C) and under (high) pressure. For biomass, the temperatures and pressures are lower, 800-1200 °C.

The gas produced, syngas, is primarily a mixture of carbon monoxide (CO) and hydrogen (H2). The formation of secondary products such as ash and tar must be taken into account when using biomass resources. The lower temperatures cause these tarry products but are required because of the lower ash melting points in biomass. The different gasification processes will not be discussed here.

Pyrolysis

Pyrolysis is a thermal cracking process, where the conversion takes place of biomass into pyrolysis oil. The process takes place at temperatures around 550°C and no oxygen is present in the process. Through the quick reaction taking place where the heat carrier (for example sand) comes into contact with the biomass, followed by a cooling step the oil is produced. Besides the oil two other products are produced: gas and char. The extent to which each product is produced depends on the raw material and the temperature and the technology used. The advantages of pyrolysis are:

- Pyrolysis oil can be used at any moment and place in time
- Production and use can therefore be separated
- Pyrolysis can be stored for longer periods where for heat cannot be stored.
- Pyrolysis oil can replace natural gas, where torrefied material is replacing the relatively cheap coal.
- The emissions with the pyrolysis technology are relatively low, partly due to the low operating temperature.

The Netherlands is a front-runner when it comes to pyrolysis; one of the leading companies (BTG-BTL) is from the Netherlands.

(An)aerobic (co-) digestion

Domestic biogas plants convert animal manure and human excrement at household level into small, but valuable, amounts of combustible methane gas. This 'biogas' can be effectively used in simple gas stoves for cooking and in lamps for lighting. Especially in remote rural areas where (reliable) electrification does not exist, farmers use biogas for illumination and cooking. The residue of the process, bio-slurry, can be easily collected and used as a potent organic fertilizer to enhance agricultural productivity.

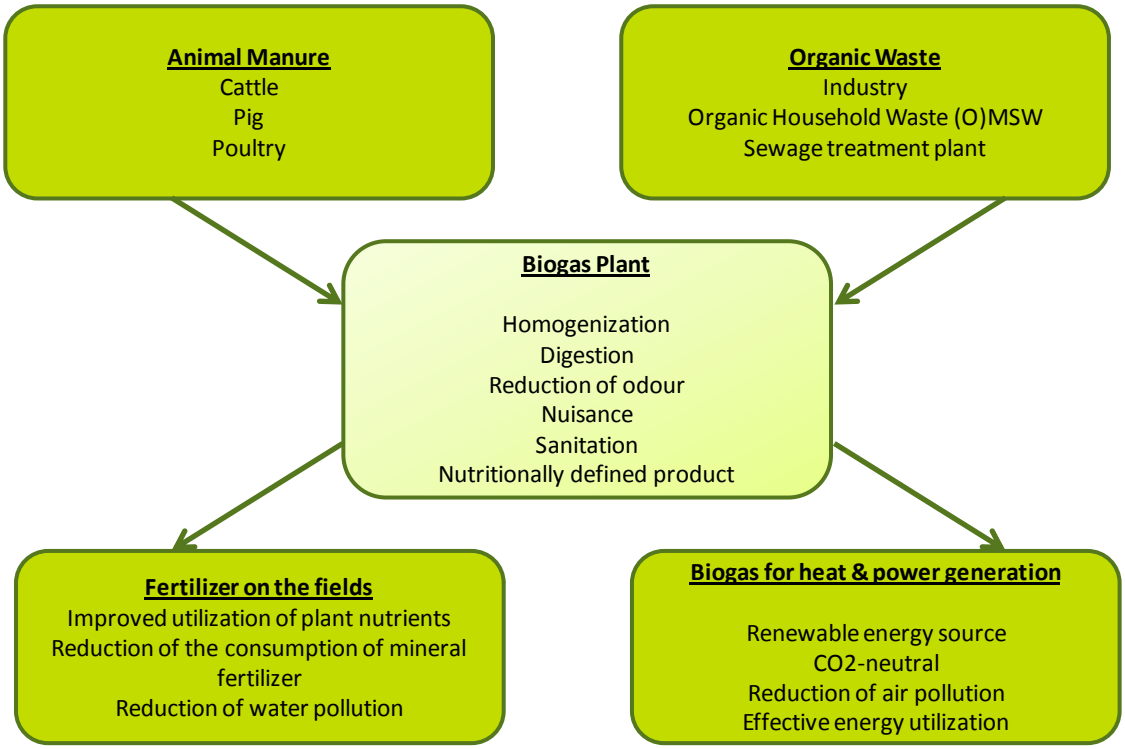

Figure 17. Biogas Cycle (Source: Heinz Peter Mang, 2011)

Anaerobic digestion or fermentation is the process that results in biogas, biodegradable materials are converted, in Vietnam mainly animal manure is being used as well as waste water, nevertheless sewage, organic municipal solid waste, plant materials and other crops can also be used. The gas contains mainly methane, but also carbon dioxide and possibly some small amounts of other contents. Large scale production of biogas, which is really common in for example the Netherlands, can be used for electricity and heat generation. The bioslurry, also with large scale production can be used as fertilizer. See also the figure above.

Biodiesel

Biodiesel production can be done either directly from vegetable oil which is extracted from for example Jatropha (or other oil-containing seeds and plants) as discussed in this report, or it can be obtained after etherification of the oil. The advantage of biodiesel is that it can directly be blended with normal (petroleum based) fossil fuels, when small amounts are blended no technology adaptations are necessary. As governments in developed countries are pushing for higher blends with biodiesel, there is an increased demand on the global market. The production of biodiesel can take place in a more decentralized way (compared to normal refinery). Jatropha is the main potential biodiesel crop in Vietnam, together with fish oils.

Bio ethanol

Crops that are rich in sugar and starches, like sugar cane and cassava in Vietnam, are a good feedstock for bio-ethanol production. Ethanol can also be blended for use without technology adaptations, (for higher blends adaptations are necessary. In Vietnam PetroVietnam is initiating several ethanol plants fed with cassava.

Appendix 2. Bioenergy Stakeholders Vietnam

The tables are not as black and white as separated here, several organizations could be mentioned in several topics. The table is also not inexhaustible, and companies/organizations might be missing.

National management & policy	
MOIT	Policy & National plan on Trade and Industry
MOC	Policy & National plan on Construction
MARD	Policy & National plan on Agriculture - Bamboo, Coconut
Department of Crop Production	Policy & National plan - under MARD - crops, trees
Livestock production Department	Policy & National plan - under MARD - livestock
Vietnam Administration of Forestry	Policy & National plan - under MARD - forest
MONRE	Policy & National plan on Environment
Vietnam Environment Administration	Policy & National plan - under MONRE - waste

Research and Development	
Bioseed Vietnam	Part of DCM Shriram Consolidated Ltd. Research and developed bioseed
FSIV (forest science institute of Vietnam)	Part of MARD - forest
Hanoi University of Agriculture	Rice and other crops
Hoa Sen University	Cooperates with Vietnam Biogas Association on Biogas issue
Institute of Agricultural science of South Vietnam	Research and application of new technologies in agriculture and rural development in southern Vietnam
IPP (Innovation Partnership Programme)	A project under MOST. As the result of cooperation between Vietnamese Gov. and Finland Gov.
IPSARD	Basic science research for agri. development - bamboo
ISPONRE	Relates to environment policy
National Maize Research Institute	Part of Vietnam Academy of Social Science Research on gene and type of maize
Nong Lam University	Rice and other crops
Research Center Coffee, Cocoa Eakmat	From the Western Highlands Agro-Forestry, Scientific and Technical Institute (WASI)
Thanh Tay University	Pilot/research planting Jatropha
Vietnam Academy of Science and Technology	Research & projects on bioenergy: biomass, biogas, biofuels (potential, technology…)
Vietnam Institute Of Agricultural Engineering And Post-Harvest Technology	Research & projects on policy, strategy, post graduation; technology transfer related to rice

State owned companies	
CASUCO	Sugar producer, bagasse, molasses
EVN	Vietnam electricity - generation, transmission and distribution of electricity of Vietnam.
EVN Finance	40% capital is from EVN. Working on CDM field
PVN	Petroleum/Petroleum products/Bio-diesel/Ethanol products: Processing plants, extract, import & export. Power plants. Focal point for Vietnam's petroleum
PVOil	Branch of PVN: relate to petro - production and bio-fuel production
State forest enterprises	Manage and protect forest, wood business
URENCO	Waste collection and treatment in Hanoi
VINACAFE	Coffee Corporation
VINAFOOD 1	exchange food & agriculture products - rice
VINAFOOD 2	exchange food & agriculture products - rice

Private sector	
Agape Co.,Ltd	Coconut fiber, charcoal, firewood from coconut
Analytica Vietnam	Int'l Trade Fair for Laboratory Technology, Analysis, Biotechnology and Diagnostics with analytica Vietnam Conference
Asia Biomass	Asia Biomass operates as both a consultancy services firm and an investor holding company
Betrimex	Import and Export: Coconut, rice, tea and other Agriculture products
Bien Hoa JSC	Producing sugar from sugarcane
Bourbon Tay Ninh JSC	Producing sugar from sugarcane
Buon Ma Thuot Coffee Exchange Center	Exchange coffee
Conbuild Vietnam	International Trade Fair for Construction, Building and Mining – Machinery, Equipment, Materials, Vehicles, Technology & Services
Dai Dong company	Jatropha planting
Dai Viet Ltd	Ethanol (96%) production, cassava supply
Datsat JSC	Pellet production from wood - export
Delta Energy Corp	Rice husk briquette, rice husk pellet, rice husk thermal power plant
Dinh Hai Cogen JSC	Rice husk power plant technology supplier
Dong Xanh Company	Green field Company - producing biofuel from cassava
Green Energy Biomass	GreenEnergy Biomass, J.S.C. ("GEB") is a Vietnamese-registered company engaged in the production of biomass derived from the plant Jatropha Curcas - an ethical, and sustainable second generation biofuel feedstock.
Hung Viet composite	Supplier of the Composite Biogas Model in Vietnam
Kim Nghia	Import industrial machinery, export agricultural and forest products (corn cob, rice husk pellet)

Le Han International Development And Services Trading Company Limited	Jatropha planting
Manh Thong J.S.C. (wood processing)	Potential producer and sales of wood pellets, currently just wood processer
Minh Phuoc Energy Co LTD	Briquette producer
Nam Nguyet Ltd Company	Coffee products - trend to export
NAVIWater	Water and waste water treatment
Nestle	Coffee producer
Nguyen Loc Investment Corporation	Wood pellet, wood briquette, rice husk briquette
Orient Bio-Fuels	Biofuels from cassava (joint venture of PVOil-Vietnam, ITOCHU-Japan)
Phuong Nguyen Phat CO.,LTD	Provide all kind of biomass as: sawdust, shaving, rice husk, coffee husk, cashew husk, cashew nut sell extracted, sawdust briquette, rice husk briquette, wood pellet, rice husk pellet. And raw cashew nut shell liquid (CNSL)
Prosperity Initiative	Bamboo and coconut - build long term economic opportunities
Son Thuan Phat	Coco peat, coconut processing
SRE	Rice husk briquette, charcoal, producing chain
SUMI VN	Biomass pellet equipments
Tam Phong JSC	Rice husk briquette, rice husk pellet
Tan Phat	Pellet production from wood - export (Registered with SGS)
Trung Nguyen Coffee	Coffee production
Truongthanh Group	Forest planting, timber processing, furniture production, pulp production
Tung Lam Ltd.	Ethanol production
Vi Thanh factory	Part of CASUCO - sugar: producing sugar from sugarcane
Viet Trung invest J.S.C.	MSW treatment, biomass electricity
Vietnam High-Tech Renewable Biomass Energy J.S.C.	Construct RE plants
Vietnam Renewable Energy Joint Stock Company	Institute of Energy is a stakeholder
Vinaexim	Export and import mechanical tools, elec. Equipments. Export for fertilizer, animal feed production and fuels
Wonderfarm	Food processing from coffee, coconut
WRE Trading in Vietnam	Work on RE projects and also CDM

NGO	
ENERTEAM	research, consultancy services, and technology developer in energy efficiency and renewable energy
GIZ	strong and firm German NGO works on wind energy field
GRET	International Aid Agency - bamboo
IFAD in Vietnam	Fund organization for Agricultural projects to support poor people in rural areas in Vietnam

Oxfam	strong and firm German NGO works on wind energy field
Polytechnical energy and environment joint stock company - Polytee	Belong to Hanoi University of Science and technology. RE, Waste Combustion Treatment
UNIDO	International Aid Agency - bamboo
UNIDO	promotes industrial development for poverty reduction, inclusive globalization and environmental sustainability - bamboo
Viet Nam Sugar Cane Association	Bridge between Private and Government sector
Vietnam Association of Seafood Exporters and Producers (VASEP)	Association of companies relates to seafood in Vietnam
Vietnam Cleaner Production Centre	Bamboo research. Other projects on Clean production
Vietnam coffee - cocoa association	Bridge between Private and Government sector
Winrock	International Aid Agency - bamboo

Carbon Company	
South Pole Carbon Asset Management Ltd.	CDM, VER and consultancy
Intraco carbon consulting	CDM, VCO (voluntary Carbon Offset): renewable energy, biogas, biomass to oil & gas field
Hanam carbon	CDM consultancy service
RCEE	Research Center for Energy and Environment (RCEE): Consultant company on Energy, Climate and Environment
Vietnam energy and environment consultancy J.S.C.	CDM and energy consultancy

Appendix 3. Relevant Stakeholders the Netherlands

The tables are not as black and white as separated here, several organizations could be mentioned in several topics. The table is also not inexhaustible, and companies/organizations might be missing.

Consultancy, Knowledge and Capacity building		Active in Asia	Active in VN
BE-Basic	BE-Basic is an international public-private partnership, funded by the Dutch government between universities, research institutes and industries of various scales in the field of sustainable chemistry and ecology. The mission is to develop industrial biobased solutions for a sustainable society. BE-Basic is coordinated by Delft University of Technology.	Yes	Yes
BGP Engineers	BGP Engineers, a specialized company with focus on climate change, renewable energy and sustainable development. The key abilities are policy advise, consulting, engineering, project development, project implementation.	No	No
BTG Biomass Technology Group	BTG Biomass Technology Group BV (BTG) is an independent, private group of companies, which is specialized in the process of conversion of biomass into useful fuels and energy. The three main activities: Consultancy, Project Development & Research and Technology Development (RTD).	Yes	Willing
BTG-BTL	Supplier of pyrolysis technology	Yes	No
CE Delft	CE Delft is an independent research and consultancy organization specialized in developing innovative solutions to environmental problems.	unknown	unknown
Control Union	Control Union is an international group of companies specializing in certification.	Yes	Yes
ECN	ECN develops high-quality knowledge and technology for the transition to sustainable energy management. And ECN introduces this knowledge and technology to the market.	Yes	Yes
Ecofys	Only Ecofys possesses deep knowledge across the entire spectrum of renewable energy, energy & carbon efficiency, energy systems & markets, energy & climate policies.	Yes	No
Ekwadraat	Ekwadraat initiates, designs and guides projects in the field of renewable energy.	Yes	No
FACT Foundation	FACT promotes sustainable biofuels for local communities in developing countries, by providing knowledge and expertise on biofuel implementation, by field testing innovative biofuels and by giving specialist advice on demand.	Yes	No

KEMA	A global, leading authority in energy consulting and testing & certification, active throughout the entire energy value-chain – in a world of increasing demand for energy, KEMA has a major role to play in ensuring the availability, reliability, sustainability and profitability of energy and related products and processes.	Yes	No
KWA Bedrijfs Adviseurs	KWA helps companies to ensure their business continuity. Our specialists are used to dealing with the possibilities and impossibilities that arise within an existing situation.	unknown	unknown
Raedthuys Group	Exact and solid know-how in the areas of project development, logistics, trade in biomass, technology, microbiology and chemistry. The team at Raedthuys Bio-energie has the required know-how and expertise available.	unknown	unknown
The Copernicus Institute	The Copernicus Institute investigates and develops processes and opportunities for innovative change towards sustainability.	Yes	No

Biogas		**Active in Asia**	**Active in VN**
Alke BV	Heaters / Cooling / Egg Hatching on biogas	Yes	Yes
Cirmac	Cirmac is a global player in gas treatment and the upgrading of biogas into green gas.	unknown	unknown
Colson BV	Environmental engineering's agency Colsen b.v. develops and combines digestion- and digestate treatment techniques in order to deliver a total concept for the digestion of a wide range of organic products.	Yes	Willing
DMT Environmental Technology BV (DMT)	Design and build standardized quality installations for biogas treatment	Yes	No
Dordtech Engineering BV	Develops and produces gensets and CHP systems, especially for alternative fuels like biogas, bio-oil and petrochemical vapors like petrol.	Yes	unknown
Gastreatment Services BV	Gastreatment Services (GtS) is an engineering firm engaged in gas treatment in the broadest sense of the word. GtS designs and realizes purification systems for biogas, landfill gas and digester gas.	unknown	unknown
Green Gas International	Green Gas International builds, owns and operates plants converting methane and waste from coal mines, landfills, biogas and biowaste into clean energy and carbon credits.	Yes	No
Frames Biogas Processing B.V.	-	Yes	No
HoSt	HoSt is an engineering and contracting organization, specialized in the engineering and supply of biomass energy installations.	unknown	No
Orgaworld	Organic waste treatment	No	No
Paques	Paques offers solutions to the sector (e.g. bioethanol and biodiesel producers) for treatment of their water and gas effluents in order to comply with discharge regulations and to produce biogas	Yes	Yes

	from their wastewater.		
	Anaerobic COD removal		
	Aerobic COD removal		
	Biogas desulphurization		
SNV Netherlands Development Organisation	SNV initiated the largest household biogas program of Vietnam in 2003 which constructed over 115.000 units by the end of 2011 (funded by the Dutch Government)	Yes	Yes
Thecogas - PlanET Biogastechniek	Constructor Biogas Installations	Yes	unknown
Van Der Wiel Group	The design, engineering, supply and installation: - landfill gas excavation and utilities systems (conversion of landfill gas-electricity/conversion of landfill gas-natural gas quality) - biogas treatment and utilization plants - biogas flare systems - MBR water treatment plants - combined heat and power plants - the production and assembly of pipeline systems, with appendages, in stainless steel and carbon steel.	Yes	unknown
VAR BV	VAR can develop, realize, implement and optimize waste processing installations. Depending on the wishes of the client, VAR Engineering can be called in on a project basis (for consulting, engineering and/or project management) or to supply a total concept for specific waste processing systems.	No	No

Technology		Active in Asia	Active in VN
AEH Power	Constructing CHP units, generator sets etc	No	No
Ecoson	Good example of the use waste materials from meat processing	No	No
Eneco New Energy	Involved in developments pellet project in Vietnam	Yes	Yes
GF Energy	GF Energy is an international trader and producer of sustainable wood pellets and other forms of solid biomass.	unknown	unknown
Kara Energy Systems BV	KARA Energy Systems is a worldwide supplier of complete combustion systems for wood and other biomass.	Yes	unknown
Kara Energy Systems BV	Second Hand Bioenergy Systems	Yes	unknown
Pelleting Technology Nederland (PTN)	the development, engineering, production, sales and service of pellet mills and associated machines for the animal feed , recycling and biomass industry.	unknown	unknown
Storq Thermeq BV	Stork Thermeq covers the complete range of expertise needed for maintenance, upgrading and production of key components in boiler systems.	Yes	No

Topell Energy	Topell Energy is a Dutch producer of bio coal; a sustainable and high caloric fuel. Using an innovative process, bio coal is produced from a raw material of wood-like residue from forestry and landscape management.	No	No
Torr-Coal Technology BV	Torr®Coal Technology BV makes bio coal (Torr®Coal) from biomass; a by-product available in considerable volumes, but in its raw state unsuitable as a fuel.	No	No
Van Aarsen	Wood processing, pellet equipment	Yes	No
WWE Sustainable Solutions	WWE's strategic vision is to forge new links in the chain of added value throughout the whole development cycle; to provide added value by gaining expertise in the planning and engineering stage and applying this during construction and operation.	Yes	Yes

Improved Cookstove – ICS (household scale)		**Active in Asia**	**Active in VN**
Philips	Co-creation made it possible to design a stove that helps fight indoor pollution. With 1.6 million people dying annually through smoke inhalation, the Chulha, the low-smoke indoor cooking stove can make a significant difference.	Yes	No
Unilever Sustainable Living Plan	The vision is to create a better future in which billions of people can increase their quality of life without increasing their environmental footprint.	Yes	No
Shell	A unique partnership involving the UN and a range of public and private partners is now working to provide millions with a cleaner, safer way of cooking.	Yes	No (ICS)
Netherlands Redd Cross	Expressed interest in applying ICS in their focus areas in Vietnam	Yes	Yes
SNV Netherlands Development Organisation	Active in the set-up of a national wide ICS program	Yes	Yes

Engineering, Management, Advisory		**Active in Asia**	**Active in VN**
DHV	DHV is a leading international consultancy and engineering firm, providing services and innovative solutions in environment and sustainability, general buildings, manufacturing and industrial process, urban and regional development and water. The range of services covers the entire project cycle, including management consultancy, advice, design and engineering, project management, contract management and asset management.	Yes	Yes
Grontmij Nederland BV	Grontmij is a sustainable design and management consultancy active in energy management; conventional power plants; energy storage;	Yes	Yes

	renewable energy; energy transmission and distribution; biofuels;		
Royal Haskoning	Royal Haskoning has all the knowledge and experience in-house which is required for core process related energy projects as well as non-process related projects. Varying from Architecture, Structural Engineering, Project Management to Building Services, Industrial Installations, Environment and landscaping architecture, all disciplines can be brought together into the project organization.	Yes	Yes
HoSt	see above		
Ingenia	Ingenia is an innovative and independant engineering and consultant firm for renewable energy and evironment.	unknown	unknown
Optimum Environmental and Energy Technologies	Engineering and Contracting company for energy solutions	No	No
Tebodin	An independent, multidisciplinary consultancy and engineering firm.	Yes	Yes
Witteveen en Bos	Reducing greenhouse gas emissions and implementing measures to counter climate change are specialised areas in which Witteveen+Bos operates both in engineering and in policy.	Yes	Yes

Financial Issues		**Active in Asia**	**Active in VN**
BID Network	BiD Network engages thousands of entrepreneurs, experts and investors from all over the world to stimulate entrepreneurship and economic growth in emerging markets.	Yes	Yes
FMO	FMO offers tailor-made financing. We advise companies with investment plans to contact us at the earliest stage possible to discuss their plans.	Yes	Yes
ICCO	ICCO's main instrument is the funding of development projects and programmes in developing countries. ICCO has developed a special programme on loans and guarantees for organisations in developing countries.	Yes	Yes
Private Sector Investment programme (PSI)	The Private Sector Investment programme, PSI (divided in PSI Regular and PSI Plus) is a subsidy programme of the Dutch Ministry of Foreign Affairs / Development Cooperation that supports innovative investment projects in emerging markets.	Yes	Yes
Shell (through the shell foundation)		Yes	Yes

Triodos Bank	The mission of the Triodos bank is to use the money entrusted to them by savers and investors to work for positive social, environmental and cultural change.	Yes	Yes
Vietnam Facility	under development	Yes	Yes
WWE Sustainable Solutions	WWE does invest in companies with an essential role in the variety of solutions that are offered by WWE in the environmental sector. Investments could either be in majority or in minority shareholdings. WWE will always be a 'hands on' shareholder. However, it will not take on a role in the executive management of the investments.	Yes	Yes

Relevant Universities
University Maastricht
University of Amsterdam
University of Groningen
University of Technology - Delft
University of Twente, MESA+ Institute for Nanotechnology
University Radboud Nijmegen
University Utrecht
University VU Amsterdam
University Wageningen
University Wageningen - Food & Biobased Research

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NL Agency is an agency of the Dutch ministry of Economic Affairs responsible for the implementation of sustainability, innovation and economic development programmes for various governmental bodies. NL Agency is a department of the Dutch Ministry of Economic Affairs that implements government policy for sustainability, innovation, and international business and cooperation. It is the contact point for businesses, educational institutions and government bodies for information and advice, financing, networking and regulatory matters.