Food and Agriculture Organization of the United Nations

Small-Scale Bioenergy Initiatives in ASEAN +3

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Food and Agriculture Organization of the United Nations
Regional Office for Asia and the Pacific
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Foreword

As the price of fossil fuels continues to rise and resources become increasingly scarce, the need for more environmentally sustainable energy sources continues to grow. Continued research and development into alternative renewable energy technologies – particularly in bioenergy – has seen the number of small-scale projects increase substantially.

This expansion is both a challenge and an opportunity for countries and regions considering bioenergy development. On the one hand, bioenergy production utilizes many of the same resources, both natural and human, that currently support food production systems. Competition for resources such as land, water and labour could lead to increased prices in food, putting more pressure on those closest to the poverty line. Large-scale expansion could also lead to disparities in feedstock production and quality, for both food and bioenergy utilization. Additionally, climate change could place added strain on the existing natural resource base, affecting both food and bioenergy systems.

However, some bioenergy technologies and projects have been able to promote economic development in rural areas without negatively affecting food security. These projects not only improve livelihoods, but can enhance energy security and promote better health and nutrition. In addition, the by-products of bioenergy production (such as bioslurry and biochar) can help reduce reliance on costly chemical inputs and improve soil biomass production.

The FAO Regional Office for Asia and the Pacific is committed to helping the region identify and strengthen efforts to balance the trade-offs associated with bioenergy development. To this effect, FAO has worked closely with Practical Action Consulting (PAC) to commission a follow-up study on Small Scale Bioenergy Initiatives in ASEAN +3. This report re-examines cases initially identified in a joint FAO/DFID PISCES publication from 2008, as well as identifying a number of new cases in the ASEAN +3 region. The analysis highlights not only the successful elements of each initiative, but also identifies barriers and bottlenecks in each part of the market system and recommends interventions to address these barriers and allow sustainable bioenergy initiatives to be scaled up and replicated throughout the ASEAN +3 region. The report examines the sustainable market development, value chains, livelihood benefits and food security issues to identify what has made them successful or unsuccessful. The aim is to use this knowledge to better support bioenergy market systems and bioenergy development throughout the ASEAN +3 region in order to enhance food and energy security, rural development and the environment.

Hiroyuki Konuma
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Contents

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Practical Action Consulting (PAC) is the consulting arm of the international NGO, Practical Action. For over 40 years, Practical Action has been using technology to challenge poverty, and empowering poor communities to build sustainable, practical solutions to work their own way out of poverty. PAC takes the lessons learned from the work of Practical Action and pushes them out over a broader geographic horizon to enhance development outcomes, scale up impact and inform policy. PAC provides quality, efficient and effective consulting services by combining international experts with local and regional specialists, delivering projects through our regional offices across Africa, Asia, Latin America and in the UK.

Abbreviations and Acronyms

AM	Alliance Manufacturer
AMS	ASEAN Member States
ASEAN	Association of Southeast Nations
ASEAN +3	ASEAN Plus Three (China, Japan and South Korea)
BAAC	Bank for Agriculture and Agricultural Cooperatives
BAT	British American Tobacco
BEFS	Bioenergy and Food Security
BIRU	Indonesia Domestic Biogas Programme
CCRD	Centre for Rural Communities Research and Development
CPO	Construction Partner Organization
DA	Department of Agriculture
DBP	Development Bank of the Philippines
DENR	Department of Environment and Natural Resources
DFID	Department for International Development
DGNREEC	Directorate General of New Renewable Energy and Energy Conservation
DOE	Department of Energy
EAC	Electrical Authority of Cambodia
EASE	Enabling Access to Sustainable Energy
EDC	Electric du Cambodge
EnDev	Energising Development
ERDI	Energy Research and Development Institute
EPPO	Energy Policy and Planning Office
ETC	Organization for Educational Training Consultants
ETE	Energy Technology for Environment Research Center
FAO	Food and Agriculture Organization of the United Nations

FIT	Feed-In Tariff
FPIC	Free Prior and Informed Consent
GBEP	Global Bioenergy Partnership
GTZ	German Technical Cooperation
HIVOS	Humanist Institute for Cooperation with Developing Countries
HFO	Heavy Fuel Oil
HKM	*Hutan Kemasyarakatan* (Community Forests)
IDR	Indonesian rupiah (unit of currency)
INGO	International Non-Governmental Organization
KASAMA	Kalibo Save the Mangoes
KHR	Cambodian Riel (unit of currency)
kWe	Kilowatt (electrical)
kWh	Kilowatt-hour
LPG	Liquefied Petroleum Gas
LPO	Lending Partner Organization
LSRM	La Suerte Rice Mill
Mtoe	Million Tonnes of Oil Equivalent
MAFF	Ministry of Agriculture, Forestry and Fisheries
MARD	Ministry of Agriculture and Rural Development
MEF	Ministry of Economy and Finance
MEMR	Ministry of Energy and Mineral Resources
MFI	Micro Finance Institutions
MIME	Ministry of Industry, Mines and Energy
MOIT	Ministry of Industry and Trade
NSDP	National Strategic Development Plan
PAC	Practical Action Consulting
PHP	Philippines Peso (unit of currency)

PISCES	Policy Innovation Systems for Clean Energy Security
PKS	Palm Kernel Shell
PPO	Pure Plant Oil
PRSP	Poverty Reduction Strategy Paper
RE	Rural Electricity
REE	Rural Electricity Enterprises
REEEP	Renewable Energy and Energy Efficiency Partnership
RMB	Chinese Renminbi Yuan (unit of currency)
SMEs	Small and Medium Enterprises
SNV	Netherlands Development Organisation
SODECO	Solidarity and Community Development
SREP	Scaling Up Renewable Energy Program
SRI	The System of Rice Intensification
STC	Sustainable Trade and Consulting
UNIDO	United Nations Industrial Development Organization
US$	United States Dollar (unit of currency)
VACVINA	National Association of Vietnamese Gardeners
VBA	Viet Nam Biogas Association
VND	Vietnamese Dong (unit of currency)

Executive Summary

Small-scale market-based bioenergy initiatives can deliver significant socioeconomic development benefits for rural communities in the ASEAN region, and the rest of the world, by stimulating local livelihoods and providing communities with access to improved energy services.

During 2008, Practical Action Consulting (PAC) collaborated with DFID and FAO under the PISCES Bioenergy Research Programme to analyse a series of 15 small-scale bioenergy initiatives from Latin America, Africa and Asia (including two cases from Southeast Asia). These initiatives highlighted innovative technologies, approaches and models in the use of a range of bioenergy resources and their applications. This new study revisited the two Southeast Asian case studies that had been analysed in the original study and has developed an analytical framework to examine eight new cases from the ASEAN +3 region.

Table 1: The eight new case studies chosen for this report

Country	Initiative title
Thailand	Chicken farm biogas
Cambodia	Jatropha electrification
	Rice husk electrification
Indonesia	Household biogas
	Biomass for processing tobacco
Philippines	Briquettes from mangroves
	Rice hull electrification
China	Household biogas

The aim was not only to highlight the successful elements of each initiative, but also to identify barriers and bottlenecks in each part of the market system and to recommend interventions to address these barriers and allow the sustainable bioenergy initiatives to be scaled up and replicated throughout the ASEAN +3 regions. To do this, an analytical framework was developed. It included an analysis of the sustainable market development, livelihood benefits and food security.

Bioenergy initiatives can include very different types of value chains. The market map includes three levels of analysis: i) the bioenergy market chain, ii) inputs, services and finance, and iii) the enabling environment factors. By reviewing all the components of a bioenergy market system, it is possible to understand what makes them successful or unsuccessful and to use this knowledge to better support other bioenergy market systems.

The selected projects present a diverse range of project initiators, from government-led programmes to private initiatives. These projects show that their success can be achieved through commercial, quasi-commercial and non-commercial business models. The project beneficiaries are the actors at different stages of the bioenergy value chain. The main barriers identified in these projects at the market chain level are:

- Cost. This remains a significant barrier at all levels of the bio-energy value chain.

- Lack of technical capacity. This is another key component of the bioenergy value chain system. At the market level it refers to the technical ability of different actors and to their capacity to use technologies and understand the businesses they are dealing with. The initiatives show that design, quality of manufacturing and materials are extremely important, and that these often represent a barrier for local entrepreneurs or households producing or using bioenergy.

- Lack of market development activities. The case studies clearly indicate that there is a need for market development for bioenergy in the region. Feedstock markets, technology and energy appliances markets are not yet connected in those countries in a way that enables small-scale bioenergy to be fully and sustainably used.

In order for the bioenergy market chain actors to carry out their functions, they need to access a variety of supporting inputs, services and finance (included in Level 3, below the market chain level on the market map).

Most of the selected projects had initial in-kind technical support from NGOs or national research institutions. Project actors were also able to access finance, lack of which is usually a significant barrier for small-scale bioenergy initiatives. Lack of adequate infrastructure, irrigation systems and roads have also been identified as another major barrier to implementation. Finally, awareness-raising campaigns at different stages of the supply chain would increase knowledge for producers, processers and users of bioenergy and for the providers of the technical and financial support they need.

Most of the barriers at the market chain and supporting services levels are in some way linked to the enabling environment. Looking at the ASEAN +3 region, it is possible to find some general trends towards new and sustainable energy supply; however, not enough awareness and interest is occurring around small-scale bioenergy. In fact, policies are designed to target larger scale bioenergy investments. This trend influences regulations, tax reduction, duty exemption and financing schemes. Regulations and standards should be based on evidence from the ground, as with the case studies presented in this report. The global situation can offer new opportunities to the governments of these countries to align their poverty reduction strategy papers (PRSPs) with sustainable and decentralised energy production by adopting bioenergy. Important synergies should happen between the agriculture and energy sectors and government, private and academia, both at national and local levels.

The third stage of the assessment framework was to identify the potential livelihood outcomes of each bioenergy initiative and their socio-economic and environmental sustainability. This was carried out through an adaptation of the Global Bioenergy Partnership Sustainability (GBEP) Indicators and Bioenergy and Food Security (BEFS) indicators as follows:

- For all the selected initiatives, no significant impact on land use or land use change was reported. A common problem in ASEAN +3 countries is an inadequate legal framework around land occupancy and ownership. While no conflicts were reported for the bioenergy initiatives considered in this report, assessment and due process did not seem to have been followed in setting up most of the selected bioenergy projects.

- The bioenergy projects reviewed in this report have not competed with agricultural land or resources and so have not had any direct influence on food price during the course of their operation.

- The bioenergy sector has the potential to provide employment and incomes for rural communities; in this respect the selected projects had a positive impact on incomes and cost savings for the communities involved. The bioenergy projects led to job creation in the local communities, and beyond the immediate beneficiaries of the bioenergy projects, access to energy has enabled the diversification of labour and income for local populations.

- Affordable universal energy access is of fundamental importance to sustainable development and it is important to measure the growth of access and also the modern energy services provided through bioenergy. The bioenergy projects improved the convenience, quality and cost of energy for the end users and brought additional benefits such as job creation and diversification of incomes, and improvements in the environment.

- As individual projects, these are too small to have a direct impact on food security at national level. It is possible nevertheless to track some trends and to determine whether the scaling up of these initiatives and their replication could eventually positively or negatively affect food security in the country. Access to food is positively increased in most of the cases studies, as most of the initiatives have led to an improvement in incomes. The analysis draws on the results from the BEFS Operator Level Tool and the analysis carried out by the local experts visiting and studying the projects. Among the four main dimensions of food security (availability, access, utilization and stability), this report focuses on the first two – food availability and access – as they are the most relevant to the kind of initiatives reviewed for this study. The cases studied show that bioenergy can contribute to increased food security by improving food availability (i.e. through increased productivity) and by increasing job opportunities, resulting in higher income through better energy services.

In conclusion, the study shows that small-scale bioenergy initiatives can have very positive impacts on rural livelihoods. The review of these case studies allowed the identification of some of the major barriers faced by bioenergy initiatives and provides recommendations of ways to address them. The successes of the initiatives – but also the barriers they are facing in scaling up – are useful indicators of how to develop an enabling environment which can facilitate the development of small-scale bioenergy initiatives. The development and use of an analytical framework which integrates a number of tools (e.g. BEFS, PMSD) has enabled the development of a number of specific recommendations for concrete interventions for each specific initiative, alongside general recommendations for small-scale bioenergy initiatives in the region and the rest of the world.

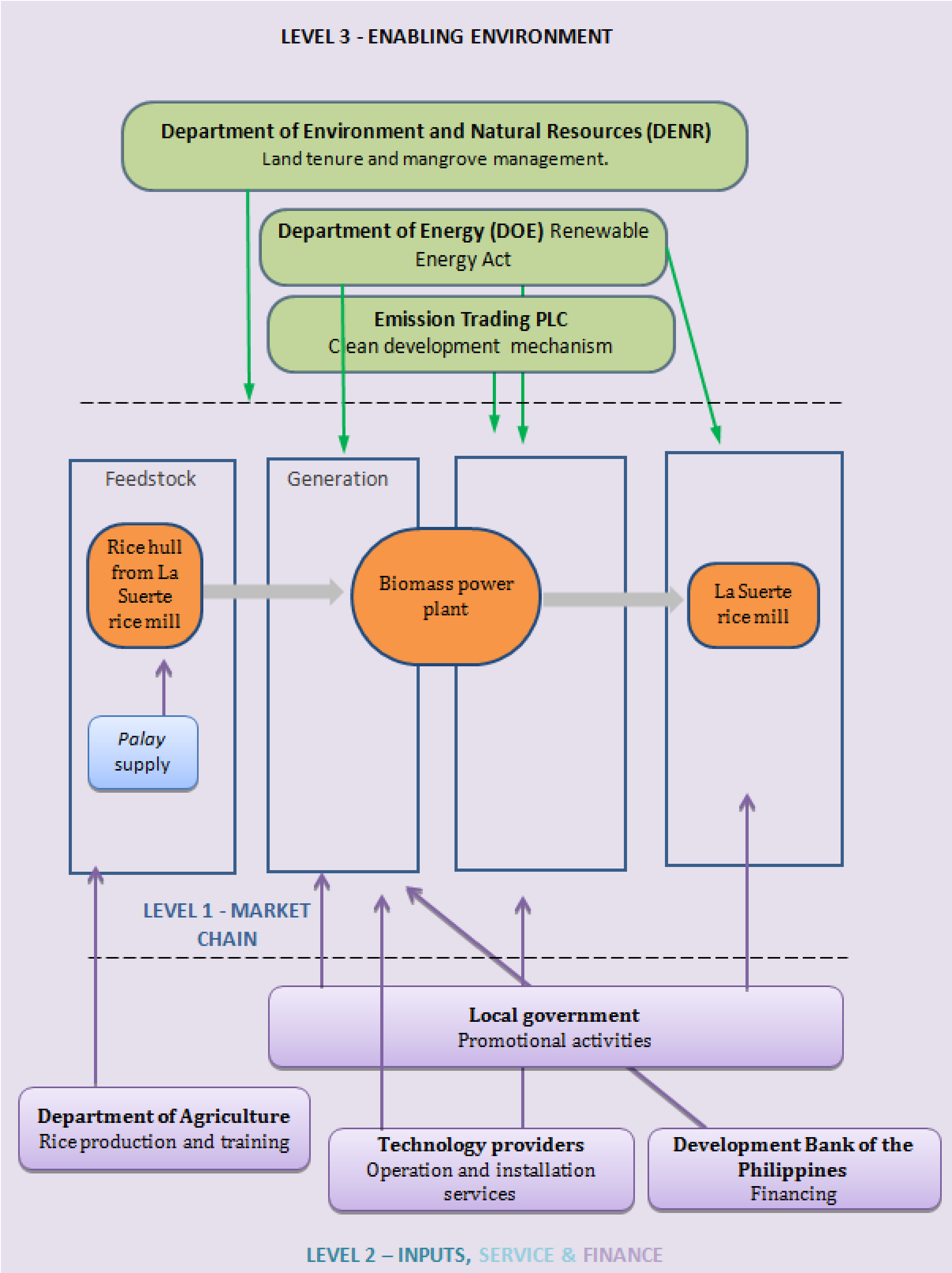

Figure 1: Initiative market map

1 Introduction

Developing markets and creating new knowledge for sustainable bioenergy

Small-scale market-based bioenergy initiatives can deliver significant socioeconomic development benefits both for rural communities in the ASEAN +3 region and the rest of the world by stimulating local livelihoods and providing communities with access to improved energy services. However, despite their promise, these initiatives are often constrained by market barriers, including low levels of capacity, lack of access to supporting services and unsupportive policies. Continued action-oriented research is required to understand how to overcome these constraints and scale-up and replicate successful small-scale bioenergy initiatives.

In 2008, Practical Action Consulting (PAC) collaborated with the United Kingdom's Department of International Development (DFID) and the Food and Agriculture Organization (FAO) under the PISCES Bioenergy Research Programme, to analyse a series of 15 small-scale bioenergy initiatives from Latin America, Africa and Asia, including two cases from Southeast Asia. These initiatives highlighted innovative technologies, approaches and models in the use of a range of bioenergy resources and their applications, constituting an excellent body of knowledge and learning to try and more clearly understand their success factors and barriers to scale, as summarised below.

1.1 Lessons from the original FAO small-scale bioenergy initiative study

The original study included a cross-section of bioenergy types (biomass, bio-resources and biofuels), end uses (cooking, production, mobility and electrical appliances) and end users (households, enterprises and community facilities). It also considered the full impact of bioenergy systems on rural livelihoods, applying the following methodologies to each case:

- mapping the market systems and specific value chains of the initiatives;
- developing a Relationships, Rights, Responsibilities and Revenues (4Rs) framework to analyse the balance between all the involved actors;
- analysing livelihood outcomes to identify the financial, social, physical, natural and human capital enhanced by the initiatives;
- drawing conclusions on the impact of the overall initiative on rural livelihoods and lessons learned for scaling and replicating.

The study identified a number of key lessons relating to small-scale bioenergy as a means for sustainable socio-economic development as folows:

i. Small-scale bioenergy initiatives allow the efficient use of natural resources

Small-scale initiatives which incorporate locally appropriate technologies, knowledge and practices offer high levels of resource efficiency; the case studies all emphasised the benefits of closed loops of resource production, processing and application including the re-use and recycling of waste products into economically valuable products.

Local staple food security did not seem to be affected, except in the case of biofuel production, where significant scaling-up plans were proposed on agriculturally productive land.

ii. **Local and productive energy end-uses develop virtuous circles**

A "local markets first" strategy produced clear benefits by providing communities with access to improved energy services, avoiding expenditures on fossil fuels or depletion of local natural resources and enabling general benefits for livelihoods. In cases where the cost of fossil energy was competitive with that of bioenergy, the partial insulation of the market chain served to encourage the emerging technology and had beneficial long term effects. These and other longer term goals (such as avoiding leakage of biofuel toward richer markets) can be supported through careful planning and regulation.

iii. **Flexibility and diversity can also reduce producer risk**

The diversification of activities for single crop farmers to start producing biocrops or carrying out forest management can bring positive livelihoods impacts. These can include benefits for local communities such as the creation of jobs and building of capacity, as well as the increase of social capital due to the formation of groups, cooperatives and rural market systems. These benefits can often offset the associated risks and initial high capital cost investments that are required

iv. **Initial market chain collaboration in key to success**

Collaboration between actors in the market chain seemed pivotal during the start-up phase of many initiatives. In addition, market chains with greater numbers of processes, linkages and by-products spread livelihoods benefits more widely within rural communities, as long as they were not overly complex and financially burdensome. Small-scale bioenergy initiatives can offer a range of benefits for remote rural communities.

1.2 Aim of this follow-up study

This new study revisited the two Southeast Asian case studies analysed in the original study to understand what has changed. In addition, this study has developed an analytical framework to examine eight new cases from the ASEAN +3 region, to identify not only the key aspects of each initiative but also the specific barriers at each part of the market system of the initiative and to suggest interventions for overcoming these barriers to allow the sustainable bioenergy initiatives to be scaled up and replicated throughout the ASEAN +3 region. This analytical framework includes an analysis of the sustainable market development, livelihood benefits and food security.

This new approach provides policy-makers and private stakeholders with tangible, focused recommendations to sustainably scale up small-scale bioenergy in ASEAN +3 countries.

2 Small-scale bioenergy initiatives in ASEAN +3

2.1 The ASEAN +3 context

Energy demand in ASEAN +3 is expected to nearly double from 513 million tonnes of oil equivalent (Mtoe) in 2007 to 903 Mtoe in 2030. Based on expected energy demand, CO_2 emissions are also expected to double from just over 1 000 million tonnes to 1 990 tonnes over the same time period. At present, ASEAN +3 member states are highly dependent on imports of fossil fuels (such as oil and coal) to meet their energy demands. Energy access is an ongoing problem in Southeast Asia, particularly in rural areas. It is estimated that in 2008 almost 200 million people in Southeast Asia did not have access to electricity, 137 million of whom are located in rural areas. The use of traditional biomass energy (such as fuel wood and charcoal) is still common in many parts of the region.

Many ASEAN member states have implemented policies to encourage development of green renewable energy (including bioenergy) to offset these trends. Some countries have also adopted policies to encourage decentralized renewable energy systems in rural and remote communities. As a result, a range of bioenergy systems has been piloted and utilized in communities across the ASEAN +3 countries. For example, biomass gasification and biogas systems are utilising waste from crop production and livestock for energy. The success of some of these systems is helping to improve access to energy and reduce dependence on traditional biomass energy, thus reducing deforestation and minimising the health risks frequently incurred from the burning of these fuels.

Harnessing more effective and efficient energy in rural communities is particularly important for improving the productivity of rural enterprises. Small and medium enterprises (SMEs) are important contributors to economic development, accounting for more than 96 percent of all enterprises in the ASEAN +3 region; they are the largest source of domestic employment across all sectors in both rural and urban areas and contribute between 30-53 percent of GDP in Asian member states. Despite the large contribution of agriculture to GDP in Asian member states, agro-based SMEs are still the smallest SME subset in ASEAN +3. Most are classified as microenterprises with less than US$5 000 in assets, and their development is being hampered by poor access to energy. However, there is growing evidence of demand for improved energy services from these SMEs. In the last decade there has been a 14 percent decline in the use of wood for fuel, while the use of charcoal increased by 27 percent in the region. This increase shows signs of emerging demand for efficient and value added bioenergy.

As shown in Figure 1 below, there are some significant differences in terms of access to energy within the ASEAN +3 region. Cambodia has the lowest level of access, with less than 20 percent of the rural population having access to electricity, against almost 100 percent of rural Thailand. Access to modern cooking fuels is major issue for most of the region: the worst situation is in Cambodia, where almost 90 percent of the population relies on solid fuels. In Thailand, the country with the highest access to modern fuel among the targeted study countries, about 13 million people still cook using traditional fuels and stoves. In China, about 600 million people are still cooking with solid fuels. Finally, these figures show a clear, unexploited potential for electricity generation using renewable energy, with the Philippines providing the best example, despite only about 20 percent of its electricity being produced through renewable energy sources.

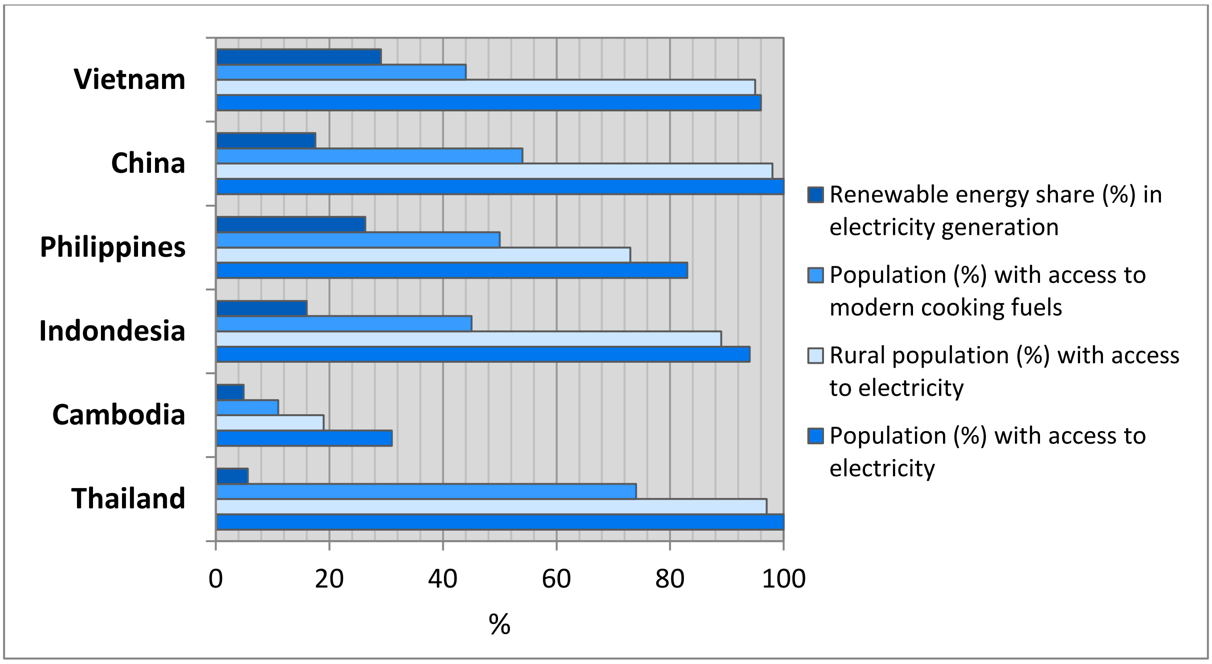

Figure 2: Access to energy in six ASEAN +3 countries. Data taken from *Global Framework Report* (World Bank, 2013)

The ASEAN energy outlook 2030 identifies bioenergy as a potential, sustainable energy source that could be tapped using cleaner and efficient technologies through North-South and South-South technology transfer. Opportunities for successful small-scale bioenergy technology transfer already exist between countries within the ASEAN region and between ASEAN +3 countries.

With FAO technical cooperation, Project TCP/RAS/3402, Bioenergy and Food Security (BEFS) in ASEAN, FAO and the ASEAN Secretariat want to verify that small-scale market-based bioenergy in ASEAN can improve energy access and efficiency, drive the development of successful rural and agro-based industries and mitigate negative environmental impacts associated with other traditional and fossil-based energy sources while having little to no impact on food security.

2.2 Lessons from small-scale bioenergy Initiatives in the ASEAN +3

This new study revisited the two Southeast Asian case studies analysed in the original study as well as examining eight new case studies from the region, using the following four key elements:

2.2.1 Updated evaluation framework

Building on the methodologies used in the original study, PAC and FAO developed an updated evaluation framework. This includes i) the entire market chain, from the costs and availability of the energy resources, through to ii) the processing equipment and energy appliances, as well as iii) an assessment of the labour requirements, technology purchase and maintenance and iv) value of the end products, both in the short-term and over the long-term.

This expanded evaluation framework places particular attention on a) the potential of small-scale bioenergy initiatives to be replicated and b) the potential role of agro-SMEs in driving demand for energy services and facilitating bioenergy systems development and technology transfer.

The framework also aims to assess how best to harness small-scale bioenergy systems for productive use by communities and agro-based SMEs.

It is hoped that this updated evaluation framework will enable policy-makers and project developers to help scale up and replicate the eight analysed case studies, as well as to identify and analyse additional sustainable, small-scale bioenergy systems with strong potential for replication and/or scale-up within the region in the future.

2.2.2 Revisited case studies from Southeast Asia

Once the updated framework had been developed, PAC and FAO revisited the two case studies in the ASEAN region to carry out an updated and expanded follow-up analysis, to identify and compare the critical success factors and challenges in their growth and development. This follow up analysis allowed a detailed understanding of how these cases have performed since the first evaluation, including the reasons behind any difference in outcomes, which will be of extreme relevance for supporting the future scaling up of the other small-scale bioenergy initiatives analysed.

2.2.3 Identification of new bioenergy case studies in Southeast Asia

The expanded framework was then applied to eight new case studies of small-scale bioenergy initiatives in the ASEAN +3 region. The initiatives were chosen based on a set of indicators, including examples of small-scale bioenergy technology transfer and small-scale bioenergy leading to agro-based SME development.

The new case study analysis also looked at the availability of financial services for all the market actors within the initiative, as well as any political regulations that affected the success or failure of the initiatives. The assessment allowed the identification of incentives and constraints faced by farmers/rural people outside the initiative (local, national and other country) to adopt the improved bioenergy technologies and practices within each of the initiatives.

2.2.4 Making the case for small-scale bioenergy in ASEAN +3

Following the case study analysis, a strategy was developed to share the lessons learned with policy-makers, communities and private sector actors. This analysis has provided a vital new source of evidence regarding the potential of small-scale bioenergy initiatives to meet the energy needs of rural communities in the ASEAN +3 region, as well as providing a range of other benefits including increased resilience (through increased energy security and crop diversification) and livelihood benefits. The analysis of these small-scale bioenergy initiatives in AMS provides a new source of information for other countries interested in understanding the benefits of bioenergy usage at the local level, as well as the barriers and opportunities that need to be identified and overcome to ensure their success within each country context, through their tailored design and implementation.

3 Analytical framework

3.1 Study methodology

This evaluation framework has been developed to better understand the challenges surrounding the development of small-scale bioenergy market systems in Southeast Asia, to identify how they can increase energy access for marginalised, poor or vulnerable people in this region, as well as their associated livelihood benefits. In addition, the framework helps identify the barriers that limit their development and appropriate interventions that could then be implemented to overcome these barriers so they can be scaled up and replicated in other regions and countries.

The development of this framework is a follow-up of a joint FAO/PISCES study published in 2008 which identified and assessed 15 small-scale bioenergy initiatives from Asia, Latin America and Africa. The first study focused carrying out the market mapping of the 15 initiatives and the market analysis of the relevant relationships, rights, responsibilities and revenues. The analysis went on to identify the potential livelihood benefits of each initiative and the human, social, physical, financial and natural capitals of each one. This follow-up assessment builds on this work, developing a more focused and specific framework to fully outline the bioenergy market systems surrounding each case study, and to identify the barriers and opportunities that can be overcome to improve the initiative and understand how to scale it up.

The BEFS programme supports countries to design and implement evidence-based policies for sustainable bioenergy development, taking into account food security issues. By using ground-based evidence (like the data collected for this study) BEFS can help decision makers in tailoring policies for the promotion of sustainable bioenergy with little to no impact on food security. In several of the ASEAN +3 countries, specifically Cambodia, China, Indonesia, Philippines, and Thailand, a number of potentially suitable small-scale bioenergy initiatives were identified to showcase evidence of small-scale bioenergy sustainability in the region.

National researchers were employed in each of the countries to carry out the analysis. Preliminary market mapping of each of the case studies was carried out, as well as the identification of the potential livelihood outcomes, such as level of employment creation, increase in energy access and reduction in energy prices.

The consultants were then brought together in Bangkok, Thailand, to be trained in how to carry out more detailed market system mapping and analysis, including an in-depth analysis of the original Viet Nam biogas case study which was revisited. More detailed market mapping was then carried out for each of the case studies, as well as the identification of a range of market barriers within each initiative and potential interventions that can be carried out to overcome the barriers and help the markets grow. The work followed the steps highlighted in Figure 3, below.

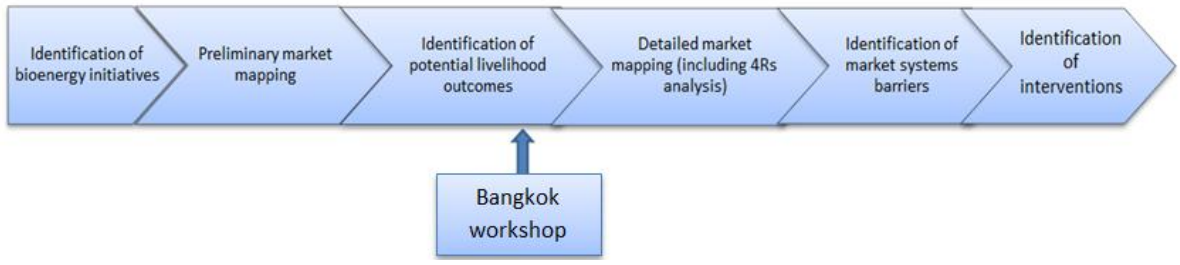

Figure 3: Main steps of the follow-up to FAO bioenergy initiatives study (2013-14)

Once these case studies were assessed (including market mapping, identification of specific market system barriers and potential supporting interventions), a set of recommendations was developed indicating how each bioenergy initiative can overcome the main market barriers. These help identify trigger points to allow them to be scaled up and replicated within each of the focus countries and the region more generally.

To take these recommendations to the next stage and to ensure that they can be acted upon, it is envisaged that a programme of policy support will be required. This will include a programme of activities to ensure that the interventions identified can be delivered to allow the identified initiatives to be scaled up and replicated (as shown in Figure 4).

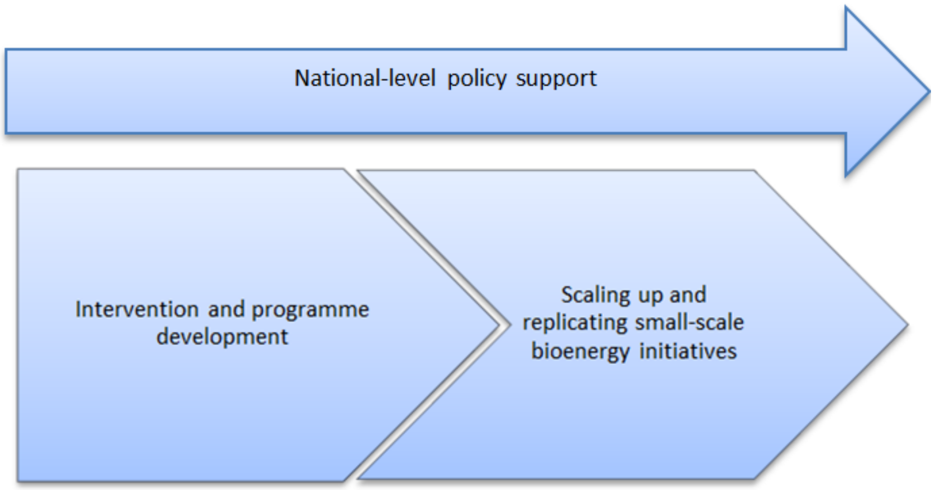

Figure 4: Outline of national-level policy support required to ensure real impact

3.2 Bioenergy evaluation framework assessment

Once a particular bioenergy resource has been identified as being of value from a range of perspectives and is being actively exploited by an organisation or group of organisations, it is useful to assess it within the context of an overall market system using a standardised framework, as outlined in the following section. This is to understand how the resource is being generated, processed, distributed and delivered to the end users, including all the organizations involved in the process. It also includes any other organization involved in support roles, or that provide the overall enabling environment for the resource, particularly the policy-makers in the particular country. This helps stakeholders understand how the entire system that surrounds a particular bioenergy resource operates as well as the issues that affect its efficient and sustainable delivery to a range of end users.

Bioenergy market systems are typically quite complex, often having a range of public and private sector actors who are constantly exchanging goods, services and information to produce and consume a set of bioenergy-related products. To deliver the best products and services often requires them to collaborate and compete, as well as to coordinate their efforts and devise strategies and learning in many different ways. Bioenergy initiatives thus tend to have very complex dynamics, from the project initiators to the range of market actors involved, as well as in terms of the range of final beneficiaries of the bioenergy products and services. The focus of this study is on bioenergy market systems and their impact on rural livelihoods.

Due the diversity and complexity of any bioenergy market (and the varying availability of data), it is often not easy to fully understand how it operates. This is where an evaluation framework can help, through the provision of a systematic set of processes to analyse the way each bioenergy market operates and what makes it either thrive or fail. Such an evaluation framework requires the systematic mapping of each bioenergy market system to visualise how each actor interacts with each other on each level of the system, as well as to identify the blockages and opportunities within the market and then developing specific interventions that can help overcome these issues.

This evaluation framework provides a systematic approach to categorising each bioenergy market, and a set of processes to analyse how each market operates and what makes each of them either thrive or fail. It follows five distinct stages:

Stage 1: Identification of bioenergy initiatives

The first step was the identification of a range of potential bioenergy initiatives in each of the target countries. These were initiatives which deliver a range of energy services through the efficient and sustainable use of bioenergy resources, and which ideally resonate rather than conflict with local food production. In addition, these initiatives should ideally support local livelihoods.

Stage 2: Market mapping

The second stage was to carry out an initial market mapping of each bioenergy market system focusing on these three main levels; the bioenergy market chain level, the enabling environment level and the supporting inputs and services level. This stage helped identify all the involved actors, as well as the role (or roles) they play and how they interact with each other to help deliver a range of products to particular end users. Following the workshop in Thailand, more detailed market mapping analyses were carried out, building on the first stage and examining the relationships between each of the stakeholders in each of the three levels of the bioenergy market system. These exercises helped to understand how efficiently the systems were operating and where the potential issues were occurring.

Stage 3: Identification of sustainable livelihood outcomes

Based on the range of actors identified in the market mapping, the analysis assessed the relationships, rights, responsibilities and revenues of the key actors in the market system. Following this, an analysis of the potential livelihood outcomes of each of the identified bioenergy initiatives was carried out, assessing the environment, social and economic sustainability and livelihoods impact of the initiatives.

This analysis was based on a selection of GBEP indicators[1], and can be used for future analysis of small-scale bioenergy initiatives. To support an initial assessment of potential food security impact of these initiatives, the BEFS Operator Tool[2] was used.

Stage 4: Identification of bioenergy market system barriers, drivers and potential opportunities

Once the mapping had been completed, the fourth stage was to identify all of the blockages within the market system as well as potential opportunities that exist within each of the identified bioenergy market systems, within each of the three levels, to help understand whether the system is functioning effectively or if it is dysfunctional, and the reasons behind this.

Stage 5: Identification and analysis of potential supporting interventions

The last stage was the development of the potential supporting interventions that can be implemented to try and overcome the issues identified within each bioenergy market system, as well as their categorisation and prioritisation. This helps identify the activities that a future support programme should focus on to try and improve the effectiveness of each bioenergy initiative analysed, in particular how each initiative can be scaled up and replicated. This stage allowed the identification of a number of recommendations for policy-makers in each of the focus countries of the study; it is hoped these will be taken forward by a range of stakeholders in the future. This stage will not allow all the barriers to be overcome or potential opportunities to be exploited but it can help identify those interventions that are likely to be critical in helping transform each of the identified bioenergy market systems.

The next chapter summarizes the ten case studies and presents a comparison and analysis of each, using the analytical framework which has been developed for this project. Full reports of the case studies with more specific analysis can be found in the annex.

[1] *The Global Bioenergy Partnership Sustainability Indicators for Bioenergy* was developed by GBEP Partners and Observers through the GBEP Task Force on Sustainability, which had been working since 2008. The report presents 24 voluntary sustainability indicators for bioenergy, intended to guide any analysis undertaken of bioenergy at the domestic level with a view to informing decision-making and facilitating the sustainable development of bioenergy (FAO/GBEP 2011).

[2] The BEFS Operator Tool is a web-based tool used to provide a preliminary indication of potential risks and benefits for food security from agricultural/bioenergy investments. The tool is meant to be used by national and local authorities to screen proposed investments, by development banks in the evaluation of investment proposals, and by investors as an ex-ante self-assessment tool. The indicators used in the tool address key environmental and socioeconomic dimensions relevant for food security (http://www.fao.org/energy/81543/en/).

4 Identification of ASEAN +3 bioenergy initiatives

The study revisited the two Southeast Asia-focused small-scale bioenergy initiatives which were included in the first assessment (the Viet Nam National Association of Viet Namese Gardeners (VACVINA) National Biogas Initiative and the Thailand Cooperative Pure Plant Oil Initiative). These visits were carried out as follow-up evaluations of their bioenergy market systems to understand what had changed since the first assessment, to identify the barriers that still remain and what supporting interventions could be developed to further improve, scale-up and replicate the two initiatives. In addition, a number of other small-scale bioenergy initiatives were selected from Cambodia, China, Indonesia, the Philippines and Thailand based on the following criteria:

- innovative use of bioenergy resources;
- apparent lack of complicity with food production;
- availability and access to relevant information;
- potential for replicability/scalability (with a specific focus on the financial/economic aspects which make them scalable);
- different types of feedstock (bio-resources, bio-residues and biofuels);
- cross-sectoral (led by public and private sectors, NGOs and hybrid);
- different types of beneficiaries;
- mix of bioenergy technologies;
- cross-section of end uses (including electricity, cooking/heat and mechanical power).

The ten bioenergy case studies are all on-going initiatives which make use of locally available bioenergy resources to provide a range of appropriate and sustainable bioenergy products and services to supply the local populations in each country, increasing livelihoods and incomes.

4.1 Overview of case studies

The aim of this study is to provide concrete recommendations to enable the replication and scaling up of a number of suitable small-scale bioenergy initiatives. Each of the case study reports presented in the annex includes a detailed analysis of the specific barriers, drivers and opportunities which enable or disable the initiatives from being even more successful or from reaching scale. The analysis is structured using the three different levels of the market map – the market chain, the enabling environment and supporting services – allowing a rapid identification of the type of barriers, opportunities and drivers of change. The expectation is that this will provide targeted advice to a range of responsible actors, from practitioners to potential investors and policy-makers, and includes clear targets for supporting each intervention. This section presents an overview of the ten case studies.

Case 1- Rural Electric Enterprise initiative using rice husk gasifier
Doun Sva village, Char Chouk commune, Angkor Chum district, Siem Reap province, Cambodia

In Cambodia, alleviating rural poverty through accelerating rural electrification is a priority for national government and the energy sector. Between 2002 and 2010 there was an increase of 310 percent in available energy (from 614.03 million kWh in 2002 to 2515.67 million kWh in 2010); however, only 26.4 percent of the total population (and 13.1 percent of the rural population) have access to electricity.


Figure 5: Gasifier reactor

A rural electrification fund has been set up by the government to promote a) equity in access to electricity supply services and b) private sector participation and investment. The rice husk gasifier project in the Char Chuk commune is an innovative project using 100 percent biomass as its energy source and is a private-public partnership, run by a private entity and supported by the government and development partners.

The plant gasifies locally-available rice husks to produce between 900 and 1200 kWh of electricity per day to supply the commune's population of 1 903 households. The number of businesses in the commune has increased, leading to additional employment opportunities and incomes. Food can be kept longer through refrigeration, meaning a greater supply of fresh produce is available and prices are lower.

While the impact of the initiative has generally been positive, concerns have been raised over air, noise and water pollution caused by the gasifier plant. In addition, it has been recognised that only weak policy and legal frameworks exist to support the sustainability of the initiative. There is also a lack of capacity to support its long-term planning and maintenance. Furthermore, Cambodia's national electricity company, Electric Du Cambodge (EDC) has monopolised its supply, buying the electricity directly from the plant and selling it at an inflated price to householders and businesses.

Case 2- Rural Electricity Enterprise initiative using *Jatropha curcas* biofuel
Trapeang Thma Kandal village, Paoy Char commune, Phnum Srok district, Banteay Meanchey, Cambodia


Figure 6: Extracted Jatropha oil and seeds

The Paoy Char commune has 2 437 households, out of which only 113 have access to electricity. Of the 2 437 households, 2 225 earn a living through agriculture (mainly rice cultivation), producing both long-term crops (such as rubber) and short-term crops (such as corn and peanuts). The Rural Electricity Enterprise initiative, which uses Jatropha seeds to produce biofuel, is appropriate to the commune as Jatropha trees are planted around household perimeters and help prevent erosion and the loss of land fertility. As they are not grown on land used for food crops, there is no conflict with food production; they can even enhance food production by reducing erosion and soil fertility loss. The seeds harvested by the householders are supplied to the Rural Electricity Enterprise to be used as feedstock for an electricity generator.

The owner of the Rural Electricity Enterprise started supplying electricity to the commune through a diesel-powered generator, but following technical support from GIZ and because of the increasing price of diesel, switched to using Jatropha oil as feedstock for the generator. Through the initiative, 600 households have benefited by selling Jatropha seeds and gaining access to electricity; 39 households have started businesses as a result of gaining access to electricity, and the Rural Electricity Enterprise has recruited four members of its staff from the commune.

The initiative has shown that through the investment and participation of the private sector and support of the government via the Rural Electrification Fund, the development and sustainable production of electricity in rural areas from sustainable bioenergy sources can be scaled up.

Case 3- Biogas development in rural areas
Xinlong village, Danling County, Sichuan province, China

Figure 7: Rural energy officer provides technical support at construction field site

Xinglong village in southwest Danling County has 721 households and a population of 2 508. The biogas development project in Xinglong was designed to facilitate a) energy recovery and b) environmental protection through waste treatment. The local economy is based on fruit plantations and livestock, the waste from which (rotten fruit and manure) is used as feedstock for 537 biodigesters producing an annual 210 000m³ of biogas for cooking fuel and bioslurry for fertiliser.

The rural energy office in Danling and the service network receive a subsidy from central and provincial governments to provide for the construction of biodigesters and procure biogas appliances for householders. Household farmers pay a membership fee to join the service network and receive training and maintenance service for the biodigesters.

Sixty two percent of the total domestic fuel used in the village is now biogas. Before the biogas initiative villagers used firewood, straw and coal as fuel which affected their health and resulted in CO^2 and SO^2 emissions which damaged the environment. As a result of using biogas rather than traditional fuel, heat efficiency has improved from 22.5 percent to 35.4 percent. A further benefit has been to householder income which has increased by an average of US$320 through energy saving and improved fruit yield.

Case 4- Biogas Rumah (BIRU) programme
Lampung, East Java, DIY, Central Java, West Java, Bali, West Nusa Tenggara and South Sulawesi province, Indonesia

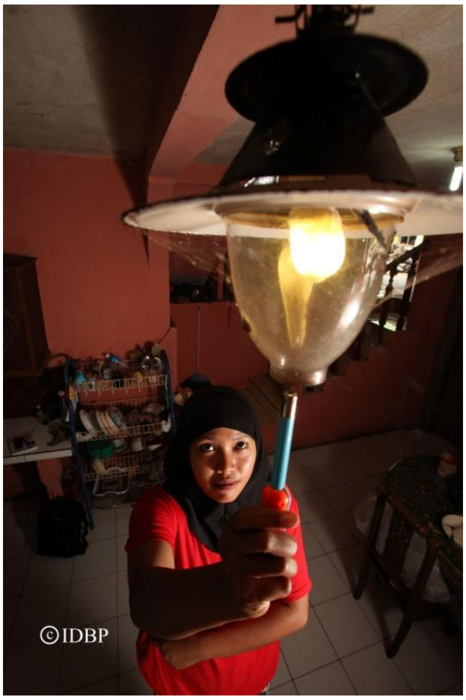

Figure 8: Using biogas for lighting
Source: HIVOS

After a decade of rising fossil fuel prices, utilising biogas technologies has become more appealing to the Indonesia government, particularly following a feasibility study carried out in 2008 to review the potential demand for biogas, as initiated by the BIRU programme in Lombok province. The government facilitated the programme and HIVOS were appointed programme managers, with SNV providing technical assistance. Funding for the programme came from the Dutch foundation Eigen Wieken; this subsidized about 30 percent of the farmers' cost of the biodigester systems. To pay the balance, the farmers borrowed funds through a microcredit system set up for the programme by the government and its lending partner organisations. Through the BIRU programme local masons and construction contractors were trained in the construction of biodigesters, and local manufacturers were engaged to produce the biogas appliances and parts.

So far the programme has installed a total of 9 700 biodigesters out of a planned 10 000. The programme has had a positive impact, sustainably supplying biogas to farming households and reducing their reliance on chemical fertiliser through the supply of bioslurry, a by-product of the biodigestion process. The householders save money and their living environment is healthier. The key reasons for the success of the programme are the awareness-raising of the programme among householders, and the subsidy, microfinance provision and training provided to farmers.

Case 5- Lombok Energy Initiative
Lombok, Nusa Tenggara Barat province, Indonesia

Figure 9: Kiln used for drying tobacco using palm kernel shells

The Lombok Energy Initiative was set up to develop a biomass energy source for tobacco kilns. This followed a study initiated by British American Tobacco (BAT) and Fauna and Flora Indonesia (FFI) which concluded that renewable biomass was the most sustainable energy source for drying tobacco on the island. The selected biomass resource plants were candlenut shell and castor bean trunk. However, these trees need a relatively long period (three to five years) to reach maturity, and in order to establish the sustainable biomass market system, 1 000 tonnes of PKS from Kalimatan and Sumatra islands were provided by STC Philippines to the tobacco farmers as an interim measure.

Funding for the initiative came from Agenstchaap in the Netherlands via the Global Sustainability Biomass Fund. FFI were responsible for training the farmers and providing them with candlenut and castor bean seed; the programme also facilitated the formation of 45 farmer groups (with 1 300 biomass farmers) in order to improve their livelihoods through agroforestry and intercropping, and to rehabilitation of the degraded watersheds.

Prior to the initiative, tobacco farmers used kerosene in their drying kilns. However, the removal of the government subsidy for kerosene in 2010 provided the push to search for an alternative energy source. With the cost of LPG prohibitively expensive, the tobacco farmers turned to biomass-based fuels, which resulted in damage to the hardwood forest areas. The move to sustainable biomass sources meant the tobacco farmers had to modify their furnaces and used credit obtained from BAT.

Case 6- Kalibo Save the Mangroves (KASAMA) briquetting
New Buswang, Aklan, Philippines

Figure 10: Briquette moulder

KASAMA is a cooperative made up of local families who are responsible for maintaining sustainable mangrove plantations in Aklan province. The KASAMA briquetting cooperative uses only branches which have already fallen from the mangrove trees, contributing a means of sustainable management to help preserve mangrove areas and providing KASAMA members with a year-long supply of wood for the production of charcoal briquettes.

A standard family household of five uses an average of 12 pieces of briquettes for cooking and heating water per day; the use of briquettes instead of LPG can save each household an average of PHP700 per month. In addition, selling the briquettes is a major source of income for KASAMA members, who can earn up to PHP2 000 per day through briquette sales.

The briquetting initiative has had a positive impact on the food supply, as the existence of the mangrove plantations has meant that fish and other sea foods have been seen to significantly increase. The mangrove plantations do not compete with crop production in terms of land use, and have improved the biodiversity of the area and encouraged wildlife. Marine life, such as fish, crabs and molluscs, can be harvested and sold for food, providing extra income for KASAMA members and fisherfolk. In addition, ecotourism has thrived in the area as the plantation has been transformed into an ecopark.

Case 7- La Suerte rice mill power plant, San Manuel, Isabela province, Philippines

Figure 11: La Suerte rice hull biomass power plant

Isabela province is a major producer of rice, contributing 14 percent of the country's rice production. The La Suerte rice mill and biomass power plant are privately owned by a rice milling family. Both the mill and plant use rice husk (a waste product of rice production) as feedstock for the biomass power plant. The province has only an intermittent power supply and the biomass plant thus provides a reliable power source for the mill; it also resolves the waste disposal problem. The sustained electricity supply enables the mill to process more rice, which increases the amount farmers can supply to the mill and therefore increases their income. The extended hours of operation means that processing can be carried out in the evening when the temperature and humidity are more conducive to the rice milling process.

Power costs can contribute up to 40 percent of the retail price of rice, and through the use of rice husk as fuel the power cost of the La Suerte mill has been reduced by over 50 percent. If a rice husk-based biomass power plant can be installed in every rice mill, power costs (and therefore the retail price of domestic rice) can be brought down and made more competitive than imported rice.

Case 8- Biogas from a laying hen farm
Gorkhoi village, Nongnam district, Lamphun, Thailand

In 2006, the owner of a laying hen farm Huaynamrin in Gorkhai village set up the biogas project using a loan of US$10 000 from the Bank for Agriculture and Agricultural Cooperatives. Following the initial success of the project, the farm owner took out a further loan of US$39 000 to expand the biogas plant. The second loan was supplemented by a US$16 000 subsidy from the Energy Policy and Planning Office.

Figure 12: Biodigester which uses chicken waste as feedstock

The farm is a medium-sized business with approximately 15 000 chickens. Biogas is produced and partially used at the plant; it is also delivered via pipeline to 77 of the 148 households in the village. The householders, who are predominantly farmers, have benefited in several ways from the project. Through use of biogas from the farm they have reduced their spending on LPG by US$10 per month. They also make use of the bio-slurry (a by-product of the biogas production process), as an organic fertiliser on their crops. The local environment has also improved considerably as the chicken manure is now no longer disposed of locally but is used as a feedstock for biogas production. The farm has benefited through reduced disease and pollution at the farm, and the lowered cost of the electricity generated from the biogas.

Case 9- Jatropha Cooperative
Viengsa district,Nan province, Northern Thailand (revisited in November 2013)

The Viengsa Cooperative Pure Plant Oil initiative was set up in 2006 by the University of Kasetsart, Thailand, working with the Cooperative League of Thailand. Using Jatropha as the biomass source, the initiative's aims were to provide biodiesel for electricity generation, farm machinery and local transport. The initial funding of US$100 000 came from the Cooperative Promotion Department, the Cooperative League of Thailand, the Nan Provincial Governor and the Viengsa Agricultural Cooperative. This was used to provide training to the farmers, and equipment for the Jatropha production. At the start of the initiative, 500 Viengsa cooperative farmer members participated in the training. The cooperative has 7 668 members, with 2 100 members currently participating in the initiative. As well as producing biodiesel from Jatropha seeds, the initiative also produces deodorised charcoal, organic fertiliser and glycerine. A practical learning centre has been set up by the University of Kasetsart, where members of the cooperative receive their training.

The Jatropha harvest of 4 400 to 5 600 kg per year was not enough for biodiesel production and so was supplemented with used cooking oil; this inadequate supply also meant that electricity generation was not pursued as initially planned.

Case 10- Development of the VACVINA biogas market
Thanh Hoa province, Viet Nam (revisited in November 2013

Viet Nam has pursued a land management scheme to make optimal use of available land through gardening, fish rearing and animal husbandry. The high population density in rural areas combined with increasing livestock production has led to health and environmental issues in these areas. The Centre for Rural Communities Research and Development (CCRD) initiated the work in 2006 using biodigesters to resolve the problem of waste from livestock management and provide a sustainable source of energy to households.

Supported by Enabling Access to Sustainable Energy programme funding from Educational Training Consultant (ETC) in the Netherlands, the scheme aimed to develop a market for biogas in the Thanh Hoa province. CCRD is responsible for VACVINA activities and has provided training and equipment to VACVINA branches. The VACVINA branches use locally available material for biodigester construction. Farmer households pay an installation cost to their local VACVINA branch.

The scheme initially produced 504 000 m3 of biogas for cooking and lighting for 560 households per year. By 2013 the number of VACVINA biogas system installations was 1 500. The amount of fuel produced daily adequately covers the energy needs of each household, removes polluting waste and improves the surrounding environment, and produces bio-slurry which is used to improve soil quality and food production.

5 Bioenergy market mapping

Although each bioenergy initiative tends to have a unique market chain, some form of generalisation is still possible. The bioenergy market system map includes three distinct levels; the bioenergy market chain in the centre in level 1, the supporting inputs, services and finance in level 2, and the overriding enabling environment factors above in level 3, as defined in Figure 13, below.

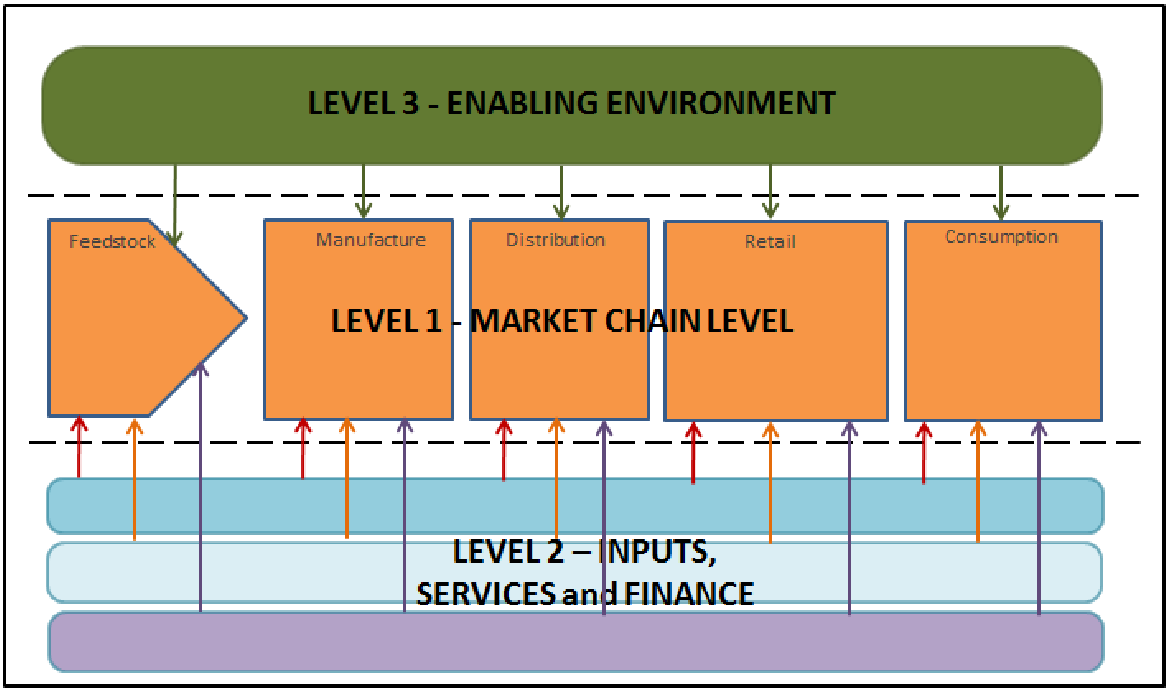

Figure 13: Simplified summary of a bioenergy market system, showing its three main levels (Note: under level 2, the blue box and red arrows refer to the required inputs, the light blue box and orange arrows refer to the required services, and the purple box and purple arrows refer to the required financial services).

Level 1: Bioenergy market system. This includes the set of networks or chains of actors that produce, distribute and retail bioenergy products, from primary production to end consumption.

Level 2: Inputs, services and finance. This includes the actors and organisations that support the market chain actors with a range of specific inputs, services and finance that they require to more effectively or efficiently deliver their products.

Level 3: Enabling environment. This includes the enabling environment factors that shape how all of the actors behave, but which can be addressed and changed. It is important to try and identify enabling environment barriers beyond their control.

Through understanding all the components of a bioenergy market system, including how the market actors are interconnected within the system and how they interact with each other to get the bioenergy products or related services from their primary production to the different end markets, it is possible to understand what makes them successful or unsuccessful and to use this knowledge to better support other bioenergy market systems.

5.1 The market chain

The market chain is the backbone of any market system. In terms of a bioenergy initiative, it describes the channels through which the bioenergy products or appliances move, from the primary generators or producers to the final end-use consumers, passing through each actor who has a legal title over the bioenergy resources, products or related appliances. It is important to note that market chain actors are the organisations or individuals who, at any one time, own the bioenergy products.

In Figure 13, the market chain is shown in the middle, as the central level of the system, and contains all of the bioenergy market chain actors. These can be broadly subdivided into five functions:

- Function 1: bioenergy resource
- Function 2: bioenergy production or manufacturing
- Function 3: bioenergy packaging and distribution
- Function 4: bioenergy retail
- Function 5: bioenergy end-use consumption

These broad functions are delivered by a range of market chain actors, who need to be identified and mapped out. They are the organisations, groups or individuals who shape the market chain with their activities and usually derive their incomes from it.

Each market chain actor transforms the bioenergy products in some way along the chain, even if this transformation is not always fundamental. Some actors completely transform a product (such as Jatropha seeds into pure plant oil) whereas others may just transport or market the products, adding value in a non-physical way. This means that the product at one point in the market chain is almost always different in some way from how it was at previous points in the market chain.

Some functions are delivered by a number of actors (such as the fairly large numbers of biogas system producers in Viet Nam, who all produce very similar versions of the same design) while some actors deliver more than one of the functions, such as the Viengsa Agricultural Cooperative in Thailand which grows the pure plant oil feedstock then processes it and uses it within a micropower plant to produce electricity for local use by households.

When mapping out the market chain it is important to include all the actors involved and the roles that each plays within these five functions, as well as the numbers of different channels of flow of the products, to allow conclusions to be made about how inclusive, productive and efficient the market system is.

Once all the actors have been identified it is important to assess the structure of the market chain (including its length, the competing actors and the different channels that occur) as well as the value addition of the products as they are passed along the chain (including how each actor adds value) and the value distribution along the market (this includes assessing where greatest value is added, the profit margins, trade volumes and total revenue streams of each actor, as well as the business models they use and the main forces or factors that shape or affect them).

Finally, it is important to look at inclusion within the market, to identify if poor, marginalised or vulnerable actors exist and if so where, what roles they play and how they can potentially benefit from improved access to more affordable and appropriate bioenergy supplies and appliances. The potential impact in the use of the bioenergy resources in terms of food and land security is also of fundamental importance and needs to be included as an integral part of the mapping process.

5.1.1 Market chain analysis of ASEAN +3 bioenergy case studies

The ASEAN +3 case studies that were reviewed present a diverse range of project initiators, from government-led programmes (such as the biogas programme in China) to local NGO-led initiatives (the mangrove project in the Philippines) and initiatives started by private entrepreneurs, such as the rice husk electrification programme in Cambodia. This diversity of initiatives shows that there is a growing demand in the region for the benefits bioenergy can bring at the small-scale level. It is not only NGOs that are starting to showcase successful bioenergy projects: governments also are starting to invest in such initiatives, while private sector organisations are beginning to understand the economic benefits that can come from the implementation of bioenergy production. What is most interesting is the collaboration between these three sectors, which can be seen as a significant reason for the success of a number of the initiatives investigated. The projects highlight that success can be achieved through a range of business models, from fully commercial to quasi-commercial and non-commercial management structures.

Table 2: Types of business model

Commercial	Quasi-commercial	Non-commercial
Jatropha (Cambodia)	Rice husk (Cambodia)	Mangroves (Philippines)
Rice husk (Philippines)	Biogas (Viet Nam)	Biogas (China)
Biogas (Thailand)		Biogas (Indonesia)
Tobacco processing (Indonesia)		

Even when bioenergy is delivered with less well-defined commercial interests there are still groups who benefit economically from the initiative. For example in the Philippines where the KASAMA cooperative produces briquettes, new jobs have been created and better environmental conditions provide cooperative members with improved health. In the case of the rice husk electrification plant in Cambodia, the business is designed to have electricity as the final resource for sale. Even in this case new business started up, with individual entrepreneurs starting battery charging businesses for households and small service enterprises in the area. For each of the biogas programmes in Indonesia, Viet Nam and China, new income opportunities emerged for the installers of the biodigester, rather than for producers of the bioenergy (the biogas), who are also the final users. The biogas users were however able to reduce their expenditure on other fuels and use the bioslurry to increase their incomes from increased food production.

Thus, the beneficiaries of the bioenergy initiatives that appear at different stages of the bioenergy value chain are:

- farmers producing the feedstock, such as rice farmers in the two rice husk initiatives;
- direct final users of the improved energy supply, such as small businesses benefiting from the battery charging services of the Jatropha project in Cambodia;
- indirect final users, such as the tobacco processers who see an increase in the quality of the tobacco drying and cleaner and safer work conditions.

Because of these reasons, a bioenergy market chain should be analysed in its multidimensionality, in the sense that it can bring benefits to different actors right along a market chain, in the following ways:

Bioenergy resource production: increased incomes through providing feedstock for bioenergy (rice farmers, tree growers);

Bioenergy generation: increased incomes for workers who operate the Rice Husk Gasifier in Cambodia;

Bioenergy distribution and retail: increased incomes through supplying energy services (e.g. battery chargers, briquettes sellers);

Bioenergy end use: increased access to improved energy services through the use of bioenergy:

- improved productive uses for small enterprises and food processing from bioenergy resources;
- improved household energy services (mainly cooking and lighting);

Bioenergy residues: improving agricultural productivity through the use of waste products of bioenergy production (e.g. bioslurry).

The direct beneficiaries of these bioenergy initiatives occur at each function of the bioenergy market chain, from feedstock production to final energy use. The table below shows the different direct and indirect impacts the initiatives have on a range of actors:

Table 3: Types of benefit obtained from bioenergy

		Improved energy access		*Improved incomes by…*						
		Households	**Productive uses**	**Supplying feedstock**	**Supplying energy**	**Improved agriculture**	**Energy saving**	**New job opportunities**	**Installing/ selling devices**	**Improved productivity**
Initiative	*Rice husk gasifier – Cambodia*	Secondary benefit	Primary benefit	Secondary benefit	Primary benefit			Primary benefit		Primary benefit
	Jatropha – Cambodia	Secondary benefit	Primary benefit	Primary benefit	Primary benefit		Primary benefit			Primary benefit
	BIOMA – China	Primary benefit				Primary benefit	Primary benefit	Primary benefit	Primary benefit	
	BIRU – Indonesia	Primary benefit				Secondary benefit	Primary benefit	Primary benefit	Primary benefit	
	Lombok – Indonesia		Primary benefit	Primary benefit	Primary benefit		Primary benefit			Primary benefit
	Mangrove briquetting – Philippines	Primary benefit			Primary benefit		Primary benefit	Primary benefit	Primary benefit	
	Rice mill – Philippines		Primary benefit	Primary benefit			Primary benefit			Primary benefit
	Biogas chicken farm – Thailand	Primary benefit				Primary benefit	Primary benefit			Secondary benefit
	Jatropha –Thailand	Secondary benefit		Secondary benefit	Secondary benefit			Secondary benefit		
	VACVINA - Viet Nam	Primary benefit			Primary benefit	Secondary benefit	Primary benefit	Primary benefit	Primary benefit	

Key: Primary benefit Secondary benefit

Most of the bioenergy market chains of the initiatives reviewed start with the farmers who produce the bioenergy feedstock. Feedstock producers and providers are at the beginning of the bioenergy value chain, for example with the rice husks in Cambodia and Philippines, and the Jatropha plants in Cambodia and Thailand. Although they are not the final beneficiaries of the improved energy services, they earn a living by selling the bioenergy feedstock, which can be increased in value if facilities exist which can use them, such as the husk gasifier electrification initiative in Cambodia.

In contrast, the biogas cases present quite unique energy value chains, as the producer of energy is also the final user. In addition, as the bioslurry is produced as a waste product has value, it forms its

Figure 14: Using bioslurry from biodigesters in Indonesia (Source: HIVOS)

own value chain, with an opportunity to improve other markets or increase the productivity of the farm through its fertilizer properties. The exception is the case of the biogas plant at the chicken farm in Thailand, where the biogas is centrally produced and distributed to the households surrounding the farm. Although the owner of the farm provides the gas for free, his benefits come from improved waste management and better living conditions for the chickens, which ultimately results in his increased income.

Other initiatives showed how biomass can be purchased and converted into bioenergy for different productive uses. The first is the example of the tobacco farmers in Indonesia who are currently using palm kernel shells to fuel their drying kilns. The same farmers are now planting their own trees specifically for producing bioenergy in order to have their own an independent source. A second example is from the Philippines where KASAMA members manage the mangrove plantation through pruning. The pruned branches are carbonised and sold as charcoal or pulverised and processed into briquettes which are provided to local household and a few businesses. The bioenergy is almost a by-product of managing the mangrove ecological zone.

Finally, is it important to highlight that some of the initiatives assessed derive their energy resource from waste products. Animal waste, rotten organic material, rice husk and used vegetable oil are all waste products which can be used as primary feedstock to supply a range of bioenergy value chains. It is important to note that bioenergy initiatives can supply a range of clean energy services while at the same time reducing waste production from other industries, creating a double win outcome.

5.1.2 Barriers, opportunities and intervention at the market chain level

This section presents a general analysis of the most important features of the bioenergy market chains with the objective of identifying common trends through the initiatives in the region. Here we discuss existing and potential barriers for replicating these initiatives at the market chain level. A full picture of these is provided in the next two chapters within the analyses of Level 2 ('supporting services') and Level 3 ('enabling environment').

Cost: Cost is a potential barrier at any point along a market chain. Within many bioenergy market chains, capital cost can be quite high compared to traditional energy supplies. In some cases (for example biogas and briquettes), although it is relatively easy to demonstrate the relatively short payback period, the high initial investment cost of bioenergy production is still a barrier to scaling up these initiatives. The competitiveness of bioenergy can be very dependent on fossil fuels price, which can therefore be a push or a barrier to bioenergy scale up, depending on whether their prices are low or high (and fossil fuels are often subsidised which makes it more difficult for bioenergy to compete.

The final cost is usually linked to a number of causes within the market level. For example, there can be price speculation on the feedstock, for example in the case of tobacco farmers in Lombok, Indonesia, who need to purchase the biomass from outside the island. Feedstock cost can also depend on the season or the weather conditions, such as the case of the rice producers in the Philippines who supply the rice husk. Implementation of parallel disaster risk reduction programmes is essential for all bioenergy initiatives, as many are dependent on the agricultural sector. The

Thailand Jatropha initiative looked very promising in 2008; however, unsupportive regulations and the low demand for the bioenergy energy product eventually impacted negatively on the entire value chain.

High capital cost is often another barrier for the adoption of bioenergy conversion equipment. From a household biodigester to a mini-grid rice husk electrification system, there is need to access appropriate finance systems, so energy producers at the household and small business levels can pay the relatively high upfront capital costs of the bioenergy systems. These finance systems are often not available. This is discussed further in the supporting services section.

Also, to ensure the long-term financial viability of most of the bioenergy initiatives, effective business models need to be developed. Part of this involves the establishment of specific tariff systems to allow the bioenergy initiatives to get off the ground (discussed further in the Enabling Environment section) and highlights that the scaling up and replication of most bioenergy initiatives requires specific policy-level interventions.

Capacity. This is another key component of most bioenergy market systems. It includes the technical ability of different actors to develop and maintain specific technologies (such as electricity gasifiers and biogas systems) and to understand how the businesses they are dealing with operate. Common to most of the initiatives studied was the lack of technical skills of a range of market chain actors, from the feedstock production to its final energy use. However, most of the problems seem to occur during the conversion phase, when the use of devices such as biodigesters or rice husk gasifiers require a range of levels of understanding, from basic operation, feedstock quality control and ongoing routine maintenance. Problems often also occur within the energy distribution stage (involving, for example, low quality infrastructure) used within electricity mini-grids, as well as at the end user level (briquettes being burned inefficiently in poorly designed stoves or the use of incorrect techniques).

This lack of capacity limits the quality of the final outputs of many of the small-scale bioenergy initiatives and needs to be addressed all along the bioenergy market chains in order to make the initiatives as successful and scalable as they have the potential to be. Supporting interventions could include support to different actors to build their technical skills through external training, but also technical advice from research institutions. Such support could be targeted to different types of producers and users, and these capacity building needs need to be assessed along the market chain for each bioenergy initiative.

Technology. The technologies used for converting a range of bioenergy resources into energy services, or the final end user appliances needed to make use of the energy service (e.g. a lightbulb using electricity to light a home) is often present a barrier, but it can also be an opportunity. The initiatives studied show that the design, quality of manufacturing and materials are extremely important to success and they often represent a barrier for local entrepreneurs and households producing or using bioenergy. The lack of quality is usually a result of low levels of affordability and lack of quality control regulations, as well as a lack of access to markets where better devices are available. Design has been highlighted as a common problem; from biodigesters which are not appropriate to the quantity of feedstock inputted into poor devices for producing briquettes. Electrification systems such as the ones being used in Cambodia and in the Philippines are designed in Europe or the United States; they need to be adapted to local circumstances and require local technicians with specific skills which they typically are not trained in. Spare parts are often rarely available or if they are, prices are high because of import duties. Local technologies can be cheaper but are often of substandard quality. All of these problems can have negative consequences on the scaling up of the initiatives, especially as their reputation can easily be damaged by poor performance. Again, there is need for supportive interventions (such as the regulated certification of quality appliances) and from better support services, in particular the after-sale service provided by sellers and installers and regular maintenance provided by users, which can be built through training and capacity building. Investment in higher quality products can be achieved through increased access to financial services (often more expensive products last longer so can be more cost effective in the long-term). Product warranties also need to be regulated by national government regulation departments to ensure they are being adhered to.

The bioenergy initiatives studied clearly show that there is need for a range of market development support; this includes the development of feedstock markets, and more effective technology and energy appliances markets, which are often not yet well-established in many ASEAN +3 countries. There is also the need for more information sharing between a range of actors, including development agencies, governments and private sector companies. By collaborating, these actors can start prioritizing the facilitation of these markets in order to increase accessibility, affordability of reliable bioenergy devices and technical skills in each of the case study countries for a range of appropriate small-scale bioenergy markets.

5.2 Mapping the inputs, services and finance

In order for the bioenergy market chain actors to carry out their functions they need to access a variety of supporting services (included in Level 2, below the market chain level in the market map in Figure 13). These supporting services have been subdivided into three main types (inputs, services and finance) and are differentiated according to colour in the map. They include the supporting functions that the market chain actors are already using as well as those that are important but which are currently missing and/or not functioning well.

Each of the supporting inputs, services and finance which are required by each of the market chain actors (within each of the five broad functions of a bioenergy market chain) need to be identified. It is important to understand how each specific supporting input, service and finance (including advice, information and training) supports each of the market chain actors within each broad function to allow them to fulfil their role in the market chain as efficiently and effectively as possible. It is also important to identify which inputs, services and finance each market chain actor currently has access to, as well as what they might need in the future to better deliver their products.

Within bioenergy market systems the supporting services typically include quality control standards for a range of products (e.g. biogas cook stoves and pure plant oil processing equipment) as well as financial loans for the bioenergy companies to purchase the production equipment they need and set up their distribution networks. Microfinance loans are often needed by the end users of the bioenergy systems to purchase the bioenergy appliances (in particular the biogas systems which are relatively expensive for households).

These supporting services are usually provided by a wide range of organisations and through a number of different mechanisms, with their nature and effectiveness varying considerably. After identifying each supporting service that is required to support each bioenergy market chain actor, it is useful to understand who provides them. They are likely to be provided by a range of organisations including private companies (such as consultancy services), government agencies, and non-governmental organisations, such as research institutions. It is also important to assess how accessible they are, how effectively they are delivered (typically through free market operators, publicly-controlled and/or subsidised markets, or fully-controlled delivery mechanisms) and how affordable they are to the market chain actors.

Bioenergy input supply: To ensure that each of the small-scale bioenergy initiatives is able to flourish, a suitable supply of resource inputs needs to be supplied. This is vital in order to maintain a growing, small-scale-led bioenergy market, sustainable in the long-term. For example, initiatives like the one for tobacco farmers in Indonesia could be replicated through incentives for sustainable biomass production and reforestation policies to manage other bioenergy resource areas.

Technical support: Most of the bioenergy initiatives assessed initially had some form of in-kind technical support from the NGOs, national research institutions or government departments. The national research institutions had a particularly important influence in enabling the implementation of many of the initiatives assessed. It is clear that the capability of these supporting service institutions can have a direct impact on the long-term sustainability of small-scale bioenergy initiatives, in particular their ability to be scaled up and replicated. Only in few cases was the project developer required to contract technical experts for initial advice – Schneider, an international energy private company, provided technical support to the rice husk project in the Philippines, in association with a national university. Again, this highlights the importance of collaboration between different actors at each level of a bioenergy market system.

Financing: Financing is another important supporting service, and often (because it is lacking or not readily accessible to the market chain actors) it forms one of the main barriers for small-scale bioenergy initiatives. The type of finance required is usually small quantities of capital investment which are traditionally supplied by commercial banks and microfinance institutions. However, as these financial institutions are usually unfamiliar with the technologies and products of most small-scale bioenergy initiatives and tend to view them as informal and high risk, they are usually reluctant to engage with them. However, several of the bioenergy initiatives considered here were able to access some form of financial services due to external support. In several cases the government provided an initial grant to some of the initiatives, while projects initiated by private entrepreneurs already had access to finance and were able to invest the initial capital requirement themselves, allowing them to initiate the project and highlight the potential opportunity to grant or loan providers. In Viet Nam the VACVINA biogas programme has been trying to access microfinance loans for the end users of the biogas systems from the Social Policy Bank, the Agricultural Bank, and the Cooperative Bank, with mixed success. To be able to replicate and scale up many of the bioenergy initiatives, ready access to affordable finance is one of the key opportunities that needs to be realised.

Research and development (R&D): A general lack of R&D is another general barrier for small-scale bioenergy initiatives. The lack of locally developed and appropriate technologies can force project developers and potential investors to only consider foreign-produced technologies which are often very expensive, not appropriate to the local context and which require specific technical skills often not found at the local level. This is particularly true for the larger and more technologically complex technologies such as gasifiers and biodiesel generators.

Some technologies have gained a bad reputation because of poor technology and implementation design, resulting in failed attempts at dissemination. Interventions to reduce this second barrier include the implementation of standards and regulations to ensure a minimum quality of products that have been tested and assured, and to allow the end users to distinguish these better quality products from low-quality products through the use of quality assurance marks. This is dealt with within the enabling environment section.

5.2.1 Barriers, opportunities and interventions

As already highlighted, access to a range of effective and appropriate supporting services is key to ensuring that the bioenergy market chain actors are able to produce, distribute and retail their bioenergy products and services to a range of end users. Some of the basic supporting services required are common to other non-energy activities, in particular agriculture and livestock markets.

Finance. As previously mentioned, another key element within the supporting services is finance. Most of the initiatives have had problems related to access to finance. Microfinance institutions often have little experience of bioenergy initiatives and are frequently reluctant to supply the funds needed, both to local entrepreneurs wanting to establish new bioenergy initiatives as well as the end users, such as farmers wanting to purchase and install a farm or household biogas system.

Loans for establishing mini-grid systems are seen as high-risk opportunities. This however is a barrier which has been overcome in some of the studied initiatives through private investment from a committed individual or family, or through donor grants (although these are often limited and only available for pilot schemes). In order to create the conditions needed for the replication of these initiatives, a supply of affordable loan financing or well-designed subsidy schemes therefore need to be in place. The BIOMA biogas programme in China also used a subsidy scheme, but it was badly-designed and subsidies were provided to households for whom a biodigester was not an appropriate solution rather than to households who really needed it. Subsidy programmes thus need to ensure they target the most needy recipients.

Technical support. Some of the barriers in the market chain are directly linked to the lack of required technical support. The most common barriers identified among the case studies are:

- lack of spare parts available in the market. This often pushes the market actors into purchasing low-quality or non-standardised parts which negatively affect the functionality of their bioenergy production systems. Another identified barrier is that some of initial technology suppliers changed their business and stopped supplying the spare parts and accessories, which could not be found elsewhere;
- irregular after-sale service; this was experienced by most of the initiatives;
- expensive technical support;
- poor-quality biogas appliances or building materials, resulting in the slowing down of demand for the technologies;
- un-honoured contracts; although most of the relationships in the chains are informal, technology suppliers are usually tied to a sale contract clause (such as warranties or maintenance) which in many cases was were not respected;
- poor quality outputs; biogas systems often produce bioslurry as a side product, but it is often not produced to a market-quality standard and therefore cannot be sold.

This analysis of a number of bioenergy initiatives has shown that there are several technical interventions at the supporting services level which could increase the expansion and replication of the initiatives. These include the provision of training and support to the local technology providers, which would enhance local manufacturing capacity or technology provision and thus the production or supply of the equipment and spare parts needed. In the case of biogas, the initiatives highlighted the importance of the creation of networks of biogas service provider companies and the establishment of practical learning centres. The creation of quality control and certification for technical expertise can also lead to an improvement in the technical quality of the systems (in terms of their ongoing gas and bioslurry production and long-term durability), a service which can be linked to a programme's ongoing monitoring activities.

5.3 Mapping the enabling environment

The third level of each bioenergy market system is the enabling environment. This typically sits above the market chain, and includes a diverse set of factors that act as the 'rules of the game', shaping how each bioenergy market chain and its supporting functions operate. The enabling environment factors typically include the following:

- macro-level economic and market trends;
- laws, policies and regulations, and the mechanisms through which they are enforced, enacted and implemented, including those that govern quality control;
- informal norms in the economy, society or culture;
- infrastructure status, including that of roads, telecommunications and transport routes;
- local ecosystem (e.g. rain patterns, quality of soil, existence of minerals or plants for fuel).

Despite the term 'enabling', these factors impact in a positive, negative or ambiguous way on each of the energy market chain actors and/or the supporting services. They can however often be changed to better support each market chain actor to better deliver their products and services at a higher quality and to more households, businesses and community services.

Within the ASEAN +3 region it is possible to identify a number of general trends in government targets towards new and sustainable energy supply (including biomass and biofuels). Figure 15 highlights the generally supportive policy environment for bioenergy in the region.

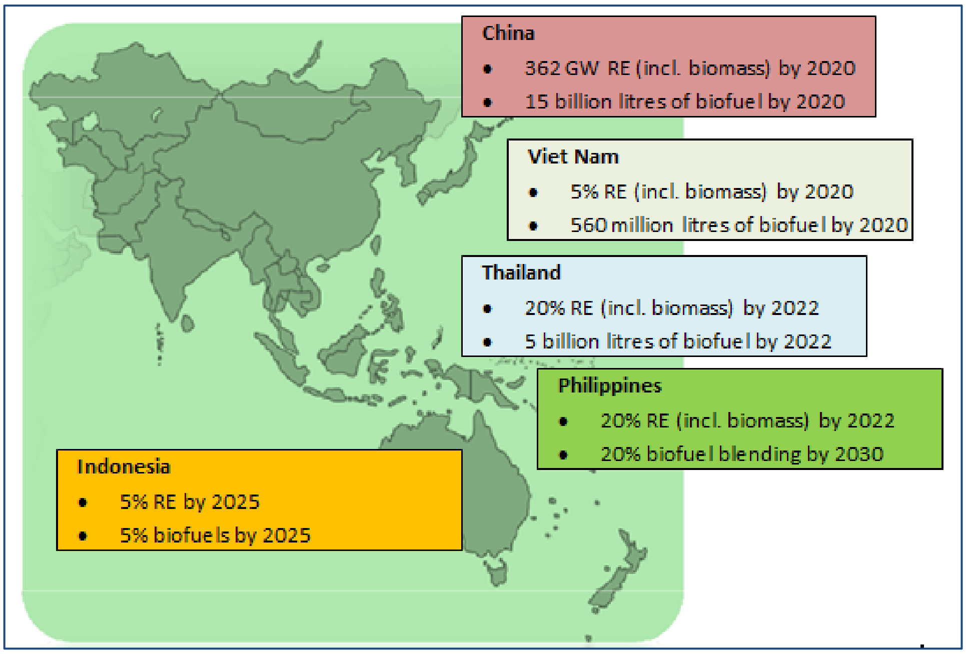

Figure 15: Government-supported bioenergy targets of ASEAN +3 countries (Adapted from: Bioenergy and Food Security in ASEAN, FAO 2013 and Philippine Biofuels Situation and Outlook, USDA 2013)

However, despite such high-level policy support for bioenergy, this analysis has shown that more focus is required on small-scale bioenergy initiatives, which are still struggling to overcome regulations designed to benefit larger-scale bioenergy investments. In addition, even within a common regional environment there are some clear differences between member countries; the enabling environment for each studied initiative therefore needs to be analysed within its country context. Table 4 highlights some of the key enabling factors which affect the scaling up of small-scale bioenergy initiatives in the countries featured in the study.

Table 4: Examples of key national policy factors affecting scale-up of small-scale bioenergy Initiatives

Cambodia	**Rice husk gasification**	The government is providing support through supportive policies and through the Rural Electrification Fund to encourage investment in the development of renewable energy sources in order to supply electricity to rural areas through a range of resources including biodiesel.
	Jatropha biodiesel	
Indonesia	**Household biogas**	Due to the rising price of oil and scarcity of wood fuel, government policies, regulation and standards have been developed to support renewable energy development, including biogas. Incentives include tax reduction, duty exemption and feed-in tariffs for the technologies.
	Lombok biomass	The government's removal of the kerosene subsidy pushed tobacco farmers away from using kerosene and towards using unsustainable wood fuel. Although some regulations exist pertaining to deforestation these are not widely enforced and biomass production is not well-controlled.

Philippines	**Mangrove biomass**	The Department of Environmental and Natural Resources provided policy guidelines for the stewardship and reforestation of mangrove areas. The Department of Energy provided policy on the use of renewable energy, including the use of biomass resources. The Philippine Cooperative Development Authority listed the provisions for operating a cooperative.
	Rice husk	The Department of Environment and Natural Resources sets the guidelines for environmental compliance and monitoring, particularly emissions. It is responsible for the application for carbon credits for renewable energy products in the Philippines. The Department of Energy is responsible for monitoring applications and the feasibility of renewable energy projects in the country.
China	**Biogas**	The Department of Agriculture developed plans for the initiative, based on: a) farmers' surveys and their demand for biogas and bio-fertiliser; b) customer demand for green fruit; c) greater awareness of environmental protection and energy saving. It established favourable policies, regulations and standards to support the production of biogas appliances and accessories, design and construction techniques. The Ministry of Labour Resource allocated a subsidy to the provincial rural energy offices and audited the projects. The Ministry of Health was responsible for disease control and monitoring zoonosis reported by disease control centres, and reporting on this to the state council.
Thailand	**Community biogas**	Due to high energy prices, the government started providing a subsidy for electric power plant construction and introduction of feed-in tariff for energy from Napier/elephant grass. The government's Community Fund also provides a subsidy to communities of 30-70 percent of the investment capital needed for energy production and sales, such as for community-scale biogas.
Viet Nam	**Household biogas**	Standards developed by the Viet Namese Biogas Association with the Ministry of Agriculture and Rural Development and supported by SNV have been endorsed by the Ministry of Science and Technology. These should be approved in 2014. However they do not include all biogas technologies in the country.

Common features include rising oil prices, general government support of renewable energy and collaboration between different governmental institutions. General trends in the ASEAN +3 region demonstrate that governments tend to prioritise large-scale bioenergy initiatives. As scant evidence has been gathered about appropriate small-scale bioenergy initiatives in the region, little awareness or interest of such projects has been generated. However, it is believed that this is at odds with the Government's attempts to provide energy access to the whole population, which cannot happen without the implementation of appropriate and sustainable decentralised energy solutions, in particular bioenergy initiatives such as the ones assessed.

The Cambodian government, for example, is actively encouraging development actors, including investors, to support the production of renewable energy resources to support electrification in energy deprived areas of the country. In Indonesia, a supportive regulatory framework has been established, with supportive policies, regulations and standards to support a range of renewable energy technologies. The same general trend has led to the development of incentives such as supportive regulations, tax exemptions (such as import duty) and feed-in tariffs; however these have mostly been targeted towards larger scale bioenergy production. This has implications for access to finance to start small energy businesses, as the taxation systems are generally designed for large-scale bioenergy production, as so are not suitable for smaller and more informal bioenergy companies and organisations, which lack the financial expertise required. In addition, the quality standards and certification for bioenergy devices and appliances also tends to relate to larger bioenergy production, and needs to be adjusted for small-scale initiatives as well.

For most of the small-scale bioenergy initiatives analysed, most of the barriers at the market chain and supporting service levels are in some way linked to issues within the enabling environment. Through the comparison of the ten initiatives, it has been possible to identify a number of common barriers within their enabling environments.

Identified barriers include the lengthy procedures needed to obtain legal status, which is often not cost effective for small-scale initiatives. This often results in small-scale bioenergy initiatives entering into informal arrangements.

Inappropriate subsidies need to be phased out, but in an effective manner. The Lombok tobacco case study in Indonesia shows that the phasing out of subsidies in kerosene pushed farmers to start using unsustainably sourced firewood for fuelling their drying kilns, as the phasing out of the subsidy was not combined with sourcing alternative energy sources. Eventually the outcome was positive, as these farmers have since started to develop a sustainable biomass system, but this has taken some time. Often subsidies and regulations which affect bioenergy come from subsidies which have been put in place to support the production of staple foods; this was a key barrier for the Jatropha project in Thailand. Although the production of Jatropha showed potential for scaling up in 2008, the implementation of a subsidy to guarantee the price of cash crops (such as rice, maize, and other agricultural products) led to Jatropha production becoming uncompetitive.

Infrastructure. In Cambodia, the lack of adequate infrastructure, in particular irrigation systems and roads, has been identified as a main barrier for the rice husk and Jatropha bioenergy initiatives. These key factors impact on the production and distribution of the required feedstock, as well as the supply of spare parts and distribution of the final energy products. In addition, in many cases improved agricultural techniques would not only increase the production of the bioenergy resources, but also increase their value, such as for rice husks used within a gasification system.

Cultural barriers. Cultural barriers can also be an important barrier to the adoption of some technologies. An example is the lack of initial adoption of biogas digesters, in Viet Nam and Indonesia, as the end users were initially reluctant to adopt the technology due to the nature of the energy resource, which is often from animal dung.

Regulations. Increased regulation with the bioenergy, which is focused on small-scale technologies and products, is also required. The establishment of formal processes to regulate, certify and standardise a range of bioenergy products and services is required to ensure that suitable quality technologies are developed and appreciated by the end users. As the case studies have highlighted, such a lack of regulations form a principal barrier within the market chain and the supporting services, and can only be resolved through suitable policy level support. Through a more regulated market where prices are regulated (and supported if required) and technology quality is assured, bioenergy products and services can start to occupy a gradually increasing proportion of the national energy market, particularly in more remote and rural areas. Of course, it is also important to ensure that such regulations are appropriate to the technologies and products, as over-regulation can be as equally damaging as a lack of regulations. Regulations and standards need to be developed from evidence on the ground, such as the case studies presented in this report, and should be constantly updated with the technology improvements or the introduction of better performing technologies.

Rural development. The current gap between access to electricity and modern cooking fuels in urban and rural areas in most of the countries studied is still quite high. As most of the small-scale bioenergy initiatives focus on producing and supplying high quality energy services and products to rural households and small businesses, this is another compelling reason why governments should prioritise their support and development. Quite a few of the case studies assessed within this report offer great potential for replication and scaling up within the region to increase livelihoods and energy access particularly in rural and more remote areas.

Agriculture and energy sector synergies. In addition, most of the bioenergy initiatives studied offer important synergies between the agricultural and energy sectors in the country, at both the national and local levels. Such initiatives need to be supported from two directions at once: from the community level to ensure the technologies are appropriate and sustainable, and that suitable financial products are available, and through government-level support to ensure the initiatives have the required regulatory and economic support and can be replicated in other areas. The ten case studies assessed have shown a mix of the two approaches, and it is important to note, that where both bottom-up and top-down initiatives have been successful, they were not designed in isolation at the government or community level, but always involved interaction between the two levels.

End user awareness-raising. To ensure that there is adequate demand for the bioenergy technologies and products it is important to develop suitable awareness-raising campaigns at different stages of the supply chain. This is important to increase the knowledge of the producers, processers and users of bioenergy, and those that are providing the technical and financial services they need. This is particularly important for new technologies which are not well-known, or technologies which potentially have some cultural barriers associated, such as biogas.

Global trends. Globalisation can offer new opportunities for country governments involved in aligning their PRSPs with sustainable and decentralised energy production through bioenergy. The development of the post-2015 Sustainable Development Goals to replace the Millennium Development Goals will likely include energy in some form. In addition, current initiatives such as the Sustainable Energy for All (SE4All) provide opportunities to link national commitments to the international agenda.

More direct interventions to enable the scaling-up of these initiatives needs to include the shaping of renewable energy policies and financing towards more decentralized energy approaches. This can lead to a catalytic effect at the capacity and financing levels. Universities and national research centres can start to develop their own research focus on such decentralised solutions, or link to international centres to bring in the required technical expertise and technology development to increase the efficient bioenergy production and use in these countries. Microfinance institutions can also benefit from this new focus, to start to design innovative financial products to allow entrepreneurs and investors to scale up and replicate such small-scale bioenergy initiatives, as our outlined in this report.

6 Outcomes for sustainable livelihoods

The third stage of the assessment framework is to identify the potential livelihood outcomes of each identified bioenergy initiative and the economic, social and environmental sustainability of each. A selection of six sustainability indicators has been used as a basis for assessing the sustainability and the livelihood impact of each initiative. These indicators are an adaptation of a number of GBEP indicators and cover a range of environment, social and economic sustainability issues that bioenergy initiatives typically face.

GBEP Sustainability Indicators

The Global Bioenergy Partnership Sustainability Indicators for Bioenergy (FAO, 2011) was developed by GBEP Partners and Observers through the GBEP Task Force on Sustainability. The report presents 24 voluntary sustainability indicators for bioenergy intended to guide any analysis undertaken of bioenergy at the domestic level with a view to informing decision making and facilitating the sustainable development of bioenergy and, accordingly, shall not be applied so as to limit trade in bioenergy in a manner inconsistent with multilateral trade obligations. The report presents 24 voluntary sustainability indicators for bioenergy intended to guide any analysis undertaken of bioenergy at the domestic level with a view to informing decision making and facilitating the sustainable development of bioenergy and, accordingly, shall not be applied so as to limit trade in bioenergy in a manner inconsistent with multilateral trade obligations.

6.1 Land use

This relates to GBEP Indicator 8: Land use and land use change related to bioenergy feedstock production. Feedstock production for bioenergy generation can have consequences for land and resources available for food production and hence food security. Reviewing the change in availability of land for growing food can aid the understanding of the environmental, social and economic effects of bioenergy production.

For all the case studies, no significant impact on land use or land use change was reported. Two of the case studies involved rice husk gasification plants; these did not take up a significant amount of space: 5 000 m² for the plant in Char Chuk commune, Cambodia, and 3 500 m² for the plant in Isabela province, Philippines.

Biogas digesters that were installed on household or farm property did not affect land use. The digester sizes ranged from 7 m³ for households with up to seven pigs or three cattle, up to 500 m³ for the egg laying chicken farm in Gorkhai village Thailand, using manure from around 15 000 chickens. The amount of land available for agriculture in Danling county, China did not change as a result of the bioenergy project. However, the land utilization changed from growing crops and vegetables for subsistence and sale on 95 percent of the land to growing fruit for sale on 70 percent of the available arable land.

Jatropha plant cultivation for biofuel in Paoy Char commune, Philippines and Viengsa district, Thailand were carried out on land not previously used for growing crops (such as the existing property of households or farms). In the case of the Lombok biomass initiative in Indonesia, the candlenut and castor bean trees were planted on degraded land. The KASAMA briquetting project in Philippines made use of unproductive mudflat and mangrove areas.

Agriculture is the predominant sector in the ASEAN countries covered by the study. Bioenergy feedstock production has the potential to have considerable environmental and social impacts in this region. Due to the nature of the reviewed bioenergy projects (which either utilised agricultural and livestock wastes or involved the cultivation of sustainable biomass on underused or degraded land), no significant land use changes were made by the projects. However, it is possible that negative effects could occur in the future, particularly if the projects are expanded without proper planning and consultation.

6. 2 Land tenure rights

Land tenure relates to GBEP Indicator 9: Allocation and tenure of land for new bioenergy production. Respect of land tenure rights is essential to ensure the fair allocation of land resources. Tenure rights determine who can use a resource, for how long and under what conditions. It is important to identify the extent to which tenure rights are recognised for new bioenergy projects. If land owners and users have a recognised mechanism that secures rights to new land, sustainable economic and social development is encouraged and energy access can be promoted.

The state owns around 80 percent of the total land in Cambodia and farmers tend not to have land use management plans or land titles for the land they cultivate. This can potentially lead to conflicts and negative impacts on the livelihoods of farmer and the community. For example, the land for the rice husk gasifier plant in Char Chuck commune had previously been used for rice cultivation; the owner did not carry out an assessment on how the tenure rights, livelihoods and food security in the community would be affected by the plant. In Paoy Char commune, a tenure rights assessment was not carried out (although any potential impact of the bioenergy project was reduced as the Jatropha trees were planted on previously unproductive land). This was also the case in Thailand, where the Jatropha trees were planted on land already owned by farmers, and so the tenure rights were not affected.

With regards to the Lombok biomass initiative in Indonesia, the land used to grow sustainable biomass was owned by the state and given to biomass farmers to manage. It was reported that the initiative had a positive impact through reducing land conflict. Since 1990 in the Philippines, the KASAMA organisation in Aklan province has had land tenure rights to the mangrove area; before their involvement, the area had been unproductive mudflats. Members of KASAMA obtained open access to the area, along with the responsibility for its sustainable use and management. The bioenergy project chosen for this case study did not have an impact on land tenure rights as the feedstock – pruned branches – is a by-product of the sustainable management of the mangroves.

The construction of a rice husk gasifier plant in Isabela province, Philippines had no effect on tenure rights as the plant was built on the owner's existing property. Similarly, the biogas digesters have been installed either on land owned by farmers or households, so there were no conflicts in securing the land for energy generation and land tenure rights were protected. Farmers in Indonesia had to sign contracts to show they willingly participated in the scheme.

A common problem in ASEAN countries is an inadequate legal framework around land occupancy and ownership. While no conflicts were reported for the bioenergy cases studied, assessment and due process did not seem to have been followed in setting up most of the bioenergy projects. Disputes between land owners and those who use and rely on land for subsistence can occur as well as greater social and economic inequality and a growing concentration of productive assets such as arable land in fewer hands through the lack of transparency in land transactions and policies that favour larger corporate owners.

6.3 Food prices

GBEP Indicator 10 relates to the price and supply of a national food basket. Bioenergy feedstock production can affect the domestic price and supply of staple crops, and the demand for resources such as land, water and fertiliser used in agricultural production. It is important to assess the effects of bioenergy feedstock production and use on the price and supply of the national food basket. If the price of the food basket or its components increases due to feedstock production and use, this can have an impact on the welfare of economically vulnerable members of the community. In addition, there are other factors, not directly related to bioenergy feedstock production, which influence the domestic price and supply of staple crops including weather, petroleum prices, and imports and exports of foodstuffs.

The price of food does not seem to have been affected by the bioenergy projects, except in the case of the biogas project in Danling county, China where the food price increased. It was due to an increase in the production of fruit, which due to the increased profitability of its cultivation resulted in a reduction in the production of cereal crops such as rice and the need to import these staples from other areas.-Prior to the installation of the biodigesters, 95 percent of the arable land was used to produce crops including vegetables for local subsistence and sale to other areas; 5 percent of the land was used for producing fruit. Through the use of bioslurry, a by-product of the bioenergy production process, the yield and quality of the fruit improved and became more profitable to grow than the staple crops, leading to the amount of land used for fruit production to increase to 70 percent. As a consequence, the amount of land available for growing staple crops reduced, resulting in these crops being imported from other areas. Although the price of food increased, household income from fruit production, as well as livestock sales, has increased.

The reports of the rice husk gasifier and Jatropha projects in Cambodia suggested there was potential for an increase in food prices. In the case of the rice husk gasifier, the plant was constructed on land previously used for growing rice, which reduced the available cultivation area. For the Jatropha project, a potential threat exists that land currently used for crops could be used to grow Jatropha instead in the future.

Food is generally becoming more expensive around the world and the prevalence of bioenergy production is increasing. While bioenergy production can be a contributing factor to food price increase, it is not the only reason and has the potential to increase or decrease food security depending on supporting policies and the characteristics of the local agricultural sector. The bioenergy projects reviewed have not competed with agricultural land or resources and so have not had any direct influence on food price during the course of their operation.

6.4 Changes in income

GBEP Indicator 11 revolves around change in income. Employment and wages in the bioenergy sector can drive social development in developing countries. Changes can occur in income as a result of bioenergy production, transportation, conversion and processing, and the supply and distribution, installation, operation and maintenance of plants and equipment. Income can be obtained through employment or can be non-wage income from the sale, barter or consumption of bioenergy products. Income changes can provide an indication of the labour conditions in this sector in relation to comparable sectors, which is important when assessing the social sustainability of the bioenergy sector.

The bioenergy projects reviewed have had a positive effect on incomes in the local communities. For example, having access to electricity has meant more businesses have opened in the Char Chuk commune, Cambodia. In addition, farmers' incomes in Char Chuk have improved as a result of being able to sell the waste product. In Isabela province, Philippines, while the income of farmers was not directly affected, their expenditure on energy was reduced through having access to electricity generated by the rice husk gasifier plant.

Households growing Jatropha in Paoy Char commune, Cambodia and Viengsa district, Thailand have the potential to increase their income through the sale of Jatropha fruit. However, this has not happened in Thailand because the government subsidy for other crops has destroyed the motivation to move to growing Jatropha. The biomass farmers in Lombok region, Indonesia were reported to have seen a significant increase in their incomes. For the households and farmers with biogas digesters, savings have been made to energy costs and there was also a marginal increase in income through the sale of bioslurry, a by-product of the process.

The bioenergy sector has the potential to provide employment and incomes for rural communities. In this respect, the projects studied had a positive impact on incomes and cost savings for the communities involved. New income sources were created through the projects. Households and rice husk producers benefited through the sale of what was an agricultural waste product. Farmers of candlenut and castor bean biomass gained through the cultivation and sale of their products. Households and farmers also benefited through the cultivation and sale of Jatropha seeds, the sale of bioslurry, and the KASAMA organisation members benefited from the sale of mangrove seedlings. Income savings were made by community members through the use of bioenergy as an efficient and cheaper cooking fuel.

6.5 Jobs and labour conditions

Jobs and labour conditions are covered by GBEP Indicator 12 ('jobs in the bioenergy sector'). Changes in the number, quality and type of job can have an impact on social development in rural areas and thus measuring job creation and diversification of sources of income for the local population as a result of bioenergy production and use can help understand the social and economic sustainability of bioenergy development. Ideally, the proportion of local workers employed and trends in the gender and age balance of the workforce should be taken into account.

Figure 16: Worker collecting rice hull, Philippines

Most of the bioenergy projects led to the creation of jobs in the local communities. For example, the rice husk gasifier plants in Paoy Char commune, Cambodia and in Isabela province, Philippines required staff for their construction and operation. The environment became more favourable for the start-up of new businesses and enhanced potential employment opportunities because of the availability of electricity in the area. The biogas projects relied heavily on local tradespeople such as masons, appliance manufacturers and distributors. In Danling province, China, new jobs were created in marketing and information provision in regards to livestock-raising and fruit-growing practices. In Aklan province, Philippines, local tradespeople and materials were employed to make earthen stoves for use with the briquettes from the KASAMA initiative.

The biomass initiative in Lombok region, Indonesia created jobs for biomass farmers who were charged with managing long-term biomass cultivation. In the short-term, jobs were created distributing the interim biomass feed of palm kernel shells. In addition, new businesses were created by householders in the region producing and selling ready-to-eat produce such as taro or papaya chips; women were predominantly involved in these new businesses. There were no significant increases in job creation for the Jatropha biofuel projects, though potentially there could be during planting and harvesting seasons.

As with income, improvements in jobs and labour conditions are desirable outcomes of implementing bioenergy projects. Direct and indirect employment has increased through most of the projects reviewed, resulting in the improvement in labour conditions through access to clean energy. The larger scale projects such as rice husk gasification created jobs directly for technicians and operators in the construction and running of the power plants. The biogas projects engaged masons, appliance makers, distributers and technicians in order to construct and maintain the biogas digesters.

Beyond the immediate beneficiaries of the bioenergy projects, access to energy has enabled the diversification of labour and increased income for local populations.

6.6 Energy access

The GBEP indicators on Energy Security and Energy Access were merged as the latest definitions of energy access include criteria such as reliability, affordability, quality and convenience.

Affordable universal energy access is of fundamental importance to sustainable development. It is important to measure the growth of access and also the modern energy services provided through bioenergy. Modern energy services include: electricity for lighting, communication and other household uses, modern fuels and technologies for cooking and heating, and mechanical power for productive use. Traditional fuels such as firewood and coal have become increasingly expensive, intensifying the need to diversify energy sources. Energy access in the rural areas covered by the case studies vastly improved through the implementation of the bioenergy projects. It would be interesting to apply the Global Tracking Framework (WB, 2013) to measure the changes on the energy access ladder.

The rice husk gasification project in Paoy Char commune, Cambodia improved the rate of economic development in the area through access to electricity. Businesses were able to use electrical equipment to carry out work and new businesses started up, improving livelihoods for many in the commune. The rice husk gasifier plant in Isabela province, Philippines provide the rice mill with access to electricity and allowed it to be in operation for longer periods. This increased the amount of rice that could be milled resulting in a reduction of the retail price.

Figure 17: Woman showing the use of biogas for cooking (Source: HIVOS)

The biogas digesters installed in households in Danling county, China, Lampung province, Indonesia and Thanh Hoa province, Viet Nam provides households with direct access to biogas. They use the biogas for cooking and heating water. The larger-scale biodigester in Gorkhai village, Thailand supplies the farm as well as half of the households in the village with biogas.

The KASAMA briquetting initiative in Aklan, Philippines provides a year-long supply of sustainably-produced charcoal briquettes to KASAMA members who use them for cooking and heating water. The Lombok biomass initiative in Indonesia has created an alternative and sustainable energy source for tobacco farmers who previously relied on kerosene and unsustainable wood based fuel.

The lack of access to clean affordable energy had hindered the social and economic development prospects of the local communities. The bioenergy projects improved the convenience, quality and cost of energy for the end users and brought additional benefits such as job creation and diversification of incomes, as well as improvements in the environment.

6.7 Food security

As is widely recognised, bioenergy production can result in a range of different impacts on food security: it can increase or decrease availability, access, utilisation and stability. The focus of this study is on small-scale bioenergy initiatives. These, as individual projects, are too small to have a direct impact on food security. Nevertheless, it is possible to identify and track a number of trends, and to determine whether the scaling up of these initiatives and their replication could eventually positively or negatively affect food security in the country. Access to food is positively increased in most of the cases, as the majority of the initiatives have led to an improvement of incomes. This report analyses the current impact of a number of small-scale bioenergy initiatives at their community level, and at the same time attempts to identify potential risks and opportunities for food security at larger scale, in case they are replicated or scaled up. The analysis draws from the results from the BEFS Operator Tool and the analysis carried out by local experts visiting and studying the projects. Among the four main dimensions of food security (access, availability, utilization, and stability), this report focuses on the first two, as they are the most relevant to the initiatives which form the focus of this study.

The cases studied show that bioenergy can increase food security (through improving food availability), increase access to food (through increasing job opportunities) and increase productivity activities (through the provision of better energy services). It can have an impact on land productivity (through the application of bioslurry) but can also limit the availability of water (for example in Jatropha processing).

Table 5 below indicates that most of the initiatives had a positive impact on food access, while food availability is not affected. This consideration is based on the current situation. A full analysis is presented in the Annex, including the potential risks of scaling up the initiative. The only initiative which seems to have no positive effect is the Jatropha project in Thailand. The main cause of this is because the project has not succeeded and the investment in time and money has not led to better incomes or improved access to energy services.

Table 5: Impact on food security (results from case studies)

	Cambodia - rice hull	*Cambodia - Jatropha*	*Indonesia- biogas*	*Indonesia Lombok*	*Phil - mangrove*	*Phil - rice husk*	*Thai - biogas*	*China- biogas*	*Viet - biogas*	*Thai - Jatropha*
Food availability										
Food access										

Key: Positive impact No impact

The typical risk for food security is when the production of biomass is directly competing with the production of food crops, in particular staple food. None of the initiatives considered here centred around the substitution of crop production with a biofuel. The energy resource of half the cases comes directly from crops, but in two different ways:

- waste product (rice husk, animal waste, food waste);
- non-edible crop (Jatropha).

On the other hand, bioenergy can positively affect food security by increasing inputs to food production. Four initiatives from Indonesia, China, Thailand and Viet Nam show that biogas, both from domestic biodigester and from agri-business systems, can positively affect food security. The by-product of biogas, bioslurry, can indeed improve the yield rate of food crops and help save money by providing a supply of fertiliser and thus reducing the need for its purchase. In addition, the savings made by the supply of free cooking fuel can improve households' ability to afford nutrient-rich food.

In the China biogas initiative, although there has been a reduction of cereal production in the area, the use of bio slurry has allowed the plantation of high value crops, increasing the production of fruit by 7.278 tonnes per year. Villagers export fruits to other areas and import staple food from the market supplied by other areas; as fruits are more profitable, staple foods become more affordable. The Philippines mangrove briquette project has also had a positive impact on the food supply in the domestic market and resource availability. Mangrove plantations can indirectly increase marine-based food sources: fish and other seafood have been seen to significantly increase (although have not yet been measured in the locality). There is no competition with existing agricultural lands since mangroves thrive on coastal land.

When bioenergy is converted into electricity (such as in the Philippines rice hull project) it can have a positive impact on food security. For example, the increase in rice milling capacity enables the processor to accommodate more rice paddy supplied by farmers, providing them with an extended and assured market. In addition to an increase in production, the quality of rice is also improved: the extended hours of operation mean that the drying of rice can now be done during the evening.

As these initiatives take place at small-scale it is important to consider the potential impact they can have on food security when they are replicated and/or scaled-up. The Cambodia Jatropha case is indicative of this. While this specific initiative has proven to be sustainable and improves livelihoods without affecting food security, its replication might lead to potential risks, as its cultivation could start to take over land formerly used for food crops. The most direct impact these initiatives have on food security is due to the ways they increase access to food by:

- **increasing incomes**. Most of the initiatives have an indirect positive effect on food security; by increasing income-generating activities, they allow more people to afford food.
- **employment opportunities**. With new job opportunities occurring at different levels of the bioenergy supply chain and consequent better incomes and living conditions, access to food is increased.

The initiatives have been analysed using the BEFS Operator-level Tool. Specific results are presented in the individual case studies. However, although the overall result showed that those initiatives are currently not negatively affecting food security, there is a potential risk for their future sustainability, as they did not undergo an independent assessment that could have determined possible negative and positive impacts on tenure rights, livelihoods and food security.

7 Conclusions

This study centres on the assessment of the series of case studies presented in the annexes, which provide detailed analysis and specific recommendations. In this report a general analysis of the initiatives has been presented as well as lessons that can be shared to allow the further development of small-scale bioenergy initiatives in the ASEAN +3 region, and beyond. The first part of this chapter is about key lessons from the study, whilst the second part is a list of specific recommendations for policy makers to enable the initiatives to be replicated and scaled up.

7.1 Lessons from small-scale bioenergy initiatives in ASEAN +3

Lessons from this study can be grouped into the following three categories:

1. Impact of small-scale bioenergy initiatives in the ASEAN +3 region
2. Challenges and opportunities on the effectiveness of small-scale bioenergy initiatives
3. Utilisation of a systemic framework integrating a range of analytical tools

1. Impact of small-scale bioenergy initiatives

The study has shown that small-scale bioenergy initiatives can have a range of positive impacts on rural communities. Their impact on improving livelihoods has been demonstrated, with benefits occurring along the market chains from bioenergy resource production, through to its conversion, distribution and retail, and end use. This includes increasing incomes, by providing new jobs, and by improving the livelihood conditions of the actors directly and indirectly involved in the bioenergy market chain.

In addition to increased job opportunities, increased energy access in remote and rural areas also forms a key factor that can transform the lives of communities around the initiatives studied.

Moreover, it has been shown that bioenergy can increase the value of materials which are often regarded as waste products, creating a win-win impact – waste products which can harbour disease and result in environmental degradation can be disposed of and increase energy production. This creation of new markets for feedstock producers can lead to the creation of new businesses.

The energy services (from heating, lighting and mechanical power) produced from the bioenergy resources have their own impact on socioeconomic development, including improved incomes, improved health, better labour conditions and improved productive uses.

In several cases food security has been improved through the bioenergy initiatives, through the increased affordability of food products, protection of food crops and increased availability of organic fertilisers, which has benefitted a range of different actors along the bioenergy market chain.

In conclusion, many of the small-scale bioenergy initiatives have led to increased rural development, through the increased productivity and incomes, as well as increased energy access in areas which often have the lowest energy access rates in most countries.

The findings from this study have also validated many of the conclusions of the small-scale bioenergy report produced in 2008, including:

Local and productive energy end-uses develop virtuous circles: Direct uses of bioenergy in enterprises for productive uses have the added benefit of developing additional financial capital within communities. This supports ability to pay for the energy services which in turn support the viability of the small bioenergy initiatives.

Natural resource efficiency: The cases have shown a mix of sources of bioenergy: bio-residues, such as animal waste and rice husk; bioresources, such as the mangroves used for production of briquettes; biofuels such as Jatropha. Those have shown an increased efficiency of natural resource use by recycling of waste and use of marginal land.

Long local market chains spread benefits: the initiatives have shown that bioenergy markets can benefit very actors across opposite sides of the bioenergy the value chain. This has led to a relative spread improvement of livelihoods at the local level.

Bioenergy improve energy access: some of the initiatives have shown that bioenergy adds value also because it can provide cleaner and more convenient cooking fuels, such as briquettes and biogas. This is an important added benefit to people livelihoods, but it is also an important push for demand of bioenergy.

Cases do not appear to show local staple food security to be affected: as it was showed by the 2008 study, this study has shown that small-scale bioenergy initiatives are not hazards to food security at local level: in most of the cases local communities have been benefited by improved access to food.

2. Challenges and opportunities of small-scale bioenergy initiatives

The study has shown that the use of the bioenergy market system framework has enabled the identification of the general barriers and opportunities within each small-scale bioenergy initiative. The key factors can be identified at each level of the bioenergy market systems, as follows:

Bioenergy market chains: development of appropriate technologies, including their cost; capacity of the market actors to produce, distribute and retail their products; and the development of suitable demand for the products.

Supporting services: access to appropriate and affordable financial services; availability of high quality spare parts and after sale service; access to affordable technical assistance, support from research and development to develop locally appropriate technologies; access to a sustainable and suitable supply of bioenergy resource inputs.

Enabling environment: often highlighted as the origin of most of the barriers affecting the market chain and supporting services. Development of appropriate standards and regulations; development of specific tailored policies for small-scale bioenergy; shared agendas between energy and agriculture, as well as health, education and environment, authorities; development of awareness-raising campaigns to increase demand.

The success of the initiatives depends on their ability to be able to identify the range of barriers that facing them and then address them. This framework provides a useful tool to identify each of the barriers and to design interventions for overcoming them so that they can be further scaled up and replicated. The framework also provides an important tool for understanding how a supportive enabling environment can be developed to facilitate the development of each small-scale bioenergy initiative. The study has also revealed potential risks to the sustainability of the initiatives, which should be taken in consideration in order to establish general guidelines for the sustainable scaling-up of similar projects. These are described in detail in the case study reports in the Annexes.

The following key factors need to be considered by policymakers and practitioners when designing programmes to support small-scale bioenergy initiatives:

- The analysis of individual initiatives and pilot projects can be essential in order to understand what the potential barriers and interventions are and to provide real life examples to government departments to understand the potential benefits of such initiatives and to provide subsequent support.
- Most successful projects have resulted through some form of collaboration between private, public and NGO and academic institutions. Such collaborations should be actively supported.
- Initiatives tended to only become successful when adequate technical training and after-sale services were put in place.
- Waste from a range of agricultural production is often available as a feedstock resource for small-scale bioenergy production and only carries a minor sustainability risk. Synergies between agricultural and bioenergy production should be actively sought and supported.

The following are the key types of support required for scaling up each bioenergy initiative, which emerged from this study:

Collaboration. Governments need to work more closely with local private sector and community organisations to understand what barriers they face and what policy and regulatory support is required to support them.

Long-term planning and business model development. The main market chain actors of each bioenergy initiative need to carry out long term planning and the development of sustainable business models. Often the market chain actors require specific capacity building which can be provided by a technical service provider if available.

Contextual differences for sustainability. Bioenergy feasibility as sustainable energy source should be assessed case by case.

Financial support. Many initiatives require access to well-designed grants, loans and, or, subsidy schemes, at least in the short term until they become established. Successful initiatives have often had access to a range of financial services.

Awareness-raising. Improved awareness is required amongst the market actors around the existing technologies and regulations, as well as for the end users of the bioenergy services and products.

Synergies. Bioenergy is a multi-sector topic. This means that any actor engaged in promoting it, should consider synergies amongst the energy and agriculture sector. Most importantly, governments should facilitate these synergies by promoting common programmes across their energy and agriculture departments.

Knowledge exchange. It is important to exchange knowledge both within the countries and within the ASEAN +3 region on the development of small-scale bioenergy initiatives, to learn from each other. Several countries in the region have been working on biogas initiatives and significant lessons can be learned and technologies transferred. In addition countries are often developing similar supportive polices and regulatory frameworks and each ASEAN +3 member states can learn important lessons from each other.

Global initiatives. Through linking small-scale bioenergy initiatives within the ASEAN +3 region to global energy initiatives, can provide the momentum and support required to treat them with the necessary support and attention they deserve.

3. Use of an analytical framework

The use of the analytical framework outlined in this report is important to provide a systemic approach to understanding small-scale bioenergy initiatives. This framework integrates a number of different tools and allows a set of concrete interventions recommendations to be made. Market mapping is a useful way to map out each actor and visualize their relationships within each bioenergy initiative. However, in order to understand their multidimensionality in terms of their impact on livelihoods and food security, it has been necessary to adapt some of the tools produced by FAO, such the GBEP indicators and the BEFS Operator Tool. National experts have used the framework to analyse a number of small-scale bioenergy initiatives in each of their countries.

The framework has allowed to identify where barriers lied in the market chain and to assess how they affected the sustainability of the initiatives. This has enabled the recommendation of targeted interventions, as presented in the case studies in the annexes.

It is now vital to understand how the results presented in this report can help ASEAN policy-makers understand the potential of small-scale bioenergy and the need to develop more appropriate enabling environments and learn and support each other.

7.2 Final recommendations for further work

Specific recommendations at country level are included in the case studies in the Annexes. Final summary recommendations of the assessment are presented here as concrete suggestions for interventions to scale up the initiatives focused on in this report:

Country-level needs assessments. National level needs assessment can be carried out in each country to understand the potential for a range of small-scale bioenergy initiatives. Such needs assessments will assess the range of bioenergy resources available in the country and the types of technologies and approaches that could be used to start to make use of them in a sustainable and appropriate way.

Bioenergy market system assessments. Once the potential bioenergy resources have been identified a market system assessment of each resource can be undertaken to identify the market chains (from the resource production to its processing, distribution, retail and end use), as well as the supporting services and enabling environment of each small-scale bioenergy initiative to identify the technology and capacity building gaps that need to be filled.

National policy and regulation assessments. Once the bioenergy resources and potential technologies and approaches have been identified, a national policy and regulation assessment needs to be undertaken to assess a) the extent to which they are supportive of a range of bioenergy initiatives and b) what changes need to be made to provide a more supportive enabling environment.

Access to financial services. Once the supportive enabling environment has been developed it is important that the required financial services are available, which can potentially include a range of subsidies, grants and loans both for the project developers and end users of the products and services.

National awareness-raising programmes. Once the support systems for each bioenergy initiative are in place it is important that the demand for the resources meets the supply, and national level awareness-raising programmes need to be rolled out. These need to include a range of government departments, in particular the energy, health and education departments.

Technical assistance and R&D support. To further support a range of bioenergy initiatives, it is important that the required technical capacity is available and the development of the technologies and spare parts are in place.

Regional policy-makers knowledge exchange. To ensure that best practice is being shared within the region it is important that regional knowledge exchange takes place between each country on a range of issues, including technology development, awareness-raising, policy and regulation development and development and access to financial services.

7.3 Final recommendations for ASEAN +3

Sustainable bioenergy development

Bioenergy development should be carried out in a way that there is little to no impact on food security. This follows on from recommendations made in the 2013 Committee on World Food Security (CFS) report, which underscored that "food security and the progressive realization of the right to adequate food in the context of national food security should be priority concerns for all the relevant stakeholders in biofuel development, which should not compromise food security, and should especially consider women and smallholders due to their high level of importance in achieving food security, while considering varied national contexts."

This recommendation was further supported by FAO's Director-General at the 2015 Global Forum for Food and Agriculture. In his opening address, the Director-General stated "In the past decades there have been a lot of debates about the priority and food versus biofuel production. But nowadays we need to move from the food versus fuel debate to a food and fuel debate. There is no question that food comes first. And there is no question that biofuel should not be simply seen as a threat. Or as a magical solution. Like anything else, it can do good or bad. We have seen successful and sustainable biofuel production systems that provide an additional source of income for poor farmers… Today we are better positioned to better evaluate the opportunities and risks of biofuel production and to use it when it pays off socially, environmentally and economically. What we can say is that mandatory biofuel policies must have flexibility. They need to be adjusted according to the reality, the ongoing balance of production and stocks of the different products used."

National Bioenergy Advisory Board

As part of coordination activities, AMS should establish a National Bioenergy Advisory Board made up of relevant Ministries, Departments, and Institutions involved with bioenergy development. This should include the Ministries of Agriculture, Energy, and Environment as the minimum number of policy actors initially involved. It is recommended to also include other Ministries such as Forestry, Industry, Trade, Transport, Finance, etc. Countries are encouraged establish a multi-stakeholder consultation mechanism to cover the many cross-cutting issues involved with bioenergy development. The main purpose of the Board would be to increase the exchange of information related to bioenergy development in order to better inform policy decisions for the future.

National Coordination Mechanism

After a National Bioenergy Advisory Board is established, a national coordination mechanism should be formulated to enhance communication between the stakeholders and other bodies not included on the Board. This would include other Ministries and Departments, educational institutions, non-governmental organizations, public outlets, and social media platforms. This is necessary to allow for a more direct exchange of information between the various Ministries, departments, institutions, and bodies responsible for bioenergy development ,related policies, and information dissemination.

Identification and selection of bioenergy crops

Countries are advised to carry out biomass resource assessments in order to determine which agricultural products are most appropriate for bioenergy utilization. When considering small-scale bioenergy initiatives, this process could help identify better alternative biomass resources for bioenergy production, enhancing the efficiency and effectiveness of the initiatives. The FAO BEFS Rapid Appraisal is one tool option for bioenergy resource appraisal.

Advanced biofuels

It is necessary to continue research and development on new technologies and bioenergy processes, including 2nd generation fuels and improved utilization of agricultural waste. This includes lignocellulosic biomass, gasification, pyrolysis, and torrefaction. These advanced processes offer more options for diversified and sustainable renewable energy sources with very little impact on food security, and as such must be considered as viable options in the future.

Continued partnerships and training

It is important for a wide range of partners, including Member States, UN entities, multilateral bodies and private-sector and civil society organizations to continue sharing information and support in terms of bioenergy development. The United Nation South-South Cooperation can help with the engagement and management of a multitude of areas concerning development through effective mainstreaming, innovation, and enabling activities for all relevant stakeholders.

Policy harmonization

As different national policies can have implications on a range of factors influencing bioenergy development, policy harmonization becomes increasingly important. In ASEAN, for example, the AEC Integration in 2015 gives member countries an opportunity to work together on all policies affecting bioenergy development- agricultural production, energy, food security, environment, trade, and other policies can be brought in line to enhance future policy decisions.

Establish regional network on bioenergy

At the request of the ASEAN Secretariat, all member countries should provide additional information on the various aspects of bioenergy development at national level. Information can then be compiled and made available on a website directly linked to ASEAN. This would enable a free exchange of information and provide more up-to-date and valid data for all AMS when considering options for sustainable bioenergy development.

ASEAN Bioenergy Policy Framework

One of the key recommendations from the the 2013 Committee on World Food Security (CFS) report was that “Governments and other stakeholders are encouraged to implement policies and investments for the production of biofuels and food in accordance with national development strategies and multilateral agreements applicable to food security. Special attention should also be given to the situation of vulnerable groups and small scale food producers.” To facilitate this, a Regional Bioenergy Policy Framework for ASEAN would not only enhance investments and the production of boienergy and food in ASEAN, but lead to increased regional cooperation and understanding to better inform long-term policy decisions.

7.4 ASEAN BEFS Regional Framework

The ASEAN Bioenergy and Food Security (BEFS) Framework is the result of the BEFS capacity building and Roadmap processes in the three identified pilot countries for the BEFS in ASEAN project. By examining and investigating the Priority Areas outlined at the national level, the basis of the regional framework can be identified. However, in order to consider this as an ASEAN-wide Framework, members of the AMS who were not involved in the pilot country activities must be given a platform to add their feedback, recommendations, and advice.

AMS were given such an opportunity at the BEFS in ASEAN+3 Final Project Meeting. During this two-day meeting, all ASEAN Member states were given the opportunity to update ASEC on the current status of bioenergy development in each respective country. The participants were also given the chance to examine the Framework in greater detail and provide experiences based on their own national context to improve and enhance the Framework.

Upon completion of the Final Project Meeting, FAO took stock of all of the recommendations from the participating AMS, incorporating changes as necessary. The final Regional Framework will be distributed to the SOM-AMAF leaders of ASEAN +3 for their consideration and endorsement.

The Regional Framework has been formed to assist ASEAN Member states ensure that sustainable, food secure, climate-friendly bioenergy contributes to economic growth. The pilot country activities in Cambodia, Indonesia, and the Philippines used BEFS capacity building to formulate individual national Roadmaps, focusing on bioenergy development at country-level. These Priority Areas give the foundation for the Framework that can help support activities to implement measures and achieve the aforementioned goal. The Regional Framework Objectives are a direct reflection of the Priority Areas identified by the three pilot countries and information provided by the other AMS. The follow-up actions, responsible institutions, outcomes, outputs, and monitoring indicators were devised during the Final Project Meeting in consultation with participating AMS and subsequent revision process.

Regional Framework Objective	Follow-up actions	Institution responsible	Outcome	Outputs	Monitoring Indicators
Objective 1: **Sustainable Production & Utilization**	• Identification of sustainable appropriate feedstocks • Foster GAPs • Coordinate with research institutions on improved varieties, seeds, technologies • Link with private sector, development agencies on waste-to-energy technologies	• FAO • FAO, AMS, ASEC • AMS, AP3, ASEC, FAO, etc. • ASEC, FAO, SNV, ADB, UNDP, etc.	• Bioenergy feedstock diversification and enhancement • Increased sustainable agricultural production • Increased sustainable bioenergy supply • More effective waste utilization	• Data on appropriate feedstocks for each AMS • ASEAN-wide publications on GAPs • Research reports on improved varieties, seeds, technologies • Information on waste-to-energy systems	• Bi-annual biomass data revision • Measurement of overall sectoral production • Measurement of yields, processing, and agricultural utilization • Measurement of sustainable bioenergy capacity
Objective 2: **Policy Enhancement**	• Formulate national and regional bioenergy policy guidelines • Amend/reform policies on land use, pricing, and tax • Adopt/benchmark policies on trade of bioenergy resources and products	• ASEC, FAO, AMS, AP3 • AMS, AP3, ASEC, ADB, etc. • AMS, AP3, ASEC	• Regional guidelines to harmonize bioenergy policy formulation • Policy reform increases transparency, awareness and encourages investment	• Specific bioenergy policy creation in AMS • Improved land use, biomass pricing, and tax policies • Information on national and regional policies on biomass/bioenergy trade	• GBEP Indicators applied to country-specific context • Yearly review of land use statistics • Yearly review of biomass/bioenergy pricing and trade statistics

Objective 3: **Optimize Investment**	• Promote public-private partnerships, small-medium enterprises, etc. for bioenergy projects • Simplify registration and accreditation processes in-line with bioenergy policy • Government support to infrastructure development	• AMS, AP3, ASEC, FAO, ADB, etc. • AMS, AP3, ASEC • AMS, AP3, ADB	• Public-private partnerships foster bioenegy incentives and increase awareness • Increase investment in the bioenergy sector • Secure long-term investment in the bioenergy sector	• Materials and guidance on PPPs and SMEs available ASEAN-wide to investors • Revised registration and accreditation forms and processes • Data on infrastructure projects, spending, and outputs	• Measurement of PPP, SME investment • Measurement of share of bioenergy in the energy mix • Data assessment of transport infrastructure, processing, storage, etc.
Objective 4: **Improve Data & Information Systems**	• Collate data from national and regional-level sustainable bioenergy assessment tools • Promote region-wide bioenergy education & information campaign • Devise mechanisms to link data and information from FAO, ASEAN, & other stakeholders via web-based platforms	• FAO • AMS, ASEC, FAO. • ASEC, ADB, and sectoral working group	• ASEAN-wide biomass assessment • Increased awareness of bioenegy resources, technologies, opportunities and challenges • Availability and access to data on bioenergy for all AMS and AP3	• BEFS Rapid Appraisal (or similar) regional data compilation • Publications, reports, campaigns, educational materials on bioenergy in the region • Online data repository on bioenergy in the region linked by individual country databases to ASEAN website	• Yearly update of data • Yearly revision of materials • Data availability on FAO, ASEAN websites

In order to meet the objectives, the activities above have been devised through consultations with supporting AMS. These activities are designed to be flexible and can be tailored to the specific needs and direction of national interests. If properly implemented in all ASEAN +3 members states, the outcomes will help ensure future sustainable development of bioenergy policies and processes. Below is an explanation of the recommended activites and how they support each Objective as outlined in the ASEAN BEFS Framework.

Sustainable Production & Utilization

An increase in productivity can be achieved through a coordinated set of actions to strengthen whole value chains and agriculture systems and strengthen support for small-scale farmers, including women. Identification of biomass feedstocks available at both national and regional levels is essential to maximizing bioenergy production potential. This approach includes introducing improved seeds, technologies and farming practices; empowering farmers through knowledge, capital and services; and creating an effective policy framework to accelerate rural and cross-border economic growth. Additionally, effectively utilizing excess waste from agricultural production can help maintain soil structure, feed livestock, and provide biomass resources for biogas and gasification installations. The following activities are all designed to support the sustainable production and utilization of biomass resources for both food and energy security.

1.1 An assessment of biomass potentially available for bioenergy production is a necessary step towards sustainable development of the sector. The valuation should identify the feedstocks available for different bioenergy technologies and processes, and also an estimation of amounts available. This can include surveys of potential feedstocks not currently utilized or under-utilized, such as invasive species, alternative crops, and agricultural wastes and residues. It is important that this data is reviewed by all of the stakeholders involved in bioenergy production. In addition, it is recommended that the biomass assessment data is regularly updated in order to monitor fluctuations in available feedstock varieties and quantities.

1.2 Agricultural practices and technologies aimed at improving productivity, conserving water, and fostering soil fertility can lessen the tension between food security and energy security by increasing overall agricultural output in a sustainable manner. This can also include applying “climate-smart agriculture” strategies to reduce greenhouse gas emissions and help avoid further deforestation, a priority in tropical regions. New strategies must also be adopted to adapt to the impacts of climate change on productivity, particularly risk management tools to enable and protect farmers’ investments. Improved farming practices, access to new tools and technologies, and extension services can help reduce farmers’ risk and protect their investments.

1.3 Develop technologies that are productive, accessible and affordable to farmers, as well as environmentally sustainable. Governments can encourage the development and deployment of such technologies by investing in human and institutional capacity (including extension programmes), particularly in poor regions, and harmonizing science-based regulatory regimes across countries to attract investment. A coordinated approach is needed to simultaneously improve seeds and farming practices, and increase the efficiency and productivity of fertilizer and water use, to improve farmers' access to advanced research technologies. Expanded R&D efforts are necessary to address the needs of the poorest farmers, particularly women, and to increase yields of staple crops.

1.4 Effectively utilizing waste and optimizing value chains: Up to 40% of agricultural produce is lost between the farm and the consumer; improving post-harvest handling and storage and encouraging other measures of value chain optimization can substantially reduce losses, increasing food supply. In particular, investing in rural infrastructure – including transportation, irrigation and post-harvesting facilities – can significantly improve competitiveness and economic opportunity in rural areas. In addition, utilizing the agricultural waste products as bioenergy feedstocks can help to improve rural development and livelihoods, increase energy diversification while reducing pressure on traditional biomass, and reduce environmental degradation.

Policy Enhancement

A major barrier to bioenergy development is the lack of consistent, transparent, and defined bioenergy policies. It is important for governments to work closely with the main stakeholders to ensure bioenergy policies are clear, sustainable, and flexible. Policies that can affect bioenergy investment and future development need to be examined closely in order to foster sustainable growth for the sector. The three activites below all relate to policy enhancement and the need for policies to be flexible and able to cope with changing political, economic, and environmental changes.

2.1 Regional policy guidelines for bioenergy development: Not all AMS have developed bioenergy policies or established guidelines for sustainable investment in the bioenergy sector. The creation of general, region-wide policy guidelines would promote sustainable development in the sector, and strengthen markets and encourage incentives for innovation and investment for the long-term. These guidelines would include recommendations on land rights and tenure, agricultural production, energy diversification, implications to food security, environmental impact, institutional support, capacity building, and national and regional coordination. Improved global standards and transparency should be applied consistently to better inform small-scale producers, private investors, and local and national government.

2.2 Amend/reform policies on land use, pricing, and tax: Reforming policies to enable increases in effective land utilization, the sustainable and equitable trade of agricultural products, waste products, and bioenergy fuels can provide significant economic opportunities for farmers, while also expanding consumers' access to affordable goods. This will also increase interest in investment in the bioenergy sector and supporting sectors, with more options for sustainable development. Land use and land ownership policies need to be equitable and fair to all parties involved. This requires clearly defined, documented, transparent, and legally established policies on land tenure. In addition, actions to mitigate the impacts of trade and taxes on both producers and consumers can include financing instruments, information access and social safety nets. By stabilizing the pricing structure of bioenergy feedstocks and the bioenergy end products, investors can be more confident that sudden fluctuations in the market will not negatively impact the sector.

2.3 Trade of bioenergy resources and products is expected to grow in the ASEAN region over the coming years. Governments need to adopt or benchmark policies on the trade of these commodities to ensure the long-term sustainability of bioenergy development. Collaboration with the ASEAN Secretariat to utilize the upcoming ASEAN Economic Community Integration is one option AMS can consider.

Optimize Investment

Significantly greater investment will be needed to meet the growing global demand for food and agricultural products, driven by population increase, rising incomes, and climate change. This is also true for bioenergy- as the pressure increases for alternative energy resources to fossil fuels, investment in the sector is crucial to its long-term development and sustainability. Attracting such investment will require improvements to the enabling environment to reduce the costs and risks of doing business; remove barriers to entry; and improve physical infrastructure, policy and legal frameworks, and institutional capacity. More broadly, effective governance and political stability are essential to the functioning of agriculture systems, which in turn directly affect the capabilities of the bioenergy sector. Below are a list of recommendations that can assist both the enhancement of agricultural production, energy security, and the sustainable development of the bioenergy sector:

3.1 Public-private partnerships can enable the public sector to harness efficiencies and the expertise that the private sector can bring for certain facilities and services traditionally procured and delivered by the public sector. Government partnerships with the private sector could benefit bioenergy by investing in infrastructure such as production and processing plants, transportation, and storage & end-use facilities. Small to Medium Enterprises can also benefit from governmental involvement. Banks and lending institutions are integral to the growth finance sector, and increasing opportunities for SMEs can lead to wider social benefits and rural development.

3.2 Simplify registration and accreditation processes in-line with bioenergy policy: A regional ASEAN agreement on biomass standards would establish basic principles and requirements that could lead to recognition, appeal and influence worldwide. There are already a number of voluntary standardization systems, such as RSPO. Through the ASEAN Secretariat, countries should agree upon a minimum of standards that apply to all AMS, and devise a universal registration system for all stakeholders in ASEAN. This would open up more avenues for long-term investment in the sector and incentivize potential investors worldwide.

3.3 Well-targeted government support for infrastructure development: Investing in agriculture and bioenergy-related infrastructure, including transport, processing and storage, will attract and accelerate investment in different market value chains. This is an area where public-private financing and collaboration can be highly beneficial. Public spending on programmes should be carefully targeted to maximize positive economic impacts on rural economies and ensure environmental sustainability, while also ensuring the efficient use of public-sector finance.

Improve Data & Information Systems

Expanding information and technology access: Greater information access and transparency will help strengthen bioenergy systems and markets, benefiting all players from farmers to private industry to policy-makers. Effective solutions – such as improved data assessments or information sharing platforms – can be identified and scaled. The recommended activities below address the issues of collecting, disseminating, and improving information systems at both the national and regional levels.

4.1 ASEAN-wide biomass data compilation: Data concerning biomass production and utilization in Southeast Asia is scattered and not always reliable. Collating the data collected from national-level sustainable biomass assessments and conducting a region-wide appraisal of current and potential biomass production data would give an indication of how effectively current resources are being utilized and for what purposes. This would also identify alternative production sources, trade and investment opportunities, and options to continue strengthening food and energy security.

4.2 Increased awareness of bioenergy sector: Information regarding the appropriateness, effectiveness, and sustainability of bioenergy practices in ASEAN is disaggregated. A bioenergy information and promotion campaign is necessary provide solid, scientifically supported educational materials to target the general public, potential investors and producers, policy-makers, government, and the ASEAN Secretariat.

4.3 Information and data exchange network: As previously mentioned, data and information regarding the bioenergy sector in ASEAN is difficult to access and not consolidated. Linking the information and data sources of governments, development organizations, funding sources, educational facilities, and the private sector provides more opportunities for synergy.

Annexes – Case studies

Indonesia (Case 1): Lombok energy initiative

Initiative name	**Lombok Energy Initiative**
Location	*Lombok, Nusa Tenggara Barat Province, Indonesia*
Initiation date and duration	*May 2010 to April 2013*
Funder(s)	*Agentschap NL*
Project initiator	*Fauna & Flora Indonesia (FFI) with technical support from STC Indonesia (STC) PT and British American Tobacco (BAT/ELI)*
Overall budget	*€900 000*
Output	*Renewable biomass-based fuels originated from planting on 430 ha of degraded land.*
Area of land	*430 ha*
Beneficiaries	*1 300 biomass farmers (planting the biomass trees)* *1 600 tobacco farmers (use of renewable biomass as feedstock in tobacco curing/drying process)*

Background and context

Tobacco production in Indonesia (and in particular Virginia tobacco, which accounts for 25 percent of Indonesia's total tobacco production) is mostly supplied by the tobacco farmers in Lombok region, Nusa Tenggara Barat Province. There are approximately 30 000 ha of tobacco plantation which yields a total annual production of approximately 45 000 tonnes flue-cured Virginia tobacco with a market value of US$80–90 million per year. This sector in Lombok provides a livelihood for over 120 000 inhabitants.

In 2010, the government eliminated the subsidy for kerosene in Indonesia, creating a major issue for the livelihood of the tobacco farmers. For the previous few decades, kerosene had been the main fuel in Lombok for most household cooking, tobacco drying, and other productive activities in the rural region. The elimination of this subsidy meant that the tobacco farmers in Lombok turned to using wood-based fuels, sourced from the local forest. This has led to severe damage to the forest area in Lombok, threatening watersheds and local water supplies. Gunung Sasak in central Lombok is an example of a critically degraded area of land. This area of 1 300 ha was once densely populated with hardwood trees until it was cleared illegally. The LPG that was designed to replace kerosene is expensive for the tobacco farmers (a government subsidy for LPG is limited to households and not for industrial use), while the use of coal is vastly increasing air pollution and emissions.

In 2008, BAT and FFI initiated a study to review the sustainability of the fuels used for tobacco drying after the kerosene subsidy would be completely eliminated. This study concluded that renewable biomass was the most sustainable option. Based on this, BAT approached FFI and consulting company STC to start developing an alternative biomass energy initiative for tobacco curing kilns. FFI was the head initiator, with the main responsibility to provide coaching, training and capacity building for the biomass farmers; STC is a private company, pioneering the development of commercially viable and sustainable international supply chain partnerships in the bioenergy sector. BAT provided support by providing access to their network in this sector. With funding from Agentschaap NL, the initiative (part of the Global Sustainability Biomass Fund, or GSBF) was set to start in 2010. The biomass being planted was candlenut and castor bean trees. These were chosen because in addition to the biomass produced (candlenut shell and castor bean trunks), farmers could also benefit from the sale of the fruits. The problem was that these trees need three to five years to grow before they can be harvested. Considering the urgent need for renewable biomass use, an introduction to the use of renewable biomass to the tobacco farmers needed to be conducted as soon as possible. STC immediately began to approach the tobacco farmers to socialize them in the use of biomass. For the initial trial, STC provided 1 000 tonnes of palm kernel shell (PKS) to be used as initial biomass fuels and the tobacco farmers in the BAT network were the initial users. These tobacco farmers purchased the PKS directly from STC as the biomass distributor. In 2013, the demand for biomass had grown to 8 000 tonnes, and STC reported having received orders for 15 000 tonnes of biomass from BAT network farmers for 2014.

The purpose of this early introduction to renewable biomass was to ensure that by the time the candlenut and castor beans were ready for harvesting, the biomass market would be already up and running. In addition, STC has provided initial training to the tobacco farmers in how to modify the furnaces in their kilns to make them suitable for biomass feeding. The tobacco farmers have contributed to the modification process, which has produced the current furnace model. BAT has also provided a credit mechanism for the farmers, specifically for use to modify their furnaces. The total investment cost was IDR2 million[3] for each furnace (one tobacco farmer normally has at least two furnaces) which can be paid back in installments agreed with BAT. Until mid-2013, approximately 1 600 of the biomass farmers within the BAT network have used biomass-based fuels for the tobacco drying process.

At the same time STC was initiating biomass demand by introducing PKS to the tobacco farmers, FFI was assisting biomass farmers to start planting the candlenut and castor bean trees on 430 ha of degraded land in the area of Gunung Sasak. A total of 1 300 farmers were involved in the initiative. FFI provided the plant seed and fertilizer, and coached the farmers in land use management. In addition to the candlenut and castor bean, the farmers planted various crops such as papaya, red chili, peanuts, taro and cassava. This formed part of the agroforestry intercropping system introduced by FFI to help improve the livelihood of the biomass farmers, a scheme well-known in the area as *hutan kemasyarakatan* (‘community forests’) or HKM. The HKM scheme in Gunung Sasak has proved highly successful in encouraging biomass farmers to actively participate in the initiative. This implementation model has resulted in both the tobacco farmers and the biomass farmers benefiting from the initiative.

[3] US$1 equivalent = IDR1 ,560 throughout this document.

Food security

Based on the input data available, the first part of the BEFS tool shows that this initiative has no significant impact on food security. No detailed data on crop production has been provided either by the farmers or by FFI and the candlenut and castor bean trees are yet to produce fruit. However, interviews with some of the farmers reveal that they have successfully harvested the intercrop plants (which they sell at local markets) once a week.

Similar results are shown in Part 2 of the tool ('resource availability and efficiency of use'). Here again, no data on total crop yields presents a limited outcome. Land use management for the intercropping system of the plants and with coaching and training was provided by FFI along with seed and fertilizer for the farmers.

The last part of the tool ('physical displacement, change in access to resources, compensation and income generation') presents more results. Data shows that the initiative created new employment opportunities (mostly on the 430 ha of land) benefiting a total of 1 300 farmers. Further employment has resulted from the distribution of PKS to the tobacco farmers. At the time of the interview in 2013, STC reported that they employed 600 part-time workers to handle the distribution of 8 000 tonnes of PKS. In 2014 the total work may be doubled as the demand for PKS has also significantly increased.

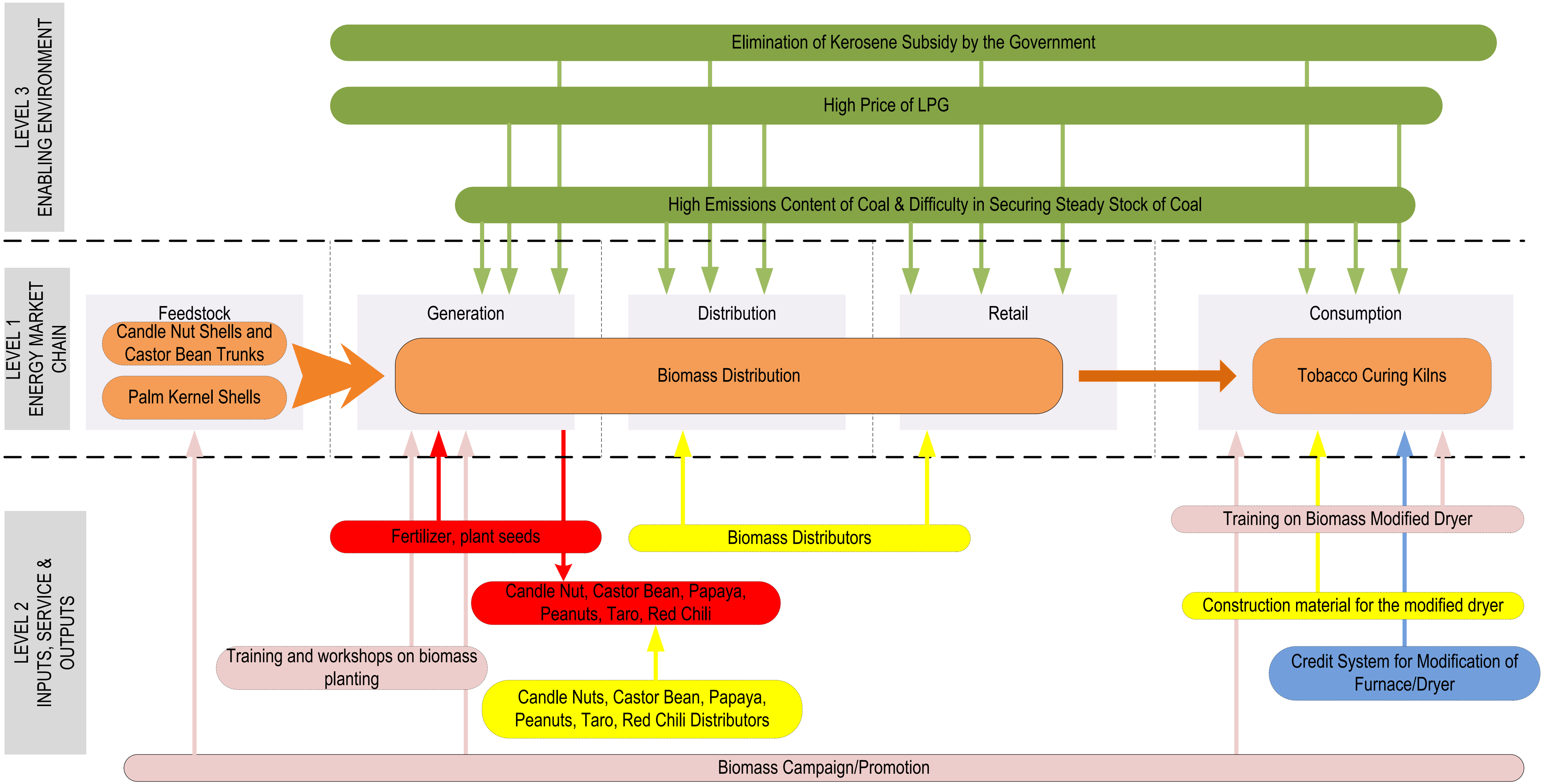

Figure 1.1: Initiative market map

The initiative market map

The initiative's main goal is to create a sustainable supply chain (production, processing and marketing) of renewable biomass-based fuels in the region for tobacco-drying activities, to avoid illegal use of wood biomass from the local forest. As explained above, in parallel with FFI nurturing the biomass farmers in planting the trees, STC organized pilot production trials of alternative biomass feedstock (mainly PKS brought from the islands of Kalimantan and Sumatra). The key strategies of BAT, FFI and STC can be categorized as follows:

The introduction of HKM (the community forests concept). FFI facilitated the formation of 45 farmer groups (with a total membership of 1 300 biomass farmers), provided seed and the planting of 115 840 candlenut trees. The goal was to improve the agroforestry system to help the rehabilitation process of degraded watersheds and improve the livelihood of biomass farmers. The planted trees yield two commodities (the fruit and the shell) which provide additional incomes in rural areas. BAT has also facilitated the rehabilitation process by providing access to its network to reach the farmers in the region.

Inception of sustainable biomass market. Access to markets is crucial to fulfill the initiative aim of economy benefits from the planting activities. When the system is well-established, the supply chain should become self-sustaining through the involvement of local and regional private companies. STC’s main task is to create outlets for the project's production, sales and distribution (due to start in 2015) and in 2010 the company therefore launched a pilot effort to a) create demand for biomass-based fuels and b) build infrastructure among producers and consumers. These activities are all part of the commercialization process of the biomass sector. STC has been working to shape the logistics and the demand side of the chain system. The distribution channels comprise 1 300 biomass farmers and over 1 600 small tobacco farmers in Lombok that are expected to facilitate the development of the market in the future.

Level 1: Energy market chain

Level 1 shows the feedstock to be biomass derived from palm kernel shells, candlenut shells and castor bean trunks. These are planted by the biomass farmers, who are usually agriculture farmers. Most farmers do not have their own farm land; the majority work as farm labourers. The functions of generation, distribution and retail deal with the distribution of biomass from the biomass seller to the end users (the tobacco farmers). Within this initiative, the initial supply chain was conducted by STC to trigger further demand in the market. In the later phase of project implementation, they reported that small biomass distributors had started to emerge in the regions.

The end users of the biomass are the tobacco farmers, who use it as part of the tobacco drying process. The project expected over 1 600 tobacco farmers to benefit from biomass use. The farmers reported that PKS use enables them to cut the cost of buying feedstock. With wood-based fuels, they spent up to IDR1 300 000 on feedstock for each drying process; this has been reduced to IDR900 000. The volume of PKS used for each drying process is also reported to be less than wood-based fuels.

The practicality factor also encouraged the transition to biomass. Using biomass does not require constant vigilance but merely checking every four to five hours and refilling the feedstock if required. In addition, PKS is quite small and therefore manageable by women. In contrast, wood-based fuels need to be looked after continuously and the logs are too heavy for many women to handle.

Level 2: Inputs, services, finance and outputs

Level 2 describes the initiative's supporting elements. FFI provides seed and fertilizer, and assistance by training and coaching the biomass farmers in land management and plant cultivation. BAT has provided seed for the biomass plants and also a financial service to support the transition process in the form of a loan to the farmers for the modification of the biomass furnaces. Installments are repaid on the basis of an individual agreement between BAT and each farmer.

The inputs of the initiative are construction materials for the modification of the tobacco dryers and furnace, and the biomass seed for planting. The candlenut shells and castor bean trunks are becoming available for harvesting and at the same time new biomass distributors are starting to emerge in the region.

Level 3: Enabling environment

The elimination of the kerosene subsidy was the main driver behind the transition to wood-based fuel as farmers in the region have no other affordable options to use as feedstock: LPG is too expensive and coal is difficult to get (and the coal available in the local market is low grade, expensive and causes severe air pollution). These driving factors created an environment where the tobacco farmers were forced to exploit the forest as the most accessible feedstock.

In Indonesia, there is no specific policy or regulation concerning sustainable biomass development. The government (through the Ministry of Energy and Mineral Resources) has issued policies to support the utilization of renewable energy, including the development of bioenergy. The most relevant is probably the Ministry of Forestry regulation concerning the utilization of industrial forest; this obligates any company that owns a utilization permit to replant trees to avoid deforestation. However, the enforcement level of this regulation is questionable and illegal logging in numerous forest areas remains a challenge.

Table 1.1: Relationships between market actors

	Biomass farmers	FFI	BAT	STC	Tobacco farmers	Biomass distributors
Biomass farmers						
FFI	Informal, technical					
BAT	Informal	Formal/informal				
STC	Informal/ formal	Formal	Formal			
Tobacco farmers	Financial	Formal/informal, technical	Formal, financial	Formal/ informal, technical		
Biomass distributors	Financial	Informal	Informal, financial	Informal	Informal, financial	

1. Biomass farmers

The biomass farmers receive technical support from FFI to plant the biomass, including land management (intercrop plant system). As biomass sellers, they either deal with biomass distributors or sell it directly to end users. The nature of their relationship with FFI, BAT and STC is both formal and informal. The informal part of the relationship provides flexibility in the coaching and training activities. Finally, tobacco farmers have an informal relationship with biomass distributors.

2. FFI, STC and BAT

These are the three initiators of the Lombok energy project. Their relationship with the tobacco farmers is both formal and informal, the latter being the most appropriate for approaching the biomass and tobacco farmer communities. There is a financial relationship between BAT and the tobacco farmers through the credit mechanism (provided to finance the furnace modification).

3. Tobacco farmers

The biomass will be used in the kilns of the tobacco farmers as the end users. As mentioned above, this requires modification of the furnace. A survey of the project location indicated that the tobacco farmers have a strong but flexible relationship with FFI, BAT and STC through this initiative. The successful transition from wood-based fuels to PKS is proof that the relationship is based on the balanced distribution of rights and responsibilities.

4. Biomass distributors

New biomass distributors have emerged in recent years due to the increased market demand for biomass, originally triggered by STC. The number of distributors is still limited but nevertheless demonstrates the impact of the project. These distributors deal mainly with the tobacco farmers for trading purposes and the relationship is mostly financial and informal.

Table 2.1: Balance of relationships: rights, responsibilities and revenues of market actors

Actors	Rights	Responsibilities	Revenues
Tobacco farmers	- Land usage for tobacco farming - Sales of produce from the farm	- Manage and protect the agriculture area - Support the biomass initiative by purchasing biomass based fuels from the producers or local distributors	- Regular income from selling the tobacco
FFI	- Selection of suitable farmers to be group members - Provision of seed for candlenut/castor bean trees	- Train and build capacity of the farmers - Supervise the rehabilitation project activities	
ELI	- Enabling of access to tobacco network	- Provide support in the use of biomass-based fuels - Provide credit mechanism for the tobacco farmers	- Revenue from the tobacco bought from the farmers
STC	- Carrying out of R&D in biogas market sector - Enabling of access to markets for producers and sellers - Provision of capacity building and necessary training to communities	- Ensure and maintain the initial supply for renewable biomass for the tobacco farmers	- Income through the distribution and sale of biomass (PKS) - Funding from Agentschaap NL is used for initial market inception and technical assistance for initial furnace modification
Biomass farmers	- Sales of biomass and fruit produced from the trees	- Manage and protect the agriculture area - Support biomass initiative by planting biomass trees	- Income from selling biomass - Income from selling the fruits and vegetables

Based on the data collected from the project field, FFI, STC and BAT have shown a balanced distribution of responsibilities. The successful project at Gunung Sasak has created an even more positive atmosphere between the initiators and the biomass farmers. Recently, BAT has also supported the initiative by distributing biomass seed to the farmers.

On the end user's side, the relationship between BAT, STC and the tobacco farmers has also shown positive signs. The farmers are accepting and actively using the biomass feedstock and have been enormously facilitated by the flexible credit mechanism provided by BAT. This scheme is an interesting example of the promotion of the balance of rights and responsibilities between BAT and the farmers.

Assessment of potential livelihood outcomes

Seven sustainability indicators have been selected to assess the sustainability and the livelihood impact of the Lombok Energy Initiative. The results are as follows:

Indicator 1: Land use

Progress of the programme by the end of 2013 showed there has been no reduction in availability of crop land as a result of biomass planting. The trees used as biomass resource are planted on already degraded land. In fact, the initiative has increased the land available for crops and supports reforestation activity through the intercropping system which also used degraded land.

Indicator 2: Land tenure rights

The land used for tree planting is owned by the government. However, it has now been handed over to the farmers to be managed, reducing the land conflict that quite often occurred in the past. As mentioned above, before the initiative most of the biomass farmers did not own land and instead laboured on land owned by other farmers. If they could not find employment they often worked on the government's land illegally and serious conflicts with regional government frequently ensued. The initiative has successfully distributed work on the 430 ha of land among 1 300 farmers, for which purpose regional government has issued a permit for land management by the community.

Indicator 3: Food prices

Progress of the project by the end of 2013 indicated it had had no impact on food prices. The initiative does however contribute to increased production of crops which can be sold at the local market.

Indicator 4: Changes in income

The Lombok Energy Initiative has without doubt opened up new job opportunities. The biomass farmers reported that their income has reached IDR200 000 per farmer every harvest time of approximately once a week, quite a significant improvement. Changes in income are also reported by the tobacco farmers. The use of PKS is cheaper than using wood-based fuels meaning they have reduced their expenses, and when the candlenut and castor bean trees are ready for harvest they will enjoy increased income.

Indicator 5: Jobs and labour conditions

Biomass and crop planting on 430 ha of degraded land has provided employment for 1 300 biomass farmers and the distribution of PKS has created at least 600 part-time employment opportunities. With the growing demand of renewable biomass feedstock, opportunities for new jobs are increasing. Other positive impacts of the initiative include the start of micro home industries for food processing. FFI reported that some households have started to process the new crops into ready-to-eat food (e.g. taro chips, papaya chips and salted peanuts). Women are mainly involved in this activity.

Indicator 6: Energy access

The Lombok Initiative involves the sustainable provision of biomass energy (especially for drying tobacco), the promotion of which has had noticeable impacts. Farmer groups and other small distributors have begun to distribute and promote biomass to their local communities, resulting in an increase in energy service in the area.

Indicator 6: Energy access

The biomass supply and distribution system are part of the sustainable supply chain being developed by STC. The biomass farmers as producers sell the biomass to the tobacco farmers, either directly or through local distributors. Using this system, it is expected that biomass will replace a significant proportion of the wood-based fuel usage in the region. The new fuel will be more accessible, in terms of convenience, quality and affordability.

Barriers, drivers and interventions

There are a number of issues with the initiative. These are indicated in Figure 2 and explained below.

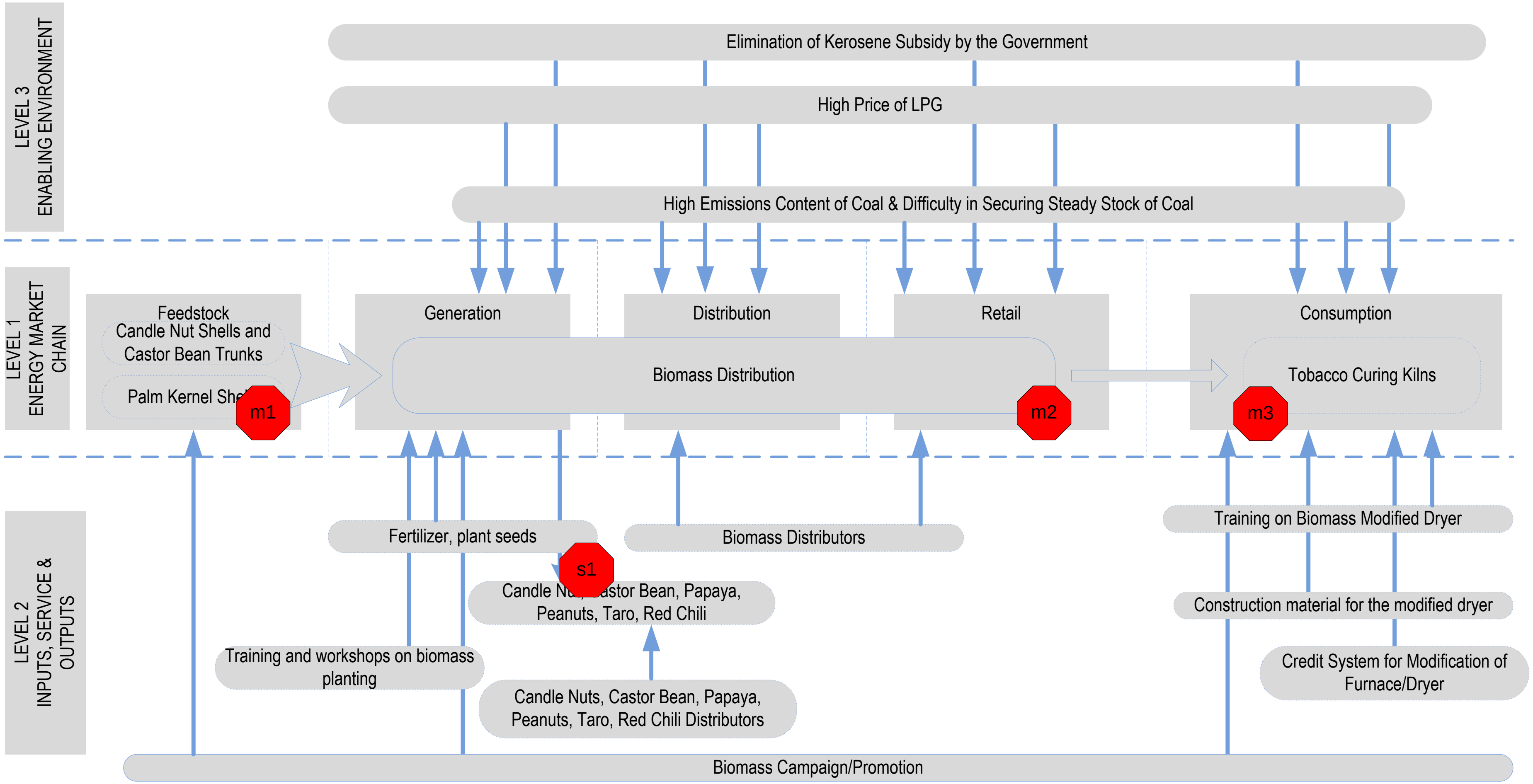

Figure 2.1: Barriers, drivers and interventions

Level 1: Energy market chain actors

M1: - availability of the palm shell biomass (temporary biomass);
- whether the candlenut shell and castor bean trunks are sufficient to fulfill tobacco industry demand.

M2: - control of biomass price by the biomass distributors;
- issue of price speculation (producers delay sale of biomass to distributors to get a higher price).

M3: - whether farmers are sufficiently informed on how to maintain the biomass furnace;
- efficient furnace/dryer technology with biomass feedstock.

Level 2: Inputs, service and finance

S1: - improvement required in developing the processed food home industry emerging sector in the region;
- minimalising of distributor involvement in marketing the products.

Table 3.1: Barriers, drivers and interventions

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
Biomass distributors (STC)	**Sustainability of the palm shell** Demand is increasing; however, availability and sustainability of PKS in the coming years is questionable	Current biomass is not sufficient to meet demand; farmers are returning to cutting down trees from local forest	Alternative sources of biomass to meet all of the demand	Conducting comprehensive survey to map all potential biomass alternative in the region
Biomass distributors	**Control of biomass price** Need to control price of biomass to avoid price fixing	Distributors are fixing price of biomass to their advantage	Fair competition among distributors or minimalisation of distributor roles in the market (direct trading between producer and consumer)	Coordination between distributors, biomass farmers and tobacco farmers
Tobacco farmers	**Proper technology for biomass fuel-based dryer** Need to find more sufficient and proper technology for biomass	Current biomass is not optimal for dryer in the kiln	Current biomass can utilized optimally in the dryer	Search for alternative technology and modifications

Conclusions

1. Impacts

Successful introduction of the concept of community forests (HKM)

The community forest concept is now being replicated in Nusa Tenggara province's other region. Its success in improving the livelihood of 1 300 farmers in Gunung Sasak has triggered the government's handing over of a further 10 000 ha of degraded land to be managed in the same way, and FFI is seeking additional funding to implement this. The demand for renewable biomass is growing and the current supply might not be able to keep up; expansion of the biomass plant is therefore essential.

Significant triggering of use of renewable biomass in the tobacco business.

Prior to the introduction of renewable biomass, farmers generally used wood-based fuels to dry tobacco; BAT recorded that in 2010-11, this grew exponentially in response to the elimination of the kerosene subsidy, from 3 to 70 percent. This initiative has proved highly successful in introducing the use of renewable biomass feedstock, to accommodate which (and with BAT support) almost all of the 1 300 farmers who are part of the BAT network have converted or modified their furnaces.

2. Lessons learned

Initiatives like these are often viewed with suspicion by farmers, and getting them involved is not easy. Extensive and intensive community coaching is needed break down barriers and earn trust. The involvement of BAT (with which farmers were already familiar) was very useful.

The successful implementation of the project has resulted in growing support from the government, which is now willing to promote the initiative and attend various activities with the farmers. FFI, STC, BAT and the farmers have learned that it is easier to start an initiative independently and seek government support afterwards, rather than make a proposal and request support in the initial stages.

3. Way forward

This initiative forms preparation for an initial phase of production and sale of biomas, scheduled to start in 2015 when the candlenut shells and castor bean trunks are ready for harvest. The result of this phase will determine the success rate of the whole initiative. The potential for scaling up is wide open, particularly in light of the government offer to replant 10 000 ha of degraded land.

References

STC. 2013. *Lombok Energy Initiative Overview*, available at: www.sustainabletradeandconsulting.com www.fauna-flora.org/explore/indonesia/.
www.antarantb.com/berita/25164/ratusan-petani-tembakau-lombok-gunakan-oli-bekas Interviews conducted 1–8 November 2013 with FFI project officers, STC project officer, biomass distributors and tobacco farmers.

Indonesia (Case 2): BIRU biogas programme

Initiative	**BIRU (BIogas RUmah) programme**
Location	*Lampung Province, East Java Province, DIY Province, Central Java Province, West Java Province, Bali Province, West Nusa Tenggara Province and South Sulawesi Province, Indonesia*
Initiation date and duration	*May 2009 to December 2013*
Funder(s)	*Dutch Government (through the Dutch Embassy, Jakarta, Indonesia)*
Project initiator	*HIVOS with technical assistance from SNV* *Currently transferred to Yayasan Rumah Energi (YRE, a HIVOS-affiliated local NGO)*
Overall budget	*EUR6 000 000*
Output	*1 300–2 300 litres of biogas per household per day*
Area of land	*Area required for each biogas digester and slurry pit is approx 24 m^2*
Beneficiaries	*10 000 households using biogas digesters by end of 2013*

Background and context

Biogas technology was introduced into Indonesia in the 1970s, when the cost of constructing a biogas system was significantly higher than it is today, thus limiting the development of the biogas sector. Other major barriers to development were a) the heavy subsidy of fossil fuels by the government and b) the relatively cheap and available wood-based fuels.

Over the last decade, with the rising price of fossil fuels and growing interest in renewable energy, biogas technology has started to receive more interest in Indonesia. In 2008, the Indonesian government proposed a feasibility study to determine the potential demand for biogas of one million household biodigesters. The study was carried out with funds from the Dutch government and results indicated that farmers on Java island were a suitable target to kickstart the programme. These farmers mostly stabled their cattle (making collection of animal waste for use as inputs relatively easy) and some were already familiar with biogas due to previous initiatives in the region.

In May 2009, the BIogas RUmah or 'household biogas' (BIRU) programme officially started. The Humanist Institute for Development Cooperation (HIVOS) was appointed by the Dutch government as programme manager, with technical assistance from SNV (the Netherlands Development Organisation). EUR6 million was allocated to implement the programme, with the target of installing 10 000 biodigesters by the end of 2013; HIVOS's latest data (mid-2013) shows however that approximately 11 000 biodigesters have been installed. HIVOS is continuously seeking further expansion of the number of households participating in the initiative.

This initiative was intended to create a sustainable domestic biogas market in Indonesia. However, despite its success, financial support is still needed to further develop and maintain programme activities, and HIVOS continues to seek additional funding to extent and expand the initiative. HIVOS data shows that the cost of building a biodigester is US$720. As part of the initiative, farmers receive a partial subsidy (US$220, approximately 30 percent of the total cost) to construct the biodigesters; they pay for the rest by through a credit mechanism. The subsidy is not paid directly to the farmers but to the construction partners who build the biogas system. HIVOS has approached several financial institutions (including local banks) to set up a microcredit mechanism enabling farmers to pay back the biodigester costs in installments over a payback period set to 3.5 years with monthly instalments of IDR144 000[4]. In East Java province, where farmers sell their dairy products to cooperatives, each installment is deducted from the monthly payment of the dairy products sold by the farmers. This scheme has been proven to be very successful and East Java is currently one of provinces where the largest number of biodigesters have been installed.

HIVOS initiated the programme by generating demand among potential household customers through awareness-raising activities and the provision of a subsidy to help farmers overcome high upfront investment costs. HIVOS also began actively working with financial and other institutions (lending partner organizations, or LPOs) to provide households with credit to build a biogas unit. At the same time, the BIRU programme selects and trains local masons or construction contractors (construction partner organizations, or CPOs) to promote and market household biogas systems; this includes the provision of three years high quality after-sale service. The programme also works with biogas appliance and parts manufacturers (alliance manufacturers, or AMs) to further ensure the development and sustainability of the biogas market.

Since the beginning of the programme, HIVOS has been working with the Indonesian government, in particular with the Directorate General of New, Renewable Energy and Energy Conservation (DGNREEC) as their counterpart. The government has facilitated and provided support during the implementation process of the programme, despite interest from the government being limited at first.

Food security

The initiative has had no significant impact on food security. There has been no change in the supply of food to the domestic market, as the biogas is not directly related to the food supply chain. Biogas production does not need to acquire crop or farming land; the biodigester is usually constructed on vacant land or takes up part of a farmer’s cowshed.

The second part of the tool (resource availability and efficiency of use) produces a similar result; land use management is not part of the biogas initiative. A different result is observed in Part 2.4 (fertilizer use efficiency): the use of bioslurry has improved and increased the crop production. The farmers reported during the interviews that their crop production has increased up to 30 percent since using the bioslurry. An additional benefit is that after applying bioslurry, farmers have been able to reduce the use of chemical fertilizer to 50 percent (and in some cases up to 70 percent). Average saving is reported at approximately IDR500 000 per month, depending on the size of the farm land. Unfortunately, HIVOS does not collect detailed data of every beneficiary; numbers are therefore based on interviews with several farmers and recorded experiences of BIRU programme officers.

[4] Average currency rate: 1US$ ~ IDR 10 000. This exchange rate is applicable for the whole document. In 2013, HIVOS stated that the payback period had been revised from 3.5 years to 5 years, with lower instalments.

Another impact is also indicated by the last part of the tool (physical displacement, change in access to resources, compensation and income generation). Information received from HIVOS officers indicates that hundreds of jobs have been created through this initiative (masons, biogas appliance manufacturers, distributors, etc). In addition to waged employment, farmers are benefiting from needing to purchase much less fertilizer and less LPG/wood/kerosene for cooking. The produce being sold to the local market has also increased, reflected in increased income generation. Once again, as no detailed data is available, input data in regard to the tool is limited.

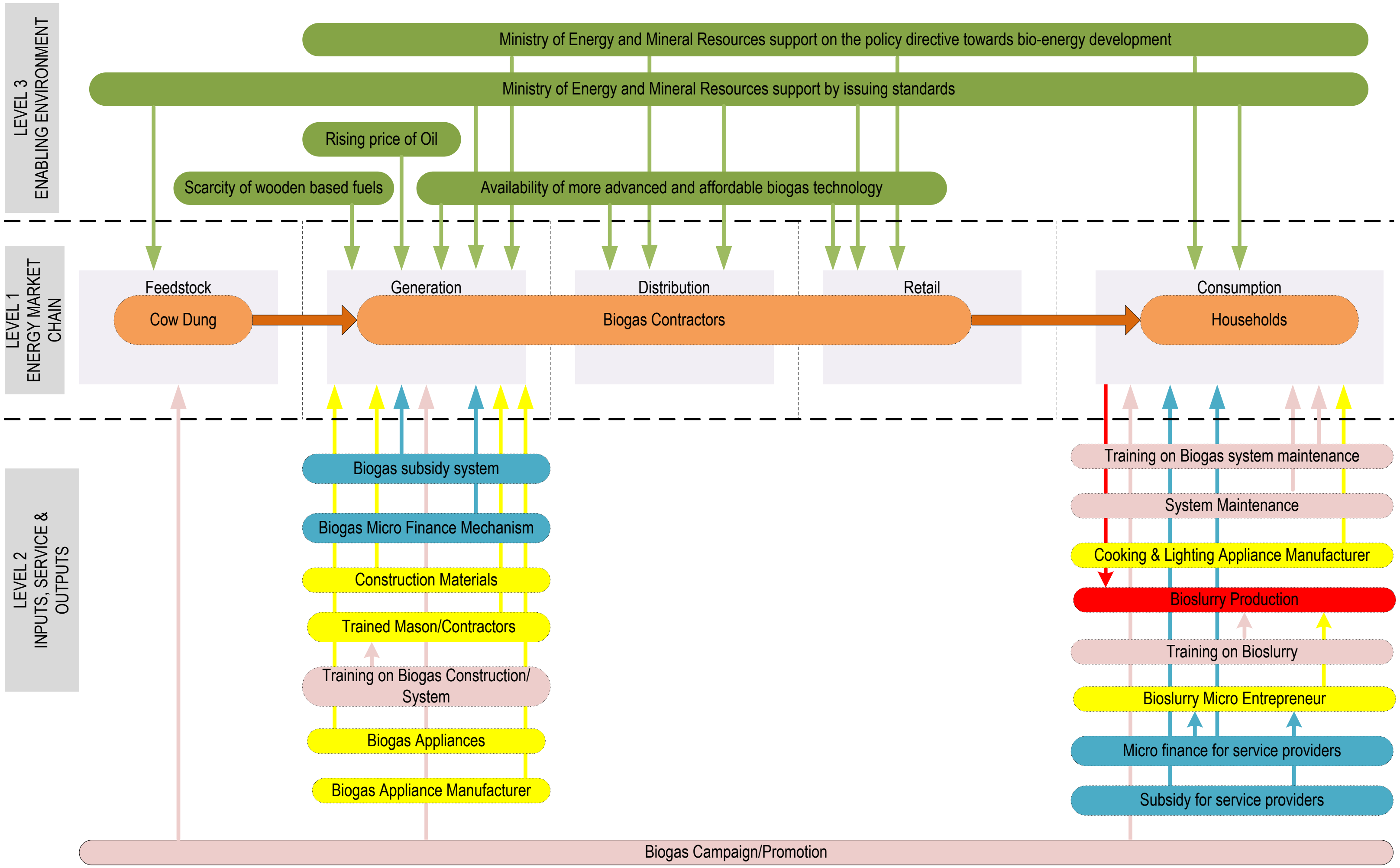

Figure 1.2: Initiative market map

The initiative market map

The main goal of this initiative is to create a sustainable and well-run market in the biogas sector. To achieve this, HIVOS is focusing on the creation of sustainable demand and supply of biogas.

Firstly, farmers have to get involved and participate willingly in the initiative. Next, HIVOS is continuously improving the quality and availability of the biodigester system. Additional assistance (through training, workshops and capacity building) to service providers as the supporting system (e.g. masons and biogas appliance manufacturers) is also provided. HIVOS also conducts routine monitoring to ensure the maintenance level of biodigesters and the appliances by the farmers.

The main partners of HIVOS in the BIRU programme can be categorized in three types: CPOs, appliance manufacturers and LPOs. The CPOs consists of numerous small NGOs and private sector organizations, including dairy companies. They train and recruit masons as well as conducting the biogas construction, after signing a contract with the farmers. The completed biogas appliances are supplied by the manufacturers; HIVOS has trained and certified local companies to produce almost all the appliances locally. The lending partner provides funding through the biogas credit mechanism; LPOs include banks and private companies (including the dairy companies/cooperatives).

MEMR as the government counterpart of BIRU has shown a growing interest and has lent its support during the course of the programme. It has issued standards for fixed dome biodigesters and, based on input from HIVOS, is in the process of issuing standards for biogas stoves and lamps. The next section of this report discusses the actors and their role in this initiative in more detail.

Level 1: Energy market chain

This identifies a typical biogas market chain system. The first function (the feedstock) is the waste produced by cattle farms, owned by the farmers. Several types of farmers participated in this biogas programme: dairy farmers and dairy + agriculture farmers. The next functions (generation, distribution and retail) deal with the construction of the biogas system. Within this initiative, this is conducted by biogas masons/contractors that have been trained by HIVOS. Regular monitoring is conducted by HIVOS to ensure the quality of biodigesters is maintained. The last function is the end user (i.e. the household of the farmer that owns biogas). A total of almost 11 000 households are currently using biogas under this initiative.

Level 2: Inputs, services, finance and outputs

Level 2 describes the initiative’s supporting elements. There are four types of financial service: i) the biogas subsidy system (provided by HIVOS for the farmers), ii) biogas microfinance (provided by the lending partner, such as banks or cooperatives), iii) the subsidy for the service providers (provided by HIVOS for biogas appliance manufactures) and iv) microfinance for the service providers (provided by the banks or cooperatives). The subsidy is intended to overcome the high upfront investment needed to build the biogas system, so that farmers will be interested in the BIRU programme and be able to participate in it.

Other services indicated at this level are those related to the building and maintenance of, and training in, the biogas system. The biogas contractors provide these services. Training is also provided by HIVOS for the biogas contractors to ensure the service provided to farmers is high quality. Simple training in biogas system maintenance is also provided by HIVOS to the farmers to equip them with sufficient knowledge of the daily operation of the biogas system, along with training in bioslurry handling and usage.

Inputs identified at this level are construction materials (available locally), biogas contractors (trained by HIVOS), biogas appliances (mostly locally made, the remainder imported) and appliances manufactures (trained by HIVOS). The biogas appliances are made locally by the appliance manufacturers, as partners of HIVOS in the BIRU programme.

Finally, the map indicates one output from the biogas programme, which is the bioslurry. This is a by-product of boiogas production and expected to add to the benefits of biogas experienced by the farmers.

Level 3: Enabling environment

The rising price of oil, scarcity of wood-based fuels and availability of more advanced and affordable technology are the overriding factors of this initiative, and are beyond the reach of its interventions. The remaining two factors (policy and standards) are reachable and therefore possible to change and improve through specific interventions.

Policy in the renewable energy sector, especially in bio-energy, has shown fairly significant improvements. In 2007, the government issued Law no 30 concerning the energy sector, and has also issued regulations and policies which have provided incentives for renewable energy developers (ranging from reductions in tax, duty exemption and attractive feed-in tariffs for renewable energy-based electricity). The government has also set a new target for the development of the renewable energy sector and has allocated sizeable funding for this. This trend is providing an increased welcoming environment for the BIRU programme implementation. Along with the issuance of policy in the renewable energy sector, the government has begun to issue standards to provide support in achieving the target.

Table 1.2: Relationships between market actors

	Farmers	Construction partners (biogas contractors)	Biogas appliance manu-facturers	Lending partners (banks/ cooperatives)	Cooking/ lighting appliance manu-facturers	HIVOS/ SNV	MEMR
Farmers							
Construction partners (biogas contractors)	Formal						
Biogas appliance manufacturers	Financial, informal	Financial, Informal					
Lending partners (banks/ cooperatives)	Formal, financial,	Formal, financial	Formal, Financial				
Cooking/lighting appliance manufacturers	Financial	Informal	Informal	Informal, financial			
HIVOS/SNV	Formal/ informal technical, financial	Formal/ informal, technical	Formal/ informal, technical	Formal	Informal		
MEMR	Formal, regulatory	Formal, regulatory	Formal, regulatory	Formal, regulatory	Formal, regulatory	Technical, formal, regulatory	

1. Farmers

Under the BIRU programme, each farmer is obliged to sign a formal agreement (verified by HIVOS) with the biogas contractor before constructing a biogas system. The relationship between the biogas and cooking/lighting appliance manufacturer is in the main strictly financial and informal. The relationship with the lending partner is largely financial and formal. The farmers depend on the microcredit mechanism to enable them to construct the biogas system. HIVOS has made efforts to cooperate with banks and cooperatives to set up an affordable credit mechanism for the farmers.

2. Construction partners

Construction partners mainly deal with biogas appliance manufacture through commercial transactions during construction or maintenance. Interviews with both actors indicate that the relationship is strong but informal. The relationship between contractors and the lending partner is mostly formal and financial. Some local cooperatives give microcredit to contractors as an upfront investment. The relationship between construction partners and lighting/cooking appliance manufacturers is mostly informal; they do not have a direct relationship, except where the biogas appliance manufacturer is the same person or institution.

3. Biogas appliance manufacturers and cooking/lighting appliance manufacturers

The relationship of these manufacturers with other actors (especially farmers and lending partners) is mostly financial. Some biogas appliance manufacturers are also cooking and lighting appliance manufacturers and they received technical support from HIVOS at the beginning of the initiative through training and workshops.

4. Lending partners

The financial relationship between the lending partners and other actors in the initiative is as a result of the microcredit mechanism. It is crucial that a proper system is in place to support the development of the biogas system and ensure it works efficiently for farmers and the service providers.

5. HIVOS/SNV

As the initiator of the project, HIVOS provides technical and financial support to the farmers (who are the main beneficiaries) and to the service provider (e.g. contractors, appliance manufacturers). HIVOS also provides inputs to MEMR in terms of developing standards for biogas systems.

6. MEMR

As the regulatory body, MEMR has been providing support in the development of bioenergy. It implemented a biogas programme in several locations in Indonesia; however, these mostly ended in failure due to poor project design and management, and limited capacity building and community coaching. One example is MEMR’s biogas programme in Nusa Tenggara region where the government distributed biogas systems to farmers with a 100 percent subsidy. However, the programme was not accompanied by sufficient training and coaching for the communities and this caused its failure. HIVOS is currently planning to fix the biogas systems from this government project and include them in this initiative.

Table 2.2: Balance of relationships, rights, responsibilities and revenues of market actors

Actors	Rights	Responsibilities	Revenue
Farmers	- Land usage for farming and raising cattle - Sales of produce from the cattle (livestock and dairy) - Receipt of subsidy for the biogas system.	- Manage and protect the agriculture area - Maintain and operate biodigester - Pay remain of the biodigester investment credit	- Regular income from selling produce (livestock, crops, dairy) - Additional revenue from using biogas for cooking/lighting - Additional revenue from using/selling bioslurry
Construction partners (biogas contractors)	- Select potential receivers of BIRU biogas in targeted area	- Train/recruit masons - Construction of biodigester/ supporting system - Ensure quality of biodigester and capacity of masons	- Income from constructing biodigester
Biogas and lighting/cooking appliance manufacturers	- Sell biodigester appliances	- Maintain quality of appliances - Maximize use of local raw materials	- Revenue from selling the biodigester appliances
Lending partners	- Enabling access to funding resources for credit mechanism	- Support the micro credit mechanism in order to support the biogas initiative	- Revenue through credit mechanism
HIVOS/SNV	- R&D in biogas sector - Enabling access to biogas for areas to utilize potentials in order to reduce poverty and improve livelihoods - Provide capacity building and necessary training to communities/stakeholders - Approve selected farmers who are entitled to receive biogas subsidy from BIRU programme	- Ensure and maintain programme objectives will be achieved accordingly.	
MEMR	- Set standards for biogas appliances - Issue regulations/directives in biogas sector	- Support development of biogas (bioenergy) sector in Indonesia - Facilitate initiatives to promote biogas sector	

The balance between these three elements is crucial to support the sustainable use of the BIRU programme. Discussions and interviews with various programme actors and stakeholders show that

HIVOS is quite successful in playing the role of initiator. The distribution of responsibilities to its partners during the implementation seems to be working quite well.

The partial subsidy provided to the farmers is one of the strategies designed to forge a sense of ownership of the biogas programme and thus their sense of responsibility. The microcredit mechanism provided by the lending partners is a way to promote the balance of rights and responsibilities (in particular between the dairy farmers and the cooperatives). The success of this scheme is a proven example of that.

One question remains concerning the role and responsibilities of MEMR as the regulatory body. Officially, the policy directives are in the favor of bioenergy, including biogas. Unfortunately this has not been followed up with a well-planned programme. On many occasions the biogas programme from the government (who offered 100 percent subsidies of the biogas system) failed. This is mainly because of the poor quality of biodigesters and the appliances, and the minimum amount of coaching and training given to the communities.

Another concern is the standards and specific regulation for biogas sector. The government seemed slow to react to this need. HIVOS has been actively giving their technical inputs in the past few years to accelerate the issuing process.

Assessment of potential livelihood outcomes

The identification of potential livelihood outcomes of the biogas initiative are assessed through drawing the understanding of the relationships between the various market actors involved in the initiative and their respective relationships, responsibilities, rights and revenues as described below. Seven sustainability indicators have been selected to assess the sustainability and the livelihood impact of the BIRU programme. The results are as follows:

Indicator 1: Land use

Based on the current progress of the programme, there is no reduction in the amount of land available for growing crops due to biodigester and slurry pit locations. Usually, biodigesters are located near the cowshed and these areas are normally not used for crop production. If the locations of the biodigester and slurry pit are partly in the crop plantation, the land used is very limited (approximately $24m^2$ for each biogas system) and practically has no effect on the crop production.

Indicator 2: Land tenure rights

The locations of the biogas digester, slurry pit and the pipelines including the area of the cowshed are owned by the farmers. There has thus been no conflict in securing the land for the initiative. However, the farmers have to sign the contract to ensure that they are willing and committed to invest in the biogas programme and agree to follow all of the necessary actions.

Indicator 3: Food prices

Based on the nature of the project, it does not have any direct impact on the food prices. Judging from previous experience, the price of food is strongly driven by the price of oil (the amount of subsidy) and the weather (for rural areas weather plays an important role in the access/road conditions).The direct impact of the project is the increasing quantity and quality of crops production due to the bioslurry use (average of 30 percent additional crops production as mentioned above).

Indicator 4: Changes in income

The BIRU programme has without a doubt opened up new business sectors. Hundreds of jobs – for example, masons, appliance makers, and distributors – have been created throughout the course of the programme and a new market has emerged. According to data provided by HIVOS, each household is able to save IDR100 000–IDR150 000 (US$10–150) per month from using biogas instead of buying wood, charcoal or LPG to use for cooking. Some of the households also use lighting from biogas energy resources which reduces their electricity bill slightly (detailed data is not available, either from the farmers or HIVOS). Additional income is obtained from additional crops and selling bioslurry (IDR150 000–IDR250 000 or US$150–US$250 per month) at the local market. Several farmers own cattle but do not have farm land; they usually sell their bioslurry to other farmers in the village who need additional bioslurry as fertilizer. The latest data from HIVOS shows that the number of microbusinesses in the bioslurry sector has increased. The demand for bioslurry as fertilizer is slowly growing. However since this market is still in its early stages, it still needs support to ensure its sustainability.

Indicator 5: Jobs and labour conditions

Detailed data regarding the total number of jobs created as part of the impact of this programme is not available. However, an interview with the BIRU programme officer and several village elders indicated that hundreds (and possibly thousands) of jobs have been created in biogas appliance manufacture, and biodigester construction or distribution. Most of these new employees are not highly educated, and some jobs (such as biodigester contractor or bioslurry seller) are part-time. Most of these jobs involve skills provided through the HIVOS/SNV training and capacity building.

Indicator 6: Energy access and energy security

Implementation of BIRU has led to approximately 11 000 households currently utilizing the energy potential from their own backyards. Some areas with a minimum electricity service from PLN (the state-owned electricity company) utilize the biogas for lighting as well as cooking. The biogas light fittings are already being made locally; a small number of imported light fittings are still available in the market. The price of the biogas lighting is IDR150 000–IDR200 000 (US$13–17). There is no data available on its life, but even when in daily use (the longest use being approximately three years) problems are seldom reported. Maintenance is simple (routine cleaning; regular changing of lamp casing).

Through their utilization of biogas the farmers have also gained easy access to an affordable and healthier means of cooking. The cleanliness level of the kitchen has improved, which in turn has improved the health quality of the household members.

The supply and distribution system of the biogas sector mainly involves the farmers, masons and appliance manufacturers. HIVOS and SNV provide continuous support to establish a sustainable market that is supported with a stable infrastructure. The market is still emerging and the supporting infrastructure developing, so it is not yet sufficiently reliable. In general however, biogas is a straightforward and simple technology. The feedstock is sustainable and secure as long as the manure is available.

Barriers, drivers and interventions

The initiative has a number of barriers, drivers and interventions, as indicated at various levels of the market map presented in Figure 2.2) and described in more detail in the following section.

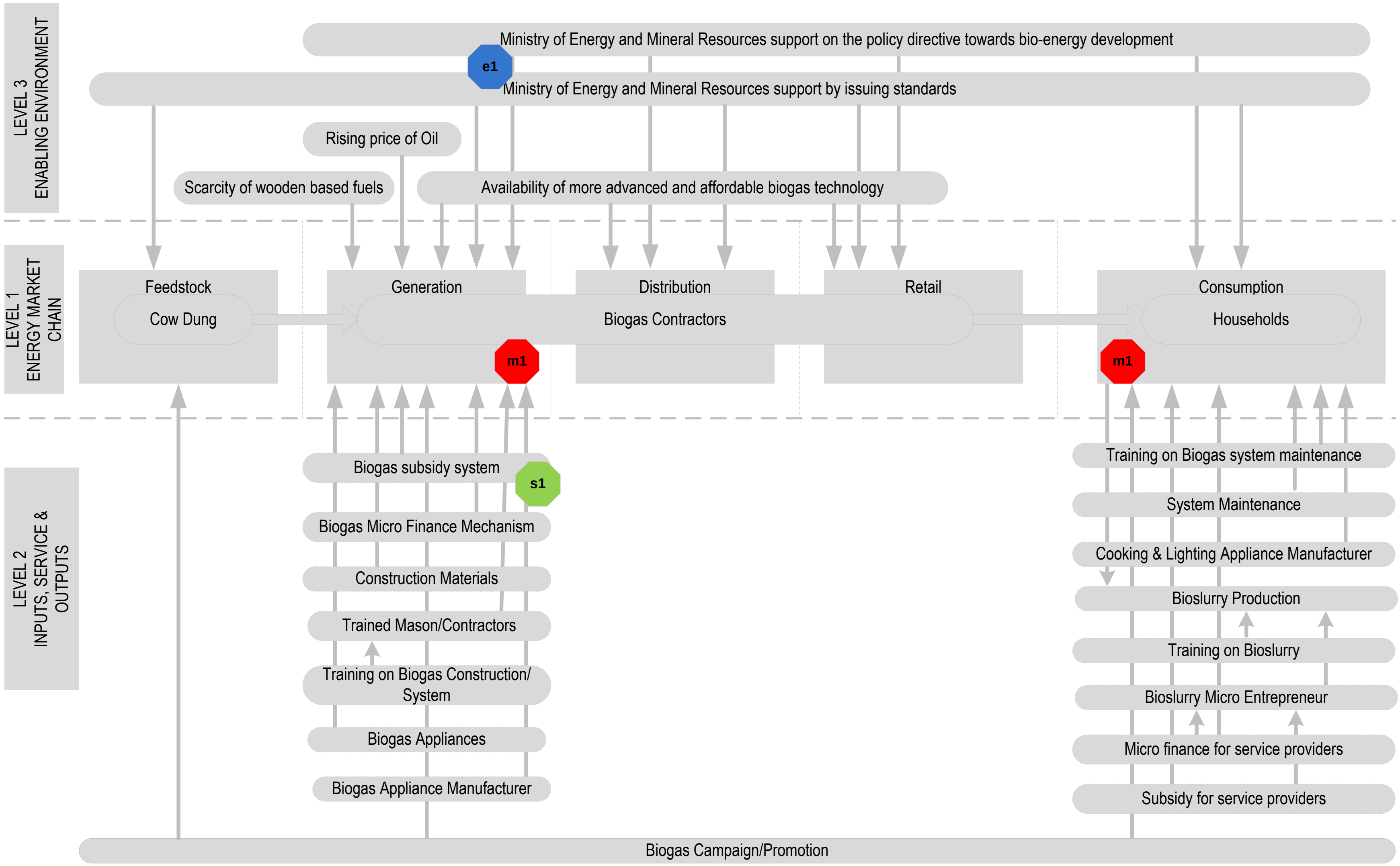

Figure 2.2: Market map indicating barriers, drivers and interventions

Level 1: Energy market chain actors

M1: - lack of sufficient space for biodigester and slurry pit for some potential farmers.

M2: - lack of awareness around purchasing high quality appliances (many unauthorized imitations of biogas appliances are sold much more cheaply).

Level 2: Inputs, service and finance

S1: - the microcredit mechanism needs to be further developed.

Level 3: Enabling environment

E1: - standards are only in place for the fixed dome and stove;
- coherence between government biogas programme and BIRU.

Table 3.2: Barriers, drivers and interventions

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
Biogas contractors	**Technology design and installation** Biogas system design requires minimum of 24 m^2 of land	Maintain quality of appliances Some farmers do not have sufficient land for the biogas system	Initiative developed new way to have a more compact and efficient biogas system that requires smaller amount of land	Develop new technology to address land deficiency issue
Lending partners	**Microcredit** More local finance institutions and cooperatives to be involved as lending partners	Difficulty finding more financial institutions to set up more developed microcredit mechanism	More financial institutions to be involved in microcredit mechanism	Carry out door-to-door lobbying; possible cooperation with government institutions
Households as end user	**Biogas appliances** Purchasing biogas appliance as part for system maintenance	Biogas users opt for cheaper appliances with poor quality; these compromise the biogas operation	Increase in awareness by end user to opt for better quality appliances	
MEMR	Issuing standards and policy for biogas sector (bioenergy sector)	Policy and standards do not provide sufficient support for development of biogas sector, as they only cover part of the sector; the government's 100 percent subsidy policy programme is proven to be not working	Well-regulated and supported biogas sector	

Conclusions

1. General remarks

Compared to other biogas programmes in Indonesia, the BIRU initiative has certainly achieved better results. Not only is this the biggest programme so far in terms of numbers of biodigesters installed, but the implementation concept has been used and replicated in many countries such as Nepal, Kenya, Nigeria (where SNV is mostly involved in the biogas programme). However, the BIRU programme is still limited geographically in Indonesia. Although statistically it has been implemented in eight provinces, most of the beneficiaries are in Central Java and Yogyakarta region (DIY), West Java, East Java and West Nusa Tenggara regions. HIVOS data recorded that in Central Java+DIY, around 1 000 biodigesters have been installed, and 1 200 in West Java. The farmers in East Java region have the highest number of household biodigesters (approx 6 000) and in West Nusa Tenggara province, 1 500 biodigesters having been installed. The remaining installed biodigesters are scattered throughout the remaining five provinces.

2. Lessons learned

Getting the farmers actively involved in this initiative was not easy, as previous negative experience with the government biogas programme made them reluctant to re-enter the biogas business. As mentioned above, the government biogas programme offered a 100 percent subsidy but did not provide sufficient training for farmers. As most of the farmers did not know how to operate the biogas correctly, and with no after-sale service or maintenance, failure ensued. Extensive and intensive community coaching was part of the programme, needed to break down such barriers and retrieve the farmers' trust. The BIRU programme was therefore designed not only to enhance demand and supply, but also to create a complete supporting system.

Further effort was required to engage poor farmers, for whom installing biogas was not the highest priority. Despite a rigorous campaign highlighting the benefits of biogas (such as saving money, having a cleaner kitchen and healthier household, and bioslurry as a by-product), these nevertheless appeared elusive. However, two and a half years after the start of the programme, these behaviours had changed significantly, especially when farmers started to experience the benefits for themselves. In interviews, some farmers stated they were very pleased with the use both of biogas for cooking and bioslurry as fertilizer. One farmer's family said that prior to the initiative they used wood-based fuel for cooking; due to the time needed to make a fire and cook, every morning they went without breakfast. This changed after starting to use biogas, which makes cooking quick and easy.

Another crucial issue is the need for coordination with the implementation process of government projects. As previously mentioned, the government has allocated sizeable funding for the bioenergy sector (including the biogas sector), and has in recent years also been extensively developing a biogas system in many provinces in Indonesia. Under this government programme, biodigesters and biogas appliances were distributed freely to the farmers. These differences in the implementation model are one of the key issues that need to be addressed. HIVOS is coordinating with both central and regional government on an ongoing basis to find the best solution to this.

3. Way forward

The potential to scale up the BIRU programme is wide open. HIVOS's target is to install an additional 30 000 biogas digesters in the next five years. This plan requires at least US$16 million from external funding (mainly to subsidize the farmers' upfront investment).

More financial institutions are needed to get involved in the programme. For example, the microcredit scheme will need three times the amount of current investment if the scaling up plan is to be carried out.

The government has recently issued policies and regulations to support the development of the renewable energy sector; these provide incentives in tax reduction and import duty for renewable energy utilization.

HIVOS pledged funds to extend the project; there is also some funding from Norway and GIZ. This however is insufficient to meet HIVOS's ambitious future plans.

It is also important agenda to strengthen the relationship among existing partners. The CPOs, AMs and LPOs are the backbone of the BIRU programme implementation model and if the initiative is to be expanded and extended, their strong cooperation and coordination are essential.

References

BIRU. 2011. *Standard operating guidelines for the Indonesia domestic biogas program* (also available at www.BIRU.or.id)

ASTAE (Asia Sustainable and Alternative Energy Program). 2013. *Indonesia: Toward Universal Access to Clean Cooking.* East Asia and Pacific Clean Stove Initiative Series. Washington, DC. World Bank.

www.spi.or.id/?p=1496

Philippines (Case 3): La Suerte rice hull power plant

Initiative name	**La Suerte rice hull power plant**
Location	*San Manuel, Isabela, Philippines, South East Asia*
Initiation date and duration	*2003 (planning stage)* *2007 (completion and commissioning)* *2008 (start of operation)*
Funder(s)	*Reynaldo Tan* *Development Bank of the Philippines* *~US$2 million (with at least 20 percent owner's equity)*
Project initiator	*Reynaldo Tan*
Overall budget (if available)	*Estimated at PHP90 million[5] +++* *(US$~2 million, with at least 20 percent owner's equity)*
Output	*0.7–0.75 MW of electricity (operating output)*
Area of land	*3 500 m² (approximately)*
Beneficiaries	*More than 200 workers (rice milling and power processing)* *More than 1 000 rice farmers (estimate, indirect)*

Background and context

Isabela is the second largest province in the Philippines, located in the far eastern part of Northern Luzon, part of the Cagayan Valley Region. The most widely-spoken language is Ilocano. It covers more than one million ha and has 34 municipalities and over a thousand *barangays*[6] (Province of Isabela, 2013). It is the home of one of the largest remaining rainforests in the world. The province is a primary agricultural basin; Isabela is country's the top producer of corn and rice is the province's next major agricultural commodity. Rice mills are widely dispersed throughout different municipalities. In 2010, around 865 000 tonnes of *palay* (unmilled rice) were produced. This translates into significant amount of rice hull waste which is generated in the mills during rice production.

The La Suerte rice hull power plant is the first rice hull-fuelled biomass power plant in the Philippines. The facility is owned and managed by a private rice milling family, headed by Reynaldo Tan from Isabela. Rice hull (or rice husk) is the outer protective covering of the entire rice grain; it is inedible and must be removed during the dehusking process of rice milling. It provides a type of biomass and is a constant by-product of the rice milling process.

[5] US$1 equivalent = PHP44.5 throughout this document.
[6] An administrative division of the Philippines.

The power plant is located in a rural area, significantly far from any major metropolitan area and beside the La Suerte rice mill (LSRM) in San Manuel, a town with a population of about 30 000. The technology used is a combination of fire and water tube boilers, including a water-cooled step grate with pushers to move the rice hull down the grate. Rice hull is carried to the boilers along conveyors, and fed into the boiler. Steam is then used to run the turbine, which has a rated electrical output capacity of 1000 kW. The flue gas is then passed through multicyclone collectors.

There are two major reasons for establishing the biomass power plant. The first is the need to dispose of the rice hull and the second is the province's unstable power supply. Solid waste management (in terms of the rice hull generated by its rice mills) is a problem for the municipality of San Manuel; in LSRM alone, 3.8 tonnes of rice hull are generated annually. Its disposal in La Suerte incurs significant costs, particularly in terms of transportation and labour. Lack of designated dumping sites is a further complication for the municipality.

The power supply is intermittent throughout the whole province, forcing LSRM to use diesel-powered generators – a high cost, intensive alternative – to maintain scheduled rice production demand throughout Luzon. Any interruption in power can significantly reduce production (and thus revenue) of La Suerte. The establishment of the La Suerte biomass power plant was the optimum way to solve the disposal issue and at the same time provide a dedicated power source for the rice mill. This model – integrating a rice hull power plant into rice milling – has been pioneered by La Suerte. The rice hull power plant has been in operation since 2008. The project's projected return of investment was around three years; it is now self-sustaining with no subsidy or external financial support.

Vulnerability factors

Employment and income trends

In the Philippines, agriculture is an industry that creates significant employment, and since 2007 employment in agriculture has increased by six percent; by 2012, 844 000 jobs were generated by agriculture. However, the share of agriculture among other industries in term of employment has decreased to about 1.3 percent (BAS, 2013). According to PhilRice (2010), more than two million households (or roughly ten million Filipinos) are engaged in rice-based farming, with nominal income from rice increasing by 38 percent between 1996 and 2007. However, inflation meant that increases in income and harvest yield were not translated into rice farmer purchasing power. Most relied on rice farming to meet household expenses and most of the income generated from rice production is allocated to education and basic necessities. By 2007, income from rice-based farm households had helped increased the poverty threshold from 46 to 57 percent. However, poverty alleviation also involves the equitable distribution of income, and closer examination of the data shows that most of the income generated by agriculture went to rich farming households, while small farmers belong to lowest income groups (PhilRice, 2010).

Gender and labour

In 2012, the agriculture sector labour force reportedly comprised a total of 9 million men and 3.09 women nationwide. These are individuals; some may belong to the same households (BAS, 2013). In Isabela, there has been a 1.7 percent growth in male farmers (in the age range of 15 years upwards) and a 1.4 percent growth in female farmers. Male farmers usually perform intensive farm activities (ploughing, harrowing, planting, harvesting) and most of the post-harvest activities. Women farmers usually carry out farm maintenance.

Price seasonality

The price of *palay* (paddy) fluctuates weekly as monitored by BAS (2013). In Isabela, rice millers and buying stations buy *palay* at an average of PHP19 (or US$0.44) per kg; however this can reach PHP23 (or US$0.53) per kg), far beyond the national average of PHP17 (or US$0.40) per kg.

Disease and mortality

Heart disease is still the top leading cause of death in the Philippines. Over five-year period (2006–11) more than 80 000 people died because of it. Other causes of mortality are vascular disease, pneumonia, tuberculosis, accidents and lifestyle diseases. In rural areas, drinking and smoking is common.

Natural calamity

Flooding is a common major natural disaster in Isabela (Province of Isabela, 2013). In September 2009, two typhoons (Ondoy and Pepeng) were recorded as having caused enormous damage to agricultural products. This was followed by El Niño (intense drought) in the early months of 2010. Isabela was heavily devastated, with 62.25 percent of its total area planted with *palay* destroyed. Damage to local agriculture affected a total of 112 000 farmers (Boongaling, 2010). Infrastructure was badly affected and prices of commodities increased beyond the seasonal average, exacerbated by the failure of the government to impose price control measures. After three years of rehabilitation and reconstruction, since 2012 Isabela is once again considered a major rice producer.

Food security

The rice hull power plant is a potential benefit for food security.

Land use and food supply

The 1 MW biomass power plant is only operating at 84 percent working capacity. It takes up less than one hectare of land and thus does not pose a threat to land use in the locality. Around 9 000 ha of rice fields are needed to fulfil the demand for rice hull; Isabela's total rice-planted area is 120 000 ha, producing rice hull that would serve as feedstock for 14 more rice hull power plants.

Since rice hull is a waste product there is no negative change to the annual supply of food. In fact, the rice supply in Isabela has increased during the five years of the power plant's operation, with rice farmers there enjoying an average of four tonnes per ha of harvest yield, ten percent higher than the national average. This high yield is attributed to its seasoned farmers and better management practices. In addition, Isabela's local government has devised a sound agricultural programme for rice production.

One advantage of the biomass power plant is its savings on power demand. Instead of using diesel generators during intermittent power supply, the biomass power plant provides a steady source of electricity which further extends the rice mill's operation for about 6 hours. The increase in rice milling capacity enables LSRM to accommodate more rice paddies from farmers. This provides extended and assured markets for rice farmers.

In line with the country's rice sufficiency programme, rice farmers are encouraged to plant rice and avoid changing to the cultivation of other crops. LSRM believes that financial subsidy to farmers can realize an indirect positive impact in terms of rice sufficiency. The savings from the power plant can actually increase buying price of LSRM for the rice paddies, which may convince more farmers to plant rice. The disadvantage is that this would threaten other rice mills in Isabela unable to compete with LSRM pricing.

LSRM has thus only slightly increased the price it pays for rice, while instead improving its credit mechanism for farmers. So far, yields are being maintained with financial aid coming directly from LSRM.

The quality of rice has actually improved with the establishment of the biomass power plant. With the extended hours of operation, drying of rice can now be done during the evening, which is ideal because of the ambient temperature and humidity[7].

The facility also produces by-products such as rice bran and rice germ (rice endosperm) which are used by feed millers for feed production. It can produce 1.7 tonnes per hr of combined bran and germ during every operation. Rice bran can be bought at PHP10–PHP14 (US$0.23–US$0.32) per kg.

The Philippines is currently moving towards rice self-sufficiency, and, at the time of writing, it was optimistic of achieving 98 percent by the end of 2013. In 2010, rice imports amounted to 2.4 million tonnes; this went down to 200 000 tonnes in 2013 (PhilStar, 2013).

Resource availability and efficiency of use

Isabela is one of the most efficient rice producing provinces in the country. One reason is that the government has devised programmes establishing good practices for land use management, some of which involve hybrid development, minimum tillage systems, precision agriculture, integrated systems for pest and disease control and improvement of nutrition. In recent years, climate-smart farming has also been introduced in the province, and as noted above, Isabela outstrips the national average rice yield.

Fertilizer efficiency is important; price increases in chemical outputs has however led to a move towards a larger share of organic farming and the Department of Agriculture (DOA) has launched demonstration farms which use organic fertilizer and pesticide. The biomass power plant provides ash to farmers as a form of support for organic farming initiatives, which is used on the rice fields as an additive to condition the soil.

Changes in resources, compensation and income

The rice hull power plant presents no issues in terms of tenurial rights and livelihoods in the province. On the contrary, it has accelerated rice production through its increase in capacity. The LSRM can act as an encouragement to other rice mills which, if they employed the same strategy, would significantly promote the overall rice production capacity of the province.

There has been no physical displacement of households and livelihoods in the locality because of this initiative. Financing provisions for farmers may have improved due to the savings incurred because of the power plant. Road networks have also improved in the locality which in turn improves access of farmers to LSRM. The power plant has also brought about financial aid and farm inputs (i.e. ash).

[7] According to the powerplant, ambient temperature in the evening serves as a buffer environment, controlling the high temperature of dryers which can potentially destroy polished the rice grain. This has been practiced by the powerplant since it began operation.

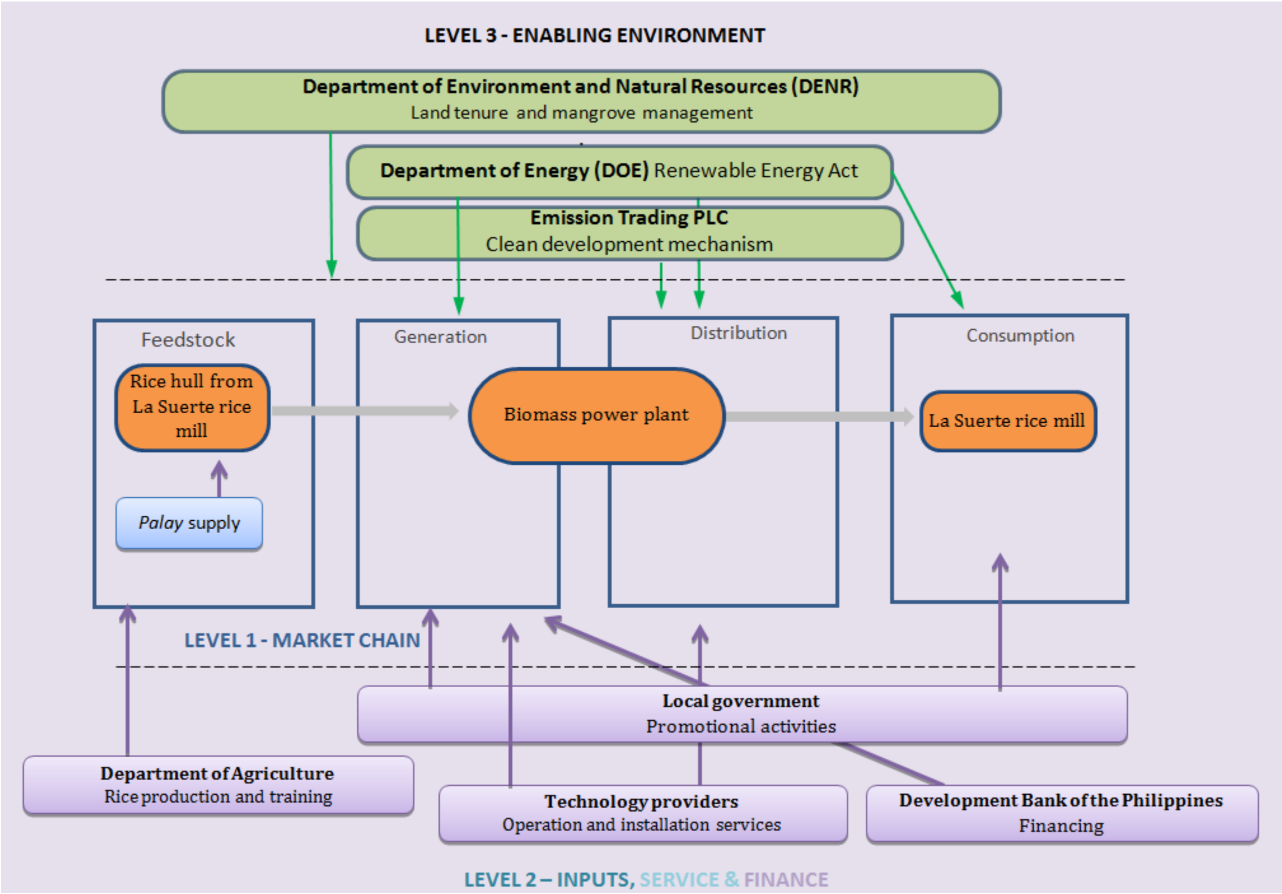

Figure 1.3: Initiative market map

Initiative market map

Level 1: Energy market chain

La Suerte rice mill (LSRM) is the source of rice hull for the biomass power plant. It has a rated capacity of 16.5 tonnes/hr of *palay* (rice paddy). Assuming 12 hours of operation at 360 days per annum, LSRM can potentially accommodate around 71 280 tonnes of *palay* and can provide a seven percent share of Isabela's total rice production (which is 865 839 tonnes). For every tonne of *palay*, 0.23 tonnes is rice husk which is a waste product; LSRM thus produces 3.6 tonnes per hour of rice hull per day.

The La Suerte biomass power plant utilizes the rice hull for power production, intended to be 1 MW per day. However, technological constraints have resulted in a maximum working capacity of 84 percent. At the same time, a major advantage for the biomass facility is that rice hull has no value, which means it can produce power without incurring feedstock costs. It is estimated that rice hull for use as feedstock can be sold to be at PHP600–PHP2 000 (US$13.95–US$46.51) per tonne.

The power produced is consumed by the La Suerte rice mill. Currently, it is more financially viable for the facility to use the power it generates; its cost is around PHP4 (US$0.093) per kWh compared to the grid cost of PHP9.60 to PHP11 (US$0.21 to US$0.25) per kWh. La Suerte is planning to construct another 5 MW biomass power plant alongside an additional two rice mills. However, the aim of this initiative is only to power the rice mills. It would be possible to expand power production and distribute the additional electricity to the grid. In fact, feed-in tariff (FIT) from biomass-generated power costs around PHP6.63 (US$0.15) per kWh to the grid. The RA 9513 mandates priority dispatch of renewable energy-sourced electricity over traditional power plants.

Level 2: Inputs, services, finance and outputs

Farmers are significant actors in the market scenario. They are the source of rice paddy which LSRM processes into rice and produces rice husk as waste. There are around 120 000 farmers in Isabela, more than half of whom are peasants or workers. A small percentage is small farm owners and some are Department of Agrarian Reform beneficiaries.

Rice paddy is the final output of rice farmers and their produce goes to the rice millers. The buying price of paddy is PHP19–PHP23 (US$0.44–US$0.53) per kg; the selling price of rice is PHP35 (US$0.81) per kg (BAS, 2013).

Buying stations are another important component of the market, accommodating 10 to 20 tonnes of paddy coming from farmers. The middlemen here sell the paddy to rice millers (they have the capability to transport large volume of *palay* coming from marginal areas). There are more than 50 buying stations in Isabela, generating income by keeping a percentage share per tonne of *palay* or by lowering the buying price of *palay* at the farmer level.

The DOA is responsible for conducting training and workshops for sustainable rice production and land management in the province. Its major programmes include seed production, rice sufficiency, zero tillage, organic farming and climate-smart agriculture. Training is usually carried out in coordination with LGU and co-sponsored by private rice mills like LSRM. Local government is also greatly involved in the promotion of the biomass power plant throughout the whole of the country, and the La Suerte rice hull power plant has been dubbed the first rice-hull fired power plant in the Philippines.

The technology provider is another actor in the market. It is difficult for La Suerte to develop technology locally, as the initiative, a pilot case, was the first of its type in the Philippines. The technology came from Malaysia and the materials and facility's components from Belgium (private firm APC Schneider carried out the installation services). A series of problems during the installation of the components lowered the intended capacity, from 1 MW to 0.840 MW.

Loans were provided by the Development Bank of the Philippines (DBP). Banks consider biomass power generation technologies to be high-risk investments; application was a long process and approval difficult to get. The lack of a demonstration project for the biomass power plant proved a major financial barrier.

Level 3: Enabling environment

The Department of Environment and Natural Resources (DENR) is the focal agency in the Philippines setting the guidelines for environment compliance and monitoring, especially in regard to emissions. It is also the national government counterpart for carbon credits applications by renewable energy projects in the Philippines. The Department of Energy (DOE) is the focal agency in monitoring applications and feasibility of renewable energy projects in the country.

The Emissions Trading PLC is the United Kingdom-based company that is supposedly the buyer of the carbon credits to be generated by the facility. However, the Clean Development Mechanism was not realized as the project design document had already been submitted to the United Nations Framework Convention for Climate Change (UNFCCC).

By-products

Under certain conditions, silica can be produced from rice hull ash. However, the ash produced by the facility did not satisfy the 35 percent silica content standard required by the glass industry. Ash is the major by-product and makes a positive contribution to farmer inputs by conditioning the soil in preparation for planting rice. The initiative thus enables the farmers to enjoy free ash, including its free transportation to their rice fields. It is also has the potential material as an input for cement industries. Oil bran is another potential value-adding stream which can be used for feed and food.

Table 1.3: Relationships between market actors

	La Suerte rice mill	**La Suerte biomass power plant**	**Rice farmers**	**Rice buying stations**	**DA**	**DENR**	**DOE**	DBP
La Suerte rice mill								
La Suerte biomass power plant	Good; technical and financial							
Rice Farmers	Good; formal financial	Good; informal						
Rice buying stations	Good; financial		Moderate; financial					
DA	Good technical	Moderate; technical	Moderate; technical and financial					
DENR	Good; technical	Good; regulatory			Government; formal			
DOE		Moderate; informal			Government; formal	Government; formal		
DBP		Good; technical			Informal	Informal	Informal	

The La Suerte biomass power plant represents a major technological and economic leap forward for Isabela, especially in terms of its rice production. The effects are felt most strongly between LSRM and the powerplant, a relationship which is purely technical and financial.

LSRM established a formal relationship with rice farmers through accommodating their extended capacity and providing financial aid. The biomass powerplant has established a good relationship with farmers as a result of its provision of free ash input to rice fields, and benefits from its location next to the rice fields, and from the free disposal of the ash.

Rice-buying stations have good relationship with the rice mills; financial arrangements occur frequently between actors. However, rice farmers have only a moderate relationship quality with buying stations, because of pricing issues and issues with other customers being permitted to jump the queue.

The government agencies facilitate technical or regulatory relationships between market actors. Financial support is possible from the DOA through grants and subsidies; the DENR carries out monitoring and environmental compliance and the DOE is responsible for technology verification and viability.

Table 2.3: Balance of relationships, rights, responsibilities and revenues of market actors

Actors	Responsibilities	Rights	Revenues
La Suerte rice mill	- Rice processor from farmers and buying stations	- Produce rice - Collect rice hull to be transferred to the biomass power plant	- Income from rice production
La Suerte biomass power plant	- Power production from rice hull	- Utilize rice hull from La Suerte mill - Collect ash generated for farmlands	- Equivalent income from savings using biomass power
Rice farmers	- *Palay* production	- Access to inputs and DA programmes - Sell the rice produced to La Suerte mill	- Income from *palay*
Buying stations	- Intermediate agents (middle men) where most farmers sell their *palay*	- Buy *palay* from farmers - Set buying price based on prevailing prices	- Income from *palay*
DENR	- Provides policy guidelines on environmental management and protection	- Compliance monitoring - Implement sanctions and penalties - Evaluate/decide on application environmental certification	- Legal fees
DA	- Rice production programmes	- Implement development programmes for enhanced rice production	None
DOE	- Renewable energy guidelines	- Provide guidelines on utilization of biomass for power production	None
DBP	- Financial services	- Provide loans	- Interest on loan

LSRM is one of main rice paddy processors in Isabela. Within the market chain, it is responsible for supplying the rice hull demand for the biomass power plant. As the feedstock source, LSRM has the right to dictate the buying price of paddy and buy the rice paddy from farmers. It can also negotiate with buying stations regarding the volume and pricing of *palay*.

Buying stations (or traders) and farmers are the input source for rice hull and provide the *palay* for millers. No farmers would mean no rice hull could be produced. However, not all farmers can deliver their *palay* to the millers. Buying stations play an interesting role in facilitating income to farmers even for those who are far away from mills. However, farmers can be at risk with unfair pricing schemes. Transactions frequently occur between millers and traders; seldom with farmers directly.

The function of government agencies (such as DA, DENR and DOE) is based on their legal mandates. Each play an important role in the sustainability of the biomass power plant. Without their proper technical, socio-economic and environmental assessments, the project may not be viable, environmentally compliant or socially acceptable. However, the involvement of human agency provides scope for illegal transactions to occur, rendering La Suerte at risk of extortion or abuse by those in authority.

Overall, a balance exists between the rights and responsibilities of the initiative's market actors. The farmers are at high risk of financial disparity and the vagaries of those in power, relying as they do mainly on other actors for their daily living; ironically, they are also the source of this bioenergy initiative. It would be logical and fair to further enhance the welfare of farmers and empower them not merely with subsidies but also through enhancing their market literacy.

Analysis of livelihoods outcomes

Land use and tenure

The biomass power plant is intended to be integrated with existing rice mills in Isabela. The land area for a modular power plant with full administrative and logistical provision is less than one hectare. The land devoted to the power plant is adjacent to the rice mill, and had no prior initial use. No significant land use change therefore occurred because of this initiative. The rice field areas remain intact and the farmers enjoy the indirect benefits of the project.

Food prices

The price of food, in particular rice, is not directly affected by the current scale of operation. The rice hull ash deriving from the facility is a good organic input for the rice fields and, when mixed with other farm inputs during land preparation and soil conditioning, possibly increases rice production. Rice hull ash is typically 16 to 20 percent of the rice hull that is supplied as fuel to the power plant. During an average 12-hour day about 7.8 tonnes of ash are produced.

Change in income

There has been no significant, measured change in income for farmers. However, income for rice millers has improved due to savings of about 40 percent of their power requirement. Being optimistic that all rice hull can be utilized for power generation, the buying price of rice paddy in Isabela can increase without affecting the selling price of retailed rice. This will benefit the farmers greatly, while they maintain a stable supply of rice to the millers as their source of income.

Jobs and labour

The rice hull powerplant has the potential to stimulate further job opportunities, on the sides both of processing and feedstock production. The model of integrating rice mills with a biomass powerplant (based on the La Suerte capacity) requires more than 200 workers on the processing side. If feedstock plantation is integrated, an estimated 9 000 farmers will be required (assuming one farmer to one hectare).

Energy access

The LSRM operation has been extended by several hours every day, further increasing its capacity to about 40 percent. Instead of relying on the national grid which burns coal for power generation, rice hull for power is utilized as an alternative.

Energy security

Power production is secure as long as the LSRM produces rice hull as a waste product. The integrated model assures the biomass powerplant sufficient feedstock to supply power to the rice mills. The facility and other infrastructure are fairly reliable, and can be repaired and maintained by local engineers and technicians. Power savings accrued as a result of the project has increased engagement between the LSRM and the farmers, and activities that support the farmers (such as training and demonstration farms) have also involved La Suerte alongside government agencies.

This pioneering feat has proved that a rice hull powerplant is technically and economically feasible. The project encounters no problems because of its proximity to the rice mill. The facility's by-products are being developed, with a focus on rice bran and ash. An increase in rice bran would indirectly increase the livelihood capacity of livestock growers (especially that of pig farmers) and an improvement of ash quality could provide an avenue for Isabela to engage in glassmaking.

Because of the nature of the power production process (i.e. the burning of rice hull), environmental concerns are focused on emissions monitoring and compliance. However, the facility has been compliant in this regard since the start of its operation.

Table 3.3: Barriers, drivers and interventions

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
La Suerte	**Technology design and operation** Technology providers are international	Design and operation may be complex for local engineers Learning curve may be prolonged	Design and operation can be understood	Integrate renewable energy technology in engineering curriculum; increase academic and industrial partnerships
	Capacity building Local technology providers should be encouraged to invest in renewable energy	Most of advanced technology providers are foreign-based		Capacitate local technology providers through training and subsidy

	Initial investment cost La Suerte incurred large investment cost for the project	High investment cost may be unattractive to investors	High investment cost but financial viability is very good	Increase awareness of the feasibility of biomass power plant
	Power supply Savings are very good because of the devoted biomass power plant	Power supply is dependent on rice hull supply		Might explore the use of multi-feedstock for biomass power plant
Farmers/ buying stations	**Accessible source of feedstock** Rice production always produces rice hull as by product	Rice hull may not be available due to natural calamity and market disruption	Rice hull is available due to vast amount of rice land	Increase disaster awareness and mitigation; improve market supply chain
	Access to financial aid and farm inputs Farmers enjoy assistance from La Suerte and government agencies	Misuse and inefficient allocation of farm inputs and other resources (S2)	Equitable allocation and efficient use of agricultural resources	Impose sanctions/penalties for misappropriation of funds; Improve farm monitoring
	Logistical requirements Rice hull produced by rice mills		Simple logistics for rice hull	
	Marketing scheme *Palay* traders mostly involved in selling *palay* to rice mills	Possible source of financial and power abuse against farmers	Better relationship between traders and farmers	Empower farmers; increase market literacy
	Foreign materials and spare parts	Local technology providers may not have available spare parts during repair		Capacitate local technology providers to fabricate equipment/machinery parts
DBP	**Financing criteria** Considers biomass technology projects as high-risk investment	High risk investment loan application is difficult and time consuming	Possible incentives for renewable energy projects	Improve loan process for renewable energy projects
LGU	**Promotions** Promotions and marketing of the biomass power plant was widely launched but inconsistent	General public may have negative perception on biomass power plants	General public have positive perception of biomass power plants	Conduct public consultations Advertisements and other promotional activities regularly
DENR	**Monitoring and compliance** Guidelines on sustainable operation of the power plant	Power plant may not abide by DENR guidelines	Power plant abides with DENR guidelines	Increase emission control capacity of power plant impose sanctions and penalties
	Carbon credits	Lengthy procedure; application is difficult		

Conclusions

Rice hull was once considered an unusable agricultural waste; now it has become a source of energy. This pioneering facility has opened doors for other rice mills in the Philippines to pursue the same concept.

Power costs contribute to 40 percent of the selling price of retailed rice in the country. The experience of La Suerte has reduced these costs by more than 50 percent. Aside from the stable power supply and better solid waste management, the success of La Suerte presents a vision of the significance of the biomass powerplant beyond 2015.

The ASEAN Free Trade Agreement (AFTA) may lead to an influx of rice from Thailand and Viet Nam, threatening local rice production. The domestic rice industry may suffer if no major intervention is carried out. Establishing biomass powerplants in every rice mill will significantly lower the price of rice, providing more leverage to domestic rice farmers against imported rice.

Employment can be directly increased with the addition of biomass power production. Furthermore, there is potential for the enhancement of livelihoods from indirect streams (i.e. by-products). Rice bran and ash are seen to be potential industry catalysts for livestock-raising and glassmaking respectively.

Replicability

Of all agricultural crops produced in the Philippines, the share of rice production is about 21 percent, second to that of sugarcane. Around 16 million tonnes of *palay* annually can be processed nationwide, producing about four million tonnes of rice hull (BAS, 2010). The province of Nueva Ecija produces the second highest annual quantity of rice (after Isabela). Out of the top ten rice producing provinces, the other eight are Pangasinan, Iloilo, Cagayan, Camarines Sur, Tarlac, Leyte, North Cotabato and Maguindanao.

A modular biomass power plant (producing 1 MW to 10 MW daily) can be integrated with every rice mill in the country. Modular power plants are well-suited to the use of biomass as fuels, as shown by La Suerte, and the modularity ensures fast and easy construction based on a standardized structure and predesigned options. The technology is quite stable, as demonstrated by other countries which have already employed it. This pioneering initiative in Isabela can provide a learning experience for other provinces. It is important to determine the capacity of the powerplant to match the rice hull production of the mills.

The initiative could explore the use of multi-feedstock biomass fuel for the powerplant. Rice straw could be collected in the fields (currently, almost all of it is burnt on-site) and used as additional fuel; the powerplant could either buy it from the farmers or provide farm inputs in exchange. Increasing feedstock alternatives might increase power production capacity and any excess electricity generated could be channelled to the grid and passed on to households.

To further promote the market penetration of this bioenergy initiative, the Renewable Energy Act must be aggressively advanced. The government needs to start investing in bioenergy and expand investment packages to establish more demonstration facilities. In this way, technical and financial barriers can be broken down, at the same time enhancing the strength of the government’s institutional and policy capability.

In order to carry out this initiative successfully, the following factors are essential:

1) the development of local capacity for biomass renewable technology;
2) an increase in technological efficiency and by-product utilization;
3) the improvement of market literacy and social awareness of biomass energy;

4) the promotion of sustainable rice production (including farmer's welfare);
5) an enhanced access to loans and grants as funds for development. Promote awareness of the incentives of RA 9513;
6) the improvement of the regulatory performance and support services of government agencies;
7) the strengthening of linkages between private, public and even academic institutions.

References and bibliography

Bureau of Agricultural Statistics. CountrySTAT.

BAS. 2013. *Gender-based indicators of labor and employment in agriculture*. Agricultural Indicator System.

Boongaling, C. 2010. *Double Trouble: Compounded effects of El Nino and Mining in Isabela*. Center for Environmental Concerns.

Business Mirror. 2013. *Rice farmers ask govt for share in CCT because of rampant rice smuggling*. Business Mirror, 19 Feb 2013.

Department of Agriculture, Regional Field Office 2.

Department of Environment and Natural Resources, Main Office.

Department of Interior and Local Government. 2013. *Region 2: The rice granary of the north*.

National Disaster Coordinating Council. 2010. *Final Report on Tropical Storm 'Ondoy'.*

Philippine Star. 2013. *Philippines rice – sufficiency by year end*.

PhilRice. 2010. *Is the household income of rice farmers getting better over time?* Philippine Rice Research Institute.

World Bank. 2013. *Philippine agricultural lands*.

Philippines (Case 4): Mangrove briquettes

Initiative name	**Kalibo Save the Mangroves (KASAMA) Briquetting Project**
Location	*New Buswang, Aklan, Philippines, South East Asia*
Initiation date/duration	*1990: start of mangrove plantation; still in operation to date*
Funder(s)	- *KASAMA* - *Population Control Management (POPCOM)* - *Aklan Local Government Unit (LGU)*
Project initiator	*Allen Quimpo, former congressman of Aklan, Philippines*
Overall budget (if available)	*PHP416 500 (US$ 9,600)* - *US$4,600: briquette shed (loan by LGU & KASAMA)* - *US$2,600: briquetting machine(KASAMA)* - *US$2,400: charcoal kiln (grant by POPCOM)*
Output	*100 kg/day (around 5 sacks) of briquettes* **maximum actual working capacity*
Area of land	*50 ha in 1990* *200 ha in 2013*
Beneficiaries	- *200 KASAMA members (direct beneficiaries)* - *210 estimated households (average 5 members each) per day as end users* - *Household consumption = 12 briquettes per day*

Background and context

Aklan is one of the oldest provinces in the Philippines, located in the western part of the region of Visayas. It occupies the northern third of Panay Island where majority of the people speak Akeanon, the province's most prominent language. The total land area of Aklan spans more than 5 075 ha, including its coastline that stretches for some 155 km through 10 municipalities and 73 *barangays* (Province of Aklan, 2009). Aklan is classified as a second-class income-generating province which depends heavily on agriculture and tourism.

KASAMA: the Aklan mangrove initiative

KASAMA (Kalibo Save the Mangroves) was founded by Allen Quimpo who is the organization's chairperson. Out of 70 major mangrove species in the world, 20 can be found in Aklan province. The initiative started in 1990, when 50 ha of mudflats were planted with mangroves.

The municipality of New Buswang, Aklan is the site for the briquetting facility. KASAMA members were trained by DENR, Aklan's local government and experts from the academe. DENR initially approved a US$22 500 loan to Aklan to plant 250 000 mangrove trees over 50 ha during a three-year period; has already been paid back (no interest rate was applied). Several private and public institutions were then involved in expanding the mangrove areas, utilizing unproductive mudflats; by 2013, this had covered 220 acres with an estimated 1.8 million mangrove trees. Currently, the mangrove forest provides food and livelihood to over 8 *barangays* (smallest administrative division in the Philippines).

KASAMA briquetting project

With the increase of mangrove areas, the KASAMA started to carry out consultations to promote the sustainable management and utilization of mangroves. DENR became the lead government agency in providing research support for the local government. Pruning the forest to prevent the trees from dying was one outcome from these consultations, which led to the establishing of a briquetting project. It was estimated that 40 000 tonnes of branches can be pruned from the mangroves annually.

In 2008, the plan to establish a briquetting facility materialized. KASAMA funds with the addition of a loan from Aklan's local government were used to start a briquetting shed. However, in the same year this was destroyed by typhoon Frank. It was rebuilt and the briquetting set was made locally with the assistance of the University of the Philippines Los Banos. The operation started formally in February 2010. The charcoal kiln was granted for free by the government Population Control Management Program. The briquette production facility has an estimated payback period of less than two years for the loan and investment.

Management of the briquetting facility was handed over to the KASAMA organization. The processing of branches into usable fuel is done regularly, whenever pruning is carried out. The facility produces briquettes as its main products; however, raw charcoal is an intermediate product and this is sold in the market. The bigger branches are usually carbonized are sold as raw charcoal while the smaller branches are ground and used for briquette production.

Vulnerability context

The province has 17 municipalities with an estimated total population of 535 000 (2010 statistic results, NSCB, 2011). There is almost a one-to-one ratio between men and women and an annual growth rate of 1.29 percent. More than 70 percent of the population is rural and half ranges in age from 15 to 64 (NSO, 2013). The majority are engaged in agriculture and fishery which is also linked with tourism. In low income households, almost every member of the family is forced to work. Access to resources is not a problem in Aklan as most of its areas are available to the public. In fact, sufficient household food can be obtained from Aklan's natural resources, both cultivated and growing wild. However, consumer behaviour pushes some community members to deviate from fulfilling their basic needs, in some cases, causing debts to accrue.

The political system in the province is highly stratified, a situation replicated throughout the Philippines. New government projects are only implemented after several years of consultation and approval from the local to the national level. Government funds are usually channelled through several agencies, unless grants are provided from private entities. There are reports of inconsistencies of approach within the government and even among several sectors of society, to an extent which affects national development.

The province is becoming more urbanized, with the urban population around half the total population. The majority of the working population have only attained elementary or secondary level education; at the same time, the number of college graduates has almost tripled since 2000. The number of businesses being established is also increasing, along with the province's internal revenue. Technology innovations are steadily penetrating the locality as academic institutions are support science and technology initiatives.

Mortality decreased by 10 percent over the last decade. The main killer disease of Aklan is pneumonia (NHO, 2013). Other causes of mortality are cardiovascular disease, heart failure, renal failure and hypertension. These are considered lifestyle diseases which are often a result of by overwork, poor nutrition and excessive alcohol consumption, especially in rural areas. Aside from disease, typhoon is a common cause of shock in Aklan. Major devastation to the agriculture, infrastructure, lifelines and public utilities was incurred in 2008 by typhoon Frank at the expense of hundreds of lives and billions of pesos (Panay News, 2008).

Rice production in the province is unstable but can still supply most of the local demand. The national government is moving towards rice sufficiency, creating more programmes for rice production. Corn is starting to increase in production while banana and mango have been fairly stable in past years. Livestock production is also stable (NSO, 2013). Local agricultural commodity prices do not vary greatly and are often correlated. However, the price of staple commodities (sugar, petroleum and cooking oil) varies greatly throughout the year. Poor families can try to prepare for any intermittency; however, these commodities are greatly affected by world market prices, and sudden changes to these could push local prices excessively. However, such fluctuations are somewhat predictable.

Food security

Overall, the Aklan briquetting project has a positive impact on the food supply of the domestic market, resource availability and usage efficiency, and has improved municipal assets and household wellbeing. It does not lead to increased food prices; it could indirectly increase marine-based food sources because of its mangrove plantations, which are managed and developed under the project.

The 200 ha mangrove sites are coastal lines, commonly referred as mudflats. These are coastal wetlands made up of mud deposits caused by tidal actions. Until 1990, the area was almost barren; mangrove plantation has however greatly increased marine life.

The province's food situation is likely to improve with the existence of the mangrove plantations, which tend to result in a significant increase in fish and other seafood (although this has not yet been measured in the locality). As an open domain, the local community regularly engage in shell-picking and catching crabs and fish (with the monitoring and permission of KASAMA). It is reported that KASAMA members can source their marine-based food demand in the mangrove plantations alone.

The establishment of the 200 ha of mangrove has improved the area's ecology and enhanced its biodiversity. For example, North Western Visayan College (the primary academic institution which maintains the mangrove trees) has reported several species of wildlife emerging. Aside from the increase of marine life, birds and insects have also increased; there are already 29 reported species of birds (such as Eurasian curlew, little egrets, zebra doves, and munias). More than 50 percent are resident birds and 30 percent are migrants. There are 33 recorded species of moths in the mangrove area, together with other insects.

There is no competition with existing agricultural lands as mangroves thrive on coastal lands. There are no reported changes in cropping systems or the production levels of agricultural crops; in fact, the food supply appears to have increased following the increase of marine wildlife. Certain species of mollusc are harvested for daily subsistence. Personal interviews with KASAMA members indicated that the harvested molluscs can also be sold for PHP50 (US$1.16) per bag. Crabs are also cultivated in the mangrove area and these can be sold for PHP350 (US$8.14) per kg.

The coastal area of Aklan has vast areas suitable for mangroves, and their use for briquette production is therefore not affected by land or water scarcity. Basic land use management involves the regular monitoring of newly planted propagules (mangrove seedlings) as well as protection against the illegal harvesting of mangroves. Mangroves require very minimal maintenance; according to Quimpo, no fertilizer inputs are applied during planting and maintenance. Planting is usually done through local government efforts and NVC reforestation efforts under DENR's National Greening Program[8]. Pruning is done ten years after planting, using a chainsaw to cut the branches (mangrove is considered a hardwood). It takes one to two years before the branches rejuvenate and can be pruned again. An annual average of 200 tonnes per ha of branches can be derived from the total plantation.

In 2000, KASAMA was registered as a multi-purpose cooperative under the DENR's Community-Based Management Agreement Program, granting the organization a tenurial right of 25 years for the total mangrove forest area. No studies have been conducted on the impacts on tenure rights, livelihood and food security involving mangroves in Aklan, Philippines; however, the establishment of the mangrove areas does not involve any physical displacement of households away from their basic resources, rather it attracted more households to become members of KASAMA for both daily subsistence and job opportunities.

[8] One hectare can be planted with 3 000 propagules using 1.5m x 1.5m spacing.

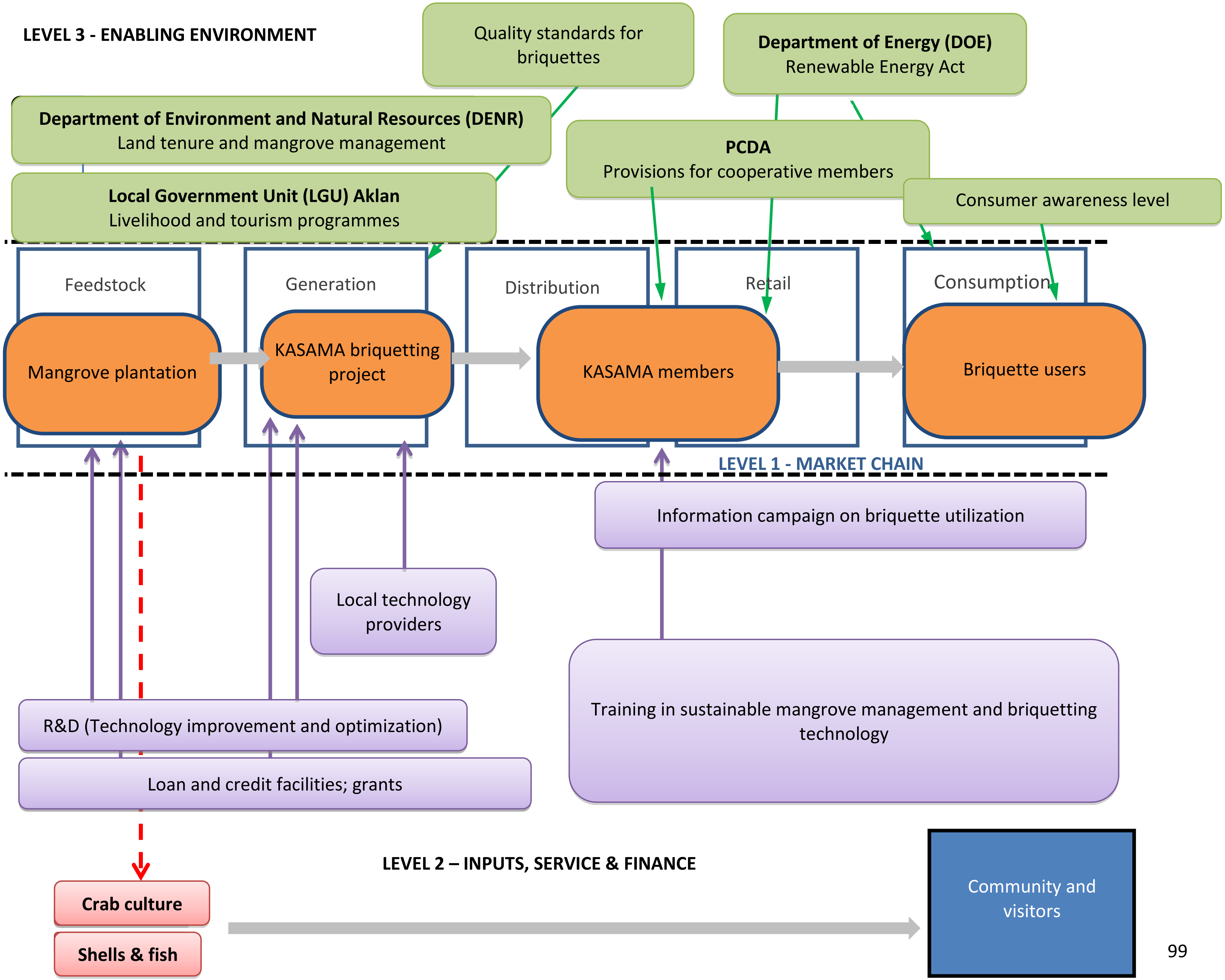

Figure 1.4: Initiative market map

Energy market chain

The market chain is short and limited to interaction between the KASAMA and community households.

The mangrove plantation is the source of feedstock for the briquettes. It is managed and maintained by KASAMA, which is also responsible for the briquette production. The mangrove branches are pruned regularly throughout the year; two KASAMA members are usually tasked to do this. The harvested branches are then transported manually to the KASAMA briquetting facility for carbonizing. After grinding, the carbonized and pulverized branches are mixed with binders; the next steps are moulding and kiln-drying. Production reaches a maximum 100 kg of briquettes per day, which are packaged into sacks, each sack with a capacity of 20 kg.

The distribution and retailing of the briquettes is done in the KASAMA facility; no retailing is carried out in the local marketplaces. The quantity of briquettes produced is based on orders by local households and a few private groups.

The consumers are community households who use both firewood and LPG. The use of cooking fuels in the locality is not monitored, with the result that there are currently no statistics available relating to the number of LPG users compared to firewood users (some households use both as fuel for their earthen/cement stoves which use firewood and gas).

Briquettes have the potential to replace firewood for cooking and heating for several households in Aklan, and the use of briquettes made from mangrove branches could thus decrease upland deforestation activity for firewood. In addition, if a family uses briquettes instead of LPG, further savings can be realized which can be redirected for other family necessities.

Briquette use incur several advantages compared with typical firewood consumption: they are cleaner, burn faster, and are more convenient. They are cheaper than using LPG. A standard household of five family members can use 12 pieces of briquettes per day (around 480 g) for cooking and heating water. At PHP20 per kg, the monthly cost of using briquettes is PHP288, compared to the cost of LPG which is around PHP900 (US$20.93)[9] per 11 kg tank, giving a maximum saving of PHP600–700 (US$13.95–16.28) per month.

LPG is also a fossil fuel, and its production involves hydrocarbons and other chemicals which incurs GHG emissions throughout its production chain. In contrast, briquette undergoes carbonization, leaving fixed carbon to be burnt during cooking. Any form of CO^2 emission is recaptured by the mangroves, providing renewable energy and achieving carbon neutrality for the whole cycle.

The inclusion of KASAMA members, who are mostly are low-income folk, further increases their income and empowers them through various roles, such as harvesters, processors, maintenance workers. As part of the community, they are also nearest to access to the briquettes, which are regarded a cheaper and convenient source of cooking fuel.

Enabling environment

The DENR provides the policy guidelines for mangrove plantations. A series of Administrative Orders has been used to set guidelines on the stewardship and reforestation of mangrove areas. Recently, the National Greening Program included the expansion of mangrove areas, especially on unproductive coastal areas.

[9] US$1 = 43 PHP.

The Aklan LGU has programmes in line with KASAMA's tourism and livelihood initiatives; these support the mangrove plantation as well as the briquetting facility.

The Department of Energy (DOE) provides the policy platform regarding the use of renewable energy based on its Republic Act of 9513. This contains provision for the utilization of biomass resources, provided it is not competing with food production. The Philippine Cooperative Development Authority (PCDA) lists the provisions for a cooperative to operate and sustain its existence while providing income and jobs to its members.

Quality standards for briquettes in the Philippines are not yet fully established. These however may vary depending on the end user specifications; briquettes are currently only for household level consumption. Plans and private negotiations are ongoing to expand the facility to cater for larger scale demand (for bakeries for example, and even cement industries). Such up-scaling may require KASAMA to comply with more stringent specifications; KASAMA has already sent samples for analysis to Manila (the capital of the Philippines) to cater a possible order for three tonnes of briquette (Quimpo, 2013).

A factor that makes briquettes useful for Aklan is the community's traditional way of cooking. Some households still uses wood-based fuel for cooking and the introduction of briquettes is an improved approach to using wood-based cooking fuel.

Inputs, services, finance and outputs

Mangrove propagules (seedlings) are required to establish a plantation. However, these seedlings are naturally self-perpetuating within the mangrove areas and there is thus no scarcity of planting materials. Cassava starch is a readily available binder for briquetting and costs around PHP1 600 (US$37.21) per sack on the commercial market. Cassava is a root crop grown regularly in the Philippines. It is not a staple food commodity, but is seen as a potential subsistence crop in some places; this is not however the case in Aklan where rice production is plentiful. Cassava starch is used in preference to corn starch (which has wider food uses); the facility utilizes less than 4 kg of starch per every sack of briquettes produced. KASAMA is conducting consultations with academic institutions to find a substitute for cassava when larger scale production will be implemented.

KASAMA members are the workers-in-charge for all activities; their tools and wages all come from the KASAMA organization. However, their main source of income is from their work as farmers or fisherfolk. Part-time paid employment within the mangrove area is limited to the 200 KASAMA members.

The mangrove plantation has been transformed into a mangrove ecopark which is open to the public. It has become a major income-generating mechanism, covering the maintenance expenses of the whole plantation. However, as the mangrove plantation continues to passively expand, more land will be needed along the adjacent, currently unproductive coastlines.

Training and capacity building are needed a) to ensure more sustainable management and b) for briquetting processing. In addition, scientific support through research and development (R&D) is an essential tool for sustainability. Academic institutions within the province are collaborating on R&D to further improve and optimize both the mangroves and the briquetting facility. As expansion occurs, better briquetting facilities will be needed with to complement the improvement and scaling up of existing briquetting equipment. These again will require more local fabricators and experts.

Grants, loans and credit facilities are needed to support the project. Grants are given mainly by government agencies and there is some participation by private entities; this however is limited to the mangrove plantation and is not directly involved in the briquetting facility. Loans are usually facilitated by the LGU.

The mangrove ecopark has greatly enhanced biodiversity in the locality. Natural by-products (e.g. shells and fish) can be obtained from the plantation; these provide an additional income source for KASAMA members. The mangrove plantation created more value-adding activities and resources, of which the latter are readily available. The crab culture programme within the plantation is another significant income source for KASAMA. Under the DENR National Greening Program, KASAMA is tasked to produce propagules in further-expanding mangroves in Aklan; this provides another source of income).

Table 1.4: Relationships between market actors

	KASAMA members	Subsistence fisherfolk	KASAMA	DENR	DOE	LGU	Academe
KASAMA members							
Subsistence fisherfolk	Moderate; informal						
KASAMA	Good; technical, financial	Moderate; Informal					
DENR	Good; technical		Moderate; technical, regulatory				
DOE	Not known; technical		Moderate; technical				
LGU	Moderate; technical	Not known; regulatory	Moderate; technical, slightly financial	Moderate; legal			
Academe	Good; technical	Not known; informal	Good; technical	Moderate; technical		Poor; informal	

The briquetting project has resulted in an improved relationship between its members and the KASAMA organization, as well as with the community members involved in it. For example, the pruning needed for a more sustainable mangrove forest meant the project has played a critical role in stimulating relationships between its stakeholders. Members have also developed increased loyalty within the organization as a result of enjoying privileges. They are the only ones who can be workers both for the mangrove areas, the briquetting facilities, and marketing and administration. KASAMA has capacitated its members through training and sought more financial support together with Aklan's LGU.

The community is the primary witness to how mangroves can improve the livelihoods of its people. KASAMA members have proved themselves to be good caretakers of the area. They also accommodate outsiders such as fisherfolk, allowing them to collect shells and fish for their daily subsistence. This relationship is however only moderately established as some of these outsiders are reported to have been illegally pruning branches for their own use.

The KASAMA organization listed itself under the Community-Based Forest Management Agreement to further forge its relationship with DENR; the mangrove initiative has increased the involvement of DENR in the coastal management of Aklan. Frequent consultations and meetings have been held between LGU and DENR and for more than a decade KASAMA has had an outstanding track record of managing the mangroves for briquette production. DENR has carried out its mandatory obligations to KASAMA as a CBFM grantee, in terms of monitoring and handing out sanctions. The strength of the relationship between the two is however moderate because of DENR's moderate interest.

The Aklan LGU has supported KASAMA from its conception back in 1990 through permits, programmes and facilitation of financial aid. The LGU, in collaboration with DENR and academe, has conducted training during the project conception. The local government is also wary of illegal settlers and harvesters within the mangrove areas. However, the implementation of sanctions is often slow. Academe has played an important role among different stakeholders. Technical training and supervision are continuously implemented for both mangrove protection and briquette production. Research and development plays a major role; however, in recent years even promotional activities are shouldered by the local academic units in Aklan. Local government collaboration with academe to promote briquette production in the locality hardly exists.

Table 2.4: Balance of relationships, rights, responsibilities and revenues of market actors

Actors	Responsibilities	Rights	Revenues
KASAMA members	- Custodians of mangrove areas - Maintenance of mangrove areas	- Mangrove pruning - Briquette processing - Fishing - Exclusive workforce of mangrove ecopark	- Income from briquettes and other marine products - Income from tourism
Subsistence Fisherfolk	- Some land management	- Fishing	- Income from fishing
KASAMA	- Mangrove forest management and marine resources - Briquette production - Administration and marketing	- Land tenure - Create activities within the mangrove ecopark - Major shareholder for briquettes	- Income from visitors to mangrove ecopark - Income from briquette production - Seasonal donations
DENR	- Forest mangrove management policy - Land tenure policy - Technical assistance	- Enforce regulations & sanctions - Monitor forest management actions by KASAMA - Training	None
DOE	- Biomass utilization policy	- Monitor briquette production	None
LGU	- Development support - Legal provisions	- Facilitate grants and investors for development	None
Academe	- R&D - Promotions	- Perform experiments in mangrove areas and briquetting facility	None

As CBFMA grantee under DENR, KASAMA is mandated to be the primary custodian of the mangrove areas. It operates under the legal provisions of the LGU and DENR. Excessive practice of member's rights in harvesting, fishing and managing can potentially threaten mangrove areas; the presence of subsistence fisherfolk is also seen as a potential threat, putting KASAMA at risk of revoking their tenure for the mangrove areas.

The distribution of roles between government agencies is already implied, based on their mandates; the briquetting project could be at risk if DENR fails to comply with its duties. Protection of mangrove areas should not be the role of KASAMA alone; DENR, together with the local authorities, should not stop at policy level but ensure the visibility of the authorities against fisherfolk.

Academe has a significant role in briquetting production and the mangroves; however, its promotional role should be shared by local government. Financial support could be facilitated by the LGU for academe as well as KASAMA, as without financial aid, academic support could die out. Local government efforts in the field of R&D are slowing down; however, it is vital that local government continues to help academe in sourcing grants and funds for the briquette project and mangrove improvement. The partnership between the government and academe needs to be further strengthened.

Briquettes are a good source of income for KASAMA members. The retail price of briquettes is PHP20 (US$0.46) per kg; KASAMA adds around 40 percent mark-up and the revenue is shared after the briquettes are sold. The price of briquettes is relatively stable over the year. Further income is sourced from occasional marine products. Members with administrative and maintenance tasks are also paid according to the prevailing minimum wage (PHP250 or US$5.81 per day) (NWPC, 2013). Revenue can also be sourced from by-products and selling propagules at PHP2.00 (US$0.0465) per seedling.

The responsibilities of government regulators and KASAMA should be revisited especially those in relation to legal support and monitoring activities. Revenues are reasonably allocated within the organization. The responsibility to promote briquette production should be intensified through KASAMA and LGU; academe should not be left out. Financial assistance is encouraged for continuous improvement. Overall, the market chain is not yet stable; this is due to an imbalance between its enabling environment and support services actors.

Analysis of livelihoods outcomes

Land use

This initiative has meant that more than 200 ha of neglected mudflats have been transformed into mangrove forests, increasing the land's value commercially and socially for the community. There are no current studies which quantitatively assess the project's socio-economic and environmental effects on the area. However, the community has observed a significant increase in marine life and birds and a decrease in incidence of flooding since the establishment of the mangrove plantation.

Land tenure rights

Land tenure rights for the area are currently held by KASAMA, giving the community open access to the mangroves provided members abide by the ethos of the sustainable use and management of the area. Not only the 200 KASAMA members benefit, but also the subsistence folk who are permitted to harvest fish and shells.

Food prices

Food prices are not affected by the project; however, marine food supply is indirectly increased because of the crabs, shells and fish wildlife in the mangrove areas. The marine products derived from the plantation contribute to the daily food basket of KASAMA members. However, the extent of which this contributes to the household food supply has not yet been measured.

Changes in income and labour conditions

The briquettes are a major income source. KASAMA gets a maximum revenue of PHP2 000 (US$46.51) per day from briquettes which is shared between its members. The briquetting initiative has improved labour conditions of KASAMA members, the majority of whom are not highly educated and who have been trained and capacitated by the project in production and management. They are paid a minimum wage of around PHP250 (US$5.81) per day for the maintenance and management of the plantation.

Energy access and security

Briquettes provide convenience for cooking, eliminating the need for the time-consuming and exhausting obtaining and stacking of firewood. The cookstoves are mostly medium grade; others are self-made and low grade. No studies have yet been conducted to assess efficiency, safety and pollution levels of the briquettes and the cookstove.

The briquetting facility is just within a five mile radius of the community. There is no shortage of mangrove feedstock, and transportation of the cut mangrove branches is also not a problem as the facility is located within the plantation area. Firewood is sourced from forest tree cuttings; minor illegal logging activities also occur in unmonitored mountain areas.

Briquette substitution of firewood can provide a practical daily source of energy for households. The briquettes can be produced every day, since the quantity of mangrove branches is more than enough for the facility. The earthen cookstoves needed for briquettes are fairly reliable and affordable, around PHP60 (US$1.40) per unit.

Table 3.4: Barriers, drivers and interventions

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
KASAMA	**Plantation infrastructure** KASAMA provides infrastructure to facilitate harvesting of mangroves	Materials (bamboo slats and wood) used for infrastructure (e.g. pathways) are not durable.	Materials used are cheap and easily installed; can be feasible with regular maintenance	Materials such as concrete and iron can be used to improve harvesting efficiency and safety; requires significant investment
	Mangrove planting materials KASAMA is tasked to maintain and manage mangrove areas together with securing seedlings for expansion	Planting materials can be destroyed by natural calamity or specific interventions.	Planting materials are virtually unlimited; mangrove areas are seen to passively expand	Secure planting materials through dedicated nursery
	Technology design and operation Design is generated in UPLB, a standard briquetting set for rural setting	Design is not efficient and quite traditional.	Design is simple and easily fabricated locally	Design must be improved using updated knowledge on briquetting from academic and research institutions
	Selling price Present markup of 40 percent is implemented to all sold briquettes per kg	Selling price is not attractive to household consumers.	Selling price is competitive with charcoal and better quality as cooking fuel.	Selling price can be reduced by improving production efficiency and using cheaper material

	Marketing location Briquettes are currently sold at the facility	Market is limited to direct buyers only.	Production can be dedicated to direct buyers or as per order	Extend marketing to local markets and business places
	By-products and services generation in the mangrove plantation KASAMA has identified by-products such as marine life, tourism activity and seedling generation which are open to public	Rampant illegal activities of local community.	Stimulate better economic and social relationship between KASAMA and community	Increase monitoring and protection
Household as end-users	**Briquettes used as cooking fuel**	Households are not aware of the advantage of briquettes as cooking fuel.		Increase promotional activities
DENR	Provides monitoring and training to mangrove and briquette facility	Provisions are not well implemented; lack of manpower for monitoring.	Support training is well carried out	Increase manpower for monitoring; strictly implement sanctions for violators
LGU	Facilitates promotional activities to KASAMA	Promotions are not consistent and continuous (may only occur at the start of operation).		Increase promotions; consider collaboration with other stakeholders
Academe	Research and development is on-going both for feedstock and processing of briquettes	Data collection is intermittent because of lack of manpower and natural weather conditions.	Data generation is not a problem; results are well channelled back to KASAMA	Proper scheduling and continuous innovation
Financial and credit providers	Provision of loans and grants	May not be available to KASAMA and its members and stop from improving briquette facility.		
Local technology providers	Fabricate and install briquette facility	Local technology providers may not be updated with the latest briquette technology and design.	Current design can be easily fabricated	Provide training and updates on local technology providers

There are additional role issues involving inadequate protection and support from government. Reports exist of spurious mangrove harvesters and illegal encroachment within the mangrove areas. These can become a barrier to the maintenance of a sustainable source of mangrove wood for briquette production. One intervention would be to deputize KASAMA members, giving them the authority to act against these violators within the mangrove areas only, another would be to encourage the government to increase their efficiency and effectiveness.

Conclusions

The briquetting project of the KASAMA cooperative in Aklan is proven to provide job and income opportunities for its 200 members. Livelihood and daily subsistence are also be derived from the rich marine resources of the mangrove forests which are good indicators of food security. Tourism from the mangrove ecopark also provides jobs for its members.

However, to maximize its potential to support rural livelihood in Aklan, interventions are needed to address the barriers and issues mentioned above. In order to successfully carry out and replicate the project, the following actions are essential:

- sustainable management and protection of mangrove areas (including waste management);
- efficient and effective government participation;
- increase in sanctions against illegal activities;
- sustainable technology for briquette production and cookstoves;
- access to loans and grants as funds for development (possibly facilitated by the LGU and KASAMA);
- increase in consumer awareness and market-based capacity of briquettes in the community;
- continuous capacity building and innovation.

References and bibliography

Luchin, A. 2013. *Personal interview with the KASAMA administrative assistant and treasurer.*

National Statistical Coordination Board. 2011. *Province: Aklan (available at:* http://www.nscb.gov.ph/activestats/psgc/province.asp?provcode=060400000).

National Statistics Office. 2013. *Summary of socio-demographic indicators of Aklan*. Aklan Quickstat.

National Wage and Productivity Commission (NWPC). 2013. *Prevailing minimum wage in Aklan*.

Panay News. 2008. *MMDA Equipment, Personnel arrives in Aklan*.

Provincial Government of Aklan. (n.d.).*Information on Aklan Province (available at:* http://www.aklan.gov.ph/).

Quimpo, A. (2013, November 24). *Personal Interview.* Head of KASAMA.

China (Case 5): BIOMA biogas development programme

Initiative name	Biogas development in a rural area of China
Location	*Xinlongcun Village, Danling County, Sichuan Province, China*
Initiation date and duration	*From 2006 to 2012*
Funder(s)	*Danling county government*
Project initiator	*Danling rural energy office*
Overall budget (if available)	*US$585 366*
Output	*400 m^3 of biogas per household per year for cooking;* *9 760 tonnes of biofertilizer per household per year for fruit planting.*
Area of land	*373 hectares*
Beneficiaries	*Economic benefits: Since 2006, the total income of the village has increased by US$151 935 per year from cost-saving on coal, firewood and LPG; average household income increased by US$237.40 per year. Bioslurry used as fertilizer for fruit crops promoted the fruit quality and achieved better sales.* *Environmental benefits: Farmers' living environment has been improved after the operation of digesters for waste treatment; air pollution has been reduced by using biogas as a clean energy source, around 62 percent of the domestic fuel in the village. CO_2 emission reduction has reached 2 700 tonnes. Bioslurry accounts for 25–40 percent of the total amount of fertilizer, reducing the need for chemical fertiliser.* *Social benefits: more job opportunities have been created in the village involving design, construction, and maintenance professionals. The successful model of pig-biogas-fruit has been applied in the neighbouring villages.*

Background and context

Xinglong village is located in the southwest of Danling county and is one of the county's demonstration sites for ecofarming models. The terrain of the village is mainly hills and dams, the average temperature is 16.8 °C and the lowest temperature is around 0 °C in winter, which restrains biogas production for about two months. Annual precipitation is 1 230 mm. The population is 2 508 with a total of 721 households. Fruit planting (including oranges and grapes) and pig-raising are the pillar economies of the village, which produces around 3 000 pigs per annum sale. The arable land area is 220 ha, 99 percent of which is used for orange planting.

Before the initiative, the combustion of firewood and coal was the major cause of high levels of CO^2 and SO^2, adversely affecting farmers' health and living conditions, and causing possible deterioration to the environment. In addition, excessive use of chemical fertilizer had caused a drop in soil fertility and was harmful to human health. To address these issues and to pave the way to a better livelihood for the farmers, the county government initiated the project with funds from central government covering one third of the total input and the rest supplied by biogas households. The county's rural energy office is the implementing authority.

The purpose of the project was to ensure a) energy recovery from waste treatment and b) environmental protection from pig dung and rotten fruit. So far the number of digesters has reached 537 among 721 households (three-quarters of the total). The total volume of digesters is 8 055 m^3 (an average of 15 m^3 each) and the annual biogas yield is 210 000 m^3, amounting to 150 tonnes standard coal equivalent. Biogas is used for cooking, and bioslurry for fertilizer. During the project the average heat efficiency of cooking fuel rose from 22.5 percent to 35.4 percent. Biogas consumption accounted for 62 percent of the village's total domestic fuel, and CO_2 emission reduction reached 2 700 tonnes. The increase in farmers' income was US$320 per household, obtained from energy-saving and fruit yield growth.

From a technical perspective, the waste from the pigs and fruit planting is used as feedstock for the digester (see Figure 1). The digesters are installed underground to save energy which is used to pump the feedstock and to reduce the area demand. Biogas is used as domestic fuel for cooking in the kitchen, and the bioslurry is used as quality fertilizer for the village's fruit crops.

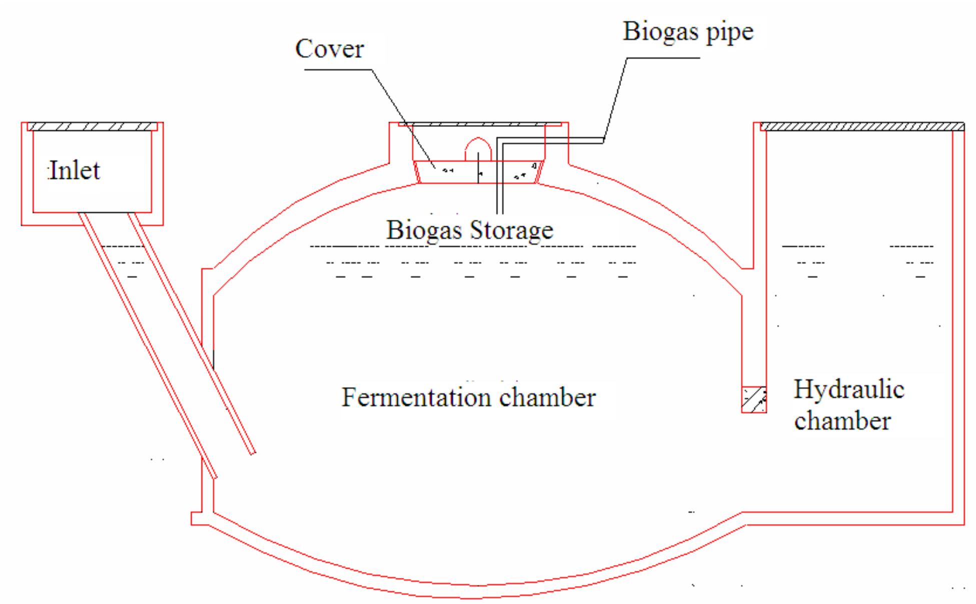

Figure 1.5: Schematic diagram of the hydraulic digester

Food security

Before the initiative, 90 percent of the village's arable land (373.4 ha) was used for planting crops, including rice (50 percent), canola (30 percent) and wheat (10 percent). Half was used for subsistence and half for commercial sale. The remaining arable land was used for vegetables (5 percent) and a small amount for fruits (5 percent) such as oranges and grapes. Since the initiative was established, 70 percent of the village's arable land has been given over to fruit planting, especially oranges. Fruit production increased by 7.278 tonnes per year, while yields of rice and wheat dropped by 744.799 tonnes per year, and yields of canola by 75.6 tonnes per year. The villagers now export fruits to other areas and import staple food from the market supplied by other areas. The higher profitability of fruits means that food is now more affordable for the villagers.

The total land available in the village for raising pigs was 2.163–2.884 ha (an average of 30–40m^2 per household). After the operation, the number of pigsties in the area remained the same, but the number of pigs for sale doubled (from 1 500 to 3 000 per year), increasing by 115.5 tonnes the annual supply of food basket items to the domestic market.

In terms of land use efficiency, the land available for orange planting (for the bio-digesters) was fully used, with a yield of 37.3 tonnes per ha, much higher than the national average annual yield (10.5 tonnes per ha). This was due to a) the optimal selection of variety of orange and b) technical guidance given by the fruit-planting consultants.

Initiative market map

Level 3: Enabling environment

This involves a number of government sectors with differing roles:

- The Ministry of Agriculture (the major force behind the initiative) develops plans based on surveys designed to assess a) the farmer's demand for biogas and biofertilizer, b) the customer's demand for green fruits, and c) the growing awareness of the need for environmental protection and energy saving. Preferred policies, technical regulations and standards related to the production of biogas appliances and accessories, design and construction techniques are established.
- The Ministry of Labour Resource authorizes the certification of biogas technicians by examination to assess the capacity building of technical strength to support the biogas service network in terms of the design, construction and maintenance of the digesters.
- Ministry of Finance allocates subsidy from central government to provincial rural energy offices, and audits the projects with national bond.
- The Ministry of Health traces zoonosis (an infectious disease passed between humans and animals), and other infectious diseases reported by disease control centres, and reports them to the state council to take action.
- At the energy market chain level, digester feedstock is mainly animal and human manure, and rotten fruits. These are available from each household, as pig-raising and fruit planting are the village's main agricultural activities.
- The Danling county rural energy office assigns construction work to the village's biogas service network; its job was to design and construct the digesters in line with the annual plan (based on the survey, the investigation of farmer demand and the farming model).
- The biogas produced is supplied to the household directly as the digesters are built underground beneath the animal house and toilet, stored in the digester, and consumed every day. The bioslurry is used as quality fertilizer for fruit planting as a self-supplied fertilizer resource.

Level 2: Inputs, services and finance

Manufacturers of biogas appliances and building materials act as material suppliers to the rural energy office and biogas service network. The subsidy from central and provincial governments is allocated to the rural energy office each year for digester construction and the procurement of biogas appliances for the households. At the beginning of the project, the service network was funded by a government subsidy of US$3 252 for the procurement of tools for repair, pumps for sludge discharge, shelves, posters and labels for digester accessories. At the end of each year, a bonus of US$2 439 is awarded to the network by the county government, based on an assessment of service quality from the biogas households. As technical support, the service network provides a maintenance service with auxiliary parts and tools, based on the demand of biogas users for the normal operation of the digester. Biogas users pay for accessories (such as the stove) and the door-to-door service. Alternatively, biogas households can register for membership of the service network and pay RMB100 yuan[10] (US$16) per year for a complete service package, covering feeding of the biodigester with feedstock to sludge discharging, as well as training on digester safety and management. The biogas institutions and agencies provide design and construction consultancy to the rural energy office service network, and develop standards for manufacturers as a basis for quality control of the biogas appliances.

Poultry and livestock markets and the green fruit market are the source of finance, which some households use to partly self-finance the construction of the digester. Fruit farmers sell their produce to markets outside the village for 10 percent higher than the fruits grown with chemical fertilizer. Biogas and bioslurry are not for sale due to the yield being limited but are available for self-consumption for cooking and fertilizer respectively.

[10] US$1 = RMB6.35.

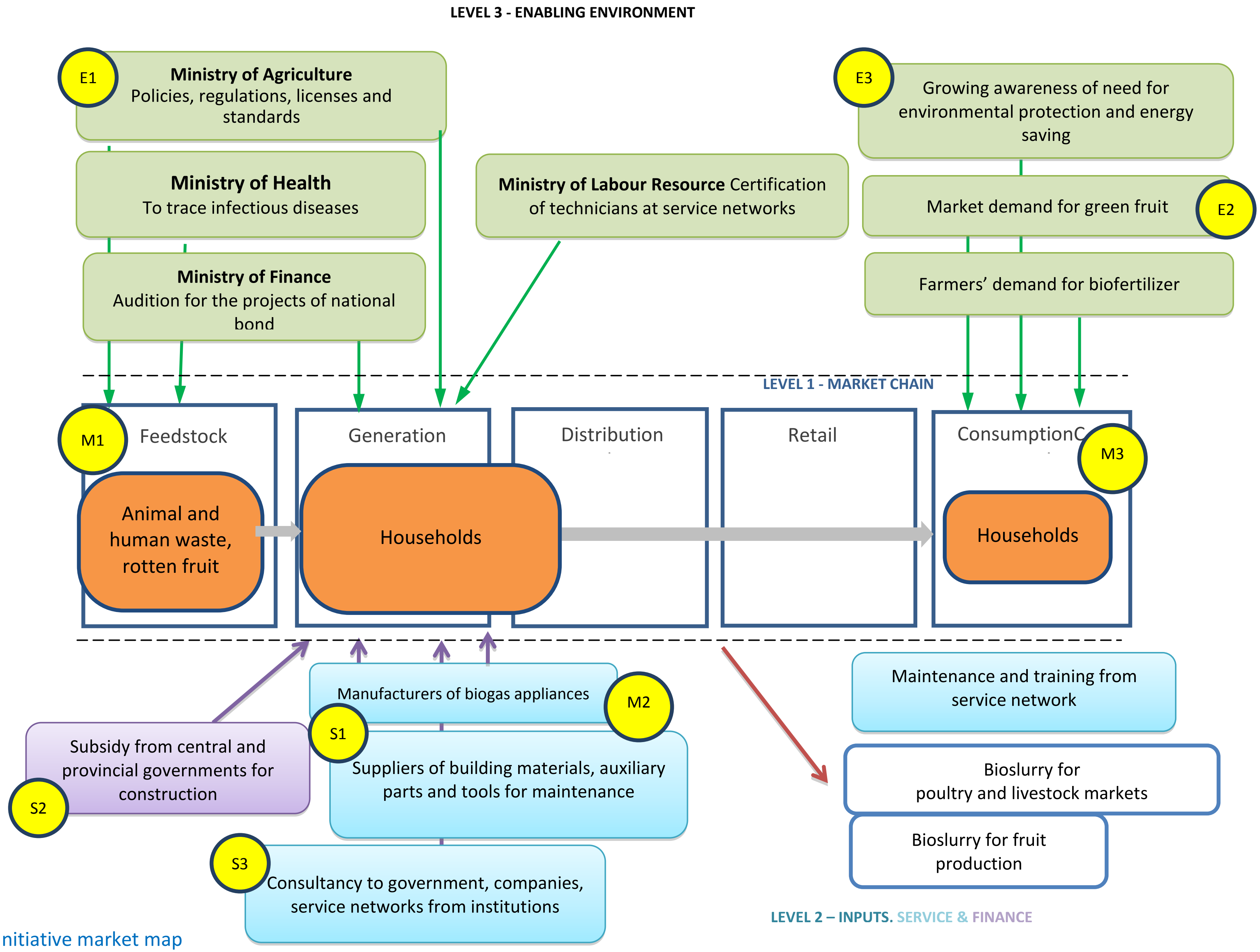

Figure 2.5: Initiative market map

Barriers

M1: - lack of pig manure or rotten fruit due to decrease in pig-raising and fruit-planting.

M2: - lack of forceful management to enable quality control of construction and maintenance service.

M3: - lack of technical guidance on the scientific utilization of bioslurry;
- biogas yield not sufficient for the households;
- lack of labour force in the households to manage the digester.

S1: - manufacturers supply low quality biogas appliances or building materials;
- aftersale service of appliances is irregular; some accessories are not available for replacement due to change of business.

S2: - subsidy does not cover increased cost of building material and labour force;
- subsidy is given to inappropriate households (i.e. not adaptable for digester construction), due to lack of survey of demand for digester construction.

S3: - institutions cannot provide consultancy at the appropriate time;
- innovative technologies cannot be realised due to the lack of government funds and promotion.

E1: - Ministry of Agriculture promulgates inappropriate policies and regulations due to lack of detailed investigation and analysis of user demand and market development;
- certification for biogas professionals is not compulsive requirement;
- audition for national bond projects is not carried out following due process.

E2: - awareness of environment and energy is weak among some households.

E3: - farmer demand for biogas and bioslurry decreased due to urbanization.

Table 1.5: Relationships between market actors

	Households	Ministry of Agriculture	Rural energy office and service network	Suppliers of biogas appliances/ building materials	Biogas institutions
Households					
Ministry of Agriculture	Financial				
Rural energy office and service network	Technical, regulatory	Financial, regulatory			
Suppliers of biogas appliances/building material	Informal	Regulatory	Informal		
Intuitions and agencies	Informal	Technical	Technical	Technical	

Biogas user households are subsidised by the government with funding from the Ministry of Agriculture. The rural energy office and service networks provide technical support to the households for design, construction and maintenance of digesters. Household farmers pay the service network for membership for regular operation of digesters and receive training in biogas and bioslurry utilization.

The Ministry of Agriculture is the leading force in this initiative, in terms of a) financial support (allocating funds to the rural energy offices at provincial and county levels), and b) promulgating policies in regard to subsidies and standards to regulate the work of rural energy offices, service networking and suppliers of material and appliances regarding the certification of technicians, quality control of biogas appliances and building material, and c) assigning research work to the institutions for technological innovation and transfer.

The rural energy office and network are the design and engineering part of the project. They have trade relationships with the suppliers of biogas appliances and building materials (through a bidding procedure), and receive technical guidance from the institutions. Network technicians receive training and certification from authorized institutions and agencies.

The suppliers of appliances and building materials follow the standards for quality control of their products developed by institutions and issued by the Ministry of Agriculture.

The Biogas Appliance Quality Inspection and Supervision Centre, as the non-governmental agency for the quality control of biogas appliances in China, publicizes qualified brands to the Ministry of Agriculture and the rural energy office. Forums on biogas industrial promotion are held by the Biogas Society to facilitate technical communication and exchange among manufacturers and institutions for technical innovation.

Table 2.5: Balance of relationships, rights, responsibilities and revenues of market actors

Actors	Rights	Responsibilities	Revenues
Households	- Use of biogas and bio fertilizer - Use of land for fruit planting	- Provide feedstock to digesters from animal manure and rotten fruits - Monitor operation of digesters - Take care of animals and tending fruit at home	- Subsidy from government in digester construction - Income from selling green fruits and animals - Saving on cost of chemical fertilizer by using bioslurry - Saving on cost of LPG by using biogas - Saving on cost of medicines for zoonosis with biogas digestion of animal manure (instead of its direct use as fertilizer)
Ministry of Agriculture	- Invite audition agencies on the projects funded with state bond - Supervise the bidding procedure of projects	- Promulgate policies, regulations, and standards, delivery of quality ranking for biogas products - Assign research tasks to institutions for technical innovation and transfer - Allocate funds to rural energy offices of provinces/counties	- None
Rural energy office and service network	-Select qualified material suppliers by bidding - Employ technicians with professional certificate - Receive technical guidance from institutions	- Design and engineering of the project - Recommend to farmers qualified suppliers	- Service network gets profit from farmers' membership fee or payment for irregular service - Service network gets digester design and construction fee
Suppliers of biogas appliances and building material	- Receive technical guidance from institutions - Attend training/forums held by institutions/agencies - Establish their own standards for a particular product with higher technical requirements	- Follows the standards for quality control of biogas products developed by institutions and issued by the Ministry of Agriculture - Supplying products to service network for digester construction and household use	- Profit of selling products
Institutions and agencies	- Ownership of novel technologies under the fund from ministries	- Provide consultancy to policy makers, rural energy offices and biogas networks - Hold training/forums for technicians/enterprises - Carry out research into biogas technological development/transfer	- Consultancy fee - Training fee - Transfer of novel technologies to enterprises

Households have the right to use biogas as domestic fuel for cooking and bioslurry for fertilizing the fruit crops. The cost-saving on LPG consumption and chemical fertilizer is a big motivation for project farmers to construct digesters. The right to use their land for fruit plantation provides feedstock for the digesters, and the profit from selling fruit in turn encourages digester construction.

The Ministry of Agriculture has the right to invite audition agencies on the projects funded with state bond as a way to supervise fund use for fear that the funds go to a wrong place. It also supervises the bidding procedure of projects for the fair competition of enterprises for biogas appliances and building materials.

The rural energy office and service network has the right to select qualified material suppliers by bidding as required by the Ministry of Agriculture. They also have the right to hire technicians with professional certificates and receive technical guidance from institutions on trouble-shooting and application of novel technologies.

Biogas appliances and building material enterprises have the right to receive technical guidance from institutions, attending training and forums held by institutions and agencies. If there is no related national or agricultural standard for a particular product, these enterprises have the right to establish their own standards with a higher technical requirement.

Institutions have the ownership of novel technologies under the fund from the ministries as a motivation to continue their research work.

The distribution of responsibilities between the actors may be implied by their role, or enforced by regulation or contracts. Households are the providers of feedstock to digesters from animal manure and rotten fruits. They are responsible for the monitoring of the operation of digesters and should report any problems to the service network. They are also the caretakers of animals and fruits planting at home. The major risks are a) that they may not resume their responsibilities once they stop fruit planting or animal keeping, and b) they overlook the advantage of using biogas and bioslurry and revert to using conventional energy and chemical fertilizer. The solution is a) to convince them of the sustainable significance of using biogas and bioslurry and b) to enroll farmers into service membership, by which they can get feedstock from the service network by paying the service fee.

The Ministry of Agriculture is in charge of the promulgation of policies, regulations, the establishment of standards, and the delivery of quality ranking for biogas products. It assigns research tasks to institutions to facilitate technical innovation and transfer, and allocates funds to rural energy offices at province and county level. Potential risks include misplacement of funds (due to inadequate surveys, standards being too low or too high to follow), wrong selection of technology (due to misunderstanding local conditions for digestion and feedstock), and weakness in certification for biogas technicians. To address this, more scientific research and demand assessments should be carried out before issuing policies.

Suppliers of biogas appliances and building material need to follow the quality control standards of biogas products developed by institutions and issued by the Ministry of Agriculture. To ensure the biogas market persists, quality products need to be supplied to the service network for digester construction and household use. However, producing a new product when there are no national or industrial standards involves risk, and innovative technology cannot be widely applied before demonstration and testing. A further risk is that farmer demand for biogas may drop, followed by a drop in demand for biogas appliances and building materials. Suppliers should continue to attending training and forums to keep up with the latest trends in technical development and market demand.

Institutions need to provide consultancy (in terms of technical updates and modification to standards and regulations) to policy-makers, rural energy offices and biogas networks. They should hold training for technicians and enterprises, and carry out research into biogas technological development and transfer. They should be aware of the risk that government funding is not in place for researches, and training cannot attract enterprises or technicians. Policy-makers need to be convinced to allocate funding to research bodies and establish networks and association in counties to enhance technical collaboration.

As part of the market chain, households can obtain a government subsidy of RMB1500 yuan (US$241.9) for construction of each digester, and make up the remaining two-thirds (RMB4000 yuan, or US$650.4) themselves. The annual biogas yield of a 10 m^3 digester is 400 m^3 and the tariff of biogas is RMB1.2 yuan per m^3. The cost saved by replacing domestic fuel with biogas is thus around RMB500 yuan per annum. When the money saved on fertilizer (around RMB960 yuan per annum) is added, the payback period is thus:

> Total cost of digester construction/cost saved on domestic fuel + saved fertilizer cost
> = RMB5 500 yuan/RMB1 460 yuan
> =3.76 (year)

If the biogas users are fruit farmers, additional economic profit accrues from the sale of fruits and animals, as well as cost savings on medicines for zoonosis (as a result of the biogas digestion of animal manure instead of its direct use as fertilizer). Here the payback period will be shorter, depending on the scale of the farmer's business.

The service network obtains profit from the annual farmer membership fee (RMB100 yuan, about US$16.3) from payments for irregular service, and from digester design and construction.

The suppliers of biogas appliances and building material make profit from selling products. The profit from the market chain pushes them to follow up with the technical trend and market demand. To join in the market competition, they are aware of the capacity building from training and technical innovation. Institutions and agencies obtain profit from consultancy work and training organization. The transfer of novel technologies to enterprises is also profitable.

The rights, responsibilities and revenues of the initiative are balanced between the market actors, as the relationship is rooted in demand and supply between the households and suppliers. The other financial, regulator and technical strengths also observe the supply-demand rule to play their part in a vigorous market chain.

Analysis of livelihoods outcomes

Land use

As biodigesters are built underground (below the animal pens and toilet) there is no area demand for their construction. The feedstock mainly comprises the animal and human waste, as well as rotten fruit. These are easily obtained through the development of animal-raising and fruit plantation. So far, around 99 percent of the land in the village has been turned to fruit farming use; only one percent remains for the planting of vegetables for consumption by some households. The 'pig-biogas-pig' model has been popularly applied. Change may be found in the varieties of fruit grown; this may bring increased profit to farmers, if accompanied by technical instruction from the fruit scientists and market demand for the flavours.

The potentiality of the livelihood was fully considered. In this case study, the household digesters were designed to cover a larger volume than the present demand in view of the potential for expansion of animal-raising and fruit-planting. For an average household of five people and three pigs, a 5 m^3 digester is enough to digest the feedstock produced. However, here 15-20 m^3 household digesters are common.

Land tenure rights

The digesters are partly subsidized by the government and along with each house constitute private property; land tenure rights are thus secured.

Food prices

The village's major agriculture products are fruits (including oranges and grapes). Fertilized by bioslurry discharged from the digesters, the fruits are found to have higher yield and better taste due to the reduction in the use of chemical fertilizer and pesticide.

Fruits are more profitable than cereal crops and vegetables and the villagers therefore plant the former in preference to the latter. As fruits have completely substituted crops, 99 percent of vegetables (some households retain land of 66.7 m^2 for vegetables for self-consumption) and food staples are imported from other areas. Consequently, the price of staple food and vegetables is higher than before. These prices, however, are in the range of farmers' affordability.

Changes in income

At household level, biogas is used as domestic fuel for cooking throughout the year, except in January and February when the temperature drops below 0 °C. Biogas has thus become the major fuel. The cost saving on conventional fuel procurement is US$81–194 per year per household. Average heat efficiency of cooking fuel has increased from 22.5 percent to 35.4 percent. The project supplies 62 percent of the village's household domestic fuel. Reliance on conventional fuels (natural gas and firewood) has been reduced, and as a consequence CO_2 emission decreased to 2 700 tonnes per year.

According to an evaluation of the composite benefit of household biogas digesters, *Renewable Energy, 2006* (2), the lower heating value of a 1 m^3 digester is 0.714 kg standard coal equivalent (around 3.13 kg firewood, 2.2 kg coal and 1.22 kg LPG). If the annual biogas yield of a digester is 450 m^3, a 10 m^3 digester with the heating value of 321 kg standard coal equivalent can replace 1 408 kg firewood, 990 kg coal, or

160 kg LPG. The normal operation of the digesters in the village can provide sufficient biogas as cooking fuel for three meals in ten months for one year.

Table 3.5: Energy replacement rate

Energy	1 m^3 biogas (kg)	10 m^3 digester per year (kg)
Standard coal equivalent	0.714	321
Firewood	3.13	1 408
Coal briquettes	2.2	990
LPG	1.22	471

The bioslurry is also used as quality fertilizer on the fruit instead of chemical fertilizer, optimizing the soil and increasing fruit yields. The cost saved from chemical pesticide and fertilizer use is 100-200 yuan (US$16–32) per household per year.

The biogas and bioslurry application has promoted a virtuous circle of the farming model (pig raising, biogas production, fruit plantation). The village's total income has thus been increased by US$180 000 per year, and average household income increased by US$249.7 per household per year. Widespread awareness of the advantages of the project means that oranges sells well in the market at a higher price than ordinary fruit, bringing increased profit direct to biogas households.

Energy access

Prior to the initiative, firewood was the major domestic fuel in the village, accounting for 60 percent of fuel used, followed by briquettes (25 percent) and LPG (10 percent). Biogas was not popularly used (found in only 35 of the 721 households), accounting for 5 percent of domestic fuel. After the initiative, consumption of clean energy rose to around 73.40 percent and that of conventional energy dropped to 26.6 percent (of which firewood dropped to 12.2 percent and coal to 0 percent; LPG rose to 17.6 percent, while biogas rose to 45.5 percent). Solar energy appeared as a new form of energy, accounting for 15.7 percent (see Table 4.5). Among the clean energy sources used in the village, biogas accounts for 62 percent, solar energy 21.4 percent, and LPG 17.6 percent.

Table 4.5: Energy proportion before and after the initiative

Energy	Before initiative (%)	After initiative (%)
Firewood	60	12.2
Coal briquettes	30	0
LPG	10	17.6
Biogas	5	45.5
Solar energy	0	15.7

Booklets on digester operation and biogas and bioslurry utilization have been produced by BIOMA staff and delivered to household users and cover a) secure maintenance of the digesters for the utilization and replacement of feedstock, and b) appliances amendment, which can be carried out by the household users themselves. Workers who are part of the village service network can provide door-to-door services.

In 2006, on the basis of demand assessment and analysis of the geographic and climate conditions, the county rural energy office developed a Development Plan for Domestic Biogas and started to promote biogas development in five demonstration villages, including Xinglong village. In line with the Plan, the village was allocated funds from central government for the modification of its farming style, from crop-planting to fruit planting and biogas digester/biofertilizer utilization. The aim was to increase farmers' income and protect the environment. Almost all households started to plant fruit alongside traditional pig-raising, and farmers began to see the benefits of using rotten fruit as feedstock for the digester.

The scheme of planning was made after the analysis of demand and conditions by institutions (which acted as consultants for policy-makers, originators of novel technologies, developers of standards, and hosts of forums for enterprises in the biogas sector which facilitated technical communication). These assisted the growth of enterprises by enhancing product quality. Technicians gained certification through attending training held by the institutions and agencies and were then hired to provide the backbone of the service network established in the village. This has played a significant role in the design, construction and maintenance of digesters. Training sessions are also held for village households as part of a scheme of technical dissemination.

These technical and policy aspects have led to improvements to farmers' livelihoods, grounded in cost-savings from bioslurry use for fertilizer, and biogas use for cooking (instead of conventional fuel).

Environmental impacts which have had a circular impact on livelihoods

The fruit and pig markets are the most significant factors impacting the household fruit planting and pig-raising; guidance on pig-raising and fruit planting is thus the direct factor impacting on household economy and the indirect factor impacting on digester operation. Without scientific guidance, the digesters would almost certainly lack feedstock and good management.

The price of biogas appliances and building materials impacts on a) the construction and operation costs of digesters, and b) interest in developing biogas use. If biogas is costly in terms of appliances and services, users may return to using conventional fuel.

The success of biogas and bioslurry use provides a good demonstration model for other households and villages in the neighbourhood. The implementation of the government subsidy policy would provide a positive environment for the replication of the model and the increased livelihood of farmers.

Table 5.5: Jobs and labour conditions

New careers	Description	Skill level requirement	Gender	Age requirement
Biogas technicians	Design, construction and maintenance of digester	Junior and senior workers Professional technicians, registered with certificates	Male	Under 50
Manufacturing industry	Manufacture of biogas products including digester, biogas appliances and auxiliary parts		Gender balance	Under 60
Marketing	Marketing of fruit and pigs		Gender balance	Under 60

The initiative has provided more job opportunities to rural households. Firstly, two local skilled biogas technicians with certificates below 60 years old were hired by the biogas service network for the design, construction and maintenance of digesters in the village area. Secondly, manufacturers of building material, biogas appliances and digester accessories provided fair job opportunities to the local people. Thirdly, the initiative created new jobs in the field of consultancy and marketing of pig-raising and fruit planting businesses.

Barriers, drivers and interventions

In the enabling environment, the authorities involving the related ministries are the major driving forces for policy-making, financing and supervision of the project. The farmers' demand for the clean energy and organic bio fertilizer is the direct factor that drives the households to participate in the project. The barriers in the enabling environment are related closely to policy-making and implementation efficiency of the project, as well as the transformation of lifestyle in the rural area. To increase project efficiency, interventions should focus on a) scientific analysis prior to policy-making, b) the regulatory framework affecting project operation, and c) regular technical updates.

In the market chain, the barriers and drivers of the county's rural energy office and the service network (as the providers of materials for digester construction and maintenance) are mainly related to the quality of biogas appliances, services and the practicability of training for farmer users (which could be solved by establishing an assessment mechanism). The households are the providers of feedstock to the digesters, and the barriers here are increasing urbanization, disinterest in the project, and failure at fruit-planting and pig-raising. The latter can be addressed by factoring in technological guidance, given to households as part of the intervention.

In terms of inputs, service and finance, barriers exist in the form of the government subsidy-giving policy. These could be modified into drivers rooted in surveys and analysis. In addition, barriers arising from a) insufficient technical consultancy to local users and managers, and b) lack of input in terms of technical innovation and application can be altered into drivers if the government has a will to do so. The fruit and livestock markets (and poultry husbandry) can play a role in terms of its pricing system which if conducive, could provide a strong incentive for farmers to continue to use bioslurry as fertilizer for green fruits, and to carry on raising pigs to supply feedstock for the digester.

Table 6.5: Barriers, drivers and interventions

Main actor	Barriers to upscaling and replicating	Drivers for upscaling and replicating	Interventions for upscaling and replicating
Enabling environment			
Ministry of Agriculture	Policy does not provide sufficient support for biogas partly because of lack of surveys on demand and construction costs; regulations/standards do not keep up with the technical development	Policies, regulations, certifications and standards are tailored to and oriented by technical developments and market demand	Policies are made on the basis of fully-tested techniques, pilot projects, and regular surveys on demand for biogas; regulations and standards are updated in line with technological innovations
Ministry of Labour Resource	Certification of technicians is not compulsory	Certification of technicians is given weight	Proof of certification is required before technical professionals can work on a biogas project
Ministry of Finance	Auditions for biogas project are not under normal process	Auditions are carried out for all projects with state bond loan	A third party is invited to participate in auditions
Ministry of Health	Trace/analysis on zoonosis and other infectious diseases in humans and livestock are overlooked	Regular tracing and analysis of parasitic/pathogenic diseases are implemented	Disease control centres submit regular reports
Farmers' demand for green energy and biofertilizer	Demand drops due to a) urbanization and b) misuse of bioslurry as fertilizer (due to lack of knowledge of mixture ratio or benefits of its use)	Demand stabilises and may be enlarged to include commercial production of biofertilizer, both for own use and for export	Modification to the biogas development plan is carried out, along with regular technical updating. Training is conducted to ensure knowledge dissemination regarding biogas/bioslurry use.
Growing awareness of environmental protection and energy saving	Awareness of need to protect the environment prand save energy is weak among some households	Households are highly concerned about environmental protection and clean energy	Publicity materials and training for households highlight benefits of environmental protections and energy saving

Market chain			
Households as feedstock supplier	Growing urbanization results in lack of pig manure or rotten fruit due to decrease in pig-raising/fruit-planting	Farmers remain in the village, or a more scientific management method is taken to ensure constant outputs from animal-raising/fruit-planting under technical guidance of societies/institutions	Price of green fruits marked higher, raising farmer activeness in using bioslurry, despite easier access to chemical fertilizer
Rural Energy Office and biogas service network	Lack of forceful management needed to ensure quality control of a) construction and b) maintenance service	Quality appliances, materials and after-sale service are provided to users	Biogas appliances are not supplied to users without inspection approval by biogas appliance quality inspection centre; selection of materials for construction follows bidding procedure.
Consumption of biogas and biofertilizer at household level	Lack of technical guidance on scientific utilization of bioslurry	Technical guidance provided by service network on mixture ratio of bioslurry and water for fertilizer	Handouts and door-to-door consultancy on biofertilizer use delivered to households
	Biogas yield not sufficient for households	Biogas sufficient for household consumption throughout the year except winter	Maintenance service provided by service network
	Lack of labour force in households to manage the digesters	Service network provides operation and management service to households	Service networks maintain regular management service to households at specific rates and reflecting subsidy from rural energy office
Inputs, service and finance			
Manufacturers of biogas appliances or building materials	Manufacturers supply poor-quality biogas appliances/building materials	Quality biogas appliances and building materials are supplied to households	Compulsory for manufacturers to invite biogas appliance quality control sectors for the assessment of products; products without certificates cannot enter market.
	Aftersale service of appliances is irregular; some accessories cannot be replaced due to change in business	After-sale service of appliances accords with demand of households; accessories are available for replacement	Service networks feed back demand from households to manufacturers on time

Central and provincial governments	Subsidy insufficient to cover increased costs of building materials and labour force	Subsidy rises with increased cost of digester construction	Increased subsidy allocated to support the project
	Subsidy awarded inappropriately, to households not adaptable for digester construction; this is due to lack of survey of demand for digester construction	Subsidies are provided, grounded in demand and the practicalities of the situation, pushing the project forward	Short-term rather than long-term plans are made
Institutions	Consultancy to biogas companies/service networks for design, construction and maintenance of biogas is far from sufficient to guide industrial promotion	Consultancy can be accessed at any time and involves the whole biogas system process	Companies and service network obtain access to technical consultancy from institutions assigned in a certain regional range; online network is set up as information database
	Little financial input is available, from government to scientific innovation and technical transfer	Technologies applied for technical transfer in time to fit biogas development	Greater concern given to development of novel technologies

Conclusions

With the farming model being transformed to energy recovery from waste treatment by pig-biogas-fruit model since 2006, all the 537 households in the village have been facilitated with biogas digesters using biogas generated from pig manure and rotten fruit for cooking and fertilizer. The total volume of digesters is 8 055 m^3, annual biogas yield 210 000 m^3, amounting to 150 tonnes standard coal equivalent. Average heat efficiency of the cooking fuel has grown from 22.5 percent to 35.4 percent. Economic, social and environmental benefits have been obtained from the enabling environment, the market chain and the inputs, service and finance. The project can be deemed successful so far owing to the tremendous input from central government, involving financial support, technical intervention and favourite policies.

The project was implemented in 2006, and has had three stages: start-up, promotion and maintenance. It constitutes part of measures taken by county administration (under the guidance of central government) to address the energy crisis and environmental pollution, and has thus been prioritized in rural energy development, and obtained popular support from local farmers in terms of their demands for access to clean energy and a better living environment. During its first and second phases, the initiative was thus scaled up, with the development of pig-raising and fruit planting. However, growing urbanization has led to an increased number of young people moving away from the rural areas, leaving the elders to raise pigs and plant fruit at home. The development of the project entering its third phase has thus been restrained by reduced feedstock and a lower demand for energy. The main task during this period is the maintenance of the digesters.

The project has maximised almost all its potential to support rural livelihoods. Benefits can be seen in changes at the household level, including environmental conservation, access to clean energy, increased income from green fruit planting, cost-savings on conventional energy, increased job opportunities, and control of sanitation-related infectious disease.

A representative of the county's rural energy office stated that despite the highly positive role played by the project, fewer and fewer households remain adaptable to digester construction. The crucial factor affecting the sustainability and scalability of the project is the economic development of China's rural areas, which is bringing about change in the economic pattern of households. In addition, the project is restrained by neglect in the areas of quality control and technical innovation. Also, the lack of investigation into actual demand for and adaptability of digesters leads to the waste of subsidies, and digesters lacking correct maintenance malfunction.

The essential factor affecting the sustainability and scalability of the project is thus the degree of concern from the government regarding policy-making and technical modification, and the extent to which this is related to the practical demands of the farmers.

References

Song Hai-jun. 2012. *Biogas construction to promote the development of economic analysis and rural economy*: [J]. Environmental Science & Technology, 2012, 35(8): pp93–96.

Introduction to Xinglong Village, Danling County, Sichuan Province, 1994-2013 China Academic Journal Electronic Publishing House.

Domestic biogas in Danling County, report from rural energy office.

Problems in the Biogas Construction in Weihui City and Development Strategies, Yilun WANG1, Asian Agricultural Research 2013, 5(2) : pp72-74, 78.

Sustainability of rural household biogas in Sichuan Province, Zhou Liao, University of Electronic Science and Technology in China.

Interviews, 4 October 2013:

Official of rural energy office of Danling County, Sichuan Province and Ms. Yang, hostess of the household, on the overall development of biogas in Xinglong Village and farmers' feedback.

Official of Sichuan rural energy office, administrator for biogas promotion in rural area.

Interview, 14 October 2013:

Official of rural energy office of Deyang City, Sichuan Province and an engineer of fibre plastic digester company, on the constraints in sustainable development of household biogas and technical modification.

Interview, 28 October 2013:

Official of rural energy office of Danling County, Sichuan Province, on detailed data collection about the project.

Cambodia (Case 6): Jatropha electrification

Initiative name	**Rural Electricity Enterprise (REE) using *Jatropha Curcas* biofuel in Trapeang Thma Kandal village**
Location	*Trapeang Thma Kandal village, Paoy Char commune, Phnum Srok district, Banteay Meanchey*
Initiation date/duration	*March 2010 to November 2013 (2 years and 9 months)*
Funder(s)	*Owner/ GTZ*
Project initiator	*Mr Tham Bun Hak*
Overall budget (if available)	*US$80 000 generator set* *US$1 500 for expelling machine* *US$1 300 for motor machine*
Output	*200 kWe*
Area of land	*REE area = 2 000 m²* *Jatropha plantation = 732 ha*
Beneficiaries	*600 households: electricity* *39 businesses, 4 REE staff*

Background and context

Cambodia is in the southern part of the Indochina peninsula in Southeast Asia. The total land area is 181.045 km². It has 23 provinces and four cities; Phnom Penh City is the capital. Its total population is 14.7 million, of whom around 80 percent live in the rural areas and 72 percent rely on agriculture as their main occupation. The country's poverty rate is 25 percent and below poverty line rate is 13 percent (Census, 2008).

Cambodia's power supply was heavily damaged during the war and genocide of the 1970s. The country has only recently been rehabilitated under the support of donors (bilateral and multilateral) and development partners (World Bank, ADB, UN, Japan, USA and a number of European countries). In 2013, the total number of households with electricity as their main source of light is 26.4 percent (87 percent in urban and only 13.1 percent in rural areas). The electricity is supplied through heavy fuel oil (HFO), diesel, gas, wood, coal, hydropower, wind and solar energy, biomass and biogas. Electricity is provided by the state-owned Electric du Cambodge (EDC), independent power producers (IPPs), provincial departments of the Ministry of Industry, Mines and Energy (MIME), licensees in small towns and the Rural Electricity Enterprise (REE) mainly in rural areas. Aside from EDC, almost all providers are using diesel and HFO to generate electricity, the dependence on which has made the price of electricity one of the most expensive in the region. Another contributory factor is high electricity tariff rates in rural areas. These range from US$0.09–US$0.25per KWh for EDC grid and US$0.40–US$0.80/KWh, and are among the highest in the region and the world (Poch and Tuy, 2012).

A report by the Electricity Authority of Cambodia (EAC) indicates that demand for electricity is increasing annually. EAC data indicates a 268 percent increase in the number of consumers from 182 930 in 2002 to 672 709 in 2010. Between 2002 and 2010, the government and private sector increased available energy by around 310 percent, from 614.03 million KWh to 2 515.67 million KWh. Despite this initiative, the current supply remains a concern for consumers, who experience blackouts particularly during the dry season. The capital Phnom Penh, for example, requires 400 MW per day, but the current available supply is only 290 MW. Based on current trends, the country will need about 3 000 MW in 2025 (ibid).

The very low access to electricity in the rural areas has made electrification a priority, both of government strategy and of the energy sector. To implement its Rural Electrification Policy, the government has established a Rural Electrification Fund. The aim of this is twofold: to promote equity in access to electricity supply services, and to encourage the private sector to participate in investing in rural power supply services in a sustainable manner, in particular to encourage the use of new technologies and renewable energy. One of the government's energy sector priorities (in the fourth legislature of the National Strategic Development Plan, or NSDP, updated 2010–13) is to reduce poverty in the rural areas by accelerating rural electrification, and this includes the use of renewable energy. In 2010, the Ministry of Industry, Mines and Energy stated that it would foster the development of all types of renewable energy (including biomass, biogas and biofuel) (NSDP, 2010).

This case study documents the use of biofuel from seed extracted from the *Jatropha curcas* plant to run the REE. The REE has operated since 2005 in Bot Trang village, Banteay Meanchey province. In 2010, after the EDC installed grids in Bot Trang, the owner transferred the REE operation to Trapeang Thma Kandal village, Paoy Char commune, in the same province. The Paoy Char commune has a total population of 2 437 households, 202 of which are headed by women. The main occupation of 91 percent (2 225) of households is agriculture; the main crop is rice. The commune has a total wet rice land area of 3 750 ha, which can produce around 6 375 tonnes per cropping season, or an average yield of 1.7 tonnes per ha. The dry rice land area is 250 ha that can produce an approximate yield of 750 tonnes (3 tonnes per ha). A number of households produce other crops; five plant long-term crops (such as rubber trees), while 18 cultivate short-term crops such as cassava, beans, corn and peanuts. Only 4.97 percent (113) of the commune's households have access to electricity; around 65.32 percent (1 486) use a car battery for lighting. Only 39 households have small businesses in the commune using electricity; seven of these are battery charger services.

Food security

The BEFS assessment results show that the REE initiative using Jatropha has no significant influence on food security. Firstly, there was no change in the utilization of the land. Interviews indicate that most of the seed produced in the village is collected from Jatropha planted as house perimeter fences. Secondly, there is no scarcity of land and water in the area where Jatropha is planted. The plants also prevent erosion and loss of land fertility; this efficient land use indicates a potential benefit for food security, as it surpasses the national average annual yield for the product. Also, as Jatropha is not commercially produced, it does not require fertilizer and thus does not compete with other crops.

Furthermore, all the households in the commune have benefited from the infrastructures built and from the area's natural resources. Each farmer is profiting from the agricultural inputs provided by the government. The introduction of Jatropha in the area has provided additional income to members of the community, and thus did not displace any income-generating or subsistence activities in the area. Information gathered from the REE owner indicated that the 600 subsistence farmers benefited from selling their Jatropha seed and at the same time obtained access to electricity. Thirty-nine households started a business, benefiting from their access to electricity, and the REE employed four of its staff from the local workforce. A total of 643 households have been directly benefited by the REE, which provides a potential benefit to food security.

However, in using locally produced renewable energy, the REE initiative could also pose a potential risk to food security, as it did not undergo an independent assessment to determine possible negative and positive impacts on tenure rights, livelihoods and food security. Also, the initiative did not obtain free, prior and informed consent before the operation, nor did it have a feasible alternative project design to prevent or minimize physical and/or economic displacement, particularly of the poor and vulnerable (the initiative did not actually need to provide compensation or assistance to any household due to its assets, or its access to assets being displaced or destroyed). Finally, the REE initiative has no mechanism to monitor impacts on affected communities and to ensure that negotiated agreements (including those pertaining to compensation) are respected.

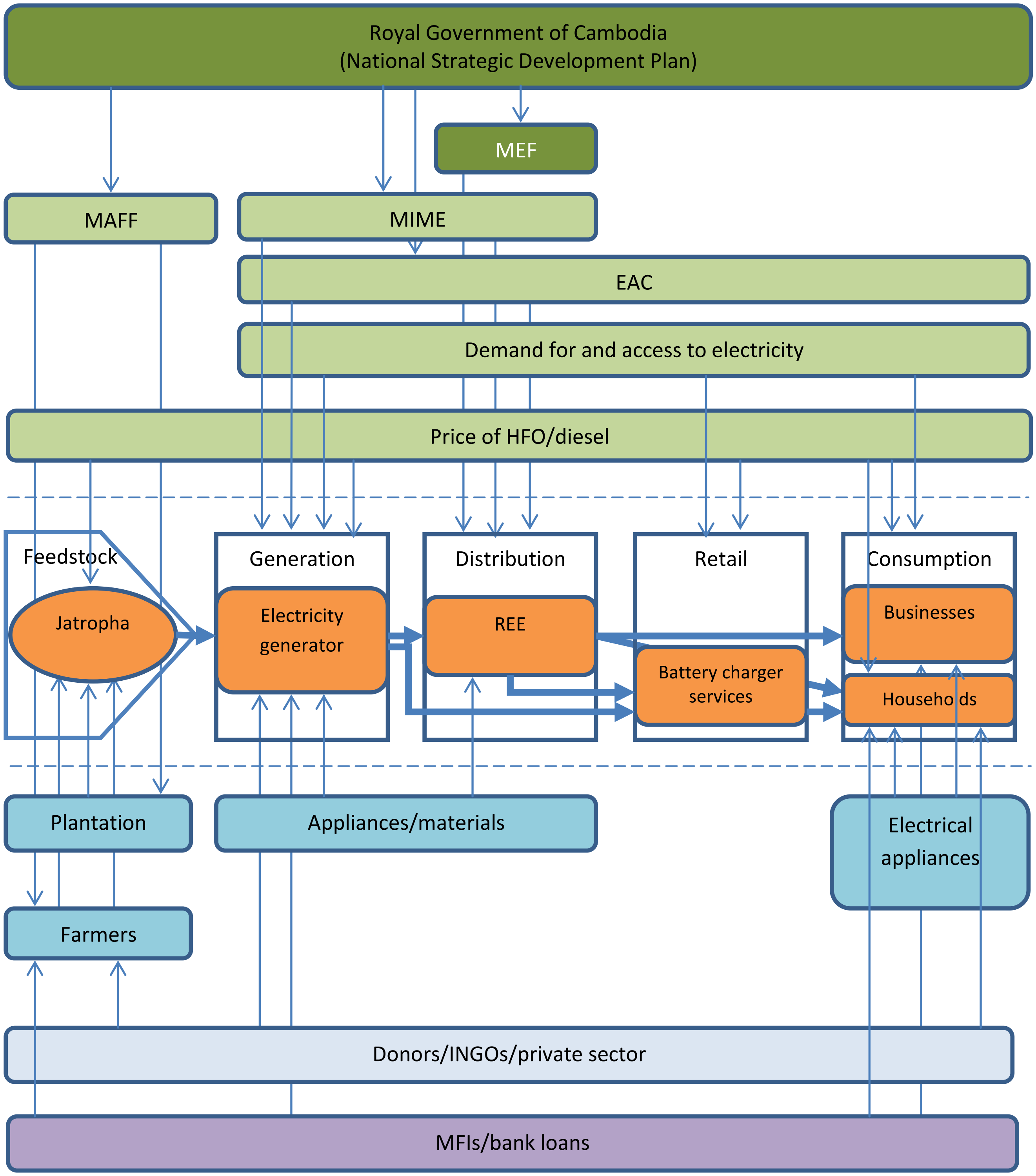

Figure 1.6: Initiative marketing map

Market chain

Jatropha curcas is a poisonous, semi-evergreen shrub or small tree which can grow to a height of six metres. It is resistant to a high degree of aridity and is cultivated in tropical and subtropical regions around the world; it has become naturalized in some areas. Jatropha has shown itself to be a versatile plant. The seeds contain 27–40 percent oil (an average of 34.4 percent) that can be processed to produce a high-quality biodiesel fuel, usable in a standard diesel engine[11]. The oil canbe used as a machine lubricant and an ingredient in high quality soap. Another byproduct is fertilizer from the seedcake residue that remains after expelling the oil. The plant itself is utilised as natural fence or hedge, which can also help prevent soil erosion from wind and water[12].

Mr Tham Bun Hak (the REE owner) started the REE in 2005 in Bot Trang Village, using diesel as the main fuel for his generator, which produced 200 kWe. He switched Jatropha oil after learning that it could be used as an alternative fuel. He almost gave up after encountering a problem in the engine's injection pump; SODECO, a women's organization promoting bio-energy development, heard about his problem and put him in touch with GTZ, an organisation which helped him convert his engine so it could use Jatropha oil without breaking down. GTZ also supported Tham with a US$1,500 oil expeller on a 50-50 partnership basis.

Tham's experience is that a three-year old Jatropha plant can produce a five kg yield every year, and that 1 300 plants per ha can produce around five tonnes of Jatropha seed. His Jatropha seed was initially sourced from two villages: Trapeang Thmor and Kampong Ampel. He collected around 60 tonnes every six months from 16 ha of plantation in Trapeangu Thmor, and 10 tonnes every year from 16 ha in Kampong Ampel (this difference in yield is caused by the system intensification of the private plantation in Trapeang Thmor; in Kampong Ampel the seed is produced by households). In comparison, in 2010 a company from Viet Nam planted Jatropha on 700 ha of unused land in Svay Pak village and produced 60 tonnes in its first year of production; unfortunately, in 2011 this plantation was flooded and all the plants destroyed.

Tham buys Jatropha seed directly from the farmers at KHR[13]400–1 000 per kg (US$0.10-0.25). This wide variance in price is based on the quality and age of the seed; older seed can produce more oil, making it more expensive. Tham can produce one litre of Jatropha oil from an investment of KHR1 175 (US$0.29); this includes the cost of seed harvesting, the expeller worker's time, the depreciation cost of the expeller and other costs. It takes 4.55 kg of Jatropha seed to produce one litre of oil, and expelling the oil from the seed collected from the two villages, Tham can produce around 15 000 litres per year. He runs his generator using 80 percent diesel and 20 percent Jatropha oil. His monthly fuel consumption is 7 000 litres; the generator can produce 200 kWe, which is enough to support 600 households.

In 2005, the REE's generator was in Bot Trang where Tham lives. When the EDC grids were installed in the village, he was forced to transfer his generator to an area that was not reached by government grids. At present the REE is operating in Trapeang Thma Kandal; this village has 600 household

[11] http://en.wikipedia.org/wiki/Jatropha_curcas.
[12] World Bank, 2002.
[13] US$1 = KHR10.

consumers who can use up to 5 000 kWe every month. Tham installed a mini grid that connects his consumers to the REE source. Each of his clients has to pay US$40 for the connection from the mini grid, and a monthly bill of KHR3 700 (US$0.92) per kWh based on household consumption, with individual household consumption ranging from 10-15 kWe per month.

Seven of Tam's beneficiaries are battery charger service operators who provide services to areas which cannot be reached by his REE grids. Around 1 486 households use a battery to provide light and to operate a television. The battery charging service owner collects the battery by cart every morning from each household on his list, and returns it in the afternoon. The charge for the service depends on the size of the battery; the cost of recharging a small car battery is KHR1 000 (US$0.25), and a big battery KHR1 500 (US$0.38). The battery life depends on consumer use; some last a week while others may last only a few days, especially among users with televisions and higher light voltage. Batteries are mostly only for household use; business establishments generally utilize generators. Businesses and households are the end users in the market chain level. The REE supplies both end users; a shop usually consumes 80–150 kWe per month and a household 20–50 kWe per month.

The household beneficiaries are also reaping gains from their own Jatropha plants. They barter the Jatropha seed at 3.5 kg for 1 kWh of electricity. Because electricity is expensive in the area, only 39 businesses in the commune use electrical equipment or tools.

Enabling environment

In the energy sector, the Government of Cambodia National Strategic Development Plan (NSDP) prioritised the development of electricity, particularly in the rural areas. The remoteness of many rural areas, coupled with poor infrastructure, led the government to establish a Rural Electrification Fund, with the aim of encouraging investors to participate in and assist with the development and production of electricity in these areas. The government is encouraging the development of renewable energy sources, including the support of MIME in the development of different sources of energy, including biofuel, bio-gas, biomass, solar, wind and hydropower. The REE is therefore encouraged to invest in and generate energy through the use of alternative renewable energy, and this includes *Jatropha curcas.*

Among others, MIME's function in terms of the electrification of Cambodia is to a) develop energy policies based on the national strategic development plan, b) provide technical support, c) monitor safety, and d) maintain environmental standards. The Electricity Authority of Cambodia is mandated to issue regulations, provide licenses to electric power service providers, review costs and approve tariffs, resolve disputes, regulate the service and impose penalties. MIME and EAC are the two main stakeholders in the governance of the electricity sector in Cambodia. Even small REEs need to renew their licenses annually, and the EAC has the power to suspend, revoke or deny these.

Tham's REE is registered with the EAC and monitored by MIME. Although there is a regulation covering the provision and pricing of electricity, in the areas without an EDC grid the REE can operate on its own and charge fees based on return of investment, which is considered by EAC. However, once the government or EDC has installed its grids in the area, the REE has to sell the generated power to EDC under a determined price, or else the owner has to stop operation. The owner can also transfer the REE to another area not yet reached by EDC/government grid.

The Ministry of Agriculture, Forestry and Fisheries (MAFF) is mandated to provide licenses to economic land concessioners to operate for 99 years. Each concessionaire can avail up to 10 000 ha. The provincial or municipal governor can also issue a license for areas of less than 1 000 ha with a land value of under US$2.5 million.[14] The provincial governor has provided a licence to an investor of a 700 ha plantation in the village of Svay Chek. MAFF monitors the different crops being produced in rural areas, including their production and yield; the ministry further provides technical support through the department of extension to farmers (such as information on the type of crops suitable in each area – this includes biofuel alternatives such as Jatropha). This government initiative has both favourable and negative aspects. If Jatropha becomes a successful source of biofuel, this could lead to the expansion of Jatropha cultivation. On the other hand, plantation expansion may also endanger food security if the land area intended for food crops will be planted to Jatropha.

Another enabling factor for the development of the REE is demand for and access to electricity of communities in remote areas, which motivates the different actors in the market chain. The end users' demand pull has encouraged the REE and battery charger services to produce electricity and provide services even in the remote areas. Finally, the price of HFO/diesel in the global market has encouraged Tham to use Jatropha oil as additional fuel to reduce the burden of high diesel cost in producing electricity. This has also prompted the government and EDC to explore and develop the use of hydro power, coal, and natural gas as the main future sources of electricity in the country.

Inputs, services and finance

Tham's Jatropha oil was initially produced from fences around the villagers' homesteads – Jatropha plants are used as live fences to protect home gardens from grazing animals and as hedges to protect the soil from eroding. Each Jatropha tree in the village can produce 15–18 seeds per branch, so the more branches, the higher its yield. A three-year old Jatropha tree in the village produces around 5 kg of seed. After the communities learned about the potential of the Jatropha as a source of income and electricity, some of them planted it in hedges or on unused land near their homes. Tham estimates that around 16 ha of household perimeters and idle land in Trapeang Thmor were planted with Jatropha. All of these households sell or (barter) their seed to Tham as he is the only one with a seed expeller.

The successful use of Jatropha oil as an alternative biofuel in the operation of the REE has led some investors to apply to the government for economic land concessions for Jatropha plantations. Two Japanese and Viet Namese companies established plantations in the province in 2010. The Viet Namese company was able to produce and sell Tham 60 tonnes of seed during its first harvest from a 70 ha plantation. However, both companies had to stop operation in 2011 due to flooding which destroyed the Jatropha plants.

SODECO, a women's organization that initially worked with Tham and households, is supporting village women engaged in planting and gathering the Jatropha seed. This organization put Tham in touch with GTZ, a German organization which gave him technical and financial support to convert his machines from diesel to Jatropha oil. GTZ hired a consultant from Elsbett Company to convert the generator (by adding a pre-heating chamber for the Jatropha oil before it enters the engine) and also assisted him in

[14] Sub-decree on Economic Land Concession in Cambodia, 2005.

buying an expeller which extracts the Jatropha oil efficiently. Tham then took out a bank loan to expand his Jatropha plantation in the village and to install the grids; these require large amount of investment. In recent years, microfinance institutions and banks have increased their services to rural and remote areas, where small businesses have started to develop because of their access to electricity. Tham's son and four staff operate and maintain the generator and services for their customers.

Table 1.6: Relationships between market actors

	Jatropha	Electricity generator	REE	Battery charger	Businesses	Households
Jatropha						
Electricity generator	Good, formal					
REE	Fair Formal	Good, formal				
Battery charger	None	Good, informal	Good, formal			
Businesses	None	Good, informal	Fair, formal	None		
Households	Good, formal	Fair, informal	Fair, formal	Good, formal	Good, informal	

Tham's generator set has been converted to suit the use of Jatropha oil (initially the oil damaged the machine's injection pump because of its stickiness). Tham learned from GTZ and Elsbett Company that the oil should first be heated before it circulates in the machine. This adjustment made the generator compatible with Jatropha oil as a fuel, making Tham's REE business more profitable as he makes savings from not using diesel, the market price of which is high. Households with Jatropha are also benefited as they can sell or barter the seed to the generator owner.

The operation of the generator – now sustained because of cheaper fuel – has provided continuous production of electricity for the REE, battery charger services, businesses and households, resulting in good relationships among these actors in the market chain. The REE provided enough electricity to the battery charger services to supply their clients in the remote areas (around 65 percent of the total population of the commune). However, businesses and households were not able to fully use the electricity because of its high price. Tham said that when he can produce more oil, he will also reduce the electricity charges, and that because of the recent flood in 2013, many Jatropha plants were damaged, meaning he had to revert to the use of diesel fuel. An alternative is used vegetable oil from restaurants.

Battery charger operators may be the actors who benefit most from the availability of electricity in the village, as they supply charger services to around 1 486 households in the remote areas. They have a good relationship with their client households. The charged battery conventionally meets the electricity needs of the households to cope with the fast development in the country.

The operation of the 39 businesses in the commune has provided the community with access to common services, such as bicycle and motor repair, agricultural machine tools, hair dressing, and a number of restaurants and shops that operate late into the evening.

The relationship between Jatropha and the REE is no more than fair and it becomes unstable when the Jatropha plantation is affected by disaster such as flooding. Eventually, Jatropha will not meet the desired input for the REE. When the supply of Jatropha biofuel decreases the REE has to use more diesel and the additional expense incurred is charged to the end users (businesses and households), resulting in a fair relationship between both parties. To address this issue, Jatropha plantations need to be relocated to elevated areas to avoid the impact of flood.

Another fair relationship is that between the household and REE generator, due to the noise pollution originating from the REE's large generator. The issue could be solved through enclosing the generator in a soundproof building.

Table 2.6: Balance of relationships, rights, responsibilities and revenues of market actors

Actors	Rights	Responsibilities	Revenues
Jatropha	- Planting in the vicinity/ on plantation - Selling of seed as feedstock	- Production of seed - Selling of seed	- Income from selling seed and bartering for electricity access
Electricity generator set	- Using Jatropha oil as feedstock - Producing electricity	- Determine use of fuel and oil - Produce electricity - Maintain sufficient and quality electricity	- Income from selling produced electricity using either diesel fuel or Jatropha oil
REE	- Determining selling price of electricity - Management of services to beneficiaries	- Install grids - Connect electricity to consumers - Collect payments from consumer - Manage and regulate provision of services	- Income in selling electricity to consumers
Battery charger service providers	- Access to electricity and charges for the service provided	- Conduct daily service to consumers not reached by grids	- Income of selling electricity to consumers not reached by grids
Business owners	- Access to electricity and selling price of commodity	- Regular payment of obligation - Provide better services to the consumers (longer time of selling) - Efficient use of energy	- Income from business that could be opened even during night time
Households	- Equal access to electricity and development in the country	- Regular payment of obligation - Support the production of Jatropha in the area - Efficient use of energy	- Income from selling/bartering Jatropha seed to the REE owner

As a source of biofuel and an alternative fuel, Jatropha has the potential to be propagated and become a source of income for the community. The households who have been participating in collecting Jatropha seed from their fences have the right to increase their production by using idle land (that prone to drought during the dry season, with no source of water and invaded by bushes) in the vicinity. As a producer of Jatropha, the household can control the price of their product and negotiate with the REE owner for reasonable charges for electricity. However, the REE retains control and the right to determine the price of the Jatropha seed and electricity; it charges consumers, as it is a profit-oriented enterprise.

The REE is always in a position of advantage as it gets more revenue from the market chain. The owner could declare that he is using 100 percent diesel fuel to run his generator and maintain the prevailing charges. Similarly, the battery charge provider could have an advantage by raising charges to compensate for the REE's high fees to be able to gain more revenues. Their need to deal with Cambodia's economic development makes consumers vulnerable to whatever charges power providers impose.

The REE and battery charge services are family businesses, and as such are profit-oriented activities. However, dealing with a public commodity also gives them the responsibility to be fair to their consumers in setting charges. They should provide other benefits, such as rebates or social services (e.g. electricity support for a community health centre). For the community, the presence and use of Jatropha as an alternative fuel could be an opportunity to balance excessive electricity fees. The savings made from decreased diesel use should be shared equitably among the different actors of the market chain. Since Jatropha is produced locally, the potential is high for increasing its production and yield to attain the needed level of supply and demand of the REE. If these could be implemented, then the price of the generated power (KHR3 700 or US$0.91) could be lowered to KHR1 700 (US0.43), enabling the end user to also benefit from the market chain.

Analysis of livelihoods outcome

Land use

A potential issue concerns land use, as Jatropha cultivation is seen to be profitable in the area in the long run (e.g. if the land where the Viet Namese and Japanese companies started to plant Jatropha used to be used to grow food crops, then Jatropha cultivation would pose a potential risk to food security). The community members are starting to increase the land area used for their Jatropha plants because of the cash value of its seed, and this may change the use of land intended for food (such as home gardens).

Land tenure

The response of the community to the demand for Jatropha seed as a cash crop might also impact land rights and tenure, as 80 percent of land in Cambodia, especially those areas considered as idle, are under state control. Any conflict on land (especially in areas of economic land concessions) would affect the livelihoods and food security of the community. In the rural areas, land grabbing is a big problem that impinges on the livelihood cycle of the local people.

Food prices

Food prices will eventually be affected once land available for crops is used to grow Jatropha as well. Vulnerable communities, particularly those without land, will be affected by the price hike of basic food commodities such as vegetables and fruits. The alternative is to provide these vulnerable communities with tenure or access to state lands considered as idle land to grow Jatropha. This way the benefits from Jatropha cultivation could be shared among the communities in the area.

Change in income

Household incomes could increase as Jatropha becomes a cash crop. For example, one household can produce around 2.5 kg of seed per tree; if they have 100 trees, then they can harvest around 250 kg at KHR1 000 (US$0.25) per kg and earn around US$62 per harvest. Jobs could also be created in the areas where there are plantations, especially during planting and harvesting seasons. The result of the BEFS assessment shows potential livelihoods and income for around 643 households who have access to electricity. The Jatropha has been planted locally and can bear fruit which will provide an income for farmers.

The technical support provided by SODECO, GTZ and Ellsbet Company have improved the operation of the generator set using Jatropha oil. Tham almost gave up his plan to use renewable energy, but because of the support of these groups he was able to reduce the use of fossil fuel, eventually increasing his income. One result is the demand for Jatropha seed, which has provided the community with a livelihood and electricity. The access to electricity also encouraged 39 businesses to start to use electrical tools (such as compressors, battery chargers, sewing machines, razors, hair dryers, hair dressers and refrigerators).

Jobs and labour conditions

Around 643 households benefited from the introduction of Jatropha as a biofuel. Some have started to expand their Jatropha area to increase their production and gain additional income. Most women are involved in gathering and selling the Jatropha seed to Tham. Tham determined the buying price, sometimes fixing it as low as KHR400 (US$0.10), depending on the quality and age of the seed sold. The generated employment or source of income for a Jatropha household is higher than a day's salary in the rural areas, at US$2.5–3.75 per day, a salary of US$60 per month.

The REE is managed by the son of the owner with the assistance of four staff, who each receive US$250 per month but other benefits (such as insurance and healthcare)[15].

Energy access

The study shows Jatropha to be a potential source of income for the community and an alternative fuel to produce energy; it is produced locally and does not need a large amount of labour to grow, harvest and process. If households (especially those in the country's remote areas without electricity) could increase production of this alternative biofuel to run electricity generators, then there would be no

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[15] In 2013, Cambodia started up a social security system for employees; most of the beneficiaries live in urban areas.

problem with power. Because it is produced in the locality, its market price would be lower than that of fossil fuel, leading to a reduction in electricity costs. There are currently 643 households and 39 businesses supplied with electricity from the REE which uses Jatropha as alternative fuel.

Energy security

The REE plant is producing 250 kWh of electricity per day to supply 643 customers. The REE installed a mini-grid in the village supplied with electricity; consumers were charged US$40 for connection. However, the government is also expanding the installation of the national grid to the rural areas; once installed, the REE must use this grid and sell the electricity produced to the EDC, which manages the national power operation. Usually, EDC determines how much should be paid for the electricity from the REE; if the REE does not agree, the owner has to close his enterprise or relocate to an area not reached by the national grid.

As for Jatropha production and the volume needed to run the REE generator, it remains in doubt whether these can be met; a number of factors may hinder its production. One is the impact of climate change, such as the heavy rains which have caused flooding in areas planted with Jatropha. In 2011 and 2013, the Jatropha plants were destroyed by floods, forcing the REE owner to revert to the full use of diesel to run his generator. Consequently, the cost of electricity in the area went up and was eventually charged to its consumers. However, Tham is now exploring the use of the oil from the seed of the Kapok tree (*Ceiba pentandra*) as an alternative.

Barriers, drivers and interventions

The following section presents the current problems and potential barriers, drivers and interventions for project replicability and scalability at three levels: i) energy market chain, ii) inputs, services and finance, and iii) the enabling environment.

Level 1: Energy market chain

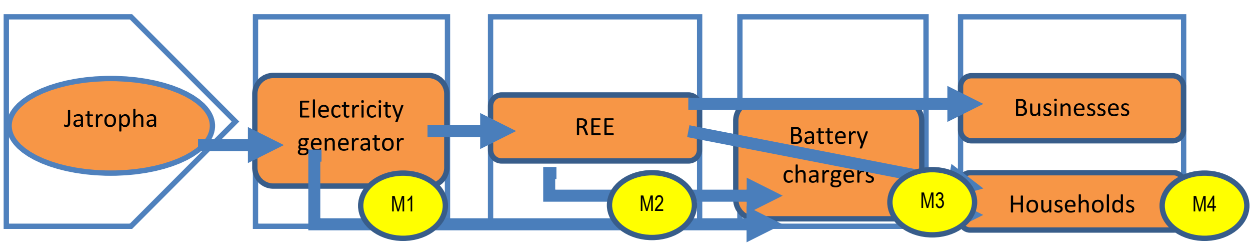

Figure 2.6: Market map: Energy market chain

M1: - limited upgrade of technology;
- lack of proper technology and infrastructure to enclose the plant to prevent noise pollution;
- lack of other alternative biofuels to run the engine (aside from Jatropha);

M2: - lack of business plan;
- excessive charges for consumers;
- no bargaining power with EDC;

M3: - lack of business plan;
- lack of business alternative once the area is reached by EDC grid;

M4: - lack of bargaining power with the providers of electricity;
- electricity from the REE is too expensive to open more businesses.

Table 3.6: Energy market chain- barriers, drivers and interventions

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
REE	Electricity demand of rural communities High price of fossil fuel	Genuine government support for small-scale bioenergy Monopolization of EDC in the provision of electricity	Use of fuel from Jatropha feedstock is cheaper compared to expensive fossil fuel Jatropha is locally produced and can survive in dry land areas	Actual government policy and support for small-scale renewable energy Support of different development partners, both for Jatropha production and use of small scale renewable energy
Battery charger	Lighting and TV demand in remote areas Available affordable electricity in the commune/ nearby village	Expansion of REE in remote villages	Only 13 percent of the total population in rural areas have access to electricity	Development of this service provider into REE in remote areas using Jatropha oil to produce electricity
Businesses and households	Demand for affordable source of electricity Share from the economic growth of the country	Providers are charging high electricity rates	Access to affordable electricity from locally produced renewable energy from cheaper feedstock Income of the community in planting Jatropha	Use of idle land in producing Jatropha Encourage other locally produced feedstock to generate power at cheaper inputs Start a cooperative source of electricity using renewable energy

Access to electricity is the main influencing factor which encouraged Tham to set up the REE in an area not yet reached by government electric grids. The high price of fossil fuel needed to run the generator has motivated him to explore cheaper sources of feedstock; locally planted Jatropha used to fence household perimeters has good quality oil that could replace the fossil fuel used. The potential barriers to scaling up and replicating this initiative is the production and yield of Jatropha seed needed to replace the 7 000 litres of diesel per month to run the generator set to produce 24-hour electricity; only

16 ha of Jatropha are used to produce the seed for this. Another barrier is the impact of climate change; in the last three years, the area was flooded twice, causing damage to the Jatropha plantation initiative. Potential drivers for scaling up and replicating include the utilization of idle land in the area that is not used for other crops because of lack of water source. However, this would require a proper selection of the suitable area to avoid the impact natural disasters (floods and typhoons). The potential intervention is the conduct of a study regarding the idle lands that are available in the area and the legal application for an economic land concession to avoid any conflict when the land is developed.

Level 2: Inputs, services and finance

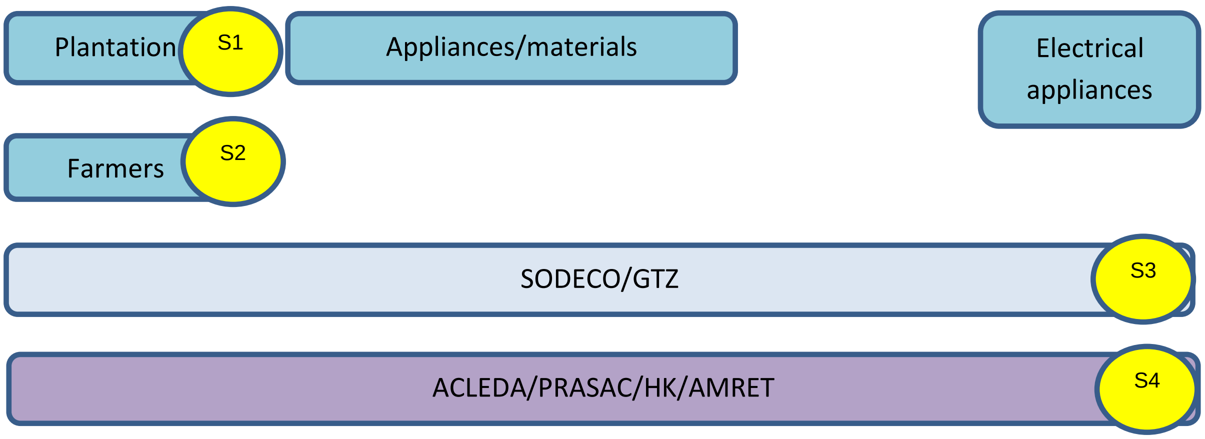

Figure 3.6: Market map- inputs, services and finance

S1: - lack of technical support/study on the area of plantation;
- vulnerability to flood/climate change;

S2: - no bargaining power with REE owner in selling their Jatropha seed;
- lack of technical support from the government;
- lack of proper knowledge in planting Jatropha;

S3: - end of support for REE and production of Jatropha;
- lack of other support in the development of small scale bioenergy;

S4: - lack of full support for the development of REE because of business instability;
- lack of or no interest by microfinance institutions in the area because of its remoteness and poor infrastructure (e.g. roads and buildings).

Table 4.6: Inputs, services and finance- barriers, drivers and interventions

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
Farmers	Jatropha could be a cash crop Could survive in dry lands/idle	Technology in growing Jatropha Land tenure of farmers	Available idle land for Jatropha plantations Development of infrastructure i.e.	Government development of infrastructure and technical support for farmers

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
	lands	Support of the government for small-scale farmers - Information/ knowledge of farmers in Jatropha growing	irrigation and roads Government support for small-scale farmers NGO support for farmers MFI support for farmers	Providing land tenure and titles to farmers NGO technical support for farmers MFI financial support for farmers
Plantations	Increasing demand for Jatropha seed as feedstock Quality of Jatropha seed as biofuel	Technology Tenure/conflict with small-scale farmers Climate change	Available technology in planting Jatropha Economic land concession availability in the country Government support	Government support Development of technology in planting Jatropha Contract agreement of REE and Jatropha plantations
Institution/ organization support	Increasing demand for renewable energy in rural areas Poverty alleviation in the rural areas Thrust of the institution/ or3ganization	Infrastructure in rural areas Remoteness of the area Government support for institutions/ organizations	Demand for energy in rural areas Priority of development partners and the government Development of infrastructure in rural areas	Policy supporting the development of small scale renewable energy in consideration of current imperatives (e.g. climate change) Good partnership/ networking of development institutions/ organizations with government in development of small-scale bioenergy
MFI/banks	Increasing clients in rural areas Development support from development partners and government is towards rural areas	Infrastructure in rural areas .Remoteness of area Stability of businesses in rural areas	Increasing demand for financial support Development partners are working in rural areas Priority of government development strategy Development of infrastructure in the rural areas	Development of infrastructure in rural areas Demand of development partners on technical and financial assistance for farmers/small-scale bioenergy

Most of the households in the village own *chamkar* (state land traditionally used for growing any crop and inherited by the household from their ancestors). The farmer usually uses this land for integrated farming (e.g. planting cashew, pineapple, rubber tree, cassava) for perennial or long-term crops. The potential income gained from Jatropha could be an influencing factor to use it to replace low-yielding, non-commercial crops. A possible constraint to replication is the use of the land for other purposes or for more traditional crops; this is what the farmers know and have inherited from their ancestors. Another potential barrier is land tenure: the land is still considered to be under the control of the state. The potential drivers for scaling up and replicating this plantation initiative would be the support of government and other institutions for the technical, financial and marketing aspects of Jatropha production. As for the potential intervention, the government could develop a policy providing guidelines and procedures on how to increase the production of Jatropha without undermining food security. Identification of the right area should be done also prior to expanding plantations, to ensure sustainability.

Cambodia's economic growth is a motivating factor behind the communities wanting to move forward and be part of the country's development. That 600 households avail electricity despite its cost indicates the community's capacity to find a way to avail services if they need them. This encourages MFIs and banks to open branches in rural areas to assist communities in their development, including access to public services. The potential barrier to scaling up and replicating this is the bad condition of the area's infrastructure, in particular roads in and out of the villages. The potential driver for up-scaling and replicating this is the willingness of the communities to avail loans to develop their agriculture activities. The potential intervention is for the government to support the development of infrastructure (particularly roads connecting villages to district and provincial centres) to link communities to these financial institutions.

Level 3: Enabling environment

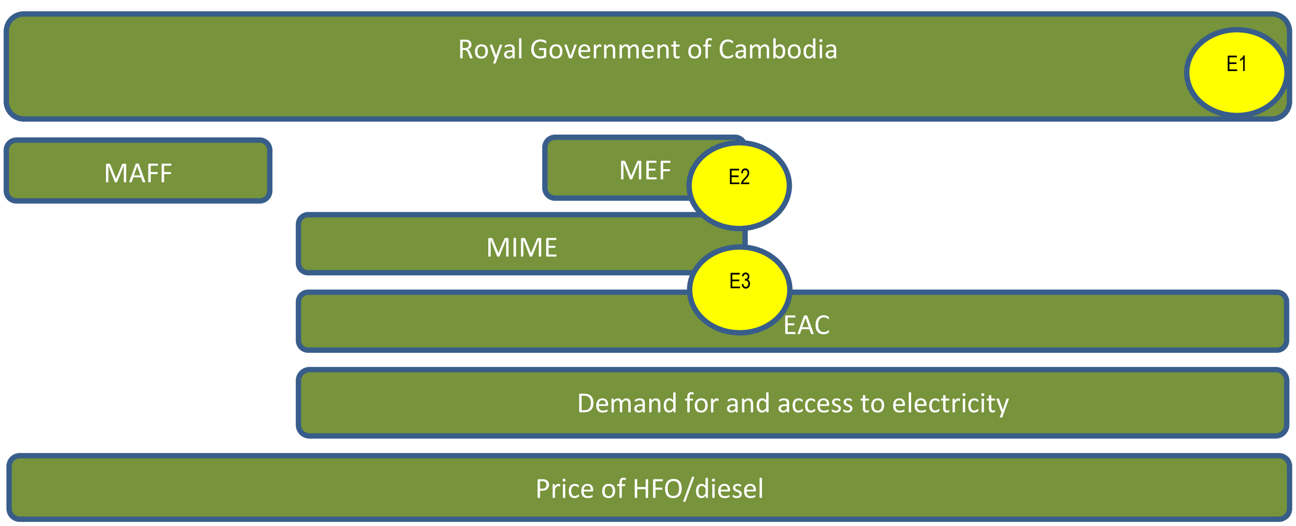

Figure 4.6: Market map- enabling environment

E1: - no long term plan for the development of small-scale bioenergy in rural areas.

E2: - no clear policy on the development of small-scale bioenergy in the rural areas;

- more support for the development of larger source of energy such as hydro power and coal power plants;
- co-owned by the EDC private company that controls the REE.

E3: - co-owned by the EDC private company that controls the REE.

Table 5.6: Enabling environment: barriers, drivers and interventions

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential interventions
RGC NSDP	Government prioritizes electrification in rural areas MDG priority	Infrastructure development in rural areas Technical and financial support in rural development Priorities of government funding in rural areas	Priorities of MDG and NSPD on poverty alleviation and development of energy access in rural areas Support of government and DPs for development of renewable sources of energy in rural areas	Prioritization of government support in rural areas particularly on development of small scale bioenergy as source of energy Development of infrastructure in rural areas to provide accessibility for DPs
Ministry of Economy and Finance	Main ministry that approves budget for the financing of government development projects	Government has other priorities for the rural development fund	DP priorities which could influence government to allot a budget for development of renewable energy, in particular small-scale bioenergy	DP priorities which could influence government allotment of a budget for renewable energy in rural areas
Ministry of Industry, Mines and Energy	Government prioritized electrification in rural areas using renewable energy	Ministry has its own priority for bigger sources of energy (e.g. hydro power, coal power plants) Lack of policies regarding priority source of energy for the sector	DP priorities which could assist in development of small-scale bioenergy DPs could influence ministry priorities, as they support the development of the country	Cooperation of REEs with DPs and government regarding small-scale bioenergy Development and advocacy of DPs regarding development of small-scale bioenergy promotion in government policy

The Cambodia government has only recently refined its various policies in the country's different development sectors. The Ministry of Industry, Mining and Energy (MIME) has been mandated to lead the development of policies towards electrification of the rural areas; it is encouraged to support the development of new technologies and renewable energy. The potential barrier to scaling up and replicating REE use of Jatropha is that based on the national priorities, MIME does not fully supporting biofuel and biomass but rather hydro and coal power plants for the long-term energy development of the country. The monopolization of the government-owned EDC is also a potential barrier for scalability or replication of the REE initiative using biofuel as renewable energy. The potential driver for scaling up and replicating this type of REE is the NSDP, which promotes biofuel as a government priority of the government for the development of the rural areas. The potential intervention would be the documentation of successful biofuel and biomass feedstock and advocacy for the development of these renewable energy sources in the rural areas.

Conclusions

The REE is using Jatropha as feedstock as a source of electricity in rural areas that are not yet reached by the national grids. The only way that the REE can lower the price of electricity is to use alternative fuel (rather than fossil fuel). The Trapeang Thma Kandal REE has been using *Jatropha curcas* to reduce the amount of diesel used in generators to produce electricity; lower fuel inputs will lower electricity prices, which will motivate investors to start businesses which can provide the needs of the community, including the development of their own livelihoods. However, the REE is a business-oriented enterprise, and does not recognize its social responsibility to provide a service to the community. In this case study the cost of electricity is still too high for the community members to start their own livelihood or to increase their income using the energy generated.

The REE initiative to use Jatropha seed as oil has provided value for this plant, which is now considered as invaluable (aside from its function as provider of a live fence for protection from grazing animals). The households involved with this plant benefited as they sold and bartered the seed with the REE owner. Some households even started to plant their *chamkar* with Jatropha, realising that it provides a higher income than the crops they traditionally planted on land. However, the impact of climate change (such as heavy rains during the wet season) could be a big challenge for the communities involved in this initiative. Flooding impacts badly on the Jatropha plant, which cannot tolerate long periods in water.

Lack of government support could also lead to the failure of this initiative. Although renewable energy is an NSDP priority, MIME supports other sources of energy (e.g. hydro- and coal power plants). The government co-owned EDC is also monopolizing the energy sector, and the REE cannot compete with it. Successful REE initiatives should thus be documented and their potential scalability and replicability presented to the government to gain its support. Development partners should also support and advocate the use of small-scale bioenergy that has proven to be effective in producing electricity.

Factors that could affect the sustainability of the use of biofuel as an alternative are its production, genuine support from the government, and support from other organizations and institutions promoting renewable energy to combat climate change. In addition, the value of the Jatropha seed is factor that will encourage communities to increase their production. However, there needs to be a clear policy to monitor the expansion of this biofuel source as it could affect food security once scaled up. Finally, the community's energy demand and access is a major factor that could affect the sustainability of the REE using locally produced fuel; this could reduce the use of fossil fuel that dictates a very high price in the local market.

References

Albu M. and Griffith, A. 2005. *Mapping the market: A framework for rural enterprise development policy and practice*. Practical Action (also available at: *http://practicalaction.org/docs/ia2/mapping_the_market.pdf*).

BEFS. *Operator Level, Food Security Assessment Tool – Version Two* (available at: http://www.fao.org/energy/befs/operator-tool/en/).

Census 2008. Royal Government of Cambodia, National Institute of Statistics, Ministry of Planning.

Commune Database. 2010, National Committee for Sub-National Democratic Development (available at http://db.ncdd.gov.kh/cdbonline/home/index.castle).

Engineering and Consulting Firms Association, Japan, Japan Development Insitute (JDI), Kimura Chemical Plants Co., Ltd. 2007. Cambodia Bio-energy Development Promotion Project.

Global Tracking Framework (available at *http://www.worldbank.org/en/topic/energy/publication/Global-Tracking-Framework-Report*).

Iied. 2005. *The Four Rs*, Power Tools. *http://www.policy-powertools.org/Tools/Understanding/docs/four_Rs_tool_english.pdf*

National Strategic Development Plan, Update 2009–2013. 2010. The Royal Government of Cambodia.

Poch, K. and S. Tuy. 2012. 'Cambodia's Electricity Sector in the Context of Regional Electricity Market Integration' in Wu, Y., X. Shi, and F. Kimura (eds.), *Energy Market Integration in East Asia: Theories, Electricity Sector and Subsidies*, ERIA Research Project Report 2011-17, Jakarta: ERIA, pp141-172.

Ryder G. 2009. *Powering 21st Century Cambodia with Decentralized Generation, A Primer for Rethinking Cambodia's Electricity Future*. The NGO Forum Cambodia.

List of interviews

8 November, 2013, Bot Trang village:

Tham Bun Haik, owner; Hout Sithat, household member; Rouen Chantha, businesswoman.

Cambodia (Case 7): Rice husk electrification

Initiative Name	**Rural Electric Enterprise (using rice husk gasifier)**
Location	*Doun Sva village, Char Chouk commune, Angkor Chum district, Siem Reap province, Cambodia*
Initiation date and duration	*January 2011–November 2013 (2 years and 9 months)*
Funder(s)	*MIME, UNIDO, IED Invest Cambodia, REEEP, Total Cambodge, and SREP*
Project initiator	*Ky Chantan (IED Invest)*
Overall budget (if available)	*US$400 000*
Output	*2.5 MWe (2010)* *200 kWe (2012)*
Area of land	*5 000 m²*
Beneficiaries	*1 903 households: electricity,* *1 522 farmers: rice husk as feedstock* *101 businesses, seven gasifier staff*

Background and context

Cambodia is located at the south of the Indochina peninsula in Southeast Asia. The country is 181 035 km² covering 23 provinces and four cities, with Phnom Penh City as its capital. It has a population of 14.7 million, of which around 80 percent live in the rural area and rely on agriculture as their main occupation. The country's poverty rate is 25 percent, with those living below the poverty line comprising 13 percent (Census, 2008).

Cambodia's power supply was heavily damaged during the war and by genocide in the 1970s, and has only recently been rehabilitated with the support of bilateral and multilateral donors and development partners (World Bank, ADB, UN, Japan, the United States and European countries). The total number of households with electricity as their main source of light is 26.4 percent (87 percent in urban areas and 13.1 percent in rural areas). The electricity is supplied through use of heavy fuel oil (HFO), diesel, gas, wood, coal, hydropower, wind and solar energy, biomass and biogas, and provided by the state-owned Electric du Cambodge (EDC), independent power producers, provincial departments of the Ministry of Industry, Mines and Energy (MIME), licensees in small towns, and private rural electricity enterprises (REEs). Aside from EDC, almost all providers use diesel or HFO to generate electricity, the dependence on which has made the price of electricity one of the most expensive in the region. Another contributory factor is the high electricity tariff rates, ranging from US$0.09-0.25 per KWh for electricity for the EDC grid and US$0.04-

0.80/KWh for rural areas. These are among the highest both in the region and the world (Poch and Tuy, 2012).

A report by the Electricity Authority of Cambodia (EAC) stated that demand for electricity is increasing every year. The EAC data indicates a 268 percent increase in consumers from 182 930 in 2002 to 672 709 in 2010. During this period, the government and private sector increased available energy by around 310 percent (from 614.03 million KWh in 2002 to 2 515.67 million KWh in 2010). Despite this, the current supply is insufficient (e.g. Phnom Penh requires 400 MW per day, but the current available supply is only 290 MW). Based on current trends, the country will need about 3 000 MW in 2025 (ibid).

The very low access to electricity in the rural areas has made electrification a priority both of government strategy and of the energy sector. The government has established a rural electrification fund to a) promote equity in access to electricity supply services and b) encourage the private sector to participate in investing in rural power supply services in a sustainable manner, in particular in the use of new technologies and renewable energy. One government priority iterated in the National Strategic Development Plan (or NSDP) (updated 2010-13) is to reduce poverty in rural areas by accelerating rural electrification, including the use of renewable energy. According to the Plan, the Ministry of Industry, Mines and Energy will foster the development of all types of renewable energy, including biomass, biogas and biofuel (NSDP, 2010).

One of the case studies examines the use of a gasifier which used 100 percent rice husk to produce electricity of around 900–1200 kWh per day. The case study was documented in Char Chuk commune, which has a population of 1 903 households. The Rural Electricity Enterprise rice husk initiative is a pilot project in Doun Sva village, where out of a total population of 1 124, 93 percent have agriculture as their primary occupation. The total wet rice land area in the village is 4 957 ha with total wet rice production of 11 375 tonnes (an average yield of 2.5 tonnes per ha) (the farmers do not produce dry rice because of the lack of irrigation). The average rice price is KHR1 074 (US$0.27) per kg. There are three medium-to-large and 45 small-scale rice mills in the commune. Only 17.97 percent of houses have electricity, of which 64.66 percent use battery light. There are seven battery charge services in the commune (MoI, CDB, 2010).

MIME, UNIDO, IED Invest Cambodia, REEEP, Total Cambodge, and SREP are the institutions implementing the pilot project, which is semi-private in its operation, being run by a private entity with the support of government and development partners. Before the initiative, the electricity produced by the REE was sold directly to the community using the REE grids. The electricity currently being generated is sold to EDC at a lower rate, as the REE uses the EDC grids to supply its consumers. Seven staff members operate the gasifier 24 hours per a day in three shifts.

Food security

The provision of assets (or access to assets) to around 1 903 households in the gasifier's operation area has potential benefits for food security. Every household has access to infrastructure and electricity and around 80 percent benefit from natural resources, and agricultural inputs and facilities. Around 1 630 households have increased their income due to the operation of the gasifier plant: these include subsistence farmers who have gained from the additional value of their rice husks, small businesses which use electricity to run their equipment and tools, and workers employed in the gasifier plant. These positive outcomes all indicate a potential benefit for food security.

However, the assessment also indicates a number of potential risks to food security from the operation of the gasifier plant. Based on an interview with the plant owner, the half ha used for the operation of the gasifier had previously been intended for rice growing and cultivated once a year. The commune's current yield is 2.5 tonnes per ha; use of the land for operating the plant has therefore reduced rice production by around 1.25 tonnes every year. There is currently no significant influence on food security in terms of land and water availability; however, this could be compromised if good practice in land use is not implemented.

The assessment also looked at cross-cutting issues, and these indicated a potential risk to food security. The gasifier plant owner did not provide an assessment which looked into impacts on tenure rights, livelihoods and food security in the operation area, nor was the free, prior and informed consent obtained of the affected community prior to the operation. The enterprise has no feasible alternative project design, either to prevent or minimize physical displacement and/or economic displacement, particularly of the poor and vulnerable. On the other hand, the project did not cause any physical displacement prior to operation

Finally, the assessment indicated a potential risk to food security resulting from there being no system or mechanism in place to monitor impacts on nearby communities and no respect for negotiated agreements including compensation. Complaints have been aired by households affected by noise pollution caused by the generator and air pollution from the dust, ash and foul odour coming from the plant's water treatment.

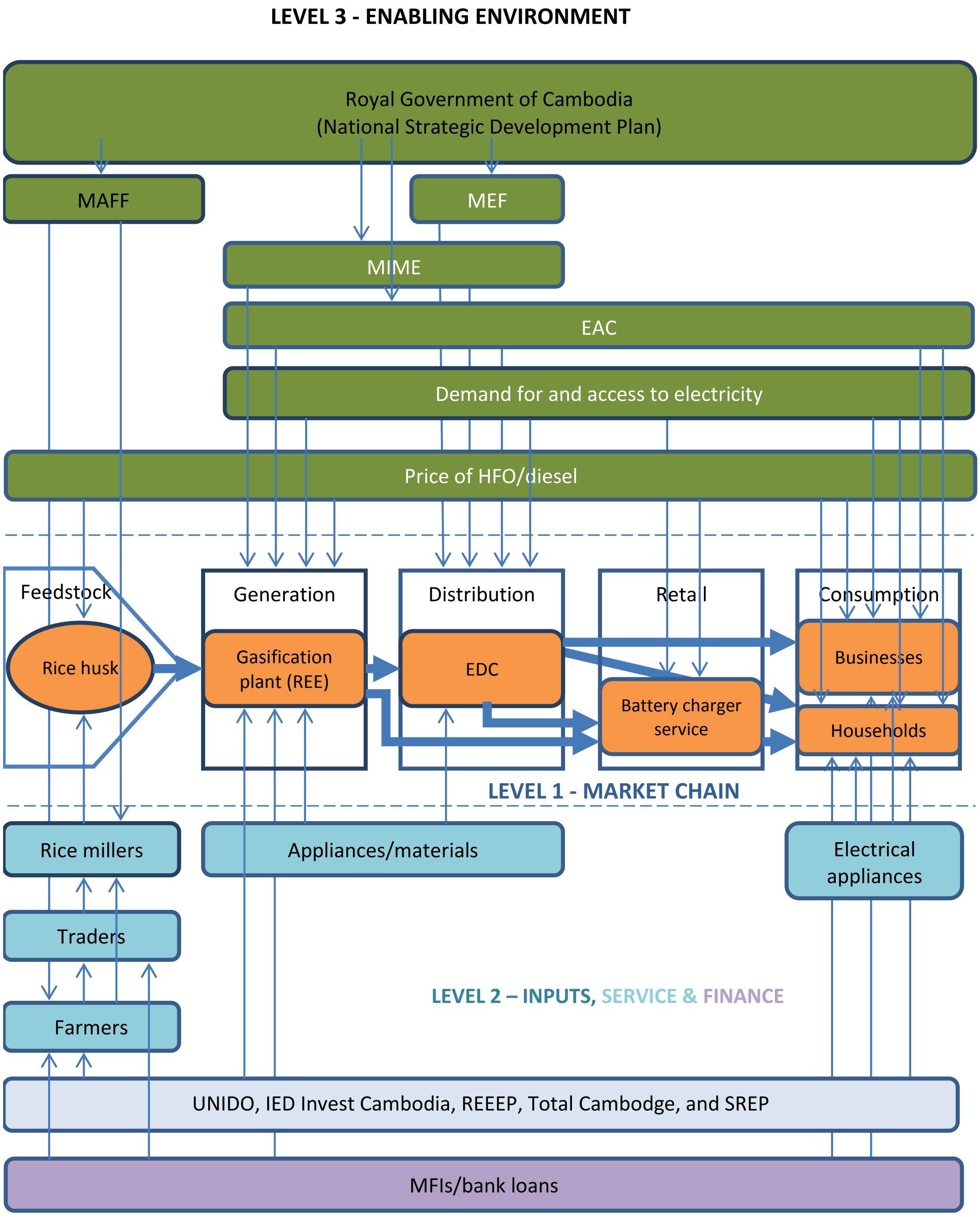

Figure 1.7: Initiative market map

Market chain

Cambodia is a Southeast Asian country where few people have access to electricity, particularly in the rural areas. In this context, the main objective of the Rural Electricity Enterprise is to produce electricity to supply power to the increasing population and develop the economy of the rural areas. IED Invest Cambodia has therefore been supported to use 100 percent biomass (in the form of rice husk) to produce 200 kW electricity in one of the communes in Siem Reap Province. Around 140 kg of rice husk per hour (around 1 200 tonnes per year) are being fed to the gasifier. The farmers produce rice as their main crop in the rural area at 2.5 tonnes per ha yield, and the rice husks from the current rice yield are used to generate electricity. The main source of rice husks is from rice mills in Doeun Penh and Krolaeng villages, which can produce more than 1 000 tonnes of rice husk per year (based on the production of the commune at more than 11 000 tonnes of paddy rice). Both traders and farmers in the districts mill their paddy rice in these two rice mills. The Ministry of Agriculture, Forestry and Fisheries continues to develop rice production through system rice intensification (SRI) and the building of irrigation systems. The government has been targeting one million tonnes of rice for export. The available rice husk from the country could thus sustain the current demand and support any expansion in the future.

The gasifier is a fixed bed downdraft imported from India (Ankhur technology), operated by a seven-member team for 24 hours. It was installed in 2011 through the support of five institutions including MIME. Initially, the gasifier plant was operated using diesel and rice husk biomass (20 percent diesel and 80 percent gas), but in early 2013 the owner decided to use 100 percent gas produced by the gasifier. His decision to give up using diesel was influenced by its price, which was increasing on the global market. The gasifier can maintain production of 1 200 kWh per day to consumers in the target villages. In 2008, the REE was selling electricity directly to households and businesses in the target villages of the commune at KHR1 750 (US$43) per kWh. However, EDC recently installed the national grid in the commune, and bought the electricity produced from the plant at KHR760 (US$19) per kWh.

EDC (a commercial entity, co-owned by government under MEF and MIME) has a monopoly of the buying and selling of electricity in areas reached by grids. Its selling price is higher than the REE's (KHR1 900 or US$47.5 per kWh). EDC plans to continue accessing electricity from the REE until it develops a cheaper source of energy (such the country's developing hydro and coal power plants). At present, EDC imports most of its supply of electricity from Thailand and Viet Nam at a very high tariff which is passed on to its consumers.

Battery charger service operators are part of the market chain, popular in the countryside especially in remote areas without grids. There are around 1 500 battery charging services in Cambodia's rural areas; there are seven battery charger operators working in the area of this case study. The charging service works like this: the battery charging service owner has a cow cart and collects a battery from each household on his list every morning. He delivers the battery back to the household in the afternoon. The charge for the service depends on the size of the battery. For example, the cost of charging a small car battery is KHR1 000 (US$25) and KHR1 500 (US$37.5) for a big battery. This charge may last a week or a few days, depending on whether users have televisions or a higher light voltage. Batteries are mainly used by households; business establishments prefer to use generators after dark. Businesses and households are the end users in the market chain level and EDC supplies both; a shop consumes an average of 80–150 kWh per month and a household an average of 20–50 kWh per month.

Enabling environment

In the energy sector, the NSDP prioritizes the development of electricity, particularly in rural areas. The government supports the Rural Electrification Fund which encourages investors to assist in the development and production of electricity in rural and remote areas where infrastructure is poor, and is encouraging the development of those renewable energy sources that can support this initiative. EAC data indicates there are around 600 REEs operating to support electricity in the rural areas.

NSDP support is a positive factor in the exploration and development of renewable energy (including the use of biomass and biofuel as sources of energy). The case study rice husk gasification case study is one example of a pilot project undertaken with the assistance of MIME through technical, financial and legal support to operate in the area. MIME's function, in terms of the electrification of the country, is to develop energy policies, strategies, and sector plans based on the NSDP plan, to provide technical support, monitor safety, and maintain environmental standards. EAC is mandated to issue regulations and licenses to electric power service providers, to review costs and approve tariffs, resolve disputes, and regulate and impose penalties. MIME and EAC are the two main stakeholders in the governance of Cambodia's electricity sector. They tend to control the operation of even small REEs, who need to renew their licenses annually (EAC has the power to suspend, revoke or deny licenses for the supply of electricity services).

The negative implication of MIME regarding REE rice husk gasification is the support it provides to EDC, which monopolizes the purchase and sale of electricity. An REE using rice husk as feedstock is not adequately protected from monopolization by the larger company. The ministry has also prioritized hydro and coal power plants as the longer term sources of the country's energy, which is a further constraint to the REE wanting to embrace biofuels.

As the country's economy develops, demand and access to electricity is increasing rapidly. Projections indicate that Cambodia will need around 3 000 MWe in 2025; as of 2010 the country had only 2 515 million kWe. Electricity demand and access are factors motivating different actors in the market chain. The end users' demand pull has encouraged the operation of battery charger services, EDC and REEs to produce electricity and provide services, including in remote areas. Another factor is the rising price of HFO/diesel on the global market, which has nudged the REE to use rice husk biomass as an alternative fuel to produce electricity. This has also moved the government and EDC to explore and develop the use of hydropower, coal and natural gas as the main future sources of electricity in the country.

Inputs, services and finance

Cambodia is an agricultural country and rice is its main crop; it produces around eight million tonnes of paddy rice per year. Five million tonnes of this are milled in the country, with the potential to produce around 1.1 million tonnes of rice husk. If 2 kg of rice husk generates 1 kWe, the country could produce around 500 MW of electricity in the rural areas every year. As the country intensifies its rice production, the supply of rice husks as feedstock could be increased and sustained. This will also benefit 80 percent of the population whose main occupation is rice farming, since rice husks can now be converted into cash rather than treated as waste. Aside from farmers as the direct source of feedstock, traders also supply paddy rice to rice mills, with a great volume milled for export. This would be a cash opportunity for rice millers who would benefit most from the use of feedstock especially since rice husks are considered waste by farmers and traders. REE currently buys rice husks at KHR1 300 (US$0.13) per kg.

Other institutions directly supporting REE use of rice husk biomass are UNIDO, the Renewable Energy and Energy Efficiency Partnership (REEEP), SREP and Total Cambodge. UNIDO provides the initiative with technical support, such as proper operation of the gasifier. REEEP (funded by the OFID-OPEC Fund for international Development) and the Sustainable Rural Electrification Plan (funded by FASEP and the French government) extend both technical and partial financial assistance to the project. Total Cambodge supports the discounted price of diesel fuel when problems occur in the operation of the gasifier necessitating the use of a diesel generator.

Some business enterprises dealing in mechanical and electrical materials, tools and equipment are now present and established in the area to meet miscellaneous mechanical and electrical needs or REE and the households involved in the project. Support also comes from financial institutions; ADB provides a subsidy for rice seed and fertilizers to increase rice production and yield. Based on reports, subsidised farmers have increased their yield from two tonnes to four tonnes per ha. This would mean an increase in the biomass for the production of electricity, which will benefit the end users.

A number of newly-established banks and microfinance institutions operating in the area extend loans to farmers (mainly those who can use their land as collateral), either to increase their agricultural production or for agricultural or business development. Some microfinance institutions, which evolved from NGOs (for example Vision Fund, previously from World Vision) also give support for agricultural production and other economic development in the area, such as business enterprises including REE.

The country's farmers were also organized into cooperatives and associations, which is a way of providing support in capacity building and organizational development through linking and networking them into the MFIs and banks to develop and increase the production of members. MFIs/banks are also supporting traders, operators of gasifiers, businesses and households in the market chain.

Table 1.7: Relationships between market actors

	Rice husk	Gasification plant	EDC	Battery charger	Businesses	Households
Rice husk						
Gasification plant	Good, formal					
EDC	None	Fair, formal				
Battery charger	None	Good, informal	Fair, formal			
Businesses	Fair, Informal	Good, informal	Fair, formal	None		
Households	Good, Formal	Fair, informal	Fair, formal	Good, formal	Good, informal	

Good relations have been established between the gasification plant owner, rice millers, rice traders and farmers, largely because of the benefits gained by each in the market chain. Initially, the owner of the gasification plant conducted a baseline study to determine the available supply of rice husks in the commune, district and province, after which he decided to convert his business into a gasifier plant. He built a good relationship with the two big rice millers in the nearby villages, which adequately meet the needed biomass of feedstock for his plant's 24 hour operation. The use of rice husks as feedstock has directly improved the business of the rice millers, traders and farmers. The rice millers are able to earn additional income from the rice husk waste and thus maintain a good relationship with the owner of the gasifier. The rice miller also encourages the traders and farmers to mill their paddy rice by providing an additional incentive through a reduced service charge for milling according to the volume of rice milled. Similarly, businesses around the area of the gasifier plant are now indirectly benefiting from the use of rice husks, as it reduced the price of electricity in the area. They are also provided with 24 hour lighting, enabling them to extend their business operation. Since most of the households in the rural areas produce paddy rice which is subsequently milled, the demand for the rice husk by-product has also directly benefited them economically.

With regard to EDC however, the owner of the gasification plant is not that satisfied with his relationship with the company. EDC installs the grids and thus monopolizes the provision of electricity to consumers. Because EDC is co-owned by the government, it can control each power producer and oblige them to sell what they generate to the company. In a way, this is good practice, as it sustains the operation of the REE; however, EDC controls the price of the electricity produced. In comparison, the relationship between the REE owner and the battery charger service operator is good as the latter provides access to electricity for the daily needs of the consumers in the remote areas. The same is true for the business owners and households who have access to 24-hour electricity. However, some households around the perimeter of the area have complained of the volume of noise created by the gasifier, the dust and bad odour of the ash, and the untreated water emitted by the plant. According to these households, although they are provided with 15kWh free every month, this does not compensate for health ailments and adverse environmental impacts that result from the operation of the gasifier. EDC's relationships with other stakeholders (such as the battery charger service providers, businesses and households) in the area are no more than fair, because of its monopolization and high electricity charges.

The battery charger operators have a good relationship with their client households, particularly those in the remote areas. The charged battery conventionally meets the electricity needs of the households to cope with the country's rapid development. The basic needs of the rural households for goods and services are met by the increasing number of businesses established in areas where electricity is available 24 hours a day.

Table 2.7: Balance of rights, responsibilities and revenue of market actors

Actors	Rights	Responsibilities	Revenues
Rice husk producers	- Producing biomass - Selling of feedstock	- Produce paddy rice - Purchase volume of paddy rice - Milled/produce rice husk - Sell rice husk	- Income from selling rice husk to gasifier plant
Gasification plant owner	- Producing electricity - Determining selling price - Plant management	- Process the production of gas - Produce electricity - Sell out electricity - Maintain enough and quality electricity	- Income from selling electricity to EDC - Income of selling ash to the farmers
EDC management	- Determine selling price of electricity, - Management of services to beneficiaries	- Install grids - Connect electricity to consumers - Collect payments from consumer - Manage and regulate provision of services	- Income in selling electricity to consumers
Battery charger service provider	- Access to electricity and charges for the service provided	- Conduct daily service to consumers not reached by grids	- Income from selling electricity to consumers not reached by grids
Business owners	- Access to electricity and selling price of commodity	- Regular payment of obligation - Provide better services to consumers (longer time of selling) - Efficient use of energy	- Income from business that could be opened even during the night
Households	- Equal access electricity and development of the country	- Regular payment of obligation - Support the production of rice husk in the area - Efficient use of energy	- Income from selling rice husks to the rice millers

The farmers, traders, and millers used to consider rice husk as waste, but its present use as feedstock means it is now valued by them. The producers (particularly the farmers) must be made aware of the potential economic benefit of rice husk which they traditionally regarded as waste. In this way the farmers will value rice husk as they value rice and thus be motivated to increase their rice production. The owner of the gasifier has invested thousands of dollars to produce electricity in the remote areas, aiming to assist communities with electricity and at the same time gain revenue. However, EDC monopolization and control of the electricity market in areas where it extended the grid created discontent in the REE, particularly with regard to EDC's low purchase price of electricity. It is felt that the plant owner should have the right to sell the generated power based on his investment and target revenue, as well as the right to be supported and protected by the government. As the grid moves towards remote areas, the battery charger service provider may also lose the source of his livelihood. The EDC or REE should therefore pay attention to this actor in the market chain, which has already built a relationship with clients and should have the right to work with EDC or REE, especially to continue to provide their battery charge services to consumers. As for the end users, they have a right to an equitable share in the benefits reaped from the production of electricity in the form of incentives such as rebates, discounts or other benefits as they consume more electricity. As the gasifier plant helps reduce expense and increase profit, the consumers – as the producers of the biomass used to feed it – should benefit commensurately.

The gasifier plant owner has a social responsibility to obtain the free prior and informed consent (FPIC) of the people in the area before building the plant, particularly with regard to potential environmental and human impacts of its operation. This was not done, and some communities adjacent to the gasifier have raised concerns about its negative impacts, which could have been addressed beforehand if the FPIC process had been conducted.

Among other measures in this sector, the government should regulate and control tariff and purchase value. However, it is a co-owner of EDC, and cannot regulate the company as the main goal of its board of directors is to earn profit rather than to provide a public service. Although EAC is an independent entity that regulates electricity services and governs the relation between delivery, receiving and use of electricity, the function of policy and strategy formulation still falls to MIME. The consumers should have the right and responsibility to convey their dissatisfaction to the service providers, but this is currently not the case.

Although each actor benefits from the introduction of electricity in the area, some gain more than others. EDC obtain the most benefit as it passes on costs to consumers, including the high tariff levied in importing electricity and in installing the grids towards the remote areas (as mentioned, it purchases electricity from IPP and REE at a very low price and earns more than double when it sells it back to the consumers). The rice millers are also obtaining revenue from the waste rice husk and this could have been shared with the farmers as the primary producers. If there was a direct relationship between the gasifier owner and the consumers, then the quantity of rice husk could be bartered with the amount of electricity used, enabling both to profit from the market chain.

Analysis of livelihoods outcome

Land use

In the current context of land use, the REE plant does not compete in any of the land uses particularly in growing food crops in the area as it only covers around half a ha. Land use for the production of rice has in fact been increased in the past years as the government intensifies production and yield. This is a positive result as it will boost rice production, and hence, increase the biomass. However, without proper land use planning for the crops planted in the country, the increasing area for rice production may affect the crop variety in the country.

Land tenure rights

The issue of land tenure and rights is a concern, as Cambodian farmers usually do not have land titles for the farms they cultivate. Around 80 percent of the total land area is considered state land, and the government has the right to decide land utilization; usually land is awarded to concessioners in the area who are willing to invest and develop it. Land conflict among farmers and concessioners often occurs in the rural areas because of the lack of proper land use management plans and land titles for farmers. Farmers are always at a disadvantage since they do not have the capacity to pay for lawyers to defend their rights. In relation to rice husk biomass, concessioners sometimes plant other cash crops (such as cassava, rubber trees, and beans) which reduce the production of rice, affecting the production of rice husk biomass.

Food prices

Varieties of food available in the villages could potentially increase as they could be preserved longer in coolers and refrigerators of newly-installed shops in the commune. Prices of food could potentially decrease as supply increases in the market, including increased production of rice, which is the staple food of people in the rural areas. Increased rice production and yield will reduce rice shortages among the poorest households, since affordable rice will be available in the market during lean season. However, there could be possible food price hikes for other crops (e.g. vegetables, fruits) if there is no proper land use planning for the areas to be used for rice production and other crop varieties.

Change in income

The increase in production of paddy rice and the additional value of rice husk would mean more income for the farmers and the creation of more jobs. The use of rice husk as feedstock enables the gasifier to operate 24 hours a day and additional workers are therefore needed. The establishment of the REE has also generated more business enterprises and thus increased household incomes. More than 100 new businesses[16] have opened in the villages because of available supply of electricity, also resulting in an increase in household income. The REE's 24-hour operation in the rural areas has been very useful to those businesses which can extend their activities to operate during the night. Electrical equipment used for businesses (e.g. battery chargers, air compressors, refrigerators, razors, dryers, electrical power tools, fruit juicers) can operate 24 hours a day because of the availability of electricity in the area.

A motorshop owner interviewed said he can earn as much as US$20–US$30 per day by selling spare parts and repairing motors using electricity to run his machines. A woman selling sugar cane juice says she can earn US$5–US$10 day using an electric presser machine to make juice. Other businesses such as barber shops and beauty parlours could earn more than US$15 per day by electrical equipment, such as electric razors. The cheaper cost of feedstock would mean sustainable operation of the REE to provide services to the community. The income of the poorest households in the commune could potentially rise due to an increase in their rice production and yield.

Jobs and labour conditions

If each business mentioned above employs an average of at least two persons, around 200 jobs could be created due to the availability of electricity. An increase in rice production will simultaneously increase the labour force in the agriculture sector, which includes the poorest households who usually sell their labour to farmers during the transplanting and harvest of rice. The rice millers will similarly employ additional staff to gather, load and transport the rice husk for sale to the REE. However, it is important to note that although the REE could bring about a creation of jobs, employee remuneration and benefits in rural Cambodia are still at its lowest (in the region of US$2.5-US$3.75 per day for those hired on short-term/daily basis, and from US$30–US$60 per day (depending on type of job and skills) for those paid on a monthly basis.

[16] Commune Database (NCDD, MoI Database 2010).

The REE employs six skilled staff members and one cook/cleaner to support the 24-hour operation of the plant. The REE manager receives US$400 per month, the technicians US$250 per month each and the cleaner/cook US$60 per month. The employees do not get any other benefits aside from free board and lodging within the plant compound. However, they have monthly medical checkups to ensure they are safe from any health ailments or hazards as a result of the plant's operation.

Energy access

Access to electricity by the rural community has improved. According to the owner of the gasifier plant, they still use diesel at times, and sometimes have to shut down operation because of the high price of diesel. The introduction of rice husk as feedstock has ensured a 24-hour continuous operation of the plant to provide electricity and services to the community. The availability of biomass in the locality also enables the initiative of modern energy service to be efficient. Based on the interview with Theang Thai (a businessman in the field of spare parts for motors, and garages), his business is operating effectively and efficiently because of the 24-hour availability of electricity, provided by EDC/REE. The increasing intensification of rice production and the presence of rice mills in the area ensures an adequate supply of rice husk biomass as feedstock for the gasifier plant producing electricity. REE provided electricity to around 1 124 households and more than 100 businesses in the village.

Energy security

Rice husk is a promising local biomass waste that can be used as feedstock and minimize the use of imported and expensive fossil fuel. The pilot project in Doun Sva village (using 100 percent rice husk feedstock to run the gasifier plant) will determine the sustainability of this initiative. A potential 80 percent of the population living in the rural areas will benefit, as their main occupation is agriculture, specifically rice farming. The MAFF has increased the land area for paddy cultivation, rice production, irrigation, and access to extension services, credits and inputs. With such support, rice production in 2012 increased to 8.25 million tonnes[17]; increasing production and yield means an increasing volume of rice husks available to use as biomass feedstock. Their current use as feedstock would increase the value of paddy rice, and thus improve the farmers' livelihoods. The gasifier plant owner has also benefited by the cheaper feedstock available locally, compared to the diesel which he used previously; however, he is bound to sell the energy to EDC, which benefits the most.

However, EDC's control of the buying and selling of electricity (including the passing on of the tariff cost to consumers) resulted in the high price of electricity in the rural areas. This high cost will eventually limit the electricity consumption of both businesses and households and their ability to operate more profitable livelihoods. In addition, the plant's sustainability also depends on technical capabilities in terms of efficient plant operations. Interviews with the operator indicate that the new gasifier plant system needs close monitoring, since it could fluctuate and stop the process, in turn halting the production of gas and thus the production of electricity. The operators need training and skills to support the long-term operation and sustainability of the gasifier plant.

The gasifer plant is producing ash and dust, which has prompted complaints to be brought to the commune and district offices. Technical necessities still need to be improved in the operation, including the proper disposal of ash and tar, water treatment and the eradication or minimizing of the sound pollution produced by the plant.

[17] Ministry of Agriculture, Forestry and Fisheries Assessment 2012.

Barriers, drivers and interventions

The following section presents the current problems and potential barriers, drivers and interventions for project replicablity and scalability at three levels: i) energy market chain, ii) inputs, services and finance and iii) the enabling environment.

Level 1: Energy market chain

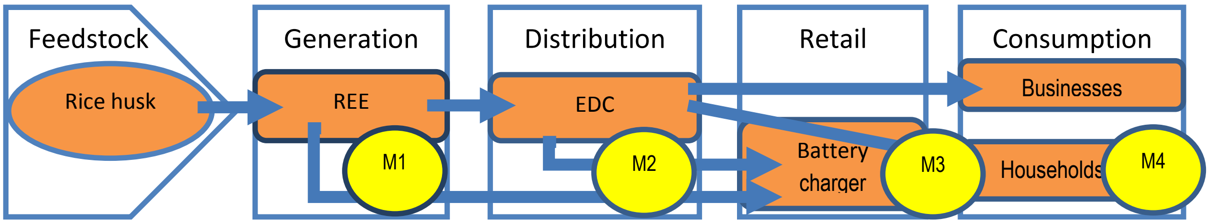

Figure 2.7: Barriers, driver and interventions- energy market chain

M1: - lack of feasibility study and long-term plan;
- lack of bargaining power with EDC;
- lack of proper technology and infrastructure to enclose plant to a) prevent noise and air pollution and b) treat the water.

M2 - business-oriented institution;
- monopolizes provision of service;
- overcharges consumers.

M3: - lack of business plan;
- lack of business alternative once the area is reached by EDC grid.

M4: - lack of bargaining power with the providers of electricity;
- electricity too expensive to open more businesses.

Table 3.7: Barriers, drivers and interventions- energy market chain

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential interventions
REE	Electricity demand of rural communities High price of fossil fuel	Genuine support of government for small-scale bioenergy Monopolization of EDC in provision of electricity	Cheaper use of gas from rice husk biomass compared to expensive fossil fuel Innovation and upgrading of REE and rice husk gasifier	Actual government policy and support for small-scale renewable energy Support of different development partners, both for rice production and use of small scale renewable energy
Battery charger	Lighting and TV demand in remote areas Available affordable electricity in commune/ nearby village	Expansion of REE/ EDC in remote villages	Only 13 percent of the total population in the rural area have access to electricity	Development of this service provider into REE in remote areas using rice husk gasifier to produce electricity
Businesses and households	Demand for affordable source of electricity	Providers are charging high electricity rates	Access to affordable electricity from	Increase rice production and encourage other

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential interventions
	Share from the economic growth of the country		locally produced renewable energy from cheaper feedstock	locally produced feedstock to generate power at cheaper inputs Start a cooperative source of electricity using renewable energy

Level 2: Inputs, services, finances and outputs

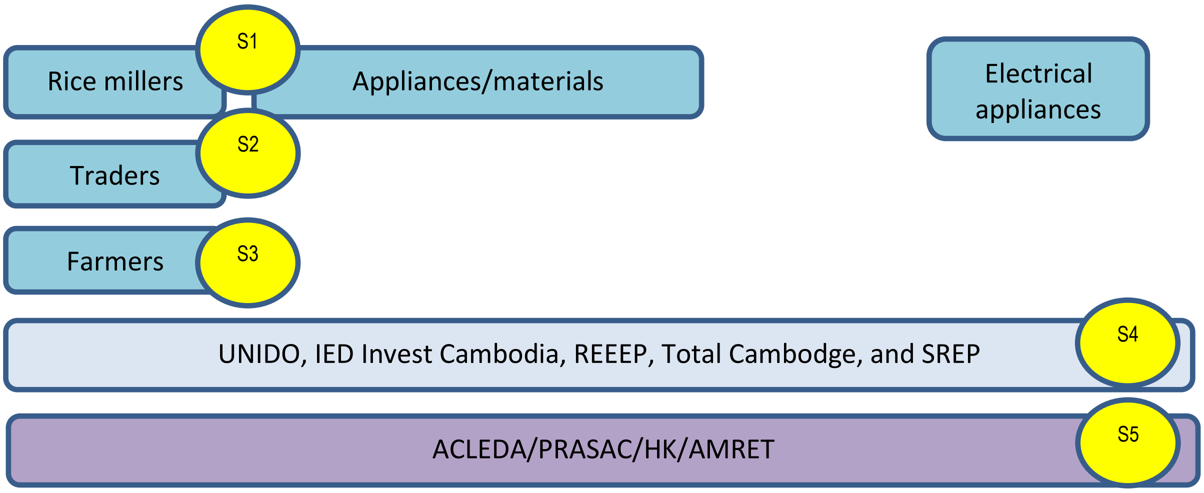

Figure 2.7: Barriers, driver and interventions- inputs, services, finances and outputs

S1: - some rice millers have installed their own gasifier for their own consumption;
- rice millers have their own associations/cooperative that could control price of rice husk.

S2: - some paddy rice traders come from Viet Nam or Thailand; they export the paddy rice bought from the farmers and mill them in their country.

S3: - lack of information on the value of their rice husk/lack of motivation;
- lack of irrigation to increase production per year;
- lack of other inputs to increase rice production in remote areas;
- lack of land tenure.

S4: - lack of full support for the expansion of small-scale bioenergy;
- no regular monitoring and follow up support for REE improvement;
- lack of proper procedures in the implementation of the rice husk gasifier pilot study;
- lack of full support for the development of REE because of the business's instability;
- lack of or no interest on the part of microfinance institutions in the area because of its remoteness and poor infrastructure (e.g. roads and buildings).

Table 4.7: Barriers, drivers and interventions- inputs, services, finance and output

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
Farmers	Rice is the country's staple food Support by government to increase production Value of rice husk will increase value of paddy	Infrastructure (irrigation, roads, buildings) Land tenure of farmers Support of the government for small-scale farmers Information/ knowledge of farmers on value of rice husk	Available land for rice farming Development of infrastructure i.e. irrigation and roads Government support for small-scale farmers NGO support for farmers MFI support for farmers	Government development of infrastructure and technical support for farmers Providing land tenure and titles to farmers NGO technical support for farmers MFI financial support for farmers
Traders	Value of rice husk as waste Availability of good millers in the country Increase production of farmers	Paddy rice is for export to Viet Nam and Thailand Quality standard of rice millers in the country Remoteness of the area	Development of rice millers in the country due to target export of government Development of infrastructure in rural areas Increase of rice production of farmers Value of rice husk in the area	Government development of infrastructure in remote areas Continuous government support regarding increasing production and yield Development of quality standard millers Expansion of REE to increase demand of rice husk as biomass
Rice millers	Increasing demand of rice husk biomass Increasing volume of paddy rice to be milled	Rice millers setting up their own gasifier Export of paddy rice to other countries Updated technology of rice mills in other countries	Increasing production of rice Value of rice husk biomass Support of the government for the sector Rice miller associations/ cooperatives	Government support for the sector Development of technology used by rice millers Contract agreement of REE and rice millers to ensure that rice mills support the needs of REE
Institution/ organization support	Increasing demand for renewable energy in rural areas Poverty alleviation in the rural areas Thrust of the institution/ organization	Infrastructure in the rural areas Remoteness of the area Government support for institutions/ organizations	Demand of energy in the rural areas Priority of development partners and government Development of infrastructure in the rural areas	Policy supporting the development of small-scale renewable energy in consideration of current imperatives (e.g. climate change) Good partnership/ networking of development institutions/

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
				organization with government in development of small-scale bioenergy
MFIs/banks	Increasing clients in the rural areas Development support from development partners and government is geared towards rural areas	Infrastructure in the rural areas Remoteness of the area Stableness of businesses in rural areas	Increasing demand for financial support Development partners are working in the rural areas Priority of the government development strategy Development of infrastructure in the rural areas	Development of infrastructure in the rural areas Demand of development partners for technical and financial assistance for farmers/small-scale bioenergy

Level 3: Enabling environment

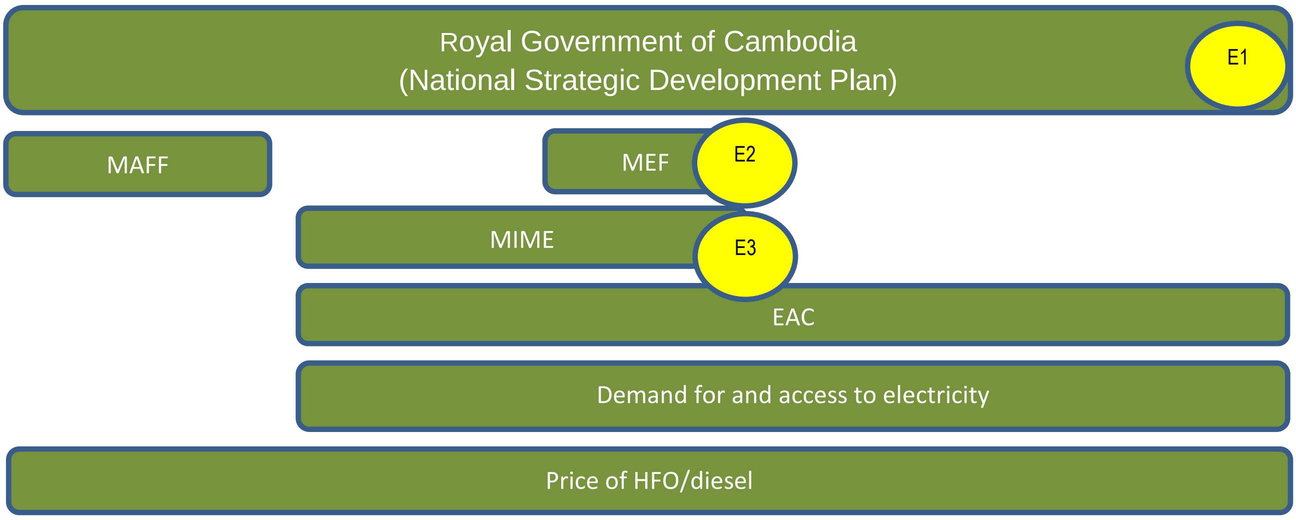

Figure 3.7: Barriers, drivers and interventions- inputs, services, finance and output

E1: - no long term plan for the development of small-scale bioenergy in rural areas;

E3: - co-owned by the EDC private company that controls REE;

E2: - no clear policy on the development of small-scale bioenergy in rural areas;
- more support for the development of larger sources of energy (such as hydro power and coal power plants);
-co-owned by the EDC private company that controls REE.

Table 5.7: Barriers, drivers and interventions- enabling environment

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
RGC NSDP	Government prioritizes electrification in rural areas Government targets 1 million tonnes of rice for export Priority of MDG	Infrastructure development in the rural areas Technical and financial support in rural development Priorities of government funding in rural areas	Priorities of MDG and NSPD: i) poverty alleviation and ii) development of energy access in rural areas Support of government and DPs in increasing rice production Support of government and DPs development of renewable sources of energy in the rural areas	Prioritization of government support in rural areas particularly for development of small-scale bioenergy as source of energy Development of infrastructure in rural areas to provide accessibility for DPs
MEF	Main ministry which approves budget to finance government development projects	Government has other priorities for rural development fund	Priorities of DPs that could influence the government to allot budget for the development of renewable energy, in particular small-scale bioenergy	DPs priorities that could influence the government allotment of budget for renewable energy in rural areas.
MIME	Government prioritized electrification in rural areas using renewable energy	Ministry has its own priority for bigger sources of energy, such as hydro power and coal power plants Lack of policies on the priority source of energy for the sector	Priorities of DPs could assist in the development of small scale bioenergy DPs could influence the ministry priorities as they are supporting the development of the country	Cooperation of REEs with DPs and government regarding small-scale bioenergy Development and advocacy of DPs on the development of small scale bioenergy promotion in government policy

Conclusions

Non-access to electricity by the community in Doun Sva village had resulted in sluggish development and aggravated poverty in the area. However, REE investment provided them with the chance to catch up with the fast development in the country's urban areas. Their access to electricity enabled them to create more than 100 small businesses using electrical tools and equipment, which resulted in the improvement of their livelihoods. The REE's use of fossil fuel limited the supply of electricity due to high costs from increasing fuel prices in the global market. This turned around with the introduction of renewable energy in the form of biomass from rice husks as feedstock for the gasifier; this change has made the generator run efficiently and reduced operation costs. Rice husk is locally produced, thus its price is around 300 percent lower than fossil fuel. At present, REE can support round-the-clock electricity in the community, resulting in the improvement of peoples' livelihoods.

One factor that may cause the failure of the REE initiative however is the lack of a long term plan. The REE has not prepared a feasibility study nor projected future revenue and sustainability of the enterprise. The REE is not properly designed to mitigate any environmental and human impacts that may occur during the operation of the plant. The management plan is also weak as it did not consider the possibility of business expansion. The technical staff need to be trained to improve their skills and be ready for any possible expansion or scalability of REE. Another factor that may affect the initiative's continuity is lack of support from the government and other stakeholders. EDC has monopolized the supply by buying electricity at a cheaper price and selling it to consumers at a very high fee. Lack of government support to ensure that private sector providers are equally benefited could result in the halting of investment by the disadvantaged provider.

On the other hand, a favourable factor that contributes to the success of the initiative is the availability of local biomass as feedstock for the gasifier. Residue previously considered waste has been valued in this initiative. The intensification of rice production would mean a commensurate increase in biomass, which could support the needed energy in the rural areas. The support from different stakeholders is however indispensable to the sustainability of the initiative, and technical, financial, and legal support is still wanting.

The REE has been influenced in its use of rice husk biomass by the demand of electricity in the remote areas and the increasing price of fossil fuel in the global market. The rural communities reached by the REE grids have benefitted from the lower REE charges, as the electricity is generated from locally produced biomass considered waste in the rural area. The driver for potential scalability and replicability of this initiative is the availability of large amounts of biomass produced in the locality. Around 80 percent of the rural population is engaged in agricultural production of rice, and they are now reaching an average yield of around 3 tonnes per ha. The government is also targeting to export 1 million tonnes of rice. Therefore, the available rice husk biomass is sufficient to support any scalability or replication of this efficient biomass feedstock to sustain the use of small scale renewable energy to produce electricity. The intervention needed is genuine government support for the development and use of small scale renewable energy, as it is a priority in the national strategic development plan. The government should continue to develop the infrastructure in the rural areas to increase farmers' access to technical and financial assistance from providers to include development partners, NGOs, financial institutions and civil society.

Finally, as a business, the REE is profitable due to the demand for electricity in the area and the use of low-cost rice husk biomass. The factors that may hinder its sustainability and replicability are EDC's monopolization, the limited capacity of the management team, and lack of technical capability to maintain the gasifier and increase its output to serve more clients. The variables that may sustain the business are i) the full support of the government and ii) development partners for small-scale renewable energy. Also of importance is a good business plan that can support the entrepreneur, including a sound market study as presented in this report. This could serve as a guide for the entrepreneur to develop a long-term plan for the business and its replication in other areas.

References

Abdul Salam, P., Kumar S., and Siriwardhana M. (2010). *Report on the Status of Biomass Gasification in Thailand and Cambodia.*

Albu M. and Griffith, A. 2005. *Mapping the market: A framework for rural enterprise development policy and practice.* Practical Action (available at *www.practicalaction.org*).

BEFS, Operator Level, *Food Security Assessment Tool-Version Two* (available at www.fao.org).

Census. 2008. Royal Government of Cambodia, National Institute of Statistics, Ministry of Planning.

Commune Database. 2010, National Committee for Sub-National Democratic Development (available at www.db.ncdd.gov.kh).

Engineering and Consulting Firms Association, Japan, Japan Development Insitute (JDI), Kimura Chemical Plants Co., Ltd. 2007. Cambodia Bio-energy Development Promotion Project.

Global Tracking Framework (available at *www.worldbank.org*).

Iied, 2005, *The Four Rs*, Power Tools (available at *www.policy-powertools.org*).

National Strategic Development Plan, Update 2009-2013 (2010), The Royal Government of Cambodia

Poch, K. and S. Tuy (2012), 'Cambodia's Electricity Sector in the Context of Regional Electricity Market Integration' in Wu, Y., X. Shi, and F. Kimura (eds.), *Energy Market Integration in East Asia: Theories, Electricity Sector and Subsidies*, ERIA Research Project Report 2011-17, Jakarta: ERIA, pp141–172.

Ryder G. 2009. *Powering 21st Century Cambodia with Decetralized Generation, A Primer for Rethinking Cambodia's Electricity Future*. The NGO Forum Cambodia.

List of interviews

Ky Chantan, owner of the micro-grid. Phnom Penh, 24 October 2013.

Sorn Vichet, power plant manager. Duon Sva village, 28 October 2013.

Choy Vuthy, operator. Duon Sva village, 28 October 2013.

Theang Thai, household member. Duon Sva village, 28 October 2013.

Hean Hun, household member. Duon Sva village, 28 October 2013.

Tham Bun Hak, owner. Bot Trang village, 8 November 2013.

Thailand (Case 8): Chicken farm biogas

Initiative Name	**Biogas from egg-laying chicken farm**
Location	*Gorkhoi village, Nongnam District, Lamphun, Thailand*
Initiation date/duration	*2006 to present*
Funder(s)	• *First biogas plant (100 m^3): self-supporting 100 percent (US$10 000)* • *Second biogas plant (500 m^3):* - *self-supporting 70 percent (US$39 000)* - *Energy Policy and Planning Office 30 percent (US$16 000)*
Project initiator	*Huaynamrin Farm*
Overall budget (if any)	*US$65 000*
Output	*300 m^3 of biogas capacity*
Area of land	*Egg-laying chicken farm: 4.5 ha* *Gorkhoi village: about 198 ha*
Beneficiaries	*77 households: biogas for cooking* *Egg-laying chicken farm: electricity* *Egg-laying chicken farm: biogas for heating and lighting*

Background and context

Thailand's alternative energy consumption has increased continuously due to the policy of alternative energy development that targeted to increase more alternative energy consumption in all sectors, especially alternative energy which can be produced in the country, to decrease the energy consumption from fossil fuel and the energy imports. In 2012, alternative energy consumption in Thailand was 7 294 ktoe, an increase of 13 percent from the previous year and shared 9.9 percent of the total energy consumption. This affected decreasing of energy imports, as amount of US$5 700 million, and also decreasing of CO_2 emission as amount of 22.37 million tonnes. Recently, the ministry of energy has set the target that in 2021, Thailand must be able to produce the alternative energy at 25 percent of the total energy consumption.

Gorkhoi village is located in Lamphun province in northern Thailand and has 148 households. Most villagers are farmers; one is the owner of the medium-sized egg-laying chicken farm with ten employees. There are 12 000–16 000 chickens on this farm, producing about 8 000–12 000 eggs per day. Manure from the chicken creates an environmental concern for the villagers, including bad smells, waste water, and a prevalence of flies and other insects encouraged by the chicken manure. Such problems make it difficult for the community to live well. The owner of a local egg-laying chicken farm (Huaynamrin farm) decided to take action to solve this environmental disaster. He constructed a biogas plant on his farm, which would produce biogas and decrease the environmental impacts both to the village and to his farm.

The chicken farm would provide free biogas to the 77 households who take part in this project to replace the LPG which is the predominant energy supply, used for cooking. Today, villagers are able to cut down their energy costs on LPG by US$10 per month. To participate in this arrangement, households must pay for the construction of the biogas pipeline in order to have an access to the chicken farm biogas. Any remaining biogas is used not only for electricity generation, but also for the LPG replacement use in the chicken farm. This project not only helps the community in terms of considerably reducing environmental impact, but also helps to trim down the energy expenses on LPG as well. This biogas project in the village apparently follows the principle of the sufficiency economy.

In 2006, a US$10 000 loan from the Bank for Agriculture and Agricultural Cooperatives (BAAC) was secured to design and construct the first biogas plant, with a biogas capacity of 100 m^3. In 2007, the second biogas plant was built, with a biogas capacity of 500 m^3. The latter investment cost was US$55 000 in total, with 30 percent being a subsidy from Energy Policy and Planning Office (EPPO) and the other 70 percent from a bank loan.

Food security

To address concerns regarding food security, the BEFS Operator Tool has been used to assess of the risk to food security associated with the biogas initiative. In terms of any change in the supply of food to the domestic market, since biogas digesters are constructed inside the chicken farm area, there is no issue regarding land use and management, and thus no area loss to the village's rice fields and agricultural crops. The feedstock used for the biogas production is the manure of the chicken obtaining from Huaynamrin farm itself, and so no land outside the chicken farm is required for feedstock production. Furthermore, all biogas pipelines used to supply households with for cooking are beneath the soil surface, with no resulting impact on land and food security.

With respect to resource availability and efficiency of use, the biogas system has no negative impact on the village's food chain. The chicken farm owner gives free bioslurry (a by-product of biogas production) to the rice farmers to replace or reduce their use of chemical fertilizers. As a result of this bioslurry use, rice production is significantly increased.

In terms of physical displacement, change in access to resources, compensation and income generation, there is no change in access to food resources in the village. As a matter of fact, the biogas digesters are owned by Huaynamrin farm and the owner is responsible for producing and providing biogas to villagers free of charge to replace LPG use for cooking. The villagers who take part in this biogas project therefore see a reduction in their energy costs.

Almost half the village continues to have no access to biogas energy. The biogas programme can be scaled up without invading the village's agricultural land, as the chicken farm still has land available. This can be used to construct new chicken buildings and biogas digesters, and produce and supply more biogas to some of the households still without it. The biogas programme also has the potential to be replicated by other small chicken farms in the village.

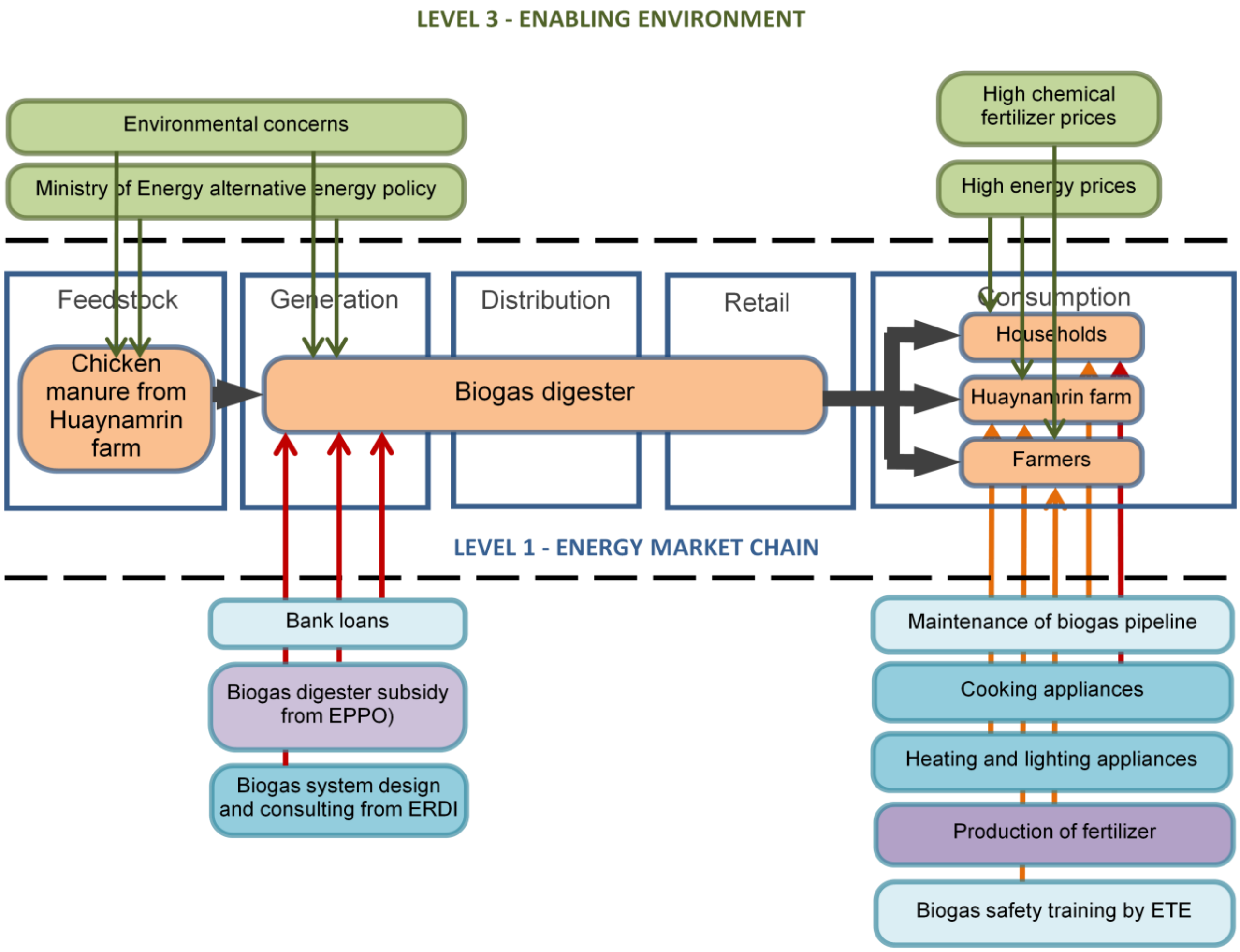

Figure 1.8: Initiative market map

The initiative market map

Within the context of the enabling environment, to address the country's high energy prices, the government's Strategic Plan for Alternative Energy Development strongly advocates the production of alternative energy for national use, and identifies a key target to increase the alternative energy share of total energy consumption to 25 percent by 2021. To achieve this, the government has implemented various incentives to encourage both local communities and the private sector to produce and use alternative energy. For example, financial subsidies to support electric power plant construction and the introduction of the feed-in tariff (FIT) programme have been provided to entrepreneurs who produce electricity from *Pennisetum purpureum* (also known as Napier grass or elephant grass). Another pilot project launched by the government is the Community Fund. This provides a subsidy of 30-70 percent of the investment capital to small communities for energy production and sale.

In terms of the energy market chain, the chicken farm owner and households are the two principle market chain actors in this biogas project and their working relationships are key to its success. The chicken farm owner constructed the biogas plant and the households paid for the gas stoves (US$20 per household) and the construction of the biogas pipelines (US$80 per household) in return for the right to free access to biogas energy. An energy cost saving of US$10 a month meant the payback period of the capital investment used for the gas stove and biogas pipeline was less than a year. There are three main PVC pipelines to supply biogas to 77 households. The first two pipelines (both with pipe diameters of 1.5 inches) are 0.8 and 1.5 km long respectively. These two pipelines cover 53 households. The third pipeline (with a pipe diameter of 2 inches) is 1.5 km long and covers the other 24 households. The total length of all main pipelines is 3.8 km. and the pressure required to guarantee sufficient flow of biogas to all 77 households is at least 0.8 bar.

After the biogas had been produced by the farm owner it was delivered by pipeline to each household participating in the project (households use biogas mainly for cooking, while the chicken farm uses biogas for heating and lighting). Any remaining biogas was delivered to the electric generator to generate electricity to be used for lighting the farm. Biogas thus reduces the living expenses of village households as well as the farm's electricity costs. Bioslurry from the biogas digester is provided to the local rice farmers free of charge, reducing chemical fertilizer use by half. Fertilizer pellets produced from sludge disposal are sold to consumers for use on agricultural crops. Since the environmental impact of the chicken farm has greatly improved, the owner can cut down on antibiotic use, and the use of chemical substances used to kill worms, flies, and insects inside the farm has also decreased.

In terms of inputs, services and outputs, in 2006, Huaynamrin farm initiated its first biogas programme. It accessed loan money from the Bank for Agriculture and Agricultural Cooperatives (BAAC), and used it to build the village's first biogas plant. This had a capacity of 100 m^3 and the following year the second biogas plant was built with capacity of 500 m^3. For the latter the chicken farm owner paid 70 percent (US$39 000) of the investment capital (loaned from BAAC) and received the other 30 percent (US$16 000) as a subsidy from the Energy Policy and Planning Office (EPPO). The Energy Research and Development Institute (ERDI) in Nakornping was responsible for managing this project. It designed the biogas system and took on the role of technical consultant until the biogas plant was finished. As for the construction and maintenance of the biogas pipeline, these were fully financed by the households taking part in the programme. Addressing safety issues, the Energy Technology for Environment Research Center (ETE) Chiang Mai University was responsible for a biogas safety training course. Since 2006, the chicken farm owner has paid approximately US$160 a year for the maintenance of the farm's biogas equipment (such as a biogas pump).

Table 1.8: Relationships between market actors

	Huaynamrin Farm	Households	Farmers	EPPO	ERDI	ETE	Bank
Huaynamrin Farm							
Households	Good, informal; provision of biogas						
Farmers	Good, informal; provision of fertilizers	Good, Informal					
EPPO	Good, formal, financial	None	None				
ERDI	Good, formal, technical	None	None	Good, formal, finance and technical			
ETE	Good, formal, technical	None	None	None	None		
Bank	Good, formal, financial	None	None	None	None	None	

Huaynamrin Farm (the project initiator) approached BAAC to secure financial loans for its two biogas plants. EPPO (responsible for promoting energy efficiency and alternative energy use) provided a 30 percent subsidy to this biogas project. ERDI (a research centre providing services on energy efficiency and alternative energy) received funding from EPPO to design and manage the biogas plant construction until its completion. The relationship between EPPO and ERDI is both financial and technical. ETE is responsible for course training on biogas safety. The relationship between ETE and the chicken farm owner is therefore purely technical-based (i.e. relating to the biogas safety issue). The farm owner has a very good relationship with households; he provides biogas without charge to 77 households for daily cooking purposes. Farmers also receive free bioslurry to fertilize their rice fields from the biogas production.

Balance of relationships: rights, responsibilities and revenues of market actors

The income of Huaynamrin farm derives primarily from selling eggs; its chickens lay an estimated 8 000 eggs each day. The farm-front price of chicken eggs is US$0.1 per egg. The owner of the farm also owns the biogas digester and is responsible for producing and distributing biogas to households in the village; any biogas left over is then used to produce electricity for use on the farm, decreasing the cost of the farm's electricity. Another source of revenue comes from selling organic fertilizer pellets, which are sold to farmers or other consumers. Since the improved farm environment results in the increased health of the chickens, the cost of antibiotics is also reduced.

EPPO is part of the Ministry of Energy, and is the lead government agency for the promotion of energy efficiency and alternative energy in Cambodia; it provided financial subsidy to the chicken farm for construction of biogas plant. ERDI earns revenue from engineering services for the biogas system and other forms of alternative energy. Its role in this project was to design and provide consultation on the biogas system technical issues. ETE is a research centre offering services on energy technology for the environment, and provided a biogas safety training course for the initiative.

No fee is charged to the households for the biogas they received from the biogas plant. However, they need to pay about US$0.7 monthly to the biogas village user fund for routine pipeline maintenance. Each household uses an average 15 kg of LPG per month (equivalent to about US$10). Rice farmers also receive free bioslurry from the biogas plant to use in their rice fields to increase the rice production.

Table 2.8: Balance of relationships- rights, responsibilities and revenues of market actors

Actors	Rights	Responsibilities	Revenues
Huaynamrin Farm	- Use of land for egg-laying chicken farm - Produce biogas	- Caretaker of egg-laying chicken farm - Caretaker of the biogas plants - Produce biogas and distribute to households - Produce organic fertilizers	- Income from selling eggs - Income from selling by-product from biogas production (organic fertilizer) - Reduce the chemical substance expenses - Reduce the electricity expenses - Reduce antibiotic use with chicken
Households	- Biogas user	- Pay monthly fee for pipeline maintenance	- Save energy expenses by reducing the use of LPG
Farmers	- Rice farmers	- Produce rice and other agricultural crops	- Income from selling rice and other agricultural crops
EPPO	- Promote the use of alternative energy - Promote the energy efficiency programme	- Provide financial support for biogas digester construction	- Income from the government
ERDI	- Conduct research activities - Provide services on energy efficiency and alternative energy	- Design biogas system - Consulting on technical issues of biogas production	- Income from the Ministry of Energy
ETE	- Provide services on energy technology for environment	- Training in biogas safety	- Income from the Ministry of Energy
Bank	- Provide financial services	- Provide financial support for biogas digester construction	- Income received in return for services rendered

Analysis of livelihoods outcomes

Land use: The biogas system helps address the adverse effects of environmental impact, both on the farm and in the surrounding area. Biogas plants are constructed inside the farm area, and most of the biogas pipeline is built under the ground; neither affect nearby natural resources or village agricultural land.

Land tenure rights: Biogas plants belong to the egg-laying chicken farm owner who is responsible for producing and supplying biogas to households in the village for free. There is no issue on land tenure.

Food prices: There is no issue affecting food prices. The biogas plants are built inside the chicken farm area, and the feedstock (chicken manure) is obtained from the farm itself. Land used for growing agricultural crops is thus not affected, and so food prices are not influenced by the biogas programme.

Changes in income: People in the village normally use LPG for cooking in their daily life; since the initiative, they have been able to reduce energy expenses by using biogas as a household cooking fuel, thereby reducing the money spent on LPG by an estimated US$10 per month. Each household makes an investment of US$100 in the gas stove and pipeline construction, which takes only 10 months to pay back. The biogas programme has also helped the chicken farm owner to decrease the cost of waste disposal, and the quantity of chemical substances used to kill worms and flies and to subdue bad smells has been greatly reduced. Not only has the environment of the chickens been improved, but savings on the cost of chemical substances are made of about US$2 500 per year. Antibiotic use has decreased, resulting in a cost reduction of around US$1 250 per year. The chicken death rate is reduced by half (from 6 percent to 3 percent). Furthermore, the remaining biogas is supplied to the electric generator (which required an investment of US$5 500) to produce electricity which is used for lighting and to power other equipment on the farm, helping the farm owner reduce electricity expenses by about US$2 000 per year. Also, some biogas is supplied to gas heaters (US$800 investment cost for gas heaters) to generate heat for baby chickens on the farm. This replaces LPG use, reducing LPG costs by US$1 500 per year. The chicken farm owner receives extra income from selling a by-product of biogas production (organic fertilizer pellet), with the sale price of US$0.25 per kg. Bioslurry is provided to rice farmers for free to apply to their rice fields. This increases rice production, contributing to the increased income of farmers.

These cost savings and income from the sale of fertilizer pellets combine to contribute to an approximate six-year period in which the original capital investment (for the biogas digester and its related equipment) is paid back.

Jobs and labour conditions: The chicken farm owner and his employees are responsible for operating the biogas plant. They have gained new knowledge in biogas system and its management techniques. Visitors now regularly visit Huaynamrin Farm to learn more about the biogas project.

Energy access and security: In this village, LPG was accessible to households and primarily used for cooking fuel. However, with the existence of biogas from the chicken farm, some households decided to switch to use biogas for cooking fuel instead. They are able to reduce the energy cost by US$9 240 per year. Every household who takes part in this project has to pay US$0.7 per month into a biogas user fund for the biogas pipeline maintenance. Some remaining biogas is generally used to supply the chicken farm with electricity.

Barriers, drivers and interventions

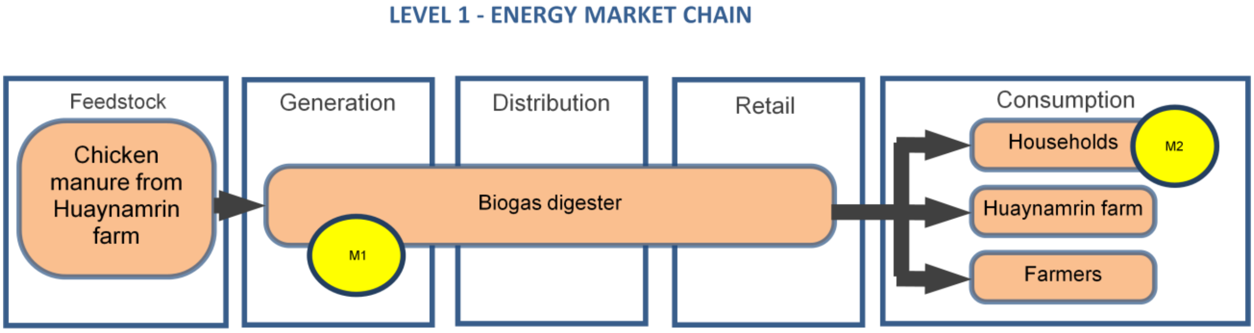

Figure 2.8: Barriers in the energy market chain

M1: - lack of engineering knowledge of biogas system and its technology.

M2: - households are unaware of technology and its benefit to biogas system.

Table 3.8: Barriers, driver and interventions- energy market chain

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
Biogas service provider	Biogas system design, construction and installation of biogas technologies	Farm owner does not have sufficient knowledge of biogas system and its technology	Farm owner has better knowledge of biogas system and its technology. As a result, biogas system design meets full potential yield of biogas produced on the chicken farm	New biogas technology and design need to be introduced to chicken farm owner and be able to supply biogas for more households
Households	Biogas for use as a household cooking fuel	Households do not have sufficient knowledge of technology of biogas fuel	Households are able to save money spending on their cooking fuel	-

LEVEL 2 – INPUTS, SERVICE & OUTPUTS

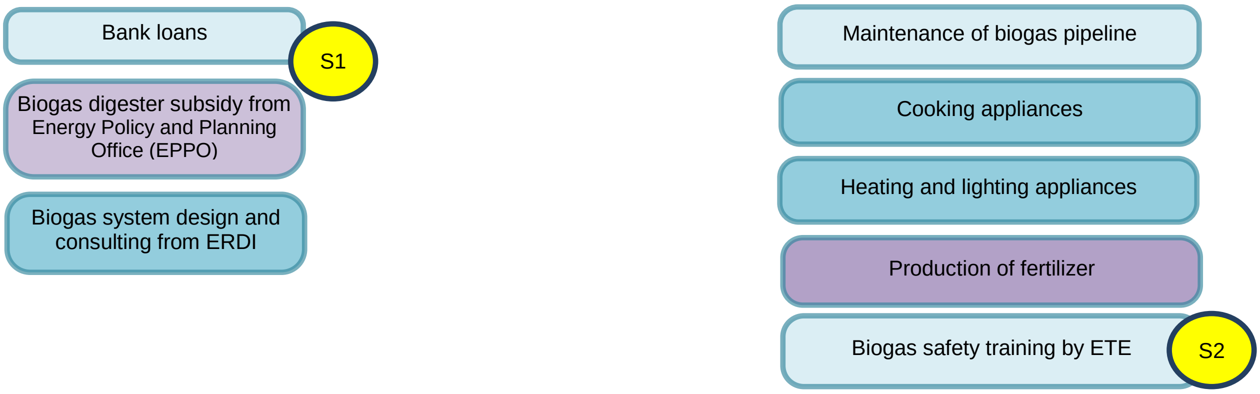

Figure 3.8: Barriers to inputs, services, finance and outputs

S1: - lack of capital investment in biogas system;

S2: - biogas workers do not fully understand the operation and safety measures of the biogas system.

Table 4.8: Barriers, driver and interventions- inputs, services, finance, outputs

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
EPPO	Provided financial subsidy to chicken farm owner for construction of biogas system	Financial subsidy from government is not available for chicken farm owner to build biogas system	Financial subsidy helps a chicken farm owner build a biogas system Subsidy for biogas programme from chicken manure is replicated in other regions in the country	Subsidy is an important element to reduce the payback period of the original capital investment on the biogas system
BAAC	Provided loan to chicken farm owner for construction of biogas system	Chicken farm owner has insufficient capital investment for biogas system construction	Financial loan is available for chicken farm owner to construct the biogas system	This is a significant constraint to scaling up biogas system from the chicken farm owner perspective
ETE	Provided training on biogas safety and technical issues for workers	Chicken farm workers have insufficient knowledge of biogas system	Chicken farm workers have better knowledge to work on biogas system	Biogas technology needs to be introduced to chicken farm owner and workers

LEVEL 3 - ENABLING ENVIRONMENT

Figure 4.8: Barriers to enabling environment

E1: - farmers are not aware of benefits of bioslurry compared to chemical fertilizer.

Table 5.8: Barriers, driver and interventions- enabling environment

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating	Potential intervention
Farmers	Bioslurry from biogas is produced as a high value organic fertilizer which helps increase rice production	Farmers are not aware of advantages of bioslurry over chemical fertilizer	Bioslurry is high quality, significantly increasing rice production and increasing farmer incomes	

Before the start of the first biogas initiative, a number of technical issues proved major obstacles to the chicken farm owners. These included the design and construction of the biogas digester and the operation of the biogas system. For an initiative like this to succeed, it is essential that basic training in the use of the biogas system and its safety is conducted with the biogas producers (that is, the owners of the chicken farms) and the end users (the villagers).

Investment money is another problem. Although a chicken farm owner can cover the design and construction costs of the biogas system, a soft loan from the bank or financial subsidy from a government agency will help them come to a decision more quickly. Lack of a subsidy programme is thus the most significant constraint preventing scale-up of the biogas system.

At the start of the initiative, the villagers were unaware of biogas fuel and its benefits and some were reluctant to accept biogas technology because of safety concerns and other issues. However, with assistance from government officials and other agencies, they were convinced that biogas fuel could help address the village’s environmental concerns and increase its energy security. The biogas system improves the living environment of the chickens, meaning they are healthier; the death rate of chickens has decreased by half.

The success of the biogas programme has encouraged other chicken farms and communities, who have visited Huaynamrin farm and voiced an interest in the chicken manure-based biogas system. A partial government financial subsidy or soft bank loan would undoubtedly encourage other chicken farm owners to start up the biogas programme without further delay; an appropriate subsidy would enable chicken farm owners to reduce the payback period of their investment. To ensure the success and sustainability of this biogas initiative model, technical knowledge must be provided, on the production, safety and benefits of biogas.

Conclusions

Agricultural land is not adversely affected by this project; rather, local rice farmers can harvest more rice by using the bioslurry obtained from biogas digester to fertilize their rice fields.

Huaynamrin farm's biogas system covers 77 out of a total of 148 households. The amount spent on energy for each participating household has been markedly reduced and as only 52 percent of the total households in the village can access biogas, opportunities remain to increase biogas production here. A number of small chicken farms in other communities have also expressed an in interest in building a biogas system. Several requirements need to be addressed (such as financial support and availability of space to build a biogas digester), along with supporting systems, such as the installation of a wastewater treatment system. If these are resolved, the biogas project can be replicated quite rapidly and without invasion of agricultural land.

Huaynamrin farm has an exhibition centre, which the farm owner utilized to convince households to participate in this project. This biogas project has been visited on a regular basis by representatives of government agencies and other communities, and is likely to be replicated elsewhere. However, it is essential that the relevant government agency provides financial incentives, and technical knowledge to both small chicken farm owners and the wider community to facilitate the design and construction of the biogas system. With a proper financial subsidy, the chicken farm owner could cut reduce his or her payback period to less than five years.

The key success factors of this biogas project are the owner of Huaynamrin farm and the villagers. The farm owner paid for most of the design and construction costs of the biogas plant and the villagers paid for the biogas pipeline construction. This collaboration plays a vital role in the success of this project.

References

Interview with Aram Uprajong, owner of Huaynamrin farm.

Department of Alternative Energy Development and Efficiency. 2012. *Thailand alternative energy situation 2012.* Ministry of Energy, Thailand.

Alternative energy development plan: AEDP 2012–2021. Ministry of Energy, Thailand.

Bioenergy and Food Security (BEFS). *Operation level food security assessment tool* (available at www.fao.org).

Thailand (Case 9): Pure Plant Oil (PPO) Initiative

	FAO-PAC report in 2009	***Revisited in November 2013***
Initiative name	***Thailand Jatropha Cooperative*** *Zero-waste management in Jatropha production for biofuel development in small-scale farmer communities*	
Location	*Viengsa district, Nan province, Northern Thailand*	
Initiation date and duration	*October 2006 for five years*	*Seven years of operation*
Funders	*Match funded by:* *- the Cooperative Promotion Department (US$30k)* *- the Cooperative League of Thailand (US$10k),* *- Nan Provincial Governor (US$30k)* *- Viengsa Agricultural Cooperative (US$30k)*	*No additional funder*
Project initiator	*University of Kasetsart in cooperation with the Cooperative League of Thailand*	*Project owner and operator:* *Viengsa Agricultural Cooperative (VAC)*
Overall budget	*US$100 000*	*No additional funding*
Outputs	*- 292 000 kg Jatropha seed per annum* *- 365 000-730 000 kg fertilizer per annum* *- 73 000 litres of biofuel per annum* *500 KW small-scale power plant:* *1 825 000–2 190 000 kg charcoal or biomass per annum*	*Farmers supplied to VAC:* *- Jatropha seed (approximately 4 400–5 600 kg per annum);* *- used cooking oil (2 000–8 000 litres per annum);* *By-products:* *- 73 000–130 000 kg fertilizer per annum (Jatropha residue mixed with other residues);* *- 600 pieces of deodorized charcoal fancy (made to order)* *No electricity generation*
	Approximately 240 hectares *(120 ha per community); expected to reach about 600 ha (5 communities)*	*Approximately 336 hectares* *(VAC members: 2 100 farmers, an average of 0.16 ha per member)*
Beneficiaries	*1 000 farmers (income)* *Expected to reach 2 500 farmers (income)* *500 households (electricity)* *5 000 farmers (fertilizer)*	*2 100 farmers are members of the biodiesel and Jatropha plantation;* *5–6 farmers are consumers and self-used by VAC;* *No electricity generation from Jatropha or biomass residues;* *Membership of VAC: 7 668[18] (2012)* *Total population of Viengsa: 68 039[19]*

Background and context

In 2006, the University of Kasetsart began work with 500 farmer members of the Viengsa Agricultural Cooperative (VAC), Nan province, Thailand to develop the production of Jatropha,

[18] Annual Report 2012, Viengsa Agricultural Cooperative.
[19] Available at http://www.amphoe.com.

primarily for biodiesel. The rationale of the project was that Jatropha could form the basis of a community-level income and employment generation programme. This programme planned to supply (i) 292 000 kg of Jatropha seed annually for the production of 73 000 litres of biodiesel (B100), (ii) 365 000–730 000 kg of organic fertilizer (made from Jatropha residues), (iii) a 500 kW small-scale powerplant (steam turbine technology and using Jatropha's branches and other biomass residues as fuel). The powerplant would serve five to ten communities within a 50 km radius (all cooperative members), and (iv) supply 1 825 000–2 190 000 kg charcoal or biomass annually for cooking application.

However, seven years after implementation, the programme outputs have changed. Farmers who have been growing Jatropha trees since 2006 have supplied only 4 400–5 600 kg of Jatropha seed per year to VAC. This is not enough, and VAC has had to buy 2 000–8 000 litres per year of used cooking oil as additional raw material for biodiesel production. The key barrier is government policy which subsidizes and guarantees the price of cash crops (rice, maize, and other agricultural products), lowering the motivation of farmers to plant Jatropha to gain additional income. In addition, until I January 2013, the daily wage from harvesting Jatropha was around US$1-US$2 for 10 kg of Jatropha fruit (working full time), less attractive that income that could be obtained from doing other work. From 2013 onwards, the Ministry of Labour introduced a minimum daily wage in Nan province of THB300 (US$10) per day.

The main byproduct of Jatropha biodiesel is 73 000–130 000 kg organic fertiliser per year. This is a combination of the Jatropha residue remaining after the oil extraction process and other residues such as chicken manure, ground maize cob, zeolite and rice bran. Jatropha branches and wood residues were also used to produce about 600 pieces of deodorized charcoal fancy.

As well as the motivation to supply Jatropha and other wood residues to VAC being low, VAC received no additional funding to invest in the 500kW small-scale power plant, planned under the zero-waste management concept. No electricity is thus generated from this programme (Viengsa district does have access to electricity from the national grid).

More detailed market mapping of the Viengsa Cooperative initiative has been carried out using this framework approach. These updated market maps show the four broad functions of the market chain, as well as all the involved actors, the specific supporting inputs and services relevant to each market chain function and actor and the most important and influential enabling environment factors (see Figure 1.9).

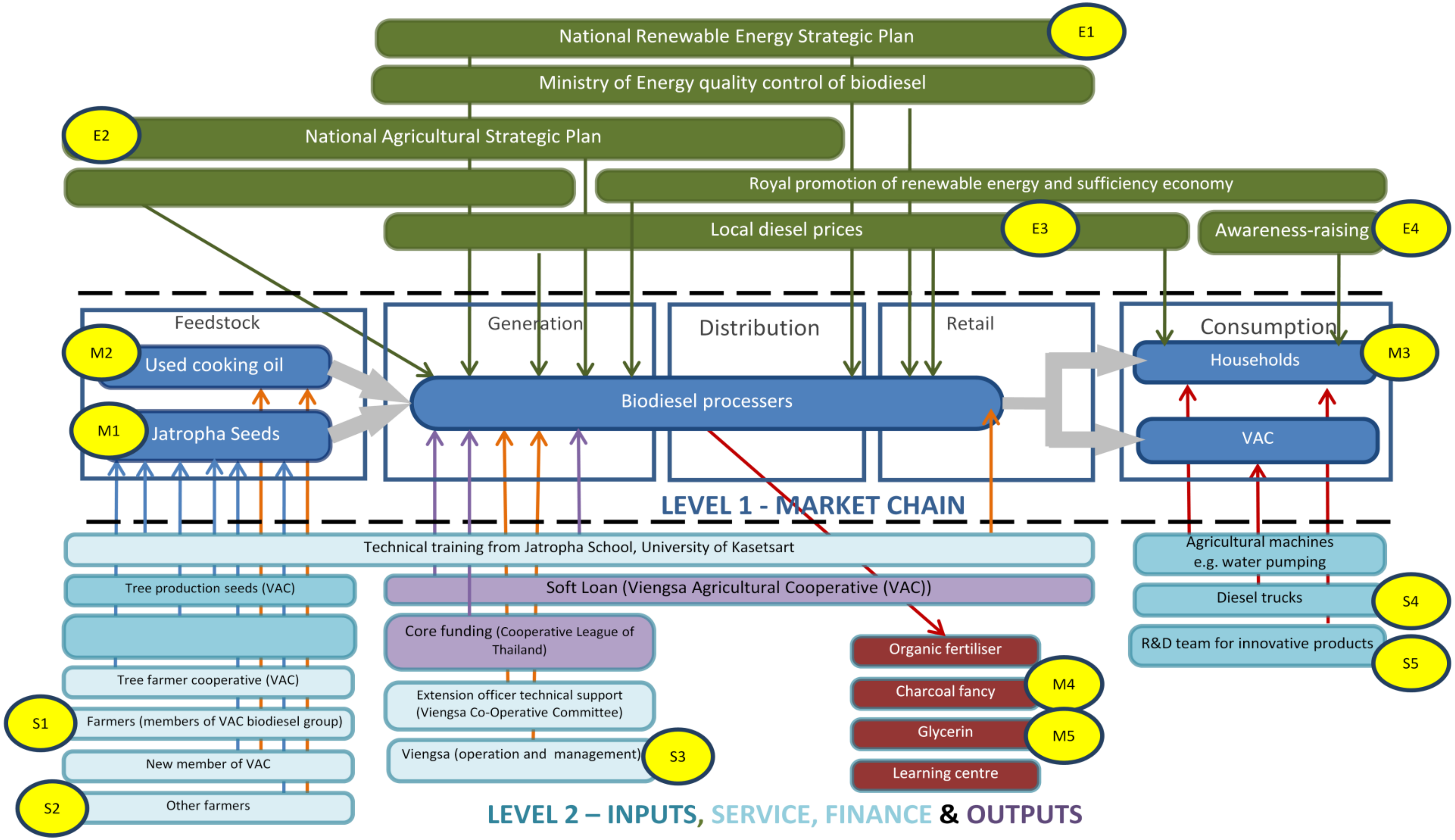

Figure 1.9: Initiative market map

The most significant features of the three market system levels are summarized as follows:

Level 1: Energy market chain

The market chain for the production of pure plant oil is relatively simple: once the raw materials (the Jatropha seed and used cooking oil) are inputted, they are processed and supplied directly to the end users within the same cooperative. The market chain is a fairly closed system and does not contain many actors. The updated market chain is included in Table 1.9.

Table 1.9: Market chain

	FAO-PAC report (2009)	Revisited, November 2013
Feedstock	Jatropha seed	Jatropha seed Used cooking oil
Generation	Biodiesel processors Micropower plant By-products: • organic fertilizer • charcoal for cooking • glycerin • handicrafts • paper fibre • particle board	Biodiesel processors 2 units x 200 litres per day By-products: • organic fertilizer • deodorized charcoal • glycerin • learning centre
Distribution	N/A	VAC members
Retail	N/A	VAC members
Consumption	Households, enterprises, public facilities	5-6 households VAC members

Level 2: Inputs, services, finance and outputs

In contrast to the market chain, the supporting services and inputs level is more complex with more actors, as it is involved in the production of the PPO feedstock, as well as for the processing of the PPO.

Level 3: Enabling environment

The main enabling environment factors and forces include the local diesel prices, as well as specific government policies on renewable energy and sufficiency economy scheme, including for cooperative promotion operations, biodiesel quality control and national renewable energy strategic plans, and the national agricultural strategic plans.

Seven sustainability indicators were applied to data collected on the second visit in 2013 to assess the sustainability and the livelihood impact of the initiative. The results are as follows:

Indicator 1: Land use

Jatropha trees were planted around the border of cash crop. There is no land use change impact on food crop cultivation.

Indicator 2: Land tenure rights

Most of Jatropha trees were planted on the land where are the farmers are the owners.

Indicator 3: Food prices

There has been no impact on food price.

Indicator 4: Changes in income

Farmers get around US$1-US$2 per day for harvesting 10 kg of Jatropha fruit (full time).

Indicator 5: Jobs and labour conditions

There is no new job creation resulting from Jatropha fruit harvesting and biodiesel production. The farmers do the work in their free time. At the same time, Jatropha fruit sells for only US$0.19 per kg, not a competitive price compared to other cash crops. The biodiesel production operators are also VAC staff; their workload is therefore increased.

Indicator 6: Energy access

Only 5-6 patrons used biodiesel for their machines (for a water pump, for example); this can be bought at US$0.81 per litre (at the time of writing the price of diesel is THB5 = US$0.97 per litre). VAC use B100 for two small trucks which helps reduce energy expenditure.

Indicator 7: Energy security

There is about 5 500 litres storage capacity of biodiesel. Biodiesel demand was 1 600–2 200 litres per year.

Barriers, drivers and interventions

Once the market system has been fully mapped, and the relationships between all the actors determined, the next step is to identify the main issues that are affecting each particular market system level. There are a number of factors which need to be identified in order to design appropriate interventions. These should improve how the system works for all the actors involved, but in particular for the target population, namely the end users of the bioenergy products and services.

It is usually productive to start identifying the barriers as they are often more obvious. Then it is useful to focus on the issues that are keeping the system in its current state and the opportunities which exist to engage others to improve it. This should provide a clearer picture of the landscape to all of the relevant stakeholders. We thus have three categories to analyse:

- **Barriers**: issues that are nobody's fault but that keep the system dysfunctional;
- **Drivers of dysfunctionality**: which commonly include rent-seeking, corruption, and abuse of power;
- **Potential opportunities**: the potential drivers of improvement – opportunities, incentives and motivations.

Barriers: market chain

The barriers in the market chain are:

M1: - low feedstock supply, lack of effective business models and low price of Jatropha fruit;

M2: - high price of used cooking oil;

M3: - low demand of biodiesel use by households due to consumers not being confident of the quality of the biodiesel and concerned it may damage their trucks). Also, the price of biodiesel (B100)[20] is cheaper than biodiesel (B5)[21] only 17 percent;

M4: - lack of effective promotion and charcoal marketing;

M5: - lack of glycerin market.

Barriers: inputs, services, finance and outputs

The barriers to inputs, services, finance and outputs are:

S1: - harvesting period of Jatropha is variable. More time and many labourers are therefore needed compared to cash crops. The maximum Jatropha fruit harvest is about 10 kg per person per day. The price of Jatropha fruit is US$0.19 per kg, not an attractive price compared to cash crops (e.g. maize and rice) or other forms of employment. In addition, government policy stipulates a minimum labour cost of THB300 per day (US$10 per day)[22], which also increases the cost of harvesting the Jatropha fruit;

S2: - low price of Jatropha fruit/seed compared to other cash crops; this lowers the motivation to plant and harvest Jatropha;

S3: - no fulltime operators for the biodiesel production department; there are currently two biodiesel production operators who also work on charcoal production, organic fertilizer production and other tasks. The workload is heavy. In addition, the new staff will be rotated with work on biodiesel which requires training,

S4: - manufacturers have yet to prove that B100 is useable by their trucks;

S5: - lack of R&D team to work on new, innovative products made from biodiesel; these would create more added value.

Barriers: enabling environment

The barriers to the enabling environment are:

E1: - lack of promotion, especially for up-scale and/or replication of Jatropha biodiesel production by Ministry of Energy at provincial level. Promotion was stopped due to the lack of a supply of the raw material (high price of used cooking oil and high cost of Jatropha harvesting);

E2: **-** policy which subsidizes/guarantees price of cash crops (rice, maize, and other agricultural

[20] The biodiesel (B100) in this programme is produced by the transesterification process of Jatropha oil and/or used cooking oil 100% (not mixed with conventional diesel).

[21] Biodiesel (B5) is mixed biodiesel: 5 percent biodiesel (obtained from transesterification process of palm oil) and 95 percent conventional diesel. This is the commercial biodiesel currently used in Thailand.

[22] Minimum daily wage effective from 1 January 2013 (available at www.mol.go.th).

products); this leads to the low motivation of farmers to obtain additional income from planting Jatropha. At the same time, Nan province is running bamboo, para rubber tree, maize, and rice plantation promotion programmes (Ministry of Agriculture and Cooperatives, 2013);

E3: - policy to control the price of diesel at less than US$0.97 per litre (less than THB30/litre)[23]; this started in 2011 until 2013. It leads to low incentive to consume and produce biodiesel (B100) from Jatropha;

E4: - lack of continuous promotion of Jatropha biodiesel (B100) consumption. In addition, there is a lack of R&D in Jatropha biodiesel (B100) utilization and its application.

Barriers, drivers and interventions

This PPO initiative has faced many barriers since operation started in 2006. The key barrier is low biodiesel demand for agricultural activities. To address this, VAC planned to increase biodiesel utilization in the transportation sector by using B100 in their small trucks. However, demand for biodiesel has not increased, due to lack of confidence in its quality. In addition, the price of biodiesel B100 is not attractive enough to compensate for the potential risk of damage to the engine. VAC therefore needs additional support for R&D into new, innovative products made from Jatropha.

The low demand for biodiesel, coupled with high operation and maintenance costs of its production and price policy of biodiesel (B5) (keeping the price below US$0.97 per litre) has led to VAC having to control the buying price of Jatropha fruit/seed from member farmers, keeping it at US$0.19 per kg. This translates into a daily wage for the farmers of US$1-US$2, not attractive when compared to potential earnings from working in cash crops (e.g. maize and rice) or other work. It does not cover the cost of harvesting the Jatropha. All these factors combine to repress the motivation of the farmers to supply Jatropha fruits/seed to VAC for biodiesel production.

VAC secured funding from numerous government agencies to start up Jatropha plantation and biodiesel production; however, this did not cover the project's operating costs. Most significant is the lack of financial support for project expansion. As a consequence, this initiative has proved hard to scale up and replicate in other communities.

The details of the main market system barriers and potential opportunities within the market system of the Viengsa PPO initiative are presented in Table 2.9.

[23] Resolution of the National Energy Policy Committee on 30 December 2010 (available at www.eppo.go.th).

Table 2.9: Barriers, drivers and interventions

Main actors	Main influencing factors/forces	Barriers to upscaling and replicating	Potential drivers for up-scaling and replicating	Potential opportunities, incentives and motivations
Level 3 - Enabling environment actors				
Thai Government National Renewable Energy Roadmap (Ministry of Energy)	Key target: to increase renewable energy share of commercial final energy to 25 percent by 2021 National New Biodiesel (e.g. Jatropha, micro algae, biomass-to-liquid) roadmap sets out government vision to 2021 of production capacity 9 million litres per day (DEDE, 2012) Establish biodiesel and by-products market	No government promotion for upscaling and/or replication of Jatropha biodiesel production provincial level Policy-fixed price of diesel (EPPO, 2010)	Renewable energy remains a national priority, investment in biofuels increases due to high local diesel price	Promote planting of Jatropha and Jatropha biodiesel production especially for upscale and/or replication by Ministry of Energy at provincial level Financial support needed for project expansion under zero-waste concept Continuous concrete policy support needed Awareness-raising programme should proceed continuously Revoke policy on the fixed price of biodiesel (B5)
Ministry of Agriculture and Cooperatives (Department of Cooperative Promotion)	Provides oversight and regulation of Viengsa Agricultural Cooperative. It funds CLT and provides funding to VAC for them to purchase equipment for processing Jatropha. National Agricultural Strategic Plan to promote, subsidy, including guarantee price of cash crops. Establish market for biodiesel and by-products	Funding to CLT and VAC for biodiesel production technology but not including biodiesel market establishment. There is policy to subsidy/guarantee the price of cash crops such as rice, maize, and other agricultural products. Therefore, it leads to low motivation of farmers to get additional income from Jatropha plantation	Funding increases so that other cooperatives can be supported and production increases. Promote and increase awareness of Jatropha plantation and biodiesel consumption	World oil price is increasing Revoke pledging policy, subsidy/guarantee price of cash crops (rice, maize, and other agricultural products) Establish and implement agricultural zoning policy (including Jatropha plantation)

Level 1 - Market chain actors

Viengsa Agricultural Cooperative (VAC)	Coop signs a contract agreement with each member who wants to start producing Jatropha, reviewed on an annual basis. Other contracts are developed between each market actor which fix and guarantee product prices.	Contracts are not attractive and farmers stop production.	Formal contracting attracts other farmers to get involved.	High-selling price of Jatropha seed helps to increase raw material supply for biodiesel production
	Cooperative provides soft loan to its members to buy raw materials to help farmers start producing Jatropha trees. This is overseen by a formal contract.	Farmers unwilling to take loans Other cash crops generate higher income compared to planting Jatropha	Availability of loans helps farmers start producing Jatropha increasing their incomes	Revoke pledging policy, subsidy/guarantee price of cash crops such as rice, maize, and other agricultural products
	Cooperative extension offices provide technical support to farmers on improved seed production	Technical support not effective Farmers are not interested due to low income compared to other cash crops	Technical support allows farmers to grow Jatropha productively and profitably Cooperation between external experts from universities and cooperative staff Periodic training and updating of new techniques	Promote R&D to improve Jatropha yield and Jatropha harvesting technique with low labour cost Ensure attractive high sale price of Jatropha seed
	Cooperative provides technical support to biodiesel producers to improve production	Technical support is not effective Some biodiesel production problems require supervision	Technical support allows Jatropha to be produced to a high quality and profitably	Develop automatic system which easy control system Develop high efficiency biodiesel reactor
	Final biodiesel product is sold to cooperative members 20 percent cheaper than open market cost; priority given to members who need fuel for their tractors	Policy B5 fixes price of biodiesel Production is not of high enough quality	PPO production replaces diesel purchase, decreasing costs of food production and increasing farmer's income	Revoke B5 policy (fixed price of biodiesel)

	An additional product (glycerin) is also used directly by cooperative farmers or new market creation	No glycerin market; used as raw material for new products	Create new market; use glycerin as raw material for new products that add significant additional value, significantly increasing profitability	Training in/promotion of glycerin utilization and its application Financial support for new production processes which use glycerin as raw material (e.g. for soap, fuel, purified glycerine)
Level 2 – Inputs, services, finance and outputs				
University of Kasetsart, Jatropha School	Jatropha School provides training in production and processing of Jatropha into marketable products	Training is not useful so does not help increase production of PPO or reduce its costs (one-off training at time of project start-up is not sufficient)	Training leads to significant increase in production/reduced cost of PPO production including by-product utilization e.g. glycerin	Periodic training; update new techniques Supply chain and appropriate business model development
	Training provided on the design and construction of machinery for processing the Jatropha oil and products to suit different scales of production	Training is not useful so does not lead to increase in efficiency or quality of PPO production	Training leads to significant increase in efficiency and quality of PPO production, leading to increased profits	Cooperation between external experts from universities and coop staff for continuous R&D Practical learning centre for students Jatropha biodiesel development and learning centre
Cooperative League of Thailand (CLT)	Provides funding to VAC to support Jatropha production and general technical support	Funding is limited so support cannot be provide sustainable operation of Viengsa PPO	Initiative is successful at producing PPO to replace diesel, increasing incomes and lowering agricultural costs; funding is offered to other cooperatives	Awareness-raising programme on biodiesel utilization should be run continuously Dissemination of appropriate business model of Jatropha biodiesel production

Recommendations for interventions for up-scaling and replicating market system development

The Thailand Pure Plant Oil initiative started in Viengsa district, Nan province in 2006. This project was funded by a number of government agencies as part of work towards the zero-waste management concept. The programme plans to supply Jatropha seed for biodiesel (B100) production, organic fertilizer (made from Jatropha residues), a 500 kW small-scale powerplant (using steam turbine technology, and Jatropha's branches and other biomass residues as fuel) and charcoal or biomass for cooking application.

Throughout the seven years of project implementation, VAC has faced numerous barriers to maintaining biodiesel production. The key barriers are biodiesel demand and Jatropha seed supply (including shortage of used cooking oil). As a result, the price of both biodiesel and Jatropha seed are the key factors in the achievement of Jatropha plantation and biodiesel production.

However, the most significant factor is government policy. Some policies are key barriers to the upscaling and replication of the project; others work as key drivers. Possibly policy interventions to consider are:

1. revoke policy on the fixed price of biodiesel (B5);
2. revoke pledging policy, subsidy and/or guarantee price of cash crops;
3. increase cooperation between government agencies (such as the ministries of Energy, Agriculture and Cooperatives, Commerce, Natural Resources and Environment, Labour, Industry) including local agencies and local participants to develop concrete policies to promote Jatropha biodiesel;
4. ensure concrete policies continuously support Jatropha plantation, Jatropha biodiesel production, and biodiesel utilization including market development of biodiesel and by-products;
5. specify appropriate area to promote Jatropha plantation and community-based Jatropha biodiesel production;
6. ensure financial support for project expansion under the zero-waste concept;
7. ensure awareness-raising programme on biodiesel utilization is run continuously;
8. establish an Energy Community Fund and use it for energy projects such as a biodiesel plant;
9. create an appropriate business model for Jatropha biodiesel production and management which increases profits and attracts private investment;
10. carry out R&D into new/innovative products made from Jatropha (e.g. bio-jet fuel) and by-products which create more value added;
11. conduct periodic training and update new/innovative techniques for continuous improvement;
12. periodically monitor positive and negative impacts of Jatropha biodiesel project.

References

Bureau of Agricultural Economic Research. 2009. *Guarantee price of maize and cassava* (available at www.oae.go.th).

DEDE. 2012. *Alternative energy development plan.* AEDP 2012–2021. Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy Thailand (available at www.dede.go.th).

DIT. 2011. Minute of meeting 1/2011, rice prawn regulatory committee. Department of Internal Trade (September) (available at www.dit.go.th).

EPPO. 2010. Resolution of the National Energy Policy Committee, 30 December 2010 (available at www.eppo.go.th).

FAO-PISCES. 2009. *Small-scale bioenergy initiatives: brief description and preliminary lessons on livelihood impacts from case studies in Asia, Latin America and Africa.* PISCES/FAO, Nairobi, Kenya. Food and Agriculture Organisation of the United Nations (FAO) and Policy Innovation Systems for Clean Energy Security (PISCES) (available at www.scholar.google.com).

Ministry of Agriculture and Cooperatives. 2013. *The appropriate area for rice, cassava, para rubber, palm oil, sugarcane and maize plantation* (February) (available at www.moac.go.th).

Ministry of Labour. 2013. Minimum daily wage (available at www.mol.go.th).

ONEP and GIZ. 2013. *Climate change policy in Nan province, Thailand.* Thai German Climate Protection Program (August) (available at www.thai-german-cooperation.info).

Viet Nam (Case 10): CCRD VACVINA biogas initiative

Initiative Name	**Viet Nam CCRD VACVINA Biogas Initiative**
Location	*Thanh Hoa province, Viet Nam*
Initiation date and duration	*From July 2006 to date*
Funder	*Enabling Access to Sustainable Energy program (EASE) of the Organisation for Educational Training Consultants (ETC) of Netherlands*
Project initiator	*Center for Rural Communities Research & Development (CCRD)*
Overall budget	*EUR73 980 (funding from ETC)* *EUR56 850 (contribution of beneficiaries)*
Energy output	*504 000 m^3 biogas for cooking and lighting* *(estimated: 900 m^3 of biogas per household per year)*
Area of land	*None*
Beneficiaries	*560 households using biogas as free fuel in this province (9 870 is the total number of households with biogas units across all 61 VACVINA chapters)*

Background and context

Viet Nam has one of the fastest growing economies in the world. Following land rights being given to individual farmers 1993, the country embarked on an integrated land management scheme supported by the Viet Namese Gardener's Association (VACVINA), which works at all levels and has national responsibility to promote its concept, known as the VAC integrated system. This involves gardening, fish-rearing and animal husbandry to make optimal use of the land. Traditional fuels such as wood and coal for cooking are becoming increasingly scarce and expensive, and their use leads to deforestation. Increasing livestock production in rural communities with high population density can incur health and environmental issues from the quantity of animal dung being produced. Biogas digesters are part of the solution, using the wastes to generate energy, and the resultant slurry as fertilizer to improve soil quality. A market-based approach has been adopted to disseminate the plants. The service provided to those buying the digester is comprehensive. The customer must have at least 4-6 pigs or 2-3 cattle; these provide all the inputs (animal dung). Households use the biogas as fuel and slurry as fertilizer. They pay the total installation cost for the digesters to local service providers (LSPs) and operate the biodigester using instructions which the LSPs provide. A biodigester produces enough daily fuel for cooking and lighting. It improves the surrounding environment, while livestock produce meat, milk and fish products for local consumption and subsistence farming. Vegetable production is enhanced through the use of biogas slurry, and latrines can be added to the system to enable human waste to be used for energy.

Although there is a range of biogas models being used in Viet Nam, a market assessment indicates that 70 percent of farmers choose the VACVINA biogas model, with about 30 percent choosing other biogas models. This is however starting to change, with the delivery of several new projects and the introduction of new composite biogas materials produced in China and Viet Nam.

Approximately 200 000 biogas digesters have been installed throughout Viet Nam, with most of these being the fixed dome design developed and supported by SNV. Approximately 1 500 of the VACVINA biogas systems had been installed in Thanh Hoa Province by 2013, up from 560 in 2008.

CCRD VACVINA Biogas Programme Summary. CCRD were involved in a programme funded by ERC which provided training to biogas masons who have established micro-enterprises. This training covered the technology as well as marketing strategies. CCRD is not currently working on biogas in Thanh Hoa, although 14 of the original 20 trained micro-enterprises still operate independently. The six micro-enterprises went out of business as they were not able to get enough customers. CCRD and VACVINA are very interested in developing new technologies, perhaps using better performing composite materials, testing to see if they perform better. The following provides an assessment of the current situation in Thanh Hoa with respect to the VACVINA biogas technology, looking at the three levels of the biogas market system: the market chain, the inputs, services and finance and enabling environment.

Level 1: Energy market chain

Biogas construction and distribution. Biogas masons and micro-enterprises set up a 'one-stop' shop providing comprehensive information about the technologies and allowing users to order their own system. It also provides follow-up advice and maintenance as required. VACVINA help arrange customer meetings at the biogas shops to try and get households interested. VACVINA model biogas systems cost around VND10 million[24] for a 7 m³ system. Other models are:

- SNV-designed fixed dome model: VND7–12 million for 7 m³
- Composite material biogas system: VND14–15 million for 7 m³

As well as the biogas system itself, households often need to make improvements to ensure the best use of a biogas system, for example carrying out repairs to their pigsty, kitchens and latrines. This can cost an additional VND10 million.

The VACVINA models biogas entrepreneurs are currently not active, because of the low demand for new biogas systems. The technicians are technically competent to construct high quality systems that operate for more than 10 years with minimal maintenance, building their systems based on the septic tank design with which they are very familiar. However they have not developed sustainable business models (which would include marketing to generate demand) and as a result, get work only when a household approaches them to install a new system.

Marketing. Micro-enterprises usually construct a demonstration model to raise the interest of households. They also employ a range of marketing approaches, such as messages on local government radio stations which are popular among farmers in Viet Nam. An early bird promotion campaign offered the first ten customers a 30 percent discount on the system. These early adopters are then required to try and get other customers interested in buying biogas systems by demonstrating it to others. Future awareness-raising

[24] US$1 = VND21 100.

campaigns need to build on this and include other forms of communication (e.g. television adverts), and more demonstrations throughout the country.

Warranty and maintenance. Warranty and follow-up service is an important overall part of the system and this is not well-established in Viet Nam. VACVINA model biogas systems generally need to be emptied every three to four years (when pig dung is used) and every two years (when cow dung is used). However, this is often not explained by the entrepreneurs. Warranties are generally not honoured and many systems fall into disrepair, reducing confidence in the system. In addition, most farmers do not get the training they need to operate the systems as well as they could. Biogas entrepreneurs need to provide better and more regular training for farmers, including follow-up training for at least the first year after installation. This needs to cover operation of the system as well as its maintenance which can be carried out by the farmers themselves. Follow-up advice and training could also be provided by VACVINA members.

End user experience. Most VACVINA biogas systems operate very well and are well-liked by the households who use them. One system installed in 2001 is still operating perfectly without requiring any maintenance, apart from the inexpensive replacement of the plastic biogas reservoir. The system produces enough biogas to meet all the cooking needs of a household of six, based on dung from eight or nine pigs, and is also used for cooking the food for the pigs. Rice wine for occasional community celebrations is made when there is excess gas. The pig dung needs to be cleaned out every day, a procedure which takes about 10 to 15 minutes and which is generally quite straightforward. The gas is much cleaner and easier to use than the fuel the households used to use (such as rice straw and maize plant residues, and coal); these were highly polluting and resulted in a longer cooking time with regular supervision which is not needed now. Health problems used to include eye irritations and coughing, and the heat produced by the earlier fuels caused discomfort to the householder working in the kitchen (usually a woman or child).

The pig dung is now disposed of safely, which reduces odour and insects, and the neighbours no longer complain. The pigs are much healthier which greatly increases their value. The bioslurry is used for fertilising vegetables, significantly increasing their production. It is however not currently valued very highly and cannot be sold. It is produced every day and if not used is safely disposed of in the canal.

End user demand. The biogas market in Thanh Hoa has not developed significantly because demand has not increased significantly. The main reasons for this are:

- Animal disease. Pigs in Viet Nam have suffered from blue ear disease; cows and buffalo have suffered from foot and mouth disease and animals have been destroyed. Pig-raising in particular disrupted was three times between 2008 and 2013.
- Access to credit. The biggest barrier for end users to take up biogas systems is limited access to credit to buy the systems which are relatively expensive.

Although the VACVINA model biogas systems are well-liked, poor marketing and their high cost means demand for them is not very high. The model is also not supported by the national programmes managed by MARD and VBA and so is not eligible for subsidies or supported to receive microfinance. The performance of the system needs to be evaluated and MARD should then be lobbied for support.

Level 2: Inputs, services, outputs and finance

Biogas construction materials. All the materials needed to construct the biogas systems are available locally in Viet Nam, apart from the valves which come from Thailand. Cement and bricks are the main components and their price has remained fairly stable over the last five years. The biogas stoves are available from local agents in Viet Nam, manufactured in Japan or China. A two-burner stove costs about US$20–25.

Day labour. Although day labourers are fairly easy to find in Viet Nam to help entrepreneurs to produce the biogas systems, labour inflation is quite high and has increased by five times in the last seven years.

Microfinance for energy users. Several new projects funded by SNV, WB and ADB are trying to overcome the issue of access to finance by helping banks and savings groups to start offering loans for biogas systems. However this only started in 2011 and only covers a number of districts in Viet Nam. The banks involved include the Social Policy Bank, the Agricultural Bank and the Cooperative bank, covering 16 provinces of Viet Nam. These banks are being supported to develop loan packages of up to US$2 500 for biogas systems, with the payback period varying between one and two years and an annual interest rate of around 10–12 percent, which is based on the market rate (this does not include the VACVINA model system as this has not yet been endorsed by MARD).

The programme is still in its early stages, making it hard to gauge its level of success. It has been criticised for being too top-down in its approach rather than being based on the needs of the end users. As it falls under an environmental protection programme it is not clear how biogas systems can meet the programme inclusion criteria. Under the programme, credit is provided for periods of one to three years (three years is the length preferred by most households). Loans of around VND20 million are needed to purchase the biogas systems and make all the required household improvements; these are paid back either monthly or quarterly. However, few banks in Viet Nam are interested in offering such small loans due to their high proportion of overhead costs.

Biogas entrepreneur loans. Biogas entrepreneurs need loans to invest in their businesses. However, for this they are required to show guarantees to the banks, which is usually not possible as they are not yet sufficiently formalised. Support needs to be provided to bridge this gap between the entrepreneurs and banks to enable access to end user finance. The entrepreneurs also need loans, to invest in production equipment, stock, marketing materials and business development support.

Viet Nam Biogas Association (VBA). This is the national association for biogas producers in Viet Nam, and should be the industry body that represents all producers to lobby for positive change, such as reducing taxes, providing incentives and regulating producers. However it is not well-funded and so does not operate well. It charges producers a membership fee, but as it is not operating it is not able to collect the fee.

VACVINA. This is a local Viet Namese NGO. It provides technical oversight of the biogas entrepreneurs to ensure that the biodigesters are completed to the appropriate standard and quality. This includes follow-up maintenance, as well as assisting with marketing and business model development. However, they have not been very effective in this role and the entrepreneurs have not yet developed into fully-functioning businesses that can operate sustainably.

Level 3: Enabling environment

Quality control and standards. Viet Nam Biogas Association (VBA) was established in 2011 with support from SNV and has been working to develop quality control standards for biogas. These standards have been developed together with MARD and endorsed by Ministry of Science and Technology (MOST), and should be officially approved in 2014. Quality control is based on the relationship between farmer and biogas producer, with regulations produced by government department and then adhered to. The standards will be overseen by the Directorate of Standards and Quality in Viet Nam, and it is expected that producers will be trained in how to use the standards once officially approved. Standards have been developed for a range of areas including feedstock production, operation and maintenance, technology, appliances and bioslurry. All the biogas programmes coordinated by MARD and VBA will be required to meet these standards. Additional standards need to be decided for other biogas technologies under development, including the VACVINA model and new composite biogas models from China.

Importation taxes. Importation taxes are relatively high in Viet Nam, and while this does not affect the VACVINA biogas system, it does increase the price of the composite biogas systems which are imported from China. The government does not prioritise renewable energy, including biogas, and provides no importation tax relief for biogas systems. In addition, government departments are not coordinated; although the biogas sector is overseen by the Ministry of Energy, importation taxes are controlled by the Ministry of Industry and Trade (MOIT).

Government departments. The Ministry of Agriculture and Rural Development (MARD) is currently leading on biogas development. However, Viet Namese government officials are not well-paid; their motivation and capacity is quite low and their programmes generally not functioning as well as they could. Other departments such as Ministry of Energy need to be better involved and coordinated. Within MARD, its agricultural extension department could provide training as currently utilisizes a decentralised approach; this however has not yet been extended to biogas. MARD also runs Viet Nam's National Biogas Programme together with SNV, as well as other programmes outlined below. Although coordination of biogas technologies and programmes has started, it needs to be extended to all technologies and programmes (including the VACVINA model) so that lessons can be learned and barriers and drivers identified. The VACVINA biogas system model is currently not supported by MARD as there are concerns over its safety due to the plastic gas reservoir being above the pigpen (although no incidents have been reported). A new model was developed in 2011 incorporating a pressurised tank which mitigates this safety concern; a recent independent evaluation concluded that the system operates well and safely.

World Bank LIFSAP programme. This began in five provinces in 2012, and was scaled up to 16 provinces in 2013 in Viet Nam (but not Thanh Hoa). It is focused on promoting competition in animal husbandry which farmers can access for biogas systems. There is a lot of support in Viet Nam for rice production but not a huge level of support for animal husbandry.

ADB QSEAP and LCASP microfinance programmes. ADB is currently funding these two programmes providing microfinance for biogas systems.

SNV RBF programme. This programme is funded by DfID and coordinated by EnDev. It will be supplying results-based finance to try and overcome the ongoing subsidy requirement for household biogas systems.

The Ministry of Energy has developed the Viet Nam Energy Master Plan which outlines the country's planned progress on energy production and usage up to 2020. Although it currently includes biogas, there are no specific details on the technologies and sizes of the systems; this needs to be developed in more detail in coordination with MARD and all relevant donors and stakeholders to ensure coordination and support.

Table 1.10: Relationships between market actors

	Farmers	Biogas service provider	VACVINA groups	CCRD	MARD
Farmers					
Biogas service provider	Technical, financial and formal				
VACVINA	Technical, financial and formal	Technical, regulatory, formal			
CCRD	Informal, technical	Technical, formal	Technical, formal		
MARD	Regulatory, financial, Informal	Regulatory, Informal	Regulatory, informal	Regulatory, informal	

Table 2.10: Balance of relationships, rights, responsibilities and revenues

Actors	Rights	Responsibilities	Revenues
Small farmers Large farmers	- Use of land for farming including animal raising - Sales of animals (pigs, cows, buffaloes) for meat and milk products	- Protecting the environment via agriculture production - Paying back loans (if any) - Operating and maintaining digesters while cleaning pigsty	- Income from farm products - Saving money by using biogas as a free fuel - Saving money by using slurry as fertilizer
Biogas service providers	- Rural and agricultural service provision	- Promoting biogas installations for sustainable rural and agricultural development (including fertilizer)	- Income from selling biodigester and/or wages building biodigesters - Income providing bio-additive to farmers for producing biofertilizer
CCRD NGO as national technical assistance centre, on VAC promotion including biogas	- R&D into advanced technologies (including biogas) - Enabling access to sustainable energy to reduce poverty - Providing information, consultancy and training - Improving community management capacity	- Enforcing VACVINA regulations pertaining to its objective of promoting VAC integrated system including biogas technology	- Income from providing bio-additive to farmers for producing biofertilizer - Income from selling tools and biogas equipment
VACVINA chapters at all level	- Developing VAC integrated systems (including animal husbandry) with farmer groups - Policy advocacy (with reference to farmer's rights)	- Enforcing VACVINA regulations, revised every five years to include responsibilities assigned to relevant chapters & NGOs under VACVINA	- Income from Association member fees

Figure 1.10: Initiative market map

Table 3.10: Barriers, drivers and interventions

Main actor	Main influencing factors/forces	Potential barriers to upscaling and replicating	Potential drivers for upscaling and replicating
Enabling environment			
Ministry of Energy	Development of supportive energy policies for up-scaling energy systems including regulations on quality control standards	Policy does not provide sufficient support for biogas and quality is not control leading to low uptake.	Biogas systems are well regulated and supported leading to high quality and wide uptake.
MARD	Approved VACVINA model and support to allow biogas systems to be disseminated nationally	Support is not sufficient to ensure uptake of systems.	Biogas becomes a national priority and is fully supported and taken up throughout the country.
Market chain			
Biogas service providers biogas service providers	Sells, constructs and installs biogas technologies for households, including ensuring warranty is honoured.	Designs are not well liked or do not function well and are not purchased by farmers.	Designs fit well with farmers needs providing cheap high quality energy and fertiliser.
	Offer at 18–25 percent price discounts to early adopters ‘early birds’	Discount is not attractive enough for farmers to purchase systems and sector does not take off.	Discount stimulates market creating increased demand for the systems becoming a sustainable industry.
	Provide training to households on effective use and maintenance of systems.	Training is not sufficient or useful and households stop using the systems after they’ve been installed.	Training allows households to make greatest use of their systems, producing large quantities of gas and fertiliser increasing their incomes.
Household biogas system users	Waste biogas slurry is produced as a high value organic fertiliser which helps increase food production.	Fertiliser is not high quality or liked and does not add any value.	Fertiliser is very high quality significantly increasing food production and increasing farmers’ incomes.
Supporting inputs and service actors			
ETC/EASE	Provided financial support for programme as well as subsidy for ‘early bird’ biogas installations	Programme does not produce desired results and funding is stopped, ending the programme	Programme helps biogas market take off in a sustainable way after initial investment and is replicated in other regions and countries.

CCRD	Provides technical capacity building to support a network of biogas service provider companies	Support is not useful or too expensive and biogas companies go out of business.	Support allows companies to set up sustainable businesses selling large quantities of systems throughout the country.
	Promotes biogas technologies through local VACVINA local network of offices	Biogas is not well promoted and not adopted by farmers	Biogas is well-promoted; farmers understand the many benefits and purchase the systems
	Provides bio-additive to farmers to produce biofertiliser	Fertiliser remains a low quality product which does not increase food productivity and is not used	Fertiliser increases significantly in quality becoming a high value product due to its ability to significantly increase food production
VACVINA	Provides monitoring of supplies and quality, as well as credit to biogas service providers	Support to biogas providers not sufficient; companies go out of business	Support allows companies to develop steadily and sustainably sell biogas systems
	Oversees biogas service providers, managing contracts and helping develop marketing campaigns	Contracts not honoured, marketing is not effective, farmers do not purchase systems	Marketing and contracts are effective and households are willing to purchase systems and use them productively
Financial service providers	Provision of loans to farmers to purchase biogas systems	Financial services not available to farmers which stops them purchasing systems	Financial services available; used by farmers to purchase biogas systems at a high level of penetration, increasing their incomes

Conclusions

The initiative appears to have had a positive effect on stable, rural livelihoods. Biogas complements sustainable agricultural production in the animal husbandry sector, generating additional income, protecting the local environment and enabling the poor to gain access to sustainable energy. Biogas is an essentially free resource with the potential to replace traditional fuels (such as coal, firewood and rice straw). Local service providers benefit through new employment opportunities and enhance their income.

The main success factor of the biogas project in Thanh Hoa is it having been based on the Enabling Access to Sustainable Energy programme, a five-step market orientation strategy focused on enhancing the capacity of community-based organisations with relevant and necessary skills. If not for this, it is likely that the biogas project impact would have followed a similar route to others based on an NGO-subsidized approach, and failed once the programme ended.

Insufficient money to buy a household biodigester has been identified as a factor that limits biogas development in the community. Biogas use entails further upfront costs for farmers if they want to incorporate a hygienic latrine. Currently, there are insufficient finance mechanisms through which farmers can access credit for building VACVINA biogas plants. The demand is however still immense, as Viet Nam has nearly 10 million households involved in various forms of animal husbandry.

References

BEFS. *Operator level food security assessment tool, version two* (available at http://www.fao.org).

ESCAP. 2013. *Advancing sustainable energy UN-energy Asia-Pacific, Bangkok, Thailand*.

FAO. 2010. *Bioenergy and food security, BEFS analytical framework*. Environment and Natural Resources Management Series No.16, Rome.

FAO. 2012. *A compilation of tools and methodologies to assess the sustainability of modern bioenergy,environment and natural resources management*. Working Paper No.51. Rome.

GBEP/FAO. 2011. *The Global Bioenergy Partnership Sustainability Indicators for Bioenergy*. Rome.

PAC/FAO/PISCES. 2009. *Small-scale bioenergy initiative: brief description and preliminary lessons on livelihood impacts.* Rome.

Practical Action. (2012). The Poor People's Energy Outlook 2012, Rugby, UK.

World Bank. (2013). The Global Tracking Framework, Washington.

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