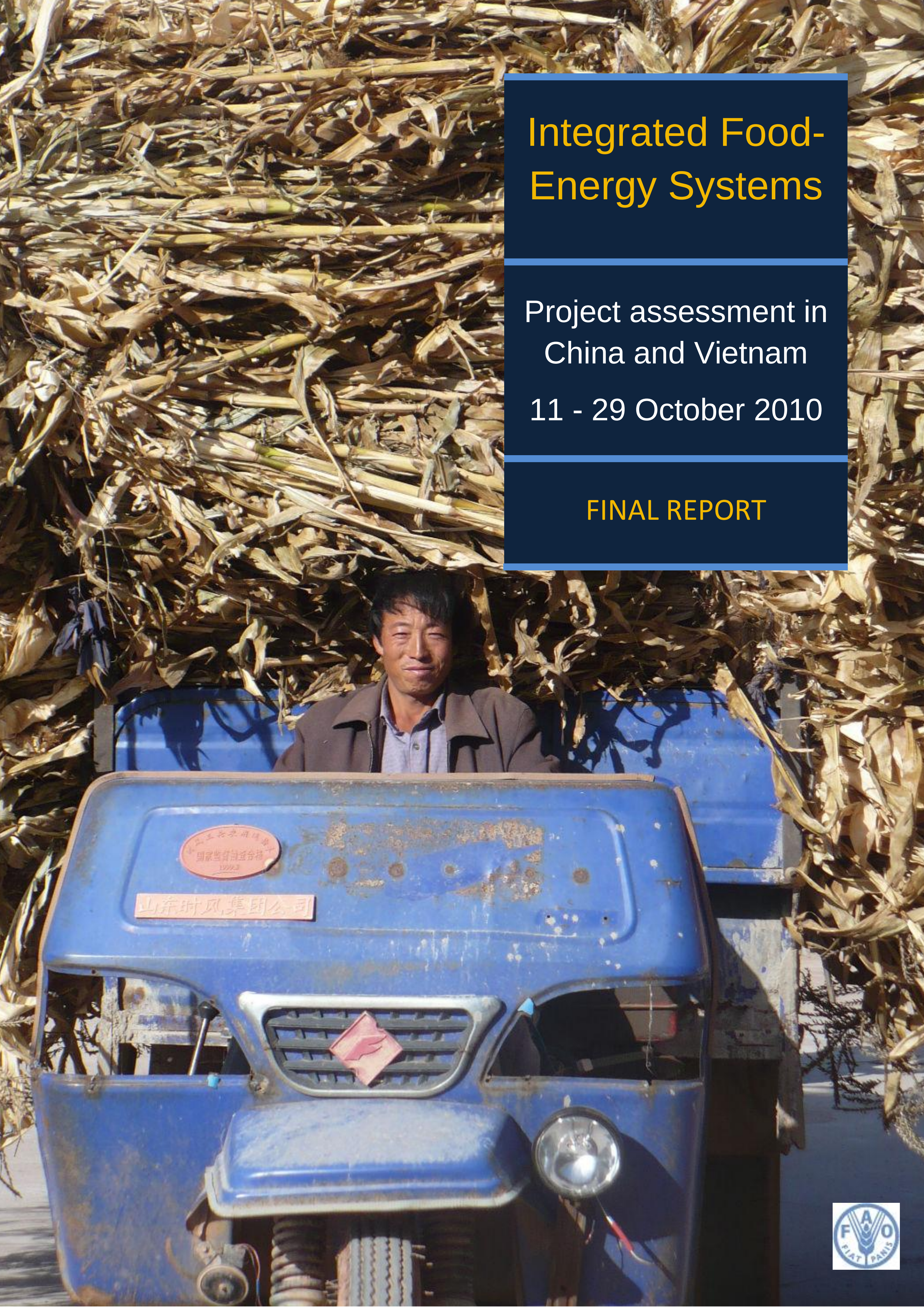

Integrated Food-Energy Systems

Project assessment in China and Vietnam

11 - 29 October 2010

FINAL REPORT

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SUMMARY

This report describes the projects visited during our technical mission in China and Vietnam which took place from 11 to 29 October 2010. The programme was set out to assess Integrated Food-Energy Systems (IFES) of different scales and modalities set up by different implementing bodies. We focused on widely disseminated schemes in both countries which benefit small-scale farmers and, contribute to the adaption to and the mitigation of climate change.

This focus allowed us to gain ample experience related to the main questions raised in the IFES overview paper “How to make IFES work in a climate-friendly way and benefit small-scale farmers and rural communities”. The assessment was hence tailored to identify those factors that had made the wide-scale dissemination of the given IFES possible, and those that secure their sustainability on the long run. We were particularly interested in how the challenges related to IFES had been addressed in each single case, and how their potential solutions could be transferred to other agricultural settings where no IFES were in place or where the dissemination of IFES had failed so far. Additionally, we became acquainted with some innovative IFES schemes which provided us with “food for thought” - new models of IFES which are still at the experimental or demonstration stage. This also gave us the chance to obtain a brief insight into the countries’ future direction regarding IFES.

The systems visited varied widely in shape, size and composition, starting from smallholder integrated crop-livestock -biogas schemes in both China and Vietnam, to medium, community scale livestock and biogas operations in Hainan, China, large-scale biogas plants near Beijing, China and Jatropha outgrower schemes in Ninh Tuan, Vietnam. All of these systems were laid out to benefit small-scale farmers and/or rural communities.

We conclude that one main reason, why IFES, in particular biogas schemes, have been successfully scaled-up in China and Vietnam is partially due to the long tradition of integrated agriculture in South and Southeast Asia which has built a solid (knowledge and resource) base for upscaling IFES. Technologies to do so exist; however the enabling environment is still weak. One of the main hindrances of upscaling IFES to date is of financial nature, particularly regarding start-up investment costs. Further issues concern the quality and continuity of technical support. Examples both in China and Vietnam showed how the right policies and institutions can address these issues. Greenhouse gas management is playing an increasingly important role in policy development.

Documenting good practice, success factors and potential failures will help inform decision making on all levels, particularly the policy and private sector. At the same time, unsolved issues need to be thoroughly assessed, to advance the upscaling of IFES as laid out in detail at the end of the report.

ABBREVIATIONS

CDM	Clean Development mechanism
CHP	Combined Heat and Power
FAO	Food and Agriculture Organization
GEF	Global Environmental Facility
IFC	International Finance Corporation of the World Bank Group
IFES	Integrated Food Energy Systems
OECD	Organization for Economic Co-operation and Development
POA	Programme of Activities
SNV	Netherlands Development Organization

1. INTRODUCING INTEGRATING FOOD ENERGY SYSTEMS

Reducing "Energy Poverty" is increasingly acknowledged as the "Missing Development Goal". This is because access to electricity and modern energy sources is a basic requirement to achieve and sustain decent and sustainable living standards. It is essential for lighting, heating and cooking, as well as for education, modern health treatment and productive activities, hence food security and rural development. Yet three billion people – about half of the world's population - rely on unsustainable biomass-based energy sources to meet their basic energy needs for cooking and heating, and 1.6 billion people lack access to electricity.

Small-scale farmers are globally the largest farmer group and of key importance to local and national food security in developing countries. Therefore safely integrating, intensifying and thus increasing food and energy production for this large group of producers may have the best prospect to improve both local (rural) and national food and energy security and reduce poverty and environmental impact at the same time.

While biomass has been – and continues to be – the primary energy source for the rural poor in developing countries, it has also been of special interest in OECD countries in recent years, mainly due to the production of liquid biofuels for transport. This has caused strong controversy, mainly regarding the potential risk that the production of biofuels may pose to food security of the rural poor in developing countries, but also regarding issues related to global climate change.

Integrated Food Energy Systems (IFES) aim at addressing these issues by simultaneously producing food and energy, as a possible way to achieve the energy component of sustainable crop intensification through the ecosystem approach. This can be achieved in two ways: Type 1 IFES combine the production of food and biomass for energy generation on the *same land*, through multiple-cropping systems, or systems mixing annual and perennial crop species, i.e. agroforestry systems. Either system can be combined with livestock and/or fish production. Type 2 IFES seek to maximize synergies between food crops, livestock, fish production and sources of renewable energy. This is achieved by the adoption of agro-industrial technology (such as gasification or anaerobic digestion) that allows maximum utilization of all by-products, and encourages recycling and economic utilization of residues. In many situations, the production of renewable energy can feasibly go well beyond bioenergy alone. Other locally available (non-biological) renewables can be incorporated such as solar thermal, photo voltaic (PV), geothermal, wind and water power.

IFES can function at various scales and configurations, from small-scale systems that operate at the village or household level mainly for the purpose of self-sufficiency, to large-scale systems adjusted for industrial operations, but involving and benefiting small-scale farmers.

The main driver for implementing IFES in *developing countries* is the need for food and energy security - the basic requirement for poverty reduction and rural development, but also concerns regarding environmental problems caused by unsustainable agricultural practises. The growing interest in establishing IFES in *developed countries* is backed by the general trend towards increased resource efficiency, especially in land use. As a positive side-effect, IFES also address several challenges posed by climate change and climate variability through agricultural practices that help to adapt to, and mitigate, the consequences of a changing climate, and reduce dependence of agricultural development on fossil fuels.

The concept of IFES as such, is not new. *Simple* integration of food and energy production at both small and large scales has shown many successful results. However, there are fewer successful examples of the more *complex* and resource-efficient systems. Examples of long-term implementation and uptake exist for simpler systems like biogas, but are relatively scarce for more complex IFES operations.

1.1. IFES in China and Vietnam

Integrated agriculture in general has evolved in many regions of the world under different names and definitions (e.g. agroforestry, mixed farming, integrated crop-livestock systems). However, South and Southeast Asia, characterized by high population densities and limited land resources, is particularly renowned for having a long tradition in applying integrated agricultural practices, i.e. integrated crop and livestock production and/or integrated crop and fish production.

Integrated farming systems have been assessed and compared to non-integrated farming systems in many ways. One particularly interesting approach in the context of IFES concerns the comparison between these systems in terms of energy efficiency . The success and sustainability of integrated farming systems in South and Southeast Asia can be partially explained by the favorable energy input/output balances that these systems have, and their ecological and energetic sustainability compared to monocultures depending on external fuel sources. Chinese farmers of the seventeenth century already practiced a diversified, organic strategy that recycled internal and renewable energy resources. Heavy production of rice, wheat mulberry leaves for silk worms, and livestock has been sustained over centuries by human labour, using intensive practices for composting and green manuring, crop rotation, irrigation, and animal husbandry (Wen and Pimentel 1986). The persistence of smallholders in an area that supported 7.8 people per hectare of farmland then and provides for 15 people per hectare today testifies to the maintenance of high yields without serious environmental degradation (Netting 1993[1]).

[1] For more details regarding energy efficiency of different agricultural systems, please refer to Netting 1993.

Pimentel and Pimentel (Pimentel and Pimentel 1979; Netting 1993) compared a rice production system farmed under these traditional Chinese strategies with three rice-production systems from the 20th century in the Philippines, China and the United States. The Philippine system lowered human labor to less than a third of the old Chinese one, partially compensating with energy from water buffalo traction and small amounts of nitrogen fertilizer. However, Philippine rice production per hectare was only 42 percent of the traditional Chinese totals, and energy efficiency dropped to 3.29 (ratio of kcal input to kcal input). Dawa, China shows the potential for increasing the remarkable traditional yields from pond fields by adding still more labor, using animal power and introducing large amounts of fossil energy. The energy ratio decreased to 3.16. However, this is still higher than the ratio in a mechanized system in Louisiana, where human labor has almost disappeared and has been replaced by diesel, gasoline, and natural-gas fuels; nitrogen, phosphorous, and limestone fertilizers; herbicides; drying; electricity; and insecticides. The ratio dropped by two-thirds to 1.30.

China's roots of integrated farming systems can be traced back to ancient times (Li & Min 1999). Since the late seventies, these traditional practices have been receiving increased attention by decision-makers, scientists and farmers again, especially due to environmental problems and a decrease in arable land. About half of China's farmers are currently using integrated crop-livestock systems (Hu *et al* 2008), and a growing percentage of them are IFES, based mostly on small, middle and large scale biogas schemes, which receive various subsidies from the Chinese government. However, both the central government and the private sector, are investing in research on how to integrate other forms of bioenergy production into existing farming systems such as the anaerobic digestion of straw and the production of bioethanol from sweet sorghum combined with livestock husbandry.

While the focus of our assessment was on Type 2 IFES, Type 1 IFES schemes can be found throughout the country in the form of traditional agroforestry systems that provide a sustainable source of fuelwood. The Chinese government has been (re-) introducing different agroforestry schemes under the overall framework of ecological agriculture since the late seventies (Hildreth 2008), and the World Agroforestry Center (ICRAF) supports several agroforestry initiatives throughout the country, also in regions where agricultural land and forestland were traditionally considered to be separate, e.g. in the Southwest (Weyerhaeuser & Kahrl 2006).

Similar terms apply for Vietnam, a nation with long traditions in integrated farming systems, whose rural population is combining livestock, fish and crop production in many parts of the country to date. IFES have received much attention from different public bodies, international organizations, local NGOs and universities, as can be seen in the quantity of different programmes promoting these systems, e.g. by VACVINA (see Picture 1 below), SNV, and MERKAN). Like in China, the focus of our assessment was on Type 2 IFES, particularly small-scale biogas schemes. However, Type 1 IFES such as traditional agrosilvicultural schemes, are widespread in Vietnam, especially in the upland areas, although their exact land coverage is not known (Jensen 1995). More complex, newer Type 1 IFES in the form of smallholder Jatropha plantings next to traditional home gardens, are currently being developed by Green Energy (see Box 6).

Picture 1: IFES in Vietnam – CCRD/VACVINA's VAC-model (Van Thanh 2010)

2. FIELD ASSESSMENT

The field assessment tour which will be described in this section took place from 11 to 29 October 2010 in China and Vietnam. A detailed agenda can be found in Annex 1. The programme was set out to assess IFES of different scales and modalities set up by different implementing bodies. We focused on *widely disseminated schemes* in both countries which *benefit small-scale farmers* and, contribute to the *adaption to and the mitigation of climate change.*

This focus allowed us to gain ample experience related to the main questions raised in the IFES overview paper "*How to make IFES work in a climate-friendly way and benefit small-scale farmers and rural communities".* The assessment was hence tailored to identify those factors that had made the wide-scale dissemination of the given IFES possible, and those that secure their sustainability on the long run. We were particularly interested in how the challenges related to IFES had been addressed in each single case, and how their potential solutions could be transferred to other agricultural settings where no IFES were in place or where the dissemination of IFES had failed so far.

Additionally, we became acquainted with some *innovative IFES schemes* which provided us with "food for thought" - new models of IFES which are still at the experimental or demonstration stage. This also gave us the chance to obtain a brief insight into the countries' future direction regarding IFES.

Complementary to our field visits, several meetings with actors from national and local governments, universities, NGOs and the private sector, completed our understanding of the given IFES schemes, including success factors and drawbacks.

In addition to our report on IFES and the technical consultation held in Rome on July14-15 2010, these findings will lay the third building block for our upcoming perennial programme on IFES.

2.1. Description of IFES schemes

2.1.1. China

2.1.1.1. Energy use from manure – biogas

The main IFES type supported throughout China are biogas schemes based on anaerobic digestion of different scales. The number of household biogas digesters in rural China is the highest in the world (Chen *et al.* 2010). The wide-spread implementation of small-scale biogas digesters of about 8 to 10m^3 started in the early seventies, and was particularly promoted from 2001 onwards through the

Programme for the Development and Promotion of Biogas Utilization in Rural China (DPBURC) which benefitted around 105 million people in rural areas (OECD/IEA 2010). According to the Ministry of Agriculture (Hao 2010, personal communication), by the end of 2009, there had been 35 million household biogas schemes installed throughout the country. Assuming each digester serves a household of five, one can say biogas serves 25% of China's rural population currently counting 720 million people. The total volume of biogas production by biogas digesters will be about 15.5 billion m^3 of biogas per year. Beyond the household level, China currently counts around 57.000 medium and large-scale biogas plants (Hao 2010, personal communication).

These developments have been supported by different policies, laws and regulations. The Law on Renewable Energy, the Law on Energy Conservation and the Law on Agriculture address the current development of rural energy provision, including biogas (for more detailed information, please refer to APCAEM-ESCAP 2010). Simultaneously, rural energy management, extension and service systems have been established and improved throughout the whole country. Currently, there are systems related to management and extension, research and development, and training and quality inspection involving 41,000 professional employees across the country. On top of this, about 276000 farmer technicians have been trained in this field. Over 100 national and industrial standards have been set to maintain and, if possible, improve the quality of small- and large-scale biogas plants; e.g. NY/T 466-2001 Household-scaled biogas & integrated farming system - Specification on design, construction and use for northern model (Hao 2010, personal communication).

The Chinese government has steadily increased its capital input into biogas developments. Input during the ninth Five-year Plan period (1996 -2000) was RMB 55.4 million, during the tenth Five-year Plan period (2001-2005) RMB 3.5 billion, and has been RMB 21.2 billion since 2006 to date (Hao 2010). On average, each household using a biogas digester saves 500 RMB (about $75) every year from reduced use of fuelwood, electricity, chemical fertiliser and pesticides (Tian and Song 2010).

At the *household level,* China distinguishes between three different integrated biogas schemes: the "Three in one Energy Ecological Mode" (also called Pig-Biogas-Fruit) which is presented in more detail below in Box 1, the "Four in One Energy Ecological Mode", and the "Five in One Energy Ecological Mode". The ''Three in One'' model combines a biogas digester with a pigpen and toilet, and is particularly popular in Southern China, where the weather is more favorable for digestion. The ''Four in One'' model combines a biogas digester, a pigpen, a solar greenhouse, and a toilet, and is recommend for Northern China, where the weather is cooler. The ''Five in One'' model includes a biogas digester, solar-powered barns, a water saving irrigation system, a water cellar, and a toilet, and is considered to be the adequate model for the water-stressed region in the Northwest. The systems were established to simultaneously improve household hygiene and prevent environmental pollution while providing energy for basic domestic needs such as cooking and lighting. Furthermore, the slurry from the biodigester is normally used as organic fertilizer.

Every town or community has a service station for biogas users. Biogas technicians have to be approved for qualification certificate through an official test supervised by the Ministry of Agriculture. Household biogas technician training covers basic technology of household biogas, design and construction of household biogas digesters, biogas utilization technology, pipeline design and installation of biogas, and biogas daily management and maintenance (APCAEM-ESCAP 2010). The fee of the service is pre-set by the extension unit.

The average costs for a household biodigester in China amount to 4000 RMB (US $ 600). The Chinese national government subsidies household users with an amount between 800 RMB (US $120) and 1200 RMB (US $180) depending on the region. The provincial and municipal governments contribute another sum, according to existing regulations. In some cases, households can also earn additional income through CDM certification. The revenue per household is relatively low - about US $ 25/year - compared to the subsidies given by the government, however, the CDM income is paid yearly as opposed to the subsidy which is a one-time payment.

China was the first country to develop a household biogas CDM methodology. The "Methane recovery methodology in agricultural activities of peasant households/small scale farms" has been recognized by the CDM Executive Council (see Box 2). Under this methodology, China has registered one project in 2009 in Enshi, Hubei. Covering eight counties and 33000 biogas peasant households, the project will cut CO_2 emission by 58400 tonnes each year. Each household may get RMB 174 (US $26) of income from emission reduction on an average basis, which are approximately 60% of the total CDM revenues. The other 18% will be used to provide technical service, and 22% will be used to conduct supervision and management. Credits will be purchased by the World Bank (Hao 2010, personal communication).

Box 1. Biogas for Hainan's smallholders: The "Three in one" household model and the "District" community model

Agriculture accounts for 30% of Hainan's economy. The province in the South of China has a population of 8.6 million, of which 60% work in the agricultural sector. Hainan has a tropical moist monsoonal climate. Paddy rice is cultivated extensively in the north-eastern lowlands and in the southern mountain valleys. Leading crops other than rice include coconuts, oil palm, sisal, tropical fruits, black pepper, coffee, tea, cashews, and sugarcane as well as rubber trees. The livestock sector, mainly based on 7 million pigs, represents a fifth of Hainan's agricultural income.

In order to solve the increasing environmental challenge of disposing pig manure, biogas digesters have been installed throughout the province - between 2003 and 2010, 300 000 household biogas devices. Current figures show that approximately 18% of Hainan's households possess biodigesters.

Hainan has 1200 biogas service stations to support the installation and maintenance of both household digesters and larger plants. Biogas technicians get trained three times a year. In turn, they provide training to farmers three times a year as well. Once a year, technicians check-up on each household digester. Approximately 60% of the fees taken cover the salary of the technicians, 30% are used to buy supplements, and 10% are needed for operational costs. Currently there is no fixed salary-based system for the technicians.

The installation of the digester is subsidized. The farmers receive 1200 RMB from the central government, 1000 RMB from the provincial government and 1000 RMB from the municipal government, and contribute 800 RMB from their own sources to finance a household digester in Hainan, which cost 4000 RMB on average. Farmers or entrepreneurs wishing to install a biogas plant between 500 and 2000m^3 receive subsidies from the central government covering up to 45% of their investment (up to a maximum of 2 million RMB).

Household model
In the village of Tuon, the implementation of household biodigester started in 2004. The majority of the villagers, 46 families, own approximately three to four pigs and a pigpen, which is connected to a cement dome biogas digester. The farmers use its effluent water to fertilize their adjacent fields every three days. Additional to the pigpen, also the toilet is connected to the digester. Since the installation of the new scheme, farmers use gas to cook and to light their houses. The produced gas is enough to cook three meals and provide lighting for a five head household. The average quantity of gas used amounts to 1 to 1.2 m^3 per day. A certain distance between the pigpen, the toilet and the biogas digester on the one hand, and the house on the other hand is required to keep the living area clean, odourless, and hygienically healthy.

The farmers make a living from selling their cash crops - pepper, lemon and bananas, while they produce paddy rice for self consumption. They are provided with water from a centralized water supply, and have access to the electricity grid as a complimentary source of energy.

District Model

A completely different model that provides farmers with biogas and slurry is the District biogas farm model recently pilot-tested in Hainan - an interesting institutional arrangement which combines division of labour and guarantee of benefits to small-scale farmers by involving these as shareholders in the district farm: Instead of raising pigs themselves, small-scale farmers pay the district farm a certain fixed amount of for as many pigs they wish – i.e. their “shares” in the district farm. Thanks to these financial contributions, the district farm, which raises all the pigs, can reach a scale which allows it to invest in more efficient biogas systems that in the vase of household systems. On the other hand, small-scale farmers benefit from a share of the revenue from the sale of the pigs, and often recoup their initial investments break even after 3-4 years – any dividend from the sale of pigs by the district farm is therefore net benefit for small-scale farmers after that period. In addition, not only shareholder farmers but all surrounding small-scale farmers benefit from the biogas and slurry by-product produced by the district farm at a discounted price.

As an example, one of the district farms visited is based on 5000 pigs and provides 135 households with biogas. Of these, 46 households have shares in the company. The two villages are connected to the district biodigester by an underground pipeline of 400 and 800m length, respectively.

Compared to the household model, the district model provides several advantages: the farmer does not have to take care of the pigs and the biogas digester himself which makes it not only easier for him, but also very time-effective. Furthermore, he receives a guaranteed income each year depending on his shares in the company. Large-scale biogas systems as such are much cleaner and environmentally friendly management systems of livestock manure both for farmers and the neighbouring environment. They are also easier to regulate and monitor. Economies of scale arise as a bigger farmers can invest in better technologies, leading to better technical performance.

However, one particular challenge might impede the large-scale implementation of these pilot schemes in the near future. Farmers would need to change their traditional way of livestock keeping, giving up on pig husbandry and becoming shareholders in a privately owned company. In the opinion of both company owners and local politicians, convincing them to do so will take time.

Source: personal communication with Wang Hong Liang, 2010; Kuang Jiyon, 2010, Zhou Shiqiang, 2010; and with farmers and company owners; APCAEM-ESCAP 2010

Box 2. CDM methodology for household biogas digesters

CDM project development requires the baseline determination and GHG emission reduction by applying a specific CDM methodology and establishing a project's monitoring plan. Until November 2010, the UNFCCC CDM Executive Board had approved three small-scale methodologies relating to animal manure management, of which one is particularly tailored for individual households or small farm biodigester schemes as described above (AMS-III R-version 01-Methane recovery in agricultural activities at household/small farm level). This category includes methane recovery systems that achieve an annual emission reduction of less than or equal to 5 t of CO_2 per system. Currently, 18 projects and 3 programmes of activities (PoA) - a set of an unlimited number of CDM Programme Activities (CPAs) that can be registered as a single CDM project - are registered under this methodology.

Taking into account that each farming household has a very limited emission reduction potential from the biogas digester, a project, therefore, has to be bundled with hundreds and even thousands of farming households to have a cost-effective CDM project. When planning to build 100,000 or even 300,000 biogas digesters each year, a province can divide them into a number of smaller projects. This may increase the difficulties of validation and endorsement. Therefore, it is suggested to develop PoA household biogas CDM projects while developing smaller tied-up projects.

Source: APCAEM-ESCAP 2010; UNEP Riso Center 2010

At present, China has approximately 4.26 million large-scale farms for pigs, cattle, and chicken (Hao 2010, personal communication). The amount of livestock and poultry excrements is 1.12 billion tons, which could theoretically produce 67 billion cubic meter of biogas annually (Hao 2010, personal communication). The "DQY Chicken Excrement Biogas" case is an example of where this potential is made good use of (see Box 3 below). It presents a Type 2 IFES at the *large-scale* which clearly shows two mayor benefits of IFES additional to food and energy production: first, how large IFES operations can benefit small-scale farmers through the division of labour, and second how IFES can contribute to mitigate climate change.

The Chinese egg company DQY and local farmers are working closely together. The farmers, on the one hand, owning approximately 20 000 mus (1300 ha) of land adjacent to the company provide the feedstock for DQY's three million chicken which consume 60,000 tons of corn annually. The estimated income to the local farmers is RMB 40 million (US $ 6million). The company, on the other hand, additional to the revenue from their main operation of selling eggs, turns the manure of the chicken farm into biogas, which is later transformed to electricity, and organic fertilizer.

Box 3. Beijing DQY Chicken Excrement Biogas Project

The adequate treatment of chicken manure is a longstanding issue for the egg and poultry industry. The Chinese egg company 'De Qing Yuan ',which is privately held and established in May 2002 , has addressed this issue with the installation of a large-scale biogas power plant, and was awarded 'Global large-scale biogas power generation technology demonstration project' by United Nations Development Program and the Global Environment Facility in 2009.

About 100 km from Beijing covering an area of 50 hectares, the DQY Chicken Farm supplies over 70 percent of the branded egg market in Beijing. It is one of the biggest chicken farms in Asia; 2.6 million chickens lay some 1.5 million eggs per day. They produce 220 tons of excrements and 170 tons of waste water which, until the end of 2007, was of no commercial value. Since the biogas power was set up in November 2007, chicken manure is converted into heat and power, bringing considerable environmental and social benefits.

After converting the biogas to electricity, the company keeps about ten percent of the production to run its own operations. The rest of the power is sold to the local grid, amounting to 25 000 kWh per day – enough to fulfill the needs of the adjacent town with 30000 inhabitants. At present, the cost of purchasing power from the State Grid is RMB 0.65/kwh, while the cost of biogas produced electricity is merely RMB 0.19/kwh. DQY Agriculture supplies surplus electricity to State Grid at the price of 0.57/kwh, which results in a revenue of RMB 8 million (US$ 1 million) every year. In addition, the heated flue gas generated by the power generators are used to maintain the temperature of the biogas fermentation system and heat the vegetable greenhouses and office buildings. This directly reduces extra annual energy expenditure of RMB 2.7 million (US$ 400 000) (IFC 2010a).

At the same time, the project is expected to catalyze Carbon emission reduction certificates (CERs), another source of income, that could be generated through the Clean Development Mechanism (CDM) for avoiding methane emissions and replacing fossil fuel. The company has the potential to reduce the equivalent of about 95000 tons of CO_2 per year.

While the power is fed into the local grid, the fertilizer is partially sold to the farmers at a low cost. This is a cost-effective way for the farmers to fertilize their corn fields, but it also a good practise in ecological terms. The nutrients which had been withdrawn from the field through the corn farming operations, are returned to the fields in form of organic fertilizer, closing the environmental loop. This not only maintains the soil resource, but - additional to the biogas operation itself - also contributes to climate change mitigation since the need for fossil-fuel based fertilizer is lower therefore reducing emissions which would have occurred through the production of synthetic fertilizers. Furthermore, it is less likely to over-apply nitrogen with organic fertilizers due to its less concentrated form as opposed to synthetic fertilizer, therefore again reducing emissions. For the farmer, using cheap and locally produced organic fertilizer also means reducing vulnerability to rising energy prices, and hence volatility of agricultural input prices.

Source: Shen 2010; IFC 2010b; personal communication with Liu 2010

2.1.1.2. Energy use of straw – biogas, briquettes and pellets

China's straw biomass accounts for 687 million tons, of which 215 million tons are wasted and directly burned (Hao 2010, personal communication). At the household level, direct combustion of straw is the main way to utilize straw as an energy source, accounting for 33–45% of energy consumption in rural areas (Zeng et al. 2007). An improved stove can save about 1 to 1.5 tons of firewood annually, which amounts to 100 to 200 RMB. To build a new, improved stove 60 to 100 RMB are required, and the cost of the firewood saved every year amounts to 100 to 200 RMB, which indicates that the investment costs for new stoves are recovered in one year (Zeng et al. 2007). According to preliminary estimates, about 50 million tons of CO_2 emissions are avoided annually in China due to the diffusion of improved stoves (Lin 1998).

On the community-scale and large-scale, China has established 888 central gas supply stations of straw gasification and 159 centralized gas supply systems of straw biogas (Hao 2010, personal communication). According to Zeng et al. (2007) 1 kg straw can produce 2 m^3 biogas and a household with 4 people only requires 5–6 m^3biogas/day to meet their basic needs. Furthermore, 259 straw densification and briquetting sites, and 40 straw carbonization sites had been installed by the end of 2009 (Hao 2010, personal communication). The straw is often purchased from small-scale farmers who are either paid or compensated with the energy product, be it gas, briquettes or pellets. A farmer gains around RMB 200 for each ton of straw he sells (Xiao 2010, personal communication).

Anaerobic digestion is yet another way of making use of straw. However, due its low content in nitrogen and phosphorous and its predominant composition of cellulose, hemi-cellulose and lignin, straw does not lend itself easily for anaerobic biodigestion, unless it is co-digested with manure. Nonetheless, to make full use of the large quantity of straw residues in China, the ministry of agriculture, several Chinese research institutes and universities are undertaking research of how to make anaerobic digestion of (pure) straw viable[2], which would not only yield gas, but also organic fertilizer. Increasing research efforts also focus on ethanol production from straw and other lingo-cellulosic feedstock (second generation biofuels) which is supported by the Ministry of Science and Technology (Li and Chan-Halbrendt 2009).

To prevent the competition of agricultural residues for energy purposes with other uses, the Institute of Energy and Environmental Protection from the Chinese Academy of Agricultural Engineering (CAAE) suggests to stick to the following principles (Xiao 2010, personal communication): Agricultural residues must first of all

[2] Selected R & D projects from China, e.g. http://www.dbfz.de/web/Workshop.70.0.html?&L=0.

serve agriculture (soil quality). Second priority concerns the livestock sector. Straw can serve as livestock feed. Third rank other uses such as energy production from residues. According to current statistics, a third of the residues are returned to the field, a third is fed to livestock, and a third has other uses.

2.1.1.3. Energy use from plants – biofuels

China's biofuel sector is steadily developing. The National Development and Reform Commission (NDRC), China's top planning agency, set a target of meeting 15% of transportation energy needs with biofuels by 2020 (NRDC 2005). At the start of 2009, China's ethanol projects had a total capacity of 2.2 million tonnes, and 2.1 million tonnes of biodiesel (Zhang 2010). Up to now, most of the ethanol was produced from grain in China. The government subsidy on grain-based ethanol production has stopped completely in 2008 (Zhang 2010) which explains the high interest in non-grain resources such as cassava and sweet sorghum.

To our knowledge, there are no biofuel IFES on the ground to-date. However, plans are under development. An innovative approach has been suggested by Mr Shi-Zhong Li from Tsinghua University. He has been involved in building a demonstration plant in Inner Mongolia Province in China, where sweet sorghum stalks are transformed to ethanol using the Advanced Solid State Fermentation (ASSF) Technology. The leaves of the feedstock stay on the field to maintain the soil organic matter and prevent erosion. Sorghum grains and the fermented bagasse are used as feed for cattle. Their manure is turned into biogas and fertilizer through anaerobic biodigestion. While the biogas is used to generate electricity, the fertilizer is brought back to the fields of the farmers, working as outgrowers for the company (Li 2010, personal communication). While the technical part of the demonstration project, the ASSF technology, has shown successful results, the integration of livestock and the feasibility of working with outgrowers remains to be seen once the operation has reached commercial scale.

2.1.1.4. Other sources of renewable energy

When the purpose of implementing IFES is to enhance energy supply to rural communities, adding other sources of renewable energy technologies can make IFES more reliable and flexible. Without knowing whether these have been installed additional to existing IFES schemes (biogas) or in other locations than IFES, China has invested in rural, small-scale solar, wind and hydro technologies. By the end of 2009, about 50 million m^2 of solar water heaters, 17 million m^2 of household solar houses, 700 000 m^2 of solar school buildings, 1.500 sets of solar stoves, 250 000 sites of solar PV power generation, 100 000 of small-scale wind power generators and 47 000 sets of micro-hydro power generators had been promoted in rural areas (Hao 2010).

2.1.2 Vietnam

2.1.2.1. Energy use from manure – biogas

Integrated Food Energy Systems, in particular smallholder biogas schemes, have received much attention from different public bodies, international organizations, local NGOs and universities in Vietnam, as can be seen in the quantity of different programmes promoting these systems.

The National Biogas Programme in Vietnam has been supported by the government and SNV (see Box 4). SNV's engagement in the field of biogas is based on the fact that, despite the urgent need for renewable energy technologies, there is a failure in the sustainable dissemination of these technologies in developing countries, including Vietnam. Moreover, there are sanitary and pollution problems surrounding the 26.9 million pigs in Vietnam, most of which live in individual household farms with five to 20 head of livestock (SNV 2010). While the majority of pig manure is re-used, mainly for fish feed and fertilizer, the unused portion is usually deposited in waterways, seriously polluting the environment.

Box 4. The National Biogas Programme in Vietnam

From 2010, the Biogas Programme in Vietnam, with technical assistance from SNV, contributed to the construction of 57,000 household biogas plants and provided training for about 500 technicians, 700 biogas mason teams and nearly all owners of biogas plants. Currently, 99% of the plants installed are fully operational and 48% of the plants have toilets attached. By 2011, the Biogas Programme aims to have built 164,000 biogas plants, reaching 800,000 people. By this time, women will have their workload reduced by 110 million hours per year, and biogas households will have their energy costs reduced by 65%. On average, 67% of households will increase their number of livestock because of the sanitary solution to animal manure that biogas plants provide.

The overall objective of the Biogas Programme is "to further develop the commercial and structural deployment of biogas, at the same time avoiding the use of fossil fuels and biomass resource depletion." The more specific objectives are to achieve economic, environmental and social sustainability, with a particular focus on the economics, as the programme must result in a commercially viable biogas sector supported by independent businesses.

One of SNV's approaches and success factors to date is to enable biogas plant builders to *become businesses* with knowledge in marketing, planning and management. SNV's strategy is concentrating on developing the biogas sector by diversifying technologies, supplying business training, and advancing market and stakeholder communication. This ensures that the renewable energy products and services facilitated by SNV can and will be sustained. Another success factor is the *involvement of all the organisational and institutional capacities and stakeholders* already available in the country, organising them into associations and other institutions as well as strengthening the capacities in cooperation with local capacity building organisations. SNV is also providing *advisory services for all stakeholders* in programme management, biogas strategy, and institutionalisation and sector building. As a result, entrepreneurs, institutions and local governments are capacitated, creating a sustainable infrastructure for a biogas sector.

One large challenge lies in the area of quality management. To tackle the problem of bad quality equipment, the payment of subsidies which are paid to the farmers for the installation of a biodigester are now closely linked to quality control. Before the quality of the unit has been confirmed by a technician from the governmental extension service, no subsidies are paid. Both SNV and local governments pay six percent of the total cost (US$500) of each unit.

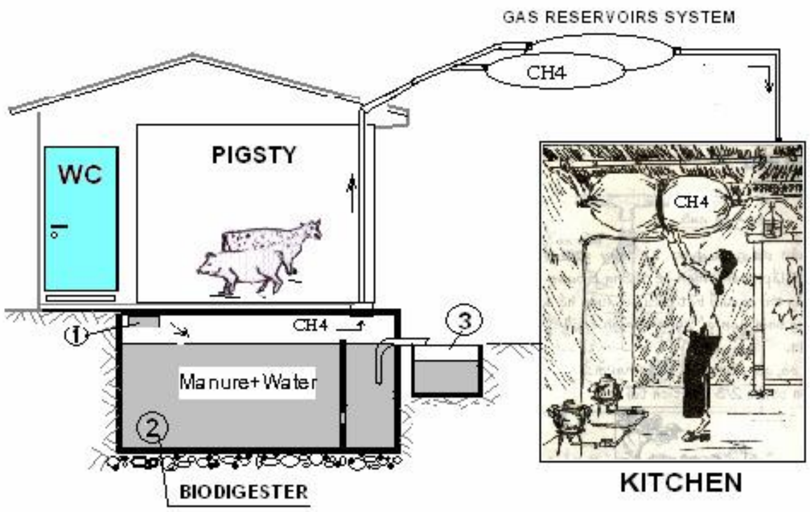
Current problems are related to financing the further dissemination of biogas schemes. SNV is therefore pushing for continued market development to up-scale the programme through the above mentioned success factors and is investing in further research and development. Particular emphasis is laid on institutionalising training and quality management, diversifying digester technology, furthering the use of bioslurry, and establishing cross cutting organizations such as the Biogas Association, the National Steering Committee and other biogas initiatives. The Asian Development Bank is currently looking into setting up a credit facility for smallholders which would allow more farmers to join the Biogas Programme.

Source: SNV 2010; personal communication with Tom Derksen 2010

Another important organization aiming to upscale IFES is Vietnam's Gardeners' organization VACVINA which was established in 1986. With more than one million members in 61 provinces, it has branches at provincial, district and communal levels. VACVINA has been promoting the VAC integrated system which involves gardening, fish rearing and animal husbandry, to make optimal use of the land. The Center for Rural Communities Research and Development (CCRD) is collaborating with VACVINA, helping them to set up household biogas digesters (see figure 1) to prevent environmental pollution, at the same time providing a source of energy and organic fertilizer. A market-based approach has been adopted to disseminate the digesters (see Box 5).

Figure 1. VAC biogas scheme

1.Inlet system 2. Digester 3. Outlet/slurry 4.Gas reservoir Source: Van Thanh 2010



Box 5. The VAC integrated system in Ha Trung District, Thanh Hoa Province

By 2010, approximately 1000 biogas plants had been installed and 70 technicians had been trained by CCRD/VACVINA in Thanh Hoa Province. Farms vary in size – between 0.5 to 2ha – and in the types and quantity of crops, vegetables and animals. The farmer needs at least four to six pigs or two to three cattle to make the biodigester viable. On an average farm, 70% of the land is occupied by crops and trees such as rice, corn and apple trees, 15% is dedicated for livestock production, and another 15% for fish ponds.

The household biodigester is an underground flat-top system which combines the pigpen with a toilet. It has a concrete floor on which the pig shelters are built. This reduces land requirements to a minimum which is crucial for Vietnamese farmers due to restricted land resources. The gas is collected in a plastic bag reservoir which is usually hanging underneath the roof of the shelter or the kitchen. Its innovative design prevents the accumulation of a hard scum layer that reduces gas output in the absence of annual cleaning. The price is half of the investment needed for the classical fixed-dome digester, which amounts to US$ 500. The gas is usually completely used for cooking.

The slurry has various uses. It is either directly applied to the fields and/or used as fish fodder. In some cases, it is used for composting. It is mixed with crop residues such as rice husk/straw and corn straw that are no used for animal feed or land cover, and an innoculum which speeds up the composting process reducing the needed time from six to seven months to 45 days.

Several success factors have been identified by CCRD/VACVINA that allow for the dissemination of VAC biodigesters. The first and most important step is the identification of a local partner for collaboration. CCRD has identified VACVINA, which is a well-known and reputable community-based organisation, and trained their technical staff in technical and marketing skills. Once this is accomplished, the biogas system needs to be promoted. CCRD/VACVINA implements several demonstration sites, makes publicity on the local radio and opens “biogas shops” that provide potential customers with information. An “Early-bird promotion” attracts further attention. Once purchased, the VACVINA technicians provide the farmers with the turn-key biodigester: They hire local masons, and provide the technical know-how during the building process.

In order to guarantee downward accountability, user surveys are used, allowing the customers to give their views about different topics, such as quality of the provided energy conversion devices, overall degree of user satisfaction, and environmental and livelihood impacts of the biogas system as a complement to crop-livestock-fish integration.

Contrary to the National Programme subsidized by the central government and SNV, VACVINA does not provide financial incentives, but offers the early-bird discount which reduces the original price by up to 30%. A household saves on firewood and synthetic fertilizer, and breaks even after ten years. The biogas produced displaces the use of firewood estimated at 2,500 kg per household per year for which families spend between $5 and $10 per month. The application of the organic fertilizer reduces the application of synthetic fertilizers by about 50 percent.

Source: Personal communication with Pham van Thanh 2010; Van Thanh 2010

2.1.2.2 Energy use from plants and animal waste - biofuels

According to the country's energy ministry, Vietnam is focusing on production of 'green gasoline' from cassava, coconut, sesame, peanut, flax and Jatropha (see picture 2), and from animal products such as catfish fat. Under the plan on biofuel development to 2015 with a vision to 2025, Vietnam will produce 1.8 million tons of ethanol and vegetable oils for use as fuel annually, meeting 5% of domestic petrol and diesel demand in the next 15 years (International Business Times 2010).

The Dong Xanh Joint Stock Company, the first in Vietnam, began operation in August 2010. Its annual capacity is 100,000 tons of biofuel a year. The plant is currently working at 70-80% of its designed capacity, supplying ethanol to state-owned Petrolimex. Its principal feedstock is cassava grown in Quang Nam and Binh Dinh provinces (International Business Times 2010). About 40 000 ton of fertilizer are produced as a by-product. The company predicts to consume nearly 1 million tons of dried cassava per year which will be purchased fresh for 1000 dong per kilogram from farmers ($US 0.05) (VNNEP 2010).Vietnam's biodiesel sector is still under development. Vietnam's leading catfish co-op Agifish plans to produce 30 000 tones of biodiesel from fish waste. The Mekong Delta factories currently process 50 000 tons of catfish fat each year (Nguyen Hong 2010). Several other firms are currently planting Jatropha on the experimental scale, among them the Dong Xanh Joint Stock Company, Green Energy Joint Stock Company and Eco-Carbone.

While the systems mentioned above might classify as IFES, more information would be needed to confirm this. During our visit in Vietnam, we assessed one approach tailored to provide sustainable biodiesel from Jatropha (see picture 2) which has been taken by the Green Energy JSC in Ninh Thuan Province. While the company is not selling the feedstock yet (apart from some seeds to produce straight vegetable oil for the local building industry), their approach has been very promising to-date and clearly classifies as IFES (Box 6).

Picture 2. Cattle in Jatropha plantation, Vietnam

Box 6. Green Energy JSC

Green Energy JSC's agricultural partners are Vietnamese cooperatives and farmer's unions. These entities are contracted over the long-term (30 years) to sell their produced biomass to Green Energy JSC - in return for the company's establishment investment, professional training, and the guaranteed purchase of their produce. Green Energy JSC processes the biomass for sale and distribution in Vietnam and globally. The actual production units are the members of the coo[erative, Vietnamese smallholders, who plant Jatropha on a portion of their own land. The smallholders are assisted in their biofuel feedstock start-up with help from Green Energy JSC via 'forgivable loans' for establishment costs, seedlings, and extensive training, which means that if the farmer meets the company's requirements, repayment of the loan will not be required.

Green Energy JSC agronomic and environmental goal is, along with its smallholder production partners, to expand the production base of Jatropha Curcas to 25,000 hectares – each one established under the principals of the Roundtable on Sustainable Biofuels and increase the Vietnamese production of substantive amounts of clean fuel.

The economic goal is to deliver additional income for approximately twenty thousand smallholder households (a 60,000 beneficiary headcount). Since Green Energy JSC does not encourage cultivation of Jatropha on productive lands this is an addition to existing income.

The direct business link is between the company, Green Energy Vietnam and the Farmer Cooperatives. The company seeks advice from a number of institutions and organisations around them to improve their business operations. GEV works together with public institutions at national, provincial and lower levels to develop appropriate policies and implementation mechanisms for the contract farming modalities.

Since the start of field testing in 2007, Green Energy JSC has developed methods for Jatropha cultivation by smallholders, trained 20,000 smallholders in these methods, and delivered 37 million income producing trees to smallholders. Green Energy JSC purchases Jatropha seeds according to the fluctuations of the oil price.

Training to farmers and local extension workers is given once a month. Farmers are encouraged to use "innovative", organic agricultural methods. During the training provided, farmers learn how to make compost from cow manure and crop residues and to apply organic pesticides such as tobacco leaves or leaves from the Nem tree. Legume trees are planted between the Jatropha rows to improve soil quality and control erosion. Jatropha seed cakes can serve as fertilizer or is used instead of coal for cooking. Cattle who used to graze on the non-productive land (defined as such by the government) has not been replaced, but is still feeding on the land which is now "intercropped" with weeds and Jatropha (see picture 2 above). This shows that there is an opportunity to intercrop Jatropha with perennial grasses or pasture crops such as alfalfa.

Source: FAO 2010; Personal communication with Tran Thi Cam Huyen, Ton That Thien Bao, Jamey Hadden from Green Energy JSC; Tom Derksen from SNV, 2010

3. FINDINGS

Integrated Food Energy Systems vary widely in shape, size and composition as we could see from many different cases in China and Vietnam, starting from smallholder integrated crop livestock biogas schemes in both China and Vietnam, to medium, community scale livestock and biogas operations in Hainan, China, large-scale biogas plants near Beijing, China and Jatropha outgrower schemes in Ninh Tuan, Vietnam. All of the systems that we visited *benefit small-scale* farmers and/or rural communities. However, the way *how* and *to what extent* these systems benefit them varied widely.

Regarding their contribution to the *adaptation to and mitigation of climate change* as well as their impact on environmental conservation in general, we again saw a large variety of different options, ranging from less to very efficient systems. By making IFES more efficient in environmental and climatic terms, they are usually also more beneficial to the rural population.

Biogas systems have another advantage in that they address the significant health risks related to livestock effluents, and this was mentioned several times by different types of people we met during our mission.

In order to study success factors and learn from failures, we focused our research on schemes that had been *up-scaled* considerably over the last couple of years, proving their sustainability and feasibility over time. However, we also assessed some *innovative* schemes that showed some promising technologies and approaches, which have the potential to promote the dissemination of IFES in the future.

IFES are, by definition, designed to supply both food and energy. However, this does not necessarily mean that a small-scale farmer owning an IFES or a rural worker employed in an IFES scheme does benefit from the operation, i.e. receives food, energy or an adequate equivalent income. Therefore, the question is which IFES, i.e. which technical, institutional and policy instruments and mechanisms, need to be in place to secure the beneficial involvement of smallholder and/or the rural population in a given setting.

To determine how this can be achieved, it is important to first determine the *ultimate purpose* of a given operation. While food and energy can be generated at the same time, it is usually one of two that motivates and determines a given operation. In the case of the household biogas schemes in China and Vietnam, the traditional crop-livestock systems providing food in the first place was complemented with a biogas digester to primarily reduce the environmental pollution caused by excess manure.

Biogas is usually seen as a by-product of this operation, nonetheless a very valuable one for most smallholders.

The opposite case can be found in commercially driven biofuel operations where the feedstock is primarily produced for energy purposes, and the by-product is food/feed as such, or is used for food production, such as the processing of bioethanol from cassava in Vietnam where a large amount of fertilizer is produced as a by-product. Another example is the production of Jatropha in Central Vietnam by Green Energy, where the smallholders producing the feedstock for the company must, by contract, not use their own, food producing land, but request extra, unallocated and less productive land from the local government. While biofuel production is the ultimate purpose of this operation, food production is maintained through this requirement.

3.1 How IFES can benefit small-scale farmers

Small-scale farmers *directly* benefit from IFES when farming their own piece of land using both food and energy for self-consumption as is the case in the smallholder biogas systems in China and Vietnam. These systems work because the pay off after a certain time. Food is produced mostly for self-consumption, but some is also sold on the market. The need to purchase synthetic fertilizer is reduced by half. Formerly purchased firewood, LPG bottles or electricity for cooking and lighting can be significantly reduced or completely replaced with biogas.

Apart from these financial benefits, the farmers' standard of living increases significantly. Long hours formerly needed to collect firewood can be saved, and respiratory and eye diseases related to smoke decrease significantly. The unpleasant odor of unhygienic pig and manure operations and the pollution of nearby waterways vanishes, which does not only serve the farmer but also the environment. Another benefit for both farmers and the environment results from reduction in greenhouse gas emissions, which slows global warming. At the same time, integrated agricultural practices increase the capacity to adapt to climate change by increasing farmers' resilience through self sufficiency in energy, income diversification (e.g. if they sell the compost generated through biogas production, or the biogas itself) and savings on farm inputs.

Another twofold benefit, put in place to mitigate greenhouse gases, is the clean development mechanism (CDM) designed for household biogas systems. The farmers who are certified under this scheme receive a share of the certificates sold.

Farmers can also *indirectly* benefit from IFES operations as was shown by the community district model in Hainan, where they become "shareholders" through their shares in the purchase of pigs by the district farm, hence a monetary contribution. Both food and energy are produced by the district farm. The farmer does not receive food, but is provided with cheap energy and revenue from the sale of the pigs. At the same time, he/she saves time which he/she can invest in other activities such as crop cultivation. In environmental and climate change terms, this operation might be more efficient since gas and manure leakage is less likely to occur here than in smallholder systems. However, this model requires a lot of capital investment in the first place. Including small-scale farmers as shareholders does not bring much profit for the company owner, but is rather linked to an agreement between him and the central government. The company can receive ample subsides for its implementation; in exchange he commits to work with smallholders – an interesting approach which, however, needs a strong government.

The district farm model is an illustration of well conceived division of labour which builds on the comparative advantages of each party involved, and seems to be a useful ingredient for scaling up IFES. The Hainan pilot approach is very important in that , if successful, could provide a perhaps more efficient and interesting alternative, or at least complement to the household biogas model. This is especially important taking into account the likely significant additional need for biogas systems due to China plans to significantly increase its meat production in the future.

Farmers also indirectly benefit from IFES when they are contracted by a company to produce one or more components of the IFES operation, hence earn from selling some of their products. Sometimes the smallholder also receives a share of the final product instead of or in addition to their income. This is the case in the DYQ egg biogas farm in China, where farmers sell corn to the company in exchange for money, organic fertilizer (slurry) and a reduced price for electricity. This examples again clearly shows the advantages of the division of labour, which is mostly applied in large operations, but also exists on the small-scale. The driver is usually of economical nature, but sometimes it is also motivated by the need for human or technical capacity or simply out of convenience. Despite several advantages, this model bears the risk that a given smallholder grows the feedstock for the company on land which was formerly used for food production. Giving up or reducing his own food production significantly makes him dependent on the income he/she earns from the company. To reduce the risk associated with giving up on food crops, one could think of a clause in the contract between farmers and the company that would stipulate that a minimum area of the small-scale farm should be used to grow food crops.

This risk is even bigger in some of the recent biofuel operations when farmers, encouraged by a given company or organization, or even contracted to do so, transform their land used for food production to plantations of biofuel crops - particularly jatropha. Some of these “contracts” have failed however due to the fact that Jatropha had not provided what was expected from this formerly denominated “miracle plant”, and farmers were left without markets. To prevent this to happen, Green Energy in Vietnam has taken an exemplary approach. As per contract, farmers are to use unproductive land outside of their plot to grow Jatropha. This, in turn, can happen, if and only if the household has formerly qualified to have sufficient labour to cultivate both their original fields and the new Jatropha plots, or if the household has sufficient means to pay extra labour to do so. Furthermore, to prevent that livestock keepers are displaced from the denominated unproductive land – defined as such in Vietnamese regulations – weeds and grasses are maintained throughout the plantation allowing the animals to keep grazing in the plantations.

3. 2 How IFES can be up-scaled

As illustrated above, IFES, if properly managed, do provide several financial advantages. It is no secret, that this fact alone can be an efficient engine to promote IFES, leading to their large-scale dissemination.

However, having the right policies in place can speed up the process significantly, or enable it in the first place, especially if small-scale farmers cannot afford the initial investment and do not have access to sources of credit through helping family members or microfinance schemes.

To provide external incentives, subsidies promote the quicker uptake of IFES, and make them easier to afford at the first place as can be witnessed in both in China and Vietnam. The Chinese central government, for example, pays subsidies both for smallholders (roughly a third of the total price) and private investors (up to 40 % of total investment).

On the other hand, disincentives can also be stimulus for IFES. In China, the manure of small-, medium, and large-scale livestock operations has to be adequately disposed to prevent environmental degradation. Otherwise, a fine has to be paid. Biogas digesters solve this issue.

Financial incentives can also be a useful tool for private companies working with smallholders to encourage them to participate in the given IFES scheme. Green Energy JSC, for example pays the farmers for Jatropha seeds according to the given oil price to balance varying input costs. Famers receive 10% more for jatropha oil than the existing fossil fuel price. Therefore, while farmers might struggle to pay for inputs for other crops when oil prices increase, they gain in the case of Jatropha.

Farmer organizations, through the promotion of IFES and the provision of material, know-how and training, further incentivize the uptake of IFES as proven by the VAC-shops in Vietnam. The same role is taken by the biogas service stations in Hainan. Both institutions finance their operations through a market-based approach, including the payment of salaries and materials used. Their success and economic viability depend on the number of customers they have, which might increase or reduce

depending on the quality (materials, training etc) they deliver. Accountability schemes as set up in Vietnam by VACVINA in the form of user surveys can help to maintain a good quality of both the service and the material delivered, or even improve it.
A relatively new mechanism that can provide incentives for both farmers and large companies to take up IFES is the clean development mechanism (CDM). Since CDM certification is based on the principle of additionality, only newly set up schemes under the mechanism itself are eligible for certification. The CDM scheme can therefore play an important role to initiate the set-up of IFES in areas where their implementation would usually not happen.

In addition, local NGOs together with international organizations play an important role in disseminating information about IFES schemes at all levels. Awareness raising about the potential benefits of IFES among rural communities, private companies, governments, or potential funding organizations has shown fruitful results. This can been achieved through linking different stakeholders by establishing cross-cutting organizations or networks, e.g. the Biogas Association established by SNV[3] (Netherlands Development Organisation) in Vietnam, a non-profit, international development organisation, or the EASE partnership[4] (short for Enabling Access to Sustainable Energy), an international network of NGOs and companies.

[3] http://www.snvworld.org/en/countries/vietnam/Pages/default.aspx

[4] www.ease-web.org/

4. CONCLUSIONS

Integrated Food Energy Systems show a large diversity in shape, size, ultimate purpose and benefits. Some IFES such as the smallholder biogas schemes based on integrated crop-livestock systems, develop organically over time. Others are specifically designed and implemented during a relatively short timeframe, such as DYQ egg biogas farm in China or Green Energy JSC in Vietnam.

One main reason, why IFES, in particular biogas schemes, have been successfully *scaled-up* in China and Vietnam is certainly due to the long tradition of integrated agriculture in South and Southeast Asia which has built a solid (knowledge and resource) base for upscaling IFES. Building on this long tradition of crop livestock systems, China introduced biogas technologies in the early 70s, and went through a steep learning curve, continuously correcting failures, and building on success factors. In Vietnam, also having a long tradition in crop livestock systems, biogas developments started later, but they were simultaneously pushed by different initiatives, each collecting experiences and factors of success and failure. This teaches us one important lesson: up-scaling IFES does" require not "just different resources and skills, but, above all, *time* to develop

What are these resources and skills? While technologies do exist (they can of course always be improved and their costs reduced), the enabling environment is still weak. One of the most burning issues upscaling IFES is to solve *financial issues*. In the case of biogas, China and Vietnam provide subsidies to tackle the first hurdle of start-up investment costs. While the central government in China affords to subsidize 30% for household digesters; Vietnam's National Biogas Programme is a cooperation between the government and the international organization SNV, sharing a 12% subsidy. CCRD/VACVINA, a non-governmental initiative, used to take a similar approach offering an early-bird fee of 30% reduction. While this was needed to take the first step and reach a minimum number of participants, VACVINA's strategy has completely changed to a market-based approach now. Also SNV is pushing for continued market development as subsidies cannot be paid on an ongoing basis in the future. Developing micro-credit schemes or improving people's access to existing credit institutions could replace current subsidies, and bring the dissemination of IFES forward.

Greenhouse gas management is playing an increasingly important role in policy development and is one of the key selling points for the development of bioenergy policy. This is particularly true for larger operations. Whether this is also feasible for small-scale CDM schemes remains to be seen as CDM development for small-scale IFES operations is still in its infancy. Other potential policy tools are listed in the FAO study “Integrated Food-Energy Systems: How to make them work in a climate-friendly way and benefit small-scale farmers and rural communities[5]”.

The Hainan district farm model being piloted in Hainan Province, China, is a very good illustration of the advantages in developing IFES schemes with a division of labour which builds on the comparative advantages of each party involved while ensuring adequate benefits for all.

The experiences from both China and Vietnam show that *policies* are an important driver of IFES schemes. Apart from policies catering for financial aspects (see above), policies can also discourage certain behavior through fines, e.g. waste and manure disposal, and therefore encourage better practices, e.g. disposing liquid waste through biogas digesters or solid residues through gasification.

The government also plays a role in setting up extension and service systems that provide training and help maintain the systems. Continued technical support and maintenance services are very important for sustainability of the biogas systems. Creating standards trough government regulations (China) or through setting specific conditions to obtain subsidies (SNV, Vietnam) that assure the quality of materials is mandatory, and so is the assurance of quality services, e.g. through user surveys (VACVINA, Vietnam). Offering training and extension services can also be feasible through a market-based approach (VACVINA, Vietnam), although initial financial help to set up the service might be needed.

Through the mechanisms described above, IFES can also be a powerful tool for adaptation to climate change and, at the same time, reducing global warming. Environmental pollution through inadequate waste disposal can be significantly reduced, and deforestation is minimized due to less need of wood fuels. This also leads to less occurrence of respiratory and eye diseases which is killing up to two million people worldwide each year. Polices that address these issues also indirectly help to up-scale IFES, as we could witness both in China and Vietnam.

While the upscaling of IFES can be actively enforced through the above mentioned factors, today’s market forces might add another part. In the case of biogas technologies, Asia’s and particularly China and Vietnam trend to consume more meat, and therefore require more (most probably large-scale) livestock operations. Given China’s environmental legislation, larger biogas plants will have to be installed. If models like the district farm models in Hainan will be widely adapted, both

[5] Bogdanski, A. Dubois, O., Jamieson, C. and Krell. R. (*in press*). Integrated Food-Energy Systems: How to make them work in a climate-friendly way and benefit small-scale farmers and rural communities. An Overview. FAO Green Paper Series.

smallholders and the rural population will benefit. The growing global carbon market will most likely further stimulate these processes.

Whether market forces promoting clean transport fuels will push towards small- and large IFES remains to be seen in the future, and will depend partially on the adaption or non-adaption of sustainable biofuel standards. It will also depend on the responsibility of each single actor in the chain of custody. While the company producing the feedstock decides in which way to grow its produce, other actors in the chain, including millers, traders, and fuel suppliers, have the choice of deciding from whom to buy it.

Therefore documenting good practice, success factors and potential failures will help inform decision making on all levels, particularly the policy and private sector. At the same time, unsolved issues need to be thoroughly assessed, to advance the upscaling of IFES as further laid out in chapter 5.

5. OUTLOOK

The authors of this report have identified the following possible follow-up actions as of interest to FAO and the countries:

1. *China and Vietnam*
   - *Document innovative and successful initiatives and/or approaches* likely to help promote IFES both in these countries and elsewhere. Such work would be very useful to help disseminate such systems and technologies, hence contributing to the global knowledge and promotion of IFES systems. Topics include use of biogas slurry (Vietnam), district biogas farm model (China), and smallholder jatropha project (Vietnam).
   - *Support to assessment and likely improvement of access to credit for small-medium and large scale biogas schemes.* There is currently controversy and lack of neutral assessment of the situation and possible existing gaps in that respect in both countries.
   - *A roadmap regarding decisions on different and sometimes competing uses of residues,* typically between soil management, animal feed and energy.
   - *What Energy for agriculture?* China and Vietnam would be interesting potential cases a different and more integrated approach to agricultural intensification compared to OECD countries. This could happen in the context of the Global Report on "Energy and Agriculture"; which would be the first output of a programme on "Energy and Agriculture (including both energy *from* and energy *for* agriculture) that FAO wishes to develop..

2. *China*
   - *Possible collaboration regarding Chinese investments in Africa r*elated to both energy for agriculture (e.g. low carbon agribusiness development) and energy from agriculture (e.g. investments in large scale liquid biofuels).
   - Possible project development on sustainable straw/biomass utilization in China.

3. Vietnam
   - Support to one year training of farmers and local technicians involved in the CCRD/VACVINA programme. The feasibility of this action will depend on its budget.

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Annex 1

Agenda China & Vietnam (10/11 - 10/29/2010)

Day	Time	Place	Activity	Contact
10/11 10/12	12:40-11:55	Rome/Beijing	Flight to China	
10/12	14:00-15:00	Beijing	Meeting with FAO Representative, Ms Sekitoleko	Dai Weidong Programme Officer, FAO Office in China Tel：010-65322835 Mob：13321170545
10/12	15:30-19:00	Beijing	Meeting with Mrs Hao from the Department of Science, Education and Rural Environment, Ministry of Agriculture	Mrs. Hao Xianrong Director The Division of Energy and Ecology The Department of Science, Education and Rural Environment , MOA, P.R.China 11 Nongzhanguan Nanli Beijing, P.R.China,100125 Tel:8610-59193032 13501271225 Email:haoxr@agri.gov.cn; xianronghao@gmail.com

10/13	07:30-14:00	Beijing	Visit of Beijing DQY Agricultural Technology CO.,LTD. 10000 m^3 Chicken Excrement Biogas Project	Mr.Liu Xuming R&D Department Beijing DQY Agriculture Technology CO. Ltd Headquarters Address: 5th floor Kehaifulin Building 12 Zhongguancun South Street.Haidian District, Beijing 100081 Phone:86-010-59798166-212 13911907785 Email: liuxuming@dqy.com.cn Web: www.dqy.com.cn
10/13	15:30-17:00	Beijing	Meeting with Dr. Sven-Uwe Müller and Mr. Qian Mingyu, GTZ	Dr Sven-Uwe Müller and Mr. Qian Mingyu GTZ Office Beijing Sunflower Tower, Room 1100 Maizidian St. 37, Chaoyang District 100026 Beijing VR China Tel: +86 1085275180 Fax: +86 1085275185 Email: gtz-china@gtz.de
10/14	12:15-16:50	Beijing/Haiku	Flight to Haiku	
10/14	17:00 – 19:30	Hainan Province	Meeting with Department of Agriculture, Hainan Province	Department of Agriculture, Hainan Province
10/15	08:30 – 18:00	Hainan Province	Visit of household and large scale biogas plants; District Farm Model	Department of Agriculture, Hainan Province
10/16	8:40-15:00	Hainan /Erdos	Flight to Erdos	

10/17	8:30 – 19:00	Erdos, Inner Mongolia	Visit of Sorghum Pilot plant	Shi-Zhong Li Institute of New Energy Technology Tsinghua University Tel.: 008610-62772123 13910097598 Email: szli@tsinghua.edu.cn
10/17	21:30 -23:10	Erdos/Beijing	Flight to Beijing	
10/18	09:00-10:30	Beijing	Meeting with Mrs Zhao Lixin and Mr. Wang Fei, Chinese Academy of Agricultural Engineering	Mr.Wang Fei Mrs. Zhao Lixin Director General & Professor Instititute of Energy and Environmental Protection Chinese Academy of Agricultural Engineering (CAAE) Tel.:86-10-65925082 E-mail: zhaolixin5092@gmail.com
10/18	11:00 – 12:00	Beijing	Meeting with China African Development Fund	Mr.Wang Yuexing, cadfund Cell phone no.:13466528306 wangyuexing@cadfund.com
10/18	14:00-15:00	Beijing	Meeting with Mrs. Hao from the Department of Science, Education and Rural Environment, MOA; And Mr. Dai Weidong from FAO	Mrs. Hao Xianrong Director The Division of Energy and Ecology The Department of Science, Education and Rural Environment , MOA,P.R.China 11 Nongzhanguan Nanli Beijing, P.R.China,100125 Tel:8610-59193032 13501271225 Email:haoxr@agri.gov.cn; xianronghao@gmail.com

10/20	15: 45-18:20	Beijing/Hanoi	Flight to Hanoi	
10/21	9:00 – 10:00	Hanoi	Meeting with FAO representative, Ms. Yuriko Shoji	Ms. Yuriko Shoji FAO Chief Representative, FAO 3 Nguyen Gia Thieu Street, Hanoi
10/21	10:30 – 11:30	Hanoi	Meeting with Mrs. Hoang Kim Giao from the Department of Livestock husbandry, Ministry of Agriculture (MARD)	Mrs. Hoang Kim Giao, Director, Department of Livestock husbandry, Tel:0084.4.37344829
10/21	14:00 – 17:00	Hanoi	Meeting with Mr. Dao The Anh, from "The Center for Agrarian Systems Research & Development" (CASRAD)	Mr. Dao The Anh, Director of the Center Centre for Agrarian Systems Research and Development Field Crops Research Institute - Vietnamese Academy of Agricultural Science Address: km9 Lang - Hoa Lac highway, An Khanh, Hoai Duc, Ha Noi Mobile: +84 (0) 913076566 daotheanh@gmail.com http://www.casrad.org.vn/
10/22	10:00 – 12:00	Hanoi	Meeting with Mr Rob Derksen from SNV Vietnam	Mr Rob Derksen Country Director SNV Vietnam Floor 6, Building B, 218 Doi Can La Thanh Hotel, Hanoi Tel: 04-38463791/ext 105

				Fax: 04-38463794 mobile: 0904295866 www.snvworld.org, www.snv.org.vn
10/23	8:00	Hanoi	CCRD/VACVINA	Mr Van Thanh Pham Director Center for Rural Communities Research and Development (CCRD) 15 Thanh Cong Str, Da Dinh District Hanoi Tel: (84-4) 37930380; Fax: (84-4) 37930306; Cell: +84913209430 email: tvc.vacvina@fpt.vn
10/23	10:30	Ha Trung District, Thanh Hoa Province	Meeting with VACVINA Leaders at the office of VACVINA chapter in Ha Trung District	Mr.Nguyen Ngoc Triu Chairman of Vietnam Gardening Association Mr. Loi Xuan Len Chairman of VACVINA in Thanh Hoa
10/23	13:30-17:00	Ha Trung District, Thanh Hoa Province	Visit of Small-scale biogas systems, the VAC-Model	
10/23	19:00	Hanoi	Meeting with Mr Van Thanh Pham	
10/24	9:30-15:00	Hanoi/Ninh Thuan Province	Flight to Ninh Thuan Province	

10/25	9:00 – 18:00	Ninh Thuan Province	Meeting with Mr. Hadden and Mr. Bao from Green Energy Vietnam / Asia Biomass; visit of Jathropha plantations, Social Inclusive Business Model	Jamey Hadden Director jameyhadden@asiabiomass.net Ton Bao tonbao@asiabiomass.net No. 160 Tran Phu Street, Phu Ha Ward, Phan Rang – Thap Cham City, Ninh Thuan Province
10/26	15:00 – 16:00	Ninh Thuan /HCMC	Flight to HCMC	
10/27	7:30	Hotel, HCMC	Meeting with Dr. Man from the MEKARN project	Dr. Man MERKAN project Nong Lam University, Linh Trung ward, Thu Duc district, Ho Chi Minh City http://www.mekarn.org/index.htm
10/27	9:00 – 14:00	Thu duc district, HCMC	Field visit of the University project(MEKARN/Sida), farms with the model "food residues from humans for pig - biogas system" and smallholder farm	
10/27	18:00	HCMC	Meeting with Dr. Man and Dr. Khang from the MEKARN project	Duong Nguyen Khang Director MERKAN project Phone: 84 989 390179 Nong Lam University, Linh Trung ward, Thu Duc district, Ho Chi Minh City duongnguyenkhang@gmail.com http://www.mekarn.org/index.htm

10/28	9:00 – 10:30	HCMC	ENERTAM Rice gasification project	Mr. Le Hoang Viet ENERTEAM (VNN) [enerteam@hcm.vnn.vn]
10/28 10/29	18:55 – 7:45	HCMC/Rome	Flight to Rome	